Guide for Design Management on Design-Build and Construction Manager/General Contractor Projects

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP REPORT 787

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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FOREWORD

By Andrew C. Lemer
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NCHRP Report 787: Guide for Design Management on Design-Build and Construction Manager/General Contractor Projects presents guidance for state DOTs and other transportation agencies on design management under CM/GC and D-B project delivery. The guidance, including case studies of projects successfully developed using these alternative procurement strategies, is written to assist agency staff responsible for management oversight of facilities development.

While the traditional design-bid-build (DBB) approach to project delivery remains prevalent among state departments of transportation (DOTs) and other owners of transportation facilities, some agencies have been selectively adopting alternative delivery methods that increase collaboration among the owner, designer, and constructor. Under the design-build (D-B) process, for example, the designer and constructor act as a unified team to deliver a completed project at a set price. Under a construction manager-at-risk (CMR) process, designer and constructor are engaged separately by the owner (as is the case under DBB), but the constructor is involved from the earliest stages of the design process; the designer and constructor are expected to work collaboratively to deliver a project that meets the owner's requirements. Some agencies have adopted the term Construction Manager/General Contractor (CM/GC) for a method that is generally similar to CMR but has more effectively facilitated the reallocation of risk among owner, constructor, and designer; and does not restrict the primary contractor's performance of work tasks. (As used in this research, CM/GC was understood to include CMR.) Among the attractions claimed for such alternative project-delivery methods are improved constructability, increased project cost certainty, improved schedule certainty, and actual cost savings.

Experience has shown that agency policies used to develop and administer traditional design contracts (that is, under DBB) are inadequate for these alternative delivery methods. The objective of NCHRP Project 15-46, "Design-Management Guide for Design-Build and Construction Manager/General Contractor Projects" was to develop a guide to effective design-management practices for owners using CM/GC or D-B. The guide was to include (a) a review and synthesis of recent experience of owners' management of design services under CM/GC and D-B; (b) critical assessments of the relative merits of alternative approaches to managing key aspects of the design that affect project scope, quality, and cost; and (c) lessons learned from design management under CM/GC and D-B that may be effectively applied under other project delivery methods.

A team led by the University of Florida, M.E. Rinker, Sr. School of Construction Management, Gainesville, FL, conducted the research. The research team reviewed recent experiences of DOTs and other public agencies regarding design management practices used on

projects developed under CM/GC, D-B, and similar methods for project delivery. The team also investigated relevant experience from other construction industry segments. Considering such issues as liability and responsibility in CM/GC and D-B project development and measures of effectiveness for design management, the team developed a framework characterizing principal areas where owners' design management practices under CM/GC and D-B project delivery processes are likely to influence project success and specific guidance for successful design management.

The product is a guidebook for state DOTs and other transportation agencies on design management under CM/GC and D-B project delivery. The guidance is supplemented by case studies of projects successfully developed by several DOTs. This document is written to assist agency staff responsible for management oversight of facilities developed using CM/GC and D-B and other such alternative procurement strategies.

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Note: Photographs, figures, and tables in this report may have been converted from color to grayscale for printing. The electronic version of the report (posted on the web at www.trb.org) retains the color versions.

SUMMARY

Guide for Design Management on Design-Build and Construction Manager/General Contractor Projects

In the 1990s, the general public began insisting that planned highway and bridge projects be completed quicker than possible using the Design-Bid-Build (DBB) construction project delivery system which had dominated the industry since the 1930s. This led state DOTs to look into fast-track methods of construction.

The Intermodal Surface Transportation Efficiency Act, passed by Congress in 1991, established, among other things, Special Experimental Projects Program 14 (SEP-14). This allowed DOTs, which had previously used state funds for fast-track highway and bridge construction to apply for federal funding for construction projects using the Design-Build (D-B) delivery system.

The D-B system has proven to be very effective and popular, with 42 state DOTs and numerous county and municipal transportation agencies now using the system. However, D-B has its downsides. Many Design Professionals (DPs) are uncomfortable being subservient to the contractor instead of the owner. Some owners complain about the lack of control over the design process that they experience with D-B. As a result, some contractors denounce attempts by some owners to interfere with the design process. This has, once again, caused public transportation agencies to search for another delivery system that might mitigate or eliminate those concerns while providing many of the advantages of D-B.

The Construction-Manager-at-Risk (CMR) delivery system offers a direct contractual relationship between the owner and the DP, which solved both problems. However, CMR did not achieve the popularity of D-B, mainly because contractors did not trust a system that forbade them from performing work themselves, as some agencies preferred, or that forced them to bid against a list of qualified subcontractors for any work that they wanted to self-perform.

A solution was offered by the Construction Manager/General Contractor (CM/GC), a system modeled after CMR that allows, or in most cases compels, the CM to self-perform a portion of the work. This mollified the contractor groups and, along with the FHWA's Every Day Counts (EDC) initiatives, gave CM/GC a boost in popularity among public transportation agencies.

The purpose of this research is to identify . . . an effective and efficient DM process for fast-track transportation construction projects. . . .

Nowadays, D-B and CM/GC are increasingly used to deliver transportation projects and, together with DBB, can be considered the industry's major delivery systems. The nature of D-B and CM/GC contracts especially affects Design Management (DM). In the scope of this research, the researchers have defined DM as the approach used by agencies to organize and oversee the process of designing the transportation infrastructure. Under D-B, the design process is led by the selected D-B entity (the Design-Builder) after a D-B contract has been awarded. Depending on the selected DM

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approach, agencies can assume different levels of involvement. Some agencies strongly rely on performance specifications or on long-term strategic partnerships with D-B entities to maintain a limited involvement. However, other agencies embedded a stronger oversight role for themselves or their consultants. Since several procurement activities affect the shaping of the DM process, they were included in the scope of this study, and the Guidebook provides a discussion on these pre-award activities. Under CM/GC, the researchers found that it is often impossible to completely separate the design process from the construction process, since the two are more closely intertwined and dependent on one another than in any of the three major delivery systems. Therefore, many of the recommendations for organizing DM under CM/GC can be easily considered as actions necessary to implement CM/GC at large.

The purpose of this research is to identify or develop a set of practices for the establishment and execution of an effective and efficient DM process for fast-track transportation construction projects, specifically those developed using the D-B and CM/GC delivery systems. To this end, the research team has executed telephone interviews with 65 public transportation agencies, done follow-up telephone interviews with, and procured supplementary data from, 18 of those agencies, and finally spent at least 2 days to a week with 9 agencies gathering information for the development of Case Studies on projects or programs using D-B or CM/GC. Among the most important findings is that the D-B and CM/GC programs have found that the easiest way to pay the contractor and please FHWA auditors is to use either straight Unit Price, or a combination of Unit Price and Lump Sum or Unit Price and Cost-reimbursable contracts.

D-B

The ability to utilize external consultants for staffing is crucial in affecting the approach to DM. Flexible staffing (through the use of external consultants in the appropriate number and with the needed expertise) allows an agency to handle the dynamic design review process in a timely manner. Equally important is allocating for the proper maximum agency review duration; and enough human resources to perform the design package reviews is critical in minimizing issues and delays.

Providing the proper level of design in the Request for Proposal (RFP) is critical in obtaining effective and innovative proposals. Agencies must provide enough design to clearly convey the project scope, but too much design may hinder Design-Builders' capacity to introduce innovations.

The success of many D-B projects is based on the level of innovation that Design-Builders provide. Therefore, agencies must establish effective VE-like processes during the pre- and post-contract award phases. Agencies that disclose submitted Alternative Technical Concepts (ATCs) before contract award or do not allow ATCs may greatly hinder Design-Builders' ability and motivation in providing innovations.

D-B project success can be strongly affected by the level of integration between contractors and DPs. Thus, agencies must adopt specific strategies to ensure that contractors and DPs are effectively collaborating during the design phase.

CM/GC

The most important advantage of CM/GC is the innovation possible through the preconstruction services of the contractor as CM. The second biggest advantage of CM/GC is the flexibility it grants the participants, before and during the project, in assigning risk in the

optimum proportions for project success. Everything should be done to retain the CM as early as possible. It is important that the design process enable the team to permit and design the project in small "mini" phases, and that this process be tailored to begin construction early. It is important to educate DPs and contractors who have never worked on CM/GC projects that the culture of CM/GC is different than DBB or D-B, and to teach them the CM/GC culture. For CM/GC to work, especially early in the life of a program, complete support from upper management is essential, as is the education of the surrounding counties, municipalities, supplier networks, subcontractors/specialty contractors, permitting agencies and utility companies. Constructability Reviews and VE are considered part of the fee the CM gets for preconstruction services.

CHAPTER 1

Introduction

Background

The traditional approach for procuring and managing design and construction services for public works has served the public well for most of the past century. This approach is based on a separation of the procurement of design and construction services. Under this system, construction firms are selected through a competitive low-bid system; but when the agency outsources design, Design Professionals (DPs) are selected based on their qualifications. The foundation of this system, often called Design-Bid-Build (DBB), is the principle of selecting DPs based on qualifications (Brooks Act—Public Law 92-582) and selecting construction contractors based on competitive sealed bids with award to the lowest responsive and responsible bidder, almost always based on 100% Plans Specifications and Estimate (PS&E). Over the decades, DBB has provided taxpayers with a large portfolio of functional, safe, and efficient transportation facilities at the lowest price that responsible, competitive bidders can offer.

The Interstate system as well as almost all state and county roads have been delivered through this traditional approach. For the most part, DBB has effectively prevented favoritism in spending public funds and has provided checks and balances through separate contracts with the DP and contractor while stimulating competition in the private sector. Under DBB, the agency has retained full control over Design Management (DM), often seen as an advantage of this approach. In the scope of this research, the researchers have defined DM as the approach used by agencies to organize and oversee the process of designing the transportation infrastructure. DBB, while adequate for most construction projects, has also demonstrated various drawbacks, including fostering adversarial relationships among the project parties, limiting innovation, and resulting in serious growth in project cost and duration. In addition, it may not necessarily provide the best value to the owner for all project circumstances or types.

In recent years, this issue has become more pressing for highway agencies, as deteriorating infrastructure and increasing population create tremendous pressure to move critical projects quickly from the planning stage through design and into construction without a commensurate increase in available funding. Underlying these external budget and time pressures is the basic requirement of maintaining quality in all phases of the highway program. Thus, there is a continuing need for highway agencies to review and evaluate alternative procurement and contracting procedures that promote improved efficiency and quality. As a result, other approaches to procuring and delivering transportation projects have been introduced over the last twenty years.

. . . (T)here is a continuing need for highway agencies to review and evaluate alternative procurement and contracting procedures that promote improved efficiency and quality.

The wide range of options for project delivery methods available today is a relatively recent development for publicly funded highway projects in the United States. DBB was the only method in transportation until the

introduction of D-B in the Intermodal Surface Transportation Efficiency Act of 1991. Another step was taken in 1996 when the Federal Acquisition Reform Act explicitly authorized the use of Design-Build (D-B) for federal projects. After that, the Transportation Equity Act for the 21st Century (TEA-21), Public Law 105-178, allowed the state DOTs to receive federal funding for D-B contracts if the enabling state-level legislation was in force (TEA-21 1998). Subsequent to the successful experience of using D-B on several projects, many states passed new legislation and codes to allow alternative project delivery methods such as D-B, Construction-Management-at-Risk (CMR), and Construction Manager/General Contractor (CM/GC).

Many public agencies have implemented D-B to accelerate project delivery. While D-B has advantages, including single-point responsibility (combining the DP and builder under a single contract), accelerated delivery, collaboration, and incentivization for innovation, it also has certain disadvantages, including less agency control over design and a preference on the part of most DPs to work for the owner instead of a contractor. In fact, under D-B, design and construction services are provided by a single contractual entity, which often contracts out design services. Whether design is self performed by the Design-Builder or by a design consultant to the Design-Builder, the management of design services is substantially different from what agencies use under DBB. Whereas the agency is highly involved in design activities during the DBB, involvement is limited under D-B to contractually allocated responsibilities for Quality Control/Quality Assurance (QC/QA). Any further involvement results in potential change orders to the initial D-B contract. Various scenarios can be used in the industry, including allocating design QC responsibilities to the Design-Builder and retaining QA responsibility for the agency; allocating both QA and QC to the Design-Builder; or securing the services of an independent QA firm. More rarely, the agency retains full QC/QA responsibility, which increases its ability to closely check for the design quality but also increases inefficiencies, risk of disputes and may slow down the design review schedule. Under any approach, the line of communication between DPs and the agency goes through the Design-Builder that is often a contractor or a joint venture of contractors.

Such concerns have caused some transportation agencies to seek alternatives to DBB and D-B for project delivery. A promising alternative that has generated interest in the highway sector, CM/GC may offer some of the same advantages as D-B related to expediting projects while allowing the agency to retain control of design (through a separate contract with the DP). Previous studies have found that adding CM/GC to a DOT's delivery toolbox provides several benefits (NCHRP 2009, Gransberg and Shane 2010). First, CM/GC provides DOTs with a conservative option when D-B and DBB are not able to satisfy contrasting project objectives. CM/GC is an integrated team approach applying professional management during the planning, design, and construction of a project. The team consists of the owner, the architect/engineer (DP), the Construction Manager (CM), and subcontractors. As in the case of DBB, the owner contracts separately for design and construction services. However, the CM may be retained about the same time as the DP, typically through a qualifications-based or best-value selection process. During preconstruction, the CM acts as an advisor, providing professional services to the owner. A CM performs constructability reviews, cost estimates, construction phasing and schedules, and budget recommendations to determine the best options for the owner based on the project budget. The CM also may perform duties not typically performed by contractors, such as assisting in securing financing or selecting or helping in the selection of DPs. When the CM is "at risk," it becomes the General Contractor (GC) during the construction phase. The CM awards subcontracts in either a fixed price, cost-reimbursable, or Guaranteed Maximum Price (GMP) contract. When a CM is bound to a GMP, the most fundamental character of the relationship is changed. In addition to acting in the owner's interest, the CM must manage and control construction costs to not exceed the GMP (AIA-MBA Joint Committee 2014).

CM/GC has a long history in both public and private sectors, particularly for vertical construction, federal sector projects, and related construction projects. While there are potential differences

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in how CM/GC is implemented for vertical construction, some of the same fundamental characteristics apply to highway or multi-modal transportation projects. Among the perceived advantages of CM/GC, the emphasis on teamwork and the fact that a CM can be involved in the design and decision making process early in the project distinguish it from traditional DBB. Generally speaking, the three biggest advantages of using CM/GC are (1) Freedom to innovate design and construction practices; (2) Flexibility to allocate risk, and then to re-allocate risk and continue to re-allocate risk throughout the life of the project; (3) Potential for great cost savings through innovation and optimum risk allocation. Other noted advantages involving design include:

- Innovation and constructability recommendations early in the design phase
- Agency retention of significant control over design
- Potential for time savings by fast-tracking early components of construction prior to complete design in phased packages
- Ability for the DP to develop a more accurate cost estimate earlier
- Allowance for the design to be accomplished in the priority order that the phases are needed for construction and budget constraints.

Problem Statement

Once an agency has decided to pursue the implementation of a D-B or CM/GC program, there are certain broad concepts that must be understood by all parties involved. Successful implementation of a D-B or CM/GC program in many cases requires a significant and aggressive change in the culture and philosophies of the parties involved from that of traditional DBB projects. In terms of DM, the standard design methods, schedules, and plans review stages frequently used in designing DBB projects may prove inadequate or insufficiently accelerated to realize the advantages of these alternative delivery methods, making the task more challenging for DPs and agency staff.

Under D-B, DPs lack a contractual relationship with the agency. With few exceptions, DPs usually are consultants to the Design-Builder even if the agency often contracts with a separate DP for preparing the conceptual design to be included in the Request for Proposal (RFP). Similarly to CM/GC, they are required to take a much more active role in working with the constructor (almost always the leading D-B entity), but their ability to communicate directly with the agency is limited when compared to DBB and CM/GC. This is particularly true when the D-B contract was awarded on a lump sum where the D-B tied the price to certain design assumptions and may tend to be defensive regarding these assumptions. Under these circumstances, agencies still may be able to implement effective DM by setting certain boundaries in the specifications and through an appropriate and clear approach to design QA and QC. However, these approaches need to be identified early and conveyed to proposers during the proposal preparation phase. Often, proposers' specific approaches to quality management for both design and construction are used as a component of the best-value evaluation.

Under CM/GC, DPs still have a contractual relationship with the agency. However, they are required to take a much more active role in working with the owner and contractor (or CM) throughout the entire design process, including early and continuous Value Engineering (VE) (though CM/GC contracts rarely have a VE clause), Right-of-Way (ROW), real-time pricing, increased coordination meetings, and accelerated design. DPs must budget additional funding and management personnel for frequent team meetings and binding decisions while working with both the owner and contractor (CM). DPs need to be educated in the process of receiving real-time input from the constructor as well as being flexible in modifying standard items such as traffic control plans to best fit the chosen approach to construction.

Overall, the fast-track nature of both alternative delivery methods leads to a short-term need for increased plan production rates. This places additional requirements on the DPs, such as

extended work hours, to keep pace with the acceleration and changes proposed by the constructor. Successful implementation also often requires that a project be broken into additional multiple "mini" phases, enabling the constructor to start work early in areas where ROW and permits have been obtained and/or utilities relocations have been completed. Early work packages can be broken down into such items as retention ponds, partial clearing and grubbing, constructing on friendly parcel takes, etc., which requires more design effort than traditional "station-to-station" designs. Standard items under the DP's oversight, such as utility coordination during design, partially transfer to the constructor to accelerate utility relocations, advance-order long lead items, have one "point" of responsibility with the utility companies, etc. These shifts in responsibilities are often required for the constructor to take responsibility for the overall project schedule and budget.

Research Objectives

The motivation behind NCHRP Project 15-46 is that a comprehensive delivery toolbox which includes the D-B and CM/GC methods would require the utilization of new practices for DM than does DBB. Therefore, the main research objective was to develop a guidebook that will aid DOTs in the successful implementation of effective DM for owners using CM/GC or D-B project delivery. The guidebook will include separate chapters to specifically address each delivery method. In addition, this guide includes the following elements:

- A review and synthesis of owners' recent experience in design services management under CM/GC and D-B, conveyed through case studies
- Critical assessments of the relative merits of alternative approaches to managing key aspects of the design that affect project scope, quality, and cost
- Lessons learned from DM under CM/GC and D-B that may be applied effectively under these and other project delivery methods.

Research Approach

Initially, the research team contacted, by telephone, every state DOT in the country (52 including Puerto Rico and the District of Columbia), plus 13 non-DOT public transportation agencies, and conducted an initial round of phone interviews with the personnel identified by the agency as the individuals most knowledgeable about that agency's design process, as well as experiences with CM/GC and D-B. This first round of interviews (i.e., Level 1) was performed using a structured questionnaire that included strategic, exploratory questions regarding the agency's recent experience with design services under CM/GC and D-B. Not all DOTs have experience with either system, but an organization potentially may have sound and effective design practices in place that could serve as building blocks for other strategies incorporated into the final products of this research.

The agencies with the most experience and information to offer were identified and asked to participate in a second round of in-depth interviews (i.e., Level 2). Agencies participating in the second round took part in a second telephone interview and were asked additional (supplemental) questions by email. Level 2 participants were asked to provide answers to more in-depth questions, as well as for data from their projects and documents. Eighteen agencies took part in Level 2. From the in-depth questions, critical assessments were made regarding the relative merits of alternative approaches to managing key aspects of the design that affect implementation, project scope, quality, and cost.

The results of these Level 1 and Level 2 surveys guided the selection of case study programs and projects that were selected to provide an in-depth diverse portfolio of sample implementations

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of DM procedures. Agencies chosen for case studies were visited by one or two team members. During these visits, the team conducted detailed interviews and gathered specific information from various parties, including agency staff and consultants, DPs, and contractors. Between 6 and 20 individuals were interviewed at each of 10 programs visited. This Guidebook includes synopses of many case studies that were conducted. Detailed narration of these case studies is also included in the Appendices.

Overview of Guidebook Content

This guidebook is organized into five chapters and includes a set of appendices containing case studies. Chapter 2 provides a general framework to implement a change in delivery by adding D-B and CM/GC. Chapters 3 and 4 include a review and synthesis as well as a critical assessment of alternative approaches to managing key aspects of design as they may affect project scope, quality and cost. These chapters utilize short versions of the case studies to convey these approaches. In addition, detailed implementation templates for the two delivery methods are provided. Chapter 5 concludes the guidebook by providing a set of key lessons learned for design services management under CM/GC and D-B and discussing general implementation issues.

CHAPTER 2

Shaping Design Management for D-B and CM/GC

Overview of DM Process Framework

This document describes the Design Management Process Framework (DMPF) that will guide the agency in shaping a DM approach for D-B and CM/GC projects. Since the nature of the two methods affects the process of implementing DM practices, the framework includes comments specific to each. More specifically, D-B has been used by a majority of agencies to deliver hundreds of projects. As a result, industry practice has produced a diverse set of D-B-specific DM practices, which are all compatible within the specificity of each agency and its constraints. Consequently, the framework pragmatically takes into consideration the diverse nature of D-B implementation by different agencies trying to help readers identify what would work for their agency based on the experience of other agencies. Instead, the majority of agencies has not used CM/GC or has only started to use it. Therefore, fewer DM practices have been developed by the few agencies that have pioneered this method, so far. Consequently, many of the CM/GC-specific framework recommendations are normative in nature and describe how to implement change within an agency so that a pre-selected DM approach would work. Therefore, while general in concept, subsections of this document include comments that are specific to each method.

Once a transportation project or program is initiated (**Start**), an agency usually deploys a process to collect data and information to define the scope of the project, including its expected cost and desired completion date as well as complexity and any constraints that may affect delivery. Using this information, at a certain point, the agency decides if this project/program will be delivered with traditional DBB delivery or with one of the innovative delivery methods available, including D-B and CM/GC (**Step 0**). Investigating how an agency should select a delivery method in this initial step was not part of the scope of this research. However, since it is important to the correct implementation of the following steps, an extensive review of previous research efforts and industry practices was performed. The DMPF is mostly focused on Steps 1 to 4, which will help an agency identify, select, and implement a feasible and appropriate approach for conducting DM on its project/program.

To enable success, an agency should identify potential constraints that would affect DM on the project/program and proactively address them.

Because each agency and project is unique, different individuals would be involved in identifying, selecting, and implementing DM. Therefore, on any given project, it is not always apparent what agency- or project-specific constraints might limit an agency's decision for shaping the project delivery at large and the DM approach in particular. To enable success, an agency should identify potential constraints that would affect DM within the project/program and proactively address them (**Step 1**).

After potential constraints have been identified, agency staff should evaluate lessons learned to select and shape a DM implementation approach (**Step 2**). Chapters 3 and 4 summarize how

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to undertake this as well as provide a brief overview of sample applications by different agencies. To illustrate how different approaches have been implemented, a compilation of case studies is also provided for referral (**Step 3**). Each case study provides a real-life example of a combination of DM practices being utilized on a project or in a program. Synopses of these case studies are included in Chapters 3 and 4 whereas full details are included in the Appendices.

Finally, after DM practices have been selected for use on the project, the agency can develop its own implementation plan (**Step 4**). The implementation plan should provide guidance on how to implement each DM practice within the framework of a specific transportation project or program. Lessons learned and recommendations are provided to supplement the implementation plan. In summary, the process framework consists of the following five steps (see Figure 1):

- Step 0. Select innovative delivery path (D-B or CM/GC).
- Step 1. Identify the agency's and project's constraints.
- Step 2. Select DM approach appropriate for addressing the agency's and project's constraints.

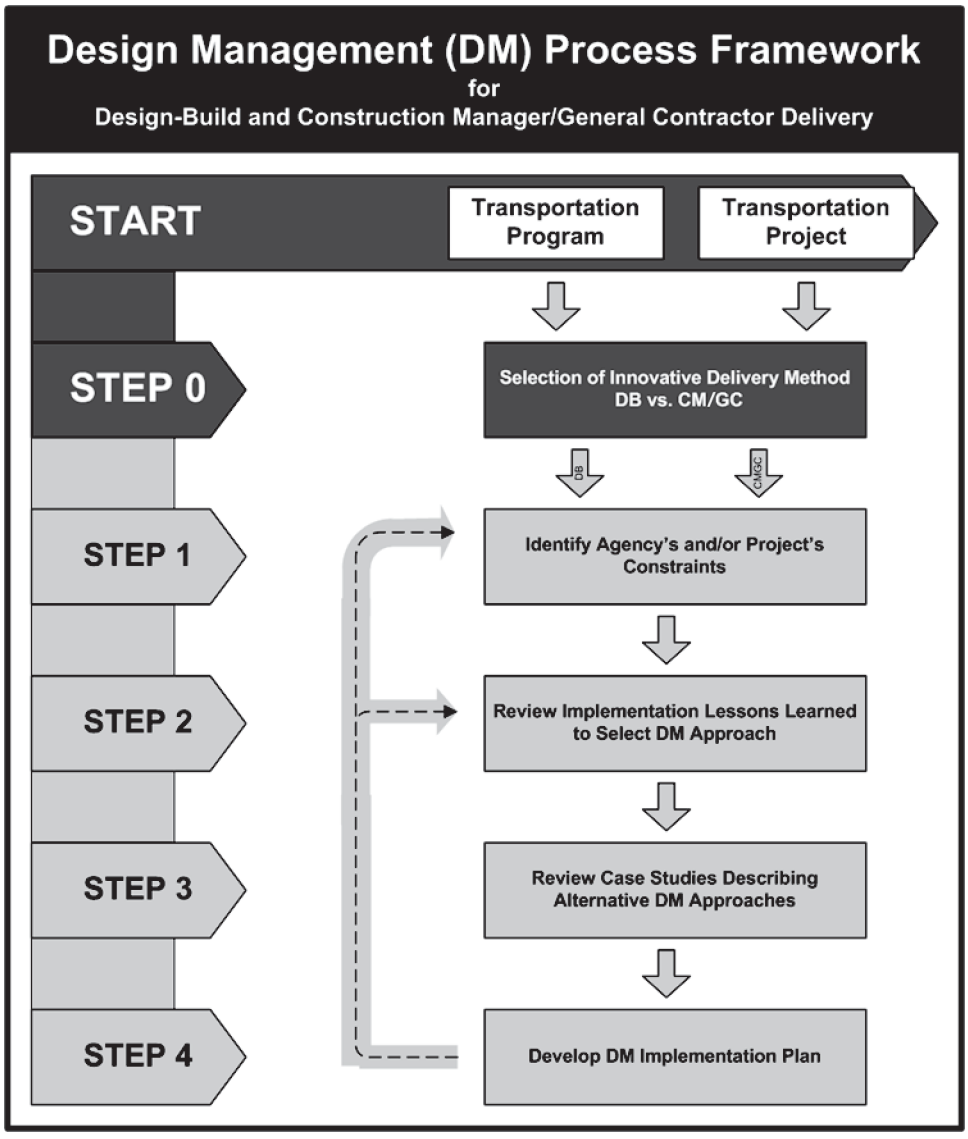

Figure 1. DM process framework.

- Step 3. Identify and review case study examples for selected DM approaches.
- Step 4. Develop DM implementation plan grounded in guide's implementation guidelines, lessons learned, and recommendations.

Start: Identification of Transportation Initiative

As part of the initial phases of a new transportation project (or program), an agency usually initiates a process to collect data and information that will help define the scope of the project, including its expected cost and its desired completion date as well as the project's complexity and any constraints that may affect its delivery.

Step 0: Selection of Project Delivery Method

At a certain point, the agency will have enough information to decide how to deliver the project. Depending on the state legislative authority, an agency can have one or more delivery options. At minimum, all agencies will be able to deliver the project with traditional DBB delivery. If the agency has the authority to select an alternative delivery method, including D-B and CM/GC, various paths exist to carry out DM for each method, described in the following steps. The DMPF is designed to help a project team that has little or no familiarity with D-B or CM/GC in identifying, selecting, and implementing a feasible and appropriate approach for conducting DM on a project/program.

Note: While the selection of the project delivery method is crucial to DM, investigating how agencies carry out this initial step was not within the scope of this study.

Step 1: Identification of Agency's and/or Project's Constraints

Because each agency and project is unique, different individuals would be involved in identifying, selecting, and implementing DM practices. Therefore, on any given project, it is not always apparent what agency- or project-specific constraints might limit an agency's decision for shaping the project delivery at large and the DM approach in particular. By reviewing information in the Guidebook chapter for the selected delivery method, an agency can learn more about different approaches for carrying out DM and any specific constraints that may affect the success of a specific approach.

For D-B, a diverse set of agency- or project-specific constraints could be developed, and was formatted in the D-B chapter (Chapter 3.A) as a self-assessment background document to help a transportation administration staff identify potential issues and constraints affecting DM under D-B. This document provides an in-depth description of potential constraints and issues relevant to a successful implementation of DM under D-B. Since this document is based on information collected throughout this research effort, an agency should review the provided self-assessment document to identify which issues may be encountered in its situation or context. In addition, the agency should also conduct a brainstorming self-assessment session to verify whether any additional issue or constraint may be present that could affect DM for its D-B project or program.

On the other hand, only a few agencies have reached maturity in implementing CM/GC. Therefore, the CM/GC chapter takes a different route by allowing agencies to conduct an initial brainstorming self-assessment session to identify how the normative approach for implementing CM/GC, described in Chapter 4.B, can be customized for its project or program.

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Step 2: Selection of DM Practices through Review of Implementation Lessons Learned

Using the list of potential issues and constraints identified by each of the parties involved, the agency can now learn about compatible DM practices by reading the template document for the selected delivery method. Chapter 3.B includes DM information for D-B whereas Chapter 4.B provides information for CM/GC implementers. Information in these sections is based on the analysis of data.

Step 3: Identification and Review of Case Studies

A compilation of case studies is included in the Guidebook as a reference to "real-life" projects or programs that have implemented DM practices. Once project issues have been identified and DM practices have been selected, an agency can refer to the case studies to learn how other agencies have dealt with similar issues. Case studies can be selected by cross-referencing the identified issues with specific cases. For example, if an agency has identified as a potential issue, the lack of design review staff on a project, case studies that have addressed this issue can be identified easily in the case study summaries. Chapter 3.C includes summaries of six D-B case studies. A full narration of four of these cases is also included in Appendix A. Similarly, Chapter 4.C includes summaries of six CM/GC case studies. A full narration of these cases is also included in Appendix B.

Once this step is completed, an agency can tentatively select a DM approach for a given project. If concerns arise on the implementation at this time, there is the opportunity to return to Step 2 to reassess constraints, or to Steps 3 and 4 to review other lessons learned, review more case studies, and select an alternative approach that would work better within the existing constraints.

Step 4: Review Implementation Guidelines, Lessons Learned, and Recommendations

Once the previous steps are completed, an agency can develop a DM implementation plan. The constraint self-assessment of the constraints provided the foundation for evaluating various DM approaches and to select the most appropriate approach for the agency and the given project. If concerns arise, there is the opportunity to return to Step 2 to reassess constraints, or to Steps 3 and 4 to review other lessons learned, review more case studies, and select an alternative approach that would work better within the existing constraints. In formulating this implementation plan, the agency could pull out from this guide specific lessons learned and recommendations and customize them to the agency context.

The final product of this step would be a detailed implementation plan providing guidance on implementing each selected DM practice within the framework of a specific transportation project or program.

CHAPTER 3

Design Management Under Design-Build

This section provides guidance for effectively shaping DM functions under D-B. Initial research included a survey to determine how many state agencies have used D-B and when they began to implement it. This survey found that about 80% of state agencies have already used D-B. However, it also showed that many agencies have still not adopted this delivery method. Additionally, among the agencies that have used D-B, about half have used it sporadically and for fewer than ten projects. In the light of these findings, the purpose of this section is twofold: while focusing on providing DM guidelines under D-B, it also summarizes the results of previous research on D-B implementation in general, so that all agencies can benefit from the experience of agencies around the country.

Subsection A gives agencies DM-specific self-assessment guidance that they can use to select the most appropriate DM approach for D-B projects. Subsection B provides two sets of guidelines: one for implementing D-B, based on previous research findings (see note below); and the other for implementing DM under D-B, based on the current research effort. Subsection C synopsizes several case studies of D-B programs or projects. The reader can use these brief case studies to learn how some of the guidelines have been put into practice. In addition, Appendix A presents full narratives of many of the case studies.

Note: One of the authors previously studied D-B implementation issues and has produced a broad implementation framework that is available in the literature in its full version (Migliaccio 2007) and in a compact version (Migliaccio et al. 2008). The same study also produced a large collection of D-B lessons learned (Migliaccio et al. 2006; Gibson et al. 2006). If an agency is interested in learning implementation issues and practices beyond DM, they can refer to these resources. This section integrates results of NCHRP Project 15-46 research activities with some of the results of these previous studies.

A: Self-Assessment Background

This subsection provides guidance on the self-assessment process for selecting the most appropriate DM approach. While some agencies pursue D-B implementation through programmatic initiatives, others adopt a project-by-project approach. This section addresses both cases. For instance, it offers program managers who are designing or reviewing a program two different levels of information about potential constraints: (1) at the agency D-B program level; and (2) at the D-B project level. Using this information, program managers can conduct brainstorming self-assessment sessions to identify and analyze any issue or constraint that could affect DM for their D-B projects or programs. All key individuals involved in D-B implementation should attend this session, focusing on how the identified constraints may manifest themselves, as well as on whether any additional constraints may be present. In the case of a single project implementation, the Project Manager (PM) would take the same approach, leading this constraint

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identification and brainstorming process. However, at the project level, the stakeholders would only include people on the project staff or in project support (e.g., DOT design division or district staff).

Note: Some of the constraints discussed herein are specific to DM, but the majority will affect D-B implementation in general. Thus, this section can also help anyone learning to implement D-B. The discussion covers issues and constraints encountered on past projects and draws on the case studies. It also reflects research team members' personal experience on projects and/or their previous research.

Agency/Program Self-Assessment Level

The agency self-assessment identifies elements within the agency that could hinder the successful D-B implementation. This assessment is particularly useful to agencies that only recently have adopted or are considering adopting an innovative project delivery method, since it allows them to address certain issues before experiencing their effects on projects. It also benefits agencies already using this delivery method to help them identify issues they might previously have overlooked.

Agency Culture

One of the most difficult questions an agency can ask is whether it is prepared to adopt and implement an innovative project delivery approach, since it forces the agency to face the reality of its organizational culture. Because the decades-long use of the DBB method has so fundamentally shaped employee perceptions and organizational structures and practices, implementing a new delivery approach constitutes a major paradigm shift for the state agencies adopting it (Miller et al. 2000). Early studies have found that "as agencies attempt D-B for the first time, they are constrained by the low-bid culture in their organizations" (Molenaar and Gransberg 2001). The U.S. DOT has acknowledged these difficulties, reporting that "states not accustomed to this method of procurement can find it difficult to oversee these types of projects" (USDOT-FHWA 2004). Moreover, although the D-B method's combined procurement of services is expected to reduce transactional costs for delivering a project (Pietroforte and Miller 2002), this approach usually prompts state personnel to spend considerable time experimenting and developing new organizational routines to support the change (USDOT-FHWA 2004). This extra time is often justified by a wider concern that safeguards embedded in traditional approaches will be lost in the change process (USDOT-FHWA 2004). However, these concerns often appear with respect to the agency's approach to DM under D-B, since losing control of design is one of the major agency concerns when D-B is implemented for the first time.

To effect meaningful organizational change, agencies must address their formal and informal cultures alike. Without attention to aligning these two organizational realities, agencies are likely to see opposition to new processes.

Effective implementation thus requires agencies to determine how change should occur, in order to establish new working relationships with contractors, suppliers, and consultants. Such challenges to changing the project delivery approach are common when an agency adopts any innovative delivery method (e.g., D-B or CM/GC) and often depend on an agency's formal and informal cultures. When an agency is procedurally rooted in traditional means and methods, it is likely to face varying degrees of opposition to innovative delivery approaches. Instead, the agency's *formal culture* should be open to innovation, risk-taking, and improvement of the *status quo.*

Similarly, the agency's *informal culture* must support an innovative project delivery method for it to succeed fully. Informal culture consists of the way an agency actually gets work done, apart from procedures and policies. It is often a response to gaps in these existing guidelines and is a result of the need to adapt them to change. Agencies

should never underestimate the impact—positive or negative—of the informal culture on the implementation of new delivery methods. In one case involving the Utah Department of Transportation (UDOT), the successful implementation of D-B for the I-15 Corridor Reconstruction project created a positive environment for evaluating and adopting innovative contracting methods. Other agencies have encountered significant challenges in their initial D-B projects, with mixed results. Within these agencies' informal organizational cultures, an initial negative perception of D-B slowed down or stopped its use. None of the selected case studies presented herein relate such failures, but the research team is aware of such situations in the industry. Sometimes, initial lack of success, or even failure, was caused by specific issues (e.g., statutory exclusions of procurement methods other than low-bid, or lack of D-B knowledge within the local contracting community). After having resolved these issues, the agencies overcame the informal cultural resistance and successfully restarted their D-B implementation processes.

Personnel/Staff

The successful implementation of innovative delivery methods requires the support of in-house personnel and staff. Several staffing issues may affect effective DM and can be grouped into five categories: (1) personnel assignments, (2) staff availability, (3) staff capability, (4) training, and (5) utilization of consultants.

Personnel Assignments. When using D-B, an agency often relies on Design-Builder innovation to provide the best value to the public. Thus, project personnel must be innovative and open to new ideas in order to help advance the application of the methodology. Agencies must select individuals enthusiastic about such programs, instead of people who will resist participation, even when they are assigned to administer them. Often, at the outset of a project, the project management will need to determine the level of expertise needed, in order to select personnel in time. For example, UDOT provides guidelines on assembling the project team; these guidelines are discussed below in the case study on the UDOT D-B program.

Staff Availability. D-B projects tend to be fast-paced and require more of a time commitment from staff, particularly in terms of the design review process. Therefore, as a Design-Builder's design production rate rises and falls, the agency's design review load fluctuates with it. Indeed, an agency may be forced into accommodating the Design-Builder's pace if the contractual agreement does not regulate the review flow. (See Processes and Standards.)

Staff Capability. D-B projects need personnel who can manage the issues and complexities unique to the D-B method. To succeed in their respective D-B roles, staff should be able to work under pressure, be flexible, and multi-task as needed. Because the D-B schedule is accelerated, the staff often needs to be knowledgeable in project control practices. And, since agency staffs on D-B projects are often smaller in size, individuals with high levels of expertise in their respective technical areas may be required to perform independent design reviews or oversee consultants involved in the review process. Agencies also often create units dedicated to supporting D-B implementation on individual projects. Such units are staffed with agency personnel experienced in D-B. Even in the absence of a D-B unit, individuals with D-B experience are used on an as-needed basis for D-B projects. For example, several of the Washington Department of Transportation (WSDOT) employees assigned to the SR 99 project had been involved in other critical D-B projects. (See SR 99 Case Study.)

Training. Staff may need additional training during DM to understand and perform the duties required of public owners managing D-B projects. Promptly assessing these needs and training these individuals are crucial requirements of a successful DM implementation on a D-B project. For example, if an agency is allowing submission of Alternative Technical Concepts

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(ATCs) for the first time, staff must be trained on the confidentiality issues that attend this approach to DM during procurement.

Utilization of Consultants. If an agency does not have the required in-house resources to develop and/or manage a D-B project, it may need to consider hiring outside consultants. Since this is a common approach to staff DM functions, a set of associated issues is described in detail below.

Consultant Utilization

The agency may opt to use private consultants on a variety of tasks as part of the D-B delivery method. The agency should address the following questions to determine which roles should be filled by consultants:

- Will the general engineering consultant role be outsourced to a private engineering company to manage the D-B process for this program/project?
- Will the agency utilize consultants as external reviewers of the design packages?
- Which roles will these consultants perform in defining the methodology used on a project?
- Will the consultants use a standard already in place, or is the owner/agency expecting them to deliver/develop a new standard?
- With respect to roles and responsibilities, is the agency willing to accept the major changes inherent to adopting an innovative delivery method?

To manage the Oregon Transportation Investment Act (OTIA) III State Bridge Delivery Program, the Oregon Department of Transportation (ODOT) selected Oregon Bridge Delivery Partners, a joint venture of two large contractors. ODOT and Oregon Bridge Delivery Partners (OBDP) collaborated closely to develop a comprehensive project delivery toolbox. This toolbox included DBB, D-B, and CM/GC for the program. The Bundle 401 project case study discussed below exemplifies how ODOT addresses issues related to consultant utilization.

Consultant utilization issues can be summarized for a generic project into three groups: (1) engineering methodology; (2) D-B process; and (3) roles and responsibilities.

Engineering Methodology. The agency must decide whether to use an established engineering standard, allow the consultants to develop their own, or to customize some established standard. Involving the consultants in this task is a great way to find effective and unique approaches to innovative delivery methods. However, utilizing multiple consultants will likely result in multiple methodologies. Caution should be taken, and strong agency leadership will be required to ensure success and prevent confusion.

D-B Process. Project resources contributed by private firms can help agencies that are new to a process advance its use on one or more projects. If an agency already has processes and procedures in place, the consultant will simply execute them on a given project. This practice allows an agency to develop and advance its policies and procedures in a real-time fashion on an existing project. However, in the absence of established procedures, the outside firm will likely apply its own approach to the project. Agencies new to the implementation of D-B (or CM/GC) should be cautious when utilizing different consultants on different projects, since the agency is likely to get differing versions of each methodology from the various firms chosen. For example, utilizing three or four firms to assist with several D-B projects could result in not one D-B methodology for the agency, but three or four. This profusion of D-B approaches will confuse in-house staff and D-B firms alike. As for engineering methodology, managing multiple firms on as many projects is acceptable, but requires strong agency leadership.

Roles and Responsibilities. When implementing innovative project delivery methods, agencies must be prepared for major changes in their roles and responsibilities. Project roles and

responsibilities should be defined clearly to prevent duplication of effort. Another important issue is the difficulty some agencies have in "letting go" of responsibilities traditionally handled "in-house." Inspection and testing are well-known examples of this issue, but the approach to structuring the design review process and performing design reviews are other examples. To ensure the successful performance of such duties, agencies must address issues of trust in the industry.

Processes and Standards

When an agency implements an innovative delivery method, it will often need to re-examine and adjust its processes and standards. To determine what needs to be changed, the agency should ask itself the following question:

- Does the agency really engineer and construct its projects to its standards, or are there "personal preferences" involved that define expectations?

Issues at stake can be grouped into two categories: (1) processes and (2) standards.

Processes. Processes should be adjusted to accommodate innovative delivery methods. For example, agencies may need to adopt new design review procedures, such as the "over-the-shoulder review" for D-B projects, or Independent Cost Estimate (ICE) for CM/GC projects. To accommodate such new procedures, UDOT created the Office of Innovative Contracting and Project Controls within its Project Development Division. This office fosters the implementation of innovative project delivery methods by developing guidelines and supporting agency staff during the procurement and contract execution phases. For D-B projects, UDOT developed several documents describing the appropriate implementation procedure, from the beginning of the process to the issuance of the RFP. Similarly, after being authorized to use CM/GC in 2012, the Minnesota Department of Transportation (MnDOT) staff composed a document compiling recommended CM/GC processes—including issues with ICE selection and use—and submitted this document to management and the CM/GC Advisory Committee.

Standards. Many agencies go through a "self-discovery" process with respect to their standards when they first use innovative methodologies such as D-B and CM/GC. They find that, over time, their engineering expectations have been driven by preferences more than by the basic standards. Because the expectations of such agencies are grounded in preference, this shift toward compliance with the higher standards stipulated in the contract places the Design-Builder at odds with the agency. To limit this conflict, agency expectations should be clearly defined in advance. To this end, agencies must acknowledge the existence of this tension and take steps to mitigate it. To that end, the agency must either accept their defined standards and redefine their expectations based on years of personal preferences, or adjust their stipulated standards to better convey their expectations.

Participation and Communication

Each D-B program/project requires the agency to adapt to its specific context, which includes external stakeholders, such as the public, elected officials, utilities, local governments and their agencies, and industry providers. Acceptance by these stakeholders is often crucial to the successful management of D-B projects in general and to the performance of DM functions in particular. Issues at stake can be grouped into two categories: (1) stakeholders and (2) proposers.

Stakeholders. The agency should ensure that all stakeholders necessary to the design process are involved early, since any lack of communication may delay the project schedule before and/or after the proposal due date. Moreover, the agency should develop a plan for cultivating buy-in from stakeholders who will not have contractual relationships with the contractor but are crucial

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Early involvement by stakeholders is key to maintaining critical communication both before and after bid; cultivating buy-in from non-contractual stakeholders—e.g., utility companies and members of the public—is also crucial to preventing delays.

to project success. For the I-15 Core project, UDOT signed a master utility agreement with all utility owners affected by the project. This effort began prior to contract award and was concluded after contract award. The Design-Builder was responsible for developing the supplemental utility agreements and for coordinating all design and construction activities with utility owners.

For the SR 99 project, the Design-Builder understood that other stakeholders may review design submittals. In this case, WSDOT entered into several MOAs with the City of Seattle, detailing oversight requirements and expectations. These MOAs were needed, since much of the project work was on and under City of Seattle property and, thus, might have affected city-owned infrastructure. But, the MOA conditions complicated design review timelines and expectations because the Design-Builder had to coordinate with many stakeholders within the city and its utility subsidiaries. It was also necessary to meet City of Seattle standards for certain work efforts and WSDOT standards for others.

Proposers. It is important to be upfront and honest with proposers during the procurement phase. This transparency allows the proposers to provide products with the best possible design and construction.

Q & A. A process should be in place to allow proposers to present and resolve any questions and issues that emerge.

Innovation. A process should also be in place allowing proposers to present innovative design and/or construction ideas for agency approval and reward. Agencies must be prepared to accept innovative ideas and concepts (e.g., ATCs), as well as the risks that attend them. Agencies should also take care to avoid the "not invented here" bias when considering innovative ideas.

Project Self-Assessment Level

Agencies should use the project constraint assessment section to identify project-specific issues and constraints that may prevent successful D-B implementation. Whereas these issues may be relevant to D-B aspects other than DM, this section only addresses issues pertinent to DM.

Project Information/Data Collection

Key Information. Providing the same information to all proposers will make for even competition and elicit better technical and price proposals. Design-relevant information is often crucial, since typical information includes design surveys, environmental permits, geotechnical investigations, and assessments of utilities, easements, and ROW. For the I-15 Core project, UDOT was responsible for procuring ROW. To allow the proposers to design the facility and develop the project schedule effectively, the agency detailed the properties it would acquire based on the existing preliminary design and also provided a property acquisition schedule during the procurement phase. Moreover, UDOT allowed the proposers to identify additional properties through the ATC process. However, UDOT limited any risk associated with the acquisition of these additional properties through the following contractual language: "In the event that implementation of an ATC will require additional real property or utility work, the Design-Builder shall have full responsibility for paying for any such real property and any related costs, including any necessary environmental approvals, or performing any such utility work without the right to a change order."

Data Collection. To take full advantage of schedule advancement, prevent delays, and limit design rework, the agency/owner should provide all critical information (e.g., concerning ROW,

easements, utility relocation, contamination remediation, or environmental permits). In fact, by providing the information ahead of time, it also will prevent duplication of efforts during the design pursuit phase. In the OTIA III State Bridge Delivery Program, ODOT hired several external consultants to perform data collection tasks. Specifically, one consultant led the efforts to collect environmental data, develop performance standards, establish the mitigation banking program, train agency staff, and implement the National Environmental Protection Act (NEPA) approach, whereas two others led the efforts to collect the engineering data.

Project Scope. Data availability will facilitate the development of project scope, which is crucial to design development. This issue has two dimensions that should be explored: (1) clarity and (2) complexity.

Clarity. A well-defined scope is necessary to the selection of a contract method. It also guides the design process and helps the project team determine construction costs. The successful completion of some of the projects discussed in the case studies is probably attributable to many merits but, especially to a well-defined scope.

Complexity (Low and High). Projects with very simple scopes (e.g., Resurface, Restoration, and Rehabilitation [RRR], mill/resurface, or sidewalk projects) may not provide enough opportunities for innovation to realize the benefits of the D-B method. However, its use can provide significant schedule advantages and, with a well-defined scope, can eliminate project risks and delays.

On highly complex projects, proposers can provide a more innovative design and construction approach for schedule advantages and cost savings.

Design and/or Construction Restrictions

Design. The agency should clearly state/define any restrictions to design, e.g., the prohibition of any modifications to typical sections, pavement design, or bridge lengths. If these restrictions are included in the RFP document, the proposers can assess the consequences of these restrictions and develop their proposals accordingly. Even if a restriction is clearly stated in the RFP document, a proposer could still submit ATCs and suggest lifting it, as long as its removal is shown to yield significant value to the agency. On the other hand, adding restrictions after a contract is in place may cause conflict.

Construction. The agency should clearly state/define any restrictions in construction approach, e.g., prohibitions on the use of certain construction methods and materials. As with design restrictions, it is important to understand how the timing of the communication of these restrictions affects the Design-Builder (i.e., pre-award versus post-award).

Construction Costs

Selection Method/Bid Type. Cost of construction is key to determining whether to use the D-B method and which type of selection approach to use (e.g., best value or low-bid). Agencies must perform initial scoping to determine probable cost of construction. Multi-criteria evaluation based on the determination of the best value is a very common approach to awarding D-B contracts, as shown in the case study discussions. However, other approaches may be preferable in other circumstances, as in the case of the I-15 core project, in which UDOT adopted a fixed price/best design approach.

Bidding Contingencies. D-B projects may only have conceptual drawings, as opposed to full construction plans, and may be missing much of the data needed to determine a bid price.

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Proposers tend to compensate for this by adding contingencies in their price proposal. The more data provided prior to bid, the better price the agency can expect (See the Project Information section). Setting and reviewing contingencies are two of several risk management processes that should be continuously monitored on D-B projects. In some cases, agencies rely on external review panels for these reviews. For instance, for the Alaskan Way Viaduct and Seawall Replacement Program, which included the SR 99 project, WSDOT relied on an expert review panel. This panel performed extensive program reviews, including ones of overall program management, risk management, budget and contingency plans, availability of financial resources, stakeholder and partner agency relationships and interfaces, and mitigation of public and political issues (See the SR 99 case study).

Project Schedule

Schedule Determination. The agency should determine the contract time for a D-B project, noting that the availability of certain critical information will greatly affect the design schedule (See the Project Information section).

Schedule as a Selection Criterion (Key and Non-Key). The agency needs to determine whether the contract time is a key criterion for the bid, since it can help determine (or be determined by) the type of bid used.

Projects for which contract time is a key criterion may include project schedule in the bid to reward bidders for a shorter contract time (This criterion can be utilized in maximum price bids).

When an early completion is not required, the agency may fix the schedule and use a low-bid method, or a best-value approach that is based on technical merit and price.

Criteria and Factors for Selection

The agency should determine which factors and criteria to use for selecting the Design-Builder. For complex projects, agencies typically include time and cost savings, innovative approach, and value-added construction methods and materials as selection criteria, in addition to contract time and bid-price considerations. For simple and less schedule-driven projects, bid price is often the most important factor. To select Design-Builders for the OTIA III State Bridge Delivery Program, ODOT and its consultants conducted a comprehensive evaluation of the technical proposals to score each D-B team (See the ODOT case study). Criteria can also be assigned for the qualification step. In its request for qualifications, the UDOT D-B program lists "experience with formal partnering activities" as a selection criterion (See the UDOT case study).

B: D-B Implementation Framework and Templates for Organizing Design Management under Design-Build

Taking the discussion in Section A of constraints at the agency/program and project levels as a point of departure, this section initially summarizes a previously developed process framework for D-B implementation (Migliaccio 2007). It then provides guidance on DM under D-B, providing DM template guidelines for different phases, including project planning and procurement, and design development.

Design-Build Implementation Framework

Migliaccio (2007) developed the Changing Delivery System (CDS) framework to help agencies implement changes in their project delivery strategies. This framework was validated for D-B projects through a series of detailed case studies and by an expert panel. This subsection

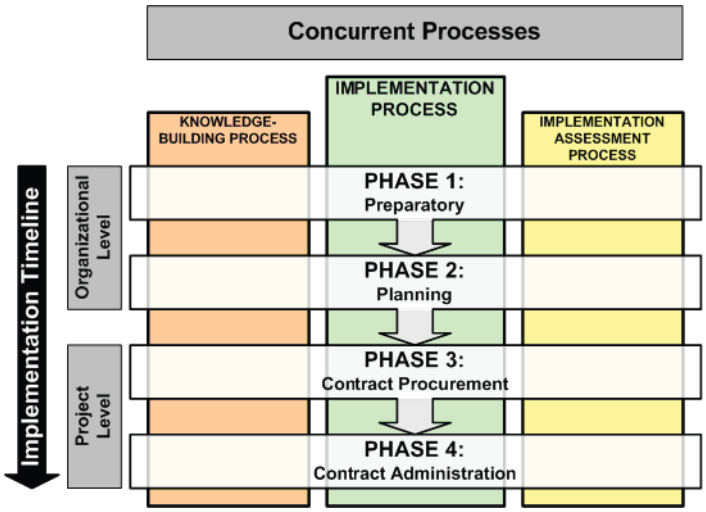

Figure 2. D-B implementation (adapted from Migliaccio 2007).

presents this framework for implementing D-B at both the program and project levels. Figure 2 illustrates how this approach acts as a strategic map for the general D-B implementation guidelines. The CDS framework relies on three concurrent processes, each rolling out through four subsequent implementation phases.

First, the *Implementation Process* facilitates implementation of D-B by identifying significant decisions to correctly implement D-B, and by aligning project D-B practices with organizational strategy. Two concurrent processes support the implementation process. The *Knowledge Building Process* manages D-B knowledge and facilitates acceptance among stakeholders (e.g., public, elected officers, industry providers, utilities, and/or local agencies) and among agency staff by collecting, verifying, storing, and disseminating lessons learned on the implementation effort, and by identifying sources of information on D-B. Finally, agencies often also need to assess D-B accomplishments through the *Implementation Assessment Process*. This process promotes continuous improvement by providing internal and external benchmarking, and by providing feedback on D-B implementation progress to organizational decision makers.

All these elements of the CDS framework were fully validated through a consensus of industry experts. However, several of them suggested that boundaries between each of the processes and phases should not be taken as absolutely defined, because they may have different overlaps, depending on the agency. In addition, the expert panel produced a set of 30 guidelines. Twenty-three of these guidelines were validated with moderate to strong consensus. The remaining seven guidelines were only suggested, since they produced a weaker consensus, and, therefore, they may be applicable only to specific situations.

General Design-Build Implementation Guidelines

Tables 1 to 4 summarize these general D-B implementation guidelines by phase.

Design Management Guidelines by Phase of Implementation Lifecycle

This section organizes the research results in a series of short guidelines for DM under D-B. These guidelines address each of the following phases: (1) planning (pre-procurement); (2) D-B contract procurement; and (3) D-B contract administration, since the preparatory phase would be at too high a level for DM considerations.

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Table 1. Preparatory phase D-B implementation guidelines (adapted from Migliaccio 2007).

Obtain legislative authority.	Validated	Strong Consensus
Description: Legislative authority to use D-B is obtained by a change in the legislative framework. A transportation agency needs legislative authority before instituting changes to its procurement and finance strategy to allow D-B. Changes to the regulatory framework occur at different levels (federal/state), and affect different aspects including the following: (a) allowed degree of project services that can be outsourced; and (b) allowed project delivery methods. An absence of legislative authority constitutes a barrier to change. **Recommendations** • Work with and educate industry providers and elected officials. • Inform the general public. • Advocate for legislative authority. • Draft legislation.		
Be sure that change to the agency's delivery is driven by a clear need to change.	**Validated**	**Strong consensus**
Description: Needs/reasons for changing the agency's approach to project delivery (by allowing D-B) can be found at different levels: context (opportunities/constraints), organizational (funding), and project (schedule). Potential reasons include: (a) cost, (b) schedule, (c) financing, (d) commitments, and (e) benefits to transportation users and taxpayers. Without a motivating factor for change, it is difficult to obtain authorization or resources to implement the change necessary to successfully implement D-B. Moreover, in order to substantiate the action plan, agency staff needs to know why a change is necessary.		
Seek support from and promote acceptance by industry providers.	**Validated**	**Strong consensus**
Description: Industry providers need to promote and/or support change that would introduce D-B as an option for delivering projects. Participation from industry providers is crucial for a successful implementation. If industry providers support the change, they will lobby elected officials and drive public perceptions. Conversely, their opposition will hinder a truly competitive bid environment. An absence of support by industry providers constitutes a barrier to change. **Recommendations** • Have a champion for the cause. • Seek and maintain credibility on change actions. • Involve key industry groups early in the process (e.g., Associated General Contractors [AGC], American Road and Transportation Builders Association [ARTBA], or other organizations). • Update industry providers on change initiative (e.g., through workshops, websites, or other media). • Seek input from industry providers on risk allocation strategy. • Partner during project implementation.		
Seek support from elected officials.	**Suggested**	**Weak consensus**
Description: Political support can be vision-driven (i.e., promoted by political champions with a vision) or environment-driven (i.e., promoted through the lobbying of groups or as a result of public perception). Having political support is important because a transportation agency needs support from elected officials to effect a change to the legislative framework. In addition to providing legislative authority, elected officials have the power to support the change by controlling funds, attracting media coverage, and driving public perception of a project. An absence of support by elected officials constitutes a barrier to change. **Recommendations** • Develop a clear and concise message explaining need. • Assess opposition. • Dialogue with and educate leaders.		

Table 1. (Continued).

Promote acceptance by other relevant parties.	Suggested	Weak consensus
Description: Other relevant parties affected by change in delivery need to accept D-B. Other parties involved in the project delivery (e.g., local agencies, other governmental agencies, utilities, environmental groups, railways, real property owners, cities, counties, or other entities) are not believed to provide active support for a change initiative, but their resistance to D-B and its processes may hinder the implementation effort. A lack of acceptance by these parties constitutes a barrier to change. **Recommendations** • Develop a plan for third party input early in the project development process. • Educate on the change initiative. • Use partnering and role-making during project implementation.		
Promote acceptance by the public.	**Suggested**	**Weak consensus**
Description: The public is not believed to support a change in delivery such as introducing D-B. However, public opposition to D-B may endanger the effort because the actions of elected officials are believed to be driven by public perception. Support from the public is more likely to occur if agency staff provides a clear, concise, and consistent message on the benefits of implementing D-B. A lack of acceptance by the general public constitutes a barrier to change. **Recommendations** • Develop a clear and concise message explaining the need for the change. • Assess opposition and develop a strategy to mitigate it. • Employ experts to conduct public workshops to promote dialogue and educate the public.		

Table 2. Project planning phase D-B implementation guidelines (adapted from Migliaccio 2007).

Be sure change in delivery is supported and promoted by the agency's executive management.	Validated	Strong consensus
Description: A change to an agency's project delivery and finance strategy affects all the elements of the D-B delivery system (i.e., procurement, contracting, financing, payment, and administration). Support by upper management is crucial to the success of the change initiative in many ways. **Recommendations** • Champion necessary for legislative changes. • Seek support by legal counsel on legislative actions. • Set clear objectives for the change. • Mandate needed internal adjustments (e.g., recruitment, outsourcing, or creation of additional organizational units). • Provide resources for implementing the change (i.e., monetary and staff resources). • Proclaim a commitment to the agency's community (to mitigate agency's internal resistance). • Manifest a commitment to knowledge building (e.g., measures, time, and money). • Manifest a commitment to implementation assessment (e.g., measures, time, and money). • Monitor change implementation.		
Be sure that using a new delivery method on a project is driven by a clear need to change the agency's usual approach.	**Validated**	**Strong consensus**
Description: Needs/reasons for changing the agency's approach to project delivery (by allowing D-B on a specific project) can be found at different levels: context (opportunities/constraints); organizational (funding); and project (schedule). Potential reasons include: (a) cost, (b) schedule, (c) financing, (d) commitments, and (e) benefits to transportation users and taxpayers. Without a motivating factor for change, it is difficult to obtain authorization or resources to implement the change necessary to successfully implement D-B on a project. Moreover, in order to substantiate the action plan, agency staff needs to know why a change is necessary.		

(continued on next page)

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Table 2. (Continued).

Put in place a method for matching projects with delivery methods.	Validated	Strong consensus
Description: Introducing a new project delivery method like D-B introduces a set of new options to the organization. Using the wrong delivery method on a project may hinder the implementation process by fostering cultural resistance. **Recommendations** • Carefully select pilot projects to avoid endangering the entire change initiative. • Employ expert consultants. • Seek advice from other agencies that previously underwent the change.		
Promote acceptance of change by agency staff.	**Validated**	**Strong consensus**
Description: A widespread resistance to change by agency staff may also hamper the D-B implementation. This problem may be due to: (a) cultural bias against change in general or D-B in particular; (b) feelings of loss of control; (c) tradition; and (d) fear of the unknown. **Recommendations** • Develop organizational knowledge on newly introduced approaches. • Use pilot projects to build consensus. • Communicate information on the status of implementation. • Empower change through leadership actions.		
Train agency staff on newly introduced approaches.	**Validated**	**Moderate consensus**
Description: A thorough understanding of newly introduced approaches by agency staff will contribute to both a reduced resistance to change and a more efficient implementation. **Recommendations** • Allocate specific human and monetary resources to staff training. • Train staff before implementation. • Focus training on procedural aspects of activities under the new approach.		
Make sure agency staff is available for implementing D-B.	**Validated**	**Moderate consensus**
Description: Agency staff is available for implementing D-B at the organizational level. Allocating insufficient resources to implement a new delivery method constitutes a barrier to its implementation. This problem may be due to: (a) a lack of upper management support; (b) a chronic lack of resources within the organization; or (c) non-availability of staff to participate in the implementation effort. **Recommendations** • Identify expert individuals. • Establish an organizational unit focused on innovative delivery methods. • Allocate dedicated staff. • Use this unit's expertise to develop a consistent programmatic approach. • Use this unit's expertise to support the implementation of newly introduced delivery methods at the project level.		

Table 2. (Continued).

Communicate intent of using D-B to affected external parties.	Validated	Strong consensus
Description: External parties affected by D-B are informed on the effort to implement it on a given project (e.g., industry providers, utilities, or local agencies). A lack of information constitutes a barrier to D-B because it may trigger misinformation about the new approach and thereby generate resistance. **Recommendations** • Identify procedures necessary to inform all interested parties. • Establish a schedule of letting dates to build up credibility within the community of industry providers.		
Assess the outcome of implementing D-B.	**Validated**	**Strong consensus**
Description: A lack of assessment constitutes a barrier to change because, without solid examples of success with the new process, doubts about the new approach may result. **Recommendations** • Promote internal benchmarking. • Compare the performance of other organizations that underwent the change.		
Develop a comprehensive implementation plan at the organizational level.	**Suggested**	**Weak consensus**
Description: There is a clear, timely, and comprehensive implementation plan at the organizational level. A lack of organizational planning on D-B implementation constitutes a barrier to change because it may hinder the D-B implementation process. **Recommendations** • Define requirements (i.e., what needs to be accomplished by changing the delivery strategy). • Identify boundaries (i.e., which practices are not being changed). • Outline a process for implementation. • Define procedures for evaluating change implementation. • Define procedures for building organizational knowledge. • Define procedures for improving implementation process.		
Redesign staffing procedures	**Suggested**	**Weak consensus**
Description: Agency procedures and policies for staffing are redesigned to facilitate the D-B implementation. Teams working on D-B projects require a different set of skills. Keeping staffing procedures unchanged may constitute a barrier to implementation. **Recommendations** • Use flexible allocation of staff. • Build project teams with technical, management, and financial expertise. • Select staff with knowledge of the new approach or a positive attitude toward adoption. • Provide career incentives to believers in the new approach. • Use incentive strategies to promote a proactive approach to internal bureaucracy. • Appoint expert program advisors (with D-B experience) external to the transportation agency's organization, to monitor the implementation. • Use consultants with D-B experience for both training of staff and staffing of project teams.		

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Table 3. Contract procurement phase D-B implementation guidelines (adapted from Migliaccio 2007).

Be sure that change to the agency's delivery and finance strategy is driven by a clear need to change.	Validated	Strong consensus
Description: Needs/reasons for changing can be found at different levels: context (opportunities/constraints), organizational (funding), and project (schedule). Potential reasons include: (a) cost, (b) schedule, (c) financing, (d) commitments, and (e) benefits to transportation users and taxpayers. Without a motivating factor for change, it is difficult to obtain authorization or resources to implement the change. Moreover, in order to substantiate the action plan, agency staff needs to know why a change is necessary. Often, it is useful to convey these drivers to the proposers, to create early alignment.		
Adopt a clear and fair approach to managing project risks.	**Validated**	**Strong consensus**
Description: The agency has developed a clear strategy for identifying, allocating, sharing, and managing project risks. Some potential problems include the following: (a) unreasonable allocation of risk with resulting high bid prices; (b) unwillingness to manage risk; and (c) unclear contractual language. **Recommendations** • Elicit input of industry associations on master contracts. • Develop risk allocation matrices for projects. • Have industry providers review the risk allocation during the procurement phase. • Develop a risk management plan with a selected provider.		
Control quality of contractual documentation.	**Validated**	**Moderate consensus**
Description: Arriving at the project procurement stage with contractual documents that are not ready or are not suitable for the new approach may result in inefficient pricing. Some potential problems include the following: (a) use of onerous specifications; (b) incomplete D-B proposals; (c) contractual terms that are not aligned with project goals; (d) use of documents from other projects that do not meet local practice or site needs; (e) unclear contract language; and (f) excessive reference to design manuals (which were not written as contractual documents). **Recommendations** • Keep contractual document aligned to project goals. • Adopt realistic requirements in request for proposals. • Use clear contract language.		
Seek acceptance by project parties.	**Validated**	**Strong consensus**
Description: There is a general acceptance of the new approach by all project personnel (both owner and industry providers). The implementation of the new approach at the project level may encounter resistance from certain project parties. Potential problems include the following: (a) unwillingness of individuals to compromise; (b) unwillingness of industry providers to adapt; (c) opposition from people with hidden agendas; (d) conflicting agendas between agency and service providers; (e) insincere commitment to partnering; (f) adversarial attitude; and (g) fear of loss of control by agency personnel. **Recommendations** • Procure buy-in from both provider and agency personnel on the implementation process. • Have project personnel (both owner representatives and consultants) who are able to work as a team and to compromise for the good of the project. • Have only project personnel who are committed to the success of the project.		

Table 3. (Continued).

Promote competitive participation in the procurement of qualified industry providers.	Validated	Strong consensus
Description: A main problem may be the industry's inability to assess redistribution of risk. **Recommendations** • Allocate project risks clearly. • Adopt an unambiguous contract award method. • Seek input on draft contract documents by industry providers. • Seek industry providers who appoint project personnel who are expert in the new approach.		
Design an efficient procurement process.	**Validated**	**Strong consensus**
Description: There is an efficient procurement process designed for the new approach. Lengthy and inefficient project procurement processes may hinder agency credibility and result in lower industry competition. **Recommendations** • Identify procedures to improve the accuracy of pre-advertisement cost estimate. • Customize the process to meet project needs. • Identify a method for awarding contracts. • Develop a realistic schedule that allocates an adequate amount of time for procurement. • Use shortlisting to select providers with the ability to perform the project. • Acknowledge the need for extended timeframes.		
Adequately staff owner project team.	**Validated**	**Strong consensus**
Description: The owner project team is adequately staffed to manage the procurement process and to administer the contract under the new approach. Some potential problems with owner teams include the following: (a) an inexperienced PM; (b) lack of staff; (c) lack of professional assistance; (d) presence of personnel in oversight roles outside their area of expertise; (e) absence of clear understanding of new processes; and (f) inconsistent direction to industry providers. **Recommendations** • Appoint an expert team leader who is empowered to make decisions. • Hire owner project personnel who are experienced, familiar, or adaptable to the new process, and have prior experience working as a team. • Use professional consultants experienced in the new approach, to fill team requirements. • Establish performance measures for team evaluation early on.		
Develop a comprehensive implementation plan at the project level.	**Suggested**	**Weak consensus**
Description: There is a detailed and comprehensive master plan for the implementation of D-B at the project level. Potential problems include the following: (a) delays from incomplete preliminary work (e.g., environmental clearance, ROW issues, utility agreements, and public hearings); (b) incorrect estimation with resulting budget crises; and (c) initiation of procurement on a project without adequate funding. **Recommendations** • Define project goals, expectations, objectives, and constraints early on. • Keep consistent project goals throughout the life of the project as much as possible. • Perform due diligence to leverage public funding. • Promote public support. • Assess the status of early milestones (e.g., early decisions, environmental clearance, or public outreach/involvement). • Establish agreements with local agencies and third parties. • Obtain cost data for the new approach from expert consultants or other agencies that have undergone the change.		

