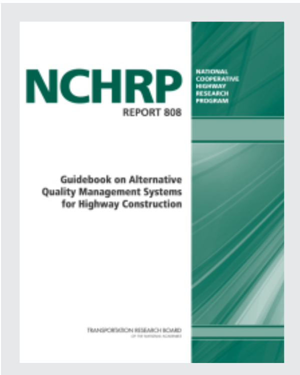

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP REPORT 808

Guidebook on Alternative Quality Management Systems for Highway Construction

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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

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

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FOREWORD

By David A. Reynaud
Staff Officer
Transportation Research Board

This guidebook provides recommendations and tools to assist in developing quality management systems (QMSs) and assistance in creating a better definition of quality management in the context of alternative project delivery. The roles of owners and contractors in QMSs are changing, leading to variation in the roles and responsibilities of quality assurance organization (QAO). These range from the agency-dominated system of quality management associated with the traditional design-bid-build (DBB) method to design-build (DB)/public-private partnership (PPP) agreements where the responsibility for quality management is shared to varying degrees between the contractor and owner. This report will be valuable to highway construction engineers by facilitating the development of QMSs for evolving alternative project delivery methods.

The need for the research conducted under NCHRP Project 10-83 is, in part, a consequence of both the growing use of alternative project delivery methods and the need for a better definition of quality management in the context of alternative project delivery. Innovations in QAOs and other features of quality programs are being used by state transportation agencies across the country.

The objective of NCHRP Project 10-83 was to (1) identify and understand alternative QMSs and (2) develop guidelines for their use in highway construction projects. However, as the researchers at the University of Colorado–Boulder, Iowa State University, and Oregon State University point out, these alternative QMSs are being applied on a project-by-project basis due to the lack of national guidance to promote standard approaches. For transportation agencies, this lack of guidance is resulting in significant investment to develop individual programs and is limiting the ability to capture and utilize knowledge across agencies. For consulting engineers and contractors, this lack of guidance is resulting in significant investment in response to project solicitations, which require unique QMSs for different agencies. The speed at which rapid renewal projects must be delivered creates a demand for a well-defined QMS that can be successfully replicated on a variety of projects. QMS guidelines on a national level will promote efficiency and allow for the transfer of knowledge to continuously improve these systems.

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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.

CHAPTER 1

Introduction

1.1 Background

This guidebook focuses on the identification, understanding, and dissemination of alternative quality management systems (QMSs) in the highway industry throughout the United States. Innovations in quality assurance organizations (QAOs) and other features of quality programs are being used by state transportation agencies (STAs) across the country. The use of non-traditional QAOs is being used with both design-bid-build (DBB) delivery and alternative delivery methods such as construction manager/general contractor (CMGC) and design-build (DB). The need for this guidebook is, in part, a consequence of both the growing use of alternative project delivery methods and the need for a better definition of quality management in the context of alternative project delivery.

The roles of owners and contractors in QMSs are changing. These changes are leading to varying QAOs, which range from the agency-dominated system of quality management associated with the traditional DBB method to DB/public-private partnership (PPP) agreements where the responsibility for quality management is shared to varying degrees between the contractor and owner (FHWA 2012). One of the attractions of projects using alternative delivery methods like these is the transfer from the owner to other parties of some project responsibilities, which may include design, finance, and/or quality management. These alternatives may result in savings to the owner and are increasingly making inroads into the highway construction industry.

This research makes a fundamental assumption—that all projects, whether using alternative quality management methods or traditional methods, must be delivered to meet the same standards and specifications that are found in the baseline method. In traditional DBB contracting in the transportation industry, decades of owner-managed quality assurance (QA) efforts and material supplier quality control (QC) experience provide a wealth of knowledge and standard practices that are readily accessible and widely accepted for producing infrastructure projects that function as intended. For projects using an alternative QMS (whether a modified baseline method or an alternative delivery method), there exists a limited, but rapidly expanding, body of experience associated with ensuring quality. The purpose of this guidebook is to bring together this relatively new body of experience and summarize it in one easily accessible reference treating the subject of quality management in alternative projects.

1.2 What Is Quality?

Transportation infrastructure project QMSs in the United States are evolving, due in part to experimentation with changes to the baseline QMS and in part as an accommodation of the needs of alternative delivery methods. These alternative delivery methods include DB, CMGC, and PPP. Their use is becoming more prevalent, particularly on larger and higher profile rapid renewal projects. The speed at which rapid renewal projects must be delivered creates a demand for a well-defined QMS that can be successfully instituted on a variety of projects. QMS guidelines on a national level will promote efficiency and allow for the transfer of knowledge to continuously improve these systems.

Project delivery methods and project quality management should be concerns for all public transportation agencies. It is important to understand how agencies are approaching the project delivery/quality management issue on their projects. When using project delivery methods in which the contractor is selected before the design is complete and is expected to contribute to the design, the agency should consider the impact of that shift on quality management planning and execution at every phase of project development. Table 1 compares the potential for meeting three quality objectives among three project delivery methods based on an analysis of federal projects (Uhlik and Eller 1999).

Uhlik and Eller (1999) conclude that CMGC project delivery has a high likelihood of delivering two of three quality

Table 1. Quality management comparison of project delivery methods.

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

Adapted from Uhlik and Eller 1999.

objectives. The third objective, single point of responsibility, can only be achieved by DB project delivery and DB has a low probability of achieving the checks and balances objective. Table 1 indicates that CMGC and DB may be the preferred project delivery methods for projects where ensuring quality is difficult. Ladino, Reedy, and Carlson (2008) reached the same conclusion: "CM[GC] improves quality and value . . . [by keeping] focus on quality and value—not low bid." The scope of this guidebook section is to discuss the state-of-the-practice regarding quality management as implemented in projects delivered using alternative project delivery methods.

1.3 Quality Definitions

The construction industry uses precise terms to define different aspects of quality programs. However, agencies often use these terms inconsistently. Among the authors of literature on quality exists what is best described as "confusion" as to precise definitions for the various aspects of quality and the terminology used to describe the tasks involved in design and construction quality management.

The American Society for Quality (ASQ) defines quality as "the totality of features and characteristics of a product or service that bears on its ability to satisfy given needs" (ASQ 2013). That definition is quite broad, but the focus on "satisfy[ing] given needs" is cogent to this guidebook. The owner must clearly articulate the "given needs" for design and construction quality in project documents (i.e., requests for proposals (RFPs), specifications, etc.). One way to ensure that these needs are understood is by requesting specific quality-related submittals as a part of any pre-award proposals, if applicable. Another way is to include the requirements for design and construction quality management as submittals required after contract award.

The ASQ goes on to define five varying types of quality as follows (ASQ 2013):

- Relative Quality: loose comparison of product features and characteristics.
- Product-Based: quality is a precise and measurable variable and differences in quality reflect differences in quantity of some product attribute.
- User-Based: fitness for intended use.
- Manufacturing-Based: conformance to specifications.
- Value-Based: conformance at an acceptable cost.

Thus, it can be seen that the concept of quality has many facets. As a result, an owner attempting to articulate the requirements for both design and construction quality needs to be very precise in defining quality for each feature of work. Additionally, as the methods used to deliver transportation projects evolve, new definitions must be developed to describe the altered state of roles and responsibilities for managing the quality definition, verification, and acceptance process. In *NCHRP Synthesis 65* (Transportation Research Board 1979), ensuring that a QMS is fulfilling a project's design and construction quality needs is simplified to four basic questions:

1. What do we want?
2. How do we order it?
3. Did we get what we ordered?
4. What do we do if we do not get what we ordered?

An example of the need for new definitions is given by Bourne, DeWitt, and Drennon (2006). These authors recognized the specific need for new definitions for actions performed when deploying quality programs on projects delivered using alternative delivery methods, stating (p. 2, emphasis added)

> As it relates to QA, the owner is responsible for oversight management and *a new definition of QA. This new definition includes oversight* to provide confidence that the design–builder is performing in accordance with the QC plan, design monitoring and verification through auditing, spot-checking, and participation in the review of the design.

For the purposes of this guidebook, *Transportation Research Circular E-C137: Glossary of Highway Quality Assurance Terms* (2009) is used to define exactly what the quality assurance terms

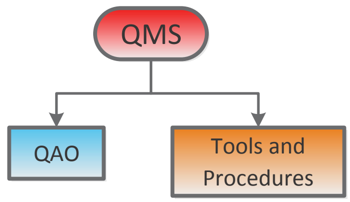

Figure 1. QAO framework.

in this report mean. The major definitions are reproduced in Appendix A.

Additionally, this guidebook makes extensive use of the terms QMS and QAO, and some care must be taken to distinguish between the two concepts. As seen in Figure 1, the QMS for a construction project consists of two primary components: a QAO and the tools and procedures used to manage quality on a project.

As used throughout this guidebook, a QAO is a component of the broader QMS used on a project as a whole and deals with organizational relationships related to quality management. QAOs give structure to the quality management process and define the roles each party will play when managing quality on a project from the start of design to acceptance of the final product. QAOs specify who will be performing quality control and acceptance functions for both design and construction on a project and will be discussed in greater detail in Chapters 3 and 4.

The tools and procedures component of the QMS consists of specific actions taken to manage the quality on a project and perform the functions specified in the QAO (i.e., over-the-shoulder design checks, design checklists, contractor quality control testing, acceptance testing, independent verification, etc.). The number and types of tools used on any given project will vary based on project characteristics, agency and project team preferences, legal requirements, and many other factors. These tools are not limited to quality control testing or inspection in the field, but can include actions taken before, during, or after the procurement, design, and construction phases.

1.4 Organization of the Guidebook

The guidebook is organized to lead the reader through the process of developing a QMS that is both responsive to specific project needs and broad enough to be replicated with project-specific adaptations on future projects of similar scope, complexity, and delivery schedule. A brief summary of the remainder of the guidebook is as follows:

- **Chapter 2: The Business Case for Alternative Quality Management Systems.** A QMS is fundamentally an assignment of roles and responsibilities for design and construction QA tasks aligned with FHWA Technical Advisory 6120.3 (FHWA 2004) for projects with federal funds between the project owner, its designated representatives, and the design and construction professionals involved in delivering the project. This guidebook starts by presenting five models that have been used successfully on projects with alternative QMSs. The purpose of this chapter is to assist project managers in relating the selected QAO and its attendant, alternative QMS tools to the current state-of-the-practice in project QA. The chapter will also assist the practitioner in articulating the improvements that the new system has over the traditional DBB QA system.
- **Chapter 3: Quality Assurance Organizations.** This chapter furnishes the information necessary to differentiate among QAOs that could potentially be applied to a given project and provides a framework upon which the project manager can build a project-specific QMS.
- **Chapter 4: Quality Assurance Organization Selection.** The essence of alternative quality management is the selection of an appropriate QAO. This chapter furnishes the necessary guidance to assist the project manager and its consultant in the QAO selection decision.
- **Chapter 5: Useful Tools for an Alternative Quality Management System.** Implementing an alternative QMS demands that the project manager carefully plan the manner in which it will be executed on a project-by-project basis. This chapter furnishes a set of tools that can be considered for each project.
- **Appendix A: Glossary of Terms.** The use of consistent definitions is paramount in quality management processes. This appendix provides the definitions of the terms used in this guidebook.
- **Appendix B: Common Quality Management Tools.** This appendix provides a list of 26 quality management tools found in the research. Each tool is described through the following questions and statements. What is it? Why use it? What does it do? When to use it. How to use it. Example applications of the tools are also provided.
- **Appendix C: Highway Project Quality Assurance Organization Selection Guide.** This appendix provides a basic QAO selection tool, including instructions on the use of the tool and blank forms for application. It also presents a demonstration of the tool on a project for illustration.

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CHAPTER 2

The Business Case for Alternative Quality Management Systems

2.1 Current Status of Highway Quality Management

This guidebook provides transportation agencies with recommendations and tools to assist in developing QMSs that expand beyond the traditional, baseline systems typically associated with DBB project delivery. While there are no significant flaws with the baseline QMS, the underlying premise of DBB is a very clear division between design and construction. DBB project delivery assumes that a project's design is complete and its technical scope and quality requirements are fully articulated in the construction documents that accompany the invitation for bids to construction contractors. As a result, any attempt to deviate from traditional DBB project delivery creates a discontinuity in the baseline QMS and the potential for costly disputes over construction quality issues precipitated by using a baseline quality system that doesn't match the organizational structures of non-DBB projects (Ernzen and Feeney 2002, Anderson and Damnjanovic 2008).

The deteriorating condition of the U.S. highway system has created pressure to accelerate project delivery, and, as a result, the traditional period allowed to complete design has been compressed to its shortest state (Lee 2008). In June 2010, the FHWA introduced its "Every Day Counts" (EDC) initiative to address this and other issues of similar importance. The program is designed to accelerate the implementation of innovative practices that are immediately available, as described by then FHWA Administrator Victor Mendez (Mendez 2010, emphasis added):

> Our society and our industry face an unprecedented list of challenges. Because of our economy, we need to work more efficiently. The public wants greater accountability in how we spend their money. We need to find ways to make our roads safer and we have an obligation to help preserve our planet for future generations. But it's not enough to simply address those challenges. *We need to do it with a new sense of urgency.* It's that quality—*urgency*—that I've tried to capture in our initiative, Every Day Counts.

Many authors have documented the "urgent need to replace aging infrastructure" (Dowall and Whittington 2003), but response has been slower than might be expected. The resistance to change is rooted in the concern that the agency's historic set of checks and balances will be upset and control over cost, schedule and quality will be lost (NSPE 1995). Hence, the FHWA EDC focus is on innovations that have already been successfully employed by typical STAs. According to Mendez (Mendez 2010, emphasis added):

> EDC is designed to identify and deploy innovation aimed at *shortening project delivery*, enhancing the safety of our roadways, and protecting the environment . . . it's imperative we pursue better, faster, and *smarter ways of doing business*

The EDC program has created the impetus to improve the baseline design and construction QMS and develop QAOs that are specifically designed to facilitate *better, faster, and smarter ways* of delivering highway improvement projects. So before the system can be improved, one must first benchmark the state-of-the-practice, which for purposes of this guidebook will be termed the baseline QMS.