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Table 4. Contract administration phase D-B implementation guidelines (adapted from Migliaccio 2007).

Seek acceptance by project parties.	Validated	Strong consensus
Description: There is a general acceptance of D-B by all project personnel (both owner and industry providers). The D-B implementation at the project level may encounter resistance from certain project parties. Potential problems include the following: (a) unwillingness of individuals to compromise; (b) unwillingness of industry providers to adapt; (c) opposition from people with hidden agendas; (d) conflicting agendas between agency and service providers; (e) insincere commitment to partnering; (f) adversarial attitude; and (g) fear of loss of control by agency personnel. **Recommendations** • Buy-in from both provider and agency personnel on the implementation process. • Employ project personnel (both owner representatives and consultants) who are able to work as a team and to compromise for the good of the project. • Employ project personnel who are committed to the success of the project.		
Implement contract administration procedures to facilitate D-B.	**Validated**	**Moderate consensus**
Description: Contract administration procedures are tailored to the selected D-B approach. Arriving at the contract administration phase without having designed procedures suitable for D-B also constitutes a roadblock. **Recommendations** • Seek input from selected provider and other agency personnel on project implementation and contract administration. • Keep the administration of the contract consistent. • Adhere closely to contractual documents. • Develop and maintain a comprehensive schedule.		
Adequately staff owner project team.	**Validated**	**Strong consensus**
Description: The owner project team is adequately staffed to manage the D-B procurement process and to administer the D-B contract under the new approach. Some potential problems with owner teams include the following: (a) inexperienced PMs; (b) lack of staff; (c) lack of professional assistance; (d) assignment of personnel in oversight roles who are operating outside their areas of expertise; (e) absence of a clear understanding of new processes; and (f) inconsistent direction to industry providers. **Recommendations** • Appoint an expert team leader who is empowered to make decisions. • Employ owner project personnel who are experienced, familiar, or adaptable to the new process, and who have prior experience working as a team. • Use professional consultants experienced in the new approach, to fill team requirements. • Establish performance measures for team evaluation early on.		
Design the project's communications to facilitate the new approach.	**Validated**	**Strong consensus**
Description: A lack of communications at the project level also constitutes a barrier to a successful implementation of the new approach, because poor communication may result in lower project performance and lower industry competition. **Recommendations** • Promote continuous participation/collaboration of project parties. • Inform project stakeholders, including public and third parties (e.g., cities, utilities, metropolitan planning organizations, and other entities). • Keep the entire team aligned with project goals. • Identify partnering/dispute resolution procedures.		

Table 4. (Continued).

Design the project's organizational structure to facilitate the new approach.	Validated	Strong consensus
Description: The agency should customize its team's organizational structure to the new approach. **Recommendations** • Allocate adequate resources to the project, beginning at the procurement phase. • Define roles and responsibilities. • Make individuals accountable.		
Develop a comprehensive implementation plan at the project level.	**Suggested**	**Weak consensus**
Description: The agency has developed a detailed and comprehensive master plan for the implementation of D-B at the project level. An absence of planning may delay and endanger the implementation effort at the project level. Potential problems include the following: (a) delays from incomplete preliminary work (e.g., environmental clearance, ROW issues, utility agreements, and public hearings); (b) incorrect estimation with resulting budget crises; and (c) initiation of procurement on the project without adequate funding. **Recommendations** • Define project goals, expectations, objectives, and constraints early on. • Keep consistent project goals throughout the life of the project as much as possible. • Perform due diligence to leverage public funding. • Promote public support. • Assess the status of early milestones (e.g., early decisions, environmental clearance, and public outreach/involvement). • Establish agreements with local agencies and third parties. • Obtain cost data for the new approach from expert consultants or from other agencies that have undergone the change.		

Project Planning Phase

Understand the Importance of the Project Planning and Procurement Phases. The agency must understand that D-B is a more sophisticated project delivery method than DBB. The more work the agency performs up front, the less likely it is that issues and disputes will occur after contract award and during design reviews. This early work is what would be needed to perform design reviews and, therefore, would be highly dependent on how many design reviews are performed and how. At a minimum, an agency should carefully define the project scope and develop contractual documents while involving all relevant project stakeholders in this process, including local government, public agencies, and utility companies.

Because D-B is a more sophisticated approach to project delivery, it requires more planning; up-front work on D-B projects prevents design- and scope-related disputes and issues.

Perform a Risk Analysis. The agency should perform a comprehensive risk analysis to identify project risks and allocate each risk to the entity that can best manage it (i.e., the agency or Design-Builder). While this is true for all projects, construction contracts under DBB have been tested and revised to the extent that only minor changes to the risk allocation can be made. On the other hand, the integration of design and construction services (and sometimes ROW acquisition and utility relocation) makes the risk allocation process under D-B more fluid. Therefore, the agency should proactively control this changeable process by performing an initial analysis of risks. This information should be used to develop a draft risk allocation that will undergo an industry review phase or be included in the RFP. In regard to DM, the

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agency should evaluate the risks associated with performing and overseeing the design phase as carefully as it would evaluate construction risks, due to the significant impact they can have on the schedule.

Educate the Agency and All Project Stakeholders About the D-B Process That Has Been Adopted by the Agency. In general, D-B is a project delivery method. In practice, agencies can take different approaches to implementing D-B. Some agency departments—such as regional offices—and some project stakeholders—such as local government, public agencies, and utility companies—may not be familiar with D-B in general or with the way the agency is implementing it in particular. Thus, the agency must actively involve all interested agency departments and project stakeholders as soon as possible, to educate them about D-B procedures and peculiarities. For instance, contrary to the DBB approach, the project scope of a D-B project must be defined clearly before the design phase. Therefore, the stakeholders willing to change the delivery method must decide before the RFP is issued.

Build a Streamlined Process for Pre-Award VE by Proposers. The agency can greatly benefit in terms of quality improvement, cost savings, and/or schedule reduction from pre-award VE concepts submitted by proposers. When these innovations are outside the scope outlined in the RFP documents, they are submitted as ATCs. Furthermore, pre-award VE allows the agency to retain all cost savings while the cost savings from post-award VE generally are shared with the Design-Builder.

However, the process for soliciting and handling pre-award VE concepts should be transparent and should not detract from the objectivity of the competition. Thus, the agency should develop a process that supports the proposers in developing and proposing innovations. This process should not be cumbersome or too prescriptive in terms of required documentation; otherwise, proposers would be discouraged from participating in the process. As part of this process, some agencies hold multiple one-on-one meetings with the proposers to discuss the proposed innovations before a formal proposal is submitted. However, an agency should analyze the pros and cons of this step—in terms of procurement process objectivity—and take countermeasures. Similarly, some agencies hold one-on-one meetings with proposers to request clarifications on the submitted ATCs. An agency should not disclose any innovation proposed by a proposing team—or even one that has simply been discussed—even through the one-on-one information meetings. When at least two teams propose the same ATC, some agencies issue an addendum to the RFP. However, when an agency decides to change the RFP to allow the incorporation of an innovation, this change should be done in a way that does not reveal the innovation, if possible. For instance, UDOT reserved the right to modify the RFP for the I-15 Core project if, based on a proposed ATC or on another type of proposal, its staff determined that the RFP contained an error, ambiguity, or mistake. However, since proposers usually invest resources into the development of innovations, knowing that their innovations might be disclosed and, therefore, shared with the other proposers could prevent them from proposing any innovation at all. Finally, some agencies use a three-way rating of ATCs: (1) rejected, (2) conditionally approved, and (3) approved. These agencies allow the proposers to include conditionally approved ATCs in the proposal. Proposers often see this approach as a burden because it would require additional time and resources, without any guarantee of reward. If the agency selects a proposal that includes conditionally approved ATCs—even if the proposer has not been able to meet the conditions by the proposal due date, it stands to retain risks associated with the implementability of the ATC under the given conditions. As a result, proposers may often decide not to pursue additional efforts on conditionally approved innovation, nor to include them in their proposals. While it is difficult to outline an alternative approach to conditionally approving ATCs and, at the same time, to request that all conditions be met by the proposal due date, doing so will limit such uncertainties in the design process.

Incorporate a Degree of Flexibility in the Programmatic Environmental Permitting Processes. When an agency submits permit requests for a number of projects within the same program, it can benefit greatly from having developed a programmatic environmental permitting process. Nevertheless, such a permitting process has to be flexible enough to accommodate the specific characteristics of each construction site.

Include Contingency Funds. Given the fast-paced nature of D-B projects, the agency should set up contingency funds to allow the agency's project team to face changes promptly during each phase, including design.

Contract Procurement Phase

Determine the Correct Amount of Design Definition to Provide in the RFP. Developing a well-defined design package can help the agency communicate the project scope. However, too much design can be detrimental to innovation. Generally, proposers use the design provided in the RFPs as a starting point. Therefore, providing an excessive amount of design can hinder proposers' efforts to propose innovations. If the process allows the submission of ATCs, this barrier to innovation can be mitigated, but it would still be present.

The most successful D-B programs handle the innovations offered up by D-B teams in the pre-award phase. When these innovations are outside the scope outlined in the RFP documents, they are submitted as ATCs. Thus, the agency should develop a process that supports the proposers in developing and proposing innovations. This process should not be cumbersome or too prescriptive in terms of required documentation; otherwise, proposers would be discouraged from participating in the process. As part of this process, the agency could hold multiple one-on-one meetings with the proposers to discuss the proposed innovations, before a formal proposal is submitted. Since proposers usually invest resources into developing innovations, knowing that their innovations can be disclosed and, therefore, shared with the other proposers may prevent them from proposing any innovation at all. Finally, some agencies do not simply approve or reject a proposed innovation, but conditionally approve it and allow the proposers to include conditionally approved ATCs in the proposal. A further mechanism for innovation is the opportunity to benefit from all bidders' ATCs: if the State Transportation Agency (STA) offers a compensatory stipend to unsuccessful bidders, a condition of their acceptance of the money is their assignment of their respective ATCs' IP rights to the STA. This assignment of IP rights allows the agency to share the ATCs with the successful bidder for potential incorporation in the project.

Clearly Communicate to the Proposers the Selected Payment Method and how it can Affect Design Activities. Since many proposers are constructors that contract out the design to design firms, they may not fully understand how the selected payment method can affect design activities. Sometimes agencies decide to pay each line of work only when it is 100 percent complete, while the proposer has not broken down the design activities into multiple lines of work to obtain payments consistent with the accomplished design activities. In such cases, the proposer and/or DPs have to finance some of the design activities. Since this may create an adversarial relationship with the agency or within the D-B team, the selected payment method should be spelled out clearly in the RFP documents. Moreover, its potential impact on design should be understood by the agency and communicated to the proposers during the procurement phase.

Clearly State Whether the Agency is Retaining Any Risk Related to the Provided Design. The agency may provide conceptual design documents to simply convey the project scope. Thus, the agency must state clearly whether the proposers can use and reference the provided documents, or it should simply consider them as an outline for the project scope.

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Provide Complete ROW Information. Agencies must clearly identify the properties that they are willing to acquire. Furthermore, given the importance of purchasing all necessary properties in a timely manner, the agency should secure properties that it is certain will be needed. In regard to other properties that may be needed or that may be affected by the project, the agency should develop a reliable forecast of when each property should be available for construction. Similarly, since proposers may need to access some properties while preparing the proposal, the agency should coordinate with property owners to ensure access.

Provide Complete Utility Information. To support the proposers, the agency should collect as much information as possible about the utilities affected by the project. This is important particularly if the utility relocations are included in the Design-Builder's scope of work. The more an agency makes information available, the less risk the proposers will retain and price.

Coordinate with Utility Companies. Utility companies may have to participate in the design approval process. Therefore, the agency must start coordinating with them as soon as possible to prevent issues and delays after contract award. For instance, the agency may develop agreements with the utility companies (e.g., master utility agreements) that will be provided to the proposers as RFP documents. The information in these agreements should allow proposers to identify and assess the impact of utility relocations on the whole project schedule.

Introduce Specific D-B Design Standards and Specifications. Design standards and specifications developed for DBB often are not usable for D-B projects. At best, they have to be adapted to D-B. Therefore, the agency has to allocate enough resources to adapt the existing standards and specifications and/or develop new standards and specifications for D-B. For instance, to foster innovation, the agency could provide performance-based specifications rather than prescription-based specifications. However, performance-based specifications can be unclear if the agency does not properly develop them. Therefore, the agency has to detail the performance specifications clearly to avoid ambiguities and prevent disputes on performance expectations.

Clearly Detail the Hierarchy of the Referenced Documents. To prevent issues and disputes after contract award, the agency must hierarchize the referenced documents affecting design activities, and consistently deploy this hierarchy in all contractual documents.

Verify Information in RFP Documents. When assembling documents for the RFP package, the agency must verify that information in these documents is complete and has been updated correctly (e.g., updated property owner information and location of utilities).

Define Co-Location Requirements. When feasible, co-location has produced great benefit to D-B projects. Nevertheless, its benefits can be limited if it is not properly implemented. In particular, the agency should require the Design-Builder to fully co-locate design and construction personnel at times when integrating these functions is crucial to project success. However, co-location may be costly and fruitless when project size and/or complexity do not demand full integration of the design and construction functions.

Hold Meetings with the Proposers to Discuss RFP Draft Documents. To develop an RFP package that clearly conveys project scope and agency expectations, the agency can review the RFP documents with the proposers during general and/or one-on-one meetings. Some agencies interact with industry organizations (e.g., AGC) during this phase through industry reviews of draft RFPs.

Develop the Project Scope in Accordance with the Procurement Method. When using a fixed price/best design procurement method, agencies may determine a minimal amount of work that the proposers are expected to complete within the contract price and asked to include

in the supporting RFP documentation. Nevertheless, proposers may submit proposals with an amount of work significantly larger than the agency minimum. As a result, the RFP documents can contain gaps that must be addressed after the fact, which then hinders the design process. To lessen the impact of this problem, the agency could include reasonable thresholds of minimal and the maximal amounts of work expected, in the project scope and supporting documentation—not only the expected minimum. Proposers could still use ATCs to go above and beyond this range in their proposals.

Contract Administration Phase

Build a Solid Partnering Relationship with the Design-Builder. Generally, D-B requires extensive and active coordination and integration between the agency and the Design-Builder. However, because design functions are often performed by a consultant to the D-B entity, the agency should require the Design-Builder to participate in formal partnering initiatives. Such efforts build trust and prevent adversarial relationships on design activities among all project participants.

Support the Design-Builder in Interacting with the Utility Companies. Although the D-B entity may be charged with coordinating utility relocations after contract award, it does not have any contractual relationship with the utility companies. Oftentimes, this relocation period is the first and only time that the Design-Builder interacts with these utilities. Thus, the agency must actively support the Design-Builder to prevent or resolve any relocation issues and disputes that emerge.

Ensure that Agency Employees and External Consultants are Knowledgeable about the D-B Process in General and about the D-B Project Requirements in Particular. Since D-B significantly differs from DBB, the agency must effectively train both its employees and the project's external consultants. For instance, design reviewers who are usually designers for DBB projects must understand that in D-B projects, their role is to oversee rather than manage the design. This means that they should minimize preferences and opinions and focus their comments on design compliance with contractual requirements.

Require the Design-Builder to Provide Design Definition Submittals for All Design Disciplines. The intent of design definition submittals is to complete enough design (e.g., 30%) to confirm that the initial design approach complies with contract requirements. These submittals clearly define the scope of the project alignment between the project stakeholders and the Design-Builder.

Perform Over-the-Shoulder and Informal Reviews. Over-the-shoulder and informal reviews greatly improve the quality of the design packages prior to submission. Furthermore, a direct and informal line of communication between the agency and the Design-Builder can help solve issues and identify possible innovations in the design.

Ensure that Design Reviewers Have a Comprehensive Understanding of the Project. It is likely that design submittals will reference one another. To avoid contradictory review comments, the Design-Builder must generate properly coordinated design submittals. Concurrently, the agency must ensure that the design reviewers have a clear and comprehensive understanding of the project. Furthermore, if a project is part of a program, it is likely to be sited in close proximity to other construction projects. Therefore, the agency must apprise the design reviewers of any interactions among all concurrent projects. For instance, if a utility has to be relocated, it is necessary to verify that the new location will not interfere with other projects in the program.

Establish Efficient Design Package Submittal Processes and Review Guidelines. Generally, the agency must allocate and coordinate extensive resources for effective and timely review of

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design submittals. To optimize their use, clear and effective design package submittal and review guidelines must be agreed upon and included in the contract. First, the agency should determine the maximum duration of a design package review, in accordance with its resources and the Design-Builder's needs. Since the design phase is generally fast-paced and integrated with the construction phase, the agency should establish a maximum duration that is as short as possible; setting such a threshold allows the Design-Builder to proceed as quickly as possible with design and construction. However, the design review duration should permit the reviewers to perform comprehensive reviews and allow the agency to compile them. Second, the agency should require the Design-Builder to provide a detailed schedule of design submittals to ensure efficient management of design review personnel. Third, the agency should set a limit on how many design packages can be submitted and/or reviewed concurrently. Furthermore, when several design packages are submitted simultaneously, the agency should require the Design-Builder to prioritize them.

Be Clear in Providing Design Package Review Comments. Before submitting the design review comments to the Design-Builder, the agency should consolidate them into one document, revising any unclear, redundant, or incongruent comments, and eliminating any of the reviewers' opinions/preferences.

Accurately Coordinate DM Personnel. Agencies may need to employ a considerable number of design reviewers in order to review design submittals in a timely manner. Thus, the agency should not only efficiently group them by design disciplines and/or task forces, but it should also oversee and coordinate these groups to avoid inefficiencies and inconsistencies (e.g., overlaps among design disciplines).

Consider Reducing the Number of Design Package Submittals. To optimize design review efforts, the agency could eliminate the intermediate design package submittal (e.g., for packages at 60-percent design complete) for some of the minor elements (when three design submittals are required).

Ensure that Design-Builder's Design and Construction Personnel Coordinate after Contract Award. Design-Builders' designers in different disciplines and/or design and construction personnel may not fully coordinate during the design phase. Since this lack of alignment may increase the number of requests for design change during final design, the agency must monitor, support, and collaborate with the Design-Builder to minimize this issue.

Educate All Project Stakeholders Involved in the Design Package Review About the Design Review Procedures. Generally, the agency should develop the design review procedures and only discuss them with the Design-Builder. Moreover, some project stakeholders may be unfamiliar with the newly adopted D-B process. For instance, a project stakeholder may not fully understand the importance of timely design submittal reviews under D-B. Therefore, the agency should educate all project stakeholders involved in the design package review process as soon as possible.

Clearly Determine who is in Charge of Modifying Previously Obtained Permits. The agency may have to obtain some permits before contract award. Since they may require modification after contract award, the contractual documents must state clearly whether the agency or the Design-Builder will be in charge of preparing the related documentation.

Utilize an Efficient Document Management System. Having an efficient document management system is a critical issue on D-B projects. In particular, the system should be capable of interacting in a timely manner with all interested parties. For instance, when a design package

is submitted for review, everyone involved in the design package review should be promptly notified and given access to the submittal documents. Furthermore, the system should correctly track iterative versions of these documents and provide the latest version when required. Thus, the agency should require the Design-Builder to deploy a computer-based document management system and to share access to it with the agency. If the agency is using or planning to use D-B for future projects, it could develop a customized computer-based document management system that can be used for any D-B project. It could then require Design-Builders to use this system, and require their personnel to attend formal training sessions on it. Regardless of the type of document management system used, both the agency and the Design-Builder should assign one person to manage the system and act as a reference contact.

Support the Design-Builder in Performing Post-Award VE. Although the agency will benefit more from including innovations prior to contract award, it should encourage the Design-Builder to propose innovations after contract award, allocate resources to support these efforts, and be willing to share the cost savings with the Design-Builder.

Partner with the Design-Builder on Typical High-Impact Issues. Some types of projects can be significantly delayed by typical and recurrent issues, such as procuring items with long lead times, such as steel bridge bearings; or certain permits/authorizations. Generally, agencies do not retain the risks associated with such issues. Yet, a major delay in the delivery of a facility affects the public. Thus, agencies should approach the design review process with these issues in mind, providing comments to the Design-Builder to minimize them.

C: Short Case Studies

This subsection synopsizes a set of case studies on DM under D-B. Readers are encouraged to use these synopses to select DM approaches most appropriate to their respective organizations and projects. For readers seeking more detail on the selected approaches to DM, the appendices provide full case study narratives of the case studies.

Program Case Studies

Design-Build Program Case Study No. 1: Maryland State Highway Administration

Since the successful completion of its first D-B project in 1998, the Maryland SHA has built almost 40 highway and bridge projects using the system.

DOT Organization. SHA's D-B projects all come under the purview of the Innovative Contracting Division. The Office of Highway Development (OHD) takes the lead in the procurement (pre-award) phase. The most important aspect of this process is its total transparency, a challenge for SHA because they involve neither a member of the contractor nor design professional community in the selection of the Design-Builder. Between award and the completion of design, the regional district, through its Construction Office, shares responsibility with OHD, before taking the lead after design. This arrangement creates two PMs throughout the contract administration process (see Figure 3). Since D-B projects are let lump sum, the contractor is paid monthly. This was difficult to accomplish until the SHA went to a unit price-like system, creating 30 major pay items that include all project tasks, and paying each item, based on percent completed during the month.

Collaborative Partnering. Partnering is one of the chief methods adopted for communicating internally on post-award design matters. Initially, Partnering Meetings are held monthly.

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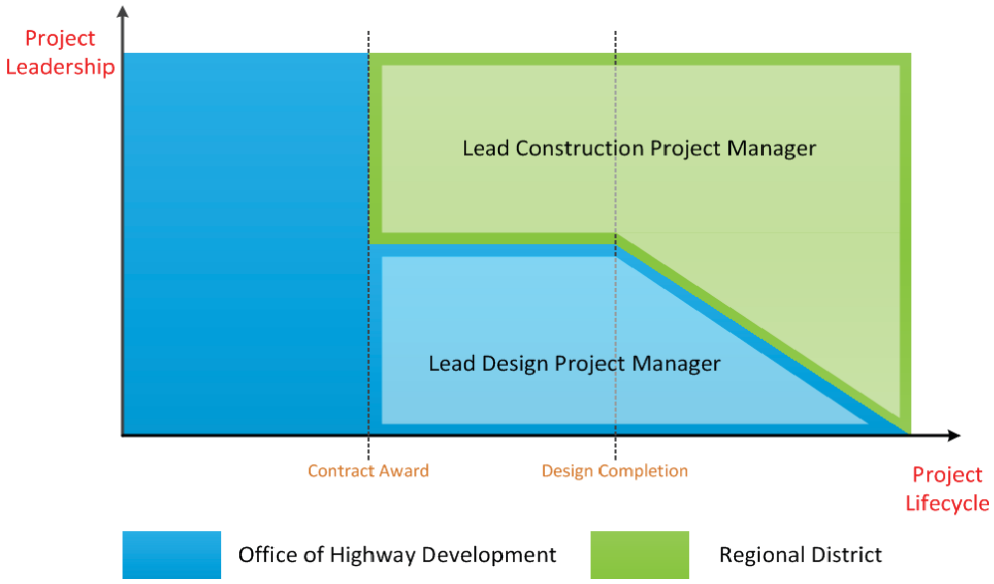

Figure 3. Schematic of project leadership throughout the project lifecycle.

Every key stakeholder is invited and, initially, most attend. These include county personnel, the DP, SHA Environmental personnel, the contractor, the SHA project team, SHA design personnel, and the SHA Community Liaison. The meetings were typically led by the SHA Project Engineer. Often, specific design issues are discussed immediately after the Partnering Meeting, so non-interested parties can leave.

Quality Management Plan. To ensure design package quality and compliance with contractual requirements, the agency requires the Design-Builder to develop a comprehensive quality program, submitted for approval after contract award. The SHA is responsible for design quality control and ensures that the design quality plan is being followed.

Partnering Meetings and Progress Meetings are often combined once the project matures and parties get to know each other. Once this happens, design issues are discussed more frequently.

Design Reviews. The Design-Builder submits plans to the SHA Design and Construction sections. The Construction Section sees that all stakeholders receive the plans to review, but the final funding decision lies with the Design Section. Stakeholders have two weeks for review. Their input comes to the Lead Design PM, who compiles all comments into letter form and submits the letter, along with a set of marked-up plans to the Design-Builder. This process is controversial among contractors, designers and even SHA personnel. Most of the controversy revolves around bridge design reviewers. Many such reviews reject a design, or return plans with a long list of required changes, even though the design meets all RFP requirements. Designers that complain are told that they (the designers) have worked with the SHA long enough to know that the SHA prefers certain things and that the designers should change their designs to meet those preferences. Designers almost always comply, stating a preference to work with SHA in the future.

Other Forms of Communication and Coordination. In addition to participating in the design reviews, the agency and the Design-Builder can communicate during: informal face-to-face meetings, electronic communications and phone calls; progress meetings to review and discuss the status of the project; weekly design management meetings; and task force meetings (i.e., meetings held when specific issues have to be solved).

Value Engineering. The contract does not have a VE clause. If Design-Builders identify ways to save money within requirements, they retain the savings.

Environmental Permits. All environmental permits are handled in the same way as DBB projects. NEPA requirements are handled by the SHA; others are by the Design-Builder, including Erosion Control, and other permitting processes. The SHA tries to procure all environmental permits except Erosion Control and Storm Water Management before issuing the RFP. Design-Builders who make a change invalidating an acquired permit must modify and re-procure the permit. The Maryland Department of the Environment (MDE) process is perceived to be slower than it needs to be, requiring a higher degree of coordination between SHA and MDE.

Right-of-Way. ROW activities are conducted by the SHA and acquisition begins at 30% completion. The RFP is issued immediately after ROW is acquired.

Design-Build Program Case Study No. 2: North Carolina Department of Transportation

Since letting its first D-B project in 1999, the North Carolina Department of Transportation (NCDOT) has let almost 90 highway and bridge projects using the D-B system.

DOT Organization. By statute, NCDOT can sign a contract only with entities capable of providing the typical construction bonds and insurances. Generally, contractors provide those bonds and insurances while design consultants cannot. Thus, NCDOT "is forced" to sign the contract with a contractor that, in turn, subcontracts out the design to a design consultant. The D-B Group is part of the Transportation Program Management section. Figure 4 shows how responsibilities change during the project lifecycle between a design PM and a construction PM. Between award and the completion of design, the regional district, through its Construction Office, shares responsibility, before taking the lead after design completion. This arrangement creates two PM throughout the contract administration process who share responsibilities after contract award.

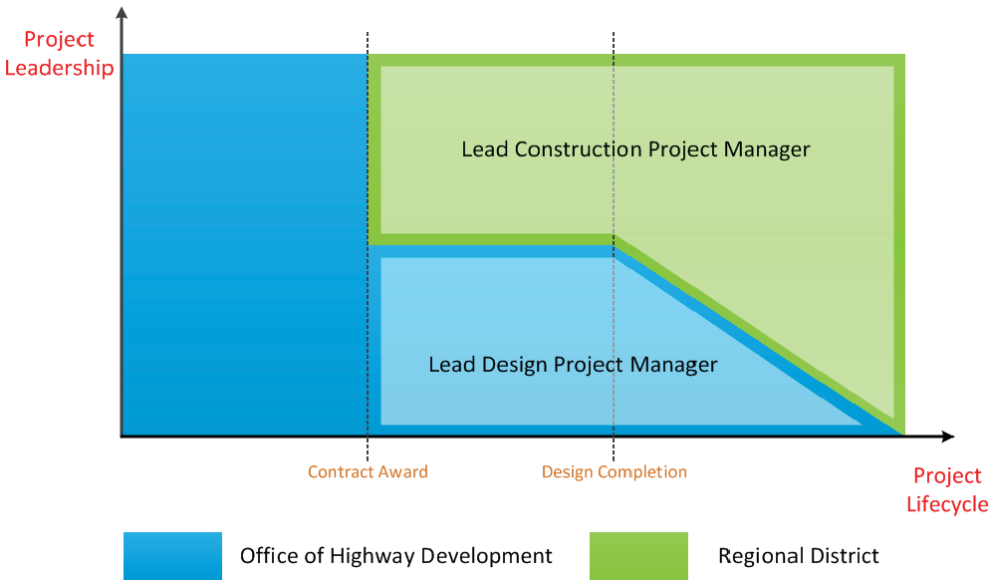

Figure 4. Schematic of project leadership throughout the project lifecycle.

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Collaborative Partnering. All projects adopt a partnering process. The frequency of the partnering meetings is left to the discretion of the regional district handling the project.

Quality Management Plan. The D-B team submits no design quality management plan. NCDOT uses its own plan, and is responsible for design quality control and ensuring that its design quality plan is followed.

Design Reviews. The design PM receives a hard-copy package with color-coded transmitted sheets used to stand out on somebody's desk and stakeholders have 10 days to turn them around. Expediting begins with a phone call if they have not returned the package within eight days. NCDOT has become adept at turning plans around in a short period of time as well as at encouraging the D-B team to be innovative. In fact, the in-house Design office reports that they are at a distinct disadvantage when designing DBB projects, compared to a D-B team. In-house designers, that also review the D-B plans, say they could design DBB projects with as much innovation as D-B teams do, except for two elements. One is that they (the NCDOT designers of a DBB project) lack the contractor's practical knowledge of the best way to build something and whether something could be built the way it was designed. But the main advantage over the NCDOT DBB design team is that each contractor has personnel with a unique set of knowledge, skills and capabilities. They also have a unique set of equipment, implements and materials sources, and can therefore generate a design best utilizing the unique abilities of the contractor doing the work. NCDOT fears that if the state's DBB design team created a project design both innovative and prescriptive, contractors lacking the ability to prosecute the work in the most efficient way given the design could see themselves at a competitive disadvantage and file legal claims against NCDOT, contending the department was favoring the contractor(s) that possessed the personnel and equipment to build the project the way it was designed.

Other Forms of Communication and Coordination. In addition to participating in the design reviews, the agency and the Design-Builder can communicate during bi-weekly/monthly progress meetings and ad hoc meetings.

Value Engineering. VE is allowed in the post-award phase. The main steps in the VE process are:

- NCDOT invites bidders to clearly state in their proposal what innovations were incorporated into their proposal and what innovations were considered but not incorporated. The agency evaluates only the incorporated innovations during the selection process. Therefore, bidders may prefer to avoid incorporating some innovations (e.g., more expensive innovations) to avoid jeopardizing their chances of being selected;
- NCDOT also invites the bidders to price a few alternative items (e.g., different aesthetic rails on a bridge) that may or may not be included in the project. However, just one of the alternative items is considered during selection;
- After bidder selection, the agency evaluates the not incorporated innovations and the alternative items previously priced, and decides about incorporating them in the project;
- If the VE process results in savings, the savings are evenly split between the agency and the D-B team.

Environmental Permits. Two situations are possible:

- If NCDOT obtains all the permits before contract award, the D-B team is responsible for obtaining any additional permit due to changes in the design; or,
- If NCDOT obtains only a few permits (e.g., NEPA) before contract award, the D-B team is responsible for obtaining all the other necessary permits.

Right-of-Way. Two situations are possible:

- If NCDOT acquires the properties before contract award, the D-B team is responsible for purchasing additional ROW due to design changes; or,
- If NCDOT does not acquire any property before contract award, the D-B team is responsible for the ROW process (i.e., the D-B team hires a ROW firm that performs appraisal, negotiation, etc.). However, the actual purchase price is paid by the agency.

Benefits of Innovation. One of the criteria NCDOT uses to select D-B Projects is the opportunity for innovation. Depending on the project, the weight assigned to the innovation criteria varies, but typically ranges between five and ten points, out of 100 available points. Additionally, the maximum Quality Credit percentage used to determine the "best value" D-B Team may also be influenced by a project's opportunity for innovation. For example, complex projects offering a lot of opportunity for innovation typically have a maximum Quality Credit percentage between 25%–30%, while projects with little opportunity for innovation or flexibility typically have a maximum Quality Credit percentage of 15% or lower. Furthermore, D-B Projects with limited opportunity for innovation and a narrow scope of work are procured as Express D-B Projects not requiring a Technical Proposal submittal.

The successful D-B team submitted a price proposal approximately 26% below . . . (e)stimate, and committed to a . . . completion date . . . four months prior to the department's required final completion date.

One example of a project team that took full advantage of the opportunity to innovate was the D-B team working on the I-485 Interchange project in Mecklenburg County. This project entailed the construction of a new interstate-to-interstate interchange between I-85 and I-485. The successful D-B team submitted a price proposal in the amount of $92,162,250, approximately 26% below the Engineer's Estimate, and committed to a final completion date approximately four months prior to the department's required final completion date. The selected D-B team received the highest overall technical score partially due to its conversion of a four-level stacked interchange to a two-level turbine interchange. This change eliminated approximately 2 million cubic yards of borrow and an I-85 detour required to hang steel during construction of a four-level interchange. The turbine interchange lowered the roadway embankment heights by approximately 40 feet, minimizing the potential closures during icy conditions that might be required for a four-level interchange. The resulting cost savings was approximately $30 million. Additionally, while the turbine interchange increased the number of bridges approximately three-fold, the smaller simpler bridges reduced future maintenance and widening costs.

Design-Build Program Case Study No. 3: Utah Department of Transportation

Starting with the successful implementation of design-build (D-B) for the I-15 Corridor Reconstruction project (1996–2001; $1.6B), design-build has been institutionalized and extensively used by UDOT. This case describes the programmatic effort of UDOT in implementing D-B for highway projects. In addition to analyzing UDOT documentation about the program, four D-B projects were analyzed: (1) Pioneer Crossing, Lehi—15 American Fork Interchange (2008–10; $175M); (2) SR-154 Bangerter at 7800 S, 7000 S, and 6200 S (2010–12; $40M); (3) I-15 at 11400 South Interchange (2008–11; $245M); and (4) I-15 South Layton Interchange (2009–11, $95M).

DOT Organization. UDOT created the Office of Innovative Contracting and Project Controls to lead the implementation of innovative project delivery methods by developing guidelines and supporting the agency's staff during the procurement and contract execution phases. UDOT developed several documents describing the procedure for implementing D-B from the beginning of the process to the issue of the RFP. Among the development steps, UDOT provides guidelines on how to assemble the project team. First, UDOT indicates that the project

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team should be consistent throughout the whole D-B process. Second, UDOT requires the project team to be led by a UDOT employee acting as Project Manager (PM). The State of Utah has four administrative regions, each managed by a regional office overseeing the administration, construction, and maintenance of the highway infrastructure in its region. The PM is generally selected from among regional office personnel in charge of the project. Third, the PM has to be supported by a team capable of managing the different technical areas of the projects. Team members can be from the UDOT central office (e.g., Innovative Contracting); UDOT regional offices (e.g., design and construction staff); or external consultants. Fourth, UDOT requires a dedicated project team for large projects.

UDOT likes "experience with formal partnering" as a selection criterion for Design-Builders.

Collaborative Partnering. UDOT strongly believes in building an effective formal partnering relationship with Design-Builders. For instance, UDOT suggests "experience with formal partnering activities" as a selection criterion for potential parties to a D-B contract. The agency specifies two main strategies to obtain an effective relationship such as co-location and adoption of a formal partnering process that is organized, implemented, and managed by the Design-Builder.

Quality Management Plan. To ensure design package quality and compliance with contractual document requirements, the agency requires the Design-Builder development of a comprehensive quality program to be detailed in a Quality Management Plan (QMP). Design-Builders must submit this for approval after contract award and UDOT lists several requirements for the development of the QMP in the contractual documents.

Design Reviews. UDOT implements different types of design reviews such as Interim Oversight, Milestone, Release for Construction, and Completed Design Reviews. Figure 5 shows when these reviews occur during the design development process. Interim Oversight Reviews can take place at any level of design (of a design package). They can be requested either by the Design-Builder or the agency. Although these reviews are usually conducted using a less formal over–the-shoulder approach, they may follow a formal process. Milestone reviews are required at 30% and 60% design complete. The Release for Construction Reviews are performed at the end of design package development. The Completed Design Review is performed when the design of the entire project is complete. Regardless of the type of review, revisions and comments provided by agency personnel may also contain constructability considerations.

Other Forms of Communication and Coordination. In addition to design reviews, the agency and the Design-Builder can communicate during: informal face-to-face meetings, electronic communications, and phone calls; progress meetings to review and discuss the status

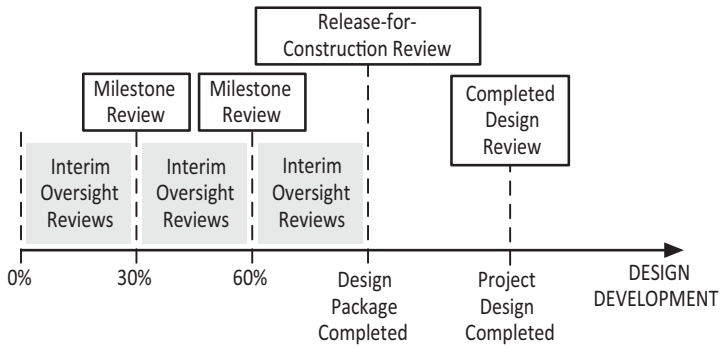

Figure 5. Design reviews during design development.

of the project; weekly design management meetings; and, task force meetings (i.e., meetings held when specific issues have to be solved).

Value Engineering. Alternative Technical Concepts are accepted in the pre-award phase, while Value Engineering Change Proposals are accepted in the post-award phase.

Environmental Permits. UDOT is responsible for obtaining the environmental permits for permanent construction elements, such as Environmental Studies and Stream Alteration Permits. Design-Builders may be required to provide this information. If the agency is in charge of a permit related to tasks and/or activities under the Design-Builder's responsibility, the Design-Builder must prepare the necessary permit application documents and submit them to the agency for approval.

Right-of-Way. UDOT is responsible for managing right-of-way procedures during the pre- and post-award phase. If possible (e.g., small projects), the agency identifies and purchases all the properties prior to contract award.

Project Case Studies

Design-Build Project Case Study No. 1: Bundle 401/ODOT

Bundle 401 was one of the bundles awarded during the delivery of the OTIA III State Bridge Delivery Program. This bundle consisted of five replacement concrete bridges on Oregon Route 38 between Elkton and Drain. Oregon Route 38, also known as Umpqua Highway No. 45, is a state highway connecting the city of Reedsport on the Pacific coast with Interstate 5. The total bundle cost was $46,390,721. The Notice to Proceed (NTP) for D-B procurement was issued in November 2005 and the project was completed in June 2009.

ODOT collaborated with state and federal agencies to develop a programmatic environmental permitting process, based on a set of environmental performance standards.

DOT Organization. To implement the bridge delivery program, ODOT substantially changed its project delivery approach in terms of internal organization and use of in-house vs. external consultant personnel. First, ODOT created a new department, called the Bridge Delivery Unit (BDU), with 22 staff members to oversee program delivery. Several external consultants were then hired as the Bridge Standing Implementation Team. Finally, ODOT selected OBDP, a private joint venture, to manage the program as owner representative.

Project Delivery Process. ODOT and OBDP collaborated to develop a comprehensive program project delivery toolbox that included DBB, D-B, and CM/GC. Further, ODOT developed a D-B project delivery process consisting of a series of steps (Figure 6). The agency determined that OBDP had to support ODOT in developing procurement documents, but could not participate in the selection process or execute a contract. However, once a NTP was issued, OBDP would take over as the project manager while being closely supported by ODOT.

Collaborative Partnering. OBDP closely collaborated with all program stakeholders. In the early stages of the program, OBDP held numerous alignment meetings with the BDU, ODOT regional offices staff members, and all other program stakeholders. Further, OBDP co-located with the BDU during the program. However, ODOT and OBDP could not co-locate with the Design-Builders because several projects were performed simultaneously. Thus, ODOT and OBDP agreed to a project kick-off meeting with each Design-Builder.

Amount of Design Provided in the Request for Proposal. Before issuing the RFP for a bundle, the agency prepared an engineering baselines report for each bridge, to identify and mitigate

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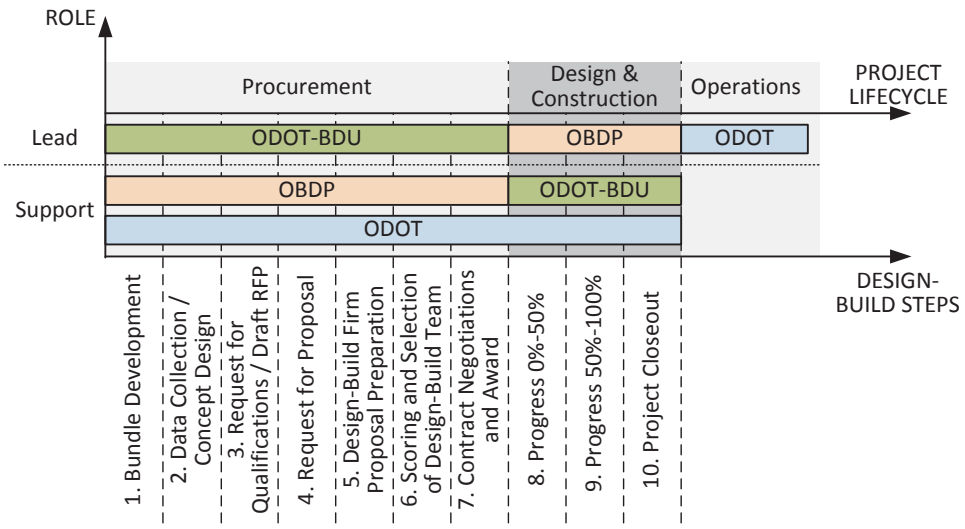

Figure 6. Role of ODOT bridge delivery unit, OBDP, and ODOT during D-B Steps and project lifecycle.

major risk areas, such as environmental permits, right-of-way (ROW), utility relocation, and railroad interferences. These were available to the bidders together with additional information such as reports about the current bridge structure. Further, the agency provided supplementary information on the RFP, such as the available ROW, specifications, geotechnical information, and LADAR data. However, no conceptual design was provided.

Design Milestones. The agency required the Design-Builder to prepare the following design milestones for each design package: (1) Concept Plans (i.e., plans submitted by the Design-Builder and the results of contractual negotiations); (2) Definitive Design (i.e., preliminary design at less than 30% design complete); (3) Interim Design (i.e., 30% and 60% design complete); (4) Readiness-for-Construction; (5) Working Plans (e.g., erections details; plans for shop fabrication); and (6) As-Constructed.

Design Review. The Design-Builder had to develop a schedule of all the design milestone submittals (except concepts plans). ODOT also required a review at each milestone according to the following steps. First, a checker (i.e., a peer of the DP or originator of the document) verifies that plans and specifications are correct and complete. Second, the Design Quality Manager verifies that plans and specifications are correct and complete; and certifies that plans and specifications meet contractual requirements. Third, after receiving the design package and the Design Quality Manager certifications, the agency Project Manager, supported by OBDP staff and other stakeholders interested in the package, performs the design package review. Fourth, the Design-Builder addresses the comments in the Review Comment Form and incorporates them in the design package.

Value Engineering. Alternate Technical Concepts (ATCs) were allowed in the pre-award phase and Cost-Reduction Proposals in the post-award phase. Although ODOT authorized the proposers to include approved ATCs in their proposals, ODOT retained the right to disclose any approved ATCs to all the bidders before contract award. This approach may have hindered contractor-induced innovation during procurement as none of the proposers submitted an ATC.

Environmental Permits. Given that hundreds of bridges were to be replaced under the OTIA III Bridge Replacement Program, ODOT collaborated with state and federal agencies to

develop a programmatic environmental permitting process. This process was based on a set of environmental performance standards.

Right-of-Way. If ODOT acquires the properties before contract award, the D-B team is responsible to purchase any additional ROW due to changes in the design; or, if ODOT does not acquire any property before contract award, the D-B team is in charge of the ROW process (i.e., the D-B team hires a ROW firm that performs appraisal, negotiation, etc.). However, the actual purchase price is paid by the agency.

Design-Build Project Case Study No. 2: I-15 Core/UDOT

In 2004, UDOT initiated the process to expand I-15 in Utah County. In March 2008, the Legislature authorized funding for the project and directed UDOT to complete the project scope and assemble a management team. Due to the 2008 financial crisis, the Legislature lowered the budget from $2.63 billion to $1.73 billion. The legislature also mandated that UDOT reconstruct I-15 from American Fork Main Street to Provo Center Street (roughly 15 miles). To meet these requirements, UDOT selected D-B as the project delivery method and fixed price/best design as its procurement approach. The agency established the contract value, challenging proposers to submit a design providing the highest value, while meeting the schedule deadline and minimizing inconveniences for the public. The fixed price/best design procurement approach proved extremely successful. The selected Design-Builder proposed to reconstruct 24 miles of the corridor, whereas the agency only expected reconstruction of 15. Construction operations began in April 2010 and concluded December 2012, 2 years ahead of schedule.

DOT Organization. Project Delivery Team leaders were selected from UDOT and consultants' personnel. Per the agency's procedures, an Executive Steering Committee was also appointed. This committee made the major project decisions, such as the procurement characteristics, and oversaw the project delivery team, while providing general oversight. The committee included the UDOT Executive Director, Deputy Executive Director, Region 3 Director, and the Operations and Project Development Director. Furthermore, the team was supported by the agency's central office and Region 3 office staff.

Collaborative Partnering. UDOT implemented two main strategies to foster successful project delivery, facilitate timely completion, allow effective collaboration and communication among project participants, and to minimize and solve problems. First, UDOT and the Design-Builder's staff co-located. Second, UDOT required a formal partnering process involving all project stakeholders. The contract mandated periodic follow-up seminars/workshops during the project. The cost associated with partnering, agreed to by both parties, did not affect the contract amount, and was shared equally between the two parties.

Construction began in April 2010 and concluded December 2012, two years ahead of schedule.

Quality Management Plan. Per agency procedures, UDOT required the Design-Builder to collect all the quality program procedures in a QMP. Furthermore, UDOT required the Design-Builder to submit the QMP for approval in two stages: Stage 1 for all non-construction-related activities; and, after Stage 1 approval, Stage 2 for all construction-related activities.

Quality Oversight (QO). UDOT performed QO during the project to ensure Design-Builder compliance with QMP and additional requirements, and to identify areas of improvement. The QO staff performed audits, reviews, interviews, inspections, and tests.

Design Reviews. The Design-Builder determined design review frequency, timing, content, and format; and performed four reviews for each design package, at 30%, 60%, and 90%,

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Table 5. Sample of UDOT design submittals requirements provided in the contractual documentation.

Situation and Layout Plans Provide Situation and Layout plan sheets for all bridges, box culverts, rigid frame drainage structures, retaining walls, and noise walls, in accordance with the Situation and Layout Checklist in Structures Design and Detailing Manual. Assign a structure number to each structure.
Released for Construction Documents These shall constitute all documents issued for the purposes of construction. All Released for Construction Documents shall meet the following requirements: Design all Work, including modifications to the Work, under the direct supervision of a Professional Engineer with a current Utah license. Indicate the timing of submission of these documents in the Project Schedules. Prepare plans similar in appearance to the UDOT Plan Sheet (Development) Standards and Structures Design and Detailing Manual. Prepare specifications in accordance with the UDOT Specification Writer's Guide. Variations are anticipated as a result of D-B delivery. Meet with the Department to obtain Approval of any variations in plan content and format.
Final Design Documents These shall meet the requirements of the Released for Construction Documents and the following additional requirements: Fully completed Released for Construction Documents, except for necessary field design changes, for a geographic area organized by discipline. Include design information from the most current version of Released for Construction Documents and all design back-up information, including design plans, shop drawings, calculations, reports, specifications, and electronic MicroStation data.
As-Built Documents These shall meet the requirements of the Final Design Documents and reflect the actual condition of the final constructed Work.

and release for construction. Although UDOT did not review all design packages, the contract required that the agency be invited to a minimum of two separate reviews for each package; the reviews had to occur prior to issuing construction documents; and, at least one review had to be performed prior to 70% design completion. Table 5 shows the UDOT Design Submittal Requirements. However, these submittals did not need agency approval.

Other Forms of Communication and Coordination. In addition to these reviews and activities, the parties could communicate during: informal face-to-face meetings, weekly and monthly progress meetings, weekly technical work groups focused on a specific discipline, and area meetings to discuss issues pertaining to different locations.

Value Engineering. ATCs were accepted in the pre-award phase, while Value Engineering Change Proposals were accepted in the post-award phase.

Right-of-Way. UDOT was responsible for procuring necessary properties. To allow the proposers to design the facility and effectively develop the project schedule, the agency detailed the properties it was going to acquire based on the existing preliminary design, and provided a property acquisition schedule during the procurement phase. Moreover, UDOT allowed the proposers to identify additional properties through the ATC process.

Design-Build Project Case Study No. 3: SR 99 Bored Tunnel Alternative/WSDOT

The Alaskan Way Viaduct is a two-mile-long, double-deck, elevated section of State Road 99. Second in traffic volume to only I-5 in the state of Washington, the viaduct is a major north-south corridor through downtown Seattle carrying about 110,000 vehicles per day. In January of 2009, WSDOT, King County, and the City of Seattle agreed to replace the Viaduct with a single bored tunnel under downtown Seattle, the SR 99 Tunnel. The procurement process started in

October 2009. In December 2010 WSDOT awarded the contract to build the SR 99 Bored Tunnel Alternative for over $1.089 billion. WSDOT awarded the contract before obtaining a Record of Decision (ROD). Since DOTs cannot approve any final design and construction activities before obtaining an ROD, WSDOT issued a first NTP for the preliminary design while waiting for the ROD. After obtaining the document in August 2011, the agency issued a second NTP for the final design and construction. Construction activities started at the end of 2011 and are expected to finish by the end of 2015.

DOT Organization. WSDOT established a PM Team consisting of a Design Engineer, who is the leader of the design phase, a Geotechnical and Utility Engineer, an Environmental Manager, a Tunnel Construction Engineer, a Contract Administrator, and a Program Manager. WSDOT also hired numerous external consultants to compensate for a lack of in-house expertise on tunnel construction. Therefore, while all team members except the Program Manager are WSDOT employees, only 50% of the support staff are such. To mitigate numerous risks, WSDOT also utilizes a Strategic Technical Advisory Team (STAT). This team is technically oriented and consists of experts in fields such as PM, geology and geotechnical engineering, construction, tunnel engineering, law, and risk and organizational management. They supported development of the RFP and procurement and selection activities. Their support continues during design review and construction through oversight of and support on technical challenges related to the tunnel and project construction. In 2011, the state legislature required that an expert review panel be convened to conduct extensive reviews of the project, including examination of overall management, risk management, budget and contingency plans, availability of financial resources, stakeholder and partner agency relationships and interfaces, and mitigation of public and political issues. This panel consists of three members with expertise in mega-project management, underground construction and risk management, and large project financing.

> WSDOT relies on collaborative relationships . . . (and) requires the parties to participate in a team-building workshop conducted by a third-party facilitator. . . .

Collaborative Partnering. To foster successful project completion, minimize issues and disputes among project participants, and better manage risks, WSDOT relies on collaborative relationships among project participants. In particular, the contract requires the parties to participate in a team building workshop conducted by a third party facilitator; coordinate respective roles, responsibilities and expertise; and foster open communications, non-adversarial interactions, and fair and transparent decision making and idea sharing.

Design Review. Per contractual agreement, the Design-Builder had to prepare three submittals for each design package (see Table 6). Two review stages were conducted for each submittal: (1) a Design-Builder internal review; and (2) a review by WSDOT and other project stakeholders,

Table 6. Design submittals.

Submittal	Description
Design Definition	Since WSDOT provides concept plans in the RFPs that are at most 30% design complete for the different design disciplines, the intent of this submittal is to ensure that all the design disciplines are 30% design complete to confirm that the initial design approach is consistent with the contract requirements.
Preliminary Design	The intent of this submittal is twofold. First, it supports the agency in completing the permitting process. Second, it allows project stakeholders (e.g., affected local governments and utilities) to ensure that the design is progressing appropriately; the plans follow the requirements; and there are no major issues within a discipline or between disciplines.
Final Design	This submittal consists of plans and specifications that are 100% design complete. After approval, the Ready for Construction (RFC) design package is prepared.

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including the City of Seattle. After the Design-Builder releases a design, WSDOT and its consultants review it. In particular, WSDOT established 14 task forces, which, at the time of the Case Study, had reviewed 777 submittals (i.e., 63 design definitions, 202 preliminary designs, 273 final designs, 173 release for construction packages, and 66 notices of design changes), consisting of an average of 150 pages each. In addition, WSDOT reviewed 171 material submittals and construction procedures, and 800 Requests for Information (RFI). To allow WSDOT to effectively coordinate design reviews, the submittals were incorporated into the project schedule.

Value Engineering. Proposers were encouraged to submit ATCs in the pre-award phase, while the selected Design-Builder could initiate change proposals in the post-award phase.

Right-of-Way. WSDOT executed property acquisitions after receiving the ROD and, therefore, after contract award. Thus, the agency retained the risks associated with their acquisitions. To allow the proposers to design the facility and effectively develop the project schedule, WSDOT provided to the proposers a property acquisition schedule during the procurement phase. This document was based on the preliminary design developed by the agency and detailed the intended property acquisitions and their timeframe. Moreover, WSDOT allowed the proposers to identify additional properties through the ATC process. In addition to the properties directly affected by the facility, the agency and the Design-Builder closely collaborated to obtain temporary easements necessary for construction activities. Furthermore, given the necessity to monitor any possible building foundation settlements precipitated by the tunnel construction, the agency and the Design-Builder had to obtain right-of-entry for the buildings above the tunnel in order to install the necessary monitoring instrumentation.

CHAPTER 4

Design Management under Construction Manager/ General Contractor

If the design phase of a CM/GC construction project could be perfectly executed, the construction phase would be completely free of the problems, challenges and difficult decisions so common in a traditional highway construction project, save force majeure and unforeseen conditions and human error. This statement cannot be made about any other system, and points to the importance of DM under CM/GC. The goal of this chapter is to help the decision makers in public transportation agencies establish and apply this unique and effective system in the most ideal way to their specific, individual circumstances, and to make CM/GC a powerful tool in their project delivery toolbox. If some of the methodologies discussed in this chapter seem unrealistic or unattainable, the agency should strive to follow them as close as possible. If they do this and have high quality, competent people that believe in the system and are willing to work diligently to see the system work and the project or program succeed, things are very likely to go well.

When reading this section, the reader may note what appears to be a very important contradiction regarding the design effort required with CM/GC in comparison to DBB. The two case studies that focused on the Utah DOT (Mountain View Corridor [MVC] and UDOT—CM/GC Case Studies) both make the point that UDOT requires "105% plans"—a very intensive design effort, greater than found on DBB projects so that problems may be avoided in the construction phase, cost estimates can be more accurate and so that risk may be more accurately allocated. The case study that focused on Osceola County said the opposite. The outcome of that case study was that an advantage of CM/GC was the reduced design effort necessary, and thus reduced design cost, when using CM/GC, compared to DBB. Could they both be right? Absolutely. And that points again to one of the biggest strengths of CM/GC—its flexibility.

These are two very different programs, with very different needs that both found what they needed with CM/GC. UDOT is an established program. It is a world leader in the use of CM/GC. Contractors, subcontractors, suppliers, local government agencies, permitting agencies and utility companies all understand, accept and mostly embrace CM/GC there, especially people within UDOT. UDOT's major consideration is cost. Even their striving for proper risk allocation has at its base, cost. They have found that the "105% plans" helps them lower cost by identifying and assigning risk, which helps the process of innovation. Meanwhile, the Osceola County program was brand new. A recently elected County Commission had hired a new County Manager and handed him a broken highway construction program that had been collecting money for years from a tax increase for the expressed purpose of building roads. They had several years' worth of highway tax money, but a record of starting virtually no highway construction. The previous two County Managers had been fired because of this. The new County Manager was told to get seven highway projects under construction within 12 months, or he would lose his job, as would his staff. Therefore, the need that this program had was speed. Speed in design and speed in starting construction. Every decision was made to meet the goal of getting as many projects started as

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possible, as quickly as possible. This was accomplished by co-locating all key parties to a contract, doing away with traditional sets of plans and designing the project through a seemingly constant series of meetings of the decision makers from all the parties around a large conference table. Their design goal was to get the CM just enough design to get started and then keep the design process just enough ahead of the construction so as to not slow down the prosecution of the work. And CM/GC, as a delivery method, was just as successful at meeting Osceola County's goal as it was in meeting UDOT's goal.

A: Background

The traditional procurement system for highway construction involving the separation of design and construction services, the qualifications-based procurement of DPs, and the competitive low-bid system for construction have served the public well during the past century. The foundation of this system, often called DBB, is the principle of selecting DPs based on qualifications (Brooks Act—Public Law 92-582) and selecting construction contractors based on competitive sealed bids with award to the lowest responsive and responsible bidder, often based on 100% PS&E. The combination of these two procurement practices helped solidify the usage of DBB in the public sector.

Over the decades, DBB has provided taxpayers with adequate, safe, and efficient transportation at the lowest price that responsible, competitive bidders can offer. For the most part, it has effectively prevented favoritism in spending public funds and has provided checks and balances through separate contracts with the DP and contractor while stimulating private sector competition. However, this process can foster adversarial relationships among the project parties, limit innovation, result in high cost and time growth, and may not necessarily provide the best value to the owner for all project circumstances or types. Also, DBB typically results in the longest duration between conception and construction, as well as between design and construction.

In recent years, this issue has become a more pressing concern for highway agencies, as deteriorating infrastructure and increasing population have created tremendous pressure to move critical projects quickly from planning through design and into construction without a commensurate increase in funding. Underlying these external budget and time pressures is the basic requirement to maintain quality in all phases of the highway program. Thus, there is a continuing need for highway agencies to review and evaluate alternative procurement and contracting procedures that promote improved efficiency and quality. The wide range of options for project delivery methods available today is a relatively recent development for publicly funded highway projects in the United States.

Things changed drastically with the introduction of D-B to highway construction through the Intermodal Surface Transportation Efficiency Act of 1991. Another step was taken in 1996 when the Federal Acquisition Reform Act explicitly authorized the use of D-B for federal projects. After that, TEA-21, Public Law 105-178, allowed the state DOTs to award D-B contracts if the enabling state-level legislation was in force (TEA-21 1998). Subsequent to the successful experience of using D-B in several projects, many states passed new legislation and codes to allow alternative project delivery methods such as D-B, CMR, and CM/GC.

Many public agencies have implemented D-B, and while D-B has advantages, including single-point responsibility (combining the DP and builder under a single contract), accelerated delivery, collaboration, and innovation, it also has certain disadvantages, including less agency control over design and the angst felt by most DPs in the event of a dispute where they find themselves aligned with a contractor against the public highway agency through which they procure much, if not most, of their business.

Most advantages of CM/GC are derived from the fact that a CM should be involved in the design and decision-making process early in the project.

Such concerns have caused some transportation agencies to seek alternatives to DBB and D-B for project delivery. A promising alternative that generated initial interest around the turn of the century was CMR. This option offers some of the same advantages as D-B, such as expediting delivery of projects, while allowing the agency to retain control of design (through a separate contract with the DP). However, the nations' contractors, except in certain limited locations, never accepted CMR because of one characteristic of the system. CMR contracts generally either forbid the CM to self-perform any work, or only allow the CM to perform work for which they underbid all subcontractors that bid on the work. This aspect of the system led to the unfounded fear that all CMR work would go to large, out of state CM firms and local companies would get none of the work. The logic of this was patently faulty from the beginning (even if a non-local company got the "prime" contract, they would have to contract someone to actually do the work, and this was almost always local contractors). Research studies that showed CMR to be a valuable tool for the toolbox of any public transportation agency (Minchin 2011) (NCHRP 2009, Gransberg and Shane 2010) debunked this notion. Nonetheless it was widespread. This resulted in an impasse that deterred transportation construction contract innovation for most of the first decade of the 21st century.

With this in mind, the FHWA launched Every Day Counts 1 (EDC-1 2010) and Every Day Counts 2 (EDC-2 2012), two priority initiatives focusing on shortening the time needed to complete highway projects through the use of new technologies and innovative processes. To deliver projects more quickly, FHWA now recommends implementing D-B and CM/GC, proposing that state DOTs make innovative contracting practices their "standard way of doing business."

CM/GC occupies the middle ground between DBB and D-B, and affords owners more opportunities for meeting the goals of the EDC initiatives than any other available delivery method. Successful use of CM/GC expedites project delivery, while allowing the agency to retain full control of the design; and positioning the DPs where they are most comfortable, directly responsible to the owner. An integrated team approach that applies professional management during the planning, design, and construction of a project, CM/GC incentivizes innovation to a greater extent than any other delivery system. In fact the system allows for, encourages and even requires innovation during the design process.

The CM/GC team consists of the owner, the architect/engineer or DP, the CM, the sub-DPs and subcontractors. The CM is best retained about the same time as the DP, typically through a qualifications-based or best-value selection process. Any agency considering using this system must understand that they are trading off control over the construction process in favor of speed, innovation, and flexibility.

Typically, preconstruction continues until the last work package is approved and released for construction. Of course, by this time the construction phase is well underway. During preconstruction, the CM acts as an advisor, providing professional services to the owner. A CM performs constructability reviews, cost estimates, construction phasing and schedules, and budget recommendations to assist in determining the best options for the owner based on the project budget. The CM also may perform duties not typically performed by contractors, such as assisting in securing financing or selecting or helping in the selection of DPs. The CM's greatest contributions during the design phase (and construction phase, for that matter) are to generate and create innovations to better perform work tasks, either from a methods standpoint or through a scheduling or financing standpoint.

Once construction begins, the CM becomes the GC. This phase typically begins when the project team releases its first work package for construction. The CM awards subcontracts in a fixed price, cost-reimbursable, or GMP contract. When a CM is bound to a GMP, the most fundamental character of the relationship is changed. In addition to acting in the owner's interest,

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the CM must manage and control construction costs to not exceed the GMP (AIA-MBA Joint Committee 2014).

Most advantages of CM/GC are derived from the fact that a CM should be involved in the design and decision making process early in the project. These include the three most important general advantages of (1) freedom to innovate design and construction practices; (2) flexibility to allocate risk, and then to re-allocate risk and continue to re-allocate risk throughout the life of the project; and (3) potential for great cost savings through innovation and optimum risk allocation. Noted advantages of CM/GC specifically involving design are as follows:

- Innovation and constructability recommendations early in the design phase
- Flexibility in the assignment of risk, reduction of risk and improved project decisions as a result
- Agency retention of substantial control over design
- The DP works to coordinate contract documents to the contractors' needs
- Cost savings by identifying real-time project costs throughout the design process
- Potential for time savings by fast-tracking early components of construction prior to complete design in phased packages
- Rapid adaptability to changing conditions and additional project requirements during design
- Ability for the DP to develop a more accurate cost estimate earlier
- Allowance for the design to be accomplished in the priority order that the phases are needed for construction and budget constraints
- Close coordination of third party issues (utilities, ROW, permits, etc.).

Note that the legal status of CM/GC for public construction projects varies from state to state. In some states, it is not legal for public construction projects at all. In other states, it is legal for public construction of vertical facilities, but not for horizontal construction like highways and bridges. In still others, it can be used for all public construction. Any state transportation agency that cannot legally use CM/GC should work within their legislative process to achieve legislation necessary to legalize its use.

B: Framework and Template for Organizing DM under CM/GC

The framework, illustrated in Figure 7, is based on the following seven fundamental principles:

- the need to understand the CM/GC concept and processes;
- the need to staff the project with as many people as possible with experience in fast-tracked construction (preferably CM/GC), and that those people be leaders as opposed to managers;
- the need to develop a strategic plan;
- the need to capitalize on early contractor involvement;
- the need to balance project risk;
- the need to tailor the project to the schedule and budget (not the other way around);
- and the need to define clear procedures for QA and QC. It is nearly impossible to completely separate the design process from the construction process in CM/GC, since the two are more closely intertwined and dependent on one another than in any other major delivery system. The framework presented in Figure 7 is presented as a DM framework, but includes a distinct flavor of CM.

Understand CM/GC

Under CM/GC, it is possible for projects to be designed around a table during regular project meetings (with the entire team present) rather than in a design office, with little or no active involvement from the team; and the system works best if this is the process. The emphasis of

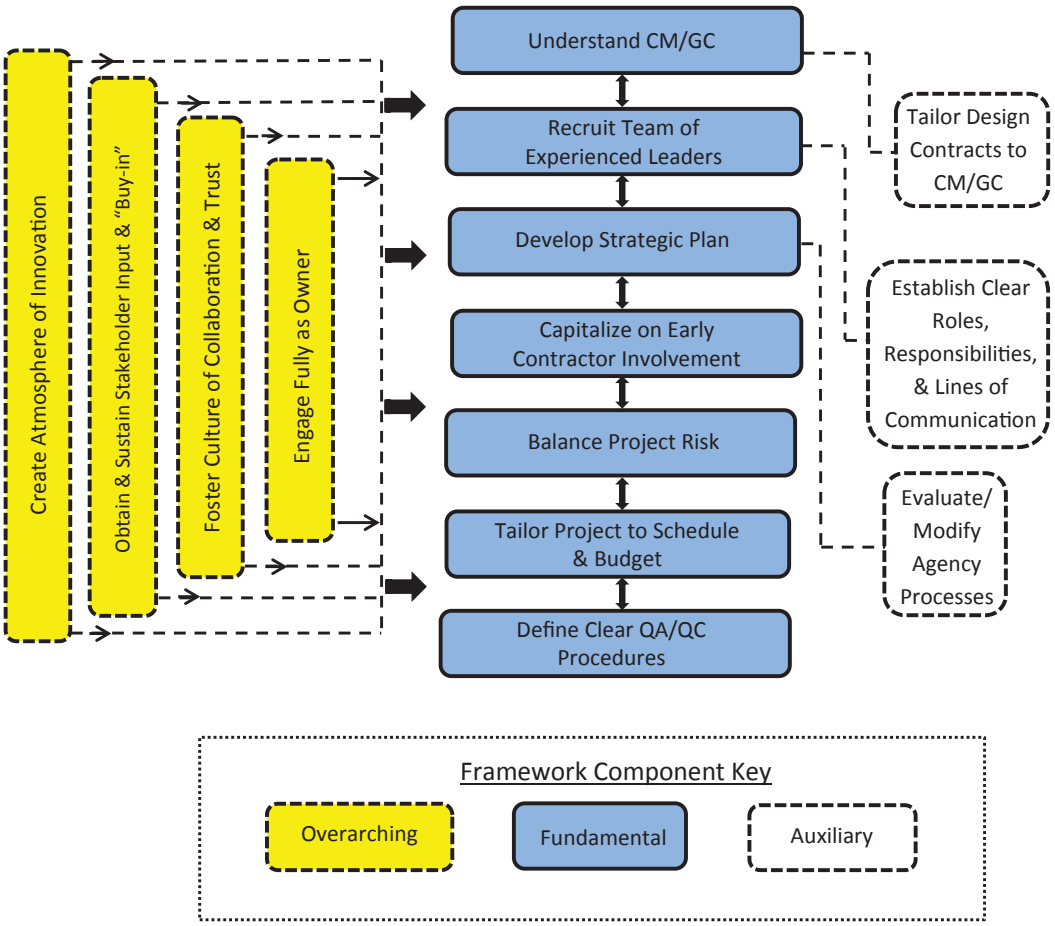

Figure 7. CM/GC design management process framework.

the design process changes in this scenario from traditional bid sets of plans to construction sets. The intensity of the design effort shifts from traditional plans production to team project planning—that is, critical design decisions are made during regular meetings with all decision makers present. CM/GC projects do not need a fully developed design package, as with DBB projects, or a complex performance specification as with D-B projects. CM/GC creates an environment where the owner, or owner's agent, must be more involved; for instance, CM/GC gives the owner the ability to get what they want from the contractor and price items accordingly. Also, since the parties are co-housed, it is simple to gather the parties together and have an impromptu meeting if something happens on the project that warrants such a step.

If executed properly, CM/GC offers the fastest way for a construction project to progress from conception to completion. It also offers the fastest way to get multiple projects designed and into construction. The Osceola County program was able to get 11 projects under construction in 1 year, whereas in the previous 5 years, only one project had been constructed (see Osceola County Case Study).

Figure 8 shows comparative durations of the design and construction phases for similar projects, when using the three most-used transportation delivery systems. The probability of establishing a successful program or project is greatly increased by following the recommendations in this Guidebook, all of which were taken from successful CM/GC projects and programs.

One of the recurring themes in the research that led to this Guidebook was that to understand the workings and execution of CM/GC, one must understand the culture of CM/GC.

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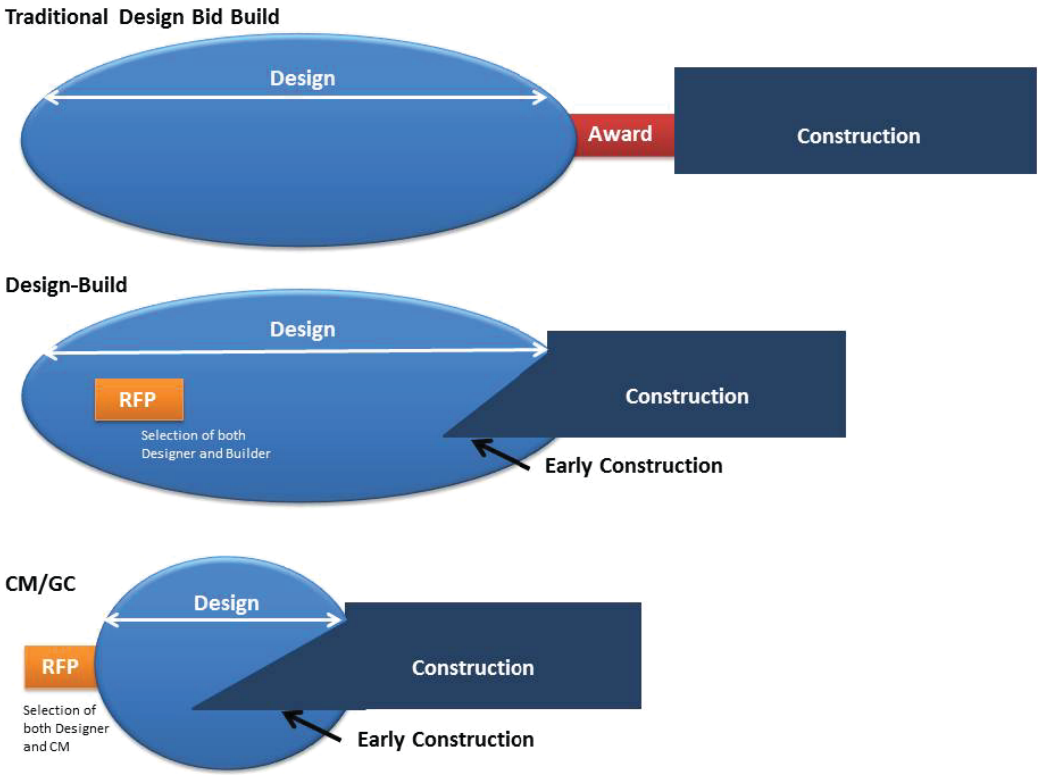

Figure 8. Comparison of durations for design and construction phases for DBB, D-B, CM/GC.

Culture

In many cases CM/GC requires a significant and aggressive change in the culture and philosophies of the owners, CMs, and DPs from traditional DBB design projects. For instance, the standard design methods, schedules, and plan review stages that are frequently used in designing DBB projects may prove to be inadequate to realize the advantages of CM/GC. DPs are required to take a more active role in working with the owner and CM during the design process. DPs may therefore need to be educated in receiving real-time input from the CM, as well as in flexibility in modifying standard items such as traffic control plans, to best fit the chosen approach to construction.

Overall, the fast-track nature of this method leads to a short-term need for increased plan production rates. This places additional requirements on the DPs, such as extended work hours, to keep pace with the acceleration and innovation changes proposed by the CM. Successful implementation often requires that a project be broken into additional "mini" phases, enabling the CM to start work early in areas where ROW and permits have been obtained and/or utilities relocations have been completed. UDOT sometimes uses as many as five "mini-GMPs" for the expressed purpose of accommodating early work items and/or early procurement items (see UDOT CM/GC Case Study). As with just about anything, however, use of multiple small early phases can be overdone. Oregon DOT feels that they may have used too many in one contract (see ODOT Case Study).

Early work packages can be broken into such items as retention ponds, partial clearing and grubbing, constructing on friendly parcel takes, etc., which requires more design effort than traditional "station-to-station" designs. Small contracts can also be written that will allow the CM to order items with long lead times.

Standard items under the DP's oversight, such as utility coordination and permitting during design, partially transfer to the CM due to the need to accelerate utility relocations, advance-order long lead items, have one "point" of responsibility with the utility companies, permitting agencies, etc. These shifts in responsibilities often are needed for the CM to take responsibility for the overall project schedule and budget.

Well thought out and finely crafted specialized and hybrid contracts—i.e., with the CM, DPs, consultants, etc.—must match perfectly the goals and objectives of the program/project. For best results, the contracts should require aggressive delivery, streamlined plans, innovation-mandatory goal percentages, advanced coordination, sufficient time for production meetings, principal involvement, strict adherence to the schedules and budgets, coordination, etc. Failure to put this language in the contracts will require asking for volunteer participation, which is much more challenging.

When one compares the means and methods of CM/GC to those of other delivery systems, it is easy to understand the importance of understanding and embracing the culture of CM/GC. For instance, the duties of the design team—such as permitting, project management, utility coordination, overall project schedules, and owner's representative duties—should be handled from the beginning by the whole team. Traditional duties are redistributed among the team, not handed off after the phases are complete. The CM should take over project administration as soon as possible and through construction while many of the duties that would be led and handled by the DP (such as utility coordination) are redistributed to the team.

Some risk and effort traditionally borne by the DP in the design phase can be lessened or even eliminated through not requiring quantity take-offs, computation books, and bid summary sheets. Some or all of these items can now be assigned to the CM as part of the GMP. Making quantities the responsibility of the CM enables the DP to strictly design instead of being concerned with plan matrices, quantity take-offs, etc. This practice also reduces the DP's scope and the cost of design; and converts the design plans to construction plans rather than bid plans. Streamlining the plans and scopes is a key principle in keeping the costs of CM/GC under control, and one of the best ways to do this is to eliminate some activities that are not as necessary as in the past, let the CM handle more of the activities for which they are better positioned to handle, and then not replicate or duplicate effort by having the DP or Construction Engineering Inspection (CEI) perform some of the same functions.

The foundation of a successful CM/GC project is trust and the best way to build trust initially is through total transparency in assembling the team.

Please note that some of the details of the process currently outlined are geared toward the program just getting started, or whose over-riding consideration is speed—speed from conception to construction or merely from design to construction. If an agency is more concerned with, say, risk identification, risk balancing, risk allocation, more complete sets of plans may be necessary. UDOT has long used CM/GC to shift risk among CM/GC team members for cost advantage (see UDOT Case Study).

Key CM contributions to the design of a CM/GC project include innovation, motivation, and a sense of urgency, thus getting utility companies and permitting agencies moving toward project goals. These functions are just as, or even more, valuable than more apparent and acknowledged contributions, such as plans reviews and constructability/biddability reviews. Of course a CM must perform constructability reviews, cost estimates, construction phasing and schedules, and budget recommendations to assist in determining the best options for the owner based on the project budget, but the sense of urgency that the contractor brings is to be valued by the agency. The City of Phoenix believes that permitting agencies and utility companies do not see a project as a "real project" until the contractor is part of the team (see City of Phoenix Case Study).

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Recruit Team of Experienced Leaders

CM/GC, unlike any other delivery method, enables an agency to build its own partnering team. It is essential that the agency capitalize on this opportunity and effectively "custom-build" its team to properly fit the specific needs and objectives of the project. This is a reason why the CM is best retained at the same time as the DP.

Proven and experienced leaders and innovators should be the first people considered for the team. In Osceola County, leadership was as highly valued as technical competency (see Osceola County Case Study). In addition, a fundamental question to ask when evaluating potential team members is: Will this individual advance the CM/GC process or impede its application? If there is any doubt that the individual will advance the process, that person should be eliminated from consideration. However, nothing should be done in secret. The most important characteristic of team assembly is transparency. This means transparency in the placing of in-house personnel on the team, in hiring new personnel, in procuring the CM, the DP, the specialty DPs, the CEI consultant, and all other team members. The role of the CEI in a CM/GC project is decreased from that in a DBB contract. The CEI in a CM/GC project is mostly limited to quality management, but is important nonetheless. When a CM/GC project team includes a CEI, the CEI arrives early in the design process and immediately assumes a key role. Additionally, the CEI often serves on various selection panels. UDOT actually uses the CEI to help select the CM (see UDOT Case Study). CM/GC offers an unprecedented way to create a strong synergy between partners; the foundation of a successful CM/GC project is trust and the best way to build trust initially is through total transparency in assembling the team.

In some cases an agency may be innovative and open to new ideas, but have some employees who are not of the same mindset. These organizations can still adopt and be successful with CM/GC, but will have to select project personnel who are willing and able to participate in such a program and who truly believe in its application. Examples exist where an agency adopts an innovative delivery method and then assigns one or more traditional staff members to its implementation only to find these individuals resisting the very program they are assigned to administer. This intentional and focused effort to identify and place the best people is equally important when recruiting external team members. The same screening criteria should apply in the selection of all DPs, PMs, QA/QC personnel, CM/GC personnel, and any other external team members.

CM/GC provides the team flexibility to react, change and adapt to difficulties with minimum delay. It also allows capacity for owners to deliver critical projects within a tight timeframe, in resource-constrained markets, enhancing capabilities and productivity. Good results come from co-housing the entire team of professionals starting at the inception of the project. This includes the construction phase as well. Retaining the "best in the industry" for all professional services should be the goal, i.e., the CM, DP, geotechnical engineer, etc., who have proven and successful experience leading major CM/GC projects, or at least D-B projects. The learning curve is often too sharp for someone with the years of experience necessary to function as a Project Leader (PL) or senior PM to go straight from DBB to CM/GC. This is especially true where the owner has limited experience with which to guide someone smoothly into the CM/GC culture. Each team member should be respected by the other team members; trust is a foundational element of CM/GC. A lack of trust is the fastest way to lose the benefits of the CM/GC process. For instance, The Utah Transit Authority UTA values trust in the contractor ahead of the contractor's capacity or technical competency (see UTA Case Study).

Importance of Qualification-Based Selection

One of the most significant advantages of CM/GC is the owner's opportunity to select the entire project team based on qualifications and past performance. The owner is therefore strongly encouraged to exercise due diligence in evaluating and selecting design, PM and other

consultants, CMs and subcontractors. Low-bid does not afford this opportunity and therefore should not be the primary criteria for choosing contractors and subcontractors. Advantages of choosing the very best people and firms are numerous. For instance, UTA can manage a project with substantially fewer staff if the right contractors and subcontractors are selected (see UTA Case Study); Osceola County found that the plans set can be substantially thinned (see Osceola County Case Study); Phoenix found that the quality of the contractors and subcontractors supersedes everything—to the point that cost is not considered at all in the CM selection process (see City of Phoenix Case Study).

Every owner uses different methods once the process arrives at price negotiation. In many scenarios, owners tend to fall back to the old familiar "competitive bid" paradigm. Many owners claim to hire based solely on qualifications, but once hiring is completed, they want the contractor to solicit subcontractor quotes, which the contractor must then beat in order to self-perform the work. Other programs like the City of Phoenix reject this. In those programs, contractors see this process as "going from this great best-value contracting back to the low-bid mentality of DBB" (see City of Phoenix Case Study).

The result of a properly executed Qualifications-Based Selection (QBS) is that every team member is regarded as a respected leader in their specific area of practice and is known for innovation and excellence. Of course, the most important personnel selections are for the PL and PMs, or whatever nomenclature the agency chooses for those positions. PL is the designation used in this Guidebook to represent the person who facilitates the entire CM/GC project and process, and has ultimate authority to make the final decision on the biggest questions. This person is an official with the agency, or the agency's assigns, or an agent of the agency.

Procurement of the CM

Regardless of which method is used to procure the CM, it is understood that as long as the CM's performance is satisfactory in the preconstruction phase of the project, the CM will evolve into the GC (contractor) for the construction phase of the project. There are three popular methods used for CM procurement: One-step QBS, One-step Best-Value and Two-step Best Value. In some cases, the differences between the methods are slight and subtle. The simplest and fastest is the **One-step QBS** method. In this method, the agency requires an SOQ in which prospective CMs are asked for any information that the agency thinks it needs to determine the best qualified CM. The agency is advised in this case to restrict itself to requesting information pertinent to this effort. While undeniably the fastest and least complicated method, the QBS method has the disadvantage of not providing the owner with the quantitative information that it could use to generate the pricing structure for the project.

In the **One-step Best Value** selection method, the candidate CMs are required by an RFP to submit their proposed fees, qualifications and a short narrative showing their understanding of and ability to successfully execute the technical aspects of the project. The award will go to the CM that achieves the highest score generated by an algorithm that was part of the RFP. The algorithm can include anything that the agency wants to be part of the selection process, but almost always includes cost/pricing and technical data as presented by the candidate and judged by the selection panel. A downside of this process is that there must be some preliminary design in place for the candidates to use in preparing prices/costs. The more transparent this process can be, the better it will be for owner-CM relationships on this project, as well as future projects. Lists of popular algorithms are available in the literature. One such list can be found in NCHRP Report 10-85, A Guidebook for CM/GC Contracting for Highway Projects.

The **Two-step Best Value** selection method is based on the method typically used by state transportation agencies in the D-B process. From the responses of a Request for Qualifications (RFQ), a selection panel narrows the number of candidates to a short list of, usually, three or four candidates. The shortlisted candidates are issued an RFP, which will require a detailed

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response including fees, organization charts, qualifications of key individuals, past construction experience, both CM/GC and otherwise, and of the company and of the key individuals, preliminary schedule, subcontracting plan, etc. A downside of this process is that there must be some preliminary design in place for the candidates to use in preparing prices/costs. Many agencies also take an opportunity here to request ATCs. If the agency issues a stipend to the unsuccessful candidates (a common practice), the agency then owns any ideas put forth through any unsuccessful proposal and can incorporate any of them into the project even though the successful CM candidate did not propose the idea. This includes ideas put forth as ATCs.

Project Leadership and Project Management

Project management is different when the PMs work with all professional firms (DP, CM, CEI firm, surveyor, geotechnical engineer, etc.) rather than with (or even for, in the case of D-B) a low-bid contractor. However, CM/GC can work well either way. It is critical to the success of this system that the person designated as the PL be a senior facilitator and decision maker. This system also requires greater experience on the part of the PMs. Everything takes teamwork. For instance, permitting becomes a collaborative effort, with greater involvement by all team members to meet the fast-track schedules. In addition, the CM and the rest of the team—not just the DP—are responsible for developing the project schedule, with the owner having active input to the overall schedule and budget. These shifts in responsibilities are often required for the CM to take responsibility for the overall project schedule and budget.

Ideally, the head of the CM/GC team (the PL) functions as the owner of the entire project and/or the CM/GC program, and is responsible for the guidance and leadership of the entire team. PMs (as assigned by the PL) review the plans and ensure that they meet the intent of the owner. Consultants and full-time staff work as design and construction PMs to review design and construction submittals for compliance with standards/criteria and to oversee the project for the owner. Co-housing the PMs helps to avoid distinction between internal staff and consultants. The whole team is involved in the RFI process, including the CM and DP, and if necessary, subcontractors and sub-DPs. UDOT and Osceola County both found that this process reduces formal submittals significantly (see UDOT and Osceola County Case Studies).

The goal of CM/GC is to have the plans reviewed during the regular design/production meetings and produce construction-ready drawings rather than bid sets. This process substantially increases production rates for design and all but eliminates lengthy owner review phases. This process also avoids touching plans twice, as the plans review is done in real time and, by the time they are a physical set of plans, the plans have already been approved by the team. Reviews are conducted only to ensure that all decisions made by the team are reflected in the construction sets.

Discuss with all stakeholders, prior to kicking off the program, the purpose of CM/GC and the goals and objectives to be met for the project to be considered successful. As appropriate, utility companies, ROW agents, permitting agencies, subcontractors, CEI firms, municipalities, counties and other local governments, owners, internal departments, procurement personnel, contractors, subcontractors, DPs, sub-DPs, law enforcement, citizens' groups, press, surveyors, attorneys, political figures, upper administration, CMs, and (most importantly) internal owner staff, leadership, and subordinates should be included in this process.

It is recommended that the principals of the DPs and all other professional services be required to be present and represent their teams in regular design production meetings; and it works best if the owner's senior leadership—i.e., people with binding, decision making authority—are actively involved in all design production meetings. All PMs and subordinate staff also should be required to attend these meetings, which should be a regular part of the schedule for participants from the beginning of the scoping of the projects to the completion of construction. This requires a tremendous effort and investment for all parties concerned. The costs for these efforts

must be made up through innovation produced as a result of the meetings. No one member dominates the team, although the PL facilitates the meetings. Also, it is wise to have a partnering retreat early in the process to introduce each member and build positive relationships. The partnering meetings also can be used to train team members in the nuances unique to CM/GC, such as responsibilities and lines of communication.

Owners must be willing to make a significant investment—more than with any other delivery method—in leading these projects to ensure success. This is not a passive delivery method for the owner. Ceding control of certain aspects of project management (mostly in the construction phase) to other parties does not equal less involvement. Poor engagement by the owner almost always leads to poor results. The owner must be the hardest-working member of the team—either actual owner personnel or the owner's assigns, or agent of the owner.

Research and experience has shown that an agency can hire a consulting firm as a program manager—the owner's agent to operate its program or project. A senior officer of this firm could act as PL. This can be effective if the firm hired to perform this function is competent and both experienced with and enthusiastic about CM/GC. Programs have been analyzed, however, where the firm procured to act as the agency's agent was all that it needed to be—competent, experienced and enthusiastic—and the PL was the most respected individual on the project, a leader in every respect, competent, experienced and enthusiastic; but the program or project was a major disappointment because the agency undermined its own PL. This occurred because some agency personnel, usually local, never supported CM/GC and resented having to use a system that they were not familiar with. This led to overruling the PL on decisions giving more flexibility and authority to the CM because the agency was reluctant to relinquish the control that it was accustomed to on DBB projects (Minchin and Li 2011).

Any team member not fully supporting the process and the success of the project or program should be removed from the team quickly and permanently, as that person's presence will damage team morale and undermine the CM/GC process faster than just about anything. It is recommended that the owner require this commitment during the RFP process and select only professionals who completely meet these requirements.

Develop Strategic Plan

One of the major benefits of CM/GC is an agency's ability to incorporate stakeholders' needs, wants, and desires successfully within the project's schedule and budget. Consequently, it is critical for an agency to spend a tremendous amount of time, resources, and effort in advance, painstakingly planning the entire CM/GC operation/project for its lifecycle. One of the agency's first and most important action items, even before selecting outside team members, is to reach out to all stakeholders and begin educating them. At the time of the writing of this Guidebook, government and industry leaders in very few areas of the country know enough about the CM/GC culture or process for the agency to skip this vital step. Therefore, an aggressive public relations and education effort must be undertaken, and it must contain a message that is consistent, no matter who is sharing or receiving the message.

This process does not end when the CM/GC team is put together. It would be wise for the team, once assembled, to exert time and energy early in the process toward educating key personnel from affected county, city, state and federal agencies about the project, the CM/GC process and the desperate need for quick permit application turnaround. Others needing early visits are utility companies and owners of land parcels that might not be an easy acquisition. The education begins inside the agency, however. All agency personnel and work groups from whom the CM/GC team will need or expect anything

CM/GC by far affords an owner the greatest opportunity for input and influence. Therefore, it is the owner's primary responsibility to lead and guide the project successfully.

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during the course of the project must be educated about the CM/GC culture and process. The only CM/GC project that could be classified as a bad project during the investigation leading to this Guidebook struggled for two main reasons that could have been avoided: (1) Reluctance on the part of the agency to relinquish the control it was accustomed to on a construction project, and (2) Failure to educate the stakeholders, both inside and outside the agency. Research shows that it is much harder for someone at a permitting agency or a utility company to refuse to cooperate with someone with whom they have a relationship. To this end the City of Phoenix assigns a person the responsibility, on every CM/GC project, of developing a personal relationship with at least one person at each applicable permitting agency and utility company (see City of Phoenix Case Study).

Of the three primary delivery methods (D-B, DBB, and CM/GC), CM/GC by far affords an owner the greatest opportunity for input and influence. Therefore, it is the owner's primary responsibility to lead and guide the project successfully, starting at a time in the preconstruction phase well in advance of design. This objective is best accomplished through strategic planning. During this process, care must be taken to include all stakeholders whose input is essential to the project. Failure to include a key stakeholder can result in an unsuccessful project. CM/GC can accomplish efficiently all project requirements and meet the needs of the stakeholders if these are properly identified and accounted for in advance.

To that end, the owner should conduct strategic planning and partnering workshops that include all stakeholders concerning the CM/GC process and overall project DM planning, to discuss agency experience with CM/GC, the project's vision, mission, goals and objectives, applicable statutes and laws, stakeholder and community input, Disadvantaged Business Employee (DBE) and small businesses, life cycle costs and sustainability, potential construction claims and adversarial relationships, project size, complexities, obstacles, opportunities and threats, budget and funding, staffing required and current staffing capabilities, design requirements, status and requirement for permits, survey, utilities and ROW, potential for accelerating project delivery, etc. Among other things, a good strategic plan will accentuate a documented benefit of CM/GC; UDOT credits the projects' strategic plans for a substantial reduction of RFIs on their applicable projects (see UDOT Case Study).

Capitalize on Early Contractor Involvement

Among the advantages of CM/GC, the emphasis on teamwork and the contractor's involvement in the design and decision making process early in the project brings important benefits. The CM (contractor) can be brought on to the project at any time during the design phase; however, there is a strong consensus that the earlier the better. The earlier the CM is retained, the more time there is to develop synergy with the DP and the rest of the team; and the more time and opportunity to enjoy the most important benefit of CM/GC—innovation. Innovation in project design, traffic control design, permit application, utility relocation, schedule of activities, ROW acquisition, construction methods and many other items is essential for the most successful execution of a CM/GC project. The CM is the single most important team member as far as innovation is concerned, and every day that the CM is part of the team is a day in which the full team can work toward time and cost saving innovations. On one project in Utah, the CM saved substantial money and time by eliminating the need to relocate a large set of gas lines traversing the project. For details, see the MVC and UDOT Case Studies.

The budget can be affected significantly by the CM's arrival if ROW, survey, permits, etc., are just beginning. Bringing in a CM, regardless of the timing, significantly reduces changes, delays, constructability issues, and schedule challenges, while increasing ease of contracting and

procurement. Permitting agencies and utility companies almost always respond more favorably and more quickly to a project team's requests and applications after the contractor is on board. These organizations will see the CM as a contractor even though the contractor is still officially serving in a CM capacity during preconstruction; and experience and research show that permitting agencies and utility companies change their attitude about a project when there is a contractor present. Suddenly the project that was a "paper project" becomes a real project. The administrators of the Osceola County program inherited projects at every possible stage of development, and observed that changing from DBB to CM/GC and immediately procuring the CM (contractor) improved every project, regardless of its stage of development (see Osceola County Case Study).

Agencies are constantly discovering new ways to take advantage of the experience and knowledge of the contractor early in the life of a fast-tracked contract. One of the tasks emerging for early-involved CMs is the acquisition of ROW. Who would better know exactly what land to procure than the people helping with the design of the project, creating innovations by which to best construct the project and ultimately constructing the project? Osceola County (see Case Study) lists in its Lessons Learned that they should have allowed the CM to handle the entire ROW procurement process, and would do so in the future. NCDOT (see Case Study) does not have a CM/GC program, but in their D-B program, they started a few years ago letting the D-B purchase any ROW that resulted from changes to the contract. They recently expanded this to having the D-B firm handle all the ROW procurement procedures right up until money changes hands. Currently, on many D-B projects in North Carolina, the D-B identifies and negotiates the purchase of the land, and purchases the land. NCDOT, however, writes the check for the purchase. Oregon DOT has both a D-B and CM/GC program. Their D-B program handles ROW acquisition the same as NCDOT (see ODOT D-B (Bundle 401) Case Study). The D-B does everything but write the check. In their CM/GC program, their Program Manager (private firm acting as owner's agent) handles the ROW acquisition (see ODOT CM/GC Case Study).

Innovation is Essential

CM/GC incentivizes innovation to a greater extent than any other delivery system. Based on this, successful CM/GC projects require the owner to explore this question: Is the agency prepared to adopt and implement a new and innovative project delivery approach?

Another critical question is this: Is the agency prepared to accept innovative ideas even if the proposed concepts have never been used on its projects in the past? The greatest benefit of CM/GC is the innovation that the whole team, working together, brings to the project. Innovation should actually be on the agenda of every CM/GC design progress meeting. However, sometimes agency culture, tradition, or attitudes prevent these fresh ideas from being implemented because they were not "invented here" or "we've never done it like this before." Avoiding this bias is an important step in achieving full CM/GC success.

The project team must innovate in order to make up all CM fees as well as those required by the design team, consultants, subcontractors, etc. Otherwise, costs will escalate. Contractual requirements should be in place for the team to target a certain amount in cost savings.

The scope of work and associated fees, for both the DP and the CM, should obligate the CM and the DP to coordinate throughout the design and construction phases and attend all design meetings. This is essential to developing the innovative options and designs that reduce overall project costs as well as make up for coordination costs and the CM's overall fees. Without CM attendance at regular design meetings, the advantage of bringing the CM on board early is reduced significantly.

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Substantial Cost Savings are Available

Lost in the amazing story of the project that just kept growing in size is the fact that to grow like that, the project had to experience substantial cost savings. In fact, Mountain View Project data shows a 27% reduction in expected cost over the design period of the project (see Mountain View Case Study). This is unheard of on a major highway construction project. In fact, costs generally go up during design. UDOT, in their public release of information has noted this savings in several of their documents. Similarly lost in the amazing story of how the CM/GC program in Osceola County got nine projects designed and under construction in 1 year was the amount of money that was saved in the process (see Osceola County Case Study). To save substantial money, the owner must understand the risk and know how to manage that risk. The owner cannot be totally risk-averse and save money. Risk management and cost savings go hand in hand. Risk management also affects quality and schedule. Hence, CM/GC is more work for the owner. It takes more owner knowledge and skill, but it pays big dividends. The owner that has the ability and desire to manage risk gets the reward.

Balance/Assign Project Risk

All major capital projects involve inherent risks (i.e., political or economic change, climate, technology, ground conditions, engineering uncertainties, errors, industrial disputes, land issues, environmental issues and many more). In order to achieve optimal outcomes the project owner must select the most appropriate strategy for managing these risks. "The traditional risk-transfer contracting models have increasingly been shown to be inadequate to deal with these circumstances" (Ross 2003).

The most successful CM/GC projects are those that take advantage of the most important opportunities offered by the CM/GC delivery system. Only the opportunity for innovation is a bigger advantage than the flexibility to assign and re-assign risk during a project.

For instance, if a CM's submitted cost for a certain work item in a certain phase or GMP of the project is high, the owner can simply ask the CM what is making that item so costly. Often, the answer is tied to risk. The owner may then offer to cover the risk that causes the cost of that item to be so high. With no risk to worry about, the CM can then lower the item's cost. If the item is a major item, the change in cost could be significant. Please see the Case Study on the MVC for an example of how this has worked on an actual project.

The process of risk assessment and allocation is a well-established one, containing Risk Registers, matrices, and the execution of a new risk assessment at every new cost estimate. Utah DOT has been a leader in risk assessment and allocation, and has become quite adept at exploiting the flexibility that CM/GC offers for assigning and reassigning risk as the project progresses. Please see the UDOT CM/GC Case Study (as well as the MVC Case Study) for more details on this unique opportunity to possibly lower contract cost, shorten project duration and even eliminate work items from the project through allocation and re-allocation of risk.

Contingency, Trust, and Allowance

Innovation is essential to reduce or eliminate change orders and finish the project. The entire project team is encouraged to agree to a zero change order policy, starting with the owner and proceeding to the DPs, other consultants, CMs, subcontractors, CEI firm, etc. Once change orders begin, the GMP process loses all effectiveness. One organization researched had an arrangement with all team members that when the budget and contingencies were exhausted, the team's work would continue on a pro bono basis. This was great motivation for all team members to effectively monitor and control spending throughout the life of their projects (see Osceola County Case Study).

Contingencies and allowances are required to successfully cover the design and construction aspect of the project and to accelerate the entire process. Contingencies are the difference between success and failure on a CM/GC project as they enable real-time decisions to be made and paid for and the project to move forward rapidly. The contingency is the part of the cost estimate that covers all the uncertain costs of the project (Gransberg 2013).

It is unwise to set a contingency amount based on some arbitrary percentage of the contract costs. Characteristics of the project must be taken into consideration. Though not common practice at this time, it is wise to set the contingency amount(s) based on the findings of a thorough risk analysis whenever possible.

Contingency funds are best managed by the owner, and there may be as many as three different types: the CM (contractor) contingency, covering material and labor cost escalation, subcontractor availability and competition level, and market uncertainties; owner contingency, covering problems with the project documents (including scope definition and unforeseen conditions), as well as regulatory changes and force majeure issues; and management reserve, a fund established for changes and operational requirements not emanating from completion of the project requirements, but effect the project nonetheless. For a detailed description of these three types of contingency, see NCHRP Synthesis 402—Chapter 6 (Gransberg 2013; Gransberg and Shane 2010).

As stated elsewhere in this Guidebook, trust is an element that glues the whole CM/GC process together (see UTA Case Study). One thing that builds trust among contract parties like few other things is the concept of "open books." This involves sharing project information among parties to the contract that, in other settings, might be considered proprietary and carefully guarded. This project information, such as actual project costs, overhead, processes and construction methods, is often shared by parties to a CM/GC contract. For example, on the MVC project, the team discovered a way to avoid relocating utilities (see MVC Case Study). The better that everyone understands the most intricate details of the budget, the better they can visualize the impact that their decisions can have on budget compliance or profit margin during the construction phase.

Tailor Project to Schedule and Budget

"Schedule and Budget Drive the Project, Not Vice Versa"—this principle is critical to controlling costs, as the administrative overhead is most expensive among the three primary delivery methods and if not controlled will cause the project to fail. Due to the high overhead, the program must be resource-loaded up front, determining how many staff to bring on, how many hours they need to work during the project, and when they need to cut back on their hours to meet budgets and staffing requirements. This needs to be understood clearly by all team members to avoid causing any friction due to unmet or colliding expectations. Costs of all cumulative GMPs should be calculated as accurately as possible prior to starting early work packages or mini-GMPs. The scopes of the design contracts should be streamlined to produce construction plans rather than bid sets, and the bulk of the design team and all other professionals should be required to be present during the regular design production meetings.

DPs must budget additional funding and management personnel for frequent team meetings and binding decisions while working with both the owner and contractor (CM). DPs that have not worked within CM/GC before probably will need to be educated in the process of receiving real-time input from the constructor as well as being flexible in modifying standard items such as traffic control plans to best fit the chosen approach to construction.

Once the project budgets have been determined, require the professionals to agree to them—i.e., design fees, CM fees, CEI fees, geotechnical fees, survey fees, overhead, and construction

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costs as well, as the overall project budget and schedules should be specifically broken into design, construction, survey, permitting, and ROW. Identify clearly all targets. For the project to succeed, costs cannot exceed the agreed-upon budget for all GMPs combined, regardless of the circumstances and problems encountered. If total project costs ever exceed the agreed-upon budget for all GMPs combined, it sets a very dangerous precedent for the program.

Guaranteed Maximum Price (GMP)

CM/GC affords the opportunity for an agency to establish a GMP for a project early in the design process, thereby allowing the agency to modify/adjust designs according to the required/targeted budget. It is not essential for project or program success that the GMP concept be utilized. Some successful programs do not adhere to its use. Most do, however, so the concept will be explained here.

First, the CM performs constructability reviews, cost estimates, construction phasing and schedules, and budget recommendations to assist in determining the best options for the owner based on the project budget. A GMP is a contracting arrangement in which an owner contracts with a firm to perform a fixed scope of work in exchange for a price that is guaranteed not to exceed the stated maximum price (CMAA 2012). A GMP contract includes a base cost along with several allowances and contingencies that can result in a final cost below the stated GMP. Savings are then provided to the owner or shared between the owner and contracted firm (CMAA 2012; Gransberg and Shane 2010). In the Osceola County program, the owner kept all the savings initially, then shared savings with the contractor but eventually saw this as unfair and damaging to the morale of other parties to the contract who might be involved in the process of saving money on the project. They intended to move to a system that allows any party that contributed to the savings to share in the savings (see Osceola County Case Study).

It is critical for the contractors and subcontractors to formulate the rough and final GMPs based on real bids, not estimates by the DPs and/or CM firms. Getting real costs at the earliest possible rough concept phases of scoping and rough plans is essential to coming in under budget and generating constructible projects within schedule and budget.

The agency and the CM must agree on each GMP. If there is ever a GMP on which the two cannot agree, most contracts contain language that allows the agency to cancel the CM/GC process for the body of work assigned to the GMP under negotiation, and let that work as a separate low-bid DBB contract. This can be an effective tool for hastening the parties to an agreement, but should be used as only a last resort. Experience and research have shown that when this clause is exercised, both the agency and the CM tend to lose (Minchin and Li 2011).

As stated earlier, once a CM is bound to a GMP, the most fundamental character of the relationship is changed. In addition to acting in the owner's interest, the CM must manage and control construction costs to not exceed the GMP (AIA-MBA Joint Committee 2014).

Independent Cost Estimates (ICE)

An ICE is a cost estimate developed by a consultant to compare with the contractor's cost estimate to ensure that the construction costs are reasonable and fair (Gransberg 2013). Only a firm that includes experienced transportation construction estimators should be considered for work as an ICE (see UTA Case Study). A properly executed ICE should never use historical figures (data). The independent cost estimator should be contacting the same people that the CM is contacting. This introduces another potential problem, however. The subcontractors and suppliers, if not contacted by the CM and/or owner and "encouraged" to support the ICE, will almost assuredly not do so–rendering erroneous prices, or none at all. Subcontractors and suppliers should be told in advance that they will be contacted by the ICE, and should be

strongly encouraged to work with them. Preferably, the ICE should engage the CM's estimators throughout this process. By allowing the parties to talk through their disagreements, the process becomes much more efficient. Conceivably, this does not present any potential conflict through these discussions. Since any differences have to be reconciled eventually, it is a good idea to let the individuals that produce these estimates sort things out directly, and as early as possible. Throughout the ICE process, the entire project team should be aware of the targeted, versus the actual, ongoing costs of the project, as it is being designed and innovations are implemented to assure that the overall project costs are kept under budget.

ICEs should be performed using contractors/entities with direct local construction bidding experience. In addition, the entire project team (including the ICE) discusses the actual bid estimates/prices, received directly from the subs, during the regular project meetings and determines if and why costs may be out of range, i.e., is the project overdesigned? Are the specifications more stringent than needed? Is the CM carrying too many risks? Is the owner asking for more than they can afford? Are contingencies and allowances needed? With this process, each pay item is treated as an individual GMP and the entire team agrees to a reasonable cost to pay for each item, prior to moving forward with the design detail. This enables real-time adjustments to each pay item, as well as each design detail, prior to proceeding to an overall GMP very early in the design process. Costs should thereby remain in control because they are controlled and adjusted during each regular production meeting.

Define Clear QA/QC Procedures

QA/QC for a CM/GC project should not be confused with QA/QC for a DBB (low-bid) project. This is due in part to the owner having direct contracts with the CM, QA team, and designer, with all three, in theory, acting as owner's representatives. A significant benefit of CM/GC is that it enables the owner to facilitate the entire QA/QC process.

Based on this innovative arrangement, the owner has the advantage/ability to engage its QA/QC team early in the DM process while also working directly with the entire project team, specifically the CM. This is a huge advantage for the owner, who can receive real-time QA/QC feedback during the DM process, a benefit traditionally available only at or around the time of bidding and/or construction. Capitalizing on this innovative QA/QC arrangement, when combined with early contractor involvement, is critical to capturing the full benefits of CM/GC.

It is important to modify QA/QC practices to reflect the CM/GC process. The DP usually has the lead responsibility for QC, with the CM/GC and QA/QC team providing additional QC. This is one of the many reasons that it is important that the Engineer of Record (EOR) has direct experience managing a CM/GC design phase and that the DP (firm) has a solid history working on CM/GC projects. Management of the QA/QC process means that the DP is required to frequently modify plans, implementing the CM/GC input, while working and coordinating directly with the QC/QA and CM/GC team related to plans production, specifications, pay items, engineering cost estimates, and plan details. This requires regular/frequent QA/QC meetings with the owner, CM/GC and QA/QC team. If, while managing the QA/QC process, the DP's plan production rates cannot keep pace with the approved project schedule/accelerated pace required for CM/GC, it can mean trouble for the project. This goes back to the importance of hiring a DP with a history of delivering accelerated and innovative designs, on schedule and within budget.

Lessons Learned

The recommendations listed herein under the title "Lessons Learned" originate in a variety of places. Some are described as "best practices" by their sources. Others are simply solutions

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to various challenges, gathered by the research team from previous experience and previous research. Please note that no distinction is made in this list between programs that have different idiosyncrasies or utilize different minor procedures or use different terminology. For instance, some CM/GC programs use a GMP and some do not. Therefore, not all of these lessons learned would apply to every CM/GC program.

Project Planning and Procurement

- The procurement process should include well-defined selection criteria and scoring methods. The selection criteria should include project-specific features, list the minimum qualifications and focus on the differentiators.
- The selection committee should be blinded for the technical evaluation: "Proposer A," "Proposer B," etc.
- Public involvement is huge.
- Establish, as early as possible, a partnering relationship with all other stakeholders and work very hard at keeping things friendly between the parties. Continued coordination with appropriate people and stakeholders is very important during the project.
- Always include a consultant and a contractor on the evaluation team/selection committee.
- Training of Selection Panels is necessary especially with a new scoring method and new approach.
- Spend whatever time and resources are necessary in the beginning to educate the permitting and other key agencies (city, county, etc.) about the project.
- Think long-term and do not start the project until the team is ready.
- The CM Preconstruction contract MUST be coordinated with design contract.
- Design contract must require engineer to cooperate with CM/GC.
- GMP components must be clearly defined in RFQ/RFP.
- Bring in necessary people early.
- One can never do too much research before starting with CM/GC.
- Research the project delivery programs and software your organization uses and how it will apply to CM/GC.
- Do not assume that an existing RFP or Contract template will work for your organization or project.
- Do not assume you will get buy-in from everyone to start using this new method.
- Sometimes the Civil Rights Office of a DOT may not be familiar enough with the specifics when establishing the DBE goal. It is helpful to notify Civil Rights about specialty work that cannot be provided by a DBE.
- Long Lead Time Procurement—Needs environmental and FHWA clearance if federally funded.
- Collaboration and constant communication with AGC state chapter and FHWA early and often is essential for success.
- Phasing the project gets the contractor out on the project earlier and saves a lot of time. Progressive GMPs reduce the need for contingencies and allow early lock in of volatile material costs.
- Address Industry concerns and feedback. There will be challenges to the program from industry. State laws will be scrutinized.
- Considering region and statewide training of CM/GC including a manual, classes, and webinars.
- Co-locating the contractor and the designer for a few days helped tremendously. It would be beneficial if they were co-located on or near the project site for the whole project.
- The easiest way to pay the contractor and please FHWA auditors is to use either straight Unit Price, or a combination of Unit Price and Lump Sum or Unit Price and Cost-reimbursable.

- The manner in which the owner procures services can have a major impact on the team members' ability to work together and, consequently, on the project's potential success.
- The most important aspect of a successful CM/GC program is transparency. Transparency in the selection process and open books for the parties to the contract.
- Managers must be educated to the very top. Executive decisions should be made long before the project executives are brought in only for big decisions.
- Most CM/GC highway projects require at least middle management support for CM/GC.
- Identify challenges early.
- You must not only educate local politicians (city, county, etc.) on how CM/GC works, but get their buy-in.
- Whoever has the purse strings and whoever makes the final decisions have to be on board with CM/GC.

Design Phase

- If a project will have multiple contracts, do everything possible to not have most of the work (money) in one contract, especially if the work in that contract comes relatively late in the project.
- In the Design Phase, it is good to keep the team focused through setting goals. One must remain constantly aware of schedule limitations and have candid budget discussions.
- BBOs should be conducted at the 30%, 60%, 90% and 100% plans stages. BBOs are used by UDOT, for example, to have a snapshot of the status of the project budget prior to official bidding. The structure package had multiple BBOs as UDOT neared its budget limit. Though the Blind Bid Openings (BBO) process greatly aided the team in tracking its budget, it was unsuccessful at reducing unit prices.
- Do not start construction before a lead DP is procured.
- Be very reluctant to change delivery systems mid-project, even if contractually allowed.
- When a CM is chosen, allow the CM to act as a CM, not as a low-bid contractor. If the CM approaches the owner with a complaint about changed conditions, delays in reviewing shop drawings, other common delays, etc., the owner should not treat this like it would if a prime contractor on a DBB project made the same advances. Most CM/GC contracts make it clear that unless an incident caused the CM or a subcontractor to do something that was outside the boundaries of the contract (a material change), the CM just has to handle the situation. That is part of their CM fee. Paying the CM for handling such items is a dangerous precedent and amounts to double-paying the contractor.
- Do a project closeout session at the end of each CM/GC project.
- Have the ROW acquisition directly under the team and preferably handled by someone hired by the CM firm.
- If design activity is put on hold, stop construction also. If construction activity is put on hold, stop design also, unless the CM is an active member of the design team.
- It would have been helpful on some projects to have more design-oriented meetings. The meetings were geared more toward discussions of the process, which were not useful in providing clear direction to the design team.
- Normally, CM/GC projects involve discreet breakout sessions for the different design disciplines. This should happen on all CM/GC projects, no matter how small.
- The roadway designers should always strive for more discussions with the contractor, and they need to become skilled at pulling the contractor into the design process.
- Schedule-driven design does not allow enough time for coordination between the true cost and the cost model, which means that the ICE has difficulty defending its numbers.
- The first CM/GC project that an agency executes is difficult. A local CM should be chosen for the first job.

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- Everyone has to buy in.
- Owner PMs will work longer hours, put in more work, and put in more effort than with other delivery methods.
- There usually is a crunch at bid time because CM/GC projects end up being schedule-driven during design. In many cases, final plans are barely complete in time to produce an adequate estimate and a sound bid. It is wise to allow the time for a sound bid.
- CM/GC can be an excellent risk-reduction process if the owner so desires. It is actually more of a risk-reduction process than an accelerated design process.
- The additional design time tends to help expedite construction by overcoming likely construction obstacles during design.
- The proper time for a design team to consider the DBE goal is after PS&E. However, once the DBE goal is established, the scope cannot change.
- Require actual construction personnel on the agency and contractor side to be involved all the way through the preconstruction phase.
- Adding major features to the project during the final stages of design goes much more smoothly with CM/GC. The process allows for flexibility in design and construction implementation.
- A rigorous analysis of risk is always beneficial to the team.
- Scoping a CM/GC project is critical with respect to scoping estimates and scope creep prevention.
- Discussions with the contractor are very beneficial to the owner when determining the costs of risk events and gauging the values of incentives.
- Do not assume equal knowledge of the process and expectations among team members.
- Contractor feedback during the RFP process (submittals and interviews) is valuable.
- Tailoring the design to meet the contractor's means and methods may not save money directly unless procedures are put in place to ensure that the savings are passed on to the bid prices.
- Contractor input is vital to tie down budgets efficiently.
- It is paramount that the contractor understands its role during design and participates in the process.
- Find a champion who has the drive, passion, and energy to put into the program.
- The contractor can help obtain site data more efficiently than with DBB or D-B (soil investigations, borings, etc.).
- Questioning the "standard" design methods is permitted and can result in tremendous savings.
- Innovations implemented may result in change orders during construction. The team recognized the tradeoffs made to meet the schedule and budget.
- A lot more communication is necessary (than with DBB). Fortunately, CM/GC helps facilitate communication.
- ICE support during the selection process was very helpful.
- Subcontractors and suppliers should be told in advance to expect to be contacted by the ICE, and should be strongly encouraged to work with them.
- People should be encouraged to give feedback, even when it is uncomfortable.
- Have a contractual coordination requirement between CM and DP.
- To make a CM/GC program or project work at its highest level of efficiency and quality, all parties must be willing to risk failure and derision.
- It is important to educate DPs and contractors that have never worked on CM/GC projects that the entire culture of CM/GC is different than DBB or D-B, and to teach them about the culture.
- Constructability Reviews and VE are considered part of the fee the CM gets for preconstruction services.
- Require contractors to submit their prices at each predetermined milestone.
- Use actual subcontractor quotes to generate the GMP.
- It is critical to educate the DP early in the process so they can aid in the education of the contractor.

- Everyone must understand the meaning of partnership and Partnering.
- Experience with CM/GC can be a deciding factor when hiring DPs.
- With CM/GC, there is more of a team atmosphere than with D-B or DBB.
- There has to be an understanding that price does not equal cost.
- Middle management must be consulted daily, and must be allowed to make decisions.
- Executives must support middle management and be available.
- Move the utilities early in the design phase, before construction starts.
- Locate GMPs in the most advantageous position and order to mitigate mobilization costs.
- People need to realize that it's all about long-term relationships. Everyone needs to let their guard down and recognize the value that each party brings. Also, more cooperation (is needed) between the DP and the CM.
- An owner contingency should be included to cover scope changes, design errors and omissions, and unforeseen conditions.
- The CM should have control over the solicitation, selection and administration of subcontractors in much the same way as subcontractors are selected through traditional DBB procurements based on experience, qualifications, track record and price.
- Generally, the CM/GC procedure will lead to minimal VE change orders as cost saving ideas should be developed in the preconstruction services and incorporated into the GMP.
- If the CM can offer a satisfactory explanation as to why an idea could not have been identified in the preconstruction services phase, then an equal sharing of the savings should be considered.

C: Short Case Studies

Program Case Studies

CM/GC Program Case Study No. 1: Utah Department of Transportation

The UDOT has a long history of innovation in highway and bridge construction contracting. Among its many such accomplishments is the execution of the largest (up to that time) D-B project in U.S. history. The I-15 reconstruction project, built for Salt Lake City's 2002 Winter Olympics, was also the largest project ever undertaken by the state of Utah. The success of this high-visibility project gave UDOT the reputation as one of the nation's most innovative public transportation agencies and showed other agencies that highway and bridge construction projects can be successfully completed using a delivery system other than DBB.

Having proven the viability of D-B, UDOT turned its sights on developing a new system providing contracted parties the benefits of D-B along with the benefits of DBB. The system they turned to was the CM/GC delivery system. UDOT now has built more than 25 projects with CM/GC since 2005, and is, therefore, the state agency most experienced in using this method on a large variety of projects.

Although [they] vary per project, there are typically three to five GMPs based on early procurement items as well as early work items.

The function of the PM is different from that of a typical DBB project in that PMs have a more prominent role in decision making and leading the projects. UDOT designs projects utilizing multiple "mini" GMPs. Although these vary per project, there are typically three to five GMPs based on early procurement items as well as early work items. The typical design milestones in a GMP contract are traditional percentage complete phase submittals (i.e., 30%, 60%, 90%, etc.) followed by a final PS&E. An ICE is then generated and compared to the Engineer's Estimate and the PS&E. There is a 10% red light/green light process wherein the PM has the power to authorize a project if costs are within 10% of the ICE.

The DP is required to take less risk on a CM/GC project, although UDOT's internal design PM manages design changes as they affect the schedule, budget, and overall GMP.

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Designs are taken to "105%" in that there is more up-front work to ensure that the prices and plan are correct. Over time, UDOT has learned that the design effort must be intensified on CM/GC projects to reduce cost. Plans are very detailed, and projects are not as schedule-driven as they are design-driven. A full risk assessment is completed in detail for every project, and 100% of the savings goes to the owner. Flexibility of risk assignment is one of the two biggest advantages of CM/GC.

In actuality, CM/GC projects are driven by the owner's PM, who manages both design and construction phases. However, both the DP and CM are the owner's representatives. As such, the CM is primarily responsible for generating some documents traditionally the responsibility of the DP, such as traffic control plans.

The DP's role during construction is minimal due to the intensive up-front effort invested during the design phase, but the QC process for design used during the design phase does not differ from the QC process for design used in the construction phase. The role of the CEI consultant differs from that in a DBB contract. The CEI enters into the design process early and is often on the selection panel. The CEI is involved during the design phase, is actively engaged in reviewing the plan sets during plan review, and attends all design meetings. UDOT's process allows DPs to adjust their plans to "real-time" information provided by the CM, no matter when the information comes to light.

It is recommended that the owner procure the CM as early as possible, ideally at the same time as procuring the DP, though sometimes this is not possible. The earlier the CM is part of the team, the more innovations may be generated during the design phase. In fact, UDOT believes that innovations generated by having the CM as part of the design team is the single biggest advantage offered by CM/GC.

When choosing a CM and DP, the selection committee consists of a representative from the state contractor and DP advocacy associations. Once construction begins, managing post-award design activities (i.e., design activities during construction) are no different from DBB activities, though the number of RFIs is reduced significantly versus DBB projects. The CM manages RFIs with owner oversight and approval. During the design and construction phases, the owner takes primary lead in coordinating design changes with DPs, and project contingency funds are used for design errors and omissions. All communications go through UDOT's design PM during the design phase; and after NTP, all go through the construction PM.

Designs typically come in at or over budget. Since more design work goes into CM/GC projects, additional overall design hours are needed to complete CM/GC projects, and fees are based on the individual UDOT PM's experience. Approximately 6–8% of the construction cost is typical for the design fee, and this percentage is higher than with DBB projects. CM/GC projects require a more detailed design; however, the construction starts earlier in the design process and responsibility for creating and monitoring the design, construction, and overall project schedules is a collaborative effort. Nonetheless, the owner is responsible in the end and establishes all schedules up front in the planning phase.

CM/GC Program Case Study No. 2: City of Phoenix, Arizona

The City of Phoenix has built more than 200 projects using what they call a CMR construction project delivery system since initiating the system in 2000. Only recently has the city commenced using CMR for horizontal construction, totaling 12 horizontal CMR projects since their first project, let in 2008.

Note: Definitions of CMR and CM/GC and a discussion on the differences between these methods are provided in Chapter 1 of this guidebook. According to these definitions, the

approach used by the City of Phoenix would better fit under the CM/GC label even if the city titles it CMR. It has all the classic characteristics of CM/GC: (1) Calls the CM a "contractor"; (2) Contract requires the contractor to self-perform work; (3) Utilizes a straight unit price system to pay the contractor. To avoid confusion, this system will be referred to as CM/GC.

When using this delivery system, the City typically procures the DP before the CM. The CM/GC process differs from a typical DBB project once the CM has been selected and is part of the team. For instance, the CM actively participates during the design phase in producing the traffic control and construction phasing plans. The DP customizes the construction documents to the contractor's needs and works on more finite cost proposals to assist with a final GMP.

Phoenix has found that it is harder for the utility company (or permitting agency) to refuse to assist someone they know than a nameless, faceless entity.

In CM (contractor) procurement, the focus is on "most qualified" (there is no price component), and for the most part, CMs are hired based on past performance with the understanding that they will move forward and help the DP and the owner design the best project constructible, work through risks, and agree on a fair price. It has been described by some in Phoenix as "a shotgun wedding of sorts." It is more of a shotgun wedding than a typical CM/GC project with a price component because there is an owner who, "99.9% of the time," has already selected a DP and now is trying to pick a contractor that will marry well with that DP due to the high level of contact between the two. This contractual relationship allows for free flow. The owner is not required to be present or privy to most conversations between the CM and DP: the flow of information is as free as the owner wants it to be.

In the design process, DPs have no incentive to control costs other than their reputation. This makes contractor input even more essential. Innovation is encouraged through VE and construction phasing and methods. Especially sought is contractor input on major structural items/elements, scheduling, and cost estimating, specifically, cost reviews and preliminary cost estimating, constructability reviews, and biddability reviews.

The utility coordination and moving utility lines starts about the same time as with DBB projects. Phoenix's CMR process enables permitting and design in small "mini" phases, and the design process is tailored to begin construction earlier than at the traditional final plan stage.

Best design practices for controlling construction costs include requiring contractors to submit their prices at predetermined milestones, requiring that all work be done using the unit price contracting method, using actual subcontractor quotes to generate the GMP, when possible, bringing the contractor and DP onboard at the same time and negotiating contracts at the same time, and finally, once the contractor is brought in, having them join in the validation and negotiate the GMP.

Five tangible things were identified as high priorities in the design phase: (1) ROW; (2) Permitting; (3) Identifying challenges; (4) Bringing in the necessary people; (5) Relocating utilities. The City has found that two things aid in moving utility lines earlier: (1) get the contractor on board early and (2) assign someone to initiate and develop a personal relationship with at least one person at each utility company (and each permitting agency). Phoenix has found that it is harder for the utility company (or permitting agency) to refuse to assist someone they know than a nameless, faceless entity.

During the design phase, the CM is contractually obligated to coordinate with the DP on estimating, construction phasing, schedule, and GMP preparations. The first GMP generally is developed and submitted at 90%, although simple phases or plan packages could be completed earlier. ROW acquisition begins about the same time, although it can begin as early as 30% with

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environmental clearance. This is earlier than with the DBB delivery system. Utility relocation coordination is completed in-house, either prior to bid or during the design and construction phases.

CM/GC Program Case Study No. 3: Osceola County, Florida

The CMR program in Osceola County was initiated under great controversy due to the long-term instability of the county road building program, and political pressures to complete and execute a major infrastructure plan. As a result, the program was under an ultimatum from the County Commission to have nine projects under contract within one year, when only one was under contract at the time. The new administration boldly decided to implement an untried delivery system to meet the target, adding to the controversy.

This program was a true CMR program, but to avoid confusion, will be referred to as CM/GC since the two are almost identical in the ways important to this study. To begin this program, a tremendous training effort was initiated, focusing first on the design community.

The program internally encountered a high degree of resistance from a group of county commissioners and the county legal department who were against the implementation of CM/GC. Similarly, the design and construction consulting communities and the local road builders were skeptical.

Tremendous money, time, and changes are saved when the CM firms and the DPs work together to produce the plans and phasings for the projects.

Because the administration inherited a program in disarray, the immediate implementation of CM/GC brought in CMs at all phases of plan completion. It was found that completing the project under CM/GC and bringing in the CM as early as possible improved the project, no matter at what stage the project was in. However, after experiencing various scenarios where CMs were brought in at every possible juncture in the life of a project, the administration concluded that the best time to bring in the CM was simultaneously with the DP.

In many cases, the program required establishing a GMP prior to preliminary plans for early work items, materials ordering, and additional geotechnical work based on only a description of the scope required. In addition, GMPs were priced at the 0%, 30%, 60%, and 90% plan stages.

ROW acquisition began as early as possible in an effort to efficiently and wisely design projects and minimize the ROW required. This also assisted in wise ROW choices based on market conditions and friendly takes rather than eminent domain. When early acquisition was not possible—as when the administration inherited plans sets already complete or nearing completion—the CM/GC process allowed for adjustments in construction and work-arounds rather than waiting until all issues were resolved. To further expedite the process, the administration decided to assign ROW acquisition duties to the CM as part of the preconstruction package for future projects. Who better to choose and buy the ROW than the people who assist the DP most with design, work with utility companies, procure the construction permits and who will ultimately execute the construction?

Quantity take-offs, computation books, and bid summary sheets (as a requirement of the DP) were eliminated, which significantly reduced the DPs' risks. These items were the responsibility of the CM as part of the GMP. Quantities were the responsibility of the CM, enabling the DP to design instead of being concerned with plan matrices, quantity take-offs, etc. Streamlining the plans and scopes is a key principle in cost control, as administratively it can be much more expensive if not controlled with de-scoping items.

Fees were inserted requiring the CM to coordinate (throughout the design) and attend all regular design meetings. This is essential in order to develop options for reducing overall design

costs and making up for coordination costs and the CM's overall fees. CM meeting attendance also is crucial to obtaining the benefits of CM/GC pertaining to reduced costs; without this, the advantage of bringing CMs on board is reduced or eliminated altogether.

Innovation was required to complete all projects under budget. During initial partnering meetings, the team agreed to the cost reductions required to meet the aggressive budgets. This is critical to success; the team, upfront and prior to the beginning of the project, must buy in to the fact that significant cost reductions are essential. In Osceola County, the owner and the CMs achieved this; but in reality, the money should have been split proportionately among all team members, to be fair and to incentivize the whole team to work toward cost savings.

The design process consists of projects basically designed around a table during regular project meetings with the entire team rather than in a design office with little or no active team involvement. The design's purpose is to provide the lightest, most innovative and cost efficient set of plans possible—versus a heavy design effort—to give the CM just the right information to bid the project. The intensity of the design effort is in the planning—not in plans production.

Though there was no specific program to train proposal evaluators, the administration was extremely selective about who was put on panels to select the CMs. Panels were set up for each selection, similar to panels for the other contract parties. The PL, in this case the Public Works Administrator, was a driving force in facilitating each panel. These panels selected the DPs, CMs, Geotechnical Engineers, CEIs, etc. Panels also included previously selected CMs, DPs, etc. as advisors who would attend the meetings whenever possible.

Design PMs (internal to the department) would review plans and ensure they met the owner's intent. Consultants and full-time staff who worked as design and construction PMs were hired to review design submittals for compliance with standards/criteria and for project oversight. These were co-housed to avoid distinction between internal staff and consultants. Also, the whole team was involved in the RFP development process, including the CMs and DPs.

Initially, typical design review submittal phases were required; but as the program evolved, formal submittals were substantially reduced. This increased production rates for design and all but eliminated lengthy owner review phases. This process also avoided touching the plans twice, as the plans review is done in real time and, by the time the plans are put in ink, they have been approved by the team. Reviews are conducted only to ensure that all decisions made it into the construction plans.

The DP, CM, subcontractor, and owner are each best at what they do; as such, each should be considered a specialist on the team. The following steps can help make this possible:

Require the PL to be in all production meetings to maintain cohesion and teamwork. There is no substitute in CM/GC for top-down leadership.

All parties should meet early in the scoping and budgeting process, including subs.

Have a partnering retreat early in the process to introduce members and build positive relationships. The partnering meetings can also train team members in the nuances unique to CM/GC, such as communication.

The surveyor and geotechnical engineer should be at both the preliminary scoping and budgeting meetings. This is essential to having effective overall plans for the project as well as for avoiding constructability and design problems. They should have an equal seat at the table.

In Osceola County, the entire team was responsible for public involvement during design. The CM and the entire team are intimately involved and aware of all issues, goals, and objectives relating to public involvement, so utilizing them for that purpose only makes sense.

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Tremendous money and time are saved, and changes are avoided when the CM firms and DPs work together to produce the plans and phasings for the projects. Utility relocation preferably was handled with the entire team during the production meetings, with the relevant utility companies present during early project scoping. This is essential to keeping a CM/GC project within budget and schedule. Failure to do this effectively can lead to a GMP that is neither valid nor accurate and a project that cannot be constructed within the schedule and GMP.

Summary

The CM/GC system was installed despite overwhelming, wide-ranging protest from local contracting, design, and CEI communities. The results were that within a year, 11 major roadway segments were ready to begin construction, thus achieving 55 times the production rate of the previous five years, and this at over 20% under budget for all projects, including design, permitting, mitigation and construction. All CM/GC fees and preconstruction fees in savings were returned to the owner. Local participation rate, the strongest of the myriad objections voiced, stood at 75% and helped keep numerous local contractors from going out of business.

Approximately $350 million were spent on construction in the first year; however, $105 million were saved due to innovations and bid packages broken into specialty items of work, a 23% savings. The total returned to the county in the first year was $36 million. Another $80 million were returned to the community through local contractors in the first four months of construction, with nine out of every 10 construction dollars going to local contractors. This was important because in the first four months, $80 million were invested in the community at a time when the local economy was depressed and had one of the highest home foreclosure rates in the nation. This does not include what was paid to the local design community.

CM/GC Program Case Study No. 4: Utah Transit Authority

UTA has used the CM/GC construction project delivery system on five major projects since 2002. At the time of the case study, the $2.5 billion cost of these projects may be more than any other agency has spent on CM/GC projects.

UTA believes that selection of personnel is one of the most important functions of an agency. A project cannot succeed if the wrong people are involved. In the past, they had the personnel for each project; those who did not believe in CM/GC or who seemed to be stuck in old ideas were not allowed on the project. UTA felt that it actually could manage the project with fewer staff if it had the right people on the job.

UTA has conducted some experimental work in alliancing. After using alliancing on the North Temple Viaduct Project, it now has applied it to the Sugar House Line, even though it's unknown if any other U.S. agency uses this system. UTA seems to have gotten most of its inspiration and practices from Australia.

The level of coordination required for a CM/GC project is more than that on a typical DBB contract and means a cultural change for some parties.

UTA performs CM/GC because it allows more speed and a greater level of control vs. DBB. The method also was reported to be a "good agency fit," developing a high level of trust among all parties. Trust is the key to success at UTA, which prefers not to do business with people it does not know and trust.

The level of coordination required for a CM/GC project is more than that required on a typical DBB contract and requires a cultural change for some parties. These changes in culture and philosophy of contractors and designers (vs. traditional DBB) include trust, the belief that all will be treated fairly, and that contractors understand how the design process works.

Shared savings and leveraged relationships help build this, especially trusting that the contractor is not going to overcharge the owner. Reverse incentives have also proven helpful. Deferring 6% of billings over time to reduce cash flow requirements became contractor insurance. Finally, UTA wants 40–70% of the work self performed (versus other owners in the area wanting 30%). Contractors like that.

The process is also different from that of a typical DBB contract. First, coordination starts earlier. Also, permitting, project management, utility coordination, overall project schedules, and owner's representative duties are different. The process employed by UTA enables the team to permit and design the project in small "mini" phases and ensures that the design process is tailored to begin construction early instead of at the traditional final plans stage.

Developing the necessary trust for a program like UTA's takes time working together. The more CM/GC projects that owners work on with contractors, the more trust can be built. In the beginning, however, any party coming from a DBB culture into a CM/GC contract must be educated in the culture. After the first time, educating the designers and contractors becomes much easier.

CM/GC creates an environment where the owner can be more involved. UTA's best cost containment practices include an early start due to the availability of equipment; iterative estimating; the owner's scope and budget adjustment toward the goal; certainty about the price; the contractor having a better handle on the real cost of the work (as opposed to the designer); and avoiding scope conflicts.

The estimating process for a CM/GC project can be either very efficient or very time consuming. UTA sometimes uses a local firm, which is composed of former contractor estimators, as its ICE. The use of consulting engineers who lack experience in the field or in generating estimates by crew and activity is not sophisticated enough for CM/GC. Using unit prices from previous projects also will not work. Using someone like this local firm as ICE allows the team to get to a number sooner.

Several tools have emerged for paying the contractor. The more traditional methods included unit price, lump sum, and cost-reimbursable. Other nuances regarding contractor payment included: (1) Progress payments were done proportionally; (2) Subjective review of percentage complete; (3) Some contractors agreed to be paid based on a cost-loaded schedule; (4) Prearranged increments helped decide the percentages; (5) Schedule of value based on the GMP is not as complicated as a cost-loaded Critical Path Method (CPM); (6) Agreed-upon progress percentages (with the owner) are relatively easy to administer; (7) The federal project was paid off a cost-loaded schedule (vs. state projects, which were done by percentage complete); and (8) The contractor would publish a revised payment forecast every quarter.

UTA's program has the flexibility required to change designs, construction phasing, and materials selected if the design team (the CM, agency personnel, and DP) discovers a better method than what is currently in the contract, even late in the design phase. There is a high degree of openness and willingness to engage new or innovative ideas. UTA's culture is very open to new ideas, but they believe that they, as the owner, must resist exercising too much control over the design.

Finally, the delivery method must be matched with the goals of the agency. The first decision is what the goals are and then the second is the best delivery method to achieve those goals. For the Commuter Rail North project, UTA had the following goals: (1) Early knowledge of the price (this facilitated their negotiations with the Federal Transit Administration regarding the amount of their full funding grant agreement [FFGA]); (2) Flexibility in the design, even during the FFGA process; (3) More UTA involvement in the design process than in past D-B projects;

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(4) Issues addressed quickly with the railroad. After reviewing the delivery methods available (D-B, DBB, CM/GC), it was clear that CM/GC was the only delivery method that would achieve these goals. It is a big mistake for owners to choose the delivery method before determining their goals. This can easily lead to selecting the wrong delivery method.

CM/GC Program Case Study No. 5: Oregon Department of Transportation

ODOT has used the CM/GC construction project delivery system on three projects since 2011. When using this system, ODOT employs several methods of managing post-award design activities. Their process allows DPs to adjust their plans with "real-time" information provided by the CM/GC firm. There are written SOPs for the design of CM/GC projects, and the agency now utilizes these contracts, because while the agency had only worked on one CM/GC project under such a contract at the time of publication, it worked well.

The function of CM/GC project management is fundamentally different from a typical DBB project in that industry personnel are not entirely familiar with VE as a matter of course and in allowing the contractor to take the lead. It requires a completely different mindset and release of control and letting the contractor lead has been the department's biggest problem in building the CM/GC program.

CM/GC designs typically come in under budget, and factors that most significantly contribute to this include constructability reviews provided by the CM.

The ODOT design process calls for multiple "mini" GMPs—and in retrospect, perhaps too many on some projects. The typical design milestones utilized in a CM/GC contract are traditional percent complete phase submittals (i.e., 30%, 60%, 90%, etc.) followed by a final PS&E.

The DP is required to take less risk, and steps are taken to manage this during design, and to share risk between the owner, DP, and CM/GC. During the design phase, the DP is designated as the owner's representative and ODOT has an agency PM overseeing design. The DP also assists in choosing the CM/GC firm.

RFIs and shop drawings on CM/GC projects are managed by the lead PM for the DP. The CM/GC and the agency's representative are primary leads in coordinating design changes during the design and construction phases, while the DP is responsible for covering design errors and omissions during design and construction.

With respect to project goals and objectives, ODOT ranked political impact as the top priority, time as second, and cost as third. As this project entailed a major interstate, a dense political climate and community involvement had to be considered at all times. These priorities can change from project to project.

During the design and construction phases various communication channels were used to keep the CM/GC, DP and agency representatives in constant touch. On projects, or portions of projects, where communication is especially important, ODOT requires co-location between the CM/GC, DP and owner's representative. During construction, the DP's role is to handle design changes, contract modifications, and other responsibilities. In fact, due to numerous site condition changes, the DP is often as active with construction concerns as with design concerns.