2.2 Defining the Quality Management Baseline

As seen in Figure 2, the baseline QMS is not just a set of organizational structures and tools. It is also a set of "hard coded" and culturally embedded standards about how to approach quality management on any given project. Thus, the baseline QMS (see discussion of the Deterministic QAO in Chapter 3) consists of a predetermined distribution of quality management tasks, tools, and standard specifications used to implement the various pieces of a QAO. Since the baseline QMS was predominantly developed for use on DBB projects, it has been traditionally used by STAs on most projects that they undertake and has become the default standard; the implicit assumption is that the baseline QMS will be used

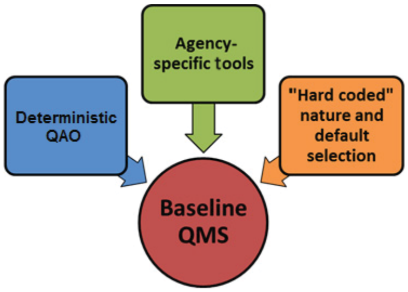

Figure 2. Current QMS model.

on most projects. Changes to both design and construction delivery methods have caused a rethinking of this historic approach.

The typical understanding of the baseline QMS is presented in Figure 3. In this arrangement, no specific designation is made for design or construction; however, in practice the baseline QMS heavily emphasizes construction quality assurance without placing the same emphasis on design quality assurance. As a result, the arrangement shown in Figure 3 applies predominantly to construction with a focus on physical inspection, testing, and contractor quality control in addition to statistical testing and verification of those tests. The baseline QMS is characterized by heavy agency involvement in all aspects of construction quality management down to field independent assurance of contractor-performed quality control tests. The control that STAs exercise in this approach renders the baseline QMS to be a reactive form of quality management applied during construction where final products are inspected for quality rather than a proactive approach in which the project team builds quality into the process from the beginning of design.

Unlike construction quality management, design quality management is typically not emphasized or formally defined in the baseline QMS. This lack of emphasis on design quality management is largely a product of the fact that STAs in the United States have historically performed most, if not all, of the design for their projects, and most continue to do so to this day. Because the design function rests within agency hands from start to finish, the baseline QMS has evolved with the assumption that quality designs are being produced by the agency without the need for a formal quality management

Figure 3. Traditional QA model (Burati et al. 2003).

model. Increasing use of outside consultants has caused a focus on systems for design quality management.

As previously mentioned, the baseline QMS is not just an approach to quality management on a project; it is also a set of institutional standards defining that approach and a reflexive assumption that the baseline approach will be used. These standards appear in the boilerplate language of standard contracts and specifications in STAs around the country with built-in assumptions through decades of use.

The implementation of a baseline approach to quality management can require a large agency staff—sufficient numbers of employees to staff internal design teams as well as the numerous construction, engineering, and inspection staff needed to observe construction as it is put into place and tested. However, even if an agency outsources many of these roles to external agents, the agency still ultimately takes responsibility for its actions and thus controls most of the quality management functions of a project. To respond to changing conditions, a more flexible definition of a QMS and QAO is required.

2.3 Future Needs of Highway Quality Management

Transportation project delivery has evolved to include new forms and procedures over the past couple of decades. The inclusion of alternative project delivery methods such as CMGC and DB as well as the use of best-value selection methods has created a new environment in which the quality of highway projects must be managed. Not only are projects being delivered at a much faster pace for rapid renewal, but they are also outsourcing more of the actual quality management tasks to consultants, construction managers, and design builders (Miron, Rogers, and Kopac 2008). Alternative project delivery methods have spawned alternative QMSs and some STAs are applying alternative QMSs such as contractor acceptance testing on traditional DBB projects (Turochy, Willis, and Parker 2006). There is a need to structure the approach to highway project quality management so that it addresses the need for rapid renewal of a deteriorating network in a manner that facilitates both the planning that leads to project delivery decisions and the successful execution of highway projects (Blanding 2006).

The baseline QMS (see Section 2.2) is frequently just an assumed standard that is hard coded into the written procedures, specifications, and contracts of most agencies. An expansion of the baseline would be to remove those policies that force the selection of a particular QAO automatically. In essence, this change would place the baseline QMS, including the Deterministic QAO (see Chapter 3) and the tools to implement it, as simply one QMS-QAO combination from which project managers could choose. While it is important to consider changing those agency policies that force the use of the baseline QMS, the more fundamental change would be encouraging a cultural shift so that project managers expect the process of selecting a QMS to involve choosing among several options. Project managers should approach any project (even those using DBB, which is typically associated with the baseline QMS) without a preconceived notion of what QAO to use for their project (see Chapter 4). The selection of a QAO should be made based on the relevant project characteristics and constraints. It is expected that in many cases practitioners may end up selecting the Deterministic QAO (see Chapter 3) at the end of the process. What is important is not that the Deterministic QAO be used with any less frequency, but rather that the unconscious selection of it by project managers ("that's how it's always been done") be replaced with a conscious decision to select that QAO on its merits.

The baseline approach (see Section 2.2) requires substantial agency resources and staff to implement. However, many STAs across the country are facing significant reductions in their budgets and staff, forcing them to increasingly rely on external consultants for design and inspection. "It is also recognized that, because of constrained staffing and budgets, it is not possible for state agencies to 'inspect' quality into the work" (Scott et al. 2006). It is precisely in these kinds of situations that project managers need to evaluate whether the baseline QMS is the best use of limited agency resources on any given project.

As more and more projects are procured using alternative project delivery methods or outsourced designs, they need to include design quality management in the project's QMS. Design quality management is an integral portion of a complete QAO and should be approached with the same level of formality and care as construction quality management. While it is important to build quality into the constructed work, it may be even more important to ensure that the designs produced fully meet all design input requirements and are delivered to the constructor without significant design errors.

As a result, an approach to design quality management and construction quality management ought to be decided upon before design begins in earnest. A further expansion to the agency's QMS development process is to undertake QMS planning as soon as possible, preferably before the agency or its consultant begins design. This would be a significant departure from the baseline QMS, in which decisions about the approach to quality management often are just assumed or are not made until construction is ready to begin.

2.4 Impact of Quality Management on Highway Projects

Driving the shift in public procurement culture is the perception by government and industry practitioners that benefits may be accrued by integrating the project team, bringing the constructor into the project before design is complete to furnish substantive input on cost, schedule, and constructability to the final design (Miller et al. 2000; Touran, Gransberg, and Molenaar 2010). Beyond time and cost savings, the salient question has been whether the quality of the ultimate product was degraded through either the speed at which the design and construction were completed or by an agency loss of control over the design and construction process (Gransberg and Molenaar 2008).

One study definitively linked construction quality to the quality of the design documents (Dunston, McManus, and Gambatese 2002, emphasis added):

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

However, the pressing need to deliver highway construction projects as fast as possible puts stress on the design quality management system by compressing the design period in order to begin construction operations as soon as possible. "Demand for increasing speed of project delivery is the top reason for decline in construction document quality" (FMI/CMAA 2003). A survey of project owners in 2003 raised serious questions about the current state of design quality management (FMI/CMAA 2003):

> In their responses to questions about the quality of construction documents, more than half of the owners surveyed responded that these documents often have significant amounts of missing information. Specifically, 45 percent of respondents indicated that construction documents, while sufficient, still had 'significant information needed,' while an additional 12 percent found that documents were typically inadequate because of major information gaps.

Dornan et al. (2005) note: "Assembling an entire design and construction project team at the beginning of the design process can promote better scope definition, more realistic expectations, and better communication throughout a project." This notion is implemented by selecting "a procurement process . . . that considers value-related elements in awarding contracts" (Scott et al. 2006); DB, CMGC, and best-value DBB all qualify under this definition. Table 2 consolidates the results of *NCHRP Synthesis 376* (Gransberg, Datin, and Molenaar 2008) and *NCHRP Synthesis 402* (Gransberg and Shane 2010), which reported STA personnel ratings of the impact of construction quality components on the procurement phase.

Since both DB and CMGC incorporate best-value award mechanisms, the data shown in Table 2 describe the parameters around which a complete QMS can be built. Some

Table 2. Impact on final project quality of procurement components for DB and CMGC.

Procurement Phase Component	Agency Ratings			DB and CMGC Contractor Ratings		
	Very High or High Impact	Some or Slight Impact	No Impact	Very High or High Impact	Some or Slight Impact	No Impact
Qualifications of DB's or CMGC's staff	91%	9%	0%	100%	0%	0%
DB's or CMGC's past project experience	76%	24%	0%	100%	0%	0%
Use of performance criteria/specifications	72%	28%	0%	67%	33%	0%
Early contractor involvement in design	70%	30%	0%	100%	0%	0%
Level of agency involvement in the QA process	69%	31%	0%	33%	67%	0%
Level of detail in the procurement documents	68%	32%	0%	0%	83%	17%
Preconstruction services	63%	30%	7%	100%	0%	0%
Quality management plans	61%	39%	0%	83%	17%	0%
Warranty provisions	55%	38%	8%	33%	50%	17%
Use of agency specifications and/or design details	51%	42%	7%	17%	67%	17%

owners have used change orders as a gauge of design quality. A Utah DOT study of $330M of CMGC projects found that change orders for CMGC and DB are virtually the same, and approximately one-third the rate of traditional DBB projects (Alder 2010), a potential indication of the impact of increased emphasis on design-phase quality systems. The UDOT study confirms the fact that alternative QMSs are currently being successfully implemented and the value of this guide in drawing from experience gleaned in the field by practitioners who have been able to improve the baseline QMS by developing QMSs that include an integral design quality process.

2.5 Summary of the Business Case

NCHRP Synthesis 379 (Anderson and Damnjanovic 2008) evaluated the potential for alternative construction methods to accelerate project completion and what the impact would be. DB and CMGC methods were included in the study. The authors found that

> quality was the same for [DB and CMGC] as compared with typical projects. This result seems to counter the perception that accelerating project completion negatively impacts quality, which was cited as a perceived disadvantage for some contracting methods.

NCHRP Synthesis 379 aptly points out the "popular mythology" that appears to surround the cultural shift from traditional project delivery to something different. There are always champions that promote the new method with evangelistic zeal and opponents that can see all sorts of unsolvable problems being spawned by the change in contractual relationships. Degraded quality appears to be one of the disadvantages cited by opponents to change while champions cite reasons why quality is actually enhanced. *The real issue with regard to quality* is not how to guarantee that it will improve but rather to *ensure that the change does not create a set of circumstances that causes it to decline.*

This quality issue was effectively debunked by the FHWA *Design-Build Effectiveness Study.* The FHWA study team found that (FHWA 2006, emphasis added):

> On average, the managers of DB projects surveyed in the study estimated that DB project delivery reduced the overall duration of their projects by 14 percent, reduced the total cost of the projects by 3 percent, and *maintained the same level of quality as compared to design-bid-build project delivery.*

In summary, the pressure to accelerate highway project delivery will not decrease and the continued deterioration of the nation's network will probably cause that pressure to increase. A public transportation agency has a fiduciary duty to furnish the traveling public with a safe, efficient, and effective transportation network and fulfilling that duty demands ensuring that the network's quality is satisfactory by delivering high-quality, rapid renewal, rehabilitation, and repair projects. In many cases, this cannot be done using traditional DBB project delivery and the baseline QMS. Rebuilding U.S. roads and bridges demands a QMS that is just as fast, just as good, and just as smart as the product it regulates. This guidebook's objective is to furnish the necessary information to permit an agency to modify its existing QAO and QMS to accommodate the demands of accelerated delivery.

2.6 Chapter 2 References

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CHAPTER 3

Quality Assurance Organizations

3.1 Introduction

Highway QAOs have been evolving since the 1960s. They have moved from a recipe of prescriptive quality specifications to developments in materials inspections and testing, to implementation of statistical process control, and ultimately toward performance-based quality management (Hughes 2005, Transportation Research Board 1979, Smith 1998). While the bulk of the research on, innovations of, and strategies for highway project QA have focused on the construction phase of the project (Hughes 2005, Transportation Research Board 1979), there is recognition that design has to be an integral part of the discussion of highway project quality (Burati 1992). The importance of including design in the QAO has been made increasingly evident due to the introduction of alternative delivery methods and changing philosophies about the use of consultants in roles historically filled by transportation agency staff. In practice, highway project QAOs have been adjusting to the needs of alternative delivery methods and other changing conditions on a project-by-project basis.

This chapter discusses development of five fundamental QAOs. These five fundamental QAOs were developed through literature review, contract document analysis, and case study evaluation. The QAOs establish a consistent and efficient approach to highway-sector QAO planning.

3.2 Methodology

Identification of the five QAO models consisted of four distinct phases. A thorough literature review and national survey were used to identify a theoretical framework with 14 potential QAOs. The second phase consisted of a content analysis of 66 contract and policy documents to identify the nine QAOs that are currently in use in the industry. The third phase was data analysis; the 14 identified QAOs were analyzed on the basis of the agency's quality roles and responsibilities within each QAO. If the agency shared a role, directly contracted the role out to an independent firm, or had sole responsibility, it was considered an agency project quality management role and responsibility. Additional QAO variations were identified depending on how an agency performed the role and/or whether non-agency quality management roles and responsibilities were contracted to a single party or multiple parties. These variants were consolidated into five fundamental models by the research team. The fourth phase was validation; the five fundamental QAOs were validated and calibrated by a panel of six industry experts. Experts on the panel had a cumulative total of 163 years of industry experience, with each individual having a minimum of 15 years of experience. The panel confirmed that the five fundamental QAOs accurately reflected and were all encompassing of current industry practices. The final report for NCHRP Project 10-83 (published as *NCHRP Web-Only Document 212*) provides a full description of the process of developing and validating the five fundamental QAOs.

The remainder of this chapter describes the five fundamental QAOs. The description focuses on agency roles in traditional DBB and three of the most common alternative project delivery methods: DB, CMGC, and PPP.