Regarding how the agency's post-award design management affects project performance, the design standards and specifications are no different under CM/GC than those used on a typical DBB project. Similarly, CEI is the same, though the coordination between the DP and the CEI is different. The CEI is not involved during the design phase, but gets involved once actual construction has commenced.

CM/GC designs typically come in under budget, and factors that most significantly contribute to this include constructability reviews provided by the CM/GC, which have saved ODOT substantial funds on CM/GC projects.

Additional fees are not included for the DPs' coordination with the CM/GC (and vice versa), but approximately 11–15% of the construction cost is typical for the design fee, and this percentage is higher than on typical DBB projects. When multiple GMPs are used, the total cumulative project costs are calculated during the design process. Design schedules typically have similar durations to those of DBB projects and the responsibility for creating and monitoring the design, construction and overall project schedules is a collaborative effort between the DP and CM/GC. Using CM/GC provided a 25% time reduction in project delivery on the one project for which this comparison was made.

For ODOT, the owner's representative manages design changes as they relate to potential impacts to the schedule, budget and overall GMP. This is primarily because it affects both the DP and CM/GC. The ICE process entails the use of a third party firm (located out of state) along with both the DP's and CM/GC's estimates. Having three estimates to compare against each other worked extremely well in identifying several cost savings options–and the agency plans to use this process in the future.

QC for design during the design phase differs slightly from that process used for design in the construction phase. Notably, QC responsibility shifted during construction from the DP to the CEI oversight firm. As a means to communicate the owner's expectations for how design QA and QC are to be ensured throughout design development, ODOT employs design QC templates and plan templates, and all who propose to work as a CM/GC are required to use these templates.

Project Case Studies

CM/GC Project Case Study No. 1: Mountain View Corridor/UDOT

The MVC is a 15-mile "planned" freeway in western Salt Lake County and northwestern Utah County servicing 13 municipalities. There actually were three contracts on this project. A small one upfront included early order items such as girders and some canal crossings that had to be done at certain times of the year, a flexibility made possible because of the CM/GC process. Eventually, the information available was enough for the development of a complete set of final plans, but that was deemed unnecessary since the project operated on a system of continuing pricing.

An integrated construction and ROW schedule was prepared during the design phase and was updated continually based on properties cleared and utility permits acquired. Float was considered a shared resource and was able to be used by the contractor or owner depending on the situation and the need. This required a high level of trust and coordination but resulted in delivery of the project with no delays to the schedule.

The process for this project had four pricing milestones—the first with an approximately 30% set of plans, the second with approximately 50%, the third at 75%, and then at 90%. At each milestone, the team also conducted a risk workshop. The contractor reviewed the plans and the team agreed on quantities from the set of plans. This risk workshop was based on these quantities, and the team discussed every possible good or bad scenario that could change the pricing. A percentage was derived, based on the probability that each incident might actually occur and what cost and schedule impact each would have. A Risk Register (in the form of a matrix) was then developed that listed each of these possible occurrences. Some of them decreased the cost of the job; most increased the cost of the job. Finally, through Monte Carlo simulations, curves were developed to identify the probability of finishing the job at certain costs. At each stage, the budget needed a 90% probability of covering the project cost.

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The DART process documented $25 million in savings from things that team members brought into the process which were not part of the original plans for the project.

Figure 9 shows an example of the curves where the project had a 50% probability of finishing with a cost of $307 million and a 90% probability of finishing at $350 million. Therefore, the budget was set at $350 million, with a 90% confidence level of finishing the project within budget. The curve flattened as the contractor identified risks that had not theretofore been considered. The cost estimate climbed accordingly as the contractor brought in all constructability issues.

As the team eliminated those risks, the price fell, allowing the team to concentrate on the biggest risks and how to remove them, mitigate them, or assign them to the contractor or owner, whoever could best manage them. At this point, the team carried $50 million in contingency, based on what the contractor thought it could deliver. As the contractor got more confident, the contingency fund went from $50 million to $30 million. That money was reinvested in more ROW, and then ultimately in extending the project. As the process of identifying, assigning, and eventually retiring risk continued, the curves were updated. Figure 9 shows the curves for the same project as shown in Figure 10 after subsequent quarterly reviews allowed the team to first identify and then retire more risks.

This whole process happened four times within about a year until the design was completed, but the Risk Register was updated quarterly throughout the project. As risk was retired, contingency was retired in kind. A 90% confidence level of delivery was always carried.

Also within the CM/GC contract were provisional sums. The team discussed every item and who should take the risk on it. A number of times the team agreed that if something were deemed 75% likely to happen, then a provisional sum would be assigned for it. Very few of the items assigned provisional sums were realized, and the money that came back to UDOT ended up allowing the purchase of the additional ROW and construction.

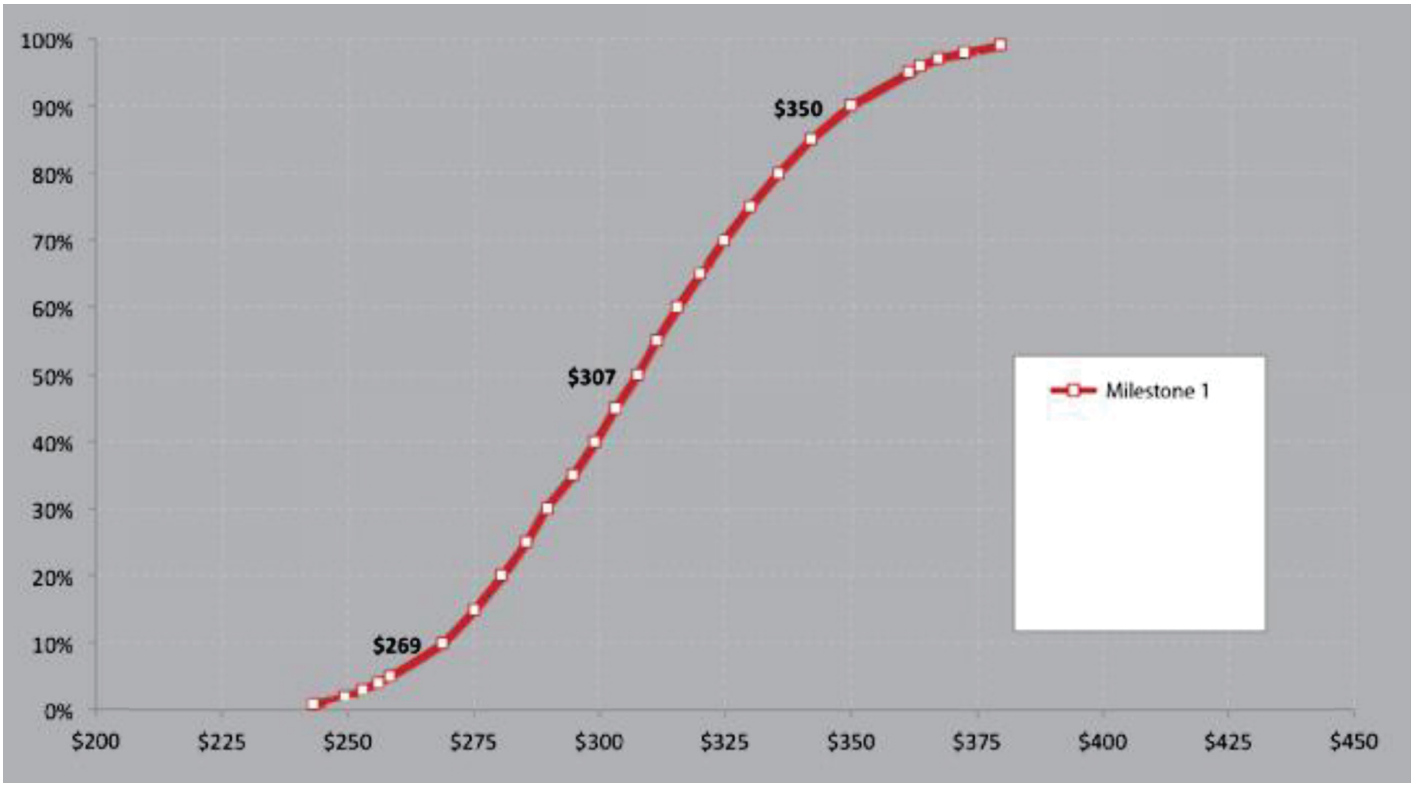

Figure 9. Curve after original risk register.

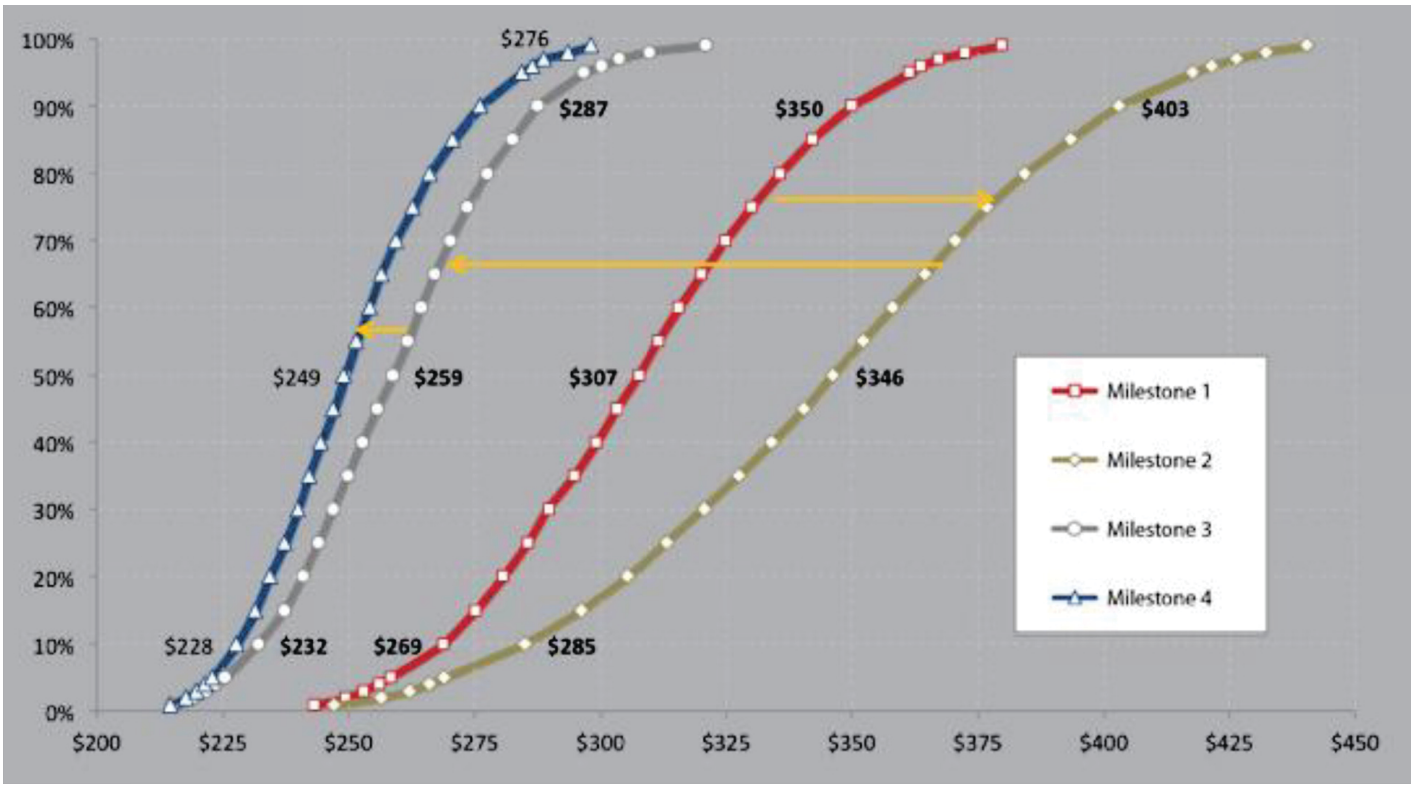

Figure 10. Risk curves on the same contract as Figure 9 after four risk registers.

The DP's responsibility for cost containment focused on monitoring its own budget and making sure the design budget was not overrun, and delivering a responsible design that could be built within the budget. Coming up with the innovations to help make this happen was the role of the whole team. The DP, as well as the contractor and owner, participated in a process called a decision analysis by ranking techniques (DART) decision. This software will determine what any change costs in terms of design, construction schedule, and construction. Ultimately, DART tells the decision makers whether the possible change saves money or whether the cost for designing and constructing the change, plus construction delays caused by the change, will be less than or greater than its benefit.

Once DART renders a positive recommendation, the innovation makes its way through a process. Ultimately, a management team has to recommend that the innovation be implemented. In all, the DART process documented $25 million in savings from things that team members brought into the process which were not part of the original plans for the project (innovations).

The contractor was retained for preconstruction services when the design was roughly 30% complete. Approximately one year was spent producing the design plans, adding innovations, doing constructability reviews, and pricing the job. Once the team was satisfied that they had constructible plans and appropriate pricing, they entered into a construction contract.

The willingness of the owner and the contractor to sit down with third parties to work on a solution allowed the team to overcome many challenges. One particular challenge was related to a 300-foot-wide utility transmission corridor. The ability to have the contractor at the table with the utility company allowed a discussion of construction methods and specific equipment. This led to the development of a protect-in-place scenario, which allowed the team to delay an $8 million relocation until future phases of the project, possibly 10–15 years in the future. The $8 million was able to be used to expand and progress current phases of the project.

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Table 7. Reinvestment of MVC funds beyond original construction limits.

Reinvestment	Reinvestment Amount
Golf Course Reconstruction	$18m
Kern River Gas Relocation	$18m
Residential Relocation (150)	$40m
Kennecott Rail Line Relocation	$11m
Rocky Mtn. Power Relocate	$20m
Water Tank Relocation	$4m
Additional Earthwork	$6m

Review risks every quarter that included Risk Registers, DART, risk assignment, and risk retirement allowed UDOT to save and set aside about $117 million. All of this money was used to extend the contract and ultimately, the 15-mile project became a 17.5-mile project. Table 7 identifies specific reinvestment of MVC funds beyond their originally scoped construction limits. These items were added gradually over time as risks were reduced and contingency could be reinvested.

CHAPTER 5

Conclusions

This section is designed to provide the reader with a review of the most important facts and recommendations related to the Guidebook as determined by the authors; knowledge from the authors' previous research and experience in the field is also shared. Many of the lessons learned and best practices for D-B and CM/GC are common to both systems; however, many are appropriate for only one. This is not unexpected, since both are fast-tracked construction delivery systems that are only as similar to the traditional contraction project delivery system as they are to each other. To allow readers to more easily identify the information pertaining to their system of interest, the Conclusions shall continue the theme of segregation.

Design-Build

After almost two decades of use in transportation, D-B is a tested delivery system that is preferred when delivery time is critical. A majority of state transportation agencies have already used D-B even if several agencies have only used it for a few projects. However, a large majority of local transportation agencies and a small group of state transportation agencies have not. A few barriers exist to its first-time use. First, public agencies often need to obtain legislative authority to employ it and to use procurement approaches specific to D-B. In addition, the approach to manage design activities is also uniquely different from traditional DBB delivery. This research has outlined a few DM features typical to D-B and found that how an agency approaches them is crucial to effective DM. However, more agencies have adopted and utilized D-B. As a result, more different approaches to DM may be effective within the context and constraints of a specific agency. Therefore, the sections of this D-B guide only highlight these different approaches without recommending one over the other.

At the program level, it is crucial how the agency allocates DM responsibilities among its units and how the project delivery process is managed by units that deal with phases adjacent to post-award design (i.e., D-B contract procurement and construction). At an extreme, three different units will manage design during (1) pre-award (during procurement), (2) post-award pure design phase, and (3) post-award construction phase. However, two approaches are common depending on the type of project and the level of maturity of an agency with D-B. When projects are unique (e.g., SR 99 Tunnel Project) or when an agency is not expert with D-B delivery, the same group manages the process from procurement and throughout post-award delivery. This approach creates a continuity of design information. In case the project lacks uniqueness and the agency is highly versed with D-B, it is common to assign pre-award design administration to agency staff (and units) that specialize in D-B procurement. Often, an individual from the same unit who is involved in the procurement is later assigned to manage design activities in post-award jointly with a construction PM. The role of this design manager decreases as the project moves

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from a release for construction to completion. This industry practice attempts to "bridge" project responsibility from pre-award to post-award.

At the project level, the approach to deal with pre-award design activities substantially affects post-award DM. In fact, a significant part of design is concurrently carried out during the D-B contract procurement by all the competing teams. Design alternatives are generated at this point and incorporated into the final design. When the procurement process allows for submittal of ATCs, some of these design alternatives can be incorporated into the final design even if the team proposing the idea is not selected. This incorporation can occur either after a team is selected and before a contract is awarded, or post-award. For readers unfamiliar with ATCs, think of them as VE proposals submitted individually by competing teams in their proposals. Some agencies require that these proposals be approved before being included in the final proposal package. A significant feature of the DM is how the agency will handle the selection, approval, and incorporation of these alternative design ideas. The case studies provide a comprehensive narration of different approaches to deal with pre-award DM, either when ATCs are allowed or not. When ATCs are not allowed, agencies rely only on post-award VE.

During post-award DM, an agency's approach to DM is mostly shaped by how it establishes a collaborative partnering environment, how it handles communications and coordination on matters that contribute to DM, how it handles VE proposals, how it handles interdependencies between design and other activity, and, especially, how it handles formal DM processes. All the case studies were similarly structured to highlight different approaches to these features of a DM process. In addition, constraints within agencies and projects that may motivate the selection of one feature over another are provided together with a set of guidelines.

Construction-Manager-as-General-Contractor

CM/GC is a delivery system with some history in commercial and industrial construction, but is new to most of the transportation construction industry. In the early days of the new century, portions of the industry tried to establish CMR as a fast-tracked alternative to the more established fast-tracked D-B delivery system. CMR offered all the speed inherent in a fast-tracked system, but also offered the owner more control over the design process than did D-B. However, contractors fought the system almost everywhere it was implemented because CMR generally either forbade the CM from self-performing any work at all, or required that the CM bid for any work against qualified subcontractors. This, the contractors feared, would eliminate smaller, local contractors from ever being awarded any project large enough to attract the larger national or international contractors or CM firms. The logic of this was faulty on the surface, as any contractor or CM firm, no matter how large, that was awarded such a contract would have to find someone, probably local, to perform the actual construction. Regardless, CMR never gained any momentum as a national delivery system option for highway construction, and CM/GC, which had been used in Utah and a few other places for a time, was embraced as the fast-tracked alternative to D-B because CM/GC either allows, or in most cases requires, the CM to self-perform a set percentage of the work.

The FHWA has supported the implementation of CM/GC from the time that it was introduced to the transportation construction industry, and has made that support tangible through the EDC initiatives (EDC-1 in 2010 and EDC-2 in 2012).

The CM/GC partnership, or team, is comprised of the owner, the CM (contractor), the DP, the sub-DPs, the subcontractors and any other party that would be beneficial to include. The CM is best retained at the same time as the DP, very early in the process. Assuring transparency throughout the process is the most important priority for the owner. To that end the committee that chooses the DP and the CM should include a design consultant and a contractor—either

active or retired. Fortunately, CM/GC facilitates openness and trust, providing real-time costs, schedule and constructability input.

During preconstruction, the CM acts as an advisor to the DP, providing professional services to the owner. Plans reviews and constructability reviews are the two most discussed of these services, but the two most important benefits of CM/GC are made possible by the early involvement of the CM: innovation and the flexibility to allocate and re-allocate risk throughout the design phase and even until relatively late in the construction phase. These two benefits are not unrelated. When UDOT took on an inordinate and unbalanced share of the risk on the MVC project, it not only brought the contractor's prices down by millions of dollars as a natural reaction to suddenly not having to add contingency to the contract price, but it also freed the contractor to implement several innovative construction methods which eliminated some work and lowered the cost to perform other work, saving additional millions of dollars (see MVC Case Study).

It is very important for those considering implementing CM/GC to consider the cultural shift that has to take place if one (agency or individual) has never worked on a CM/GC project before. The importance of this is most manifested in the importance of choosing the right people to lead the GM/GC team, as well as who makes up the team. The agency can pretty well assemble its own partnering team, and it needs to take maximum advantage of that opportunity. A fundamental question to ask when evaluating potential team members is: Will this individual advance the CM/GC process or impede its application? If there is any doubt that the individual will advance the process, that person should be eliminated from consideration as a team member. However, nothing should be done in secret. The most important characteristic of putting the CM/GC team together is transparency. Transparency in the placing of in-house personnel on the team, transparency in hiring new personnel, transparency in procuring the CM, the DP, the specialty DPs, the CEI consultant, and all other team members.

To help assure success, the owner should spend great volumes of time, resources, and effort early in the process, planning in detail the entire CM/GC operation/project for its entire service life; and one of the initial actions for the agency, even before selecting outside team members, is to reach out to the community and all stakeholders and begin the process of educating them. Very few areas of the country know enough about the CM/GC culture or process for the agency to skip the vital step of an aggressive public relations and education effort, and the effort must contain a message that is consistent, no matter who is sharing or receiving the message.

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Glossary

Agency: any transportation-based entity that works within the federal or local governments in the design, construction, and maintenance of road and highway projects, such as state Departments of Transportation.

Alliancing: a collaborative working arrangement between the owner and one or more service providers (designer, constructor, supplier, etc.) whereby a new organization is formed for the duration of the project with personnel seconded from each participating company or organization based on the best person for the role. The alliance is governed by an Alliance Board comprising equal representation from each participating organization.

Alternative Technical Concepts (ATC): the innovative and cost effective solutions proposed by contractors that potentially exceed the criteria stipulated in RFP.

Biddability: the status of a set of design documents as it relates to whether a contractor can submit a competitive bid based on what is shown in those documents. If a set of documents are biddable, a competent contractor should be able to generate an accurate and competitive bid for the project, based on the contents of the documents.

Blind Bid Openings (BBO): as used by UDOT, the CM (contractor) generates a "bid," at designated milestones throughout the life of the project, estimating the eventual cost of the project. These figures are compared with an engineer's estimate and an ICE. This process helps keep project costs within acceptable limits.

Buy-In: support and agreement by members of a group for proposed solutions.

Construction Engineering Inspection (CEI): the services provided by certified engineers that include contract administration, inspection, and materials sampling and testing for the construction projects.

Cost Growth: the actual cost of construction becomes higher than estimated or the original contract amount.

Cost-Reimbursable: when a project award is of this type, the sponsor reimburses the grantee only as allowable costs are incurred by the contractor. Documentation of expenses subject to audit, then, is necessary on cost-reimbursable grants. The unspent sponsor funding authorization remaining after the closing date of the project reverts to the sponsor. The contractor is typically reimbursed for cost incurred, plus a fee, either a set amount, or a percentage of the cost incurred. In the unusual instance that a sponsor advances payment to the contractor, a refund of the unspent advance must be issued to the owner.

Decision Analysis by Ranking Techniques (DART): A process for which the primary purpose is containing project costs and the design budget. The software determines change costs in terms

of design, construction schedule and construction. The program tells the decision makers if the investigated change saves money, or if it will cost more than the intended benefit.

Design-Builder: The contractual entity that enters in a design-build contract with the agency for the delivery of the project.

Design Package: A set of documents published by the STA that contains the Public Advertisement (Notice to Bidders), the RFP, General Requirements, Design Scope of Work, Technical Specifications, Price Proposal Documents including the Bid Schedule, and any forms, drawings and other supporting documents necessary to guide the proposers in preparation and submittal of a proposal for a design-build project.

Disadvantaged Business Enterprise (DBE): is a legislatively mandated USDOT program that applies to Federal-aid highway dollars expended on federally assisted contracts issued by USDOT recipients such as State Transportation Agencies (STAs). The U.S. Congress established the DBE program in 1982 to:

- Ensure nondiscrimination in the award and administration of DOT-assisted contracts;
- Help remove barriers to the participation of DBEs in DOT-assisted contracts, and
- Assist the development of firms that can compete successfully in the marketplace outside of the DBE program.

Every Day Counts (EDC): an initiative that is designed to identify and deploy innovation aimed at reducing time it takes to deliver highway projects, enhance safety, and protect the environment. EDC-2 and EDC-3 have followed.

Fast-track: the starting or implementation of a project by overlapping activities, commonly entailing the overlapping of design and construction activities.

Independent Cost Estimate (ICE): refers to the process in which a third party is hired to conduct a detailed estimate of the cost of a proposed construction project. An ICE can provide a more objective view of the cost and is used mainly for the purpose of transparency.

Innovative Contracting Practices: non-traditional contracting methods that are competitive in nature but do not fully comply with the requirements in Title 23 United State Code.

Integrated Team Approach: the professional management of a project during planning, design, and construction that involves the combined efforts of multi- and interdisciplinary teams working together from the conceptual onset to the final completion.

Lump Sum: a bidding system for construction work under which the contractor is required to perform a take-off on the contract plans in order to develop project quantities. The contractor then submits a lump sum bid for the entire contract.

Over-the-shoulder Review: an informal review of the design usually conducted by the contractor literally looking "over the shoulder" of the DP while the DP is in the process of designing the project. The concept is extended to include non-literal settings where the contractor is very closely involved in the design, to the point that the contractor can raise questions and make design changes as the design progresses instead of only at designated times.

Partnering: a process used on many large transportation construction projects around the nation that molds groups of unorganized, sometimes uninterested, individuals into organized, interested teams whose members all share a common purpose—the successful completion of the construction project. To accomplish this requires developing a team concept in the minds and actions of personnel from the owner, the contractor and all other project stakeholders. Among the many outcomes of successful partnering is the ability of personnel at the project level to make important, binding decisions on issues that develop in the course of the project.

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Pay Item: material components used in the construction of a transportation job for which a contractor is seeking payment.

Phased Package: tasks and activities, usually related in some way, that occur within the same phase in the design or construction process.

Phasing Plan: the organization of individual phases/segments of a construction project. Especially important in a delivery system that allows the contractor to begin work before the completion of the project design. The best phasing plans are those that take advantage of areas with quick ROW acquisition, where permits have been acquired and utility problems are absent to allow the contractor to begin construction at the earliest possible time.

Preconstruction: the phase of a transportation construction project that precedes the construction phase and can include conception, planning, design, reviews, and ROW acquisition.

Procurement: a process for acquiring professional and construction services for a construction project. Includes establishing contractual relationships to accomplish project objectives and the assembly, tendering and award of contracts or commitment documents.

Project Delivery Method/Project Delivery System: the system used to procure those parties, materials, lands, and means necessary to execute the completion of a construction project. Includes the overall processes by which a project is designed, constructed, and, under some systems, maintained.

Project Delivery Toolbox: The list of delivery systems available to decision makers in transportation agencies to acquire a completed constructed facility.

Qualifications-Based Selection (QBS): the procurement process established under the Brooks Act for public agencies to use when selecting architectural and engineering services for public construction projects. It involves the submission of a consulting firm's qualifications to the owner/agent who then evaluates the submissions and selects the most qualified firm. Project scope, schedule, budget, and fees are negotiated after the fact.

Real-time Pricing: material, labor, or equipment prices as influenced by immediate responses to the outside stimulus of actual costs and prices on the open market at any point in time.

Scope Creep: ongoing requirements increase without corresponding adjustment of approved cost and schedule allowances. As some projects progress, especially through the definition and development phases, requirements tend to change incrementally, causing the project manager to add to the project's mission or objectives without getting a corresponding increase in the time and budget allowances.

Self-perform: self-performing general contractors use their own labor force to accomplish a portion of a construction project, particularly critical path components.

Shortlisting: a list of preferable candidates that have been selected for final consideration, when making the award of a project.

Stakeholder: anyone who has a vested interest in the project.

Time Growth: an increase in the projected time scheduled to complete a project.

Unit Price: a construction contract in which payment is based on the work done and an agreed on unit price. The unit price contract is usually used only where quantities can be accurately measured in advance.

Work Package: a group of related tasks that are defined at the same level within a work breakdown structure; or a group of tasks or work items assigned or contracted to a single entity.

The authors thank the following sources for their help with the definitions and descriptions: Dictionary of Construction; Energy Facility Contractors Group; Federal Highway Administration; Florida Department of Transportation; Florida Educational Facilities Planners' Association, Inc.; Dictionary.Com; Max Wideman's Project Management Glossary; McCarthy; The Project Management Hut; and Project Time & Cost.

Abbreviations and Acronyms

AGC	Associated General Contractors
AIA-MBA	American Institute of Architects Master Builders' Association
ARTBA	American Road and Transportation Builders Association
ATC	Alternative Technical Concepts
BBO	Blind Bid Openings
BDU	Bridge Delivery Unit
CDS	Changing Delivery Strategy
CEI	Construction Engineering Inspection
CM/GC	Construction Manager/General Contractor
CM	Construction Manager
CMAA	Construction Management Association of America
CMR	Construction-Manager-at-Risk
CPM	Critical Path Method
DART	Decision Analysis by Ranking Techniques
D-B	Design-Build
DBB	Design-Bid-Build
DBE	Disadvantaged Business Enterprise
DM	Design Manager/Management
DMPF	Design Management Process Framework
DOT	Department of Transportation
DP	Design Professional
EDC	Every Day Counts
EDC-1	Every Day Counts 1
EDC-2	Every Day Counts 2
EOR	Engineer of Record
FFGA	Full Funding Grant Agreement
FHWA	Federal Highway Administration
GC	General Contractor
GMP	Guaranteed Maximum Price
ICE	Independent Cost Estimate
MDE	Maryland Department of the Environment
MnDOT	Minnesota Department of Transportation
MVC	Mountain View Corridor
NCDOT	North Carolina Department of Transportation
NCHRP	National Cooperative Highway Research Program
NEPA	National Environmental Protection Act
NTP	Notice to Proceed
OBDP	Oregon Bridge Delivery Partners

ODOT	Oregon Department of Transportation
OHD	Office of Highway Development
OTIA	Oregon Transportation Investment Act
PL	Project Leader
PM	Project Manager
PS&E	Plans Specifications and Estimate
QA	Quality Assurance
QBS	Qualifications-Based Selection
QC	Quality Control
QMP	Quality Management Plan
QO	Quality Oversight
RFC	Ready for Construction
RFI	Request for Information
RFP	Request for Proposal
RFQ	Request for Qualifications
ROD	Record of Decision
ROW	Right-of-Way
RRR	Resurface, Restoration and Rehabilitation; or Repair, Renovation and Restoration
SEP-14	Special Experimental Projects Program 14
SHA	State Highway Administration
SOP	Standard Operating Procedures
SOQ	Statement of Qualifications
STA	State Transportation Agency
STAT	Strategic Technical Advisory Team
TEA-21	Transportation Equity Act for the 21st Century (Public Law 108-178)
UDOT	Utah Department of Transportation
UTA	Utah Transit Authority
VE	Value Engineering
WSDOT	Washington Department of Transportation

APPENDIX A

Design-Build Full Case Studies

Contents

Case Study—Project: I-15 CORE

1. Background: Interstate 15 Reconstruction

Interstate 15 (I-15) is one of the major highways in Utah and it is the most important north-south corridor in the state. Completed in 1974 (section from St. George to Brigham City), I-15 runs through the central and southwestern parts of the state and serves several major metropolitan areas, such as Salt Lake City, Provo, and Ogden (Figure 1).

In the 1990s, I-15 grew outdated and inadequate due to increases in population and traffic. In fact, the Interstate was designed to handle a traffic capacity that was half the traffic capacity recorded in 1997 (FHWA 2006). Therefore, the Utah State Legislature authorized a $1.6 billion project to reconstruct 16 miles of I-15 in Salt Lake County (Figure 2). The Utah Department of Transportation (UDOT) adopted, for the first time, design-build (D-B) to deliver this mega-project on time for the 2002 Winter Olympics. The I-15 reconstruction project lasted four years (1997–2001) and significantly improved I-15 traffic capacity. Some items included in the scope of work were as follows (FHWA n.d., 2006; UDOT n.d.):

- Reconstruction of 16.2 miles of Interstate
- Addition of three lanes in both directions—two high occupancy vehicle (HOV) lanes and one auxiliary lane
- Replacement of 142 bridges
- Reconstruction of eight urban interchanges
- Reconstruction of three freeway-to-freeway connections

1.1 The Utah County I-15 Corridor Expansion

After reconstructing I-15 in Salt Lake County, it was necessary to continue the reconstruction in Utah County (Figure 2). In 2004, UDOT initiated the process to expand I-15 in Utah County (UDOT n.d.) (Figure 3). As a first step, UDOT and the Federal Highway Administration (FHWA) began the environmental impact statement (EIS) procedure to analyze the possibility of improving I-15 in Utah County. In March 2008, the Utah State Legislature authorized the use of state funds for the project and directed UDOT to complete the project scope and to assemble a team in charge of managing the project. In June 2008, the project officially was named Utah County I-15 Corridor Expansion (I-15 CORE), and the project team was assembled. The environmental NEPA process was initiated in 2004 and completed in August 2008 when FHWA signed the Record of Decision. Given the consequences of the 2008 financial crisis on the U.S. economy, the Utah State Legislature reconsidered the funds allocated for the project. After recognizing the importance of the project for the state economy, the Legislature decided to move forward with the project but cut almost $1 billion from the budget. The budget went from $2.63 billion to $1.725 billion. The legislature also established that UDOT, within the given

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Figure 1. Map of Interstate 15.

Figure 2. Map of Salt Lake County and Utah County.

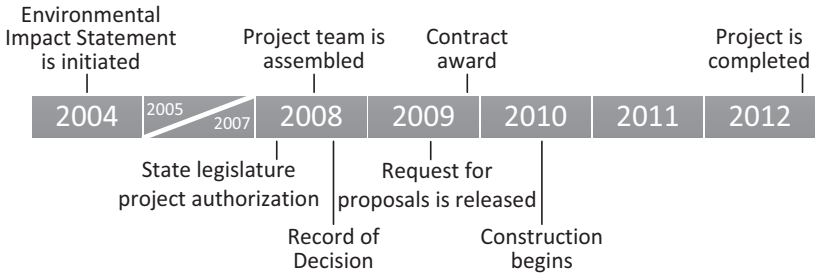

Figure 3. Utah County I-15 Corridor Expansion timeline (UDOT n.d.).

budget, had to reconstruct I-15 at least from American Fork Main Street to Provo Center Street (Figure 2). UDOT had to also deliver the project within a reasonable amount of time.

In June 2009, UDOT issued the request for proposals detailing the following project goals (UDOT 2009a):

- Deliver I-15 CORE within the budget.
- Provide the highest value for the budget.
- Minimize inconveniences for the public.
- Complete I-15 CORE by 2014.
- Uphold the public trust.

Given the project goals, UDOT selected D-B as the project delivery method and fixed price/best design as the procurement approach. Under this procurement approach, UDOT established the contract value and challenged the proposers to provide a design that gave the highest value for the budget while meeting the schedule deadline and minimizing inconveniences for the public (Figure 4).

Among the three selected design-builders to bid on the project, Provo River Constructors (PRC) was awarded the contract in December 2009. The fixed price/best design procurement approach was extremely successful for UDOT. In fact, PRC proposed to reconstruct 24 miles of the corridor (from Lehi Main Street to Spanish Fork Main Street; Figure 5), whereas the agency was expecting to obtain only the reconstruction of roughly 15 miles (from American Fork Main Street to Provo Center Street) (UDOT n.d.). The design-builder proposed to complete the

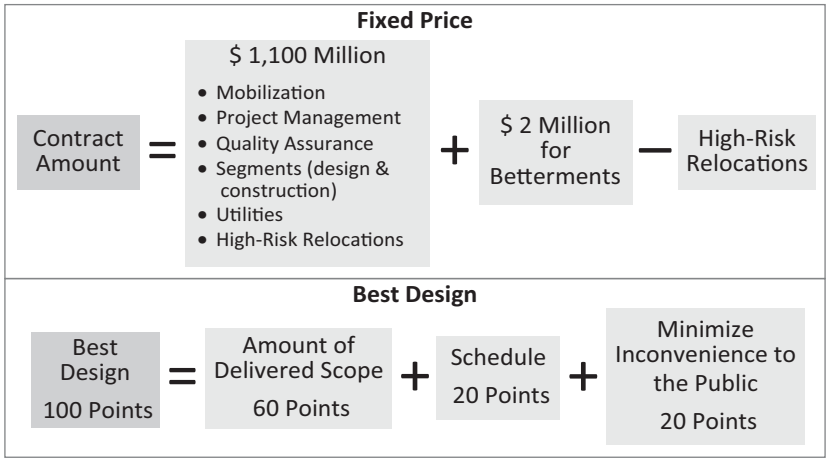

Figure 4. I-15 CORE fixed price/best design procurement approach.

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Figure 5. I-15 CORE map (Credit: UDOT).

project by December 2012, 2 years in advance of the required completion. Some of the project accomplishments were as follows (UDOT n.d., 2012):

- Expansion of I-15 by two lanes in each direction from Lehi Main Street to US 6 and by one lane from US 6 to Spanish Fork Main Street
- Replacement of the original asphalt pavement with concrete pavement with 40-year design life
- Reconstruction and reconfiguration of ten freeway interchanges, among which were a continuous flow intersection and two diverging diamond interchanges
- Reconstruction or replacement of 63 bridges
- Installation of several advanced traffic management system devices such as sensors, cameras, ramp meters, and permanent variable message signs.

2. Project Partners

2.1 UDOT

In accordance with the legislation, UDOT assembled a team in charge of delivering the project. The team leaders were selected among UDOT employees. Several consultants also were hired. In particular, HNTB (Kansas City, MO) was in charge of providing project management consulting services, such as the following (HNTB 2011):

- Human resources
- Procurement

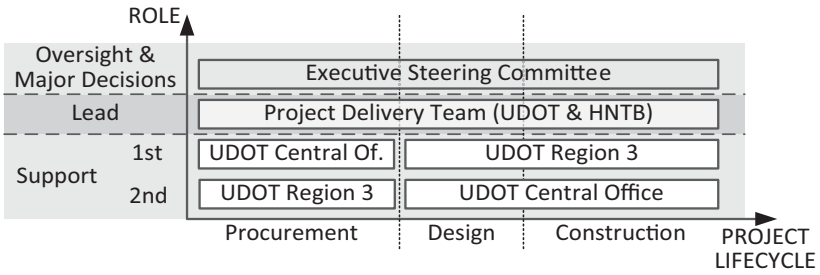

Figure 6. Role of UDOT and its consultant over project lifecycle.

- Risk analysis and Monte Carlo assessment
- Preliminary design
- Utility investigation and master utility agreements
- Third party agreements
- Design and construction oversight and auditing
- Funding scenarios
- Project controls/systems
- Baseline survey control
- Project management
- Right-of-way acquisition
- Contract administration
- Communication and public involvement
- Safety and quality oversight.

According to the agency's procedures, an executive steering committee also was appointed. The committee took the major decisions about the project, such as the project procurement characteristics, and oversaw the project delivery team. The committee included UDOT Executive Director, Deputy Executive Director, Region 3 Director, Operations, and Project Development Director. Furthermore, the project delivery team was supported by the agency's central office and Region 3 office staff (Figure 6).

2.2 Provo River Constructors

PRC was a joint venture headed by Flour Corporation (Irving, TX) that included Ames Construction (Burnsville, MN), Ralph L. Wadsworth Construction Company (Draper, UT), and Wadsworth Brothers Construction (Draper, UT). The design was contracted out to several consultants. The main design consultants were Fluor/HDR Global Design Consultants, which led the design; Michael Baker Corporation (Coraopolis, PA); Jacobs Engineering Group (Pasadena, CA); and Kleinfelder West (San Diego, CA). A complete list of PRC members and consultants is presented in Table 1.

Table 1. Provo River Constructors members and consultants (UDOT n.d.).

Joint Venture Members	Consultants	
• Fluor Corporation. • Ames Construction Company, Inc. • Ralph L. Wadsworth Construction Company, Inc. • Wadsworth Brothers Construction Company, Inc.	• Fluor/HDR Global Design Consultants, LLC • Michael Baker Jr., Inc. • Jacobs Engineering Group, Inc. • H.W. Lochner, Inc. • Kleinfelder West, Inc. • Intermountain GeoEnvironmental Services, Inc. • CRS Consulting Engineers, Inc.	• Raba-Kistner Consultants, Inc. • TransCore IP, Ltd. • Stillwell & Associates, PLLC • Applied Research Associates, Inc. • Fehr & Peers Transportation Consultants • Psomas • CME Transportation Group

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3. Project Design Management

The following sections describe how the agency and design-builder have organized and conducted design management functions. The first section describes the partnering effort between UDOT and PRC that was enacted to facilitate collaboration among parties. Later, the formal processes associated with design management are explained. Next, additional forms of communication and coordination are discussed, which were adopted in support of design management functions (beyond the formal submittal and review process). Finally, a brief overview of pre-award and post-award value engineering procedures is included.

3.1 Collaborative Partnering

UDOT implemented two main strategies to foster a successful project completion, to allow effective collaboration and communication among project participants, and to minimize and solve problems and disputes. First, UDOT and the design-builder's staff co-located. Second, UDOT required a formal partnering process involving all project stakeholders.

> The Department and the Design-Builder, its Subcontractors, and other stakeholders, where appropriate, agree to utilize a formal partnering process on the Project. The partnering relationship will be structured to draw on the strengths of each organization to identify and achieve reciprocal goals. The objectives include effective and efficient Project performance and completion on schedule, within budget, and in accordance with the Contract Documents (UDOT 2009b).

The contract stated also that the agency and the design-builder had to organize a partnering development seminar/team building workshop to initiate the partnering process and to develop and sign a project partnership charter (UDOT 2009b). The mandatory attendees for the seminar/team were the agency's management staff, the design-builder's key personnel, field supervision personnel, and the key management personnel of major consultants and subcontractors. The contract mandated that periodical follow-up seminars/workshops were to be held during the project. The cost associated with partnering efforts agreed upon by both the agency and the design-builder did not affect the contract amount and was equally shared between the two parties.

3.2 Formal Design Management Processes

To ensure design package quality and compliance with the contractual document requirements, the agency focused its attention on the development and implementation of the design-builder's quality program. In fact, UDOT streamlined the review of design packages by limiting the amount of design submittals being reviewed, detailed numerous requirements for the development of the quality management plan, performed quality oversight, and participated in the design-builder design reviews.

3.2.1 Quality Management Plan

UDOT required the design-builder to collect all quality program procedures in a quality management plan (QMP). The agency detailed several requirements to obtain an effective QMP (Table 2).

Furthermore, UDOT required the design-builder to submit the QMP for approval in two stages—Stage 1 for all non-construction-related activities and Stage 2 for all construction-related activities (Figure 7). The contract also stated that:

- The design-builder's senior management had to approve and endorse the QMP.
- QMP revisions and changes (e.g., staffing levels, key personnel) proposed by the design-builder had to be approved by the agency.
- QMP revisions and changes proposed by the agency had to be addressed by the design-builder within ten working days.
- The design-builder had to formally review and assess the effectiveness of the QMP at least quarterly.

Table 2. QMP contractual requirements (UDOT 2009c).

Section	Requirement
General	The QMP shall delineate how the Design-Builder will ensure that all disciplines, aspects, and elements of the Work will comply with the requirements of the Contract Documents (p. 1-2)
Documentation	The QMP shall describe the routing, filing, control, naming convention, and retrieval methods for all documents. […] The QMP shall describe the methods by which all Project documents issued and received by the Design-Builder shall contain the following: 1. A unique serialization. 2. Date issued or received. 3. Project name and number. 4. Specific subject or content of the correspondence. 5. Name of sender and recipient. 6. Reference information to which the correspondence relates, such as prior correspondence (p.1-2)
Responsibility, Authority, and Communication	The QMP shall describe all confirmation resources, such as auditors, reviewers, checkers, inspectors, and testers that the Design-Builder will utilize (p. 1-3)
Planning of Product Realization	The QMP shall document the Inspection and Test Plan, which shall describe all of the proposed inspections and tests to be performed throughout the construction process. The QMP shall include a procedure that standardizes the format and structures of documented processes, such as the Maintenance Work Plan, Environmental Protection Program, Design-Build Aesthetics and Landscaping Concept Design Report, and Geotechnical Instrumentation Plan (pp. 1-5, 1-6)
Design and Development Planning	The QMP shall meet the following requirements: 1. Describe the design (QC) and confirmation (QA) activities separately; 2. Describe how the design team schedules the design efforts, including design reviews; confirmation and checking stages; and issue dates of design submittals; 3. Identify the Control Points at which Work shall be formally accepted by QA personnel prior to proceeding to the next stage of the Work; and, 4. Describe the coordination of the design with construction (pp. 1-7, 1-8)
Design and Development Inputs	The QMP shall describe how all design criteria, Contract Document requirements, and other design inputs are defined, reviewed, and approved (p. 1-8)
Design and Development Outputs	The QMP shall define the design outputs (i.e., the specific plans and specifications) to be produced (p. 1-8)
Design and Development Review	The QMP shall describe the frequency, timing, content, and format of such reviews (p. 1-8)
Design and Development Validation	The QMP shall describe all confirmation, validation, monitoring, inspection, and activities to be carried out for the purposes of demonstrating that the Work is acceptable (p. 1-8)
Control of Design and Development Changes	The QMP shall describe how changes to design inputs are identified, reviewed, and approved by authorized personnel prior to their implementation. The QMP shall describe how changes to design outputs are categorized (i.e., minor versus major) and approved. The QMP shall describe the method of communicating changes or revisions to or from the field (pp. 1-8, 1-9)
Monitoring and Measurement	The QMP shall describe the Design-Builder's approach to ensuring the Department has the opportunity to attend Control Point reviews (*i.e., sampling and testing of construction products*) (p. 1-9)
Control of Nonconforming Product	The QMP shall describe the approach to resolving differences in quality results between QC (*i.e., quality control*), QA (*quality assurance*) and/or QO (*quality oversight*) (p. 1-11)
Analysis of Data	The QMP shall describe the approach to summarizing, analyzing and reporting monthly on the effectiveness and continued improvement of the Quality Program (p. 1-11)

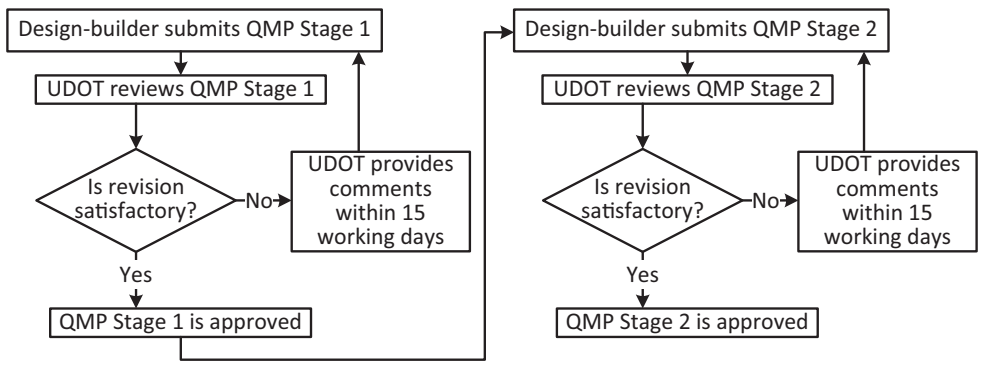


Figure 7. QMP approval and review procedure workflow.

3.2.2 Quality Oversight, Assurance, and Control

The agency performed quality oversight (QO) during the project to ensure design-builder compliance with the QMP and additional contract requirements and identify areas of improvement. In particular, QO staff oversaw the design-builder's activities by performing audits, reviews, interviews, inspections, and tests. Furthermore, the contract described roles and responsibilities of the design-builder's personnel in charge of implementing quality assurance and control procedures (Table 3).

3.2.3 Design Reviews

As shown in Table 2, the design-builder determined design review "frequency, timing, content, and format" (UDOT 2009c p. 1-8). The design-builder performed four reviews for each design package at 30%, 60%, and 90% design complete and release for construction. Although the agency did not review all design packages, the contract required that:

- The agency had to be invited to a minimum of two separate design reviews for each design package.
- The reviews had to occur prior to issuance of release for construction documents.
- At least one review had to be performed prior to 70% design complete.

The contract also stated the following:

> The reviews are not hold points that restrict the progress of design. They are reviews of the design as it progresses, which provide opportunities for the Department to comment on the design. The Design-Builder shall respond to the Department's review comments via the Department's quality database. Review comments will include potential Nonconforming Work and opportunities for improvement (UDOT 2009c p. 1-8).

Furthermore, the design-builder was required to submit four design submittals for each design package—situation layout plans, released for construction documents, final design documents, and as-built documents (Table 4). However, these design submittals did not have to be approved by the agency (Table 5).

3.3 Other Forms of Communication and Coordination

In addition to QO-related activities, the agency and the design-builder could communicate about design matters during the following times:

1. **Informal face-to-face meetings.** UDOT and the design-builder's staff co-located so the design-builder's construction and design personnel could communicate directly with the agency.

Table 3. Quality assurance and quality control staff roles and responsibilities (UDOT 2009c p. 1-3).

Role	Role and Responsibility
QA Manager	1. Have overall responsibility for implementing the requirements of the QMP to assure success of the Quality Program. 2. Have no responsibilities in the production of the Work.
QA Staff	1. Be responsible for quality. 2. Provide a certified testing laboratory located within 20 miles of the Project Site. 3. Have no responsibilities in the production of the Work. 4. Have no reporting responsibilities to production. 5. Have the authority to stop Work. 6. Be responsible for confirming and providing confidence that all Work meets or will meet the Contract requirements. 7. Be co-located at the Project and Segment offices.
QC Staff	1. Be responsible for quality. 2. Only have responsibilities in the production of the Work and shall remain independent of the QA staff. 3. Have the authority to stop Work.

Table 4. Design submittals requirements (UDOT 2009c pp. 3-1, 3-3).

Situation and Layout Plans Provide Situation and Layout plan sheets for all bridges, box culverts, rigid frame drainage structures, retaining walls, and noise walls, in accordance with the Situation and Layout Checklist in Structures Design and Detailing Manual. Assign a structure number to each structure.
Released for Construction Documents Released for Construction Documents shall constitute all documents issued for the purposes of construction. All Released for Construction Documents shall meet the following requirements: • Design all Work, including modifications to the Work, under the direct supervision of a Professional Engineer with a current Utah license • Indicate the timing of submission of these documents in the Project Schedules. • Prepare plans similar in appearance to the UDOT Plan Sheet (Development) Standards and Structures Design and Detailing Manual. Prepare specifications in accordance with the UDOT Specification Writer's Guide. Variations are anticipated as a result of Design-Build delivery. Meet with the Department to obtain Approval of any variations in plan content and format.
Final Design Documents Final Design Documents shall meet the requirements of the Released for Construction Documents and the following additional requirements: • Shall be fully completed Released for Construction Documents, except for necessary field design changes, for a geographic area organized by discipline. • Include design information from the most current version of Released for Construction Documents and all design back-up information, including design plans, shop drawings, calculations, reports, specifications, and electronic MicroStation data. • […]
As-Built Documents As-Built Documents shall meet the requirements of the Final Design Documents and reflect the actual condition of the final constructed Work.

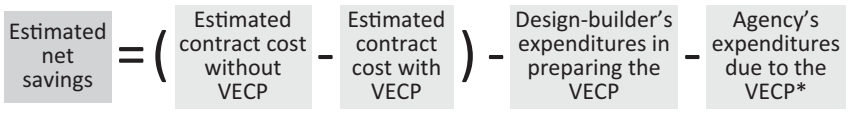
2. **Electronic communications and phone calls.** The contract required the design-builder to utilize a web application platform to manage all electronic documentation (UDOT 2009c). UDOT and design-builder's staff could communicate directly through phone calls and e-mails.
3. **Formal meetings.** Per contractual agreement, the design-builder had to "plan for weekly and monthly meetings with the Department to discuss Project progress, issues, and all planned Work" (UDOT 2009c p. 2-17). Two types of meetings were organized to communicate specifically on design matters—technical work group (TWG) meetings and area meetings. TWG meetings were held weekly and focused on a specific discipline (e.g., design, utility, right-of-way). Given that the project involved the reconstruction of 24 miles, the design-builder also held area meetings to discuss issues pertaining to different geographical locations. Generally, the design-builder led TWG and area meetings and invited the agency to attend them. Furthermore, formal issue resolution meetings could be held to discuss and solve problems and disputes.

3.4 Value Engineering

To allow and foster the proposal of original technical solutions during the pre- and post-award phases, UDOT established value engineering procedures. In particular, ATC were allowed

Table 5. Submittal table (UDOT 2009c p. 3-5).

Submittal	For Approval	Schedule
Bridge situation and layout plans along with bridge foundation and hydraulic design recommendations	No	Prior to submission of released for construction documents
Released for construction documents	No	Prior to construction contemplated in the construction documents
Final design documents	No	At completion of all design development
As-built documents	No	Prior to final acceptance



*including costs relating to any Relocations and ROW and implementation costs

Figure 8. Estimated net saving equation.

in the pre-award phase, while value engineering change proposals (VECP) were allowed in the post-award phase.

3.4.1 Pre-Award Value Engineering: Alternative Technical Concepts

In the request for proposals, UDOT defined ATCs as alternatives that are "equal or better in quality or effect" (UDOT 2009a p. 9). Furthermore, the agency stated that "a concept is not an ATC if, in the Department's sole judgment, it merely results in reduced quantities, performance or reliability" (UDOT 2009a p. 9). Proposed ATCs were discussed during one-on-one meetings, and the agency determined to provide one of the following judgments to a proposed ATC:

1. The ATC is approved for inclusion in the Proposal.
2. The ATC is not approved for inclusion in the Proposal.
3. The ATC is not approved in its present form, but may be approved upon the satisfaction, in the Department's sole discretion, of certain identified conditions which must be met or clarifications or modifications that must be made.
4. The submittal does not qualify as an ATC but may be included in Proposer's Proposal because it appears to be within the requirements of the RFP (UDOT 2009a p. 11).

Furthermore, the agency could approve ATCs that required additional permits, properties, or utility work. Nevertheless, the design-builder retained full responsibility for obtaining and paying for the additional permits, properties, or utility work.

Although ATCs were confidential until contract award, the agency stated the following:

> If the Department determines, based on a proposed ATC or otherwise, that the RFP contains an error, ambiguity, or mistake, the Department reserves the right to modify the RFP to correct the error, ambiguity, or mistake, regardless of any impact on a proposed ATC (UDOT 2009a p. 11).

3.4.2 Post-Award Value Engineering: Value Engineering Change Proposals

UDOT also encouraged the design-builder to submit VECPs by awarding 50% of the estimated net savings (Figure 8).

4. Interdependencies Between Design and Other Activities

4.1 Environmental Permits

UDOT was responsible for completing the NEPA documentation and obtaining the major environmental permits, such as the Record of Decision from the FHWA and the permit for Section 404 of the Clean Water Act that regulates impact on wetlands from the U.S. Army Corps of Engineers. The design-builder was responsible for obtaining the remaining environmental permits, such as the Utah Pollutant Discharge Elimination System (UPDES) general permit for construction activities, the stream alteration permits, and any permit modifications.

4.2 Other Permits

The design-builder was responsible for obtaining all construction-related permits, such as permits for construction, maintenance, and removal of temporary roadways and any permits from railroad companies for conduit crossings.

4.3 Right-of-Way (ROW)

UDOT was responsible for procuring the necessary properties. To allow the proposers to design the facility and develop the project schedule effectively, the agency detailed the properties it was going to acquire based on the existing preliminary design and provided a property acquisition schedule during the procurement phase. Moreover, UDOT allowed the proposers to identify additional properties through the ATC process. Nevertheless, UDOT did not retain any risk associated with the acquisition of these additional properties. "In the event that implementation of an ATC will require additional real property or Utility Work, the Design-Builder shall have full responsibility for paying for any such real property and any related costs including any necessary Environmental Approvals, or performing any such Utility Work without the right to a Change Order" (UDOT 2009a p. 9)

4.4 Utility Relocation

The agency signed a master utility agreement with all utility owners affected by the project. This effort began prior to contract award and was concluded after contract award. The design-builder was responsible to develop the supplemental utility agreements. Therefore, the design-builder had to coordinate all design and construction activities with utility owners.

4.5 Public Involvement

The public involvement efforts were led by the agency with the design-builder in a support role. Division of responsibilities for public involvement activities is described in Table 6.

Table 6. Public involvement responsibilities (adapted from UDOT 2009d).

Agency	Design-Builder	Shared
• Oversight • Status, schedule updates to public • Communication with public and media communications • Communications strategy • Crisis communications execution • Public involvement plan development • Research/surveys • Messaging • Branding • Web site • Hotline, email • Prepare monthly status reports	• Provide information • Provide emergency response contact list • Maintain constituent issues and complaints log • Respond to constituent issues and complaints • Review monthly status report with PI team	• Event participation • Crisis communication plan

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Case Study—Project: Elk Creek—Hardscrabble Creek—Bundle 401

1. Background

1.1 The Oregon Transportation Investment Acts

At the end of the twentieth century, Oregon faced a lack of funds to properly maintain and improve the state's highway infrastructure. The State of Oregon issued various bills to constitute sections of the Oregon Transportation Investment Act (OTIA), which provided the Oregon Department of Transportation (ODOT) with almost $3 billion to improve state, county, and city roads and bridges. In particular, four house bills were approved by the Oregon State Legislature. In 2001, the Legislature passed OTIA I (House Bill 2142), which authorized the issuance of up to $400 million in highway user tax bonds to improve lane capacity and interchanges, maintain road pavement, and repair and replace bridges (ODOT, n.d.-a) (Table 7). In 2002, the Legislature passed OTIA II (House Bill 4010), which amended the previous bill. To take advantage of favorable bond rates, OTIA II extended the issuance of bonds from $400 million to $500 million. Under OTIA I & II, ODOT completed the following (ODOT n.d.-a):

1. More than 50 projects to improve lane capacity and interchanges.
2. More than 40 projects to maintain state highway and local road pavement.
3. More than 50 projects to repair or replace state and local bridges.

In 2003, the Legislature passed OTIA III (House Bill 2041), which provided ODOT with more than $2.4 billion (Table 7) and doubled ODOT's annual construction program (ODOT, n.d.-b). The main focus of OTIA III was to repair or replace hundreds of concrete bridges that were reaching the end of their design lives. In particular, ODOT allocated $300 million to repair or replace about 140 bridges on county and city highways and created a $1.3 billion program called OTIA III State Bridge Delivery Program to repair or replace 365 aging bridges on state highways across the state. In 2005, the Legislature passed House Bill 3415, which authorized ODOT to re-allocate unspent funds from their OTIA III State Bridge Delivery Program to other needed projects, including highway and freight projects.

Given the magnitude of the OTIA III State Bridge Delivery Program, ODOT would have had to hire almost 600 employees to deliver the program using only in-house personnel (ODOT, n.d.-c). So in 2004, the Legislature passed a budget note[1] (House Bill 5077—Budget Note #2) stating that ODOT was expected to contract with the private sector to manage the overall

[1] In Oregon, "budget notes are highlighted items in the budget denoting areas of special interest for the legislature. They are directive in nature, but do not hold the weight of law and could request reports on issues at periodic intervals." [source: http://www.ode.state.or.us/services/budget/glossary.aspx] "Budget notes are not part of the budget itself and do not affect the numbers. Instead they add information or provide recommendations for future budgets." [source: http://www.ehow.com/info_8340037_budget-notes.html]

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Table 7. OTIA budgets, in millions (ODOT, n.d.-a).

OTIA	Improve Lane Capacity and Interchanges	Maintain Road Pavement	Repair or Replace Bridges	*Total*
I	$200	$70	$130	*$400*
II	$50	$5	$45	*$100*
III	$500	$361	$1,600	*$2,461*

implementation of OTIA III and the OTIA III State Bridge Delivery Program (Oregon State Legislature 2004). The Legislature specified the following:

The Department [i.e., ODOT] and the private sector are directed to develop a strategy to complete the bridge repair and replacement program that maximizes the following:

1. Ease of traffic movement—contracting strategies that keep traffic moving will minimize effects on other industries and the public;
2. Expedient delivery—quick project delivery will allow freedom of freight movement and ensures that products can be delivered throughout the state;
3. Involvement of Oregon construction firms and employees—the use of Oregon firms and employees, emerging small businesses and minorities will result in economic stimulus that will benefit the state overall (Oregon State Legislature 2004).

Based on the Legislature's input, five primary goals for the program were identified (ODOT 2005):

1. Stimulate Oregon's economy.
2. Employ efficient and cost effective delivery practices.
3. Maintain freight mobility and keep traffic moving.
4. Build projects sensitive to their communities and landscape.
5. Capitalize on funding opportunities.

1.2 Oregon 38: Elk Creek—Hardscrabble Creek—Bundle 401

To allow local construction companies with limited bonding possibilities to participate in the OTIA III State Bridge Delivery Program and thus stimulate Oregon's economy, the projects were grouped into bundles of different sizes and bridge types (ODOT 2005). Bundle 401 is the object of this case study (Figure 10). This bundle consisted of five replacement concrete bridges (bridge# 01614, 01601, 01465, 01406, and 01424) on Oregon Route 38 between Elkton and Drain. Oregon Route 38 (Figure 9 and Figure 11), also known as Umpqua Highway No. 45, is a state highway connecting the city of Reedsport on the Pacific Coast with Interstate 5. The total

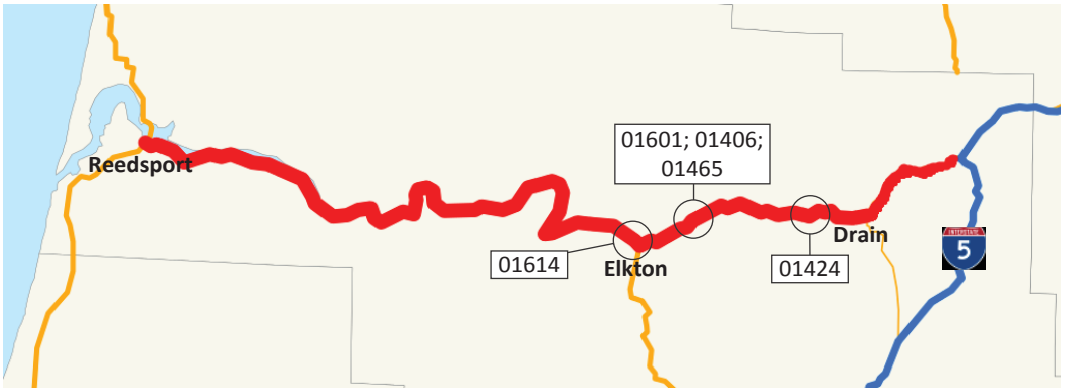

Figure 9. Bundle 01 bridge position on Oregon Route 38 (adapted from image in public domain http://en.wikipedia.org/wiki/File:Oregon_Route_38.svg).

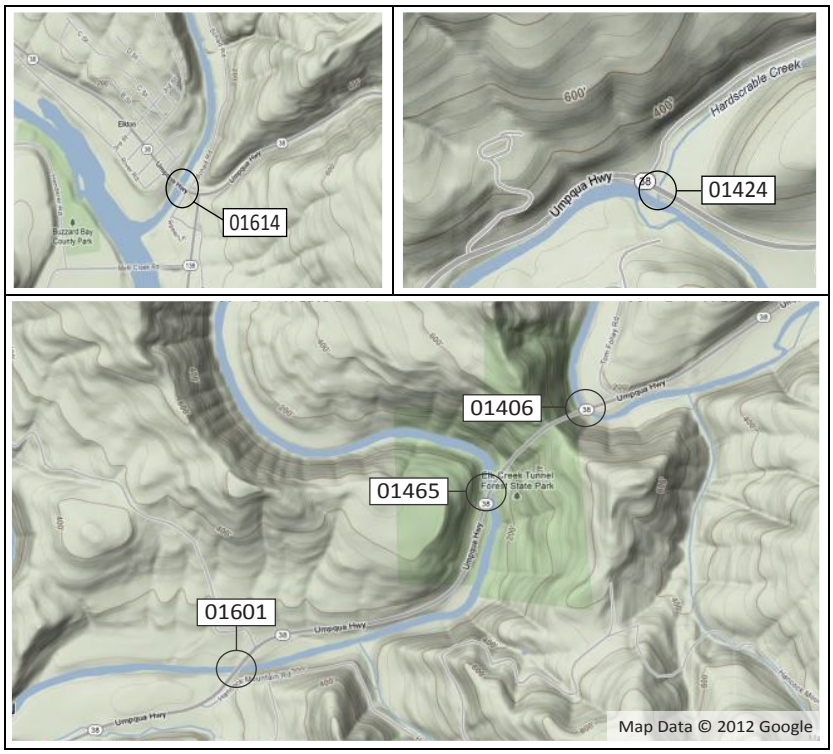

Figure 10. Bundle 401 bridges (Credit: 2012 Google).

bundle cost was $46,390,721 ($45,900,500 of base contract amount and $490,221 of total change order amount). The schedule milestones are presented in Table 8.

2. Project Partners

2.1 Oregon Department of Transportation

To implement OTIA III, ODOT changed substantially its project delivery approach in terms of internal organization and use of in-house vs. external consultant personnel. The major changes are described in the following sections.

Figure 11. Bridge 01601 under construction (Credit: OBDP).

Table 8. Bundle 401 schedule milestones.

Date	Milestone
November 2005	Notice to proceed (NTP) for DB procurement is issued
March 2006	Request for proposal (RFP) is issued
May 2006	Request for qualification (RFQ) is issued
December 2006	NTP for the selected design-builder is issued
February 2008	50% of the bundle is complete
June 2009	Bundle completion

2.1.1 OTIA III Bridge Delivery Unit

ODOT created a new unit, called Bridge Delivery Unit, under the Major Project Branch (Figure 12) with 22 staff members in charge of overseeing the delivery of the OTIA III State Bridge Delivery Program (ODOT n.d.-c). ODOT divides highway operations into five geographical regional offices (i.e., Region Offices in Figure 12). Although these regional offices are in charge of managing the maintenance and construction of highway projects, the Bridge Delivery Unit acted independently of the regional offices in overseeing the bridge construction operations.

Several external consultants also were hired to create the Bridge Standing Implementation Team. The team's objective was to support the Bridge Delivery Unit in implementing the State Bridge Delivery Program. In particular, Parametrix (Auburn, WA) led the effort in collecting environmental data, developing performance standards, establishing the mitigation banking program, training agency staff, and implementing the NEPA approach. David Evans and Associates (Portland, OR) and W&H Pacific (Bend, OR) led the effort in collecting the engineering data (ODOT n.d.-d) (Figure 13).

2.1.2 Oregon Bridge Delivery Partners

ODOT selected Oregon Bridge Delivery Partners (OBDP; Salem, OR), a joint venture of HDR (Omaha, NE) and Fluor (Irving, TX), to manage the OTIA III State Bridge Delivery Program. OBDP has performed a role of owner representative under this outsourcing scheme (Figure 14).

2.1.3 Project Delivery Process

ODOT and OBDP collaborated closely to develop a comprehensive project delivery toolbox that included design-bid-build (DBB), design-build (D-B), and construction-manager-as-general-contractor (CMGC). About D-B projects, ODOT determined the following:

> A contract is executed directly between ODOT and the design-build team. OBDP does not directly participate in the selection process or execute a contract, but the OBDP Design-Build Project Manager supports ODOT during the process and assists in developing procurement documents. Once a Notice to

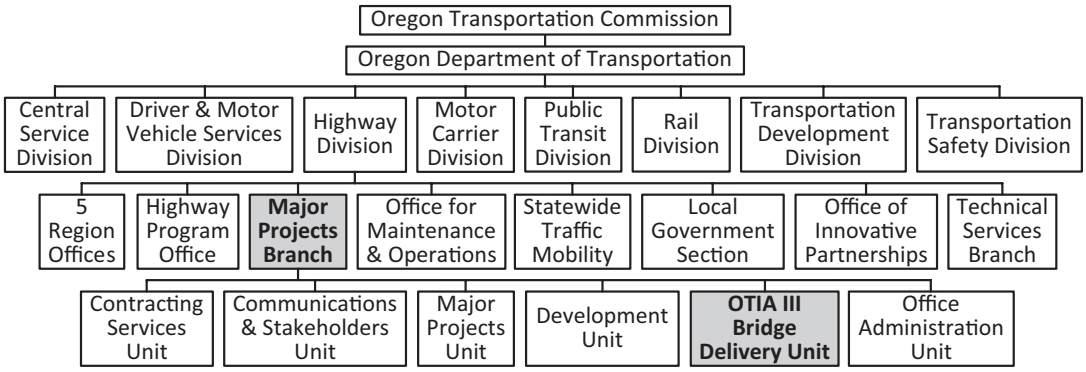

Figure 12. ODOT organizational chart.

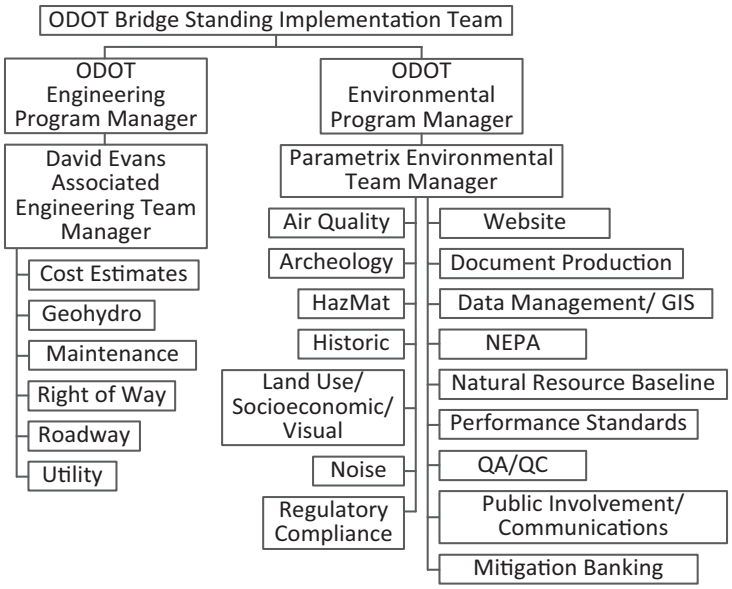

Figure 13. ODOT bridge standing implementation team organizational chart (adapted from ODOT [n.d.-d]).

Proceed is issued to the design-builder, the OBDP Design-Build Construction Coordinator takes over as the project manager, similar to design-bid-build projects, and is closely supported by an OBDP Design Coordinator (ODOT, 2005, p. 32).

Furthermore, ODOT and OBDP developed a series of steps to implement the different delivery methods (OBDP, n.d.; ODOT, 2005). The steps for projects delivered with D-B are presented in Table 9 and Figure 15.

2.2 Slayden Construction Group

Slayden Construction Group (Stayton, OR) was the selected contractor for Bundle 401. As discussed previously, Slayden signed the contract with ODOT, and OBDP acted as owner representative. Slayden contracted out the design and design quality control to T.Y. Lin International

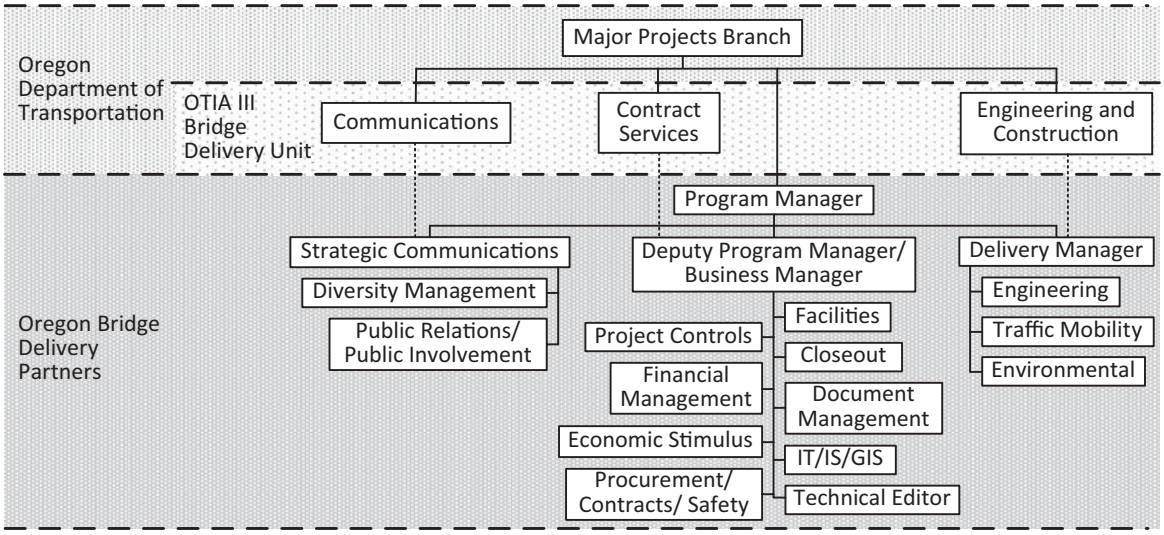

Figure 14. OBDP organizational chart.

Table 9. D-B implementation steps (OBDP, n.d.).

No.	Description
1	*Bundle Development.* Bridges are bundled to optimize the delivery of the bridge program. Out-of-scope work elements and project special needs are also identified and considered. Input is obtained from the region and design technical staff on the scope of work for each bridge. The internal kick-off meeting (the start of the D-B procurement phase) concludes this process.
2	*Data Collection/Concept Design.* Essential project data is collected from available sources including the regions, key stakeholders, and through site visits. A risk assessment meeting is conducted to determine, allocate and mitigate risks between the Design-Builder and ODOT. Conceptual Design is performed to collect data, identify design exceptions and define the limits of the project for conclusion in the Requests for Proposals. Completion of Concept Design deliverables concludes this process.
3	*Request for Qualifications/Draft RFP.* The information required to evaluate and shortlist qualified design-build teams is developed in the Requests for Qualifications. Concurrent with the RFQ, the draft Request for Proposals is developed. This step concludes after the Statement of Qualifications is received and the notification of shortlist is issued.
4	*Request for Proposal.* The performance specifications and all exhibits that will form the contract for the project bundle are developed. This step concludes with issuance of the Request for Proposal (RFP) to the shortlist.
5	*Design-Build Firm Proposal Preparation.* The shortlisted, qualified design-build teams develop their complete offer. This step concludes with submission of their design-build proposals.
6	*Scoring and Selection of Design-Build Team.* A comprehensive evaluation of the technical commercial proposals takes place to score the design-build teams. This step concludes with issuance of notice of competitive range (NOCR).
7	*Contract Negotiations and Award.* A contract is negotiated with the selected design-build team or the alternate, if necessary. This step concludes with issuance of a Notice to Proceed to the design-builder.
8	*Project Kick-Off.* The Project Kick-Off meeting brings together project management, key technical staff associated with the project, the contractors/subcontractors, and key stakeholders to review the schedule and identify potential construction, traffic, and mobility issues. The meeting establishes a team-wide understanding of the planned project staging and sets the ground rules, roles, and expectations for the parties involved. This step concludes with the design mobilization meeting.
9	*Progress 0%-50%.* The design-builder's work progresses to the point where 50% of the total contract budget has been expended. This step concludes when cumulative invoices equal to or exceeding 50% of the design-build contract budget have been verified, submitted and paid.
10	*Progress 50%-100%.* The design-builder's work progresses […] *and* all required work has been successfully completed. […]
11	*Project Closeout.* This step includes final documentation of the contract bid item work and concludes when semi-final project documentation is complete, which is generally within ninety days of the issuance of Second Notice (referred to in the D-B contract as the ''third notification'').

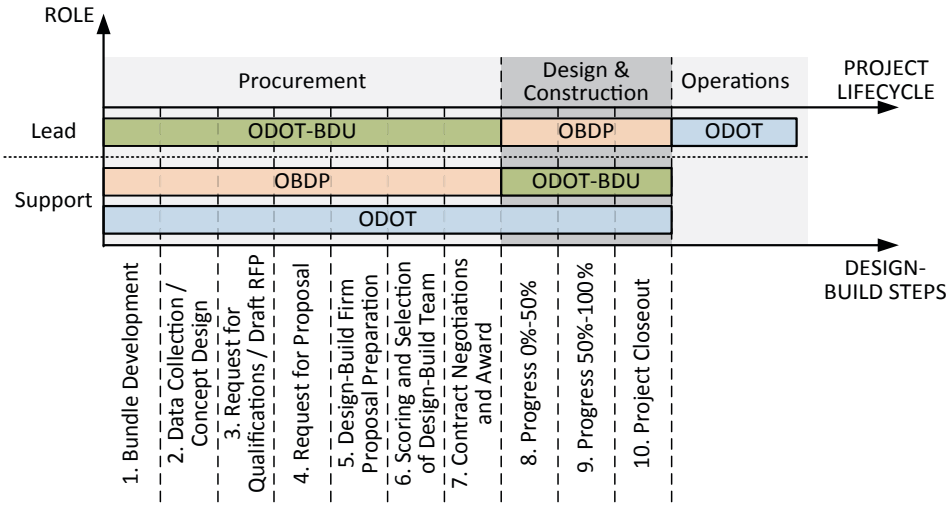

Figure 15. Role of ODOT Bridge Delivery Unit (BDU), OBDP, and ODOT (other units/departments) during D-B steps and project lifecycle (adapted from ODOT 2005).

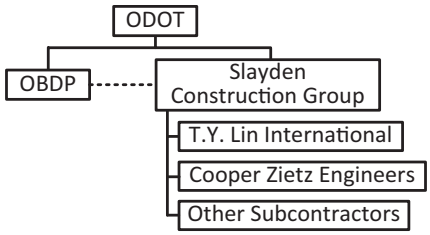

Figure 16. Bundle 401 contractual framework.

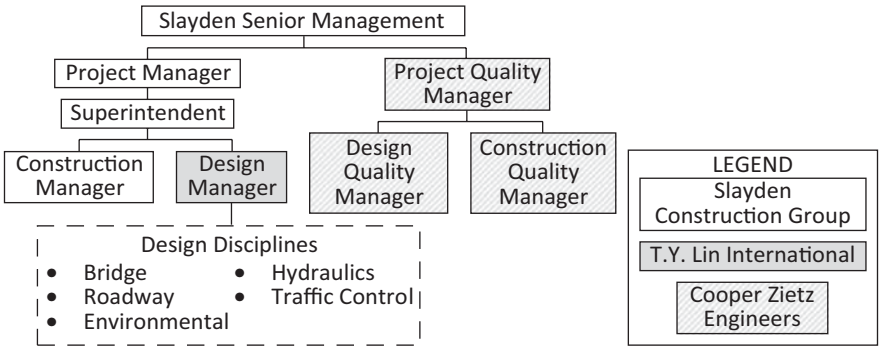

Figure 17. Streamlined design-builder organizational chart.

(San Francisco, CA) and hired Cooper Zietz Engineers (Portland, OR) to perform the quality assurance work. In accordance with contractual requirements (ODOT 2007a), the Project, Design, and Construction Quality Managers were independent of the design-builder's production team, and the Project Quality Manager reported directly to Slayden senior management. Bundle 401 contractual framework and the design-builder organizational chart are shown in Figures 16 and 17, respectively.

3. Project Design Management

The following sections describe how ODOT, OBDP, and the design-builder organized and conducted design management functions on the bundle. The first section describes the partnering effort between ODOT and OBDP and the design-builder. Later, the formal processes associated with design management are described. Next, additional forms of communication and coordination adopted in support of design management functions (beyond the formal submittal and review process) are discussed. Finally, a brief overview of pre-award and post-award value engineering procedures is included.

3.1 Collaborative Partnering

To foster successful bridge replacement program completion, OBDP collaborated closely with all program stakeholders. In the early stages of the bridge replacement program, OBDP held numerous alignment meetings with ODOT Bridge Delivery Unit, ODOT regional office staff members, and all other program stakeholders (e.g., Federal Highway Administration, Dept. of Employment, Dept. of Economic and Community Development). Furthermore, OBDP co-located with ODOT Bridge Delivery Unit during the program. However, ODOT and OBDP could not co-locate with the design-builders because several projects were performed simultaneously. ODOT and OBDP agreed to hold a project kick-off meeting with each design-builder.

This meeting was structured to establish a collaborative partnering work relationship among project participants. The meeting characteristics are presented in Table 9.

3.2 Formal Design Management Processes

3.2.1 Amount of Design Provided in the Request for Proposal

Before issuing the RFP for a bundle, the agency prepared an engineering baseline report for each bridge in the bundle to mitigate major areas of risk, such as environmental permitting, right-of-way (ROW), utility relocation, and railroad interferences. These reports were available to the bidders together with summarized "information about the current bridge structure, conditions at the bridge site, the repair/replacement options evaluated, the feasible alignment option (i.e., the preferred option), construction issues and potential impacts at the site, estimated schedule and budget, and technical reference materials" (ODOT, n.d.-e). The agency also provided supplementary pieces of information in the RFP, such as the available ROW, specifications, geotechnical information, and LADAR data. However, no conceptual design was provided.

3.2.2 Design Milestones

Per contractual agreement (ODOT 2007b), the agency required the design-builder to prepare the following design milestones for each design package (Figure 18).

1. **Concept plans.** These plans include the conceptual plans submitted by the design-builder in the proposal and the results of contractual negotiations.
2. **Definitive design.** Documents at definitive design level include the preliminary design (i.e., TS&L) for each bridge. They may include preliminary foundation, hydraulics, slope stability, site investigation findings, and environmental reports.
3. **Interim design.** Any document between the definitive design level and readiness-for-construction level is considered at interim design level. For these bundles, the design-builder decided to have two interim design milestones at 30% and 60% design complete.
4. **Readiness-for-construction (RFC).** Documents at the RFC level include final plans and specifications, quantity estimates, and final environmental documentation for each bridge in the bundle.
5. **Working plans.** These documents include erection details; plans for shop fabrication, trenching, and shoring; etc. Working Plans may not be necessary for the design packages.
6. **As-constructed (AC).** Documents at the AC level include AC plans and specifications, final design reports and calculations, warranties, and operations and maintenance manuals, procedures, and instructions.

3.2.3 Design Reviews

Per contractual agreement (ODOT 2007b), the agency required the review of each design milestone submittal (except concept plans) according to the following steps:

Step 1. A checker (i.e., a peer of the designer or originator of the document) verifies that plans and specifications are correct and complete.

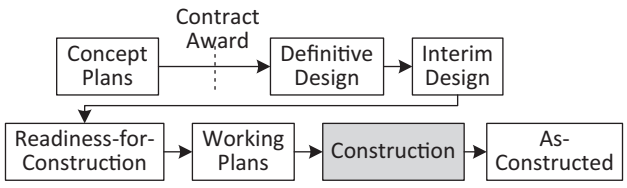

Figure 18. Design milestone development process (adapted from ODOT 2007b).

Step 2. The Design Quality Manager verifies that plans and specifications are correct and complete and certifies that plans and specifications meet the contractual requirements.

Step 3. After receiving the design package and the Design Quality Manager certifications, the agency Project Manager, supported by OBDP staff and other project stakeholders interested in the design package, performs the design package review and consolidates the reviews and comments into the Review Comment Form (Figure 19). Although the agency had 21 business days to transmit the Review Comment Form to the design-builder, the average review duration was ten business days.

Step 4. The design-builder addresses the comments in the Review Comment Form and incorporates them into the design package. If necessary, the design-builders can meet with the agency and OBDP personnel to further discuss and resolve the comments and reviews.

In addition to the design reviews required by the agency, the design-builder construction personnel also performed internal constructability reviews simultaneously to the agency reviews (i.e., step 3).

The agency also required the design-builder to develop a detailed schedule of all design milestone submittals (except concept plans). The agency detailed the major features of the design reviews in the contract (Table 10).

3.3 Other Forms of Communication and Coordination

In addition to participating in the design reviews, the project stakeholders and the design-builder could communicate during the following times:

- Informal meetings and phone calls. The design-builder and its consultants were encouraged to contact the agency and OBDP personnel to informally discuss issues and design approaches.
- Weekly meetings. Interactions between ODOT and OBDP and the design-builder on design matters occurred mostly through weekly meetings that were jointly attended by the design-builder design and construction personnel. These meetings were not required contractually and were organized and led by the design-builder Project Manager. During the meetings,

Bundle No.: 0 **Date:**
All Br/Proj No.: 0
Contract No.: 0 **Discipline:**
Key No.: 0
Doc. Reviewed: 0 **Reviewer:**

Comment Disposition: A = Will Comply; B = Needs Further Investigation; C = Delete Comment; and D = Comment Resolved

		Ref.	General Comments	Init. Disp.	Response	Fin. Disp.	Verified
DEFINITIVE DESIGN	1						
	2						
	…						

		Ref.	Comment on Bridge/Project No. XXX	Init. Disp.	Response	Fin. Disp.	Verified
DEFINITIVE DESIGN	1						
	2						
	…						

Figure 19. Review Comment Form template.

Table 10. Design reviews major features (ODOT 2007b, pp. 155–8,155–9).

Definitive Design Review The Definitive Design Review shall be the first Design Review requiring participation of Agency and is intended to verify that the Contract Baseline Concepts proposed by Design-Builder meet all Contract requirements. The Design Quality Manager shall verify prior to the Definitive Design Review that: • All Contract requirements applicable to the proposed Contract Baseline Concepts, including all applicable Standards and Legal Requirements, have been identified, and the proposed Contract Baseline Concepts are in compliance • The Contract Baseline Concepts are substantiated and justified by adequate site investigation and analysis • Right-of-Way requirements have been identified • The proposed Contract Baseline Concepts are constructible • Required Materials and Equipment are available • The Contract Baseline Concepts meet all quality requirements, and all required design quality procedures have been followed
Interim Design Review Design development occurring after Definitive Design Acceptance and prior to Readiness-for-Construction submittal may call for Interim Designs to remedy conflicts, account for exceptions, and incorporate betterments. Design-Builder shall notify Agency if Interim Design Reviews are necessary for particular Design Units, and shall schedule the necessary Design Reviews following independent review by the Design Quality Manager, which may be presented at a design workshop or meeting with Agency. Design-Builder shall also use Interim Design Reviews to verify that the concepts and parameters established and represented by Definitive Design are being followed, and that all Contract requirements continue to be met. Design-Builder shall specifically highlight, check, and bring to the attention of Agency any information differing from or supplemental to that presented at the Definitive Design Review. Significant changes to the Definitive Design will require a re-submittal and Agency review and Acceptance prior to the submittal of the Readiness-for-Construction Plans and Specifications.
Readiness-for-Construction Design Review Design-Builder shall use the Readiness-for-Construction Design Review to verify that the concepts and parameters established and represented by Definitive Design are being followed and that all Contract requirements continue to be met. Design-Builder shall specifically highlight, check, and bring to the attention of Agency any information differing from or supplemental to that presented at the Definitive Design Review. Prior to scheduling the Readiness-for-Construction Design Review with Agency, the Design Quality Manager's independent review shall have been completed.
Working Plans Design Review It shall be solely Design-Builder's responsibility to provide Working Plans of such a nature as to develop a finished Project in accordance with the Readiness-for-Construction Plans and Specifications, and all Contract requirements. Design-Builder shall verify pertinent dimensions in the field prior to conducting a Working Plans Design Review. Design-Builder shall invite Agency to participate in a Review and Comment of Working Plans. Agency may invite Stakeholders to attend reviews of Working Plans. Design-Builder shall check, review, and certify Working Plans as specified herein, prior to their being issued for or used in construction. This includes Designer, Design Manager, and Design Quality Manager reviews, approvals, and certifications. Subsequent modifications must be processed through Design-Builder's design review and approval/certification process and Agency Review and Comment prior to being utilized.
As-Constructed Design Review Design-Builder shall submit the As-Constructed Plans and Design-Builder Specifications for each Design Unit to Agency for review and Acceptance within 30 Calendar Days of completion of the construction Work. As-Constructed Plans and Design-Builder Specifications shall thoroughly describe and identify every aspect of the Project as-constructed. Design-Builder shall make all corrections noted in Agency comments, if any, resulting from Agency's review, and shall resubmit the corrected version to Agency PM for review and Acceptance.

the agency and ODBP representatives could perform constructability and over-the-shoulder reviews. Issues encountered by project participants could be discussed.

1. **Attendees.** Generally, the attendees were the ODOT Project Manager; OBDP representatives; design-builder Project Manager and Superintendent; design-builder Construction, Design, and Quality Managers; Design Discipline Leads; and, if necessary, large subcontractors and environmental staff.

2. **Task force meetings.** These meetings were held when specific problems had to be solved. As in the weekly meetings, these meetings were open to the agency and OBDP representatives.
3. **Additional design reviews.** In addition to the reviews of milestone design submittals, the agency could perform over-the-shoulder reviews to monitor and ensure consistency among plans and specifications.
4. **Contractually required meetings.** The contract (ODOT 2007c) specified several mandatory meetings and conferences. The characteristics of some mandatory meetings are described in Table 11.

3.4 Value Engineering

To allow the proposal of original technical solutions during the pre- and post-award phases, ODOT established value engineering procedures. In particular, alternate technical concepts (ATC) were allowed in the pre-award phase, while cost-reduction proposals were allowed in the post-award phase.

3.4.1 Pre-Award Value Engineering: ATCs

Although ODOT authorized the proposers to include approved ATCs in their proposals, ODOT retained the right to disclose any approved ATCs to all bidders before contract award.

> Nothing [. . .] shall restrict the Agency's right at any time during the solicitation process to modify RFP requirements through the issuance of Addenda to accommodate authorization of a particular Alternate

Table 11. Sample of mandatory meetings and conferences (ODOT, 2007c, pp. 180–214).

Design Mobilization Meeting Design-Builder's Project Manager shall consult with Agency PM and shall arrange and lead a design mobilization prior to Design-Builder's initiating Design Services. The agenda shall be developed in consultation between Agency PM and Design-Builder and prepared by Design-Builder, and shall include, at a minimum, all of the following: Design development and Design Review process; Description and breakdown of Design Units; Design development and Design Review schedules; and, Design Quality Management.
Pre-Design Meeting A maximum of 15 Calendar Days prior to beginning Design Services, unless otherwise authorized in writing by Agency, Design-Builder shall meet with Agency at a time mutually agreed upon. Among other matters, the purpose of the meeting will be to establish the level of detail to be required for measuring progress with regard to those design Price Items referenced in DB General Provisions […].
Preconstruction Conference A maximum of 15 Calendar Days prior to beginning construction, unless otherwise authorized in writing by Agency, Design-Builder shall meet with Agency for a preconstruction conference at a time mutually agreed upon. Among other matters, the purpose of the meeting will be to establish the level of detail to be required for measuring progress with regard to construction Price Items, in accordance with the provisions of DB General Provisions […]. Before meeting with Agency for the preconstruction conference, Design-Builder shall hold a group Utility scheduling meeting with representatives from the Utility companies involved with the Project. Design-Builder shall incorporate the Utilities' time needs into Design-Builder's Baseline Progress Schedule submitted at the preconstruction conference.
Right-of-Way (ROW) Services Kick-Off Meeting Prior to initiating any ROW Work, Design-Builder's ROW Project Manager will arrange for a kickoff meeting with all parties to the ROW activities of the Contract to discuss the services to be provided under the Contract.

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> Technical Concept, if the Agency determines that such modification is in the best interests of the State (ODOT 2006, p. A–11).

None of the proposers submitted any ATCs.

3.4.2 Post-Award Value Engineering: Cost-Reduction Proposals

ODOT allowed the design-builder to modify plans, specifications, or other contract documents to reduce the total cost of construction. In case a cost-reduction proposal was approved, the agency issued a change order and the savings were split evenly between the agency and the design-builders.

4. Interdependencies between Design and Other Activities

4.1 Environmental Permits

Given that hundreds of bridges were planned to be replaced under the OTIA III Bridge Replacement Program, ODOT collaborated with state and federal agencies to develop a programmatic environmental permitting process. This process was based on a set of environmental performance standards. If the design of a project respected these standards, the environmental permits were granted automatically.

4.2 Other Permits

The design-builder was responsible for obtaining all construction-related permits and licenses, such as building construction permits, permits to cross or encroach on navigable streams, and permits to remove materials from or deposit materials into waterways (ODOT 2007d).

4.3 Right-of-Way (ROW)

Although ODOT established in the RFP which property was necessary to acquire, no property acquisition was accomplished before contract award. OBDP was in charge of procuring the ROW. Thus, OBDP had to coordinate with property owners, perform the appraisal, negotiate, etc.

4.4 Utility Relocation

Although ODOT performed a preliminary assessment and coordination to determine adjustments and relocations of utilities within the project limits (e.g., identify and contact the utility owners and determine which utility facilities likely were to conflict with the project activities), the design-builder fully was responsible for coordinating and performing all utility relocations.

> Design-Builder shall have the responsibility of coordinating the Project design and construction with all Utilities that may be affected. Design-Builder shall be responsible for identifying, verifying the existence of, determining if conflicts exist, and resolving all Utility conflicts on the Project. Activities include, but are not limited to, the following:
>
> 1. Identifying the full extent of Utilities in the Project Site
> 2. Verifying Utility owners and locations of Utilities
> 3. Locating Utilities and identifying potential conflicts not previously identified
> 4. Providing information to Agency to assist in acquiring additional ROW or easements, if necessary

5. Coordinating and/or designing/constructing the Adjustment of Utilities and/or new Utilities [. . .] (ODOT, 2007e, pp. 174–4).

4.5 Public Involvement

Per contractual agreement (ODOT 2007c), the design-builder was responsible to lead the public involvement effort and had to appoint a Public Information Manager. In particular, the design-builder organized public meetings and public service announcements, involved local schools, and provided ODOT and OBDP with information to update the program and project's websites.

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Case Study—Program: Utah Department of Transportation

1. Background

In 1995, Salt Lake City was chosen as the host city of the 2002 Winter Olympics. This created the necessity to improve road and highway infrastructures in the Salt Lake City area to meet the increased mobility demand due to the Olympic Games. Among the selected improvement projects, the expansion and upgrade of Interstate 15 (I-15) in Salt Lake County was of particular importance. In fact, state officials asserted that I-15 would not have been able to sustain the combined load of routine traffic and increased traffic due to the Olympic Games in Salt Lake County (Federal Highway Administration 1998). Furthermore, I-15 in Salt Lake County had experienced considerable congestion since 1980; it was severely deteriorated, and its structures did not meet the current safety and seismic design standards (UDOT 2002). Utah Department of Transportation (UDOT) began developing a program to reconstruct I-15 in 1984. The findings showed that with a traditional design-bid-build (DBB) procurement process, it would have taken eight to 10 years to expand and upgrade the roughly 17 miles of I-15 in Salt Lake County (Federal Highway Administration 1998; UDOT 2002). Thus, it was necessary to use a different delivery method to accomplish the project in time for the Olympic Games. In 1996, UDOT determined that design-build (D-B) was the most suitable delivery method to meet such deadline. Since D-B was not permitted, the Utah State Legislature modified the procurement laws in 1996. In particular, the legislature allowed UDOT to award the contract using a best-value selection instead of a lowest-bid selection (Page 2012). The same year, UDOT began the process for the I-15 Corridor Reconstruction project (Figure 20) and, in April 1997, awarded the $1.6 billion contract to Wasatch Constructors (Table 12). In the procurement documents, UDOT required that the project be completed by October 2001. Wasatch Constructors committed to complete the project by July 2001 and was successful in respecting the schedule (UDOT 2002).

The successful implementation of D-B for the I-15 Corridor Reconstruction project created a positive environment for the evaluation and adoption of other innovative contracting methods for highway projects. In particular, two innovative project delivery methods such as design-build and construction-manager-as-general-contractor (CMGC) have been institutionalized and used extensively by UDOT. As shown in Figure 21, significant funds constantly have been committed to D-B and CMGC projects over the years. The data also show that D-B and CMGC projects generally are bigger in scope than DBB projects. In fact, the average committed funds per year (i.e., committed funds/-number of projects) constantly are higher for D-B and CMGC projects than for DBB projects (Figures 22 and 23).

Furthermore, UDOT created the office of Innovative Contracting and Project Controls within the Project Development Division (Figure 24). This office is in charge of leading the implementation of innovative project delivery methods by developing guidelines and supporting the agency's staff during the procurement and contract execution phases.

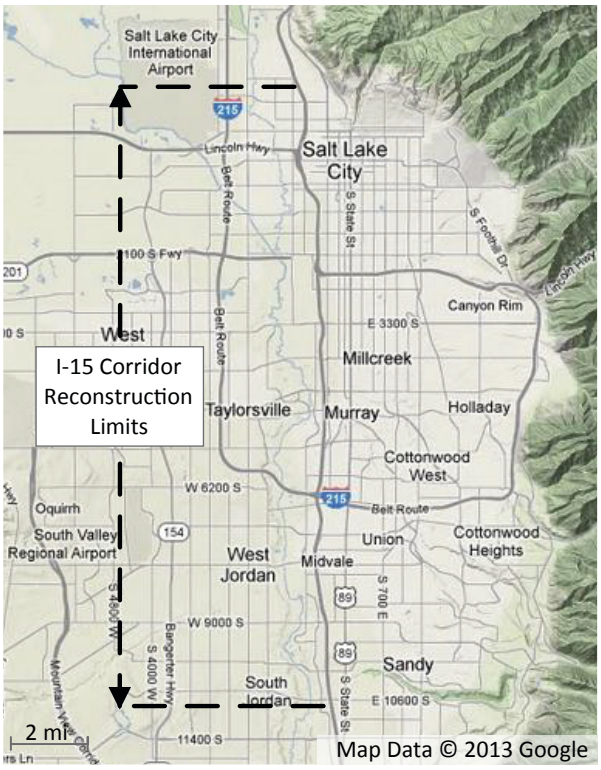

Figure 20. I-15 Corridor reconstruction project map.

Table 12. I-15 Corridor reconstruction project main characteristics.

Location	Salt Lake County, UT	**Duration**	1996–2001	**Cost**	$1.6 billion
Design-Builder	Wasatch Constructors. A joint venture of Peter Kiewit Sons' Inc. (Omaha, NE), Granite Construction Company Inc. (Watsonville, CA), and Washington Construction Company (acquired by URS Corporation, San Francisco, CA)				
Scope	• Reconstruction of 16.2 miles of Interstate • Construction of three lanes in both directions • Replacement of 142 bridges • Reconstruction of eight urban interchanges and three freeway-to-freeway connections				

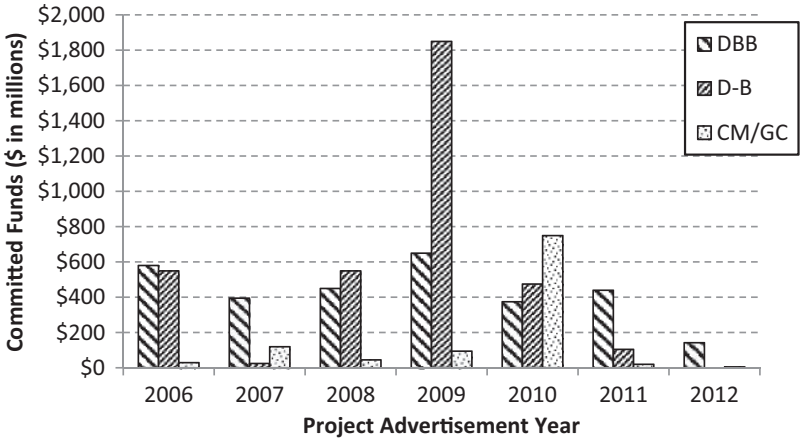

Figure 21. Committed funds per year for DBB, D-B, and CMGC (adapted from Page 2012).

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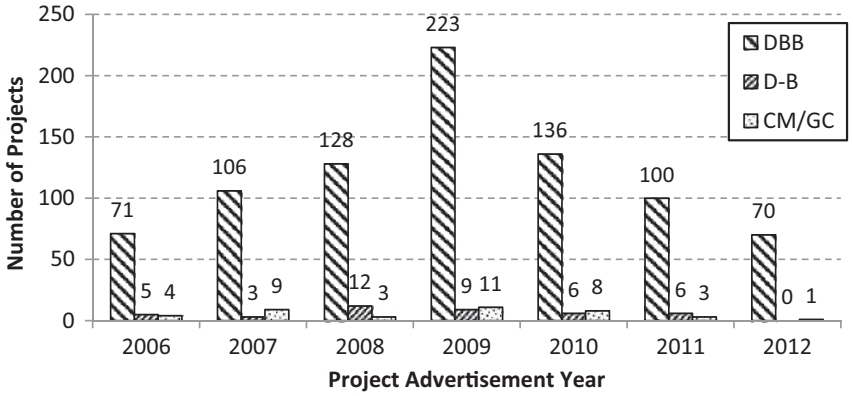

Figure 22. Number of projects per year for DBB, D-B, and CMGC.

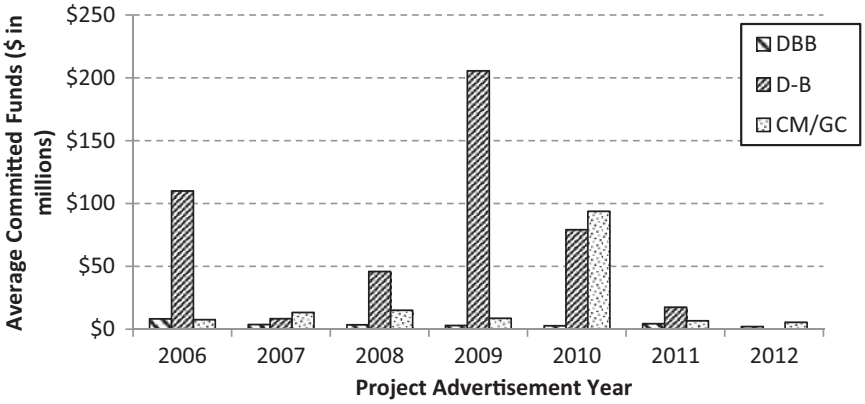

Figure 23. Average committed funds per year for DBB, D-B, and CMGC.

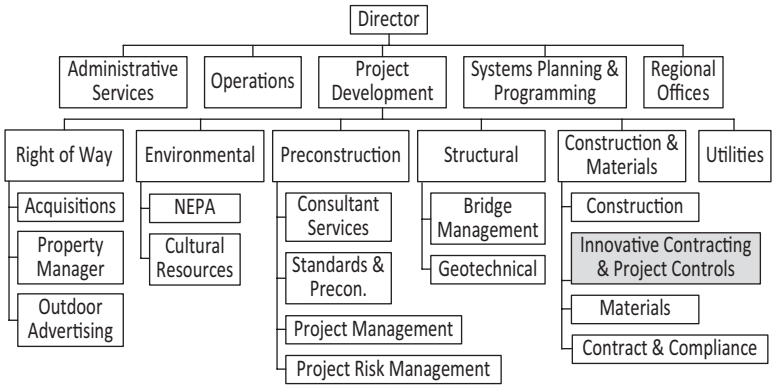

Figure 24. Simplified Utah Department of Transportation organizational chart.

1.1 Information Presented in the Case Study

This case describes the programmatic effort of UDOT in implementing D-B for highway projects. In addition to analyzing UDOT documentation about the program, four D-B projects were analyzed.

1. Pioneer Crossing, Lehi—15 American Fork Interchange (Table 13)
2. SR-154; Bangerter at 7800 S, 7000 S, and 6200 S (Table14)
3. I-15 at 11400 South Interchange (Table 15)
4. I-15; South Layton Interchange (Table 16)

Table 13. Pioneer Crossing, Lehi—15 American Fork Interchange project main characteristics.

Location	Lehi and American Fork, UT	**Duration**	2008–10	**Cost**	$175 million
Design-Builder	Kiewit-Clyde. A joint venture of W.W. Clyde & Co. (Springville, UT) and Kiewit Southwest Co. (Salt Lake City, UT)				
Scope	• Construction of a diverging diamond interchange at I-15 and American Fork Main Street • Construction of a five-lane roadway in Saratoga Springs that switches to a seven-lane roadway in Lehi • Construction of a bridge over the Jordan River • Construction of a bridge over the Union Pacific Railroad				

Table 14. SR-154; Bangerter at 7800 S, 7000 S, and 6200 S project main characteristics.

Location	West Jordan, UT	**Duration**	2010–12	**Cost**	$40 million
Design-Builder	Ralph L. Wadsworth Construction Co. (Draper, UT)				
Scope	• Construction of continuous flow intersections at 6200 South and 7000 South along the Bangerter Highway • Construction of a separated-grade, single-point, urban interchange at 7800 South and Bangerter				

Table 15. I-15 at 11400 South interchange project main characteristics.

Location	South Jordan, UT	**Duration**	2008–11	**Cost**	$245 million
Design-Builder	A&W Highway Contractors. A joint venture of Ames Construction (Salt Lake City, UT) and Wadsworth Brothers Construction (Draper, UT).				
Scope	• Construction of single-point, urban interchanges at I-15 and 11400 South • Reconstruction of the freeway from 10600 to 12300 South • Reconstruction of 11400 South from I-15 to Bangerter Highway • Construction of a traffic bridge and a pedestrian bridge over the Jordan River and a bridge over the existing railway				

Table 16. I-15; South Layton interchange project main characteristics.

Location	Layton City, UT	**Duration**	2009–11	**Cost**	$95 million
Design-Builder	Ralph L. Wadsworth Construction Co. (Draper, UT)				
Scope	• Construction of single-point, urban interchanges at I-15 and South Layton • Removal of an existing partial interchange • Widening of 1.8 miles of I-15 • Construction of a five-lane roadway from Fort Lane to Flint Street				

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2. UDOT Project Team

UDOT developed several documents describing the procedure that should be followed in implementing D-B from the beginning of the process to the issue of the request for proposals (UDOT n.d., 2010a, 2011). The major steps of the process are shown in Figure 25. Although the steps are presented in a sequence, most steps cannot be considered concluded when the successive step begins. For instance, although the risk allocation matrix has to be populated in the early stages of the project development process, the project team should continue to update it during the process as soon as more information is available. In fact, project risk analysis can be considered concluded only after contract award.

Among the identified project development steps, UDOT provides guidelines on how to assemble the project team. First, UDOT indicates that the project team should be consistent throughout the whole D-B process (i.e., from beginning of the process to project completion). Second, UDOT requires the project team to be led by a Project Manager (PM). The State of Utah is divided into four administrative regions. Each region is managed by a regional office (Figure 24), and the personnel of each regional office manage the administration, construction, and maintenance of all road infrastructures located in their region. Therefore, to avoid conflicts with these pre-existing procedures, the PM generally is selected among the regional office's personnel in charge of the project. Furthermore, to foster successful contract planning

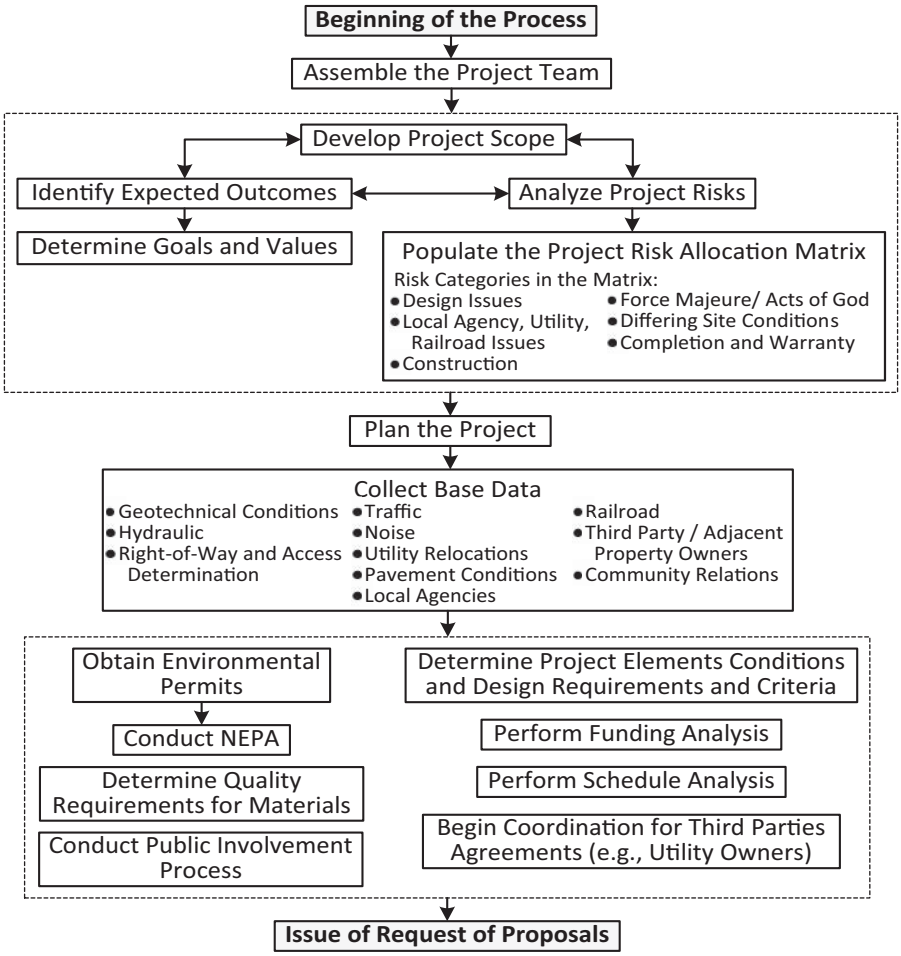

Figure 25. D-B project development (from beginning to request for proposal).

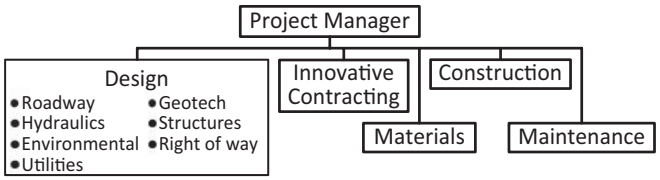

Figure 26. Typical project team technical areas.

and execution, UDOT specifies clearly that the PM should have enough experience to be capable of understanding correctly the project and the project delivery method. Third, the PM has to be supported by a team capable of managing the different technical areas of the projects (Figure 26). In accordance with the project's needs and characteristics, the team members can be from UDOT central office (e.g., innovative contracting), UDOT regional offices (e.g., design and construction staff), or external consultants. Finally, UDOT indicates that a dedicated project team should be established for large projects.

3. Project Design Management

The following sections describe how the agency and design-builders generally organize and conduct design management functions. The first section describes the partnering effort between UDOT and design-builders. Later, the formal processes associated with design management are explained. Next, additional forms of communication and coordination adopted in support of design management functions are discussed. Finally, a brief overview of pre-award and post-award value engineering procedures is included.

3.1 Collaborative Partnering

UDOT believes strongly in building an effective formal partnering relationship with design-builders. For instance, UDOT suggests "experience with formal partnering activities" as a selection criterion for the request for qualifications (UDOT 2010a). The agency specifies two main strategies to obtain an effective partnering relationship such as co-location and adoption of a formal partnering process.

Co-location. UDOT indicates that co-locating with the design-builder is likely to improve communication. Nevertheless, UDOT also indicates that co-location may not be cost effective on small projects (UDOT n.d.).

Formal Partnering Process. Generally, UDOT requires the design-builder to organize, implement, and manage a formal partnering process involving all project participants. An example of the language and requirements used by the agency is provided in Table 17.

3.2 Formal Design Management Processes

To ensure design package quality and compliance with the contractual document requirements, the agency requires the design-builder to develop a comprehensive quality program, participates in the design-builder design reviews, and performs design reviews.

3.2.1 Quality Management Plan

The Quality Management Plan (QMP) is the document detailing all quality program procedures adopted by design-builders. UDOT requires the design-builders to submit the QMP for

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Table 17. Partnering requirements (UDOT 2010b pp. 2–41, 2–42).

A. The Design-builder shall implement a facilitated partnering program, and execute it in conjunction with the Subcontractors, design consultants, design subconsultants, and the Department. This approach uses the strengths of each organization to identify and achieve mutual goals. Partnering does not change the legal relationship of the parties or modify the Contract, and does not relieve either party from any of the terms of the Contract. Nor does it create a legal partnership between the parties. Rather, it is intended to denote a cooperative collaboration between the parties to efficiently accomplish the Work and complete the Contract.
B. Implement partnering in accordance with the UDOT and Utah AGC Partnering Field Guide. Refer to http://www.udot.utah.gov/go/standardsreferences:
1. Contact the Department within 30 days of Notice of Award and before the pre-Work conference to implement a third party facilitated partnering initiative;
2. The Design-builder and Department select a facilitator for the meeting and develop the attendees list, agenda, duration, and location of a partnering workshop;
3. Partnering will be held for both design and construction throughout the project. Review survey responses and results monthly with the Engineer; and
4. Perform a design lessons learned session within two weeks of the final drawings being released for construction.
C. Share any costs equally with the Department to accomplish partnering except that each shall pay full costs associated with its staff attending partnering sessions.
D. Follow-up workshops may be held as agreed by the Design-builder and the Department.
E. Hold a weekly Executive Partnering meeting with the Department's Project Manager and Resident Engineer. This weekly meeting will begin at NTP and end at Contract Completion.

approval after contract award and lists several requirements for the development of the QMP in the contractual documents. Examples of the QMP requirements are provided in Table 18.

3.2.2 Design Reviews

UDOT defines different types of design reviews such as interim oversight reviews, milestone reviews, release for construction (RFC) reviews, and completed design review. Figure 27 shows when these reviews take place during the design development process. The typical characteristics of these reviews are presented in the following paragraphs.

Interim oversight reviews. As shown in Figure 28, these reviews can take place at any level of design (of a design package). These reviews can be requested either by the design-builder or the agency. Although interim oversight reviews are conducted "using an over–the-shoulder technique with the intent of minimizing disruption of ongoing design Work" (UDOT 2010c pp. 3–15), they may follow a formal review process (Figure 28). First, the documents to be reviewed (e.g., progress prints, computer images, draft documents, working calculations, draft specifications or reports) are submitted to the agency and, if necessary, other interested stakeholders. Second, the project stakeholders review the documents and provide comments within a certain number of days (e.g., seven). Finally, after inviting the agency to attend the review, the design quality manager (DQM) conducts the review with the involved design-builder's design personnel.

Milestone reviews. The agency requires the design-builder to hold these reviews for each design package at 30% and 60% design complete (Figure 27) "to determine whether the Contract requirements and design criteria are being followed and that QC/QA activities are following the approved QMP" (UDOT 2010c pp. 3–15). These reviews follow a formal procedure (Figure 29). First, the design package is submitted to the agency and, if necessary, other interested stakeholders. The design package must include, "as a minimum, design drawings, calculations (as appropriate), reports, specifications, geotechnical data, environmental requirements, and any other relevant design information" (UDOT 2010c pp. 3–15). Second, the project stakeholders review the documents and provide comments within a certain number of days (e.g., ten). Third, after

Table 18. Quality management plan (QMP) contractual requirements (UDOT 2010c).

Section	Requirement
General	The QMP shall delineate how the Design-builder will ensure that all disciplines, aspects, and elements of the Work will comply with the requirements of the Contract Documents and that all materials incorporated into the Work will perform satisfactorily for the purpose intended. The Design-builder may use any nationally accepted format and process for the QMP (p. 3-1).
Department Contract Administration	All Department Contract Administration responsibilities are either explicitly or inherently distributed to the applicable section of this Part 3 (Quality Program). The QMP shall define how these Department responsibilities are integrated to assure and document their execution. At its discretion, the Department may utilize requirements of the Design-builder to fulfill a number of activities outlined in the Construction Manual of Instruction (p. 3-4).
Quality Management Plan Contents	The QMP shall address Project elements, organized in the following sections: 1. Management; 2. Key Staffing Positions; 3. Administration; 4. Progress Payment; 5. Investigations, Inspections, and Testing; 6. Design; 7. Construction; 8. Environmental Monitoring and Compliance; and 9. Maintenance of Public and Private Facilities (pp. 3-4, 3-5).
Construction Quality Manager (CQM)	The QMP shall name the CQM, who will be responsible for the quality of the construction elements of the Project (p. 3-6).
Design Quality Manager (DQM)	The QMP shall name the DQM, who shall be responsible for the quality of the design elements of the Project (p. 3-6).
Design Requirements	In general, Section 6 (Design) of the QMP shall describe design quality management practices and processes that are intended to: 1. Place responsibility for design quality on the Design-builder; 2. Ensure that Work is designed and built in accordance with the Contract; 3. Ensure that all design documents are prepared in accordance with generally accepted design and engineering practices and meet all the requirements of the Contract; and 4. Allow the Department to fulfill its responsibility of exercising due diligence in overseeing the design process and design products (p. 3-12).

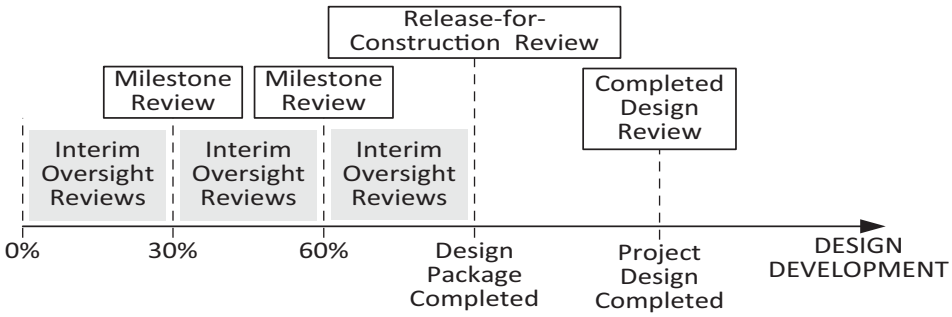

Figure 27. Design reviews during design development.

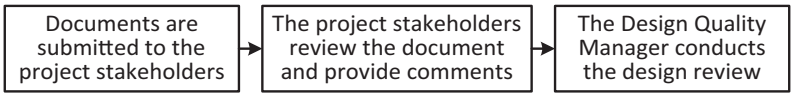

Figure 28. Design interim oversight review formal process.

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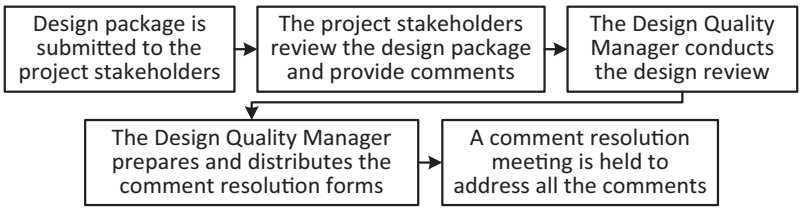

Figure 29. Milestone review formal process.

inviting the agency to attend the review, the DQM conducts the review with the involved design-builder personnel. Fourth, the DQM compiles and distributes among the review participants the review minutes and a comment resolution form. Finally, a comment resolution meeting is held with the agency to address and resolve all the comments.

Release for construction reviews. The RFC reviews are performed at the end of the design package development. RFC reviews follow a formal procedure similar to the one implemented for milestone reviews.

Completed design review. The completed design review is performed when the design of the entire project is complete. In this review, the DQM reviews "the completed design as defined by the scope of work" (UDOT 2010c pp. 3–16). In particular, the DQM must verify that:

1. All plans, reports, and specifications are signed and stamped by the Engineer-in-Responsible-Charge.
2. All comments and problems are addressed and resolved.

Regardless of the type of review, revisions and comments provided by the agency personnel also may contain constructability considerations.

3.3 Other Forms of Communication and Coordination

In addition to participating in the design reviews, the agency and the design-builder can communicate during the following times:

1. **Informal face-to-face meetings, electronic communications, and phone calls.** The design-builder's construction and design personnel could communicate directly with the agency through face-to-face meetings, emails, and phone calls. Furthermore, UDOT generally requires the design-builders to utilize a Web application platform to manage all electronic documentation.
2. **Meetings.** Per contractual agreement, design-builders have to "participate in monthly progress meetings or meetings held at the request of the Department to review and discuss the status of the project" (UDOT 2010b pp. 2–16). These meetings are a venue to identify, discuss, and resolve any deviation from the expected schedule. In addition to the progress meetings, design-builders usually invite the agency to weekly design management meetings and task force meetings. Design management meetings can either focus on a single design discipline or involve all design leads. Task force meetings are a venue to discuss and resolve specific problems and, therefore, are not held on a regular basis.

3.4 Value Engineering

To allow and foster the proposal of original technical solutions during the pre- and post-award phases, UDOT implements value engineering procedures. In particular, ATC are allowed

in the pre-award phase, while value engineering change proposals (VECP) are allowed in the post-award phase.

3.4.1 Pre-Award Value Engineering: Alternative Technical Concepts

UDOT defines ATCs as deviations from the contractual documents that "result in performance and quality of the end product that is equal to or better than the performance and quality of the end product absent the deviation, as determined by the Department in its sole discretion" (UDOT 2008 p. ITP–17). Furthermore, UDOT clarifies that concepts cannot be considered ATCs if they require any of the following:

1. A reduction in project scope, performance, or reliability.
2. The addition of a separate department project to the contract (such as expansion of the scope of the project to include additional roadways).
3. An increase in the amount of time required for substantial completion (UDOT 2008 p. ITP–17).

Proposed ATCs are discussed during one-on-one meetings and the agency can provide only one of the following statements to a proposed ATC:

1. The ATC is acceptable for inclusion in the proposal.
2. The ATC is not acceptable for inclusion in the proposal.
3. The ATC is not acceptable in its present form, but may be acceptable upon the satisfaction, in the Department's sole discretion, of certain identified conditions which must be met or clarifications or modifications that must be made.
4. The submittal does not qualify as an ATC but may be included in proposer's proposal because it appears to be within the requirements of the RFP (UDOT 2008 p. ITP–20).

Although ATCs are confidential until contract award, the agency states that

> If the Department determines, based on a proposed ATC or otherwise, that the RFP contains an error, ambiguity, or mistake, the Department reserves the right to modify the RFP to correct the error, ambiguity, or mistake, regardless of any impact on a proposed ATC (UDOT 2008 p. ITP–19).

Furthermore, if the agency approves an ATC requiring additional properties, the design-builder will retain full responsibility for obtaining and paying for the additional properties.

3.4.2 Post-Award Value Engineering: Value Engineering Change Proposals

UDOT encourages design-builders to submit VECPs by sharing equally the resulting savings. Nevertheless, the agency usually does not reimburse the costs incurred by the design-builder in developing, designing, and implementing the VECP. Furthermore, the agency indicates the following requirements for VECPs:

1. VECPs apply only to the current contract and become property of the department regardless of their approval.
2. The department only considers VECPs that meet the following conditions:
   a. Impose no restrictions on use or disclosure.
   b. The department may duplicate or disclose any data necessary to use the VECP.
   c. The department may apply a VECP for general use on other projects it administers without obligation to the design-builder.
3. This provision does not deny rights provided by law with respect to patented materials or processes.
4. Use only proven features that have been employed under similar conditions or projects acceptable to the department (UDOT 2010c pp. 2–49).

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4. Interdependencies Between Design and Other Activities

4.1 Environmental Permits

UDOT is responsible for obtaining the environmental permits for permanent construction elements such as environmental studies and stream alteration permits. Furthermore, UDOT is in charge of conducting the NEPA process and obtaining the record of decision. Design-builders may be required to support the agency by providing information. If the agency is in charge of a permit that is related to tasks and/or activities under the design-builder's responsibility, the design-builder will have to prepare the necessary permit application documents and submit them to the agency for approval.

4.2 Other Permits

Design-builders are responsible for obtaining all construction-related permits, such as permits for construction, maintenance, and removal of temporary roadways and permits from railroad companies for conduit crossings.

4.3 Right-of-Way (ROW)

UDOT is responsible for managing the ROW procedures during the pre- and post-award phases. If possible (e.g., small projects), the agency identifies and purchases all properties prior to contract award.

4.4 Utility Relocation

If possible, UDOT coordinates with the utility owners to relocate all affected facilities prior to contract award. If it is not possible to relocate the utilities prior to contract award, or it is viable and effective to include such relocations in the scope of work, UDOT coordinates with the utility owners to obtain a master utility agreement. Then design-builders are responsible to coordinate with the utility owners to obtain the supplemental utility agreements and manage the utility relocation activities.

4.5 Public Involvement

Since the public holds the agency accountable for long-term project outcomes and short-term construction activity consequences (e.g., traffic delays), UDOT retains ultimate responsibility for public involvement and information (UDOT 2010a). Therefore, UDOT leads the public involvement and information efforts and requires the design-builders to support its efforts. For instance, design-builders must:

1. Provide information about the project progress and effects on traffic.
2. Address concerns of road users, local businesses, and residents.
3. Provide material to update projects' websites.

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Case Study—Project: SR 99 Tunnel (Alaskan Way Viaduct) Washington Department of Transportation

Background

The Alaskan Way Viaduct is a two-mile-long, double-decked, elevated section of State Highway SR 99 (Figure 30). The Alaskan Way Viaduct, completed in 1953, runs west of Seattle downtown along the Elliot Bay waterfront from South Nevada Street to Belltown Battery Tunnel (Figure 31). Second only to Interstate 5, the Alaskan Way Viaduct is a major north-south corridor through downtown Seattle that carries about 110,000 vehicles per day (WSDOT 2009).

In 1989, a structure similar to the Alaskan Way Viaduct, the Cypress Street Viaduct (Oakland, CA), collapsed during the Loma Prieta earthquake (6.9 moment magnitude). To address the numerous concerns about the Alaskan Way Viaduct seismic vulnerability, WSDOT thoroughly investigated the Alaskan Way Viaduct conditions and determined that the viaduct was likely to be severely damaged and collapse in a design-level earthquake (Kramer and Eberhard 1995). The same report defined a design-level earthquake as one with "design-level motions with a 10% probability of exceedance for an exposure period of 50 years" (Kramer and Eberhard 1995 p. 9). Whereas this report forecast that such a seismic event is likely to occur once every 475 years, on February 28, 2001, the Nisqually earthquake (6.8 moment magnitude) severely damaged various elements of the viaduct, including joints and columns (WSDOT 2009). Moreover, concerns about the Alaskan Way Seawall structural stability also were raised due to the severe viaduct foundation settlement that occurred after the earthquake.

Although the facility was repaired and reopened (Figure 32), WSDOT determined that retrofitting the facility to minimize its seismic vulnerability was not cost effective. Concurrent inspections of the Alaskan Way Seawall also found signs of significant deterioration despite regular maintenance.

Therefore, in late 2001, WSDOT launched the Alaskan Way Viaduct and Seawall Replacement Program (Figure 33). As a first step, numerous design concepts were taken into consideration and discussed with the public. Ten goals were developed to guide the selection of viable concepts (Table 19). In particular, all the concepts had to meet the necessary seismic design standards (i.e., goal one) to be considered viable. In 2002, 76 viaduct replacement and seven seawall replacement concepts were selected and further analyzed. In 2004, five build alternatives with a no build alternative (Table 20) were finalized and included in the draft environmental impact statement (EIS) (Sheridan 2004). At the end of 2004, federal, state, and city stakeholders streamlined the initial list by eliminating the Aerial, Bypass Tunnel, and Surface alternatives. They also suggested the Tunnel alternative as preferred with the Rebuild listed "as a contingency plan in case the agencies fall short of raising the estimated $3.4 billion to $4 billion for the tunnel" (Steakley 2004). At that time, a cut-and-cover tunnel along the waterfront was the preferred technical solution. In 2005, the program goals were modified to incorporate safety and access improvements in the

Figure 30. The Alaskan Way Viaduct (Credit: WSDOT).

area north of the Battery Street Tunnel (WSDOT 2009). Thus, the following three alternatives were included in a supplemental draft EIS published in 2006:

- **Cut-and-cover tunnel alternative**—A double-decked, cut-and-cover tunnel (three lanes per direction) built parallel to the Alaskan Way Viaduct
- **Elevated structure alternative**—A modified rebuild alternative
- **No build alternative**

Figure 31. Map of the Alaskan Way Viaduct (Credit: WSDOT).

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Figure 32. WSDOT crews repairing earthquake damage on the viaduct in April 2001 (Credit: WSDOT).

In 2007, the City of Seattle held an advisory ballot to allow citizens to provide input on the preferred alternative between an elevated alternative and a hybrid alternative with a cut-and-cover tunnel and surface roads. Seattle citizens rejected both alternatives. After the advisory ballot, program proponents decided to solve critical safety and mobility issues at the north and south ends of the Alaskan Way Viaduct by initiating a sub-program called Move Forward. The main projects under the Move Forward sub-program were (WSDOT 2009):

- Repair of columns in the Pioneer Square area;
- Relocation of electrical line in the viaduct's south end;

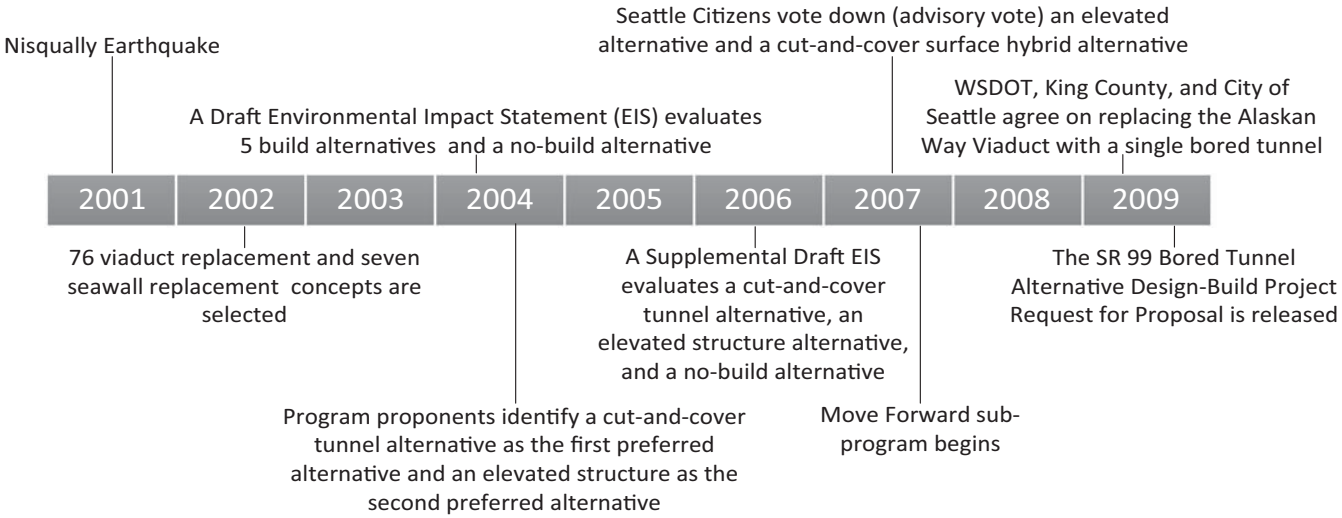

Figure 33. Alaskan Way Viaduct replacement program timeline.

Table 19. Goals for screening the proposed concepts (WSDOT 2009).

Goal Number	Goal Description
1	An alternative must provide facilities that meet current seismic design standards.
2	An alternative must maintain the current transportation functions of the Alaskan Way Viaduct Corridor.
3	An alternative should not further degrade the operation of other major transportation facilities.
4	An alternative should improve traffic safety.
5	An alternative should maintain regional transportation linkages.
6	An alternative should support bicycle and pedestrian accessibility and mobility.
7	An alternative should be compatible with local, express, and high-capacity transit.
8	An alternative should support land use and shoreline plans and policies pertaining to development of the downtown Seattle waterfront.
9	An alternative should support improved habitat for fish and wildlife along the Alaskan Way Seawall.
10	An alternative should rely on proven construction methods, minimize construction duration, and promote effective traffic management during construction.

Table 20. Draft environmental impact statement build alternatives (Sheridan 2004).

Alternative	Description
Rebuild	• An at-grade roadway from S. Holgate Street to S. King Street • Reconstruction of the viaduct from S. King Street to the Battery Street Tunnel
Aerial	• A double-level aerial structure from S. Holgate Street to the Battery Street Tunnel
Tunnel	• An at-grade roadway from S. Holgate Street to S. King Street • A tunnel with three lanes in each direction with portals in S. King Street, Pike Street, and Alaskan Way north of Pine Street • An aerial structure from Pike Street to the Battery Street Tunnel
Bypass Tunnel	• An at-grade roadway from S. Holgate Street to S. King Street • A tunnel with two lanes in each direction with portals in S. King Street and Pike Street • Widening of Alaskan Way to carry the additional traffic
Surface	• An at-grade roadway with three lanes in each direction from S. Holgate Street to S. Atlantic Street • An at-grade roadway with two lanes in each direction from S. Atlantic Street to Yesler Way • An at-grade roadway with one lane in each direction and a center left-turn lane from Yesler Way to Pike Street • An aerial structure from Pike Street to the Battery Street Tunnel
No Build	• Scenario 1—Continued operation of the viaduct and seawall with continued maintenance • Scenario 2—Sudden unplanned loss of the facilities but without major collapse or injury • Scenario 3—Catastrophic failure and collapse of viaduct and/or seawall

Figure 34. Map of the SR 99 tunnel (Credit: WSDOT).

- Maintenance and repair of the Battery Street Tunnel; and,
- Replacement of the viaduct between S. Holgate Street and S. King Street (south end).

In January 2009, WSDOT, King County, and the City of Seattle agreed on replacing the Alaskan Way Viaduct with a single bored tunnel under downtown Seattle, the SR 99 tunnel (Figure 34). WSDOT selected design-build to deliver this project due to its uniqueness, size, technical complexities, and schedule. Design-build allowed the agency to solicit original technical solutions while providing for a fast-tracked delivery schedule. In addition to the tunnel project, WSDOT, King County, the City of Seattle, and the Port of Seattle planned several street, transit, seawall, and waterfront betterment projects (Figure 35). All of these projects were included in the scope of the Alaskan Way Viaduct and Seawall Replacement Program. Table 21 includes a breakdown of the program budget.

Figure 35. Map of the major projects for the Alaskan Way Viaduct Replacement Program (Credit: WSDOT).

Table 21. Alaskan Way Viaduct and seawall replacement program design, management, and construction activities.

Design, Management, or Construction Activities	Budget (million)
WSDOT (Total Budget $3.2 billion)	
Program management	$75.0
Environmental impact statements (EIS), right-of-way acquisitions, and design costs	$173.7
Moving Forward projects: repair of columns in the Pioneer Square area; relocation of electrical line in the viaduct's south end; maintenance and repair of the Battery Street Tunnel; construction mitigation to transit service and travel time monitoring and demand management services; and replacement of the viaduct between S. Holgate Street and S. King Street (south end).	$551.3
SR 99 Tunnel Project. This project consists of several sub-projects: SR 99 Bored Tunnel Alternative (i.e., SR 99 tunnel); north end; south end; and South Atlantic Street Overpass	$2,034.4
Central Waterfront Construction Mitigation	$30.0
New Alaskan Way with connections to Elliott and Western Avenues; Alaskan Way Viaduct removal; and Battery Street Tunnel decommissioning	$290.0
City of Seattle (Total Budget $1.4 billion)	
Phase 1: Elliot Bay Seawall Project	$300.0
Mercer Corridor Project	$260.0
South Spokane Street Viaduct Widening Project	$162.0
Waterfront Seattle	$480.0
Utility relocation	$226.0
King County (Total Budget $190 million)	
Transit investments	$190.0
Note: King County was in charge of administering additional $32 million provided by WSDOT for construction mitigation measures to transit services as part of the Moving Forward projects.	
Port of Seattle (Total Budget $53.6 million)	
East Marginal Way Grade Separation	$53.6

SR 99 Bored Tunnel Alternative

In October 2009, WSDOT began the procurement process by holding a request for qualifications (RFQ) voluntary meeting. At the end of 2009, WSDOT shortlisted three proposers, which were invited to submit a proposal in response to the request for proposals (RFP) document issued in May 2010. However, only two teams submitted a proposal by the due date. In December 2010, Seattle Tunnel Partners (STP) was awarded the contract to build the SR 99 Bored Tunnel Alternative for more than $1 billion.