3.3 QAO Presentation

Each QAO is graphically represented using the generic QAO framework shown in Figure 4, adapted from Gransberg, Datin, and Molenaar (2008). The generic framework shows all of the project quality roles, their relationships, and the surrounding project quality activities that should be considered when designing a complete QAO, including both design and construction. Design quality has not been traditionally included in highway QA discussions, but is required for the alternative delivery methods that are becoming prevalent in the industry. In the variants presented in this chapter, a dotted line is used to indicate whether the agency, contractor,

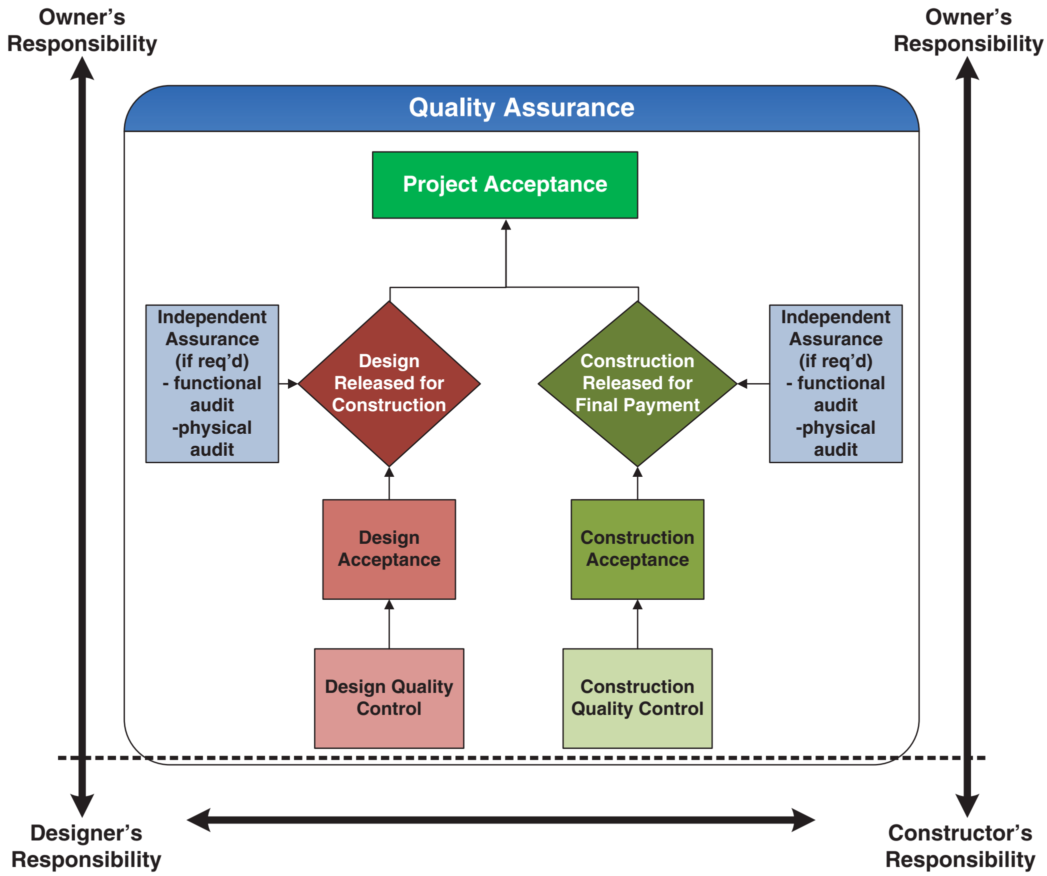

Figure 4. Generic QAO model (adapted from Gransberg, Datin, and Molenaar 2008).

designer, concessionaire, or design builder is responsible for a project quality role. Items appearing above a dotted line are the responsibility of the agency. A vertical dotted line appearing below a horizontal dotted line separates the responsibilities of the designer and the contractor.

3.4 Fundamental Highway QAOs

The five fundamental QAOs for the highway construction and design industry identified in this research are the following:

- **Deterministic.** The traditional approach to quality within the highway industry, in which the agency retains responsibility over all project quality roles, responsibilities, and activities.
- **Assurance.** The agency is responsible for all aspects of quality except for design and construction QC.
- **Variable.** Design and construction take different approaches to quality. For example, the STA may assign both design phase QC and acceptance to an outside party, while the construction phase QC only may be assigned to an outside party. This approach was found on DB projects.
- **Oversight.** The agency takes on an oversight role by assigning design QC, design acceptance, construction QC, and construction acceptance to outside parties.
- **Acceptance.** The agency is responsible only for verification testing and final acceptance. All other quality roles and responsibilities are assigned to the concessionaire. This variation was found only in PPP arrangements.

Figure 5 shows a summary of the five QAOs with respect to both the level of agency control and the approach to project quality assurance.

There are two distinct approaches to quality: reactive and proactive. The reactive approach is aimed at detecting and correcting problems that already exist. Desai and Mital (2009) state that "the designer of a product/process/service incorporates a system of checks and measures that serves to isolate and catch defects as and when they occur. By their very nature, reactive quality assurance strategies are better suited to identify problems and resolve them and as such are clearly defensive in nature." The reactive approach inspects the quality into the final product. Conversely, the proactive approach to quality is aimed at preventing problems, defects, and/or errors before they occur. The proactive approach provides the project team

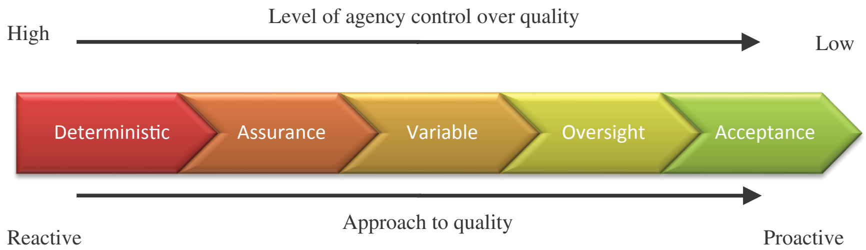

Figure 5. Fundamental highway industry QAOs based on approach to control and quality.

with the ability to build quality into the final product beginning at the design stage instead of inspecting it at a later stage (Desai and Mital 2009).

The sections that follow present each of the five QAOs with a description of the assignment of the roles and responsibilities, the approach to quality, the applicable project delivery methods, and the existing variations on the fundamental QAO. The description of the assignment of the roles and responsibilities clearly identifies the team member responsible for each task and discusses the level of owner control for that QAO. The approach to quality indicates whether the QAO results in a reactive or proactive approach to quality. The project delivery methods where the QAO has been implemented in the industry as well as the feasibility of the application of the QAO to other project delivery methods are discussed, and, lastly, the variations of the QAO are identified.

3.4.1 Deterministic QAO

Figure 6 shows the traditional quality organization on highway construction projects and is well understood by the primary parties involved in a project: agency, contractor, and designer. The agency's roles in the Deterministic QAO include design QC, design acceptance, construction QC, and

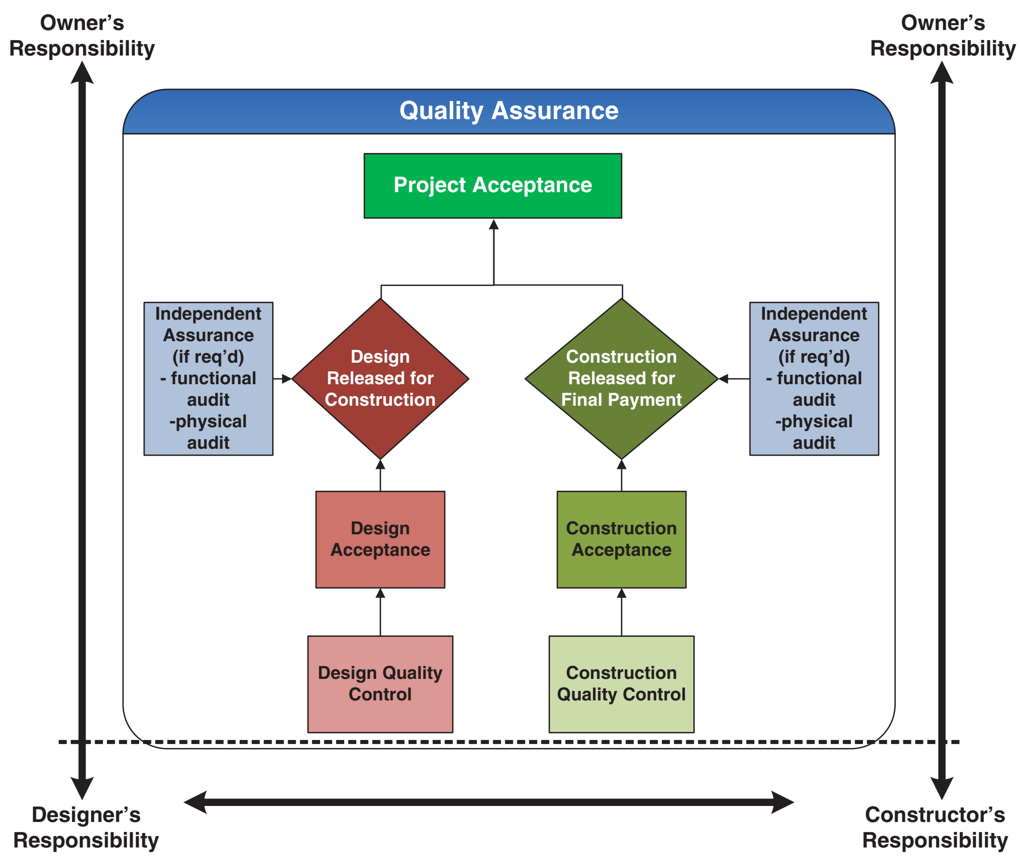

Figure 6. Deterministic QAO.

construction acceptance. The agency can use third-party consultants to perform any of their roles, but the agency is ultimately responsible for ensuring these roles are successfully completed on the project. The STA provides guidelines to the contractor as to possible necessary tests and inspections appropriate for the project, but the contractor is primarily reacting to the agency's direction through the specifications of the project.

Smith (1998) states that "the DOT's role is to approve the QC program, monitor contractor procedures, test results, perform independent tests, and determine acceptance." The agency is responsible for all acceptance (design and construction) on the project. The Deterministic QAO represents the baseline for alternative QAO discussions and comparisons for this guide.

Because of the controlling role of the owner in the Deterministic QAO, it is considered a reactive approach to quality (Postma et al. 2002). The agency develops the designs, specifies the materials to be used, and watches over the construction (Gransberg, Datin, and Molenaar 2008). In the Deterministic QAO, "the contractor works within a very controlled environment like that in a method specification project. Assurance using method specifications is based on the owner having complete control of the process and enumeration of contractor means and methods. Detailed owner-directed inspection is the primary control process and final acceptance of the work is essentially automatic" (Smith 1998).

The lack of collaboration in the Deterministic QAO contributes to the frequently contentious relationship between the owner and the contractor. This adversarial relationship is so pronounced that the Deterministic QAO is sometimes referred to as the "catch and punish" method (Postma et al. 2002). There is no opportunity for collaboration because the contractor (and often the designer) has no input in the QC or acceptance of their own product; they are merely responding to what the agency directs within the RFP, plans, specifications, and bidding documents. Difficulties can arise if there are conflicts because the quality expectations are not explicitly stated in bidding documents and/or contract change orders. The Deterministic QAO is most often implemented on DBB projects, especially when the design is performed within the agency. Gransberg and Shane (2010) concluded that the quality systems used in DBB also pertain to CMGC because the owner still occupies the same contractual position with respect to the designer and builder. The Deterministic QAO would be most appropriately applied to CMGC if the scope of preconstruction work for the contractor was limited to items not directly relating to the design: cost estimates and project scheduling. In contrast, the Deterministic QAO is not well suited for a DB project. This is because the DB delivery method requires the agency to transfer some of the risks associated with the quality of design and construction, which requires a shift in authority for each of these tasks. Applying the Deterministic QAO to a DB project means that the agency retains the quality authority for design and construction, which no longer allows the design builder to manage and assume the risks associated with those tasks (Gransberg, Datin, and Molenaar 2008).

3.4.2 Assurance QAO

In the Assurance QAO, the agency has the responsibility for acceptance of design and construction and the decisions to release the design for construction and to release construction for final payment. These responsibilities can be performed in house or by an independent consultant/engineer.

Figure 7 graphically depicts the Assurance QAO as applied to a dual contract project (separate contracts for the designer and the contractor). The designer and the contractor are responsible for performing QC of their respective areas because the agency is still responsible for all acceptance on the project. While the contractor and the designer perform their own QC, typically the agency will perform independent assurance and testing to verify the QC tests results (Gransberg, Datin, and Molenaar 2008).

The Assurance QAO is a small step beyond the Deterministic QAO. Because the agency is still responsible for acceptance design and construction on the project without input from either the designer or contractor, the owner still has a very controlling role in the project. The quality responsibilities have not shifted very far from the deterministic method, and there is still a focus on inspections and materials testing as the way to ensure quality, rather than an emphasis on building quality in through a transfer of responsibility. Additionally, because the owner is so heavily involved in establishing the quality parameters of the project, the designer and the contractor are constrained from straying from the prescribed standards. The high level of agency control over the quality on the project also inhibits collaboration between the agency and the designer and contractor regarding quality definition. The lack of collaboration along with the strong emphasis on ensuring quality through inspections of the final products makes the Assurance QAO a reactive approach to quality.

The Assurance QAO has been applied to both DBB and DB projects. When applied to DBB projects, as shown in Figure 7, the QC activities above the dotted line are the agency's responsibility, and the vertical dotted line represents the separate design and construction contracts. When applied to the DB delivery method, with a single contract for design and construction, all QC activities are the responsibilities of the design builder, as shown in Figure 8. Gransberg, Datin, and Molenaar (2008) suggested that agencies with limited DB experience apply these types of quality management policies and procedures because the agencies are still evolving from the DBB method where the contractor controls construction

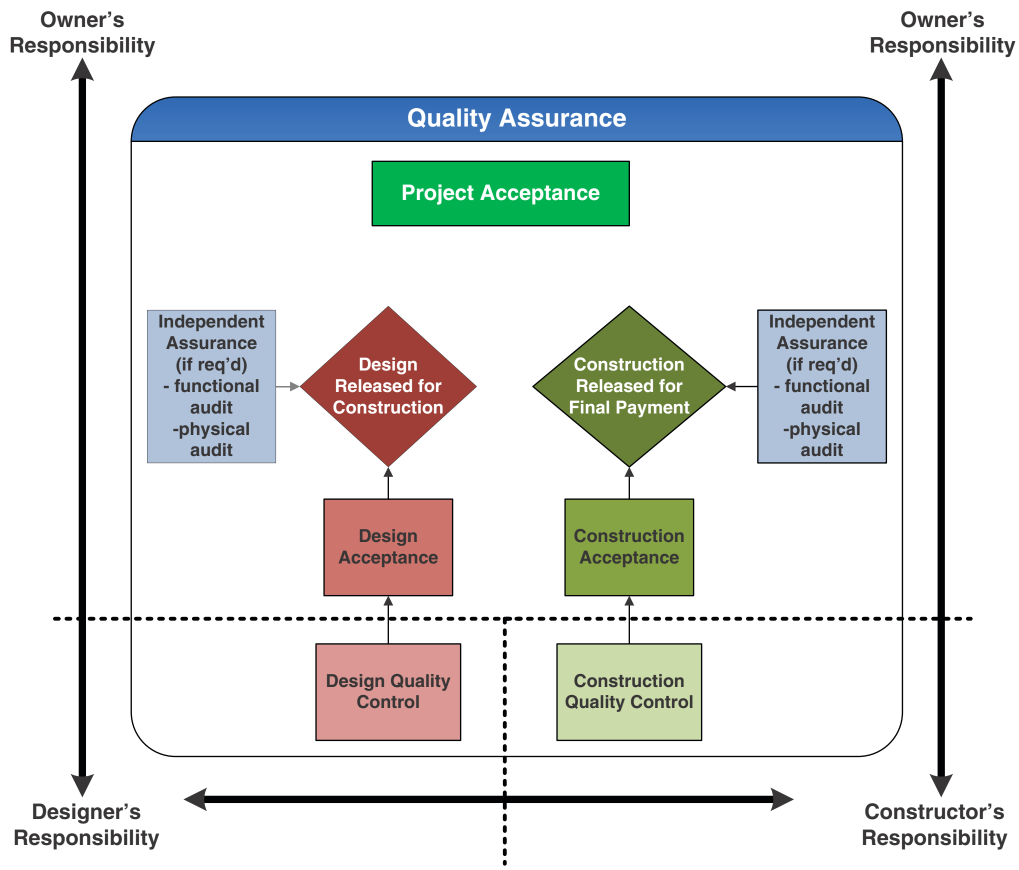

Figure 7. Assurance QAO.