According to the contractual agreement, STP will build the approximately two-mile-long tunnel with a 57.5-foot earth pressure balance (EPB) boring machine. The new SR 99 tunnel is sized to accommodate a two-lane, double-decked structure (Figure 36) to support northbound and southbound traffic. The route of the new SR 99 tunnel starts at the south end stadium district, extends along Alaskan Way, travels to the northeast in the vicinity of Yesler Street, travels northerly along 1st Avenue, and then continues on a northeast route toward 6th and Mercer, where it ultimately connects to existing SR 99 just north of the Battery Street Tunnel entrance. This route traverses almost two miles underneath a variety of streets and building and structure foundations. As shown in Figure 37, WSDOT obtained the EIS record of decision (ROD) after contract award. Since final design and construction activities cannot be performed before obtaining the ROD, WSDOT had to issue two notices to proceed (NTP). The first NTP allowed STP to perform the preliminary design while WSDOT was waiting for the ROD to issue the second NTP

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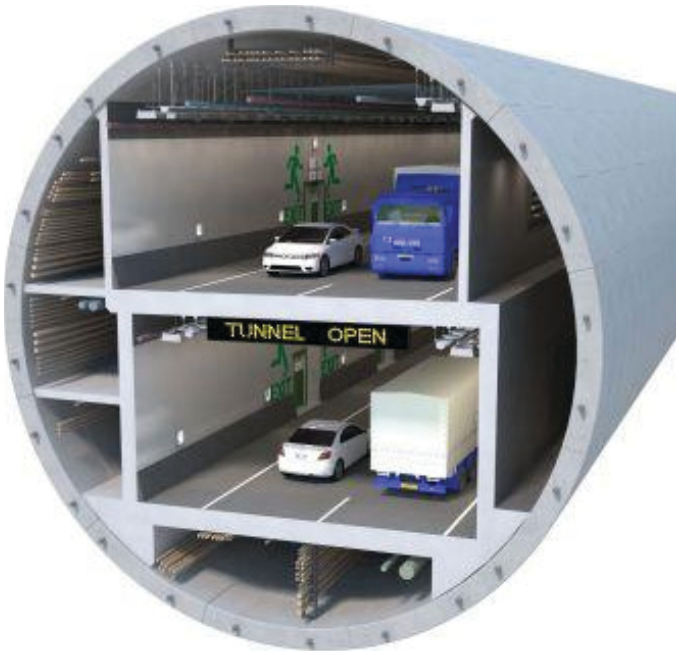

Figure 36. SR 99 tunnel design concept (Credit: WSDOT).

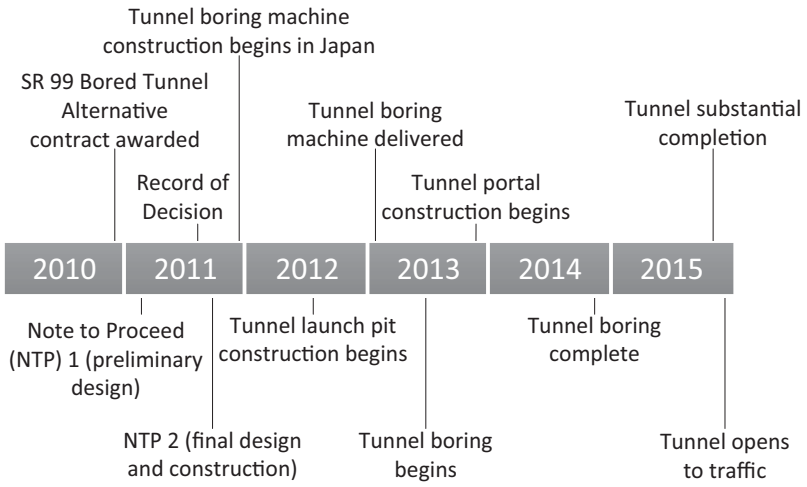

Figure 37. SR 99 bored tunnel alternative timeline.

final design and construction. An analysis of the project timeline in Figure 37 shows that the project schedule is extremely compressed with the design and construction phases expected to last only 5 years, from the beginning of 2011 to the end of 2015.

Project Partners

WSDOT

Within the Alaskan Way Viaduct Program, WSDOT established a project management team in charge of the SR 99 Bored Tunnel Alternative project (Figure 38). The project management team consists of a design engineer, who is the leader of the design phase; a geotechnical and utility

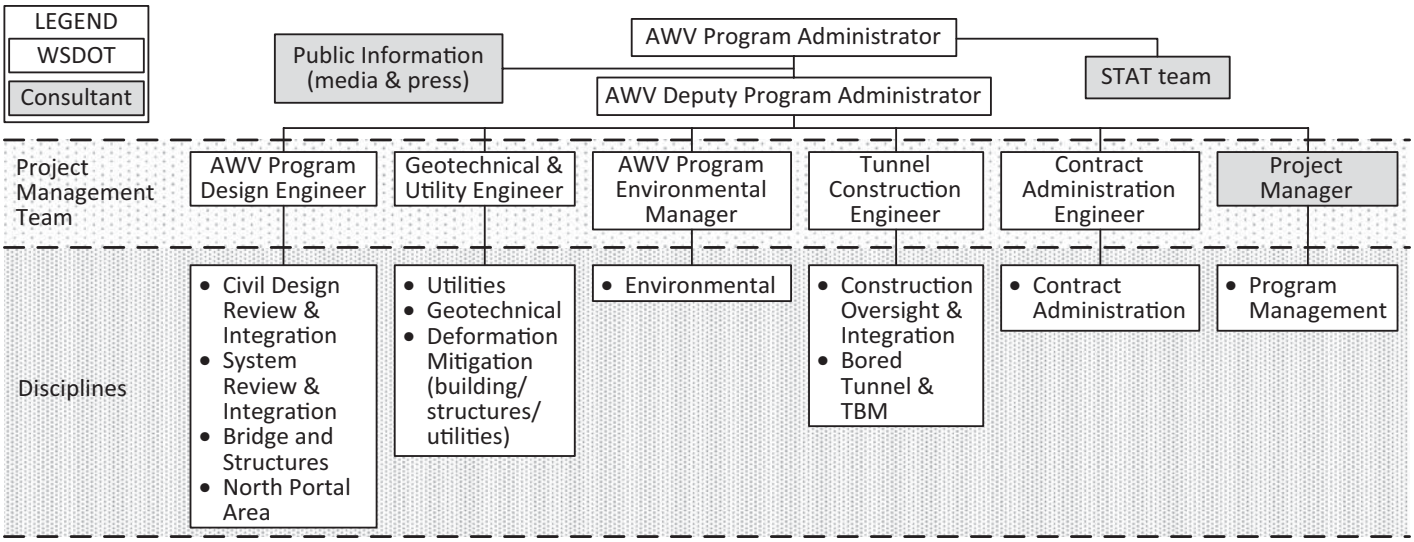

Figure 38. WSDOT Alaskan Way Viaduct (AWV) organization chart.

engineer; an environmental manager; a tunnel construction engineer; a contract administrator engineer; and a program manager. As shown in Figure 39, each team member is in charge of one or more disciplines. Moreover, WSDOT does not have in-house expertise to effectively manage all the issues related to the construction of a tunnel. Therefore, the agency decided to hire numerous external consultants. In particular, while the team members are WSDOT employees with the exception of the program manager, only 50% of the support staff consists of WSDOT employees. Furthermore, to mitigate the numerous risks associated with the project, WSDOT utilizes the services of a strategic technical advisory team (STAT). The STAT is technically oriented and provides oversight and support on technical challenges related to the tunnel and project construction. This team supported development of the RFP, procurement and selection activities, and continued support of the project during the design review and construction phases. In addition, a 2011 budget proviso legislation required that an expert review panel be

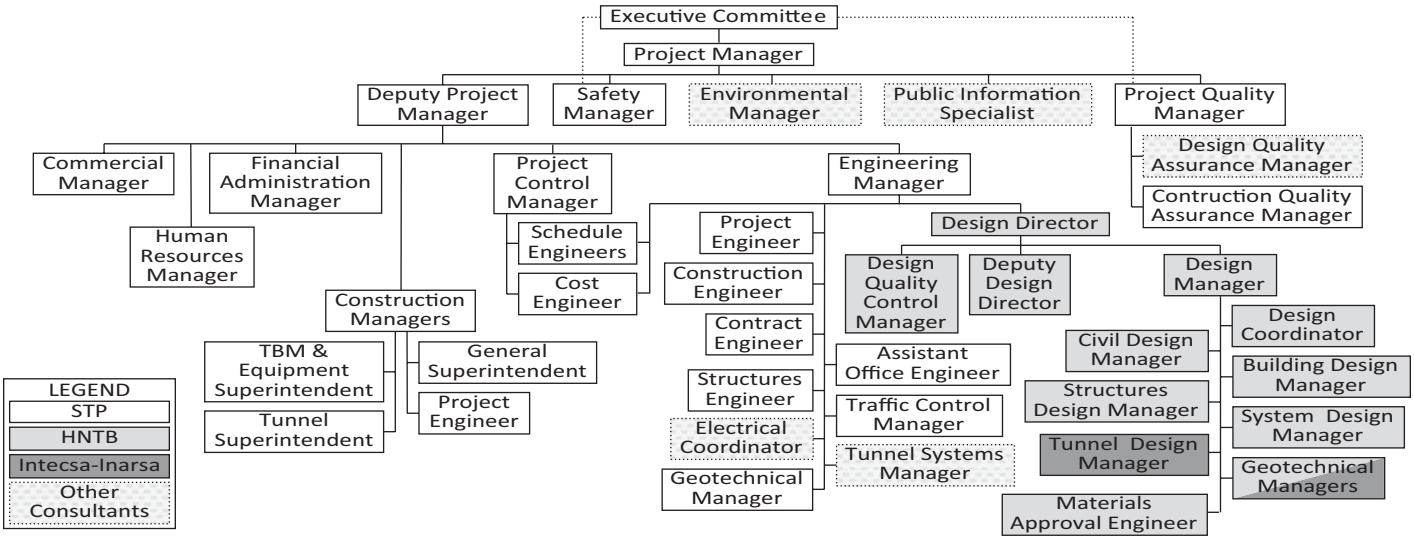

Figure 39. STP organization chart.

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convened to evaluate the financial feasibility of the overall program. The expert review panel has performed extensive reviews of the program, including overall program management, risk management, budget and contingency plans, availability of financial resources, stakeholder and partner agency relationships and interfaces, and mitigation of public and political issues.

Seattle Tunnel Partners

STP is a joint venture of Dragados USA (55%) and Tutor Perini Corporation (45%). STP contracted out the design to HNTB Corporation and Intecsa-Inarsa. In particular, as shown in Figure 39, HNTB Corporation leads the overall design while Intecsa-Inarsa leads the tunnel design. Moreover, STP selected Hitachi Zosen Corporation to design and manufacture the tunnel boring machine and Frank Coluccio Construction, Malcolm Construction, and JH Kelly Construction as local subcontractors.

Project Design Management

The following sections describe how the agency and the design-builder have organized and conducted design management functions on this unique project. The first section describes the partnering effort between WSDOT and STP that was enacted to facilitate collaboration among parties. Later, we explain formal processes associated with design management, including how design packages were reviewed internally by STP and later reviewed and approved by WSDOT and other project stakeholders. Next, we discuss additional forms of communication and coordination adopted in support of design management functions (beyond the formal submittal and review process). Lastly, a brief overview of pre-award and post-award value engineering procedures is included.

Collaborative Partnering

To foster a successful project completion, minimize issues and disputes among project participants, and better manage overall risk, WSDOT relies on a collaborative partnering work relationship among project participants. "WSDOT believes that Project objectives can be best achieved through a collaboration that promotes and facilitates strategic planning, design, construction and commissioning of the Project" (WSDOT 2012 p. 121).

In particular, the contract requires that the parties:

- Participate in a team building workshop conducted by a third party facilitator;
- Coordinate respective roles, responsibilities, and expertise; and
- Foster open communications, non-adversarial interactions, and fair and transparent decision making and idea sharing.

Formal Design Management Processes

Design Review Milestones

Per contractual agreement, STP needs to prepare three design submittals for each design package. The whole design management process was developed around these three milestones (see Table 22) and included two stages of reviews: (1) an internal review that was described in the STP Design Quality Management Plan, and (2) a review by WSDOT and other project stakeholders, including the City of Seattle and its offices.

Table 22. Design submittals.

Submittal	Description
Design Definition	Since WSDOT provided concept plans at maximum 30% design completion for the different design disciplines in the RFPs, the intent of this submittal is to bring all the design disciplines at 30% design completion to confirm that the initial design approach is consistent with the contract requirements
Preliminary Design	The intent of this submittal is twofold. First, it supports the agency in completing the permitting process. Second, it allows project stakeholders (e.g., affected local government and utilities) to review "the construction documents in order to ensure that the design is progressing appropriately and proceeding in the right direction; the plans reflect the requirements for construction; and there are no fatal flaws within a given discipline or between disciplines" (STP 2012 p. 18).
Final Design	This submittal consists of plans and specifications at 100% design completion. After approval, the ready for construction (RFC) design package is prepared.

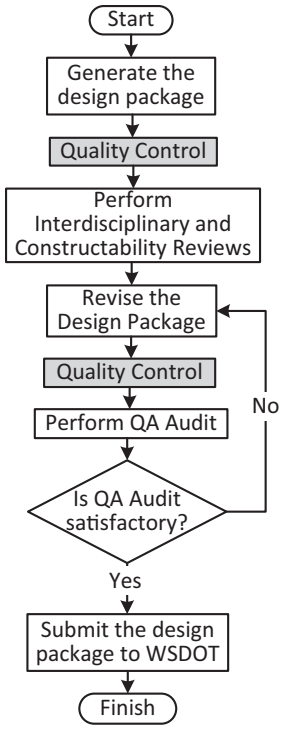

Figure 40. Design-builder internal design review flowchart.

Design-Builder Internal Design Review

STP (design-builder) planned a detailed internal procedure to ensure the quality of the design packages. The basic design-builder internal design review process is shown in Figure 40. The design review steps are described in the following paragraphs.

1. **Generate the design package**. STP design team (coordinated by HNTB) prepares the plans, specifications, calculations, reports, and other design documents. To ensure effective communication and coordination, weekly task force meetings are held.
2. **Perform quality control (QC).** QC reviews are performed to verify that the generated documents are in conformance with the design criteria and standards and the contract. QC reviews consist of four steps (Figure 41):
   - Check—By validating the assumptions, calculations, specifications, drawings, and details in conformance with the design QC procedures, the checker (i.e., a peer of the designer or originator of the document) reviews the documents and determines whether revisions are required.

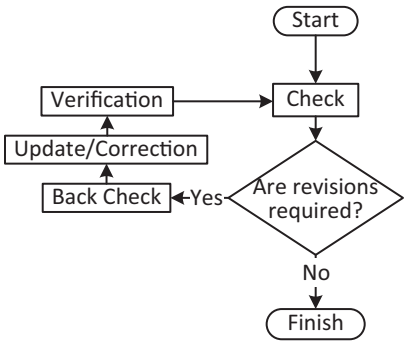

Figure 41. Design-builder quality control review flowchart.

- Back Check—After reviewing the checker revisions, the back checker (typically the designer or originator of the document) accepts the agreed-upon revisions and discusses and resolves revisions not agreed upon.
- Update/Correction—In accordance with the revisions, the corrector (typically a drafter involved in originating the document) updates and corrects the documents.
- Verification—The verifier (typically either the checker or the back checker) verifies the completeness and correctness of the corrections/updates.

3. **Perform the interdisciplinary and constructability reviews.** The interdisciplinary reviews are performed to ensure that design responsibilities and design details are being coordinated effectively between and within disciplines. In particular, the reviewers check the documents to detect interferences and incompatibilities among design disciplines. The constructability reviews are performed by the design-builder to minimize and control risks regarding "tolerances, site access and restrictions, traffic handling during construction, economics of design and materials, availability of materials, construction equipment and required labor, consistency with environmental permit requirements, interferences and conflicts among construction disciplines, completeness, and prudent construction practices" (STP 2012 p. 26—Att.A).
4. **Revise the design package.** Comments and revisions generated during the interdisciplinary and constructability reviews (or during the quality assurance audit) are incorporated in the documents and, if necessary, a comment resolution meeting can be held to further discuss and resolve comments and revisions.
5. **Perform the quality assurance (QA) audit.** The design quality assurance manager performs an audit to verify that the QC procedures have been followed. Moreover, the design quality assurance manager verifies that previous comments and revisions have been correctly incorporated into the documents.
6. **Submit the design package to WSDOT.** After completion of the QA audit, the design package is submitted to the project stakeholders (e.g., WSDOT, the City of Seattle, utility companies).

Agency's and Other Project Stakeholders' Design Review

After a design package has been released by STP, it is reviewed by WSDOT and, if necessary, by other project stakeholders (Table 23). The design review procedures adopted by WSDOT are described in the following paragraphs.

Table 23. Role of the project stakeholders in reviewing design packages (adapted from STP, 2012).

Reviewer	Role
WSDOT	Review plans for conformance with the discipline criteria and contract requirements
Local governments (e.g., the City of Seattle)	Review plans for conformance with respective standards and other issues of local government concern
Seattle Fire Department	Review plans for conformance with tunnel safety standards and requirements

To allow effective WSDOT coordination in reviewing the design submittals, the submittals are incorporated into the project schedule. Moreover, regardless of the dimension of the design package under review, it is contractually required that WSDOT completes the design review within 14 days. Nevertheless, to limit WSDOT workload, "WSDOT reserves the right to extend the review time by up to seven calendar days for submittals that are received between November 15th and January 1st, and for submittals with overlapping review periods" (STP 2012 p. 24). If WSDOT does not provide reviews and comments within 14 days for a design package, STP can assume that there are no reviews or comments on the design package. In addition, a design review can be accelerated up to five days if requested by STP. Generally, an accelerated review is requested for design changes originating from the field that have to be promptly addressed. The main steps for a typical WSDOT design review are as follows:

- The program design engineer receives the design package and distributes it among the other project management team members.
- The project management team members provide reviews and comments (typically 10 days for the standard review process) to the program design engineer.
- The program design engineer compiles and consolidates the reviews and comments into the comment summary and the resolution form to avoid duplicate or conflicting comments (typically three days for the standard review process). Furthermore, the program design engineer verifies that the comments are neither directive nor shift any contractually assigned risk back to the agency.
- The program design engineer submits the compiled reviews and comments to STP (typically one day).
- STP incorporates the comments and reviews in the design package and, if necessary, a comment resolution meeting can be held with WSDOT personnel to further discuss and resolve the comments and reviews.

As previously described, STP is in charge of performing design QC/QA. Although WSDOT personnel are not directly involved in performing any design QC/QA procedures, they may audit the design QC reviews and QA audits to verify that the design QC/QA procedures are implemented correctly.

Other Forms of Communication and Coordination

In addition to participating in the design reviews, the project stakeholders and STP may communicate during formal task force meetings or informal, over-the-shoulder review meetings (Table 24).

Value Engineering

To allow and foster the proposal of original technical solutions during the pre- and post-award phases, WSDOT establishes value engineering procedures. In particular, ATC are allowed in the pre-award phase, while design-builder initiated change proposals are allowed in the post-award phase.

Pre-Award Value Engineering: Alternative Technical Concepts

WSDOT defines ATCs as proposals that are deemed, in WSDOT's sole discretion, "equal or better" than what is specified in the RFPs (WSDOT, 2010). WSDOT determines to provide one of the following judgments to a proposed ATC:

1. The ATC is approved;
2. The ATC is not approved;

Table 24. Task force and over-the-shoulder review meeting characteristics (STP 2012).

	Task Force Meetings	*Over-the-Shoulder Review Meetings*
Scope	• Review design packages before submittal. • Document formal agreements on code and design manual interpretations. • Solve issues affecting project direction and schedule. • Review status of design submittal package, status plan sets, and calculations.	• Review specific design packages. • Discuss design approaches and code/manual interpretations. • Identify items to discuss in task force meetings.
Attendees	Required attendees: • WSDOT project management team members • STP project discipline leads • Representatives from other project stakeholders	Expected attendees: • Interested WSDOT project management team members • STP engineering manager • Interested STP project discipline leads • Design team package lead • STP construction personnel • Interested representatives from other project stakeholders
Agenda	The STP engineering manager is in charge of detailing and sharing the agenda with meeting participants a minimum of three days prior to the meeting.	These meetings allow participants to talk informally about project issues. Thus, only a general agenda is maintained. Decisions made in these meetings are recorded at task force meetings.
Schedule	Typically, these meetings are held monthly for most of the disciplines during the design phase.	Typically, these meetings are held weekly for most of the disciplines during the design phase.

3. The ATC is not approved in its present form but may be reconsidered for approval upon satisfaction, in WSDOT's sole discretion, of certain identified conditions that must be met or certain clarifications or modifications that must be made as described hereunder. The proposer shall not have the right to incorporate this ATC into the proposal unless and until the ATC has been resubmitted within the time limits in the ITP (instructions to proposers), with the conditions stated below satisfied, and WSDOT has unconditionally approved the revised ATC; or
4. The submittal does not qualify as an ATC but appears eligible to be included in the proposal without an ATC (i.e., the concept appears to conform to the basic configuration and to be consistent with other contract requirements) (WSDOT 2010 p. 14).

Moreover, WSDOT retains the right to request additional information about a proposed ATC and to hold one-on-one meetings with the proposers to review and discuss the proposed ATCs. Furthermore, since WSDOT provides a stipend to the proposers ($4 million), WSDOT retains also "the right to use any ideas or information contained in the unsuccessful Proposals" (WSDOT 2010 p. 13).

Post-Award Value Engineering: Design-Builder Initiated Change Proposals

WSDOT also encouraged the design-builder to submit VE change proposals by awarding part or all of the associated cost savings, depending on the nature of the proposal. Different categories of VE proposals were stipulated into the contract (WSDOT 2012).

a. **Shared savings**—If approved by the agency, the cost savings realized by these types of changes are equally split between the agency and the design-builder (after discounting all the additional

costs incurred by WSDOT due to the design-builder initiated change proposal). These changes could occur in two circumstances:

- The change requires design deviation; or
- The change includes ideas from unsuccessful proposals.

b. **Design-builder retained savings**—The design-builder retains all the cost savings if the proposed change is considered by WSDOT to be equal to or better than the requirement proposed to be changed.

c. **Negotiated savings**—The cost savings generated by changes different from the changes previously described are shared as the parties mutually agree. These proposed changes are denied if the parties are not able to find an agreement on how to share the savings.

Interdependencies Between Design and Other Activities

Environmental Permits

WSDOT was responsible for completing the NEPA documentation and obtaining the environmental permits, such as the ROD, the National Pollutant Discharge Elimination System (NPDES) permit, the coastal management permit, and the shoreline permit.

Other Permits

The design-builder was responsible for obtaining all the construction-related permits, such as the City of Seattle street use permits, haul road agreements, and permits and/or easements associated with the construction site access.

Right-of-Way (ROW)

WSDOT executed the property acquisitions after receiving the ROD and, therefore, after contract award. Thus, the agency retained the risks associated with these property acquisitions. To allow the proposers to design the facility and effectively develop the project schedule, WSDOT provided to the proposers a property acquisition schedule during the procurement phase. This document was based on the preliminary design developed by the agency for the request for proposals and detailed the properties that the agency was going to acquire and the timeframe for such acquisitions. Moreover, WSDOT allowed the proposers to identify additional properties through the ATC process. Nevertheless, WSDOT did not retain any risk associated with the acquisition of these additional properties. In fact, the contract stated that the "Design-Builder agrees that it shall be fully responsible for and shall bear all risk of increased costs and delays resulting from or arising in connection with the acquisition of such additional property rights" (p. 25; WSDOT, 2012).

In addition to the properties directly affected by the facility, the agency and the design-builder closely collaborated to obtain the temporary construction easements necessary for the construction activities. Furthermore, given the necessity to monitor the possible building foundation settlements due to the tunnel construction, the agency and the design-builder had to obtain the right-of-entry for the buildings above the tunnel to install the necessary monitoring instrumentation.

Utility Relocation

Public Utilities

Most of the utilities affected by the project were utilities owned by either the City of Seattle or King County. Prior to contract award, the agency and the public utility owners signed Intergovernmental Agreements to govern all the utility adjustments and/or relocations. These

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agreements were incorporated into the contract documents. Therefore, public utility relocations were included in the project scope, and the design-builder was held responsible to perform all necessary work.

Private Utilities

The design-builder was responsible to coordinate with the private utility owners and negotiate all the necessary adjustments and relocations. Two types of private utilities were defined in the contract documents.

- Category #1—Private utility owners that had cost responsibilities associated with the utility adjustments and/or relocations.
- Category #2—Private utility owners that did not have cost responsibilities associated with the utility adjustments and/or relocations.

For utilities owned by Category #1 owners, the design-builder had to seek reimbursements from the owners, and it could not include any cost related with these utility adjustments and/or relocations in the contract price. For utilities owned by Category #2 owners, the design-builder had to reimburse the owners, and such reimbursements could be included in the contract price.

Public Involvement

The public involvement efforts were shared between the agency and the design-builder. WSDOT was responsible for leading the public involvement at a macro level, such as involving and discussing with elected officials, issuing press releases, and managing the Alaskan Way Viaduct Replacement Program website and the Milepost 31 Information Center. The design-builder was responsible for supporting the agency (e.g., by providing graphics and updates for the website) and leading the public involvement at a micro level, such as talking with property owners affected by construction activities.

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APPENDIX B

Construction Manager/General Contractor Full Case Studies

Case Study—Project: Mountain View Corridor Utah Department of Transportation (CM/GC)

Background

Project Description

The Mountain View Corridor (MVC) is a 15-mile "planned" freeway in western Salt Lake County and northwestern Utah County servicing 13 municipalities. It is designated a "planned" freeway because in its current configuration, the MVC crosses intersecting roads at grade, necessitating traffic signals at each intersection. These intersections will be converted to interchanges built to Interstate standards in the future. In fact, the MVC currently widens at each intersection, with the extra lane in place to serve as the exit ramp when future construction transforms the at-grade intersections into freeway interchanges. The corridor currently extends from Redwood Road at 16000 South to 5400 South. Future construction will lengthen the road, as it will extend from S.R. 73 to I-80. The southernmost part of the current configuration contains two two-lane, one-way roads with wide medians. These roads are future frontage roads, as four limited access lanes will be built between them. Currently, there are no bicycle or walking trails or special lanes for buses, but these are planned for the future. Figures 42–44 show artist renderings of how the mainline, bicycle, and walking trails and bus lanes will look when constructed.

The final section of the current version of the MVC was opened to traffic on December 15, 2012. The cost of the total project, including right-of-way (ROW) and construction will be a little more than $1 billion, including about $130 million for future construction.

The MVC is designated as a Greenfield Project. Greenfield land is undeveloped land in a city or rural area that is built upon for the good of the community or left to nature. This land can be unfenced open fields, urban lots, or restricted closed properties kept off limits to the general public by a private or government entity. The Greenfield portion of the project is seen in Figure 45. Not all of the MVC is built on Greenfield land, and the non-Greenfield areas presented the usual challenges of new construction in urban and suburban areas. Figure 46 shows one of these areas during preconstruction.

The need for the project was established by traffic projections showing that travel times between the two endpoints of the now-completed project would double by 2030.

The decision to build the project was the result of a process typical of any modern transportation agency's decision making process for such a large project. The process timeline is illustrated in Table 25.

The funds to build MVC came from the Critical Highway Needs Funds (CHNF) of Salt Lake County and Utah County, a large private land donation, the Utah Legislature, and the Utah Transportation Commission. The breakdown of the funds accumulation can be seen in Table 26.

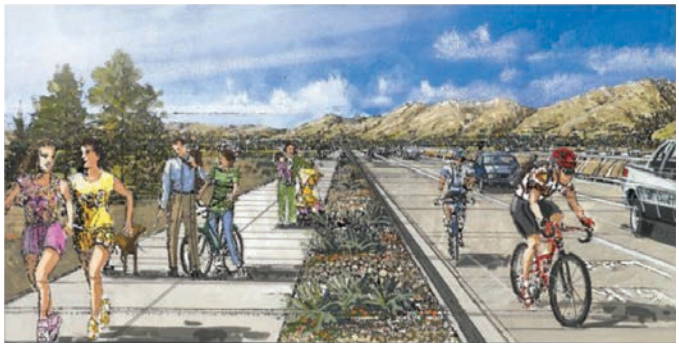

Figure 42. Future bike path and walking trail (Credit: UDOT).

Figure 43. Future look of mainline MVC (Credit: UDOT).

Figure 44. Artist rendering of future bus lanes (Credit: UDOT).

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Figure 45. Greenfield portion of the project before construction (Credit: UDOT).

Figure 46. Urban and suburban portion of the project before construction (Credit: UDOT).

Table 25. Planning timeline.

Year	Event(s)
2003	Growth Choices Workshops
2004	Talk Truck Meetings
2005	Alternatives Refinement Open Houses
2006	Town Hall Meetings
2007	DEIS Comment Period
2008	Record of Decision

Table 26. Cost breakdown for Salt Lake County portion.

Year	Amount	Source
2008	$230,000,000	Salt Lake County CHNF
2008	$130,000,000	Utah County CHNF
2009	$45,000,000	Private Land Donation
2009	$500,000,000	Utah State Legislature
Total	$905,000,000	

Why CMGC?

Only the 15-mile stretch of highway in Salt Lake County was built using the construction-manager-as-general-contractor (CMGC) delivery system and thus will be the focus of this case study. A map of the entire project with the Salt Lake County portion highlighted can be seen in Figure 47. The budget for this part of the construction was $905 million.

Before deciding which delivery system to use for each portion of the project, UDOT did its due diligence and analyzed each possibility. Its decision was to construct the vast majority of the project (the Salt Lake County portion) using the CMGC delivery system. The reasons published by UDOT for the decision for CMGC were as follows:

1. Contractor innovations
2. Expedited start
3. Many risk items difficult to allocate to the contractor
4. Flexibility allows co-procurement with another project (UDOT 2012)
5. Open-book pricing
6. Integrated ROW and construction schedule
7. Risk allocation discussion before pricing

The Salt Lake County (CMGC) portion of the project included 6 million cubic yards of earthwork, 300,000 tons of asphalt, 300,000 square yards of Portland cement concrete, 170,000 lineal feet of storm sewer, 160,000 square feet of retaining wall, and 10 highway bridges (UDOT 2012).

Project Goals

The goals of the project, as published by UDOT, are the following:

1. **Design and construct to budget.** Utilize the CMGC delivery system to design and construct as much of the corridor as possible. This delivery system will allow UDOT to adjust the scope and limits of the project based on the funds available for design and construction.

Build a professional and collaborative project team with the owner, program manager, designer, and contractor. Utilize the CMGC delivery system to select highly qualified professional designers and builders to form a single project team with UDOT to deliver the MVC project.

1. **Optimize construction schedule to achieve high quality and maximum value.** Allow the contractor the flexibility to adjust the construction schedule to minimize project cost and risk and maximize how much of the project can be constructed within budget. Develop a construction schedule that accommodates major utility relocation and maximizes benefits to UDOT and public stakeholders.
2. **Provide maximum opportunity to utilize innovative design and construction practices.** Build a unified project team and a collaborative work environment that fosters innovation, openness, transparency, and acceptance of change while maintaining quality and ensuring safety.
3. **Maintain public trust and confidence.** Fulfill the commitments made during the environmental process. Establish open communication through an effective and engaging public information campaign (UDOT 2012).

Procurement of the Team

Figure 48 shows the factors that went into selecting the CM along with their accompanying weights. Note that cost/price makes up 30% of the total and that the selection committee was more interested in how the cost/price was determined than it was in the cost/price itself. This was because UDOT was interested in the priorities of the candidates in terms of whether their

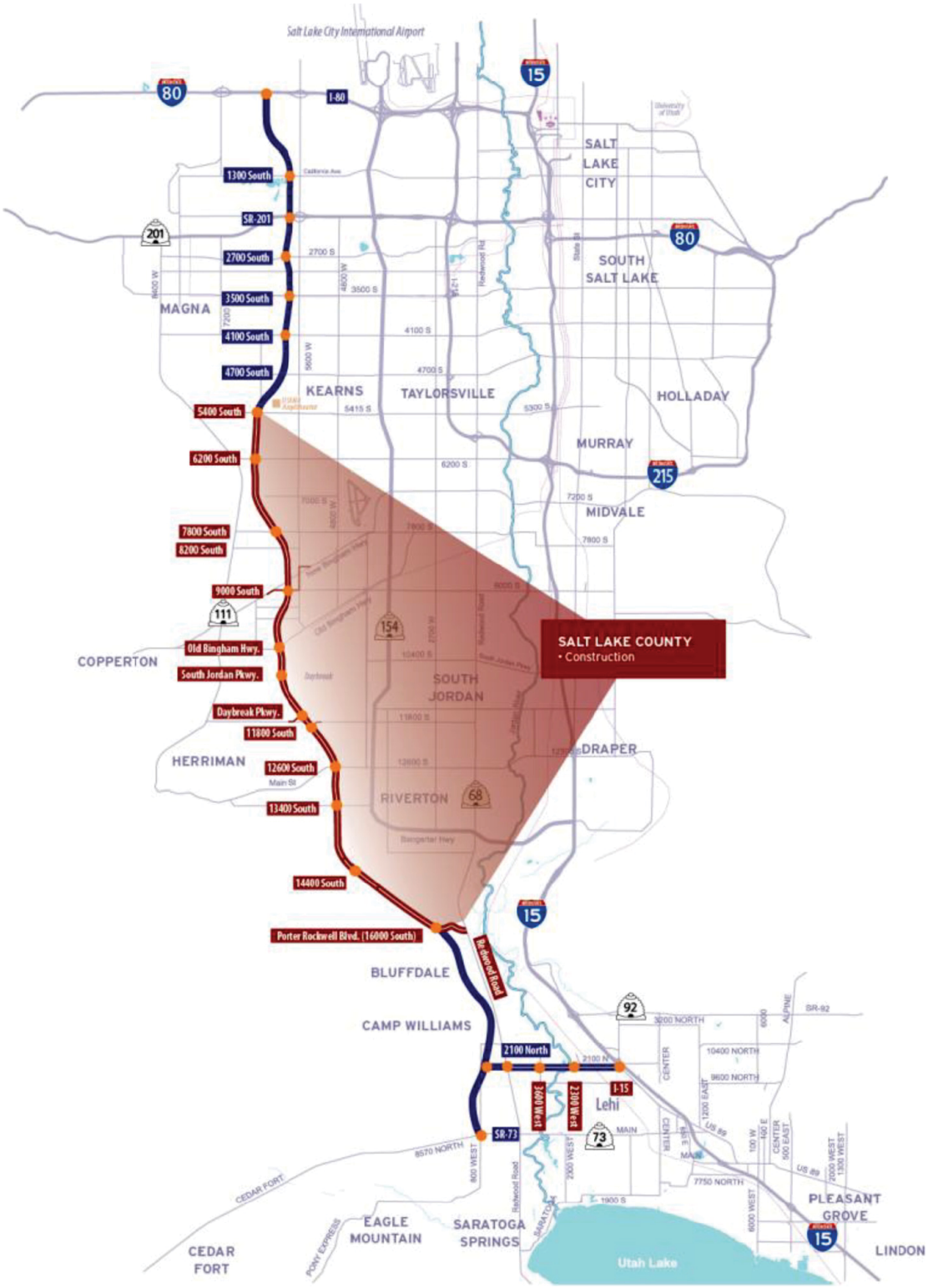

Figure 47. MVC map with CMGC portion highlighted (Credit: UDOT).

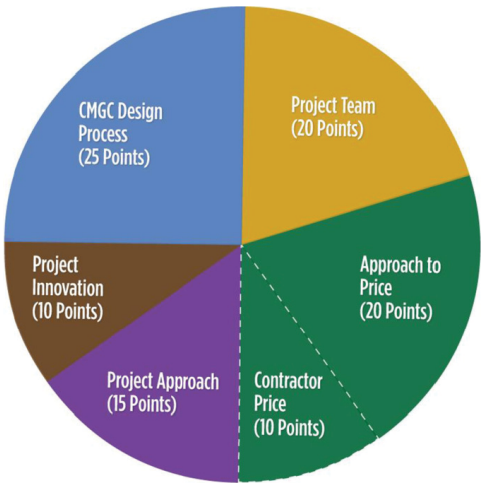

Figure 48. Procurement selection criteria (Credit: UDOT).

methods of pricing showed the kind of collaborative spirit for which UDOT was looking in a CM. What was possibly more important, however, was that UDOT was aiming to do something which no state transportation agency (STA) ever had done before. Its aim was to save money wherever possible and invest the money in the same project, allowing for project expansion.

STAs often had tried to save money, and many had put the savings into building more projects in the future. However, UDOT was going to exploit the CMGC delivery system to take on more risk than was customary for an STA and, by taking on the risk, would be paid for it. If UDOT avoided the dangers inherent in the risk, it would not pocket the money to pay for another project but would use the money to buy more ROW, pipe, roadside ditches, and maybe even asphalt pavement or bridges, thus turning a 15-mile project into something longer. For this, the methods and priorities shown by some contractors in calculating their price/cost could well be more conducive to such a strategy and objective as UDOT had for this project. Therefore, UDOT was very interested in how the cost of the construction was handled by the contractor. However, even given this, the issue of money was worth less than one-third of the whole when CMGC was chosen to build the MVC.

Based on the criteria in Figure 48, the CM chosen was a joint venture called Copper Hills Constructors. Copper Hills comprised heavy construction giants Granite and Kiewit along with Utah-based contractor W.W. Clyde. The design team selected was made up of Lochner, Baker, URS, and Horrocks. Those firms that joined UDOT to compose the PM team were national entities HDR and Parsons-Brinckerhoff (see Figure 49). The timeline from conception—the point of receiving sufficient funding to start the process—through the time of construction startup is shown in Figure 50.

Managing Post-Award Design Activities

ROW, Permitting, and Utility Relocation

On Mountain View, the utility coordination process was different because of some major cross-country transmission lines, natural gas lines, and power lines. There also were concerns about having the equipment on top of the gas lines and being able to have the contractor set the power cable while debating whether it needed to relocate the gas lines or go over the top of them.

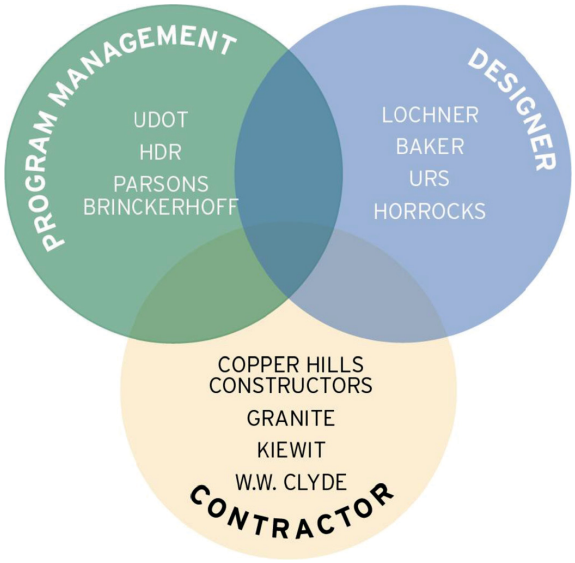

Figure 49. The team (Credit: UDOT).

Having the contractor present to talk about specific equipment it would use, the weight of the equipment, what its process was for the construction, and how it would protect the utility in place allowed the team to actually leave some of the gas lines in place where plans previously had been to relocate them. It made a huge difference to have the people who were actually going to do the work sitting at the table as the solutions were being developed.

The financial and time savings from this were huge. At UDOT, the utility coordination process generally has the same timing with CMGC as with DBB. On this project, that process started early in the design phase, the same as on a DBB job, to try to work out the solutions as early as possible. Construction started when utility issues still were being resolved. The contract was let knowing that there would be design changes because of the progression of the utilities. It allowed a little more time to work something out.

ROW acquisition was handled in-house during both design and construction phases. ROW risk was handled by the owner and consultants via the program management contract. In order

Figure 50. Project timeline from funding through commencement of construction (Credit: UDOT).

to minimize risk, utility companies and permitting agencies were made an important part of the design process. Regular meetings were held with utility companies to help progress the design and continued as the project moved into the construction phase.

UDOT is very strong in the areas of utility, permitting, and ROW acquisition and would have developed the schedule for those things on its own; but since the contractor was on board, it developed its construction schedule at the same time. All of UDOT's ROW, permitting, and utility issues were imbedded into the contractor's schedule, and the parties entered into an iterative schedule development process. The process started at the time the contractor was hired for the CM portion of the work (preconstruction services). At the beginning of the process, no ROW had been acquired. Prioritization of properties was the main early aim of this effort. There were certain pieces of property that, for whatever reason, were deemed best to work on first. These were given the highest priority to obtain, get permits done, and have utilities moved. If there were a piece of property that looked as if it were going to be difficult to acquire or get permitted, a decision was made to buy the easier property first and work around the difficult properties. Work often went back and forth geographically according to ROW and utility issues. Utility and ROW were risks taken by the owner, so the whole ROW/permitting/utility process was coordinated on the ever-changing schedule. This process was repeated all the way through the preconstruction process.

Scheduling utilities and design was part of an all-encompassing schedule. When the design was complete to the point at which the parties were comfortable enough to start working on a final price, a date for final pricing was set, as was a date to go to contract. The project went to contract (for the construction phase) with 90% of the plans imbedded in the schedule. The time at which any design details or design changes had to be in place was a function of when the contractor needed to be working at a certain location. Therefore, the entire process was very iterative. It allowed for a lot of flexibility in the process and more accurate prioritization as far as when to concentrate on what geographic areas.

The goal was always to keep the contractor's cost low so that more project could be built. When program managers (PMs) were hired and integrated into the team, ROW, utilities, and geotechnical engineering were done under the umbrella of the PM role, and DPs had all of that information provided to them. DPs actually produced the design, but the effort really was coordinated among the PM (consultant), DP, and contractor/CM, where the contractor/CM continued to perform constructability reviews and develop innovations while constructing the project until the end of the design phase.

An integrated construction and ROW schedule was prepared during the design phase and was updated continually based on properties cleared and utility permits acquired. Float was considered a shared resource and was able to be used by the contractor or owner depending on the situation and the need. This required a high level of trust and coordination but resulted in delivery of the project with no delays to the schedule.

Design and schedule coordination meetings were held weekly along with quarterly milestone meetings that consisted of design and constructability review, quantity reconciliation, pricing, and risk assessment. These meetings included the owner, PM (consultant), DP, and contractor.

The willingness of the owner and the contractor to sit down with third parties to work on a solution allowed the team to overcome many challenges. One particular challenge was related to a 300-foot-wide utility transmission corridor. The ability to have the contractor at the table with the utility company allowed a discussion of construction methods and specific equipment. This led to the development of a protect-in-place scenario, which allowed the team to delay an $8 million relocation until future phases of the project, possibly 10–15 years in the future. The $8 million was able to be used to expand and progress current phases of the project.

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Education/Training

Educating the DP early in the process of a CMGC project to ensure collaborative effort is really important. On this project, a larger number of players were brought together in a very short time. The biggest challenge in the beginning is trying to get everybody to work collaboratively from the start and trying to help everybody understand what his or her role is and is not. If the team could do it all over again, they would try to take time to educate everybody, not just "key" designers, because there is a need for strong communication. The level of coordination required on a CMGC project is much more than is required on a typical DBB contract. In fact, a more important factor than educational effort/formal training in transitioning the parties to the contract from the traditional DBB world to CMGC is the individuals' and organizations' commitment to work in a collaborative environment.

Executive and middle management commitment is critical to the success of a CMGC project. UDOT's executive and middle management gave very strong commitment to the CMGC process, and that really helped because the CMGC pricing process is not UDOT's traditional pricing method. If the team does not have support at the right time and place, that can make it really difficult to deliver a project through CMGC. Therefore, it is vital that executive management be trained in the nuances of CMGC, as well as middle management.

Managing Cost Estimates

An engineer's estimate was prepared by a former contractor and was set up like a contractor's estimate, with materials, labor, equipment, and overhead instead of using historical average bid prices. There also was an independent cost estimate prepared by an independent cost estimator (ICE). The team then had three sets of estimates to which to refer when developing the appropriate pricing.

Agency's Best Practices in the Design Phase to Keep Down Costs in the Construction Phase

There actually were three contracts on this project. There was a small one upfront that included early order items such as girders and some canal crossings that had to be done at certain times of the year. The CMGC process gives the flexibility to do such things. Eventually, the information available was enough for the development of a complete set of final plans, but that was deemed unnecessary since the project operated on a system of continuing pricing.

Early in the design process, there seemed to be a large amount of pressure on the DP to get everything ready for construction because the contractor has a lot less patience for design than for construction. The whole time the contractor is working in the design phase, it is anxious to get started on the construction phase. Therefore, there is a lot of pressure on the DP and the owner to get the utility work into the design plans and schedule. The pressure on everyone in the preconstruction design phase is concentrated not only on getting the contractor going but also on keeping the contractor going in the construction phase. Pressure to get utilities moved remains in the construction phase; but at that point, more of the pressure is on the contractor to maintain its schedule.

UDOT's best design practice for keeping construction within budget is that when the team designed and priced the job, the contractor was at the table. Therefore, if there had been something missing in the design plan, the contractor would have been as responsible as anybody else. The contractor was paid for a CM role, which made it responsible for reviewing the set of plans and giving its input.

The process for this project had four milestones for pricing—the first milestone with an approximately 30% set of plans, the second with an approximately 50% set of plans, the third at 75%, and then at 90%. In addition to the four milestones, the team conducted risk workshops. Each time a pricing was developed, a risk workshop was conducted along with it. The contractor would review the set of plans, and the team agreed on quantities from the set of plans. The risk workshop was based on these quantities, and the team discussed every possible good or bad thing that could happen to change the pricing. Then a percentage was derived, based on the perceived probability that each possible occurrence might actually happen and what cost and schedule impact each occurrence would have. A risk register (in the form of a matrix) then was developed that listed each of these possible occurrences, good or bad. Some of them decreased the cost of the job; most increased the cost of the job. Finally, through Monte Carlo simulations, curves were developed to identify the probability of finishing the job at certain costs. It was important that the budget for the project was an amount that had a 90% probability of covering the project cost.

Figure 51 shows an example of the curves where the project had a 50% probability of finishing with a cost of $307 million and a 90% probability of finishing with a cost of $350 million. Therefore, the budget for the project was set at $350 million, with a 90% confidence level of finishing the project within budget.

The curves all were based on data. On this project, a cost was developed from all the data that the owner and DP thought were germane. A probability curve then was developed using the process just described. Then the contractor was brought on board. The curve began to flatten as the contractor began to identify risks that had not theretofore been considered. The cost estimate began to climb accordingly as the contractor brought in all constructability issues.

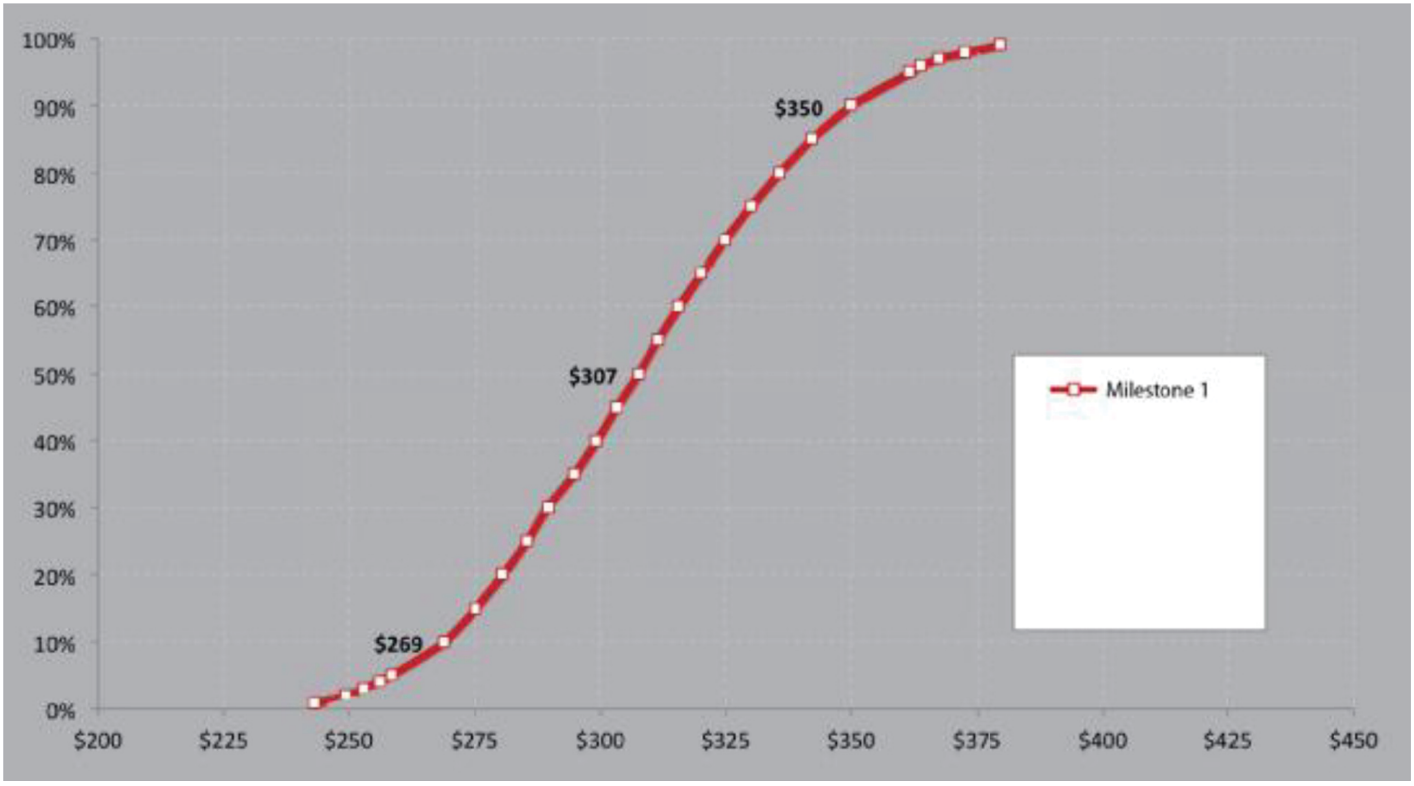

Figure 51. Curve after original risk register.

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The next time the project was priced, the team had been able to retire several risks, and the contractor had led the team to numerous innovations. As the team got rid of those risks, the price began to fall, allowing the team to concentrate on the biggest risks and how to get them off the list or at least mitigate them or assign them to the contractor or owner, depending on who could best manage them.

At this point, the team was carrying $50 million in contingency, based on what the contractor thought it could deliver. As the contractor got more confident, the contingency fund went from $50 million to $30 million. That money was reinvested forward in more ROW and then ultimately in extending the project. As the process of identifying, assigning, and eventually retiring risk continues, the curves are updated. Figure 52 shows the curves for the same project as shown in Figure 51 after subsequent quarterly reviews allowed the team to first identify more risks and then retire risks.

This whole process happened four times within about a year until the design was completed, but the risk register was updated about quarterly through the whole job. As risk was retired, contingency was retired in kind. A 90% confidence level of delivery was always carried, but that amount kept falling as risks were retired.

Also within the CMGC contract were provisional sums. The team would discuss every item and who should take the risk on it. Take for instance, untreated base. UDOT would tell the contractor that it (the contractor) was best to handle that risk. UDOT perhaps would not take tickets, so that if the contractor were not sloppy with its construction and did not spread the material out to the side further than needed, it would make out fine. UDOT would offer to pay based on plan quantity. So the contractor accepted plan quantity and priced accordingly. In this way, there should be no overruns unless there were changes in the design plans. Provisional sums

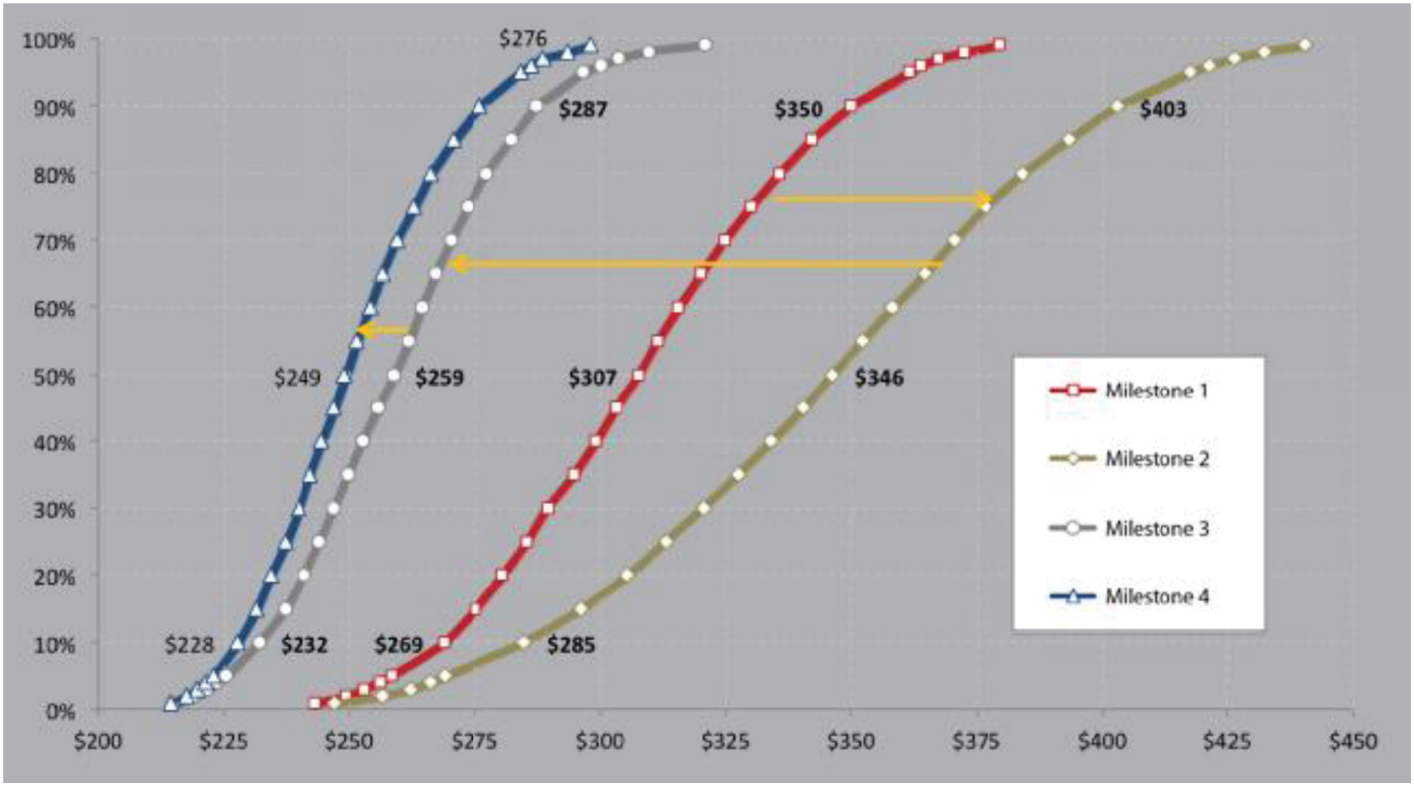

Figure 52. Risk curves on the same contract as Figure 51 after four risk registers.

were deemed a shared risk. UDOT said that in 15 miles of new corridor, it is likely to have some soft spots that UDOT proposed to pay for instead of the contractor pricing for soft spots within its earthwork price. That way, there is no money changing hands if there are no soft spots. This was written up as a provisional sum and assigned a certain dollar amount for soft spots. The project ended up with very few and small soft spots. Those savings went back to the owner, even though they were in the contract. There were a number of things where the team agreed that if something were deemed 75% likely to happen, then a provisional sum would be assigned for it. It so happened that very few of the items assigned provisional sums were realized, and the money that came back to UDOT went into the fund that ended up allowing the purchase of the additional ROW and construction.

This was not only a good move financially, but it also eliminated the need for renegotiation of the cost of any item. Another example was when the project's ICE suggested that the contractor crush stone onsite, which would be much cheaper. The contractor replied that it did not want to take the risk of crushing onsite because one does not really know until the crushing operation has really gotten into the materials whether onsite crushing is feasible. UDOT then decided to take the risk on that. At that point, the contractor could price the job based on crushing onsite. If it had turned out that it could not crush onsite economically for the price given, then UDOT would consider a price increase for crushing onsite or for bringing in crushed stone from offsite, but not without agreeing on the price first. The parties agreed on the cost to haul in the material from offsite, and UDOT held the money. As it turned out, the contractor was able to crush all onsite and did not have to haul any materials to the site. This money also went toward expanding the project.

ROW acquisition was all owners' risk, so if ROW delivery was delayed, the team would fall back to a secondary plan. The things such as ROW delays that had the highest potential to delay the project had been identified, and prices had been negotiated for the contingency plan assigned for each. If the unwanted delay occurred, the assigned and appropriate contingency plan was executed and the previously negotiated prices paid.

The DP's responsibility for keeping costs within budget focused on monitoring its own budget and making sure the design budget was not overrun and delivering a responsible design that could be built within the budget. Coming up with the innovations to help make this happen was the role of the whole team. So the DP, as well as the contractor and owner, participated in a process called a decision analysis by ranking techniques (DART) decision. This software will determine what any change will cost in terms of design, construction schedule, and construction. Ultimately, DART tells the decision makers whether the change being considered will save money or whether the cost for designing, construction delays caused by the change, and the construction cost of the change will be less than or greater than the benefit derived from the change.

Any innovation idea from a team member was run through DART. The DART process documented $25 million in savings from things that team members brought into the process which were not part of the original plans for the project. All of this money was saved prior to construction.

DART basically analyzed any innovation and rendered an opinion. It was a cost-benefit analysis, but it also required a series of signatures. Once DART rendered its recommendation, the innovation made its way through a process. Sometimes, the innovations got stopped before they made their way completely through that process. Ultimately, for implementation, there was a management team which had to recommend that the innovation be implemented. If the recommendation was to implement, there was implementation; if not, the issue was filed away and usually forgotten. The same innovation should not be brought up over and over, and this rarely happened.

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Table 27. Reinvestment of MVC funds beyond original construction limits.

Reinvestment	Reinvestment Amount
Golf Course Reconstruction	$18m
Kern River Gas Relocation	$18m
Residential Relocation (150)	$40m
Kennecott Rail Line Relocation	$11m
Rocky Mtn. Power Relocate	$20m
Water Tank Relocation	$4m
Additional Earthwork	$6m

The contractor was retained for the CM (preconstruction services) portion of the job when the design plans were roughly 30% complete. Approximately one year was spent interactively producing the design plans, doing constructability reviews, adding innovations, and pricing the job. Once the team was satisfied that they had a good, constructible set of plans and appropriate pricing, they entered into a construction contract with the contractor. The owner, PM, DP and contractor (CM) all participated in bringing innovations and constructability to the project during the design phase.

After all was said and done, the process to review risks every quarter that included risk registers, DART, risk assignment, and risk retirement allowed UDOT to save and set aside about $117 million. All of this money was used to extend the contract. Table 27 identifies specific reinvestment of MVC funds beyond originally scoped construction limits (north of 5400 South). These items were added gradually over time as risks were reduced and contingency could be reinvested.

Constructability/Value Engineering

Constructability reviews and value engineering were much different on MVC under CMGC than under previous projects using DBB. On DBB projects, it was a constant struggle to get constructability reviews because contractors do not want to talk as a group. Even if they can be isolated for a private discussion, they still do not want to divulge anything that they might want to implement after the contract is signed. This is a big frustration for UDOT and the project DP.

Also, trying to evaluate a VE study without involving of the contractor that is going to build the project in the process is more difficult. The preconstruction team does not get the full benefit of the process without having the person who is actually going to build the project at the table.

With CMGC, the constructability reviews and value engineering are just part of the contractor's CM (preconstruction services) contract. Also, instead of savings being split between owner and contractor—or all retained by UDOT as happens with DBB projects—the savings of these processes on MVC went toward buying additional ROW and building additional highway.

Other Issues That May Affect or Be Affected By Design Management

Paying the Contractor

The contractor was paid unit price. The unit price sometimes changed based on whether or not UDOT wanted to take the risk on an item or give that to the contractors, so there was that kind of back-and-forth. The standard bit items used in a DBB contract were not always used;

the actual pay items were chosen based on which party ended up with the risk. Payments to the contractor were based on a cost/resource-loaded schedule produced by Primavera. There was some resistance to basing payment on the schedule early on, but it proved effective and accurate once the project had gone through the whole process one time. A schedule update would be completed before each payment was made to the contractor; the schedule had to be approved before the payment was made. Of course, this made for more detailed questions that had to be answered every month by various team members, which led to more effort to find the answers. In the end, this only made the parties to the contract more familiar with the details of the project and the contract, which strengthened the team and added to cohesiveness. All in all, the practice of paying from the cost and resource-loaded schedule ended up being a powerful and valuable tool that allowed the team to determine how much work had been done, how much remained to be done, and whether payments for work were completed at the right times.

Case Study—Program: Oregon Department of Transportation (CMR)

Introduction

The Oregon Department of Transportation (ODOT) has executed approximately three projects with the construction-manager-as-general-contractor (CMGC) construction project delivery system since 2011.

Program Description

ODOT employs several methods of managing post-award design activities when using the CMGC project delivery system. The agency's process allows designers to adjust their plans with "real-time" information provided by the CM firm. There are written standard operating procedures for the design of CMGC projects, and the agency utilizes program management contracts. While the agency has worked on only one project under a management contract, it did work well with CMGC.

The function of the project management is "absolutely" different from that of a typical design-bid-build (DBB) project in that they are not entirely used to value engineering and allowing the CM contractor to take the lead. There is a completely different mindset under CMGC than in low-bid, and release of control was the biggest problem.

The ODOT design project called for multiple "mini" GMPs—in retrospect, perhaps too many. The typical design milestones utilized in a CMGC contract are traditional percentage complete phase submittals (e.g., 30%, 60%, 90%) followed by a final PS&E.

The designer is required to assume less risk on a CMGC project, and steps are taken to manage risk during design and to share risk among the owner, designer, and CM. During the design phase, the designer is designated as the owner's representative; in fact, ODOT has an agency project manager that oversees design. The designer also assists in choosing the CM firm.

The approach for managing post-award design activities for CMGC was similar to those used with DBB activities. While there were some differences, overall the two are very similar.

RFIs and shop drawings on CMGC projects are managed by a lead for the design firm. Primary lead in coordinating design changes (with designers) during the design and construction phases is accomplished by the CM manager working with the agency's representative. The design firm is responsible for covering design errors and omissions during design and construction.

With respect to goals and objectives that were set for this particular CMGC design project, ODOT ranks political input as the first goal, time second, and cost as the third. As the project entailed a major Interstate highway, a dense political climate and the inclusion of community involvement were high on their list of objectives.

During the design and construction phases, certain communication channels were employed. Among them were agency representatives as well as required co-location among the CM, design firm, and owner's representative. During construction, the designer's role was that of handling design changes, contract modifications, and other responsibilities for the EOR. In fact, due to numerous site condition changes, the designer was as active during construction as it was with design.

Regarding how the agency's post-award design management affects project performance in terms or cost, schedule, and quality, the design standards and specifications are no different under CMGC from those used on a typical DBB project.

The role of the CEI is the same as that of one under a DBB contract. The CEI is not involved during the design phase—it is involved once actual construction has commenced—and the coordination between the designer and the CEI is different than under DBB.

CMGC designs typically come under budget, and factors that most significantly contributed toward this result include constructability reviews provided by the CM. The CM participated early in design, and its constructability input saved ODOT considerable money.

Additional fees are not included for the designers for coordination with the CM (and vice versa). Approximately 11–15% of the construction cost is typical for the design fee, and this percentage is higher than what is typically experienced on DBB projects.

Concerning the use of multiple GMPs, the total cumulative project costs are calculated during the design process as opposed to being calculated up front. Design schedules typically have similar durations to those of DBB projects. The responsibility for creating and monitoring the design, construction, and overall project schedules is a collaborative effort between the designer and CM. On average, CMGC provided a 25% time reduction in project delivery. However, it should be noted that this was not an accurate average calculation but rather an approximation for only one project.

For ODOT, the owner's representative manages design changes as they relate to potential impacts to the schedule, budget, and overall GMP. This is primarily because it affects both the designer and CM. The Independent Cost Estimate process entailed the use of a third party firm (located out of state) along with both the designer's and CMGC's estimates. Having three estimates to compare worked well in identifying several cost savings options, and the agency would certainly use the process again in the future.

Generating traffic control plans is presumed to be the designer's responsibility, with input from the CM; however, there was noted uncertainty in this response. There were no reported steps for the client to take in minimizing problems during construction.

The quality control (QC) process for design used during the design phase differs slightly from that used in the construction phase. Notably, QC shifted during construction to have the CEI oversight firm handle QC responsibilities. As a means to communicate the owner's expectations for how design quality assurance (QA) and QC are to be ensured throughout design development under CMGC project delivery, ODOT employs design QC templates, plan templates, and expressed expectations in the A&E contract; and all are requirements for those proposing.

Interviews

Interviews were conducted with eight individuals who have worked with ODOT. These interviewees included three owners (or agents of the owner), two designers, and three contractors.

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When asked about the utility coordination process on a CMGC project, seven interviewees described the process as different from that of a typical DBB contract; however, one individual said that it was the same. Coincidentally, seven individuals commented on early involvement by the CM (relating to how things are placed and/or constructed), and one interviewee remarked about earlier involvement in the process by the entire team.

Seven interviewees said that the coordination process started earlier on a CMGC project than on a DBB project, and one interviewee said that the utility process started at the same time. The one singular individual also remarked that the design firm is responsible for determining utility conflicts and coordination during the early design stage.

When asked if the traditional duties of the design team (e.g., permitting, project management, utility coordination, overall project schedules, and owner's representative duties) are different on a CMGC project compared to a typical DBB project, seven respondents said that they were different, while one said that the traditional duties are the same. Additionally, the individual made the following remarks:

1. The team works on all these issues with the designer being the lead (2 said this).
2. It's a more concerted effort and requires considerable teamwork and coordination.
3. The process was more involved and time consuming relating to the designer's role.
4. The CM helps the owner satisfy the completion date, ensuring high quality plans and early work amendments.
5. There was input from all team members versus segmented design and construction.
6. The expectation is that design by the A&E firm would mirror that by the agency's design team with minor differences (e.g., collaboration with the CMGC, independent cost estimates).
7. All eight individuals said that the process employed by ODOT enables the team to permit and design the project in small "mini" phases and that the design process is tailored to begin construction early rather than at the traditional final plans stage.

Furthermore, they made the following comments:

8. The work was started early and planned to be phased with early work packages (2 said this).
9. Early work packages are part of ODOT's CMGC procurement process.
10. This was critical to moving forward with the project.
11. Starting the project early was vital, politically, and was the number one priority.

When asked how important it is to educate the designers early in the process to ensure a collaborative effort, a few of the respondents said that it was extremely important. Two respondents also mentioned that co-housing was critical and/or a major key to the success of the project. Additional comments include those found in Table 28.

Table 28. Importance of educating designers.

Statement	Respondents
Education is extremely important.	4
Co-housing is critical / one of the major keys to success.	2
Independent estimates should be performed using contractors/entities with direct local construction bidding experience.	2
The three-team approach (i.e., planning, design, and construction) in CMGC is different from what A&E design firms are used to.	2
It is vital to start early work packages with designers to take them off the critical path and on to other design packages.	1
The CM's estimate must be part of the contract documents.	1
Assumptions and clarifications must be part of the contract documents.	1
Owners must be at the table from the very beginning.	1

Table 29. Comparing challenges encountered in the design and construction phases.

Statement	Respondents
Managing of personalities and agendas is a huge challenge.	3
Designer, owner, and CM must understand their mutual goals.	2
Construction team personnel need to be assigned at the beginning of design to ensure commitments and budgets are known during construction.	1
Estimating throughout design and construction are different processes.	1
Auditors were not necessarily used to the CMGC method, versus low-bid.	1
The construction phase brought challenges of savings justification (i.e., methods were discussed during design and incorporated during construction, but the risks encountered by the CMs were overlooked).	1
Every CMGC project is typically a new owner, and the training process starts all over again.	1
Owners and designers are not used to negotiating numbers directly with the CM.	1
Design is very time consuming and continues through construction.	1

Interviewees were asked to compare the challenges typically encountered during the design phase to the challenges faced during the construction phase. Notably, several individuals mentioned that the managing of personalities was a major concern. Also, ensuring individuals are informed throughout all stages of the project permeated the interviews. Additional responses are found in Table 29.

When asked what level of executive and middle management commitment is required to successfully execute a CMGC project, more than half of the respondents mentioned only "decision makers." Others mentioned the need for significant management and commitment at all levels. Additional responses are listed in Table 30.

When asked what role the CM plays in the overall design process, several interviewees commented on the active and collaborative role they must have with all other members of the team. Further remarks are included in Table 31.

Money Matters—Cost, Budget, Payments, Benefits

Interviewees were asked what their agency's best practices were to ensure that the construction costs are kept within the budget. Among the responses were suggestions to include innovation and early estimates. Involvement by key personnel—and exclusion of non-essential stakeholders—also was a recurring trend. Other responses are found in Table 32.

When asked who is responsible for monitoring the project budget (including design, inspection, permitting, right-of-way, utilities, construction, etc.), seven of the respondents said that the owner was. The eighth respondent said that the agency is responsible for monitoring the design budget and the CM is responsible for monitoring all construction-related costs.

Table 30. Level of executive and middle management commitment.

Statement	Respondents
Only decision makers are required.	5
High level of management is needed.	2
Commitment by all levels is essential to the success of a CMGC project.	1
Clear understanding of the CMGC concepts is important.	1
The PM staff should be secondary (to the decision makers).	1
Without the "right people," project intent, pricing, and schedule can be compromised.	1

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Table 31. Role CMGC plays in the overall design process.

Statement	Respondents
Play an active role to capture the benefits of the CMGC process.	3
Play a team role.	2
Be an active advisor to the designer and owner.	2
Develop detailed cost estimates.	2
Provide constructability review services.	2
Provide alternative methods for construction.	1
Provide risk analysis and assessment.	1
Develop and update project schedules throughout preconstruction.	1
Collaborate with the agency and A&E in the development of early work packages.	1

Table 32. Best practices to ensure that construction costs are kept within budget.

Statement	Respondents
Innovations and modifications (i.e., more efficient means and methods).	3
Detailed/early estimates and understanding what makes up the overall budget.	2
Control owners from allowing external stakeholders (i.e., citizens' groups, politicians, etc.) to make demands.	2
Early contractor involvement.	1
Keep tabs on architectural features / keep the job design basic.	1
Discuss budgets initially with project team / phase the project to design and build within budget.	1
Review of cost estimates by an independent cost estimator *(ODOT's current process is to assume all risk in pricing in order to manage cost).*	1

When asked what the designer's role was in the CMGC process, the interviewees referenced involved responsibilities with both the design and cost estimate of the project. Established relationships with the CMs and owners also were highlighted, especially with regard to making scope-involved decisions. Additional responses are found in Table 33.

Several payment tools have emerged across the nation for progress payments on CMGC projects, including unit price, lump sum, and cost-reimbursable. The interviewees were asked to describe the ones they have used as well as the advantages and disadvantages. Their answers are listed in Table 34.

When asked which contract type best describes the CMGC process as their agency administers it, eight individuals said unit price, five stated lump sum, and four mentioned cost-reimbursable.

In the instances where the respondents mentioned use of lump sum and cost-reimbursable, they were subsequently asked how they paid the CM and designer on federally funded projects. While three individuals were excluded from the questioning (as their responses from the previous question were specifically "unit price"), three made mention of a combination of unit price and lump sum. The full responses are seen in Table 35.

Table 33. Designer's role in the CMGC process.

Statement	Respondents
Work with the CM and owner to bring costs under budget.	2
Come up with alternate designs and possibilities for the CM to price and propose modifications to.	2
Guide the owner in selecting design options.	2
Estimate the design as it is being completed.	2
Ensure that the scope is within the true market value.	1
Estimators working as program managers must have local experience.	1

Table 34. Payment tools used, advantages, and disadvantages.

Statement	Respondents
Production risk should stay with the contractor.	3
Owner should not micromanage the costs by the contractor and should stay away from making a low-bid project.	2
Preferably, all three methods should be used.	1
Unit price, overall, with elements of lump sum and reimbursements should be applied.	1
CM should reap the savings (i.e., if there is an overage, the CM is responsible for it).	1
CM should have input as to which payment method is best for the CMGC process and the project.	1
Payment should be a different process and not a low-bid process of pricing.	1
For preconstruction, the CM is paid on a monthly basis based on hours per task. Construction services are paid on a lump sum basis, prorated monthly *(ODOT also withholds 2.5% retainage for each monthly progress estimate).*	1

Table 35. Payment for CM and designer on federally funded projects.

Statement	Respondents
N/A – (previous responses for payment type was "unit price")	3
Combination of unit price and lump sum (subs are bid by the CMs using unit prices and they convert them to lump sum if needed)	3
Preferably, a combination of unit price, lump sum, and cost-reimbursable	1
For preconstruction, the CM is paid on a monthly basis based on hours per task. Construction services are paid on a lump sum basis, prorated monthly (ODOT also withholds 2.5% retainage for each monthly progress estimate)	1

Interviewees were then asked if their method of paying the principals and their record of payment documentation satisfy FHWA auditors. All eight responded "Yes." Notable comments to these responses are as follows

1. Though satisfying FHWA, internal DOTs and their auditors were not satisfied **(3 said this).**
2. Independent audits are not proceeding well. (Does not involve FHWA, but were requested by the owner as part of the CM process) **(2 said this).**
3. DOJ auditors have had some issues with how the project was paid.

Asked how constructability reviews and value engineering are managed versus a typical DBB project, a large majority of the respondents mentioned that weekly meetings were conducted with the lead and that all the team discussed design steps (see Table 36). It was also noted that ODOT performs value engineering on select projects only and that value engineering and constructability reviews are ongoing throughout the project and rely heavily on the CM.

All eight respondents said that the design, construction phasing, and materials are selected and modified/substituted during the design process in an effort to bring projects in under budget. Among the responses, the interviewees made the following supplemental comments:

1. The team worked closely together, in real time **(5 said this).**
2. Bringing in other municipalities and stakeholders was an advantage.
3. ODOT has a "Changes to the Work" article allowing adjustments to the GMP.

Table 36. Management of constructability reviews and value engineering.

Statement	Respondents
Weekly meetings were conducted with all the leads.	7
All the team was present to discuss design steps.	6
ODOT performs value engineering during design, but only on select projects / VE and constructability are ongoing and rely heavily on the CM.	1

Table 37. Design steps taken to minimize remobilization.

Statement	Respondents
Bid mobilization in the original package and only add in individual early work packages.	3
Coordinate up front.	1
Discuss phasing up front.	1
Mobilization was only needed one time, and the CM was prepared to build the project in phases.	1
No fees were charged for mobilization as part of the contract.	1

Issues Affecting or Affected by Design Management

The engineer's estimate, when using CMGC versus a typical DBB project, functions as a comparison tool for most of the respondents. Seven respondents mentioned how the engineer's estimate was used as a baseline, ensuring that the costs from the CM are fair and reasonable and forcing the CM to adhere to the estimate prices. Notably, the eighth interviewee said that engineer's estimates are not typically created for CMGC; the A&E design firm, CMGC, and agency all provide cost estimates, which are compared to develop the final cost estimate.

Seven respondents said that the engineer's estimate was less important. The reasoning for this was described by the following comments:

1. Engineer's estimates are taken out of context of the real work and what the team is doing in relation to the risks and challenges **(4 said this).**
2. Engineer's estimate did not reflect the true cost of work where the work was being performed.

When asked what steps could be taken during the design phase to minimize or eliminate potential remobilization-related cost and schedule impacts resulting from delays in right-of-way acquisition, permitting utility relocation, or other unanticipated delays, a few individuals suggested bidding mobilization in the original package. Further suggestions were to coordinate up front, mobilize only when needed, and discuss phasing up front to prevent mobilization (see Table 37).

According to seven respondents, the entire project team should be involved in coordination meetings (during the design phase). Furthermore, according to five respondents, the owner typically leads the meetings with the designer taking a very active role. One respondent mentioned that the designer initially ran the meetings, and the owner and CM were both active. However, one respondent mentioned not being involved in the meetings.

Seven respondents stated that the level of coordination required for a CMGC project is more than that required on a typical DBB contract.

When asked what educational effort/training was required for the owner's staff, design consultants, contractors, and CM firms to transition from the traditional DBB world to CMGC, there was a variety of responses (see Table 38).

Table 38. Training required to transition from DBB to CMGC.

Statement	Respondents
Project must not be treated as a low-bid process (it detracts from the CMGC advantages).	3
Intense partnering meetings were required up front.	1
Overall mentality must be changed from a low-bid to more of a DB mentality.	1
Understanding pricing and sharing how subcontracting is done is critical.	1
There must be a project-first mentality versus a low-bid or company mentality.	1
Training should have been available.	1

Table 39. Changes in culture and philosophy required of contractors and designers.

Statement	Respondents
There cannot be individuals who are out for themselves and impede teamwork or progress.	4
There cannot be mistrust within the team concerning costs.	2
Get away from the mindset of DBB.	1
Agency staff versed in alternative contracting are few.	1

Table 40. Level of industry collaboration and support.

Statement	Respondents
Extremely high level of collaboration/support.	6
Stakeholder involvement was important.	1
Industry personnel with previous experience in CMGC were heavily relied upon.	1

Table 41. Ensuring value-added guarantees in CMGC contracts.

Statement	Respondents
Early CM involvement in the design and budget	4
Teamwork to ensure VE is performed and innovation is implemented	2
Team required to co-locate and work on the project daily	1

Changes in culture and philosophy needed by the contractors and designers (versus traditional DBB) include mostly selfless attitudes and trust. Specifically, the respondents made the comments seen in Table 39.

When asked about the level of industry collaboration and support required to successfully execute a CMGC project, many respondents said that a high level of both are needed. Further support should come in the form of stakeholder involvement and previous experience (see Table 40).

Interviewees were asked how right-of-way acquisitions and permitting were handled. One individual said that they were handled in-house during the design and construction phase. Four said that the right-of-way was managed by the owner's PM and in-house ODOT departments. Three others said that right-of-way was managed by the program management firm.

Regarding how utility companies and permitting agencies fit into the project team and design process, seven individuals specified that meetings were held to include them in the process as early as possible.

When asked how they ensure value-added guarantees in their CMGC contracts, most of the interviewees mention early involvement. Additional responses are included in Table 41.

Case Study—Program: Osceola County, Florida (CMR and CM/GC)

Introduction

In 2007, a newly appointed team assembled in Osceola County, Florida, was faced with a unique and daunting challenge. Three previous county administrations and their staffs had been removed by the Board of County Commissioners for failing to deliver an aggressive impact fee-funded roadway program totaling approximately $1 billion. The program required the concurrent construction of nine to 11 major roadway projects with an additional seven being completed in design each calendar year, beginning in the first year of the newly adopted impact fee ordinance. This ordinance had set some of the highest impact fees in the nation, which discouraged construction activity and resulted in very few projects being attempted. Based on the requirements set forth, the county was eighteen projects behind schedule, totaling more than $400 million in design and construction. Less than seven years into the program, there were $5 million in change orders for which nothing had been accounted. Designs were as much as 200% over budget, in some cases remaining at the 30% design phase for more than eight years. One project had taken 18 years from start of design to completion of construction. Lack of solid leadership by the county staff and administration resulted in 18 different projects at various stages of design with none being truly ready for construction.

Design and construction consultants were frustrated by the lack of clear direction from county staff and the numerous inconsistent and costly changes. Initially, when looking into construction-manager-at-risk (CMR), very few design professionals (DP) were strong advocates of using the system for such a large program (18 major roadways). In their opinion, the county did not need to add yet another layer of management to an already overburdened, costly, slow, and bureaucratic system. Furthermore, they believed that CMR was an unproven method for roadway construction and that the outcome could be catastrophic. Many design firms believed that the proposed constructability reviews overlapped those being covered under existing design contracts. Several firms had existing PM contracts with the county, which they believed performed the same services as a CM firm.

Another concern was that involving a CM firm at such a late point in the design stage would increase the design budgets, which already were spent in many cases. They also believed that coordinating with the CM firms would be very costly in terms of time, which they could not afford to lose in such a challenged market. These all were valid concerns but proved to be incorrect.

Program Description

The CMR program in Osceola County largely has been disassembled through the efforts of those within the county government who opposed the use of CMR from the start and led to the firing of the County Administrator in May 2010. The Public Works Director and Assistant

Director resigned immediately thereafter, thus ending a program that had brought national recognition to the county and the three leaders of the administration.

In order to begin this program, a tremendous training effort was initiated, which focused first on the design community. The program internally was working against a group of county commissioners and a county legal department who were against the implementation of CMR, the skeptical design and construction consulting communities, and the local road building contractors.

CMR differs from construction-manager-as-general-contractor (CMGC) mainly in the area of self-performance by the CM. CMR, as practiced in Osceola County, prohibited the CM from self-performing any work. This is similar to the CMR program operated by Florida Department of Transportation (FDOT), which prohibits the CM from self-performing any work unless the CM outbids potential subcontractors for major items of work. These policies contrast with those of the CMGC programs of the western U.S., where the CM—referred to there as "the contractor"—is compelled to self-perform 40% or more of the work. However, from the design aspect, there should be very little discernible difference, if any, between the two delivery systems; therefore, through the rest of this case study, the program will be called CMGC. This will allow for more consistency with the rest of the report.

During the life of the Osceola County CMGC program (defined as from the time of implementation to the time when the political enemies of the program had their way and began to dismantle it), the program executed nine CMGC projects, beginning with the first in 2008.

Due to the fact that the administration inherited a program in disarray, CMs were brought in at all phases of plans completion, depending on the point in the design process at which the decision was made to deliver the project using CMGC. It was determined that using CMGC and bringing in the CM improves the projects immensely, regardless of how much of the project has been completed. Having seen the results of bringing in the CM at all stages of plans completion, the conclusion of the administration is that, if given an opportunity, the best time to bring in the CM is simultaneously with the DP. Doing this requires limited CM staff to be brought in (with limited hours) as the budget can be affected significantly if right-of-way (ROW), survey, permits, etc., are just beginning. The results of the administration's experience of the subject were that bringing in a CM, regardless of the timing, significantly reduces changes, delays, constructability issues, and schedule challenges, as well as increasing ease of contracting and procurement.

In many cases, the program called for the establishment of a guaranteed maximum price (GMP) prior to preliminary plans for early work items, materials ordering, additional geotechnical work, etc., based on only a description of the scope required. In addition, GMPs were priced at the 0%, 30%, 60%, and 90% plans stages. The final GMP typically came at between 90% and 100% plans.

ROW acquisition began at the earliest point possible in an effort to efficiently and wisely design projects and minimize the ROW required. This also assisted in wise choices of ROW based on market conditions and friendly takes rather than eminent domain. Previously, ROW acquisition did not start until 100% plans using DBB, which delayed projects 18 months or more. When it was not possible to start the ROW early—as in the case when the administration inherited plans sets already complete or nearing completion—the CM process allowed for adjustments in construction and working around the ROW issues rather than having to wait until all issues were resolved prior to starting construction.

Quantity take-offs, computation books, and bid summary sheets (as a requirement of the DP) were eliminated, which significantly reduces the risks taken by the DPs. These items were the responsibility of the CM as part of the GMP. Quantities were the responsibility of the CM,

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which enabled the DP strictly to design instead of being concerned with plan matrices, quantity take-offs, etc. This practice also reduces the DP's scope and cost of design and converts the design plans to construction plans rather than bid plans. Streamlining the plans and scopes is a key principle in keeping costs of CM under control as administratively it can be much more expensive if not controlled with de-scoping items such as above.

Fees were inserted that contractually required the CM to coordinate (throughout the design) and attend all weekly and daily design meetings. This is essential to coming up with value engineering (VE) options and designing smartly to reduce overall project costs and make up for coordination costs and the CM's overall fees. CM meeting attendance also is crucial to obtaining the benefits of CMGC pertaining to reduced project costs; without this, the advantage of bringing CMs on board is reduced significantly if not eliminated altogether.

Innovation was required to complete all projects under budget. During initial partnering meetings, the team agreed to the cost reductions required to meet the aggressive budgets. This is a critical principle in making CMGC successful; the team, upfront and prior to the beginning of the project, must buy in to the fact that significant cost reductions are essential. In Osceola County, the owner and the CMs realized the cost savings; but in reality, it should have been split proportionately among the team to be fair and to incentivize the team to push for cost savings. The cost-cutting goal must be a clearly defined number in order to make the targeted budget.

The difference in the design process between CMGC and DBB is that with CMGC, projects are designed basically around a table during weekly project meetings with the entire team present rather than in a design office with little or no active involvement from the team. Plans also were streamlined from bid sets to construction sets, which is a completely different process than that of DBB. The purpose of the design is to provide the most innovative, cost efficient, and light set of plans possible—versus a heavy design effort—to give the CM just the right information to bid the project. The intensity of the design effort is in the planning—not in plans production.

Though there was no specific training program for proposal evaluators, the administration was extremely selective about who was put on the panels. Panel membership was restricted to senior leaders who had major PM experience and had intimate and clear understanding of the project challenges as well as the CM and design team required to meet the project goals and objectives successfully. The head of the panel was the Project Leader (PL) for the entire $1 billion program, which was essential for the guidance of the entire panel. In addition, the administration used consultants as advisors to the panel to assist them in making the best choice to meet the stringent project requirements.

Design PMs (internal to the department) would review the plans and ensure that they met the intent of the owner. Consultants and full-time staff who worked as design and construction PMs were hired to review design submittals for compliance with standards/criteria and to oversee the project for the owner. These were co-housed to avoid distinction between internal staff and consultants. Also, the whole team was involved in the RFP development process, including the CMs and DPs; and the administration asked CMs to provide examples of RFPs that had been used in the past as part of market research prior to releasing RFPs and contracts.

Initially, the typical design review submittal phases were required; but as the administration evolved, it reduced formal submittals significantly. The goal of CMGC was to review the plans during the weekly design/production meetings and produce construction-ready drawings rather than bid sets. This increased significantly production rates for design and all but eliminated lengthy owner review phases. This process also avoided touching plans twice, as the plans review is done in real time and, once put in ink, has been approved by the team. Reviews are conducted only to ensure that these decisions made it onto the construction sets.

Each of the DP, contractor, and owner is the best at what it does; as such, each is a specialist on the team that cannot be replaced. Each is highly valued by the other team members and has an equal seat at the table. No one member dominates the team. The following steps can help make this possible.

1. Require the PL to be in all production meetings to maintain cohesiveness and teamwork. There is no substitute in CMGC for top-down leadership.
2. Bring all players to the table early in the scoping and budgeting process and include subcontractors.
3. Have an upfront partnering retreat to introduce each member and build positive relationships. The partnering meetings also can be used to train team members in the nuances unique to CMGC, such as communication.

The surveyor and geotechnical engineer should be at both the preliminary scoping and budgeting meetings. This is essential to having effective overall plans for the project as well as for constructability and design issues. They should have an equal seat at the table.

In Osceola County, the entire team was responsible for public involvement during design. This is very different from the process in DBB. The CM and the entire team are intimately involved and aware of all issues, goals, and objectives relating to public involvement, so utilizing them for that purpose only makes sense.

Tremendous money, time, and changes are saved when the CM firms and the DPs work together to produce the plans and phasings for the projects. Utility relocation preferably was handled with the entire team during the production meetings, with the relevant utility companies present during the early scoping of the project. This is essential to keeping a CMGC project within budget and schedule. Failure to do this effectively can lead to a GMP that is neither valid nor accurate and a project that cannot be constructed within the schedule and GMP.

Interviews

Interviews were conducted with the Public Works Director and Assistant Public Works Director from Osceola County. These men, along with the County Administrator, built the CMGC program from nothing in a matter of months.

Approach for Managing Post-Award Design Activities

Successful implementation of CMGC in many cases requires a significant and aggressive change in the culture and philosophies of the DPs from that of traditional DBB design projects. The standard design methods, schedules, and plans review stages frequently used in designing DBB projects may prove to be inadequate or insufficiently accelerated to realize the aforementioned advantages of CMGC. DPs are required to take a much more active role in working with the owner and CM for early and continuous VE, ROW phasing, real-time pricing, increased coordination meetings, accelerated designs, etc., during the early stages as well as throughout the entire design process. DPs must budget additional funding and management personnel for frequent team meetings and binding decisions while working with both owner and CM.

The Osceola County program allowed the designers to adjust their plans at any time using real-time information provided by the CM. The CM and DP met weekly to go over design and construction operations from the beginning of the design phase until the end of the project. This process works both ways, as the weekly detailed meetings allow for the CMs to adjust their construction phasing and methods and the DPs to adjust their designs based on myriad factors

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such as real-time costs, materials, permits available, ROW available for construction, and specifications called out.

A complete set of standard operating procedures (SOP) were developed by the county. Initially, the program deadlines were too fast to develop them prior to starting. Limited SOPs were developed prior to beginning the first project, which was critical to the program's success. These were discussed and reiterated during weekly meetings.

Converting to CMGC enabled the county to convert the existing project management contracts into project management contracts, saving hundreds of thousands of dollars. The CMGC process eliminates the need for the PM as the CM manages each individual project and one CM is brought in per project, enabling a large number of projects to be run concurrently without a PM.

Having both a CM and a PM was a duplication of effort and a waste of money and resources. The role of the PM is to enable multiple projects to be run concurrently with little internal staff, which is the same thing that CMGC accomplishes.

The traditional (DBB) project management system needed to be modified. In the CMGC process, the owner's project managers (PM) are managing the DP and the CM rather than the DP and the contractor as in DBB projects. It is the CM's responsibility to manage the contractors and subcontractors.

The owner's PMs also must be trained highly in overall senior project management, as they are required to make binding, real-time decisions with little time to consider their options; to keep up with the aggressive schedules; and speak for the owner at the weekly project meetings. Osceola County required two PMs per project—one for all design issues and one for all construction issues—so that there would be two people at all times who knew the project well and one who completely and intimately understood design and construction principles. This was a critical element to the success of all CMGC projects.

Osceola County CMGC projects all were designed using small mini-phases in lieu of the traditional single large project style. The multiple GMPs were based on beginning construction as quickly as possible on any area within the entire project length; i.e., a pond section or areas where permits were not required or were already obtained or where the county already owned the ROW. This reduces significantly the overall construction and design times, as each segment is constructed as soon as it is available rather than waiting for the entire project to be designed, approved, and permitted and for all ROW to be obtained. The elimination of design reviews was another factor in the program's success. This enabled some projects to be started as early as two weeks after bringing the CM on board. This also enables design mini-sections to be completed, which saves the DPs time and money.

The 30%, 60%, and 90% submittal and review process did not allow for necessary cost savings in every area (design, mini-phasing, construction, ROW acquisition), as it is a relic of the more traditional DBB process, for which it works well. The traditional submittal and plans percentage system was modified significantly into the initial permit packages, i.e., construction sets submitted to the permitting agencies (in an effort to start the permitting process early). Permitting often ends up on the critical path. These plans also were used for an initial GMP and rough bidding as well as for identifying ROW needs. Further modifications then were made, working toward the bid sets in order to bid and determine the true cost of the work. From this point, modifications were made based on numerous changing variables such as mandated permit conditions, ROW procurement status and availability, utilities and easements, VE, and subcontractor constructability involvement. These variables led to developing the final construction plan sets, which then would be signed and sealed just prior to construction starting. Eliminating the

traditional 30-60-90 allowed for innovation, increased plans production speed, reduction in the level of detail required for the designs, real-time adjustment in the plans, and elimination of time consuming reviews. The required and suggested plans modifications were reviewed in the weekly meetings, thereby eliminating the requirement for formal submittals to the owner.

The DP was required, in concept, to share more risks with the owner and CM due to its role as an equal partner on the CM team. This risk was spread as evenly as possible among the owner, CM, and DP. The elimination of the formal plans reviews by the owner put additional pressure on the DP, as they no longer had a traditional, "in writing," formal sign-off/approval of plans on which to fall back. The level of detail required of the plans also was reduced significantly, and in many cases the CM designated standard technical specifications and handled the utility coordination typically conducted by the DP. More reliance was based on the actual performance of the CM and DOT standard practices. However, with increased risks, there also were measurable reduced risks in areas of quantities, phasing, specifications, TCPs, etc. In addition, due to the more aggressive and innovative designs, project allowances were budgeted to account for potential impacts of lighter and faster plans rather than falling back on errors and omissions. If an error was made, the team accounted for it within the overall project budget.

The CM and the owner were required to share part of the risks that were placed on the DP in order (in some cases) to help the DPs feel comfortable being more aggressive on schedules and a reduced level of design details as well as using an increased number of cutting edge designs and innovative ideas, i.e., more aggressive designs in plan sets. Making this shared risk work requires a strong owner and constant assurance that the owner will stand behind its word in sharing the risks and not blame the DP if there are problems during the project.

Initially, it was challenging to convince the CM and DP that neither was the prime owner's representative, i.e., one did not answer to the other. In reality, both parties were owner's representatives, and the project was led by the owner. Although the CM was responsible for the overall project schedule, success, and budget, each team member shared this responsibility in a collaborative effort where the ultimate say and responsibility for everything was the owner. This process needs an active owner—one that will stand behind its decisions and hold each party accountable—to meet deliverables and agreements. This same argument also was applicable to construction engineering and inspection (CEI) firms, who were used to being the sole owner's representatives on projects.

In the case of Osceola County, all DPs already were selected and the majority of designs were well underway when the new administration took over; so they had some input into choosing several of the CMs. If the administration had been seated prior to starting the designs, the preference would have been that both parties have equal input into the selections, i.e., CMs on board for other concurrent projects could have helped with the DP selections for new projects and vice versa. Ultimately, the deciding factor should be the owner, which in the end is responsible for the overall success of the projects.

The additional costs incurred by these coordination efforts should be returned through the savings realized in the VE process and the reduced level of detail required in producing plans and specifications. DPs may need to be educated in the process of receiving real-time input from the CM as well as being flexible in modifying standard items such as traffic control plans to best fit the CM's approach to construction. Plan production rates increase as well, placing additional requirements on the DPs, such as extended work hours, to keep pace with the acceleration and VE changes being proposed by the CM. Successful implementation often requires also that a project be broken into additional mini-phases, enabling the CM to start work early in areas where ROW and permits have been obtained and/or utilities relocations have been completed.

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Early work packages can be broken into such items as retention ponds, partial clearing and grubbing, and constructing on friendly parcel (ROW) takes, which requires more design effort than traditional "station-to-station" designs. Standard items under the DP's oversight, such as utility coordination during design, partially transfer to the CM due to the need to accelerate utility relocations, advance-order long lead items, maintain one point of contact with the utility companies, etc. These shifts in responsibility often are required for the CM to assume and maintain responsibility for the overall project schedule and budget. Additionally, CMGC often results in an increased risk to the DP as plans are streamlined and often are not taken to the level of design detail to which DPs are accustomed. This requires an extreme level of trust within the team due to the CM distributing the risks of the project more equally among the owner, DP, and CM. Overall project risks are reduced significantly in comparison to DBB due to the extensive constructability reviews and cost estimating performed with CMGC.

As with the DPs, the majority of project management firms initially were not convinced that using CMGC for roadways would work. Many of these firms currently performed what they classified as design and construction management and therefore believed that there was a clear conflict between what they already provided and what the CM was going to provide. In reality, this was not the case. The county had been using a failed system of project management whereby three firms conducted the PM for the entire impact fee program. These firms were tasked with managing the design and construction, and the county was tasked with managing the PMs. As noted earlier, the existing program had failed miserably with hundreds of thousands of dollars being spent on project management with little or no construction to show for it. In addition, design budgets were overrun and construction was well behind schedule and over budget. In order to begin this program, a training effort similar to the one aimed at the design community was initiated with the project management community.

The following advantages of CMGC were explained to the DPs that were or desired to be involved in the program:

1. Enables the DP to work daily/weekly with the CM firm to review designs as they are conceived and drawn rather than at 30%, 60%, and 90% plans stages, for constructability, budget, and VE
2. Allows the DPs to adjust their plans using real-time information and costs rather than waiting for a project to be bid or an estimator to review the plans in their entirety
3. Removes the requirement to have 100 percent signed and sealed drawings to bid the work—plans need only to be at a level of completion that allows contractors to estimate the work. The designs still are taken to 100% signed and sealed drawings after reviews and estimates are completed
4. Enables maintenance-of-traffic (MOT) to be designed with the CM actively participating rather than having to change the MOT plans during construction
5. Saves (potentially large sums of) money, as the DP and CM are able to phase construction and permitting in an effort to cut costs and tie the MOT directly to the parcels that currently are owned and permitted
6. Allows the team to permit the project in small mini-phases, allowing construction to begin prior to all design being complete and up to year sooner
7. Allows work to be designed only in the phases needed at the time by the CM rather than having to be completed in the traditional station-to-station manner
8. Guarantees that the estimate from the DP is the actual cost to construct the work rather than having to wait for bid opening or for the construction to be complete
9. Enables the owner to put more designs on the street (due to having a CM staff that works with the DPs on each project) rather than having to individually manage each one with county staff—DPs can compete for one project every five years using DBB or 18 projects in 18 months with CMGC (one project per month)

10. Reduces design fees and scopes due to detailed plans and specifications not being needed—the CM is responsible for all quantities and putting together specifications for the county
11. Enables the DP to be a "true" owner's representative, whereas in D-B the design firm contracts directly with the contractor and thus is potentially loyal and tied to the contractor

The following advantages then were explained to the (construction) PMs that were or desired to be involved in the program:

1. Enables the county to reduce significantly the positions dedicated to internal oversight of the private DPs, thereby potentially reducing up to 40% of the internal overhead
2. Eliminates PM contracts, potentially saving millions of dollars over the life of the impact fee ordinance
3. Assigns two PMs to each project—one for design and one for construction—thereby reducing significantly staff positions and legacy costs; once the projects were completed, these PMs would return to their firms. This allows for program ramp-up during busy times and program draw-down during slow times
4. Enables the PMs to work directly with the CM firms early on, focusing strictly on project management fundamentals such as budget and schedule
5. Allows PMs to work more closely with DPs rather than spending copious time preparing bid and specification packages
6. Enables the PMs to stay clear of the debilitating details of each project and therefore more effectively oversee and lead each project
7. Allows the county to recruit highly trained PMs who specialize in either design or construction rather than being generalists in both

The utility coordination process is different from that of a typical DBB contract. The CM is lead and is over all utility coordination efforts instead of the DP. The DP is responsible strictly for placing utilities on plan sets and coordinating relocations and design details with the CM and the owner. This enables the designers to focus strictly on design rather than coordination efforts with utilities. Utility companies are included very early in the plan development as joint ventures. The utility work is included in many cases under one contract with the CM rather than being subbed out directly by the utilities. This allows for one construction contract, one schedule, and one point of responsibility. It also allows economy of scale with inspection resources.

The utility relocation process starts much sooner in CMGC than DBB as the utilities have direct say in the plan development without being forced to relocate. The CMGC contracts are formed with the utilities up front, enabling better pricing, consolidation of work, efficiencies, and coordination.

The duties of the design team—such as permitting, project management, utility coordination, overall project schedules, and owner's representative duties—are different from those on a typical DBB project. The process is much more of an upfront team effort with CMGC rather than a linear effort in segmented specialties such as design, ROW, bidding, and construction. Traditional duties are redistributed among the team, not being handed off after the above distinct phases are complete. The CM takes over much of the administration of the project up front and through construction, and many of the duties that would be led and handled by the DP (such as utility coordination) are redistributed to the team. Project management also is quite different, as the PMs are working with all professional firms (DP, CM, CEI firm, surveyor, geotechnical engineer) rather than a low-bid contractor. It is critical to the success of this system that the PM be a senior facilitator and decision maker. This also requires much greater experience on the part of the PMs. Permitting becomes a collaborative effort as well, with greater involvement by the CM, team, and owner to meet the fast-track design-build schedules. In addition, the CM and the team—not the DP—are responsible for developing the project schedule, with the owner having active input to the overall schedule and budget.

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It is critical that the designers be educated about CMGC early in the process to ensure a collaborative effort. The entire team needs to be educated early in the process for this system to be the most efficient and to end up with a successful project. Partnering and detailed scoping and visioning meetings were held (CM, DP, geotechnical engineer, surveyor, permitting, ROW, budgeting, owner, utilities, joint municipalities, contractors and subcontractors, CEI firm, PMs, etc.) to ensure that everyone on the team had equal input to the inception and creation of the projects as well as the management roles and responsibilities. Failure to do this results in increased costs and lost production as well as extreme tension among the team members. A strong owner is needed to facilitate these meetings and ensure that the process is executed and led correctly. Continual communication and collaboration are required to run these meetings effectively. An emphasis on tracking the budget and schedules continually also is required to keep all parties on task and accountable.

Designing in mini-phases captures the true benefits of CMGC as the projects can start very early, sometimes one to two years ahead of schedule. This allows the designs to be broken into three to seven permitting and construction phases, which then can be broken into small bid packages (per trade—flatwork, piping, etc.), eliminating the prime contractor's markups up to 30% on some projects and enabling the phases to be permitted individually, which speeds up permitting time as much as 50 percent. Design should begin early when using this process in order to save design fees without having to break an existing design into mini-phases once it is completed. Permitting phases also need to be designed and split apart, specifically taking into account such concerns as different drainage basins and permits in existence, in order to speed up the permit approvals. In addition, mini-phases need to be broken into ROW parcels that already are owned and then in progression of the next ones to be acquired. Starting construction early also reduces the overall length of the projects, which reduces overhead costs for the entire project team.

CMGC requires a much greater and more upfront investment into the project than DBB. This is due to preliminary permitting and ROW acquisition in addition to design. CMGC also takes a tremendous amount of time through meetings, risk considerations, innovations, communication, and time for all team members to brainstorm and solve every issue imaginable that might occur prior to the construction phase. The process, if run correctly, makes the actual construction a simple exercise of putting the highly orchestrated plan into action whereas on a traditional DBB project, construction typically is the heavy (investment) end of the project.

Specific and individual leaders—both at the executive and middle management levels—were recruited heavily into the Osceola County program to take charge of each individual area of design, permitting, inspection, ROW, utilities, geotechnical, environmental, and construction. Without strong top-level leadership, this system can become extremely ineffective for many reasons. CMGC cannot be run effectively on a consistent basis at staff level. In order to work successfully, CMGC must be based on strong executive and middle management leadership (by every entity).

The CMGC process further requires that the owner take an active lead as the PL with the CM assigned as the primary contractual "at-risk" manager for the project. In addition, the owner must commit to be present at all major weekly project meetings in order to expedite decisions at all levels. Plans reviews, budget approvals, ROW acquisitions, etc., must be expedited in order for the system to work efficiently and effectively. Osceola County's program mandated contractually that all principles of the companies—i.e., executive leaders—be present at all major weekly meetings with binding, decision making authority for all consultants, all contractors, the owner, and the CMs in order to ensure top-down leadership and buy-in on the project decisions, schedules, budgets, and activities. This process would not have been as effective with only the typical lower level management PMs being present to represent the different entities such as

design PMs, CM PMs, and owner PMs. All representatives were required to have signature and binding, decision making authority for their company.

The CM is an active participant in the design process, meetings, and design decisions as well as the contractual "at-risk" manager for the entire project. All decisions are joint decisions with the DP, CM, and the project team. This point is critical to capturing the benefits of CM and ensuring that the designs are constructible, within the allowable budget, and on schedule. CMs were required to be engaged actively in this process. One of the primary reasons for this requirement is that CMs were obligated to return the CM fees (in VE savings), thus requiring innovations and cost reductions as part of the design process.

In addition, the CMs were required to take over quantity estimates and matrices, so computation books are no longer required of the DP. The quantities are the CM's responsibility, which takes tremendous risk away from the DPs. Traffic control and construction phasing also are joint efforts between the DP and CM, thereby removing the DPs from the sole responsibility of attempting to phase and control the construction portion of the project. Engineering estimates also are turned over to the CM, removing that responsibility from the DP. These are, in turn, converted into direct construction estimates as they are created with direct input from contractors and subs. The CM also works with the DPs to ensure that what they are designing is within the allowable budget. Therefore, designs constantly are fine-tuned and adjusted to ensure that they fit the budget. As DPs are coming up with design options, the CM is pricing and reviewing them to ensure that they will work prior to proceeding with the design efforts.

Money Matters—Cost, Budget, Payments, Benefits

In order to experience the benefits of the CMGC process, the team needed the ability in most cases to modify significantly the standards and specifications typically used for DBB projects. In these cases, the project team would determine the standards and specifications required on a project-by-project basis, taking into consideration the schedule and budget as well as VE and constructability ideas and requirements. In many cases, the specifications were developed late in the process—after the project and budget issues were resolved—based on what was affordable for the project as well as acceptable to the traveling public and outside agencies such as DOTs, environmental agencies, etc. This was required in many cases to bring the costs down and avoid problems related to overdesign for the sake of reduced risk to the DP and the owner. Improved risk allocation resulted in lowered costs to all parties.

There are several key differences between CMGC and DBB in this area. Standards and specifications are developed by the team using CMGC instead of being inserted by the DP or from the owner's standard manuals prior to bid. In the CMGC process, nothing is finalized as far as what is required or acceptable until the team discusses everything item by item. This was a very fluid and flexible process compared to DBB. In Osceola County, the CM was responsible for inserting many of the standards and specifications into the bids as well as the quantities. As an example, the consultant providing CEI developed with the team's input some of the standards and specifications relating to asphalt, and then the CM inserted them into the plans prior to bid. This was a much simpler process than having a canned bid package prior to bid.

The CEI in many cases was brought into the project very early in the design phase to provide input to the process and was an integral part of the project and design team. In addition, the CEI duties are reduced significantly, resulting in costs savings in some cases of 5% to 7%. In CMGC, the CEI firm is able to be more involved in constructability reviews during design, project specification, schedule development, and QA/QC for design plans and construction operations. Many of the owner's representative duties are reduced significantly or eliminated due to the CM being the overall owner's representative and managing the contractors instead of the CEI

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firm needing to manage the contractors as well as be an agent of the owner. The overhead also can be reduced significantly by sharing field trailers, etc., during construction.

The CEI firm is brought as early as possible into the design to help with constructability, reduced costs, and QA/QC on the plans. This also involves the CEI firm on the team early, thus avoiding situations where it comes in later as a potential outsider looking in.

On standard DBB projects, the CEI firm reviews the final design for errors, omissions, and constructability issues just prior to and/or during construction. In the CMGC process, the CEI firm comes alongside the DP early to assist in producing an overall better product and streamlining many of the sometimes tedious and unnecessarily stringent specifications, including proposed alternative materials for construction. Additionally, the CEI firm provides real-time QA/QC rather than waiting on traditional 30, 60, and 90% plans reviews, thereby saving design fees. By the inception of construction, the CEI firm and the DPs are a tight-knit team working closely on all issues relating to the project.

If the process is managed correctly, CMGC most often reduces significantly the level of design needed and the time spent in design. Approvals are obtained weekly, thereby eliminating redundancy and waiting on sometimes lengthy reviews, direction, and possible redesigns. Scopes are defined clearly up front and adjusted in real time, which reduces significantly the design production hours necessary. Another major factor is that the costs of the design are known very early due to the team participating in pricing; therefore, designs do not need to be modified late in the process to reduce the costs or meet the budget. In addition, the engineer's estimate becomes the contractor's estimate and therefore typically is constructible for the costs estimated.

The factors most significant in affecting this outcome are strong owner leadership, direction, and guidance; strict adherence and real-time adjustments to the design and construction schedules; and early team involvement by all parties—i.e., CM, CEI firm, owner, geotechnical engineer, surveyor, ROW agent, utility companies, environmental agencies, etc. Other significant factors include requirements for CMs to provide cost savings as well as innovative and cost-cutting ideas to the designers and team, reduced design plan detail, reduced specification development by the DPs, reduced utility coordination by the DPs, reduced schedule development by the DPs, and weekly team meetings from the onset of design attended by all stakeholders and decision makers.

Additional fees are added for "daily and weekly coordination" with the CM firm as well as additional plans revision time for modifications, VE, and/or innovations. Overall, the design budget is reduced but the DPs are paid to work with the CMs, ensuring that coordination will take place and the DPs will be making money while participating in the coordination rather than potentially viewing this coordination as a waste of time and resources. In some cases, additional design fees also are added to ultimately reduce the cost of construction, i.e., if a VE proposal is approved that is a significant redesign, the reduction in construction cost justifies the additional fees, and the budget still benefits although the design budget may end up being higher than originally budgeted due to this change.

Additional fees are not based on a percentage of the design fee or any other formula. They are based on the complexity and length of the project. The hours are estimated on the number of weekly meetings and the number of potential innovations for each particular job, as each one differs.

There is no "typical" percentage of construction cost for the design fee. The percentage varies on a project-by-project basis between the aforementioned ranges. The further along one gets into streamlining the process using CMGC, the lower the design fees due to reduced design efforts and limited plans and specifications. The same results were accomplished on CEI costs.

Once the program was up and running, the team began fine-tuning the individual team tasks, which before had significantly overlapped in many cases.

Initially, CMGC actually added costs to the existing designs due the contract documents being well underway and designed for DBB. The team had to immediately add coordination fees and redesign fees. On the new design contracts, CMGC eventually resulted in reduced design times and fees. It also resulted in significantly fewer design change orders from the owner, due in part to the scopes being so well laid out and understood by the entire project team.

The total cumulative project costs (if multiple GMPs are used) sometimes were calculated up front and sometimes during the design process. Initially, when quickly breaking ground was a priority, a mini GMP could be planned and designed to get the project moving. Once this was accomplished, the GMPs for the project would be planned out during design and compiled to ensure that the sum of all GMPs, including the first one, did not exceed the budget or the overall targeted GMP for the project. This critical step also ensured that each GMP fit together like a puzzle, completing the entire project in a logical and constructible sequence.

Initially all designs were accelerated regardless of the delivery method in an effort to reduce the overall project lengths. The CMGC process enabled this already-accelerated design process to be met more easily. The key to this sped-up design was the ability to design in mini-phases. The mini-phases could be designed quickly, as less detail and effort were required, producing lean and fast mini-phases rather than one big design that often can be cumbersome to break into smaller bodies of work for the designer and the contractor.

The owner ultimately was responsible for the construction start and finish dates as well as ensuring that the schedules were met. However, the CMGC contractually was responsible to ensure that the overall project schedule was met, including the design, permitting, ROW, utility, and construction schedules. The process used called for the owner to set the major milestone dates prior to advertising the project and then for the team to work collaboratively in determining how to meet the project schedule. Every team member was responsible for keeping the project on schedule in all the above areas. Due to the fact that the CM cannot control all areas of work above, it is not feasible to hold it solely responsible for the schedules as the DPs, utility companies, and ROW agents do not work under its contract. Each of the entities ultimately is responsible to meet its individual schedule as well as assist in the other entities meeting theirs.

On average, project durations were shortened by 30 to 50% through the use of CMGC in the Osceola County program. Construction times were not necessarily reduced significantly but started much earlier in the process and finished on schedule, reducing the overall times. Design times were reduced due to the fact that construction mini-phases could start before designs were completed, thereby accelerating the design process. Construction did not have to wait until design completion. Design times also were reduced due to the lower level of detail required in the plans as well as the DPs not having to prepare final bid packages and quantities.

In the Osceola County program, the PL—i.e., the owner's design PM—was responsible for design changes with potential impacts to the schedule, budget, and overall GMP and actively led the process. The CM technically and contractually managed and accounted for the potential impacts. The project team ultimately was responsible and took an active role in managing and tentatively approving all design changes. The final decision making authority on all of these impacts was the owner. Fundamentally this was simple, as all projects were required by the County Commission to finish on schedule and under budget.

The program in Osceola County did not hire independent cost estimating firms or estimators to verify the CM's costs. Internally, highly trained and experienced design and construction staff were hired who worked intimately with the CMs to negotiate and approve all costs and

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estimates. The overall project team looked at all project costs in an effort to ensure that the overall project came in 30 percent under the approved budgets.

Improvements to the Osceola County program could have been affected by the following requirements:

1. During the RFP process for the CMs, inform the proposing firms that all fees, costs, and estimates will be reviewed thoroughly in detail prior to acceptance, and standard CM practices and overhead rates by the CMs will not be approved cart blanche. In addition, failure to negotiate will result in the owner going to the next selected firm.
2. Hire an independent firm to estimate, in addition to the highly trained staff.
3. Require in the RFP that all costs be itemized in detail from office overhead rates to field trailer rates, profit, contractor bids, etc.
4. Disallow up front in the RFP certain fees such as raises, vehicles, vacation allowances, etc.
5. Require the prospective CM to agree to the owner's CM allowable costs up front, prior to submitting on the RFP.

The project team and the CM were the lead and were responsible for generating traffic control plans (TCP), as opposed to the traditional method in which they are determined by the designers. Initially, the majority of TCPs had to be modified or deleted due to designs already being well underway prior to the team and the CM coming on board. On the new designs or designs that were not as far along, the DPs were asked to not prepare the TCPs and instead work directly with the CMs and the project team to develop them. The team broke the traditional TCP phases into multiple mini-phases to match these in the roadway plans, thereby rendering most traditional TCPs irrelevant. In some cases, the CM developed the TCPs and proposed them to the project team, thus saving design costs. This enabled the TCPs to be constructible and phased according to how the phases actually were going to be constructed in the field.

If the owner makes sure to involve the project team and the CM very early in the process prior to designs being underway, problems in the construction phase will be minimized. This will reduce significantly or eliminate the traditional or systematic problems so often seen during construction. This also will help the design process. It is important to bring on the team prior to establishing the project schedules and budgets, because these become tough to meet when they are unrealistic or put together incorrectly or by the wrong groups or individuals. All things being equal, it always helps if the builder of the project helps design the project.

There were no major differences in how the quality control process for design used during the design phase was different from those used in the construction phase. The system was established, and the entire project team remained intact throughout the entire design and construction phases.

No templates were used for describing the owners' expectations for how design QA and QC were to be ensured throughout design development under CMGC. The QA/QC plans were developed by the project team and reviewed during the weekly progress meetings.

Among Osceola County's best practices to ensure that the construction cost was kept within budget were monthly reports turned in along with the invoices for the CM. These gave detailed information on all costs to date and were compared to the schedule of values that had been approved for the project. Also, actual costs were provided during each step of the preliminary designs, which eliminated the traditional procedure of waiting for bids to come in once the entire project is designed to completion or preparing a final engineer's estimate, as in DBB.

Commitments were given by the contractors and subs to the CM to perform the work, as roughly outlined, for the costs provided. VE was performed intensively by the team during the conception of the project to ensure that the cost for construction and design was under budget.

This procedure is the reverse of some DBB processes. In CM, the intent of the project, the schedule, and the budget are targeted first, and then the design scope and details are formed around those three primary priorities. This is the case in some DBB projects, but they do not have the benefit of having direct pricing and scoping from the contractors and subs.

It ultimately was the owner's responsibility to monitor the project budget, including design, inspection, permitting, ROW, utilities, and construction, as the owner is the designated PL. However, the CM contractually is responsible to monitor these items and ensure that they are completed within schedule and budget. In addition, the intensive collaboration, which is started very early in the scoping of the project, makes the entire team responsible to ensure that all of these items are successfully monitored and tracked. This is why collaboration and communication are so important to the success of this process. There are too many players involved to ultimately hold any one group completely responsible, so the owner has to take the lead and ensure that these are monitored correctly by the entire team.

The designer has a vital role in monitoring the above items as well—keeping the design on schedule while constantly creating VE options to accelerate all processes and reduce the overall budgets. The designer must be involved actively and creatively in the process and preferably should be senior level design principals with experience and authority to generate and review cutting edge ideas from the team and to comfortably accept significant risk in designing and, in some cases, going against standard protocol, specifications, and design details.

Overall, the contracts were lump sum, with a total not to exceed GMP, along with a standard buyout for savings produced during the project and/or unspent money, units, allowances, or contingencies. In negotiating and approving actual costs bid and billed monthly, a combination of lump sum, unit price, cost-reimbursable and allowance was used. The payment depended on the type of work, ranging from reimbursables to unit price items, lump sum items, allowance items, and contingencies. Progress payments for certain lump sum items were made from an approved and negotiated schedule of values, and all types of payment measures used were tracked. It is advantageous to use several methods and vary them depending on the project. Certain items such as asphalt were bid specifically as unit price. This was based on politics, as the county needed to justify what they had paid per ton and square yards of asphalt. The prices then potentially could be converted to lump sum, depending on the condition of the roadway and how much risk the team was taking. In some cases, better pricing resulted from sticking to unit prices with allowances for overage. Any savings then would be passed to the owner rather than the CM. One disadvantage to lump sum is that the CM receives the entire savings, not the owner.

In the CMGC process, constructability reviews and VE are managed using a team effort from the earliest stage possible in design. The CM firms and all team members review the conceptual design plans and run the ideas by the contractors and subcontractors. This produces instant feedback as to the viability of the VE plans, as well as whether or not the plans are constructible and within the budget as designed. This process occurs very early in CMGC rather than at final plans or bidding stage as often occurs on DBB projects. If the process starts soon enough and the team is brought on early enough, plans sets will not be finalized until the reviews and VE are brainstormed, performed, and verified by contractors. Many factors are reviewed by the team such as permitting issues, ROW available, environmental issues, timing, budget, material delivery, and equipment available.

The CM firm, designers, geotechnical engineers, surveyor, permitting, ROW agents, budgeting personnel, utilities, owner, contractors and subcontractors, joint municipalities, environmental agencies, CEI firm, PMs, etc., are involved in constructability reviews and VE. Benefits are maximized by early involvement and frequent and design production meetings. A critical step to maximizing the benefits is to have the contractors and subcontractors present at the meetings at the earliest stages possible. This is essential to generating VE plans that actually are

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viable and can be built within the allowable budgets and schedules. Failure to do this early can jeopardize the efficiency of these meetings.

If the CMGC process is run correctly and the CM does not act as just a "broker"—but is actively engaged in the design effort and involves its contractors and subcontractors early in the process—designs, construction phasing, and materials may be selected, modified, and substituted during the design phase in an effort to bring projects in under budget. This requires a strong and active owner and can be a major downside to CMGC if not led and monitored carefully. The CM fees need to be made up as well, or the projects potentially can come in over budget by an amount equal to the CM fee and overhead. In the end, the cost will be compared against that of similar DBB contracts and thus must be presented as a challenge up front for the project team to meet.

Issues Affecting or Affected by Design Management

Engineer's estimates become the responsibility of the CM and are converted to preliminary GMPs using actual bids. If an engineer's estimate already was prepared by the DP, it is used only as a comparison and a negotiating tool with the CMs. Typically, the engineer's estimates are eliminated if the CM is brought in early enough, as real-time pricing by subcontractors and contractors make them almost irrelevant. This is one of the big advantages of CMGC versus DBB, as engineer's estimates in most cases are only as good as the data used to calculate them and the estimator deriving them. They also are often not based on actual bids but averages derived from DOT bid data.

Eliminating engineer's estimates saves the DPs time, money, and the risk associated with having to bring the bids in under the estimate. It also enables the DPs to focus strictly on their specialty instead of getting involved directly in the estimating or having to sub out the estimating to a professional estimating firm. It also potentially eliminates the need for time consuming computation books and pay item matrices and tables typically listed in plan sheets for DBB projects.

Plan sets are designed and constructed in mini-phases, which have resolved or will resolve issues such as potential remobilization-related cost and schedule impacts resulting from delays in ROW acquisition, permitting, utility relocation, or other unanticipated delays. This enables construction to begin much sooner while the above issues are being resolved in other mini-phases. Bidding these mini-sections of work eliminates remobilization or demobilization fees associated with the overall project. In addition, the CM places a clause in all contractor and subcontractor contracts that no remobilization fees will be charged on the projects for delays due to the aforementioned items. In addition, there are no delay claims on CMGC contracts due to the CM taking the risk for finishing on time and under budget. Any delay claims should be handled by the CM, not passed on to the owner. Another important factor is that the contractors are chosen not by low-bid but by best value; therefore, any claims placed would hinder their ability to bid on future mini-phases as well as future projects with the CMs.

Most projects had three frequent, periodic project meetings—one with the standard team (weekly), one with adjacent municipalities (bi-weekly), and one with the utilities (bi-weekly/monthly depending on fast-track schedule). This enabled segmentation of the meetings, which helped ensure that everyone's time was spent wisely on issues that did not involve other parties. This especially was the case in the utility and municipal meetings.

The level of coordination required is much more than on a typical DBB contract because CMGC is a partnering process with fast-track schedules that moves very quickly and needs complex decisions made daily by top-level decision makers. Failure to coordinate correctly removes many of the benefits gained by CMGC and potentially turns it into an expensive process with the CM acting only as a broker that adds 5% to 7% in fees on top of the costs of a low-bid system.

Changes in culture and philosophy are required for all three major parties to the contract (owner, DP, CM). The primary paradigm shift is that this is not a low-bid project but a best-value project. In addition, the relationships must be modified significantly from adversarial to partnering. Each entity is hired as "professional services" and has equal say at the table. All parties are looking to make the project successful. This also relates to inspection requirements in the field. The inspectors are no longer the owner's exclusive representatives during construction but are part of the overall team and are involved early in the design process primarily to ensure that the entire project team delivers a quality product that will hold up—not to verify quantities and contractors' adherence to plans and specifications.

A high level of industry collaboration and support is required to execute a CMGC project successfully. Upfront and early stakeholder buy-in must be secured from outside the team—i.e., cities, counties, subs, suppliers, etc. Failure to do this could cause a project to fail, as all of these entities are required to make the project successful. In addition, early and detailed buy-in to every facet of the project is required from these groups in order to meet the schedules, approve and fund the budgets, contract directly or under the general contract with the CM in order to organize everything under one project leader, etc.

ROW acquisition and environmental permitting were handled in a variety of ways according to the situation. Because plans at all levels of completion were inherited, each project varied. However, one of the elements that made the projects inherited nearly impossible to complete on schedule was the fact that the ROW was not under the control of the project team. The procurement was performed by an outside governmental department. Lessons learned would be to have the ROW acquisition directly under the team and preferably handled by someone hired by the CM firm.

Early involvement by utility companies and permitting agencies in design is critical to the success of a project. They must be included to ensure that the designs are viable and can meet the desired budgets and schedules. When possible, they were included early in the project meetings to ensure buy-in and determine whether the proposed scope of work and schedules have been budgeted and approved. Rapid acceleration of the permitting process was required to keep the project and the team moving. Typical permitting schedules were not viable for these projects. In addition, typical utility relocation schedules and construction contracting methods would not work on this set of projects. In many cases, the utility work was combined under the CM's contract to ensure that one entity was in control of the construction schedule. Controlling all critical path items under the CM is important for success.

In addition to making up their fees in savings, the CMs were required to come up with 30% savings on all projects. The project team also was tasked with value-added innovations as part of their scopes. The entire team is run in an effort to maximize savings in both dollars and time. This is essential to running a successful CMGC project. It also is essential in delivering the projects under budget, as CMGC will add five to seven percent to the cost of a project if savings are not guaranteed.

The approach for managing post-award design activities can be similar to D-B as the design is underway well into construction and in some cases is not complete until the last mini-phase is underway. Therefore, the DPs stay engaged in the construction up until the last GMP is underway. This method allows for harvesting the benefits of the CMGC process. Plans also are changing constantly, in some cases during construction, in an effort to adjust to permits becoming available, ROW acquisition changes, etc. In addition, the plans are lighter in nature and the DPs therefore are more involved in the product actually constructed in the field.

The processing for requests for information (RFI) was managed overall by the CM. However, the owner and overall project team took a much more active and aggressive role as decisions often were needed daily or weekly at the team level. Therefore, RFIs had to be run through the

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owner as well as the project team. Plans and specifications were much more fluid, and the entire team needed to buy in to all changes, modifications, material substitutions, etc., as one change had the potential to affect the entire project (permits, ROW, etc.).

The owner ultimately was responsible for the scope of the project, the budget, and the schedule. This process required a much more active owner than a DBB project.

The project team budgeted for and covered the majority of all errors and omissions, which took a strong commitment from the team as well as the owners. This also required the designers to redesign with no additional fees and finish the designs regardless of the design budgets remaining. When each of the specialty line item budgets was met, the team was required to work without additional fees being accrued. However, if money was left at the end of the projects, it could be distributed accordingly to make up for additional services needed for project success. The goal was for the entire team to make money on the projects if at all possible, but the primary goal was to finish the projects on schedule and under budget.

The communication channels used during the design and construction phases were a function of the way the project team was set up. From the inception of any project, specialized project teams were established, and mandatory, weekly project meetings began for the entire team. Each team member was required to have binding, decision making authority for its area of expertise. The owner led the meetings as the PL, and the CMs acted as managers of the overall project. The owner had highly trained project managers assigned to both design and construction. There was not one project manager covering both areas but one specific project manager for construction and one for design during the entire project length. Also required in the meetings were specialty areas such as permitting, design, survey, ROW, geotechnical engineering, traffic engineering, budgeting, and legal.

The DP's role during the construction phase was such that the designs still were underway actively during construction. Most projects were being designed in mini-phases, each of which had different construction start dates. As one design mini-phase was completed, another started while the one before it went to construction. Therefore, DPs and the team remained intact almost through the end of the final construction mini-phase. In addition, the designs were not to the level of detail typically required and therefore needed real-time input from the DPs while in the construction phase. There were no distinct, separate design and construction phases as in more traditional delivery methods. The designers also were required to be actively engaged in RFIs and shop drawing reviews during construction; the CEI firm handles these responsibilities in other systems.

Miscellaneous Statements

The following sections are based on interviews from the case study of the CMGC program administered by Osceola County, Florida. Some of these discussions fit well within the context of the research topic, while others range into aspects of CMGC dealing only indirectly with issues discussed previously.

Goals and Objectives of a CMGC Design

The following 11 goals and objectives were the ideal for which each project team was bound to strive, as instructed by the leadership of the Department of Public Works, Osceola County, Florida. It was believed by the leadership that a majority of these goals and objectives were met to a satisfactory level on every project. The projects that came the closest to perfection in these areas were the projects on which the CM was retained earliest.

1. Finish the projects successfully and on time.
2. Return all CM fees to the owner.
3. Finish the projects 30% under budget.
4. Build one of the most highly technical and trained design teams in the nation.
5. Employ mostly local DPs.
6. Reduce overall project times by two to five years, depending on project size.
7. Be accountable and transparent in all operations.
8. Involve and engage the project teams from the conception of the projects.
9. Start projects prior to having all ROW, designs, permits, and utilities.
10. Develop and incorporate hybrid and streamlined specifications, permits, plans, and inspection.
11. Continually improve the overall project delivery system and each of its components.

Accomplishments of the Osceola County CMGC Program

This program has been highlighted as the largest and most rapidly deployed, innovative, and successful roadway construction program in the nation to date with CMGC as its sole delivery method. Documented accomplishments of the program are summarized below.

- Had eleven major roadway segments ready to begin construction in one year, thus achieving 55 times the production rate of the previous five years
- Returned all CM fees and preconstruction fees in savings to the owner
- Achieved 75% local participation and helped keep numerous local contractors from going out of business
- Saved millions in construction due to VE and breaking bid packages into specialty items of work, returning $36 million in savings to the county
- Returned $80 million to the local community through local contractors in the first four months of construction, not including what was paid to the local design community
- Finished 20% under budget for all projects including design, permitting, mitigation, and construction

Factors Critical to the Success of a CMGC Project During the Design Phase

1. **"Fast-Tracking"**—Have the agency pass a fast-tracked resolution with all stakeholders committing to place these CMGC projects as top priority over all other agency projects in all areas—procurement, contract and RFP approvals, legal review, council and commissioner approvals/dockets, municipalities, utilities, governing and review boards, permitting agencies, citizens' groups, etc.
2. **"Brainstorming"**—Assemble potential DPs, CMs, and CEI firm prior to writing the actual RFPs and contracts to discuss scoping, schedules, budgets, etc.—What is the intention of all of the projects within the program?
3. **"Buy-In"**—Discuss with all stakeholders prior to kicking off the program the purpose of CMGC and the goals and objectives that have to be met to be considered successful—utility companies, ROW agents, permitting agencies, subcontractors, CEI firm, municipalities, owners, internal departments, procurement, contractors, subcontractors, engineers, citizens' groups, press, surveyors, attorneys, political figures, upper administration, CMs, and (most importantly) internal owner staff, leadership, and subordinates.
4. **"Up-Front Scoping"**—Determine the project budgets up front and require the professionals to agree to them—what will be the design fees, CM fees, CEI fees, geotechnical fees, survey fees, overhead, and construction costs, as well as the overall project budget

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and schedules specifically broken into design, construction, survey, permitting, and ROW. Identify clearly all targets. All of these items need be included in the RFPs for design, CEI, consultants, and CMs, including such additional critical professional services such as geotechnical, survey, etc.

5. **"Cutting Time and Overhead"**—Streamline the scopes of the design contracts to produce construction plans, rather than bid sets, and require the bulk of the design team and all other professionals to be present during the weekly design production meetings.
6. **"Top-Down Leadership"**—Require the principals of the design firms and all other consultants to lead their teams in the weekly design production meetings. This is across the board for all professional services.
7. **"Leadership Presence"**—Require that the owner's senior leadership—i.e., the ones with binding, decision making authority for their companies—be present and lead all design production meetings. Other PMs and subordinate staff also should be required to be there.
8. **"Building the 'A' Team"**—Require the "best in the industry"—senior leaders and senior PMs for all professional services, i.e., the CM, DP, geotechnical engineering, etc.—who have proven and successful experience leading major D-B projects and/or CMGC projects. The learning curve is too sharp to go from DBB to CMGC under an accelerated and new CMGC program. Each team member should be the best at what it does—a specialist that cannot be replaced. Each is highly valued by the other team members and has an equal seat at the table. No one member dominates over the team.
9. **"Not a Training Ground"**—Bring in only proven, seasoned construction, design, contracting, and subcontracting consultants who have a burning desire to see that CMGC is successful regardless of the circumstances and who have an absolute "program first" and "team sacrifice" mentality rather than a typical DP, owner, or contractor mentality.
10. **"Budget and Schedule"**—The guiding factors and targets that the team must live by are "budget and schedule" at all costs in order to bring a CMGC project in under budget and on time. Costs cannot exceed the agreed-upon budget for all GMPs combined, regardless of the circumstances and problems encountered.
11. **"Communication and Leadership Planning"**—Weekly production meetings are required by all top leadership from the beginning of the scoping of the projects to the completion of construction. This requires a tremendous effort and investment for all parties concerned. These costs also must be made up through schedule and innovations.
12. **"Team Building and Networking"**—Co-house the entire team of professionals starting at the inception of the project, and require all senior leaders and PMs to work out of the same office space.
13. **"Upfront Cost Control"**—Lay out the cost of all cumulative GMPs prior to starting early work packages or mini-GMPs.
14. **"Buying and Developing the Vision"**—Include CEI, survey, geotechnical engineering, subcontractors, contractors, etc., on the production team early to review the scope and specification requirements for all projects as well as constructability issues.
15. **"Influencers in the Room"**—Require that all contractors and subcontractors be part of the mandatory project team meetings from the inception of the projects and, at a minimum, always be present when their areas of work are being discussed as well as during scoping, scheduling, and budgeting.
16. **"Sense of Urgency"**—Require the entire team—i.e., owner, contractor, CM, subs, DPs, professional services, etc.—to commit to a "sense of urgency" and to place these projects above all other items and projects on their slates. This also applies to procurement agents, commissioners, governing officials, permitting agencies, utilities, etc.
17. **"Schedule and Budget Drive the Project, Not Vice Versa"**—This principle is critical to controlling costs on a CMGC project as the administrative overhead is most expensive among the three primary delivery methods and if not controlled will cause the project to fail. A

detailed CPM schedule and budget with all required critical path items must be completed prior to releasing the first RFP.

18. **"A Good Plan Violently Executed Now Is Better Than a Perfect Plan Executed Next Week"**—The entire team must make timely, difficult, and binding decisions within the scheduled time available. Hesitation will kill the project's momentum, schedule, and budget and will cause the team members to lose interest and move on to other urgent projects.
19. **"Innovation and VE Are Mandatory"**—The project team must innovate in order to make up all CM fees as well as the additional fees required by the design team, consultants, subcontractors, etc. Otherwise, costs will spin out of control. Contractual requirements should be in place for the team to target a certain amount in cost savings.
20. **"Lead by Example"**—Owners must be willing to make a significant investment—more than with any other delivery method—in leading these projects to ensure success at all costs. This is not a passive delivery method, and poor engagement by the owner leads to poor results. The owner must be the hardest-working member of the team. Owners must act as PL and run all production meetings.
21. **"Effective Resource Loading"**—Due to the high overhead on CMGC projects, the program must be resource-loaded up front, determining how many staff to bring on, how many hours they need to work during the entire project, and when they need to cut back on their hours to ensure that budgets and staffing requirements are met. This needs to be understood clearly by all members of the team to avoid causing any friction in expectations.
22. **"Zero Tolerance for Change Orders"**—The entire project team must agree to a zero change order policy, starting with the owner and proceeding to the consultants, CMs, contractors, CEI firm, subcontractors, etc. Once change orders begin, the GMP process essentially is useless. When the budget is exhausted, the team works pro bono. Innovation is required to ensure that there are no change orders and that the extra work is zeroed out.
23. **"Budget for Contingencies and Allowances"**—Contingencies and allowances are required to successfully cover the design-build aspect of the project and to accelerate the entire process. Contingencies are the difference between success and failure on a CMGC project as they enable real-time decisions to be made and paid for and the project to move forward rapidly.
24. **"Contracts That Specifically Match the CMGC Delivery Method"**—Well thought out and finely crafted specialized and highbred contracts—i.e., with the CM, DPs, consultants, etc.—must match perfectly the goals and objectives of the program/projects. The contracts must require aggressive delivery, streamlined plans, VE mandatory goal percentages, advanced coordination, sufficient time for production meetings, principal involvement, strict adherence to the schedules and budgets, coordination, etc. Failure to put it up front in the contracts will require asking for volunteer participation, which is much more challenging.
25. **"Attitudes, Team Players Only, and Sacrificial Service to the Team and CMGC Program"**—It is critical to have strong desire and relentless pursuit toward project success, regardless of the challenges faced. Any member that does not embrace this principle must be removed from the team quickly and permanently, as its presence will damage the CMGC process irreversibly. Require this commitment during the RFP process and select only professionals who completely buy in to these requirements.
26. **"Cost Estimates Are Bid Prices, Not Engineer's and CM's Estimates"**—It is critical to have the contractors and subcontractors who perform the work formulate the rough and final GMPs based on real bids, not estimates by the DPs and/or CM firms. Getting real costs at the earliest possible rough concept phases of scoping and rough plans is essential to coming in under budget and generating constructible projects within schedule and budget.

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Summary

In 2007, the Osceola County, Florida, Department of Public Works was faced with a unique and daunting challenge. The three previous County Administrations had been removed by the Board of County Commissioners for failing to deliver an aggressive impact fee-funded roadway program totaling approximately $1 billion. The program required that the recently hired County Administrator and his staff put nine to 11 major roadway projects under construction by the end of their first year and to have an additional seven under contract each calendar year, beginning from the first year of the newly adopted impact fee ordinance. The new impact fee ordinance had been assessing some of the highest impact fees in the nation, negatively affecting development with very few roadways constructed. Based on these requirements, the county was 18 projects behind schedule, totaling more than $400 million in design and construction when the new team was hired.