QC and the STA has control over all acceptance functions and over design QC.

Another variation on the Assurance QAO used in DB projects is the shared variation. In this variation, the responsibilities for design acceptance and construction acceptance are shared by the owner and the design builder, as shown in Figure 9. This organization is still considered to fall into the Assurance QAO because the owner has a role in the assurance on the project. When stakeholders share roles on a project, it is critical that a clear identification of all roles that will be shared in the task are specifically addressed and assigned to prevent confusion on the project. The shared variation of the Assurance QAO could also be applied to the CMGC delivery method, but the contractor would be responsible for con-

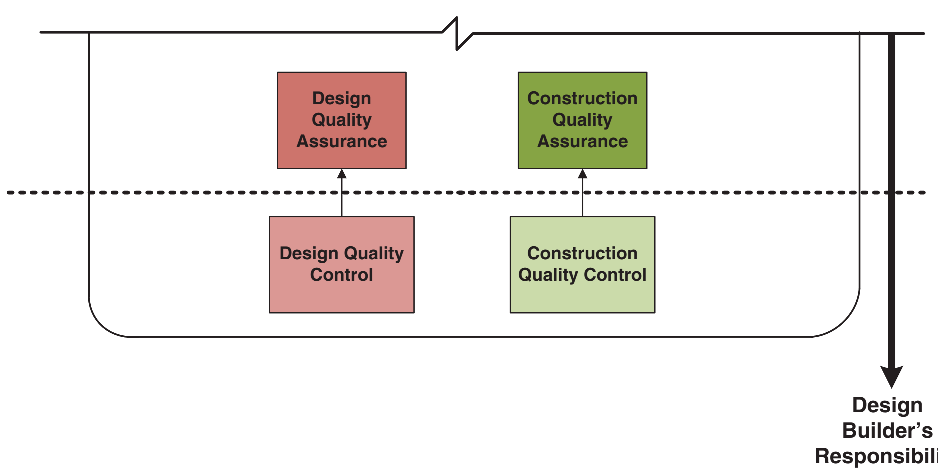

Figure 8. Assurance QAO with single contract variant.

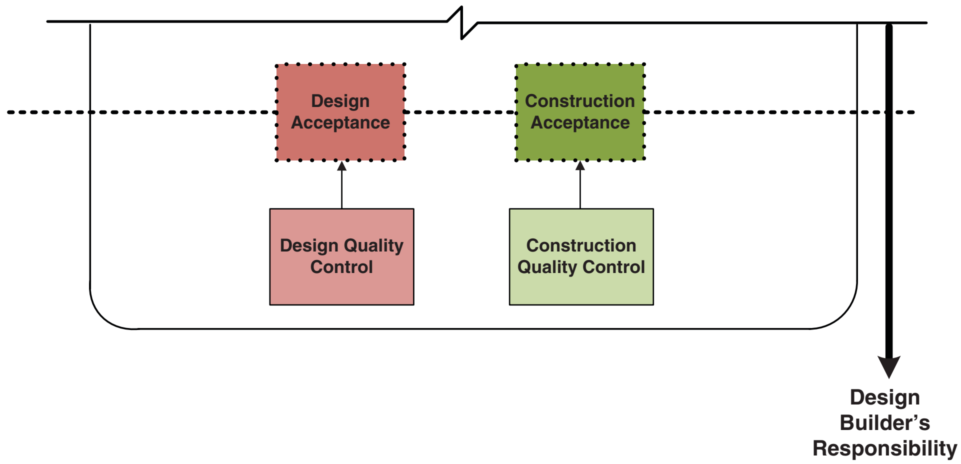

Figure 9. Assurance QAO with single contract variant and shared assurance.

struction acceptance, and the designer would be responsible for design acceptance.

3.4.3 Variable QAO

The Variable QAO differs from the others because the design and construction approach to quality may take on one of several variations. An example of this method has been found on DB projects where the agency is responsible for the construction acceptance but not design acceptance, as shown in Figure 10. Because the agency is no longer responsible for design acceptance, the contractor must perform project acceptance on the design side of the project (Gransberg, Datin, and Molenaar 2008). Because the entity producing the final

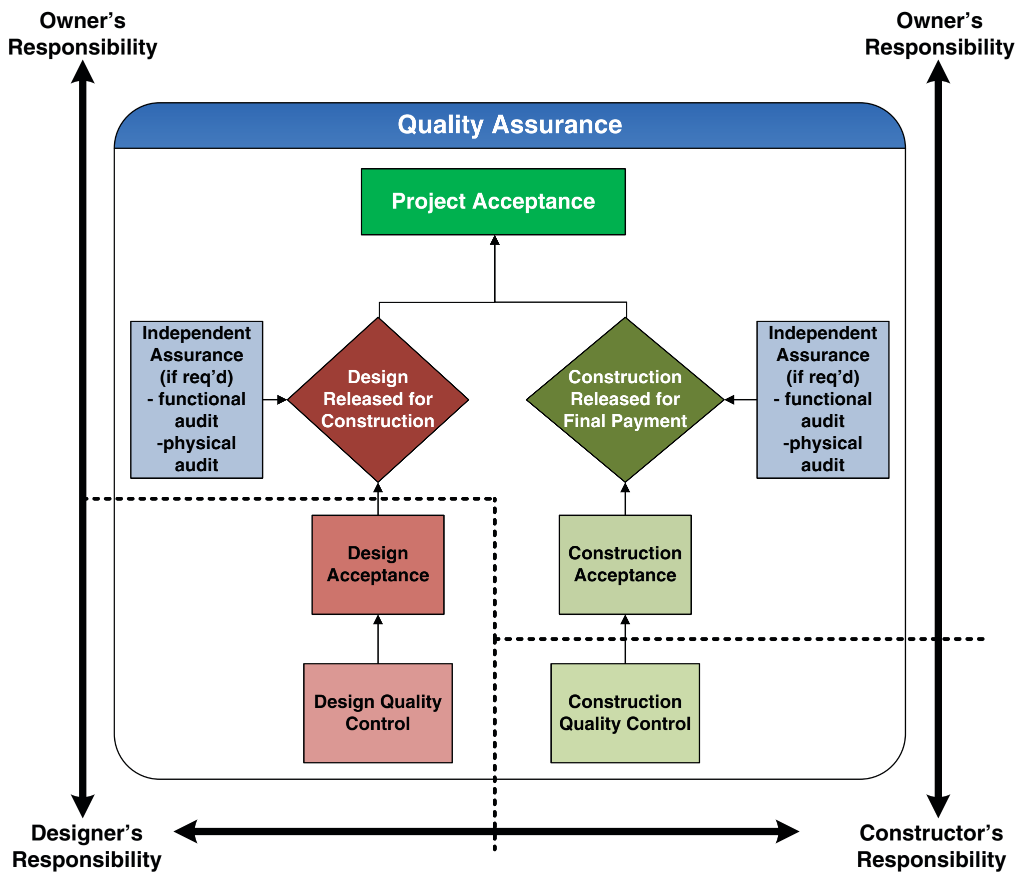

Figure 10. Variable QAO with single contract variant and construction assurance.

design product is responsible for internal acceptance, the design phase of the project is considered to have a proactive approach to quality. On the construction side, however, the agency still maintains control of construction acceptance, resulting in a reactive approach to quality on the construction side. For the example considered in Figure 10, the agency is taking a different approach to quality in the design phase than it is taking in the construction phase. This results in implementing two different approaches to quality across not only the agency but also the design builder, which can complicate attempts at creating continuity across the project.

Another example of the Variable QAO is when the responsibilities of the agency include design QA, but do not include construction acceptance and QC. Figure 11 presents this variation. In this case, the design phase of the project has a reactive approach to quality, and the construction phase has a proactive approach requiring the owner to perform project acceptance for construction activities. This version of the Variable QAO also has different approaches to quality in the design and construction phases, complicating efforts to have a single quality philosophy across the entire project.

A critical element of a proactive approach to quality and an agency successfully shedding acceptance responsibility is the agency's communication of the quality requirements within the RFP. Agencies must provide enough guidance so that respondents can include the appropriate services and approach to quality in their proposals (Gransberg, Datin, and Molenaar 2008). While this arrangement requires fewer agency resources over the duration of the project, these resources must be focused on ensuring that the quality requirements are communicated within the contract documents. Figure 11 shows the Variable QAO with design assurance and a single contract variant. This variant results in a proactive approach to construction quality. However, it results in a reactive approach to design quality because the agency maintains control of the design acceptance function. The reactive approach forces the agency to focus on the reviews and inspections required to perform design acceptance. The Variable QAO can be difficult for an agency to manage because the project team must have the ability to manage both proactive and reactive quality approaches.

As with the previous model, another variation of the Variable QAO occurs when the design phase quality management is reactive and the construction phase quality management is proactive. In this case, the agency is responsible for both design acceptance and design QC, while the contractor/design builder is responsible for construction acceptance and construction QC. Figure 12 shows this variation. While this variant was not observed in the industry during this research, it involves different approaches to quality in the design and construction phases, so it is a valid variation of the organization. The oversight panel for this project verified that it should be included in this guidebook. The reverse of this variation, in which the agency is responsible for construction acceptance and QC while the designer is responsible for design acceptance and QC, would not occur because construction QC always resides with the contractor.

The Variable QAO construction assurance variation has been implemented on DB projects as shown in Figure 10. No examples were found in this research with the design assurance variation being used on either DBB or CMGC projects; however, there is nothing within the variation itself that would prevent it from being implemented on a dual contract (DBB or CMGC) project.

3.4.4 Oversight QAO

In the Oversight QAO shown in Figure 13, the agency is responsible for the decisions to release the designs for construction and to release construction for final payment. The designer is responsible for design QC and acceptance,

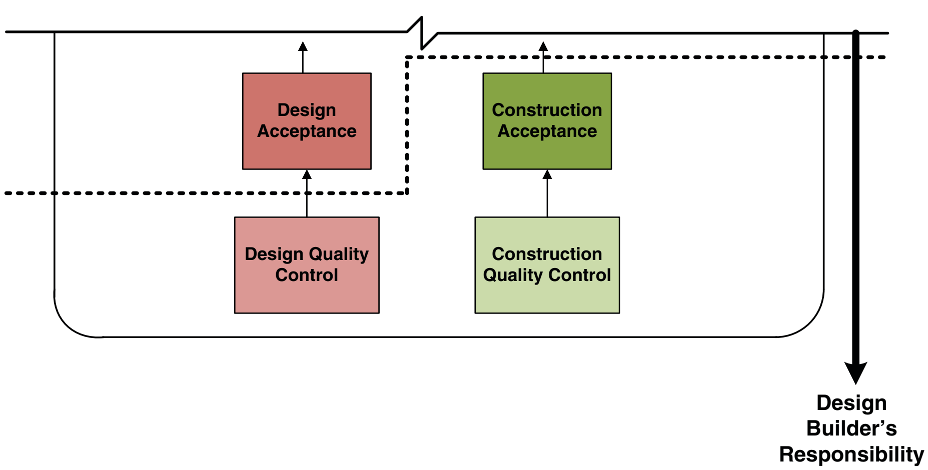

Figure 11. Variable QAO with single contract variant and design assurance.

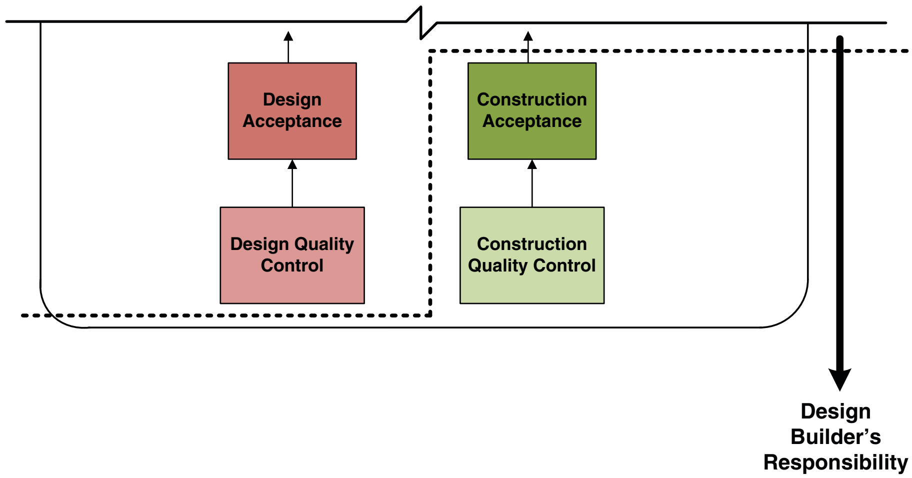

Figure 12. Variable QAO with agency design quality responsibility.

while the contractor is responsible for construction QC and acceptance. In the Oversight QAO, the agency no longer has direct control over the day-to-day quality management of the project and is no longer dictating how to produce the quality required by the project scope. Rather, the agency's role is to ensure that both the designer and contractor quality assurance plans are effective at meeting the agency's quality requirements (stipulated in the contract) and that the plans are being implemented.

From the agency's perspective, the Oversight QAO must be a proactive approach to quality. The producers, the designer, and the contractor are responsible for all aspects of the quality of the products that they produce. The agency's primary responsibility is oversight of the quality of the project. The

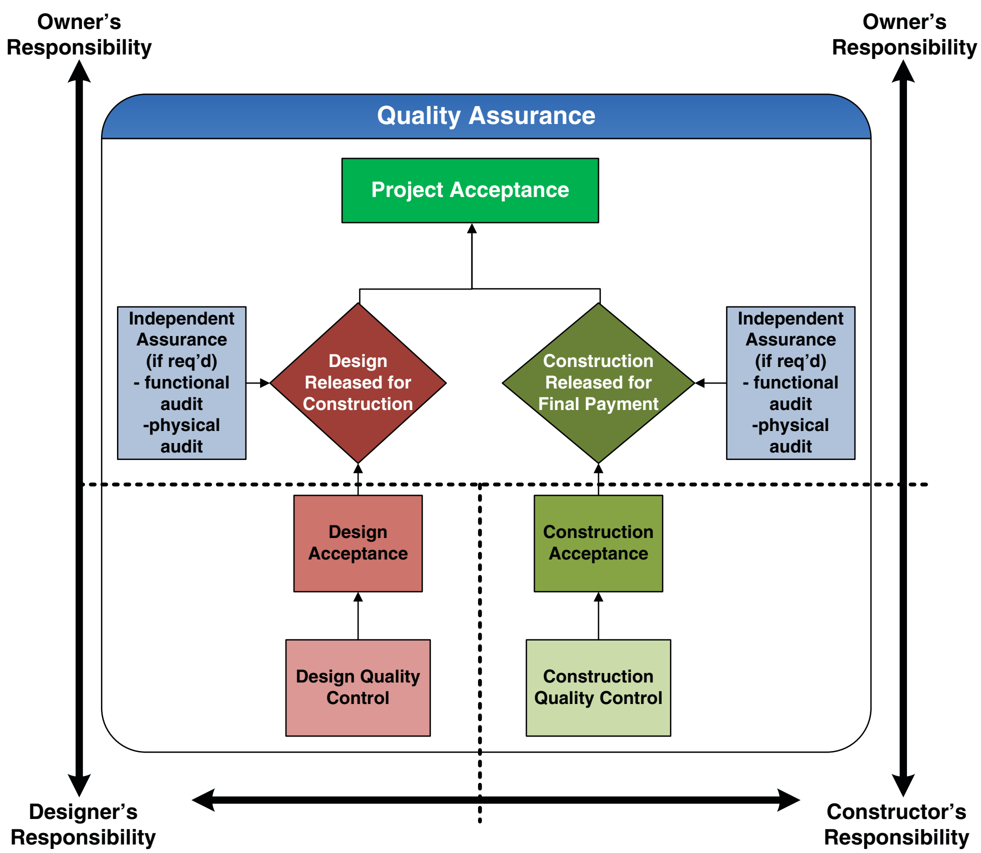

Figure 13. Oversight QAO.

agency can conduct project oversight inspection and testing either with in-house staff or with an independent quality firm contracted directly to the agency. To effectively perform the project oversight role in house, the agency should educate its staff on the non-traditional skill set required to be successful. The designer and contractor approach to quality does not have to be proactive, unless required by the agency's contract. The designer and/or contractor can create an oversight plan in which the approach to quality is reactive (focused on inspecting a final product rather than finding the defects before they are implemented). Either way, designers and contractors have not historically had much responsibility for the QA aspects of projects and may need specific acceptance training to perform this function.

While the agency ultimately retains the risk for quality on every project, in the Oversight QAO, risk is shifted to the designer and the contractor. Shifting the risk results in both the designer and contractor having to "buy-in" to the quality management of the project because they are each responsible for creating their respective acceptance plans that ensure that the quality goals and requirements of the project are met. Because the Oversight QAO shifts the responsibility for acceptance to the designer and the contractor, agency, designer, and contractor integration increases, requiring a higher level of collaboration among the three in order to meet the quality requirements of all parties. In this QAO, all parties are involved in the quality management of the project, and the designer and contractor also have contractual accountability for not only the quality of the final product that they deliver to the agency, but the actual processes of delivering that product.

Because of the high level of collaboration required by the Oversight QAO, it would be difficult to implement on a project with a linear approach, where the designer and the contractor are not involved early in the project; thus, the Oversight QAO would not be a good choice for a DBB project. However, for project delivery methods in which the designer and contractor are brought in early on a project, such as DB and CMGC, the Oversight QAO is complementary to the inherent collaboration of the methods. In a DB project, all QC and acceptance for the project would fall to the design builder, as shown in Figure 14.

3.4.5 Acceptance QAO

The Acceptance QAO is specific to PPP projects. In this organization, the owner has responsibility only for final project acceptance and owner verification testing. The party contracted to complete the project, typically the concessionaire, is responsible for all other quality activities on the project, as shown in Figure 15. Since the agency is no longer providing 100 percent of the financing for design, construction, operations, and maintenance, there is a shift in financial liabilities, which also pertains to the shift in quality responsibilities (Gransberg, Datin, and Molenaar 2008). Because PPP delivery is not as prevalent as other delivery methods within the United States, limited projects were included in this research. The Acceptance QAO shown in this guidebook is based on several Texas Department of Transportation projects that are using the PPP delivery method, but other PPPs around the country apply similar approaches. There are additional variations of the PPP quality methods in use around the world, but because they are not implemented in the business environment of the United States, they were not included in the document review or the survey responses.

Of all the QAOs, the Acceptance QAO provides the agency with the least amount of direct control over the quality assurance of a project. The agency's primary focus, as required by FHWA Technical Advisory 6120.3, is to perform oversight of the design and construction quality management efforts to satisfy their legal responsibilities to the public (Gransberg, Datin, and Molenaar 2008). This requires the agency to perform

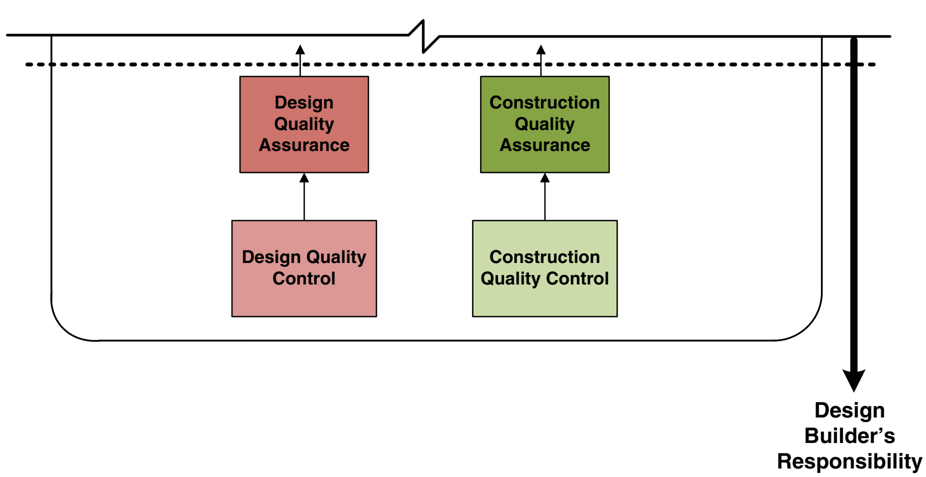

Figure 14. Oversight QAO with single contract variant.

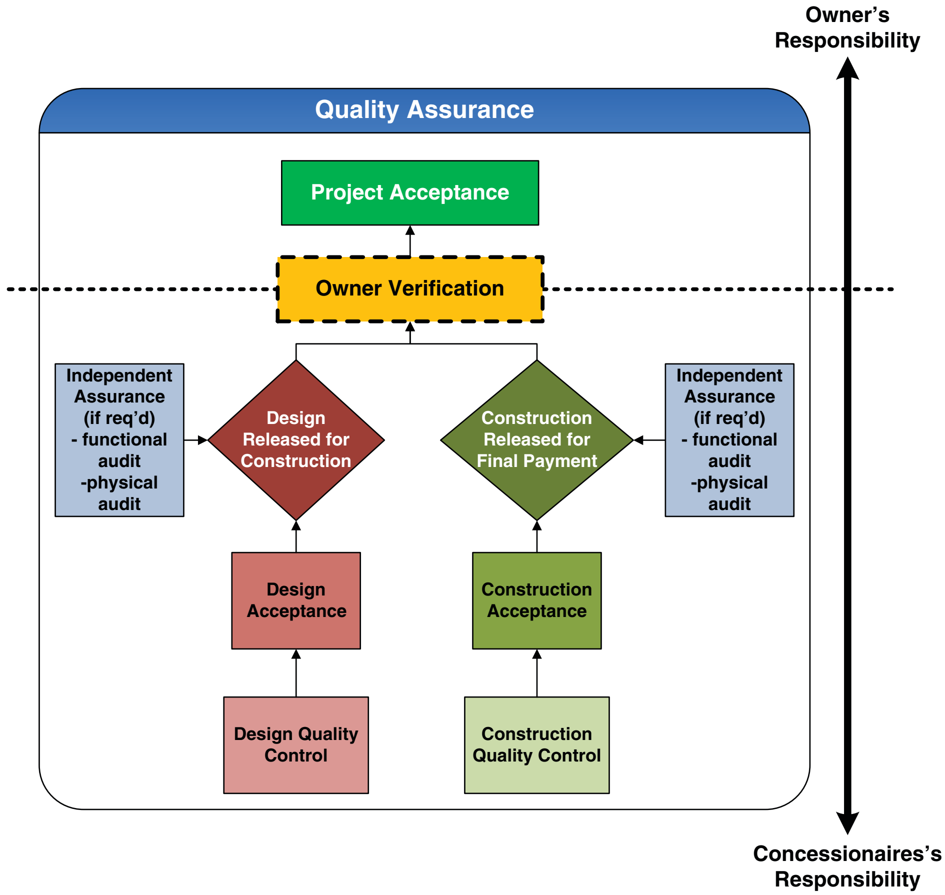

Figure 15. Acceptance QAO.

owner verification testing, which is commonly performed by an independent engineer. The independent engineer is hired jointly by the concessionaire and the agency and performs not only owner verification testing but also independent assurance and any other acceptance activities that are part of the concessionaire's responsibility. However, the agency typically pays 100% of the fee for owner verification testing. Note that even the decision to accept the design for construction and accept the construction for final payment is the responsibility of the concessionaire. This is because of the concessionaire's financial liability for corrections to any design or construction deficiencies during the operations and maintenance period (Gransberg, Datin, and Molenaar 2008).

The agency's involvement in ensuring the quality of the project is focused on establishing the quality requirements, accepting or approving submitted quality assurance plans, and ensuring that quality plans are being implemented. Therefore, the agency must take a proactive approach in the Acceptance QAO. The agency will have some oversight responsibilities to meet the due diligence requirements for federal funding, but these responsibilities are not considered to dominate the overall quality assurance of the project. This oversight is usually conducted through agency verification by either in-house staff or an independent engineering consultant contracted to the agency. The designer, contractor, and/or concessionaire create the quality plans required by the contract, and, as long as the plans meet the requirements of the contract, the agency approves them. In the Acceptance QAO, succinctly stating the quality requirements in the contract with the project team is the primary responsibility of the agency in delivering a successful project that meets quality expectations.

Collaboration between the agency and the concessionaire in the Acceptance QAO is low because, after the quality requirements are stated within the contract documents with the concessionaire, the agency is minimally involved. Meeting the quality requirements of the project is the responsibility of the concessionaire, while the agency performs enough of an oversight role to ensure that it is meeting federal requirements for due diligence and to ensure that the concessionaire is following its own project quality management plan.

3.5 Conclusion

Quality roles and responsibilities on projects are transitioning due to the use of different project delivery methods, the needs of the industry for faster and better projects, and the

Quality Assurance Organization	Design Acceptance	Design QC	Construction Acceptance	Construction QC
Deterministic	Agency	Agency	Agency	Contractor
Assurance	Agency	Designer	Agency	Contractor
Variable	Designer	Designer	Agency	Contractor
Oversight	Designer	Designer	Contractor	Contractor
Acceptance	Concessionaire	Concessionaire	Concessionaire	Concessionaire

Figure 16. Roles and responsibilities of the five fundamental QAOs.

growing acceptance of the utilization of consultants by STAs. The five fundamental QAOs for the highway design and construction industry range from a QAO in which the agency has sole responsibility for all quality functions to a QAO in which the agency is only responsible for final acceptance and meeting federal requirements.

Figure 16 summarizes the roles and responsibilities of the five QAOs at the highest levels. When DB is the project delivery method, all of the non-agency quality responsibilities become the responsibility of the design builder. The Acceptance QAO has only been found in PPP projects, so the concessionaire is the party performing all non-agency quality roles and responsibilities.

Further investigation of the QAOs was conducted to identify the approach to quality, the level of owner control, and the delivery methods for which the QAO is applicable. The approach to quality was expressed as reactive, heavily focused on final product inspections; or proactive, building quality into the process. The level of owner control was expressed as high, medium, or low. It was found that as the level of owner control moved from high to low, the approach to quality moved from reactive to proactive. Identifying applicable delivery methods was done through review of actual examples in the industry. A delivery method was also identified as potentially applicable if the QAO could align with the project delivery method based on the timing of the parties' involvement, the level of collaboration involved in the QAO, and the level of owner control. A summary of these results is shown in Figure 17.

Common traits/factors are observed among all of the QAO models:

1. Construction QC is the responsibility of the contractor. "The contractor is, as is any manufacturer, the only one who can control the quality of his work" (Shilstone 1992).
2. Final project acceptance is always performed by the agency.
3. The contract verbiage regarding the roles and responsibilities for quality has to be very concise and well documented to be successful.

Quality Assurance Organizations	Quality Management Approach	Level of Owner Control	Identified Delivery Methods	Potential Delivery Methods	Example States and Agencies Using QAO
Deterministic	Reactive	High	DBB, CMGC	None	All
Assurance	Reactive	High	DB	CMGC, DBB	NM, SD, LA, MS, NC, AK, FL
Variable	Mixed	Medium	DB	CMGC	NC, FL, MN, VA, UT, ME, CA
Oversight	Proactive	Low	DB	CMGC	CA, CO, MN, MO, NV, OR, TX, UT, VA, WA, WASH DC, FHWA Eastern Federal Lands Highway Diversion, Alberta, Canada
Acceptance	Proactive	Low	PPP	None	TX, FL

Figure 17. Characteristics of the five fundamental QAOs.

4. The QAO decision should be made before the first team member is procured (e.g., request for qualifications [RFQ], RFP, or invitation for bid [IFB]), whether it is for design, construction, or both at the same time. The quality management responsibilities have to be clearly laid out in the procurement documents in order for the designer and/or the contractor to be able to appropriately provide for the amount of staffing and risk they will be assuming on the project.