Initially, when looking into CMCG, very few DPs were strong advocates of the system for such a large program. In their opinion, the county did not need to add yet another layer of management to an already overburdened, costly, slow, and extremely bureaucratic system. In addition, they believed that CMGC was an unproven method for roadway construction and that the outcome could be catastrophic. Many design firms believed that the proposed constructability reviews overlapped the constructability reviews being paid for under the existing design contracts. Several firms had existing PM contracts with the county, which they believed performed the same services as a CM firm.

Another concern was that involving a CM firm at such a late point in the design stage would increase the design budgets, which already were spent in many cases. They also believed that coordinating with the CM firms would be very costly in terms of time, which they could not afford to lose in such a challenged market.

The CMGC system was installed despite overwhelming, wide-ranging protest from the contracting, design, and CEI communities in the local area. The results were that within a year, 11 major roadway segments were ready to begin construction, thus achieving 55 times the production rate of the previous five years. All CMGC fees and preconstruction fees in savings were returned to the owner. The local participation rate, the strongest of the myriad objections voiced, stood at 75% and helped keep numerous local contractors from going out of business. Millions of dollars were saved in construction costs due to the built-in VE process and bid packages broken into specialty items of work. The total returned to the county in the first year was $36 million. Another $80 million was returned to the local community through local contractors in the first four months of construction. This does not include what was paid to the local design community. The portfolio of projects finished 20% under budget in the first year for all projects including design, permitting, mitigation, and construction.

After only one year, the members of the administration team began to gain recognition nationwide. Articles were written about the program in *Engineering News Record* (ENR), *Public Works*, and *Construction Today* magazines in 2009 and 2010. The Osceola County Public Works Administrator, the driving force behind the CMGC program, was named one of the "Top 25 Newsmakers for 2009" by ENR.

Case Study—Program: City of Phoenix, Arizona (CMR)

Introduction

The City of Phoenix has built more than 200 projects using what they call a Construction-Manager-at-Risk (CMR) construction project delivery system since initiating the system in 2000. Only recently has the city commenced using CMR for horizontal construction, totaling 12 horizontal CMR projects since their first project, let in 2008.

The fact that Phoenix calls its program CMR is a sign of the infancy of the delivery system's use in the U.S.. The most basic terms are not set, and some are used interchangeably. Such is the case here with "CMR" and "CMGC." One of the reasons for the existence of the Construction Manager/General Contractor (CMGC) delivery system is the fact that the construction manager (CM) is not required to self-perform any of the work. In fact, as can be seen in the Case Studies or descriptions of other CMR programs, this typically is the case. The CM on the largest CMR project ever funded by the Federal Highway Administration (FHWA) could self-perform work only if it quoted a price for performing a certain item of work against the subcontractors on that same work item, and their quote was the lowest. This mega-project is the Miami Intermodal Center let by the Florida Department of Transportation. In the very successful CMR program in Osceola County, Florida, the CMs were forbidden to perform any of the work with their own forces under any circumstances.

Another characteristic of a CMR project is that it can be cost-reimbursable or lump sum, as well as unit price, often using a combination of the three on the same contract. Finally, the constructor on a CM project always has been referred to as "the CM." The City of Phoenix goes against all of these tenets, requiring that their "contractor" self-perform at least 40% of the work and using a straight unit price system for paying the contractor.

Contractor advocacy groups stood against CMR mainly because of the requirements for the CMs, or prime contractors, to not self-perform any of the work. In this context, the City of Phoenix can be said to have operated under what is now referred to as the CMGC delivery system, just now coming into popularity with the Every Day Counts initiative of the Federal Highway Administration.

Program Description

When using the CMGC delivery system, the City of Phoenix typically procures the design professional (DP) before procuring the CM. The City has separate contracts with the DP and with the CM. They report that federally funded projects generally do not allow procurement of the CM earlier than the 30% plans stage. Locally funded projects likely would allow such procurement at 60% plans or later, but could range from 0% to 90% plans, depending on project

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complexity. Specialty team members such as surveyors and geotechnical engineers work with both the DP and the CM at different times and work phases.

The design process using CMGC is different than that of a typical DBB project, but only after the CM has been selected and is part of the team. The CM actively participates during the design phase in producing the traffic control and construction phasing plans. The DP works to customize the construction documents to the contractor's needs and works on more finite cost proposals to assist with a final GMP. Furthermore, quantity take-offs, computation books, and bid summary sheets are handled with more collaboration and earlier in the process on CMGC projects versus DBB.

During the design phase, the CM is contractually obligated to coordinate with the DP on estimating, Value Engineering, construction phasing, schedule, and GMP preparations. The first GMP generally is developed and submitted about 90% plans, although simple phases or plan packages could be completed earlier. Right-of-way (ROW) acquisition begins about the same time, although ROW acquisition can begin as early as 30% with environmental clearance. This is earlier than the City gets started on these items when using the DBB delivery system. Utility relocation coordination may be completed in-house prior to bid or handled in-house during design and construction phase.

Innovation is encouraged in the design process through Value Engineering and construction phasing and methods. No incentives exist for designers to control costs other than maintaining a strong reputation in the industry.

The City of Phoenix does not currently have a specific program for the training proposal evaluators. However, they are planning to conduct training sessions for that purpose to be completed by the end of March 2013. The City has internal staff available to review design submittals for compliance with standards/criteria. This is achieved through a combination of reviews by the Procurement Section and Project Management staff. To assure familiarity with the projects and uniformity in the process, the City typically involves review staff in the RFP package development. Typically, four design review submittals are required, at the 30%, 60%, 90%, and final plans stages.

The City believes that contractor input on major structural items/elements during the design phase is critical to the success of a CMGC project, as is contractor input on scheduling and cost estimating. To help with this, certain members of the team take advantage of a communication and training program customized for the use of CMGC offered locally by a nonprofit group affiliated with a local university.

The City believes that public relations is important on any project that might have a negative impact on the traveling public. Depending on the scale of the project, the CM may get involved with this effort. However, this typically is handled by the City with DP support. A contracted third party (public relations firm) also is typically used on major projects.

Interviews

Interviews were conducted with six individuals who work within the City of Phoenix horizontal construction program. One of the interviewees was non-responsive to most of the questions posed but made many interesting statements. Several of his comments are included in a following section. The interviewees included two city personnel, two DPs, and two contractors/CMs.

Approach for Managing Post-Award Design Activities

Two interviewees described the utility coordination process as different from that of a typical DBB contract, but three said it was the same. One said that utility coordination was started earlier in the process on a CMR project than on a DBB project, but four said that the utility

process started at the same time, regardless of the delivery system. Four said that the traditional duties of the design team, such as permitting, project management, utility coordination, overall project schedules, owner's representative duties, etc., are different when using CMR versus a typical DBB project, while one said that the traditional duties are the same. Four respondents said that the CMR process utilized by the City of Phoenix enables the team to permit and design the project in small "mini" phases and that the design process is tailored to begin construction early versus at the traditional final plans stage. One respondent disagreed on both points.

When asked about the importance of educating the DP early in the process to ensure a collaborative effort, the interviewees responded with the following comments:

- It is critical/very important to educate the DP early in the process.
- Everyone must understand the meaning of partnership and Partnering.
- We use experience with CMR as a deciding factor when hiring DPs.
- Designers are naturally collaborative.
- We had to educate the contractors (as opposed to DPs).
- With CMR, there is more of a team atmosphere.

When asked to compare the challenges typically encountered during the design phase to the challenges typically encountered during the construction phase, the interviewees responded with the following comments:

- Design: Some poor CMs do not do a good Constructability Review
- Design: A major challenge is to stay within budget and address 100% of the scope
- Design: Getting GMP negotiated
- Design: Dealing with unknowns, but unknowns still come up in construction phase
- Design: Meeting DBE goals
- Design: It is easier to design a project that meets the budget in CMR
- Construction: Same challenges as DBB, but fewer
- Construction: Less of an adversarial relationship

When asked what level of commitment is required of executive and middle management to successfully execute a CMGC project, the interviewees responded with the following comments:

- You must educate local politicians (city, county, etc.) on how CMR works and get their buy-in. (2 said this)
- Most highway projects require at least middle management support.
- Executive decisions should be made long before the project. Executives are brought in only for big decisions.
- Whoever has the purse strings and whoever makes the final decisions have to be on board.
- There has to be an understanding that price does not equal cost.
- Managers must be educated to the very top.
- Middle management must be consulted daily.
- Middle management must be allowed to make decisions.
- Executives must support middle management and be available.

When asked what role the CM plays in the overall design process, the interviewees responded with the following comments:

- The contractors (CMs) get a lot more involved with the design than with DBB
- Depends on when (how early) they are brought on board
- Material reviews
- Cost reviews/preliminary cost estimating (not engineer's estimate) (2 said this)
- Means and methods
- Constructability (3 said this)

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- Bidability (3 said this)
- Value Engineering
- Review of plans
- They coordinate the relationship between the designer and the owner
- CMs are better schedulers than owners or DPs

Money Matters—Cost, Budget, Payments, Benefits

The six interviewees disagreed on what type of basic construction contract best describes a CMR project the way the City of Phoenix administers the contract. Three said that unit price was the contract type that best describes how the City of Phoenix administers the contract, and two said that cost-reimbursable best describes it. One interviewee stated that when the FHWA audited his project, the agency was satisfied with the method of payment, while the other five indicated that they never had been associated with a project that had undergone an FHWA audit.

When asked to identify the City's best practices to ensure that construction cost is kept within the budget, the interviewees responded with the following answers:

- They (City personnel) are involved on a daily basis in the field.
- We (the City) manage all construction activity.
- Contractors must submit their prices at each contractual milestone.
- CM uses sub quotes to formulate its GMP.
- All work is done in unit price.
- If we are not within budget at any time, the CM is not doing its job.
- They (City personnel) always should keep the CM and DP appraised of any potential obstacles.
- We (the City) bring the CM and DP on board at the same time—same advertisement, same selection panel—and negotiate contracts at the same time.

When asked to identify what steps are taken during the design phase to manage the construction cost, the interviewees offered the following responses:

- They depend on the CM to come up with ideas to make project phasing as efficient as possible.
- Before the CM is on board, we (the City) validate everything with our own design people.
- Once the CM is on board, it joins in the validation and negotiates the GMP. (2 said this).
- We (the City) bring in a contractor for plan review and constructability review to get unit cost projections and engineer's estimate.
- CM does its own geotechnical investigation as part of the preconstruction services contract.
- The CM gets the prices from the subs, so there are no surprises when the work is actually accomplished.
- We (the City) perform constant plans reviews—30, 60, 90%.
- Contractors are better estimators than engineers.
- If the GMP comes in over budget, the CM has not done its job.

When asked to identify who is responsible for monitoring the project budget, including design, inspection, permitting, ROW, utilities, construction, etc., the interviewees responded with the following answers:

- The owner. The agency. (2 said this)
- Whoever owns the funds.
- The CM cannot even spend its contingency funds without permission from the owner.
- During design phase, the Lead Design PM monitors the project budget.
- During construction, the CM monitors the project budget.
- The agency monitors against the project budget.
- The CM monitors against the GMP.

When asked to identify the DP's role in monitoring and controlling cost, the interviewees had a hard time thinking of any but offered the following responses:

- Providing a third party estimate. That's it, unless they have a contract for CEI.
- They have almost none.
- They have to complete a design that can be built for the money budgeted.
- They have to approve all CM pay requests.

When asked to identify the payment tools used by the City to pay the contractor, only three said that they knew the answer, and all three of these said that the City used straight unit price exclusively, whether the project is federally funded or not.

When asked to identify how constructability reviews and Value Engineering are managed in a Phoenix CMR project versus a typical Phoenix DBB project, the interviewees responded with the following comments:

- The City of Phoenix has no VE clause in a CMR or DBB contract.
- They are done the same way on both delivery systems.
- Constructability reviews: CM does them on a CMR contract. On DBB, we (the City) hire a contractor.
- Both are considered part of the fee the CM gets for preconstruction services.

When asked to identify what parties are involved in the VE and constructability review process, two of the interviewees identified a DP executive, two answered the CM, and one said the owner.

When asked if the City would allow the designs, construction phasing, and materials to be selected, modified, or substituted during the design phase in an effort to bring projects in under budget—even if it was late in the design phase—the interviewees all responded in the affirmative, although one qualified his answer by saying that this would be done only if the change(s) did not undermine the integrity of the contract.

Issues Affecting or Affected by Design Management

No respondent thought that a DBB project takes more of a coordination effort than a CMR project. Three interviewees believed that CMR takes more of an effort to coordinate, all citing the speed with which everything is happening and the higher number of parties involved in the project. One interviewee saw no difference in the effort required.

The engineer's estimate (EE) is a very important item on a DBB project. Bidders know that their bid must be within 10% of the EE, so they use the EE as a guide and the owner uses the EE to budget the project. The question was posed to those interviewed as to whether the EE was as important to a CMR project let by the City of Phoenix as it is to a DBB project. One respondent said that the EE is more important in a CMR project since more things are compared to it. One respondent said that the importance of the EE is the same regardless of the delivery system, and two said that the EE is less important on a CMR project. Both of these people cited the fact that on a CMR project, the CM generates and negotiates a GMP with the owner that uses real prices, not estimates based on history, and which the owner can use to budget the project, thus rendering the EE less important.

When asked about the function of the EE in a CMR project versus a DBB project, two described the EE as "another check." Other comments on the question were as follows:

- Any CM is going to believe that he can generate a better estimate than an engineer.
- Generating an EE should be easier with CMR, with less risk for the DP.
- On a DBB project, the EE helps the owner budget for the project.

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When asked how ROW acquisitions and permitting are handled in a City of Phoenix CMR project, all answered that the owner handled those issues in-house. However, one said that they are handled prior to bid and the other said that they are handled during the design and construction phases.

When asked to identify what steps can be taken during the design phase to minimize or eliminate potential remobilization-related cost and schedule impacts resulting from delays in ROW acquisition, permitting, utility relocation, or other unanticipated delays, the interviewees responded with the following comments:

- Identify challenges early.
- Bring in necessary people early.
- Public involvement is huge.
- Coordination with appropriate people and stakeholders is very important.
- Move the utilities during the design phase.
- Locate GMPs in the most advantageous order to mitigate mobilization costs.

When asked to identify what parties routinely are involved in coordination meetings (during the design phase), who takes lead at the meetings, and how frequently they are conducted, three interviewees identified the owner as being involved, three identified the DP, and three identified the CM. Two identified the utility company(ies), and one just gave the broader answer of "stakeholders." Other comments were as follows:

- The meeting leader is the Lead Design PM.
- Meetings occur bi-weekly or monthly.
- Meetings are conducted as needed.

No one interviewed thought that educating and training the owner's staff, design consultants, contractors, and CM firms to transition from the traditional DBB world to CMGC was particularly important. One said that these people must understand the CMR process already or should not get involved. Another said that senior management (executive) buy-in is essential.

Most of the interviewees did, however, think that an attitude change, paradigm shift, or change in culture was essential when coming from the DBB culture to the CMR culture. Some of the comments on this subject were as follows:

- People need to realize that it's all about long-term relationships.
- Everyone needs to let their guard down and recognize the value that each party brings.
- Everyone must drop the adversarial attitude. (2 said this)
- Instead of competing for the owner's favor like in DBB, the CM and DP need to realize that they can help each other find favor in the owner's eyes.
- Everyone must work together more.
- More cooperation (is needed) between the DP and the CM.

When asked what level of industry collaboration and support is required to successfully execute a CMGC project, the interviewees responded with the following comments:

- Educate local subs, suppliers, city politicians, and county politicians. (2 said this)
- Everyone has to buy in.
- A lot more communication is necessary (for CMR).
- CMR helps facilitate communication.
- The first time is hard.
- A local CM should be chosen for the first job.

When asked how utility companies and permitting agencies fit into the project team and design process, the interviewees responded with the following comments:

- They are full partners—fully integrated.
- They are included in the design.
- Face-to-face (personal relationships) facilitates a higher level of cooperation and makes things go faster. (3 said this)
- Utilities are coordinated by the owner.
- Design phase: Permitting coordinated by the DP.
- Environmental permits are handled by the CM.

When asked how the City of Phoenix ensures value-added guarantees in their D/B (CMGC) contracts, one interviewee said that if something is part of a DP or CM proposal, the City will review and will put an innovation into the contract. Another said that if it is something tangible, the City would put it in the contract

Miscellaneous Statements

The following sections are based on interviews from the Case Study of the CMR program administered by the City of Phoenix. Some of these discussions fit well within the context of the research topic, while others range into aspects of CMR dealing only indirectly with the pre-award design process.

Uniqueness of the Phoenix Model

In its CMR program, the City of Phoenix focuses on most qualified (there is no price component), and, for the most part, CMs are hired based on past performance with the understanding that they will move forward and help the DP and the owner design the best project constructible, work through the risks, and agree on a fair price. It was described by one interviewee as "a shotgun wedding of sorts." It is more of a shotgun wedding than a typical CMGC project with a price component because there is an owner who, "99.9% of the time," has already selected a designer and now is trying to pick a contractor that will marry well with that designer due to the high level of contact between the DP and the CM. This contractual relationship allows for free flow. The owner is not usually present or privy to most conversations between the CM and DP, even though it could be if it wanted to be. That flow of information is as free as the owner wants it to be. The City can control as much or as little as it wants. That (the lack of any price component) is what makes the Phoenix model so unique.

Importance of Quality-Based Selection

Every owner is different in its methods once the process arrives at the point of price negotiation. In many scenarios, owners tend to fall back to the old familiar competitive bid paradigm. The City of Phoenix hires based on qualifications. Other owners like to say that they do the same, but once hired, they want the contractor to solicit subcontractor quotes, which the prime contractor must then beat in order to self-perform certain, or any, work. In those programs, Phoenix contractors see it as "going from all this great best-value stuff back to the old low-bid, low quality, but we can do the cheapest kind of way."

Field Problems Versus Design Services

A contractor's money is made and lost in the field. Unless it is a particularly large or complicated project, contractors give their project managers multiple projects. If a project manager has a field problem on one project and a service responsibility on another project, the project manager will address the field problem. Only when the field problem is solved will he turn to

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address the service responsibility. This also is true on a large project where the project manager has only that one project. The field problems always will take precedent.

Some CMs claim to not make money on design phase services, but only cover their costs. This practice clearly adds to the CM's proclivity of taking care of field problems first. Most CMGC programs require a cost component. One contractor interviewed claimed to "do design phase services for a quarter of a percent, knowing that it's going to cost me a percent and half. But I will get (my money back)." The preconstruction services are such a small part of the work, relative to the actual construction of the project, that contractors can make a great impression on the owner during negotiations by coming in with a really low services contract and then make it up by adding a relative pittance to the construction contract. Any good CM is going to perform the same preconstruction services, and also pretty much the same construction services, anyway. The cost for all the work is going to be "in there somewhere." One of the contractors making this assertion said, "Our cost is our cost. It's auditable." This situation actually is much like a DBB contractor submitting an unbalanced bid; but in this case, it all is negotiated after award.

Shortening the Planning and Design Phases

One of the many advantages of having the CM on board as early as possible is the fact that the CM brings energy to the team. The CM, in a City of Phoenix contract, is nothing but a contractor providing preconstruction services. Any contractor is anxious to get out of the planning and design phases and into the construction phase. Construction is what they do, it is what they enjoy, and it is how they make their money. To execute the duties in their preconstruction services contract, contractors structure themselves to be a professional services firm. They structure themselves so that their project manager applies his knowledge in leading a team consisting of the contractor's superintendent, their estimators, their general supervision, etc., to provide those services and the responsiveness necessary to stay on track. Staying on track often means driving the other parts of the design team to a point outside their comfort zone. Sometimes this results in strained relations with the DP, but these feelings are usually only temporary when the DP sees the results. Many owners profess to need and want that help; they want the CM to push the DP, push the permitting agency, push those responsible for ROW, and especially to push the utility companies to move their utility lines.

Increasing Construction Budget Through Use of CMR

The City of Chandler, AZ, was a great example of how the proper application of CMR can mean more highway construction let in a shorter amount of time, thus increasing the agency's construction budget. That city went from a $60 million program in one year to $750 million by switching from strictly competitive low-bid (DBB) lettings to a program relying mostly on CMR. Just as significant is the fact that they were able to manage the $750 million CMR budget using the same number of people with which they were managing the $60 million DBB budget due to the reduction in paperwork, inspections, etc.

Expectations in a Diverse Culture

The implementation of the CMR delivery system in the City of Phoenix has rendered unexpected benefits. One such benefit reported by those interviewed is the fact that the expectation for civil discourse and cooperation as part of the CMR process has, by some sort of social osmosis, found its way into the Design-Build (D-B) and DBB highway construction programs administered by the City. Since many of the same City officials are involved in all three programs, contractors have noted that contractors that present themselves as cantankerous entities

characterized by adversarial attitudes and behavior on a DBB project are not often found on short lists for CMR projects. This phenomenon is probably enhanced by the fact that the Arizona Department of Transportation (ADOT) utilizes all three delivery systems in their highway and bridge construction program. One contractor commented: "Whether I like it or dislike it, if I get a hard bid job for an owner that I do CMR or Job-Order-Contractor-D-B for, the expectation of the owner is that I am going to treat him the same way I treat him on a DBB job as on a CMR job. It is a fact that I won't get future work in CMR (if I am a jerk on a DBB project). I've got to constantly try to find win-win solutions. But that's why it works for us so well. That's the way we manage our own business."

Self-Work Requirement

ADOT has a 45% minimum self-perform requirement for CMR on horizontal construction; the City of Phoenix requires 40%. "If we didn't have that," the local industry in Phoenix would have fought the introduction of CMR because "you'd have the out of state big boys do the CM briefcase thing and come in and just take it all away from the local guys."

Summary

The City of Phoenix has a CMR program that has executed more than 200 CMR projects since 2000, but only 12 of those are horizontal construction, all built since 2009. Six individuals (two City officials, two CMs/contractors, and two DPs) were interviewed to gain data and insight into the CMR program in Phoenix. When one analyzes the Phoenix CMR program, it is quickly apparent that the system used is not like other CMR systems and better fits the description of CMCG. This is due to the fact that the constructor is referred to as the "contractor" instead of the "CM," the contractor is required to self-perform 40% of the work, and its contracts are designed as strictly unit price for the construction stage.

The DP usually is brought in first, and the contractor can be procured anywhere between the 0–90% plans stage, depending on the perceived need, but it cannot be procured before the 30% plans review on federally funded projects. Once the contractor comes on board, the design process becomes different that that used in the DBB delivery system. The contractor is contractually obligated to coordinate with the DP on cost estimating, Value Engineering, construction phasing, schedule, and GMP preparations.

The first GMP generally is developed and submitted about 90% plans, although simple phases or plan packages could be completed earlier. ROW acquisition begins about the same time, although ROW acquisition can begin as early as 30% with environmental clearance. This is earlier than the City gets started on these items when using the DBB delivery system. Utility relocation coordination always is completed in-house, either prior to bid or during design and construction phases.

In the design process, there is no incentive for the DPs to control costs other than to retain their good name in the community. This makes contractor input even more essential. Especially sought is contractor input on major structural items/elements, scheduling, and cost estimating, specifically, cost reviews and preliminary cost estimating, constructability reviews, and bidability reviews.

The utility coordination and the effort to have utility lines moved out of the way starts about the same time on Phoenix's CMR projects as on its DBB projects. The CMR process utilized by the City of Phoenix enables the team to permit and design the project in small "mini" phases, and the design process is tailored to begin construction early rather than at the traditional final

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plans stage. All interviewed agreed that it is important to educate the DP, local politicians, local subcontractors, specialty contractors, and suppliers early in the process on how CMR works to ensure a collaborative effort, but there seems to be no consensus on the main challenges facing the DP in the design phase or the construction phase.

The City's best design practices for controlling construction costs include requiring contractors to submit their prices at each predetermined milestone, requiring that all work be done using the unit price contracting method, using actual subcontractor quotes to generate the GMP, and, when possible, bringing the contractor and DP onboard at the same time—same advertisement, same selection panel—and negotiate contracts at the same time. The final best practice is that once the contractor is brought in, they join in the validation and negotiate the GMP.

Contractor input is given great weight in the design. If the contractor identifies a potential problem in the design, the CMR system allows the designs, construction phasing, and materials selected to be modified or substituted during the design phase in an effort to bring projects in under budget—even if it was late in the design phase.

CMR takes more of an effort to coordinate in the design phase than a DBB project due to the speed with which everything is happening and the higher number of parties involved in the project.

The owner (the City) handles ROW acquisition and permitting in-house, either prior to bid or during the design and construction phases, though the preference definitely is to get these and other things done as early as possible. Besides ROW and permitting, four things were identified as particularly needing early attention in the design phase: (1) identifying challenges, (2) bringing in the necessary people, (3) procuring permits, and (4) moving utilities. As for moving utilities, the City has found that two things really help in getting utility lines moved earlier: (1) get the contractor on board early and (2) assign someone the responsibility to initiate and develop a personal relationship with at least one person at each utility company (and each permitting agency). Those interviewed have found that it is harder for the utility company (or permitting agency) to refuse to assist someone they know than a nameless, faceless entity.

Once the construction begins, it is mainly the owner's (City's) role to monitor and control the construction cost. The DP has no role past its work in the design phase except approving the contractor's pay requests.

Case Study—Program: Utah Department of Transportation (CMR)

Introduction

The Utah Department of Transportation (UDOT) has a long history of innovation in highway and bridge construction contracting. It successfully executed the largest (up to that time) design-build (D-B) project in the history of the U.S. The I-15 reconstruction project, built to prepare Salt Lake City for the 2002 Winter Olympics, was also "the largest project ever undertaken by the state of Utah. This $1.59 billion project would involve reconstruction of over 156 miles of Interstate mainline and the addition of new general purpose and High Occupancy Vehicle (HOV) lanes, construction and reconstruction of more than 130 bridges, the reconstruction of seven urban interchanges, reconstruction of three major junctions with other Interstate routes including I-80 and I-215, [and] construction of an extensive region wide Advanced Traffic Management Services (ATMS) component" (UDOT 2012).

The success of this high-visibility project gave UDOT the reputation as one of the nation's most innovative public transportation agencies. It also gave other such agencies the confidence that they also could successfully execute a transportation construction project of this magnitude. Finally, it showed other agencies the reality that highway and bridge construction projects could be successfully completed using a delivery system other than design-bid-build (DBB).

With this project, UDOT and its partner, the Utah Transit Authority (UTA), led public transportation agencies into a new era of innovative transportation construction contracting. During the succeeding decade, UDOT has continued to be a leader in innovative contracting. Having proven the viability of D-B, UDOT turned its sights on developing a new construction delivery system that could provide to contracted parties the benefits of D-B along with the benefits of DBB. The result was the construction-manager-as-general-contractor (CMGC) delivery system. UDOT now has built more than 25 projects with the CMGC construction project delivery system since 2005.

Program Description

When using the CMGC project delivery system, UDOT employs several methods of managing post-award design activities. The agency's process allows designers to adjust their plans with "real-time" information provided by the CMGC firm. The process is deemed very involved with the designers because the CM is hired soon after the designers are brought on board. There are no standard operating procedures for the design of CMGC projects, but the agency does utilize program management contracts that work well with CMGC.

The function of the project management is different from that of a typical DBB project in that project managers have a more prominent role in decision making and leading the projects.

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UDOT designs projects that call for multiple "mini" GMPs. Although these GMPs vary per project, there typically are three to five GMPs based on early procurement items as well as early work items. The typical design milestones utilized in a GMP contract are traditional percentage complete phase submittals (i.e., 30%, 60%, 90%, etc.) followed by a final PS&E. UDOT also employs GMPs that are in line with the phased submittals; but they can be iterated per project to be tailored individually to the needs of the project.

The designer is required to take less risk on a CMGC project. Designs are taken to "105%" in the sense that more up-front work is put into the design to ensure that the prices and plan are correct. Over time, UDOT has learned that the design effort must be intensified on CMGC projects to reduce cost. Plans are very detailed, and projects are not as schedule-driven as they are design-driven, intensifying the effort to thorough completion. Steps are taken to manage risk during design and to share risk among the owner, designer, and CM. UDOT operates on the premise that the entity most capable of taking the risk should do so. A full risk assessment is completed in detail for every project, and 100% of the savings goes to the owner.

Both the designer and CM are designated as the owner's representative; during the design phase it is the designer, and during the construction phase it is the CM. In actuality, the projects are driven by the owner's PM, who is responsible for managing the project during both design and construction. UDOT uses two PMs—one for design and one for construction. Furthermore, these are the owner's PMs in addition to the PM for the designer and the PM for the construction manager.

The designer assists in choosing the CM firm for the project, acting as an advisor for the selection committee. Additionally, the selection committee consists of a representative from AGC and AEC for both the contractors and design associations.

The approach for managing post-award design activities (i.e., activities during construction) for CMGC is no different from that used with DBB activities. More money is budgeted for the up-front design effort in order to minimize design during construction. Also, more money is budgeted for high-risk projects, and items are added on these projects for contingencies and redesign effort.

RFIs are reduced significantly on CMGC projects, and the CM is responsible for managing them with owner oversight and approval. A shared database is used to track and monitor all RFIs. During the design and construction phases, the owner takes primary lead in coordinating with designers any necessary design changes, and project contingencies are used in dealing with design errors and omissions. All communications go through UDOT's design PM during the design phase; after NTP, all communications go through the construction PM. Coordination meetings are held with all parties from the inception of design through construction.

The designer's role during construction is minimal due to the intensive up-front effort invested during the design phase. Monthly executive partnering meetings, held during both design and construction phases, ensure that projects are going well. All upper management are in attendance for these meetings with the exception of high-risk projects. In addition, weekly and bi-weekly design and construction meetings are held throughout both phases. Overall, UDOT sets the following goals and objectives for CMGC design projects: (1) efficient design, (2) efficient schedule for construction, (3) efficient use of taxpayer dollars, and (4) keeping the stakeholders happy.

When looking at how UDOT's post-award design management affects project performance in terms of cost, schedule, and quality, several key issues were brought to light. The design standards and specifications for CMGC projects are the same as for typical DBB projects. In fact, UDOT uses the same standards and specifications for all projects. However, if there are innovative ideas that involve streamlining, UDOT is open to modification.

The role of the CEI in a CMGC project differs from that in a DBB contract. The CEI enters in the design process early and has a seat at the table. Additionally, the CEI often is on the selection

panel. The CEI is involved during the design phase, is actively engaged in reviewing the plan sets during plan review, and attends all design meetings.

Designs typically come in at or over budget, and as more design effort is placed into CMGC projects, design is taken to approximately "110%." Factors most significant in controlling this outcome include the fact that design fee estimates are done up-front by UDOT's PMs, prior to starting design; that more experienced PMs used in CMGC produce better design estimates; and that different processes and hours are needed for the project.

Coordination between designers and CM does not necessarily require the inclusion of additional fees. Instead, additional overall design hours are needed to complete CMGC projects, and the fees are based on the individual UDOT PM's experience. Approximately 6–8% of the construction cost is typical for the design fee, and this percentage is higher than what typically is experienced on DBB projects. However, the percentage varies by project, and more design is required with UDOT's process for CMGC. Total cumulative project costs are calculated up front during the design process, 90% of the time, and they always have a targeted maximum price.

Design schedules have both shorter and longer durations compared to typical DBB projects. The design process is longer, overall, for CMGC projects due to the complexity of the detailed design; however, the construction starts sooner in the design process due to early work packages. Responsibility for creating and monitoring the design, construction, and overall project schedules is a collaborative effort. Nonetheless, the owner is responsible in the end and establishes all schedules up front in the planning phase. As the design schedules are much longer for CMGC projects, the overall design is not accelerated. On average, when using CMGC, construction time is reduced by one construction season.

UDOT's internal design PM manages design changes as they relate to potential impacts to the schedule, budget, and overall GMP. The independent cost estimate (ICE) process on CMGC projects entail pricing at 30%, 60%, 90%, and final completion of plans. Furthermore, there is a 10% red light/green light process wherein the PM has the power to authorize a project if costs are within 10% of the ICE. The CM primarily is responsible for generating traffic control plans.

The quality control process for design used during the design phase does not differ from that used in the construction phase. In fact, the same process is used for all other project delivery methods. Moreover, the owner's expectations for how design QA and QC are ensured throughout design development is expressed by means of a detailed process including three key checklists—one internal to UDOT, the designer's, and the inspector's.

In order for the client to minimize problems during the construction phase, UDOT identifies the following factors: (1) very detailed plans; (2) detailed communication and understanding of all project assumptions; (3) clearly defined risks and assigned costs; and (4) openness as a team on all issues.

Interviews

Interviews were conducted with 25 individuals who have worked with UDOT. The interviewees included 14 owners (or agents of the owner), five designers, and six contractors.

Approach for Managing Post-Award Design Activities

Twenty-one interviewees described the utility coordination process on a CMGC project as different from that of a typical DBB contract, but two individuals said it was the same. Nine interviewees said that the coordination process started earlier on a CMGC project than on a DBB project, and one interviewee said that the process started later; however, 13 said that the utility process started at

Table 42. Importance of educating designers.

Statement	Respondents
Education is critical/very important.	15
Designers must understand the meaning of partnership.	8
Designers are defensive/resist change.	3
Designers need to know what your ideas/expectations are.	2
DPs need to understand what is going on.	2
A clear definition of the roles is needed, and all members of the team must understand their roles.	2

the same time. Twenty respondents said the traditional duties of the design team (e.g., permitting, project management, utility coordination, overall project schedules, owner's representative duties) are different on a CMGC project from a typical DBB project, while four said that the traditional duties are the same. All 25 individuals said that the process employed by UDOT enables the team to permit and design the project in small "mini" phases and that the design process is tailored to begin construction early versus during the traditional final plans stage.

When asked about the importance of educating the designers early in the process to ensure a collaborative effort, a majority of the respondents said that it was either critical or very important. Table 42 summarizes the responses provided regarding the education of designers.

Other notable comments include the following:

- Designers naturally are collaborative.
- Anyone that has not gone through the process is a potential problem.

Interviewees were asked to compare the challenges typically encountered during the design phase to the challenges faced during the construction phase. Notably, several individuals mentioned that during the design phase they try to "avoid" problems while during the construction phase they try to "solve" problems. Particular to the design phase, several respondents mentioned bringing the CM on board earlier in the process as a means of building trust and teamwork. Specific to the construction phase, several mentioned that the challenges for a CMGC project were similar to those encountered on a DBB project. Additional responses provided are summarized in Table 43.

Other comments include:

- Design: Get people out of their rigorous mindset. Understand those who make decisions. Know which processes can be changed and which ones cannot be changed.
- Construction: Some issues that were related to design manifested in the construction phase.
- Construction: The pressure is on the contractor to meet his construction schedule.

Table 43. Comparing challenges encountered in the design and construction phases.

Statement	Respondents
Design: Bring the CM in earlier so the challenges revolve around building a team, coming together, building trust, etc.	4
Design: The CM is not really in it until the end.	3
Design: A lot of pressure is on design, and the CM wants to get started.	3
Design: The DP would not listen to the RE and CM. The CM and DP need to take each other seriously.	2
Construction: The same challenges exist as in DBB.	4
During design we try to avoid problems, and during construction we try to solve problems.	5
There are problems with scheduling issues.	3
There are problems with unknown conditions.	3

Table 44. Level of executive and middle management commitment.

Statement	Respondents
Executives must support middle management and be readily available.	10
Support of CM is consistent at all levels of the project.	9
A high level of commitment is needed from middle management.	6
Middle management has to be immersed in the project.	3
Executive commitment is crucial.	2

- Construction: Problems occur involving utilities and ROW.
- Construction: There are fewer problems than on a DBB project because we are more involved in the design.

When asked what level of executive and middle management commitment is required to successfully execute a CMGC project, all the respondents thought commitment was required in some form from either level. Specifics as to their thoughts varied slightly, but most thought it crucial that the executive level must support middle management during project execution. Additional responses include those listed in Table 44.

When asked what role the CM plays in the overall design process, a large portion of the respondents mentioned cost reviews, constructability, and minimizing risk as the top tasks performed by the CM. A slightly smaller portion cited scheduling, implementing innovations, and plan reviews as equally important tasks. Additional comments mentioned by the individuals are listed in Table 45.

Other comments include:

- Sharing insight into the design
- CM more involved with design than on DBB

Money Matters—Cost, Budget, Payments, Benefits

Eighteen interviewees indicated that the unit price contract type best describes how UDOT administers the CMGC process. Ten of the interviewees responded with lump sum, and ten considered cost-reimbursable to best describe how the CMGC process is administered by UDOT.

Except for one interviewee, who stated that it was an occasional problem when the FHWA audited his project, thirteen respondents said that the agency was satisfied with the method of payment. This was not applicable to the other two interviewees.

Eight interviewees said that either unit price or lump sum method of payment was employed in the construction phase on a federally funded project. Eight interviewees reported that cost-reimbursable was utilized in the preconstruction phase. Three answered that the unit price method of payment was used just like DBB on a federally funded project.

When asked to identify UDOT's best practices to ensure that construction cost is kept within the budget, the interviewees responded with the answers in Table 46.

Table 45. Role CM plays in the overall design process.

Statement	Respondents
Cost review/preliminary cost estimating (excluding the EE)	13
Constructability	13
Minimizing risk	12
Scheduling	8
Implementing innovations	8
Reviewing plans	7

Table 46. Best practices to ensure that cost is kept within the budget.

Statement	Respondents
Eliminating risk/risk mitigation	7
Cost estimate (usually based on milestones)	4
Having contingency funds for several risky items	4
Bringing in ICE	4
Analysis of cost and scope, keeping the project within budget by reducing scope or innovation	3
Monitoring the budget/cost on a regular basis	3
Using engineer's estimate	3
The GMP	2
Using an opinion of probable construction cost during design	2

Other comments include:

- As part of RFP, owner asking for the cost of a handful of bid items
- UDOT expecting a cost-loaded schedule, which is reviewed monthly
- Innovation tracking
- Owner doing "blind bids," which are like practice bids on key items
- Limiting change orders
- Cost/resource schedule by bid items
- Baseline CPM with regular updates
- Early cost model from the CM
- All work done in unit price
- Innovative material selection
- Owner remaining open with what the budget is and expecting the CM to be equally open

When asked to identify the steps taken during the design phase to manage the construction cost, the interviewees offered the responses found in Table 47.

Others comments include:

- As the design progresses, we (contractor) produce cost estimates at 30%, 60%, 90%, and 100%.
- Early packages lock in prices for materials and equipment.
- DARTs looked for improvements to save money.
- Optimize the schedule to reduce the overhead cost.
- The designer (agent of the owner) should get input from the CM and the ICE and look at different options to see how they affect schedule and cost.
- ICE and the CM both produced an estimate, and the estimates were opened at the same time.
- We (owner) broke up the cost estimate analysis and took immediate steps.

When asked to identify who is responsible for monitoring the project budget—including design, inspection, permitting, ROW, utilities, construction, etc.—the interviewees responded with the answers summarized in Table 48.

Table 47. Steps taken to manage construction cost.

Statement	Respondents
Risk management	4
"Blind bid" at different stages	4
Innovations	3
Constructability reviews	2
Open-book process	2

Table 48. The person who is responsible for monitoring the project budget.

Statement	Respondents
Owner/agency	2
The agency's PM	17
Lead design PM	3
Everyone involved with the job	3

Other comments include:

- The CM controls this cost with the contract—lump sum.

When asked to identify the DP's role in monitoring and controlling cost, the interviewees offered the responses found in Table 49.

Other comments include:

- Providing input into the EE
- DP gets assigned the lead for some of the items on the risk register
- Keeping any future inspection cost/budget within project budget
- Participating in many value engineering exercises
- Providing information or technical options so that costs can be determined for the GMP
- Reviewing things, but not so much the budget

When asked to identify the payment tools used by UDOT to pay the contractor, the interviewees provided the comments in Table 50.

Other comments include:

- If quantities are known, lump sum; otherwise, unit price
- CM phase: an hourly rate with a multiplier

When asked to identify how constructability reviews and value engineering are managed in a UDOT CMGC project versus a typical UDOT DBB project, the interviewees responded with the comments in Table 51.

Table 49. The DP's role in monitoring and controlling cost.

Statement	Respondents
Producing the EE	6
Completing a design that can be built for the money budgeted	12
Taking input from CM with a thorough understanding of the quantities on the project	2
Almost none	2

Table 50. The payment tools used by UDOT.

Statement	Respondents
Preconstruction phase: CM is paid as a consultant—cost plus fee	3
Construction phase: CM is paid just like DBB—unit price	3
Straight unit price	9
A unit price on risky items with a contingency fund connected to each risky item	2
Unit price with some lump sum items	3
Percent complete/proportionally paid as project progresses	2
A cost-loaded schedule	5

Table 51. How constructability reviews and value engineering are managed.

Statement	Respondents
Contractor is involved in the constructability review in CMGC, but not in DBB.	4
Constructability review was incorporated into regular meetings done by the CM.	2
In DBB, the owner will do the CR and VE during design phase.	3
CR and VE are considered part of the fee the CM gets for preconstruction services.	9
CMGC is an ongoing process, whereas DBB is a one-shot deal.	2

Other comments include:

- VE is not applicable in CMGC. There was no VE clause.
- VE is started even in our proposal.
- CM does VE and CR on a CMGC contract; on DBB, a contractor is hired.
- CM does CR if CM is involved early; VE is done in design phase. In DBB, everything is done afterward.
- In CMGC, VE and CR are done by ICE; in DBB, they are done internally.

When asked to identify the parties involved in the VE and constructability review process, four interviewees said that the CM was involved, two identified a DP, four indicated that all parties are involved, and two said the owner. ICE and utilities were identified by one interviewee. One responded that it was beneficial to have the end user, the one required to meet the standard (DP), and the one that has to build it all involved.

When asked if UDOT would allow the designs, construction phasing, and materials selected to be modified or substituted during the design phase in an effort to complete projects under budget, all twenty respondents answered in the affirmative. It is noteworthy that four of them said that this was just part of the CMGC process. One stated that there was a high degree of openness and willingness to engage new or innovative ideas. One pointed out that it requires UDOT to understand the additional cost for redesign versus increased savings in construction cost—sometimes an order of magnitude.

Issues Affecting or Affected by Design Management

No respondent thought that a DBB project takes more of a coordination effort than a CMGC project. Twenty-one interviewees believed that CMGC takes more of an effort to coordinate, with eight ascribing this to the higher number of parties involved in the project and three citing the speed with which everything is happening and the time that takes to manage. Two interviewees saw no difference in the effort required.

The engineer's estimate (EE) is a very important item on a DBB project. Bidders know that their bids must be within 10% of the EE, so they use the EE as a guide and the owner uses the EE to budget the project. The question was posed to those interviewed as to whether the EE was as important to a CMGC project let by UDOT as it is to a DBB project. Three respondents said that the EE is more important in a CMGC project. Four respondents said that the importance of the EE is the same regardless of the delivery system, and four said that the EE is less important on a CMGC project, citing the use of independent cost estimate (ICE).

When asked about the function of the EE in a CMGC project versus a DBB project, nine interviewees indicated that the EE is used the same in each delivery system. Three responded directly that in CMGC, the function of the EE was somewhat diminished by the ICE, while fourteen

interviewees said that ICE was used in a CMGC project and eight mentioned the use of the CM's estimate. Other comments on the question were as follows:

- The engineer gets more input (officially or unofficially) in CMGC, so the EE might be a little twisted.
- With CMGC, we (owner) use EE and ICE and compare the GMP to both.
- In DBB, the low-bid is compared to the EE.
- In DBB, EE is a target that we have to shoot for as our project budget.

When asked how ROW acquisitions and permitting are handled in a UDOT CMGC project, seventeen answered that the owner handled those issues in-house during design and construction. However, fourteen said that they are handled prior to bid and four said that they are handled by the CM firm during the design and construction phases.

When asked to identify what steps can be taken during the design phase to minimize or eliminate potential remobilization-related cost and schedule impacts resulting from delays in ROW acquisition, permitting, utility relocation, or other unanticipated delays, the interviewees responded with the comments found in Table 52.

When asked to identify the parties routinely involved in coordination meetings (during the design phase), who takes lead at the meetings, and how frequently they are conducted, the respondents answered as seen in Tables 53 and 54.

Other comments include:

- PM
- CMGC coordinator (person tracking and innovation)
- ICE

Table 52. Steps taken to minimize potential remobilization-related cost and schedule issues.

Statement	Respondents
Identify challenges early.	2
Optimize staging and phasing to work around ROW or utility property problems.	5
Use risk register.	6
Schedule development related to ROW and utilities.	8

Table 53. Parties routinely involved in coordination meetings.

Statement	Respondents
Agency's PM	6
Owner	7
DP	13
CM	14
RE (resident engineer)	2
Utilities	2
Other stakeholders	6

Table 54. Lead and frequency of the meetings.

Statement	Respondents
Whoever had the most to say	2
Lead design PM	12
Owner's PM	7
Meetings occur weekly or bi-weekly	7
Depends on the phase of the project	4

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Other comments include:

- Owner
- Contractor

When asked about the educational effort/training required for the owner's staff, design consultants, contractors, and CM firms to transition from the traditional DBB world to CMGC, the interviewees said that experience/on-the-job is better than any formal training, that experience is key, but partnering training helps (can lead to a shift of attitude). Other comments include:

- SCAN tour would be good.
- For DP, it is about learning to work together; CM needs to know the standards and specifications the DP is using and must adhere to.
- The DP needs to be trained in what the law requires to make things work out, in the process of CMGC, and in how the contractor thinks and places cost.
- The important thing is UDOT's openness to and of the process.
- Contractors need to be educated on how to transition from being a contractor to a CM.
- Owners need to educate themselves on how a contractor estimates a project.

When asked what changes in culture and philosophy are required of the contractors and designers versus traditional DBB, most of the interviewees did think that an attitude change or a change in culture was essential when coming from DBB into CMGC. Fourteen interviewees thought that everyone must work together more; five responded that everyone needs to let their guard down and increase their trust. One suggested that more cooperation is needed between DP and CM.

When asked what level of industry collaboration and support is required to successfully execute a CMGC project, nine interviewees thought a high level of collaboration and support was needed and four said that everyone has to buy in. Other comments were as follows:

- Subs and suppliers play such a major role. They really need to understand the process.
- AGC does training of local contractors.
- Every player needs to understand the process.
- Get everyone on board as early possible, and let all know exactly what you need from them and when you need it.
- You (owner) have to educate the staff of the city/county commissions' staff people more than the actual manager/commissioners.
- We (owner) should have had more subs on the CM contract in order to hear from the specialties.
- The DPs and subs must have trust.

When asked how utility companies and permitting agencies fit into the project team and design process, the interviewees responded with the comments found in Table 55.

Other comments include:

- Make them the team members, and treat them like members.
- Utilities were brought in for global work issues that covered all projects.

Table 55. How utility companies and permitting agencies fit into the project team.

Statement	Respondents
They should be brought in early.	6
Utilities were invited to all project meetings.	9
Utilities/permitting agencies were not part of the team.	5

- They coordinated with the DP to plan the moving of the utilities.
- With CMGC, the contractor is another resource to call on to make the process work.
- We (owner) will do a field review with them.
- They were included in the design.
- Separate meetings were held with utilities.

When asked how UDOT ensures value-added guarantees in their D-B (CMGC) contracts, five interviewees stated that they include good ideas in the contract to ensure value-added guarantees. Two said that good ideas or innovation were put into plans, and three said that good ideas were put into specifications. Other comments were as follows:

- Measure it from start to finish.
- Any good idea put forward is going to be expected to be delivered; however, we (UDOT) have to be reasonable.
- Ideas or sales pitches in their proposals are expected to be performed. If you do not do it (as a CM), you probably won't be shortlisted next time.
- Incorporate the ideas into the RFP and then into the construction documents.
- Any innovation that we (contractor) or the DP comes up with is already in the contract documents.
- In CMGC, CM's proposals or the DP's original ideas may be usurped by better ideas. But if a better idea is not found, an idea put forward by the CM in its proposal could very well be required of them by UDOT.
- Ideas the CM comes up with in preconstruction get into the construction constructability.

Summary

Having achieved early successes with D-B, CMGC, and rapid bridge replacement, UDOT is now in its second decade as a leader in innovative thinking and execution among public transportation agencies. The agency has a CMGC program that has successfully completed more than 25 horizontal transportation construction projects using the CMGC delivery system since 2005.

UDOT's process allows designers to adjust their plans to "real-time" information when it is provided by the CM firm, no matter when the information comes to light. UDOT projects also are designed with multiple "mini" GMPs to allow for maximum flexibility in construction as well as design. Designs are taken to "105%" in the sense that there is more up-front work put into the design to ensure that the prices and plan are correct. Both the designer and CM are designated as the owner's representative; during the design phase it is the designer, and during the construction phase it is the CM. Projects actually are driven by the owner's PM, who is responsible for managing the project during both design and construction. UDOT uses two PMs—one for design and one for construction.

When the time comes to choose a CM and DP for a project, the selection committee consists of a representative from AGC and AEC, the contractor and DP advocacy associations. Once the project begins, the approach for managing post-award design activities (i.e., design activities during construction) in CMGC is no different from that used with DBB activities. The number of RFIs are reduced significantly on CMGC projects versus DBB projects, and the CM is responsible for managing them with owner oversight and approval. During the design and construction phases, the owner takes primary lead in coordinating with designers any necessary design changes, and project contingency funds are used in dealing with design errors and omissions. All communications go through UDOT's design PM during the design phase; and after NTP, all communications go through the construction PM. All in all, the

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designer's role during construction is minimal due to the intensive up-front effort invested during the design phase.

The design standards and specifications for CMGC projects are the same as for typical DBB projects, unless their contract documents do not cover a situation. In this case, they will handle the situation with project-specific specifications, just as they would with a DBB project. The role of the CEI in a CMGC project differs from that in a DBB contract. The CEI comes in early in the design process and immediately assumes a key role. Additionally, the CEI often is on the selection panel.

Designs typically come in at or over budget. Since more design effort is placed into CMGC projects, design is taken to approximately "110%." Therefore, additional overall design hours are needed to complete CMGC projects, and the fees are based on the individual UDOT PM's experience. Approximately 6–8% of the construction cost is typical for the design fee, and this percentage is higher than what typically is experienced on DBB projects. Design schedules have both shorter and longer durations compared to typical DBB projects. The design process is longer, overall, for CMGC projects due to the complexity of the detailed design; however, the construction starts sooner in the design process due to early work packages. Responsibility for creating and monitoring the design, construction, and overall project schedules is a collaborative effort. Nonetheless, the owner is responsible in the end and establishes all schedules up front in the planning phase.

UDOT's internal design PM manages design changes as they relate to potential impacts to the schedule, budget, and overall GMP. There is a 10% red light/green light process wherein the PM has the power to authorize a project if costs are within 10% of the ICE. The CM primarily is responsible for generating traffic control plans. The quality control process for design used during the design phase does not differ from the quality control process for design used in the construction phase.

Twenty-five individuals were interviewed face-to-face about their experiences with projects let by UDOT. The comments of those interviewed were noted and stored in a spreadsheet. The answers to questions were tabulated, and to make sure all responses were properly categorized, key word searches were conducted to place every thought and idea expressed in its proper category. The comments were then tabulated. Most questions were open-ended, so it was significant when two individuals gave the same answer. The closed-ended questions were few, but they reveal important details about the UDOT CMGC program. Among these are as follows:

- A majority (13) said that the utility moving process starts at the same time on a CMGC project as on a DBB project. Nine said that it started earlier, two had no opinion, and one said that it started later.
- Twenty respondents said that the traditional duties of the design team (e.g., permitting, project management, utility coordination, overall project schedules, owner's representative duties) are different on a CMGC project compared to a typical DBB project, while four said that the traditional duties are the same. One had no opinion.
- All 25 individuals said that the process employed by UDOT enables the team to permit and design the project in small "mini" phases and that the design process is tailored to begin construction early versus during the traditional final plans stage.

As for the open-ended questions, the comments made by at least five individuals are noted here:

- It is very important/critical that DPs be educated regarding the CMGC process and culture prior to their involvement in a CMGC project.
- DPs must understand the concept of partnership to be successful in the CMGC process.

- In comparing challenges faced in the design phase to those faced in the construction phase, during design the team is trying to avoid problems and during construction they are trying to solve problems.
- Executives must support middle management and be readily available for CMGC to work.
- Support of CMGC must be consistent at all levels of the project.
- A high level of commitment is needed from middle management for CMGC to work.
- During the design phase, the CM provides the following services: cost review/preliminary cost estimating (excluding the EE), constructability, minimizing risk, scheduling, implementing innovations, and reviewing plans.
- The single best practice that UDOT does in the design phase to keep cost down in the construction phase is its process for eliminating risk and risk mitigation.
- The person responsible for constantly monitoring costs related to budget is the UDOT project manager.
- The DP's largest contribution toward controlling project cost is to complete a design that can be built for the money budgeted.
- The contractor payment tools used by UDOT are straight unit price and a cost-loaded schedule.
- Constructability reviews and value engineering are considered part of the fee the CM gets for preconstruction services.
- Steps taken by UDOT in the design phase to minimize potential problems with cost and schedule are to optimize staging and phasing to work around ROW or utility property problems, to use the risk register, and to develop the project schedule to include ROW and utility issues.
- Parties routinely involved in coordination meetings are the agency's project manager (the owner), the DP, and the CM.
- The lead design PM or the owner's PM usually leads the coordination meetings, which are held weekly or bi-weekly.
- As far as the educational effort/training for the transition from DBB to CMGC, experience is best, but on-the-job training and training in partnering is helpful.
- As for how utility companies and permitting agencies fit into the project team, both entities should be brought in as early as possible and invited to all project meetings. However, they are not really considered part of the design team.

Case Study—Program: Utah Transit Authority (CMR)

Introduction

The Utah Transit Authority (UTA) has worked on five major projects with the construction-manager-as-general-contractor (CMGC) construction project delivery system since 2002. At the time of the case study visits, it was confirmed that these five projects, totaling $2.5 billion, may be more than anyone else in the country.

General observations include culture as a major issue. UTA has cultivated it and demands it from its contractors much like a parent expects good behavior from their children. Trust is a major issue. A lack of trust loses the benefits of the CMGC process. The level of cooperation is very high, and the partnership is very strong.

There clearly is an advantage to not having federal funding or involvement in the project. Federal agencies are concerned about a variety of the processes involved with CMGC such as those involving payment. It seems that a lack of trust has prevented them from accepting or even understanding the whole CMGC process.

UTA has conducted some experimental work in alliancing. After using alliancing on the North Temple Viaduct Project, it now has applied it to the Sugar House Line. It is unknown whether any other agency in the U.S. currently is using alliancing. UTA lacks even the most basic model for alliancing and seems to have gotten most of its inspiration from results of projects in Australia.

Anecdotal evidence suggests that there is a greater level of CMGC buy-in with UTA than UDOT. UTA officials noted the higher cost of UTA, yet no other agency has been able to achieve commuter rail construction per mile for less than it has done.

Program Description

UTA performs CMGC because it allows more speed and a greater level of control vs. DBB. The delivery method also was reported to be a "good agency fit," with a high level of trust developed among all persons involved. Trust is the key to success at UTA, which generally does not do business with people it does not trust.

UTA performs general oversight while contractors do their own QC. This allows contractors to take advantage of the owners if they so desire. There have been NCRs on five UTA projects totaling $2.5 billion. Contractors have written hundreds of NCRs. It takes time for the contractors to know and trust their partners, and they have to adjust to an owner with an open culture.

The contractor needs to buy in to the joint relationship and fix problems as soon as they are found. Issues are resolved in real time, saving money and helping the contractor in the long run. Early input by the contractor helps in the timeliness and speed of decision making.

Interviews

Interviews were conducted with eight individuals with prior experience working with UTA. These interviewees included five owners (or agents of the owner), two designers, and one contractor. From among the interviews, three case study questionnaires were completed and several individual question/answer discussions were conducted. For the responses that follow (detailing the questionnaire interviews), four individuals were queried in total; however, since two of these respondents were interviewed together, their joint answers have been combined as one interviewee response.

Approach for Managing Post-Award Design Activities

When asked about the utility coordination process on a CMGC project, all three interviewees described the process as different from that of a typical DBB contract.

Two interviewees said the coordination process started earlier on a CMGC project than on a DBB project, one interviewee said the utility process started later, and one interviewee said the utility process started at the same time.

When asked if the traditional duties of the design team (e.g., permitting, project management, utility coordination, overall project schedules, owner's representative duties) are different on a CMGC project compared to a typical DBB project, two respondents said they were different while one said the traditional duties are the same.

All three respondents said the process employed by UTA enables the team to permit and design the project in small "mini" phases and that the design process is tailored to begin construction early vs. at the traditional final plans stage.

When asked about the importance of educating the designers early in the process to ensure a collaborative effort, the following remarks were made:

- Designers were flexible with design and priorities.
- Education is needed the first time around, after which it becomes easier.
- Previous experience with either D-B or CMGC is helpful.
- CMGC creates an environment where the owner can be more involved.

Interviewees were asked to compare the challenges typically encountered during the design phase to the challenges faced during the construction phase. Notably, there was mention of communication in both the design and construction phases as well as general reference to the speed of the CMGC process. Below are the provided responses.

- Design—more practical because of cost feedback and ongoing communication
- Construction—more and frequent discussion of technical issues
- Biggest challenge is more technical coordination with third parties
- Overlap due to the speed of the process (CMGC contractors want to get going)

Regarding the level of executive and middle management commitment required to execute a CMGC project successfully, one interviewee said culture in site organization is key as the contractors trust that they will not be taken for granted. Another interviewee stated that support of

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CMGC should be consistent at all levels of the project, as it could pose a problem for agencies that cannot give up on traditional methods.

The interviewees were asked what role the CMGC plays in the overall design process. The responses include being able to move forward with trust, the CMGC giving the owner the ability to get what they want from the contractor and price items accordingly, and the CMGC being involved in the design constructability reviews.

Money Matters—Cost, Budget, Payments, Benefits

Interviewees were asked about their agencies' best practices to ensure that the construction costs are kept within the budget. Among the responses was an early start due to the availability of equipment. Further comments include iterative estimating, having the owner adjust scope and budget toward the ultimate goal, certainty about the price, the contractor having a better handle on the real cost of the work (as opposed to the designer), and avoiding scope conflicts.

When asked who is responsible for monitoring the project budget (including design, inspection, permitting, right-of-way [ROW], utilities, construction), various responses were provided.

- Contractor and owner worked together with the project owner.
- The CM controls the cost within the contract.
- The contractor owner sometimes encourages UTA to handle at a progressive level.
- Designs are reviewed by UTA.

Regarding the designer's role in the CMGC process, one interviewee said they provide information or technical options so that costs can be determined for the GMP. Another noted that designers participated in many VE exercises. Finally, the third respondent said there was no role for the designer in the CMGC process.

Several payment tools have emerged across the nation for progress payments on CMGC projects, including unit price, lump sum, and cost-reimbursable. The interviewees were asked to describe the methods they have used as well as their advantages and disadvantages.

- Progress payments were done proportionally.
- There is a subjective review of percentage complete.
- They agreed to be paid based on a cost-loaded schedule.
- Prearranged increments helped with deciding on the percentages.
- Schedule of value based on the GMP is not as complicated as a cost-loaded CPM.
- Agreed-upon progress percentages (with the owner) are relatively easy to administer.

Of the three contract types (unit price, lump sum, and cost-reimbursable), two individuals said lump sum best describes the CMGC process as their agency administers it.

As a follow-up, regarding how they paid the CM and designer on federally funded projects, the following answers were provided:

- The federal project was paid off schedule (vs. state projects, which were done by percentage complete).
- The contractor would publish a revised payment forecast every quarter.
- PTG was paid via normal UT methods.

Interviewees were then asked if their method of paying the principals and their record of payment documentation satisfy FHWA auditors. Not all respondents answered the question, and one said it was not applicable.

When asked how constructability reviews and value engineering are managed vs. a typical DBB project, the respondents said reviews were integrated into the day-to-day production of design, reviews were iterative, and reviews were numerous.

When asked if the agency's program has the flexibility required to change designs, construction phasing, and materials selected if the design team (the CM, agency personnel, and design firm) discovers a better method than what is currently in the contract documents, even if it is late in the design phase, the following responses were given:

- The process is very flexible.
- The culture of UTA is very intuitive to new ideas.
- Owners must resist carrying the design too far.
- There is a high degree of openness and willingness to engage new or innovative ideas.
- They would have summit meetings to review issues.

Issues Affecting or Affected by Design Management

When asked about the function of the engineer's estimate using CMGC vs. that of a typical DBB project, the respondents had the following statements:

- The most cost effective projects in the country hire outside expertise to produce an ICE.
- One estimate was done at the PE state, and UTA hired its own estimator.
- Estimates generally are in the ballpark thanks to the ongoing communication.
- There was a lot of work up front that eliminated disputes on overhead fees.

One respondent said the engineer's estimate was more important while one said he did not know. When asked what steps could be taken during the design phase to minimize or eliminate potential remobilization-related cost and schedule impacts resulting from delays in ROW acquisition, permitting utility relocation, or other unanticipated delays, the interviewees made the following remarks:

- UTA was in charge, dividing ROW and acquiring it in pools.
- Problems encountered included the site not being permitted fully and going outside the approved boundaries unknowingly.

When asked what parties are involved routinely in coordination meetings during design phase, who takes the lead at the meetings, and how frequently they are conducted, the following replies were given:

- Separate meetings were held with the third party, and about 13 cities were involved.
- The contractor leads the meetings; alliancing was used to work together and share the savings.

All three respondents stated that the level of coordination required for a CMGC project is more than that required on a typical DBB contract.

When asked about the educational effort/training required for the owner's staff, design consultants, contractors, and CM firms to transition from the traditional DBB world to CMGC, one individual mentioned experience, while the other two cited on-the-job training.

Changes in culture and philosophy needed by the contractors and designers (vs. traditional DBB) include trust, the belief that you will be treated fairly, and the understanding by contractors of how things work.

Interviewees were asked how ROW acquisitions and permitting were handled. One individual said they were completed in-house prior to bid. There was no response from the other two individuals.

Regarding how utility companies and permitting agencies fit in to the project team and design process, one respondent said they held separate meetings with the utilities. Another mentioned bringing in utilities for global works to help prioritize.

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When asked how they ensure value-added guarantees in their CMGC contracts, trust seemed to be a common theme. Among the responses are the following statements:

- CMGC works well when you have a contractor that works well with the process.
- Trusting that the contractor is not going to overcharge the owner is important.
- Shared savings and leveraged relationships worked well.
- Procure the contractor after the designer and owner start, but not too late.
- ICE helps subcontract positions that have multiple and open bids.
- On CMGC vs. DBB, changes are due to scope—like a lump sum, no excuse scenario.
- UTA wants 40–70% of the work self performed (versus others wanting 30%).
- The advantage is in having your own people.
- The disadvantage is that you do not want to be really involved and subcontractor selection is handled by UTA, which does not like to meddle.
- Reverse incentives were helpful.
- Deferring 6% of billings over time to reduce cash flow requirements became contractor insurance.

Interview with Mike Robertson

Mike Robertson is a consultant who has worked with UTA for more than a decade. He has been involved intimately in their CMGC program and is one of the key "thought leaders" in advancing the process. He now consults around the country on large transit capital projects and alternative delivery methods in addition to his ongoing work at UTA.

The Commuter Rail North project originally was not going to use CMGC. The UTA was thinking it would use D-B. Stacy Witbeck came in and presented to UTA the benefits should the project be done using CMGC. After some discussion and review, UTA agreed on this delivery method.

Mike made the point that the delivery method must be matched with the goals of the agency. The first decision is what the goals are and then the second is the delivery method that best achieves those goals. For the Commuter Rail North project, UTA had the following goals:

- Early knowledge of the price (this facilitated their negotiations with the Federal Transit Administration regarding the amount of their full funding grant agreement (FFGA))
- Flexibility in the design even during the FFGA process
- More involvement by UTA in the design process (than its past experience with D-B projects)
- Issues addressed quickly with UPRR

After reviewing the delivery methods available (D-B, DBB, CMGC), it was clear that CMGC was the only delivery method that would achieve these goals.

Mike noted that, in his experience, too many owners choose the delivery method before determining their goals. This may lead to selecting the wrong delivery method.

The language in the existing statute was broad enough that UTA officials determined they did not need additional statutory authority to use CMGC. In actuality, the statute neither authorizes nor denies the use of CMGC. The UTA attorney advised that the lack of prohibition was grounds enough to proceed.

UTA performed peer reviews to learn more about the CMGC process. UTA officials talked to people such as Rick Thorpe (Expo Authority in LA) and Don Irwin at Tri-Met. They were able to take what they learned to create a hybrid for their own CMGC process.

Mike emphasized strongly that selection of personnel is one of the most important functions of an agency. A project cannot succeed if the wrong people are involved. In his past experiences, they have the personnel for each project; those who did not believe in CMGC or who seemed to

be stuck in old ideas were not allowed on the project. UTA felt that it actually could manage the project with fewer staff if it had the right people on the job.

The focus of UTA was on collaboration, which allows the owner to make changes in a more timely fashion. One of the most important points regarding CMGC is that the real cost savings come via this collaboration.

UTA was building this project adjacent to an active UPRR line with many interactions. It met with the UPRR in Omaha every six weeks to work through any issues. UTA took the contractor and designer along and was able to respond to issues that the UPRR brought up in a timely manner. UTA adopted a cooperative approach, and the UPRR responded well to this. This relationship proved beneficial for UTA during construction of the Commuter Rail South line. UTA's open, up-front dealings with the contractor on the goals of the project helped in the discussions they had as they worked through the issues.

Mike noted that Stacy Witbeck was characterized by important cultural and leadership aspects that made them an ideal firm to build the Commuter Rail North project. Picking the right firm for this method is very important.

The estimating process for a CMGC project can be either very efficient or very time consuming. UTA used a local firm called Stanton, which comprised former contractor estimators, to do its independent cost estimates. The use of consulting engineers who lack experience in the field or in building up estimates by crew and activity is not sophisticated enough for CMGC. Using unit prices from previous projects also will not work. Using someone like Stanton allows the team to get to a number sooner.

In their cost estimating and comparison process with the contractor, UTA would agree first on quantities. By dealing with this issue early and directly, a potential area of disagreement was taken off the table. UTA also used a software product called HCSS, which enabled it to reach agreement very quickly on all but 10–20 bid items. UTA then was able to focus on those 10–20 items and resolve them in short order. This is a much more efficient process than other agencies have used for CMGC cost estimating. After reaching an agreement on the line items, UTA would negotiate the soft costs.

UTA allowed Stanton to engage the contractor's estimators throughout this process. UDOT does not allow this under the assumption that it taints the independence of Stanton. UTA feels that by allowing the two parties to talk through their disagreements, the process becomes much more efficient. It does not see any potential conflict in these discussions. The fact is any differences have to be reconciled eventually, so why not let them sort it out directly.

UTA decided that the way to reduce soft costs was to be more collaborative and thus encouraged VE. The contractor's team also needs the right people. A contractor's representative who is unwilling to work with the team or contribute positively must be removed from the process as swiftly as possible. The tendency is to wait, but as time passes, that person can create numerous problems and inefficiencies in the process.

Every agency must evaluate its culture realistically. Not every agency is suited for CMGC; it may be a good delivery method for certain projects, but an incompatible culture is capable of negating any potential benefits. Some agencies cannot evaluate their culture objectively and thus are oblivious that their culture is not suited for a particular delivery method.

On the North Temple project, UTA approached the contractor and asked them to identify areas where UTA was costing them money. They were able to negotiate a savings amount that would be refunded to the agency (hard cash that was then put back into the project) if UTA changed whatever it was doing that was inefficient. This was a very successful process.

Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
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	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
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
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