3.6 Chapter 3 References

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CHAPTER 4

Quality Assurance Organization Selection

4.1 Introduction to QAO Selection

The selection of a QAO should occur as early in the project development process as possible. At a minimum, it should be completed before any procurement of design and/or construction begins. Inclusion of the QAO in the procurement process allows for the RFQ, RFP, and/or IFB to define the project QAO so that the responding party can appropriately account for costs, risks, or staffing requirements.

Agencies tend to default to the traditional Deterministic QAO, in which the agency is responsible for all of the quality responsibilities. This research did not find a standard procedure or any formal guidance for defining roles and responsibilities when an agency determines that an alternative QAO is required. The purpose of this chapter is to provide guidance in selecting a project QAO. This chapter presents the factors that influence the selection of a project QAO and provides a tool to select appropriate QAOs based on the relationships between particular selection factors and the QAOs. The project QAO analysis selection tool provides transparency and further understanding to better define appropriate project QAOs.

4.2 Factors Influencing the Selection of the Project QAO

Appropriate project QAO selection requires an analysis of the factors that influence the selection and their relationship factors to each QAO. Ten different factors influencing the selection of a project QAO have been identified through interviews with agency project staff from 23 different projects in 13 different states. Further, the relationships between the selection factors and the fundamental QAOs have been determined by a panel of 12 experts through a three round Delphi study rating the appropriateness of each QAO to different categories of each selection factor. The contractor's final report for NCHRP Project 10-83 (published as *NCHRP Web-Only Document 212*) provides a detailed description of this process.

In this research, 10 factors that influence the selection of a project QAO were discovered and validated. These 10 factors fell into three groups: project, agency, and industry (see Table 3). The selection is intended to be made prior to any procurement. Any factors that were a condition of circumstances occurring after the procurement process were excluded because this information is unknown at the time QAO selection for a project takes place.

4.2.1 Project Factors

Project factors include four factors that influence the selection of a QAO: (1) project size, (2) project complexity, (3) schedule sensitivity, and (4) project delivery method. Project size is determined by the budget of the project including both design and construction. Project complexity is related to how similar the project is to a typical agency project. Complexity can result from characteristics including project scope, design requirements and constraints, construction methods, site conditions, budget and funding constraints, quality requirements, project delivery method, and specialty materials. Schedule sensitivity refers to the vulnerability of the project schedule to changes due to delays, conflicts, and/or events outside of the designer's and/or contractor's control. Examples include schedule items such as coordination of observations, inspections, and/or testing performed by the agency. Project delivery method is "the process by which a construction project is comprehensively designed and constructed for an owner including project scope definition, organization of designers, constructors and various consultants, sequencing of design and construction operations, execution of design and construction, and closeout and start-up" (Touran et al. 2011). The delivery methods include DBB, CMGC, DB, and PPP.

4.2.2 Agency Factors

Agency factors are the characteristics and abilities of STAs that are responsible for projects. The four agency factors

Table 3. Factors influencing the selection of a project QAO.

Selection factor group	Selection factor
Project	Project size Project complexity Schedule sensitivity Project delivery method
Agency	Culture Staffing availability Staffing experience Amount of quality responsibility shifted away from the agency
Industry	Ability to manage its own quality Trust between industry and agency

are (1) culture, (2) staffing availability, (3) staffing experience, and (4) the amount of quality responsibility the agency wants to shift to another project participant. The culture of the agency is the agency's attitude toward the implementation of change in quality management techniques. Agency staffing availability stems from quantity of staff available at an STA. Agencies across the nation have noted that they are experiencing a reduction in staff size. This factor is defined by the quantity of agency staff available to commit to projects as compared to the traditional levels of agency staffing for comparable projects. Agency staffing experience is the average number of years of experience of the agency staff committed to the project.

The amount of quality responsibility shifted away from the agency has to do with shifting responsibility for quality to another project participant. These shifts refer to the amount of liability for the management of the project's quality that an agency wants to shift to another project partner (e.g., contractor, designer, engineer, design builder, CMGC, or concessionaire).

4.2.3 Industry Factors

Industry factors are the characteristics or abilities of local design, engineering, contracting, and consulting communities. The two industry factors are (1) the industry's ability to manage its own quality and (2) the level of trust established between the industry and the agency. The industry's ability to manage its own quality refers to the local communities' levels of competence in managing their own quality. This competence may result from education, training, experience, or industry culture, or a combination of these. The level of trust established between the industry and agency is important because as agency control over a project is reduced, increased levels of trust are required, and the project becomes more collaborative. Effective collaboration depends on an agency's level of confidence that project decisions made by industry partners will be based on achieving the best results for the project, rather than on the partners' interests.

4.2.4 Establishing Relationships Between Selection Factors and QAOs

Four ratings were developed to indicate the relationship between the selection factors and the QAOs. These ratings are fatal flaw (denoted with ×), least appropriate (−), appropriate (+), and most appropriate (++). The selection factors and the appropriateness ratings presented in this section form the basis for the development of the project QAO selection process tool with the intent of providing guidance, transparency, and understanding to the process.

4.3 Guidance on Using Project Factors to Select a QAO

The goal of the QAO selection process is to help STAs identify the most appropriate QAO for projects at hand by rating the appropriateness of the five fundamental QAOs according to the categories of selection factors that apply to the projects. This guide strongly suggests that project QAOs be selected before the RFQ, RFP, or IFB process for design or construction begins so that project quality roles and responsibilities can be accurately accounted for the procurement.

The QAO selection process tool uses a three-step process for selecting the most appropriate QAOs for a particular project (see Figure 18). The three steps are identifying barriers to QAO adoption, creating a selection process profile, and applying the QAO factor analysis to select the most appropriate QAO. The steps are discussed in more detail in the following sections, and forms for the process are provided in Appendix C of this guidebook.

4.3.1 Step 1: Identifying Barriers to QAO Selection

Barriers are regulations or policies that either prevent the use of an alternative QAO or dictate that a specific QAO be used on the project. Possible barriers include, but are not limited to, federal, local, or funding regulations; political issues; and agency policies. It is important to identify these barriers at the beginning of the QAO selection process because it is very likely that if barriers exist, the QAO selection process will begin and end at this step. For example, when a specific QAO is required, that QAO must be selected.

4.3.2 Step 2: Preparing the Project QAO Selection Factor Profile

The goal of the second step is to prepare the project QAO selection factor profile (see Figure C5). The project QAO selection factor profile identifies which category of each selection factor applies to the project being analyzed.

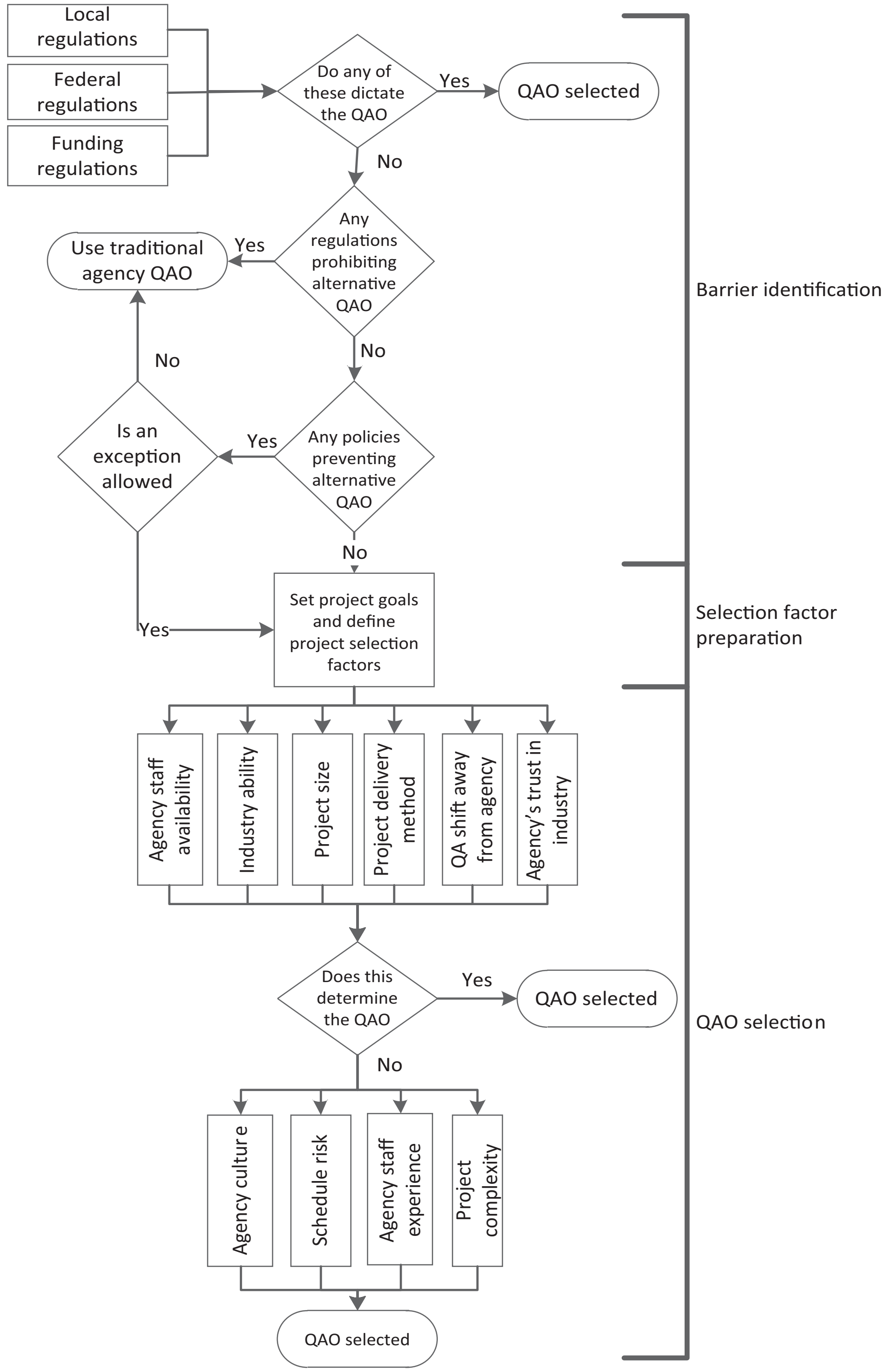

Figure 18. Project QAO selection process flowchart.

The information in the selection factor profile will be used in Step 3 to identify the appropriateness ratings for each selection factor that applies to the project. For some selection factors, such as project size or project delivery method, it is easy to identify which category applies to the project; however, identifying the correct category for selection factors such as the amount of quality responsibility the agency wants to shift to other project participants requires the project goals to be established and understood so that the correct selection factor category is determined. The project goals also provide the user with further understanding of the motivation of the project as a whole, including why the project is diverging from the standard default project QAO for the agency. This ensures that the agency is making a fully educated decision. Once the

Table 4. Project delivery method selection factor appropriateness ratings.

Selection factor category	Deterministic	Assurance	Variable	Oversight	Acceptance
Project delivery method					
DBB	++	+	+	+*	–
DB	–	–	+	++	–
CMGC	–	+	+	++	+
PPP	x	–	–	+	++

*Needs to be considered in conjunction with other factors

goals are established, the user can complete the project QAO selection factor profile form.

4.3.3 Step 3: Using the QAO Analysis Form to Select an Appropriate QAO

The final step of the QAO selection process is a comprehensive understanding of the appropriateness ratings for each QAO. In this step, the user transcribes the appropriateness ratings for the category of each selection recorded in the project QAO selection factor profile form (see Figure C5 in Appendix C) onto the project QAO analysis form (see Figure C6 in Appendix C).

The four appropriateness ratings are fatal flaw (denoted with ×), least appropriate (–), appropriate (+), and most appropriate (++). The fatal flaw rating (×) indicates that a particular selection factor category has potential to irrevocably harm the success of the project, effectively eliminating that QAO from further consideration. A least appropriate rating (–) indicates that for the particular selection factor category the QAO can work, but it is not the best option, and, if this QAO is implemented, there may be extra measures needed to accommodate this issue. An appropriate rating (+) indicates that the QAO can work for that particular selection factor category. In essence, it neither harms nor improves the potential success of the project. Finally, the most appropriate rating (++) indicates that a project can be improved by the implementation of the associated QAO.

As an example, the factor appropriateness ratings for the project delivery method selection factor are provided in Table 4. Looking at the appropriateness ratings for the project delivery method selection factor categories in combination with various QAOs shown in Table 4, it is apparent that as the amount of project responsibility shifts away from the agency (i.e., from DBB to PPP) the amount of project quality responsibility shifts away from the agency (i.e., from Deterministic to Acceptance), allowing both the project responsibilities and the quality responsibilities to remain in sync. Note that there is fatal flaw rating for the implementation of the Deterministic QAO on PPP projects. The Deterministic QAO requires the agency to retain all control of quality assurance. However, PPP projects shift almost all quality control away from the agency to the concessionaire. Acceptance is rated least applicable for both DBB and DB because the agency retains some responsibility for the day-to-day management of the project, which does not equate to the limited amount of quality responsibility the agency retains with the acceptance QAO.

The factor appropriateness ratings for each selection factor/QAO combination are transcribed onto the project QAO analysis form. This form is organized into two sections: primary selection factors and secondary selection factors. The primary factors are selection factors that resulted in at least one fatal flaw rating during the research and testing for NCHRP Project 10-83. The secondary selection factors did not result in a fatal flaw. Primary factors have a more decisive role in the project QAO selection. In many cases, a tally of the primary selection factor results will narrow down the choice of QAO to one or two options. If this is not the case, a tally of the secondary selection factor results can be used to get more information. This section has presented the three steps of the project QAO selection tool: barrier identification, selection factor preparation, and QAO selection. Appendix C presents the selection tool with forms and instructions. It also provides an abstracted demonstration project from this research study as an illustrative example.

4.4 Chapter 4 References

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CHAPTER 5

Useful Tools for an Alternative Quality Management System

5.1 Introduction

The guide intends to assist project managers and quality managers in developing a QMS that is well suited for the needs of their specific project and that reflects the advances made by STAs across the country in developing various quality management approaches. In implementing any QMS, tools and procedures are needed to implement the quality management plan. This chapter presents tools of various types, which are potentially valuable aids in a quality management plan. These include items that could be incorporated into procurement documents, a contract, or quality management plans. This chapter provides a brief description of these tools and guidance on selecting tools on the basis of individual project characteristics.

Combining the QAOs of Chapter 4 with the tools and procedures presented in this chapter, users of this guidebook will have many of the necessary components to create a QMS tailored for their project. In addition, this chapter provides two examples of complete QMSs developed elsewhere: the U.S. Army Corps of Engineers (USACE) system and the application of International Organization of Standardization (ISO) 9000 principles to highway construction.

5.2 Tools for Alternative QMSs

The tools for alternative QMSs presented in this chapter were discovered through a literature review and an evaluation of case studies. These tools encourage effective quality management across a variety of QMSs, including both the baseline and alternative systems. This section introduces some of the useful tools identified through both of these discovery processes. The purpose is to provide a matrix of each tool and suggestions of where the tools may be applied. Appendix B provides a more in-depth discussion of each tool. The tool descriptions include examples of how these tools were applied in various case studies and sample language to assist with their future application.

This guidebook subdivides the tools into two major categories, pre-award and post-award. Additional tool subcategories aid in tool selection and ultimate application to the various phases and parties that make up a project.

5.2.1 Pre-Award Quality Management Tools

Pre-award quality management tools are incorporated into project documents before the award of design or construction contracts. These tools help owners better define requirements for the project, inform interested designers or contractors of warranties designed to encourage a quality-focused approach, allow contractors to suggest changes to project documents or concepts before having to bid on them, and provide other quality management opportunities. Pre-award quality management tools set the right tone and expectations for the project in terms of quality. They pave the way for delivering quality designs and construction later on.

This guidebook further subdivides pre-award tools into owner-led tools and contractor-led tools. **Owner-led** tools are those that an STA initiates. These types of tools may include specific procedures to select designers and contractors on the basis of the quality of their work, project warranties to ensure project members guarantee a quality product, or broad project goals regarding quality and its implementation.

It may seem counterintuitive to have **contractor-led** quality management tools that are used before a construction contract has been awarded; however, several of the tools focus primarily on receiving contractor feedback regarding RFP details, project specifications, and/or project designs during the procurement phase. STAs have found that the contractors who compete to build their projects have valuable insights to share with project planners that can lead to a higher quality product. STAs have further found that in the right settings, contractors are willing to share those insights before a contract award has been made.

5.2.2 Post-Award Quality Management Tools

Post-award tools are those procedures and tools implemented after the completion of procurement and through the end of the project. These include quality management tools for both the design and construction processes.

The post-award tools represent a majority of the tools for alternative QMSs. The guidebook subdivides the post-award tools into the specific project phase for which they apply—design or construction—as well as by the nature of the tools. **Design review** tools provide ways to further ensure the production of quality designs. **Teaming** tools focus primarily on increasing the levels of communication and cooperation on a project during the construction phase. These tools seek to enhance these aspects of a project specifically to increase the quality of the final product. **Process control** tools represent ways to increase quality or the efficiency of the quality management process as work is actually put into place. These tools assist project managers by providing streamlined access to quality management reports and information, by incentivizing or de-incentivizing contractors specifically with regard to quality, and by offering innovations to some well-established existing processes. Finally, **training** tools assist the project team in focusing on quality issues specific to the project and in extending a broad-level quality focus from the upper management down to individual subcontractors.

5.2.3 Selection of Tools

The tools shown in Table 5 are not necessarily compatible with every project delivery method or QAO. In developing a full QMS, project managers must carefully consider the goals of the project and the reasoning behind their selection of a particular set of tools and procedures for use. For example, if a project has no administrative or legal authority to alter its quality standards or overall design, then inviting contractor input into the design or quality procedures would not be worthwhile and could in fact be counterproductive.

Table 5 presents a matrix that agencies can use to identify a set of tools compatible with both the project QAO and the specific project requirements. As previously described, the guidebook subdivides tools in several distinct categories. Using their knowledge of the project, project managers should approach the matrix by first identifying categories of tools they are interested in adding to their QMS. After finding that category in the chart, users of this guide should then identify those tools which are compatible with the QAO selected for their project.

Appendix B provides a detailed description of each tool, its purpose, and how it is applied. The tools selected by the project managers can then be added to the set of procedures compatible with the transportation agency building the project. From this final set, project managers can select a combination of quality management tools that best meet the needs and goals of their project. Not every tool is useful for every project, and managers should not expect to incorporate all or even most of the tools listed here on their particular project.

5.3 Examples of Alternative QMSs

This section highlights two existing alternative QMSs and their key points to provide example approaches. The USACE QMS is a well-developed system complete with its own QAO and well-defined system of tools, which has been used very successfully. ISO 9000 is an international system used by a diverse set of industries to improve production quality. It emphasizes complete organizational support for quality principles and has the potential to offer a great deal to the highway construction industry in the United States.

5.3.1 USACE Quality Assurance Policy for Alternative Project Delivery

The USACE has been using alternative project delivery methods since the 1980s (Henner 2007). The overarching document is Engineer Regulation 1110-1-12, "Quality Management" (USACE 2006). It furnishes the following definitions for each component to the overall USACE quality management program:

- Project Management Plan . . . The Project Management Plan identifies the scope, schedule, and resources needed to accomplish the work.
- The Quality Management Plan . . . is the quality component of the Project Management Plan. Its purpose is to document the project-specific quality control and quality assurance procedures appropriate to the size, complexity, and nature of the project.
- The Quality Control Plan . . . is the quality control component of the Quality Management Plan and defines how quality control will be executed for products and services.
- The Quality Assurance Plan . . . is the quality assurance component of the Quality Management Plan and defines how quality assurance will be executed for products and services that are completed by outside resources, including architect-engineer contractors as well as other USACE Districts and Centers.
- The Contractor Quality Control Plan . . . is a written plan, provided by an architect-engineer contractor that defines how quality control will be executed on products and services that are completed with architect-engineer resources.

The USACE model operates on Total Quality Management (TQM) principles and prescribes a Plan-Do-Check-Act (PDCA) cycle (commonly referred to in industry as the Deming Cycle). Understanding the USACE approach entails carefully applying the USACE definitions for key terminology and not confusing them with the FHWA definitions for the same

Table 5. Tool selection chart.

	Tools	QAOs Compatible				
		D	A	V	O	S
Pre-Award Tools						
Owner Led	*B.1. Pre-bid meeting with specific focus on quality	+	+	+		
Owner Led	B.2. Industry review of requests for proposals with a focus on quality			+	+	+
Owner Led	B.3. Alternative quality management approaches in procurement	+	+	+	+	+
Owner Led	B.4. Quality-based selection system	+	+	+	+	+
Owner Led	B.5. Use of warranties	+	+	+	+	+
Owner Led	B.6. Requirements management—verification	+	+	+	+	+
Contractor Led	B.7. One-on-one procurement meetings with a focus on quality			+	+	+
Contractor Led	B.8. Contractor involvement in establishing and streamlining quality control standards	+				+
Contractor Led	B.9. Alternative Technical Concepts		+	+	+	
Contractor Led	B.10. External contractor panel input	+	+	+		
Post-Award Tools						
Design Review	B.11. Independent party design review	+	+	+	+	
Design Review	B.12. Over-the-shoulder agency review			+	+	+
Design Review	B.13. In-progress design workshops			+	+	
Design Review	B.14. Discipline task force	+	+	+	+	+
Construction – Teaming	B.15. Formal partnering with regulatory agencies	+	+	+	+	
Construction – Teaming	B.16. Formal team-partnering/goal-setting process	+	+	+	+	+
Construction – Teaming	B.17. Co-location of quality management personnel	+	+	+	+	+
Construction – Teaming	B.18. No low-bid requirement for subcontractors	+	+	+	+	+
Construction – Teaming	B.19. Use of dual CEI/OCEI roles					+
Construction – Process Control	B.20. Innovation in witness and hold points			+	+	+
Construction – Process Control	B.21. Continuous internal process audit					+
Construction – Process Control	B.22. Real-time electronic quality management information	+	+	+	+	+
Construction – Process Control	B.23. Financial incentives/disincentives for quality	+	+	+	+	
Construction – Process Control	B.24. Contractor-controlled QC testing	+	+	+	+	+
Construction – Training	B.25. ISO 9000 training sessions					+
Construction – Training	B.26. Project-specific quality management team training	+	+	+	+	+

D = Deterministic QAO, A = Assurance QAO, V = Variable QAO, O = Oversight QAO, S = Acceptance QAO
+ = Compatible, blank cell = Incompatible
*B.1, B.2, etc., refer to numbering of tools in Appendix B.

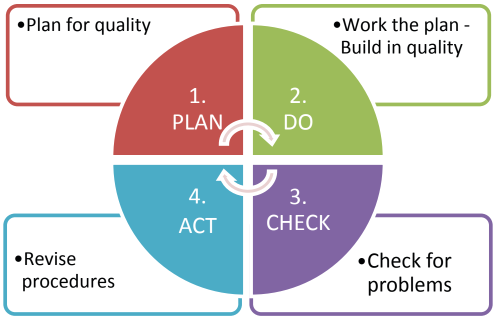

Figure 19. USACE QA model for alternative project delivery (adapted from USACE 2006).

terms. The USACE model is graphically presented in Figure 19. Each step in this process is defined as follows (USACE 2006):

- Plan—design the Project Management Plan to achieve customer requirements and provide for high quality products and services.
- Do—implement the Quality Management Plan, including the quality control and quality assurance procedures.
- Check—evaluate the project results.
- Act—identify and implement process changes for continual improvement.

The USACE utilizes a systems approach to quality and does not break quality out as a separate category of agency responsibility. The quality management plans are included as an integral part of the project management plan, which also includes other components such as a "Production Schedule; Risk Management Plan; Value Management Plan; and Change Management Plan" (USACE 2006).

5.3.1.1 USACE DB Quality Management Philosophy

The USACE specifically states its expectations in a chapter devoted to applying Engineer Regulation 1110-1-12 to DB project delivery. Important elements considered when shifting from the legacy DBB system include the following:

- The DB contractor is responsible for design quality.
- The USACE project delivery team has the role primarily of quality assurance.
- The USACE project delivery team develops and provides a quality control review of the performance criteria and prescriptive requirements in the RFP.
- The DB contractor is charged with a higher standard of care for correcting construction associated with faulty design.
- The DB contractor's construction function will address constructability, coordination, and also ensure that the project cost is within the contract budget/price amount.
- The DB contract will include a warranty of design provision(s) to provide for an extended callback, the callback is due to design errors and omission.
- The DB contract will address QC for both design and design-related activities that are required during construction.
- The DB contractor will ensure that the project is constructed in accordance with the accepted design and the contract.

The USACE project delivery team has the role of quality oversight through concurrence with the designer of record and contract quality control activities.

5.3.1.2 USACE CMGC Quality Management Philosophy

The USACE quality management approach for projects delivered using alternative methods can be summarized as follows:

- USACE sees QA as the agency's role in quality management.
- USACE uses a systems approach to quality management and has detailed guidance for QA in each phase of the life cycle of a CMGC, early contractor involvement (ECI), or DB project.
- USACE uses a standard series of quality management plans to codify, quantify, and assess quality performance on both design and construction quality.

5.3.2 ISO 9000 QA Principles Applied to Alternative Project Delivery

The ISO 9000 standard provides a common foundation for instilling a quality culture in organizations with eight quality principles (Miron, Rogers, and Kopac 2008):

- Customer focus
- Leadership
- Involvement of personnel
- Process-based approach
- Systems approach to management
- Continual improvement
- Factual approach to decision-making
- Mutually beneficial relationships with suppliers

ISO provides a wealth of information on quality management in design and manufacturing that has direct application to highway projects. For example, an article written in 1998 describes how an ISO 9002–certified Canadian contractor applies the fundamental principles of ISO 9000 to "produce, monitor and control its own concrete mixes, not only to ensure mix quality, but to more efficiently feed its continuous concrete paving operations" (Dufferin 1998). The primary application of

ISO 9000 was on the contractor's mobile concrete batch plant. This fits neatly into the manufacturing standards available from ISO. Since highway construction is equipment intensive and becoming more highly automated, the opportunity clearly exists to apply manufacturing standards to appropriate construction systems, such as GPS-driven construction machine guidance or in-place recycled asphalt paving trains, as shown by the ISO-certified Canadian batch plant.

The FHWA used ISO 9000 principles to guide an initiative titled "Advanced Quality System (AQS)" (Miron, Rogers, and Kopac 2008). AQS is defined as follows:

> An AQS is an integrated quality management system to fulfill the customer's expectations of pavement performance by making optimum use of the available tools and resources to continuously improve the system processes and the quality of the product delivered while fostering cooperative working relationships among all parties.

An "integrated quality management system" is one where the designer and the constructor work together during the design and construction phases, which includes both CMGC and DB project delivery methods. In its AQS initiative, tools developed by the FHWA such as pavement design, quality, and warranty products were considered effective measures of an integrated quality management system. Therefore, the application of this ISO 9000–based initiative to alternative project delivery requires little or no alteration to be able to implement.

5.3.2.1 ISO 9000 Applied to Design Quality Management in CMGC and DB

Design quality management is the place where ISO 9000 principles may be most applicable. The principles of "involvement of personnel" and "factual approach to decision-making" personify integrated delivery methods. The Oregon DOT lists the major services that can be performed by the construction contractor during the design phase of CMGC projects as follows (Lee 2008):

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

ISO 9000 argues that a critical factor in achieving high-quality design is free and open communication among all parties during the design phase (Miron, Rogers, and Kopac 2008; Beard, Loulakis, and Wundram 2001). The FHWA AQS initiative recognizes this and prescribes that the design and associated drawings and specifications define what the transportation agency wants and that they all need to be consistent (Miron, Rogers, and Kopac 2008).

5.3.2.2 ISO 9000 Applied to Construction Quality Management in DBB, CMGC, and DB

Construction quality management in a CMGC project will not differ greatly from that found in a DBB project. The owner still occupies the same contractual position with respect to the designer and builder. Therefore, the ISO 9000 systems in use in DBB projects can be directly applied to CMGC projects with little alteration. The key difference is the change in motivation of the constructor with regard to quality. In DBB, the constructor has no input to the design and must build what is shown in the construction documents. In CMGC, the contractor assists in developing the final design and as a result assumes a significant degree of ownership in the design product. *NCHRP Synthesis 402* (Gransberg and Shane 2010) describes the idea of having "buy-in" to the design making the CMGC less prone to submit a claim for additional compensation for design problems in features of work for which the Construction Manager at Risk had been paid to review and furnish input.

In DB, STAs have the opportunity to allow design builders to use construction means and methods to differentiate themselves from their competitors and to provide efficiencies that may not have been contemplated by the agency. This creates an opportunity to use ISO 9000 certification of construction companies as a mechanism to mitigate the risk that the construction means and methods used by the design builder may not achieve the same quality as those prescribed in DBB contracts (Battikha and Russell 1998).

5.4 Summary Guidance for Assembling a QMS

This guidebook provides suggestions for designing a QMS that meets the user's needs. The framework of a full QMS is introduced in Chapter 1. QAOs and their selection are discussed in Chapters 3 and 4. Alternative tools to use and their selection are introduced in this chapter. This section suggests a process, as shown in Figure 20, to combine the QAO/tool combinations selected into a broader QMS applicable to every aspect of a project.

Development of a QMS begins with an understanding of the project conditions, especially a consideration of the project delivery system and whether the design and construction organizations vary from the "baseline" systems noted in this guidebook. The next step is to determine potential QAOs, using the techniques described in Chapter 4 and the appendices. Once the options for QAOs are clear, then it is appropriate

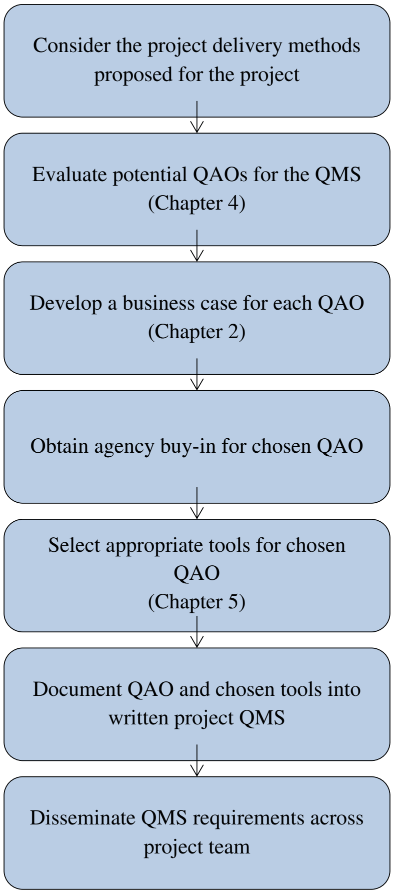

Figure 20. Process for assembling a QMS.

to establish the "business case" for each QAO, carefully considering the pros and cons for each one, especially in relation to administrative and regulatory requirements and industry custom. Once the business cases are established, any QAO that varies from the baseline QAO for the organization should be presented to appropriate decision-makers in the agency. Selection of the QAO for the project should be a collaborative effort of project personnel and administrative decision-makers. Consideration should be given to soliciting industry input as well. The chosen QAO can then be matched with the tools described in this chapter to assemble a complete QMS that will become the guiding quality principle for the project. Clear documentation of the holistic QMS will provide the basis for contractor and consultant proposal and contract documents, aligning team efforts toward the same quality goal and establishing each party's role in the process.

As the project participants are brought on board, it is important to disseminate the principles and procedures outlined in the project QMS. It is also important to recognize that some QMSs differ from the traditional QMS, and, without specific communication, any new party to the project could just "default" to the traditional system, causing misunderstandings and conflicts.

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APPENDIX A

Glossary of Terms

The definitions of most of the quality assurance terms used in this guidebook and given below are from *Transportation Research Circular E-C137: Glossary of Highway Quality Assurance Terms* (2009). Terms that are not included in *Transportation Research Circular E-C137* are referenced separately.

Acceptance: The process of deciding, through inspection, whether to accept or reject a product including what pay factor to apply.

Acceptance plan: An agreed-upon method of taking samples and making measurements or observations on these samples for the purpose of evaluating the acceptability of a lot of material or construction.

Construction deliverable: A product produced by the design builder's construction team that is submitted for review to the agency (e.g., shop drawings, product submittals, etc.).

Construction Manager/General Contractor (CMGC): A project delivery system that entails a commitment by the construction manager to deliver the project within a guaranteed maximum price (GMP), in most cases. The construction manager acts as consultant to the owner in the development and design phases and as the equivalent of a general contractor during the construction phase.

Contract payment provision: The contract language that defines how design and construction professionals will be paid for their services. The four primary contract payment provisions are fixed price lump sum, guaranteed maximum price (GMP), cost plus fee, and cost reimbursable.

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

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

Design deliverable: A product produced by the design builder's design team that is submitted for review to the agency. (e.g., design packages, construction documents, etc.).

Independent assurance (IA): A management tool that requires a third party, not directly responsible for process control or acceptance, to provide an independent assessment of the product and/or the reliability of test results obtained from process control and acceptance testing. (The results of independent assurance tests are not to be used as a basis of product acceptance.)

Manufacturing-based quality: Conformance to specifications (ASQ 2013).

Product-based quality: Quality is a precise and measurable variable and differences in quality reflect differences in quantity of some product attribute (ASQ 2013).

Project delivery method: The comprehensive process by which designers, constructors, and various consultants provide services for design and construction to deliver a complete project to the owner. While names can vary in the industry, and owners often create hybrid delivery methods, there are essentially three primary project delivery methods: DBB, CMGC, and DB.

Quality: (1) The degree of excellence of a product or service, (2) the degree to which a product or service satisfies the needs of a specific customer, or (3) the degree to which a product or service conforms with a given requirement.

Quality assurance (QA): All those planned and systematic actions necessary to provide confidence that a product or facility will perform satisfactorily in service. (QA addresses the overall problem of obtaining the quality of a service, product, or facility in the most efficient, economical, and satisfactory manner possible. Within this broad context, QA involves continued evaluation of the activities of planning; design; development of plans and specifications; advertising; and awarding of contracts, construction, and maintenance, and the interactions of these activities.)

Quality assurance organization (QAO): The assignment of the roles and responsibilities associated with the quality management of a project from concept through completion.

Quality control (QC): Also called process control, those QA actions and considerations necessary to assess and adjust production and construction processes so as to control the level of quality being produced in the end product.

Quality management: The totality of the system used to manage the ultimate quality of the design as well as the construction encompassing the quality functions described above as QA, QC, independent assurance, and verification (Gransberg, Datin, and Molenaar 2008).

Relative quality: Loose comparison of product features and characteristics (ASQ 2013).

User-based quality: Fitness for intended use (ASQ 2013).

Value-based quality: Conformance at an acceptable cost (ASQ 2013).

Appendix A References

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APPENDIX B

Common Quality Management Tools

- B.1 Pre-Bid Meeting with Specific Focus on Quality
- B.2 Industry Review of Requests for Proposals with a Focus on Quality
- B.3 Alternative Quality Management Approaches in Procurement
- B.4 Quality-Based Selection System
- B.5 Use of Warranties
- B.6 Requirements Management—Verification
- B.7 One-On-One Procurement Meetings with a Focus on Quality
- B.8 Contractor Involvement in Establishing and Streamlining Quality Control Standards
- B.9 Alternative Technical Concepts
- B.10 External Contractor Panel Input
- B.11 Independent Party Design Review
- B.12 Over-the-Shoulder Agency Review
- B.13 In-Progress Design Workshops
- B.14 Discipline Task Force
- B.15 Formal Partnering with Regulatory Agencies
- B.16 Formal Team-Partnering/Goal-Setting Process
- B.17 Co-Location of Quality Management Personnel
- B.18 No Low-Bid Requirement for Subcontractors
- B.19 Use of Dual CEI/OCEI Roles
- B.20 Innovation in Witness and Hold Points
- B.21 Continuous Internal Process Audit
- B.22 Real-Time Electronic Quality Management Information
- B.23 Financial Incentives/Disincentives for Quality
- B.24 Contractor-Controlled QC Testing
- B.25 ISO 9000 Training Sessions
- B.26 Project-Specific Quality Management Team Training

B.1 Pre-Bid Meeting with Specific Focus on Quality

Project plans and specifications or procurement documents are not often perfect. As a result, when contractors prepare bids for projects having only seen the plans and specifications, confusion regarding the intent of the design team and agency can exist. A useful practice to clear this confusion up, improve the accuracy of submitted bids, and improve the quality of the final product is a pre-bid meeting with a focus on quality.

Compatible Quality Assurance Organizations (QAOs)

Deterministic, Assurance, Variable

What Is It?

A pre-bid meeting—with either a focus on quality or a portion devoted to quality—provides parties competing for the project with an opportunity to ask clarifying questions of the agency's design team and project managers. The meeting is designed to reduce or eliminate confusion during the bidding process in order to receive more accurate and responsive bids that have adequately considered all of the key project issues and quality concerns.

Why Use It?

Helping prospective bidders understand a project and its requirements is in the best interest of all project parties. Devoting a section of a pre-bid meeting to quality ensures that interested bidders pay adequate attention to the quality provisions of project documents and gives them a chance to discover what the agency's prime concerns are. Using this information, they can develop estimates that should better reflect the true cost of quality management programs.

What Does It Do?

A pre-bid meeting with a focus on quality helps bidders to understand the emphasis placed on quality. It provides bidders the time necessary to focus on quality provisions and requirements by prompting them to generate useful questions for the meeting and gives them a chance to hear the concerns and questions of others.

When to Use It

The agency typically hosts pre-bid meetings several days or weeks after plans are advertised for construction bids, but well before the bid deadline. This necessary interval of time allows prospective bidders to evaluate the project documents and examine the requirements, especially unusual features of work containing important quality requirements. While clarifying meetings are useful for many reasons, the use of pre-bid meetings focusing on quality is especially useful when complex quality requirements have been introduced to a project or when some flexibility in the interpretation of quality requirements exists.

How to Use It

In order to maintain a competitive bidding process that does not discourage any potential bidders, attendance at pre-bid meetings should not be mandatory and should be open to the public and all prospective bidders. At the agency's discretion, minutes from the pre-bid meeting can be made publicly available online for anyone who could not attend the meeting to review if desired.

Agencies should publicly post the meeting time and location and inform any known prospective bidders of the meeting when the project is first advertised for bids. Depending on project needs and site constraints, the agency may elect to have the meeting at the prospective project site. Agencies can elect to generate a simple agenda with ideas for discussion, or can leave the meeting open to contractors to bring their questions and concerns. If the pre-bid meeting is open to more than just quality clarifications, time should be set aside for each of the issues to be discussed (quality, design clarification, etc.).

Example—George Sellar Bridge Project (WSDOT)

The Washington State Department of Transportation (WSDOT) conducted a pre-bid meeting on its project to add an eastbound lane to the SR285 George Sellar Bridge in Wenatchee, Washington. At the meeting, project designers from WSDOT's bridge engineering department were on hand to answer questions from contractors interested in bidding on the project. While the meeting was open to the public and bidders were not required to attend, the winning bidder indicated that the meeting was extremely useful in preparing its bid and clarifying the intent of the designers.

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B.2 Industry Review of Requests for Proposals with a Focus on Quality

When developing a request for proposals (RFP), it is crucial to have as much information as possible in order to reduce project risk and successfully communicate the needs of the project. An industry review process involves releasing draft sections of the RFP to short-listed firms. The firms are then able to provide valuable feedback to the owner before the official RFP is released.

Compatible QAOs

Variable, Oversight, Assurance

What Is It?

The industry review is an interactive process in which the first version of the RFP is released to firms that have been short-listed by the agency after evaluating request for qualifications (RFQ) submissions. The firms then provide written comments in response to the draft RFP, and one-on-one meetings between each firm and the owner are arranged to discuss these comments. There may be more than one round of meetings depending on the complexity of the project and the procurement schedule. The RFP is then reviewed and modified before the official RFP is released to the relevant parties. The industry review process may include the development of a risk allocation table which contributes to the enhancement of overall project quality.

Why Use It?

The primary purpose of an industry review process is to gather information from interested firms in order to reduce risk. The process includes developing a risk allocation table, developing schematic design, defining proposal evaluation details, and other preliminary engineering. The time spent on the industry review process facilitates thorough project planning and preparation of the RFP. An industry review process has the potential to provide firms with a better understanding of the project and provides an opportunity to address ambiguous project details before the RFP is released.

What Does It Do?

The industry review process results in the final documentation that is released for an official RFP. The RFP preparation is carried out by state transportation agency (STA) personnel and external technical and legal consultants who facilitate the interactive, iterative review process. The industry review process is critical because it includes the development of a risk allocation table as a trade-off with the proposers.

When to Use It

The industry review process is designed to take place after RFQs have been received by the owner and before the official RFP is released. For this reason, an industry review process can be implemented on any project that has a two-stage procurement process.

How to Use It

Once the short-listed firms have been selected based on qualifications, the owner should release draft sections of the RFP to the firms and await written comments. A time frame should be provided for returning written comments in order to keep the project procurement process on schedule. One-on-one meetings should then be scheduled to discuss the written comments. The resulting documentation should then be reviewed, edited, and modified as necessary and resubmitted to proposers with other draft sections of the RFP. This process is an iterative process in which the number of rounds of one-on-one meetings should be dictated by the project complexity and the procurement schedule pressure.

Example—SH 130 Turnpike Project (TxDOT)

The Texas Department of Transportation (TxDOT) utilized an industry review process on the SH 130 Turnpike Project. The public-private partnership (PPP) involves a new 49-mile tollway extending from IH-35 near SH 195, southward to US Highway 183 in Texas. The industry review process enabled the owner to gather as much information as possible on project risk. As a result, a risk allocation table was formed which clearly assigned responsibility among the project team.

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B.3 Alternative Quality Management Approaches in Procurement

Alternative quality management (QM) approaches in procurement deal with how designers and contractors are selected for a project. By using prequalification and bidding procedures that consider a designer's or contractor's past performance or that reward approaches that deliver a higher quality product, STAs can improve the overall quality of the field from which they select a designer or contractor.

Compatible QAOs

Deterministic, Assurance, Variable, Oversight, Acceptance

What Is It?

Many STAs have prequalification policies in place that require parties interested in participating in their projects to meet certain administrative requirements (e.g., capabilities, bonding capacity, etc.). This tool goes a step further and uses performance-based prequalification procedures or bidding processes that include a quality of approach component to improve the quality of parties interested in participating in a project.

Why Use It?

The use of this tool rewards designers and contractors that have delivered superior levels of quality or performance on their past projects and those that have solutions to project challenges that further the agency's project or quality goals. By encouraging higher quality parties to pursue projects, an STA should have a better field participating in its procurement process, which should translate into the delivery of a project with a higher level of quality.

What Does It Do?

In contrast to verifying quality after a product is complete, this tool emphasizes building quality into the project from the very beginning. By rewarding project participants who have demonstrated high levels of performance on their past projects or who have approaches to the current project that further the goals of the STA, this tool helps identify and select high-quality design consultants and contractors. Using higher quality designers and contractors is a proactive form of quality management, which seeks to improve the quality of the project construction process itself.

When to Use It

Forms of this tool exist in most two-stage procurement processes for design-build (DB) or construction manager/general contractor (CMGC) projects and in the qualifications-based selection of many design consultants. However, for design-bid-build (DBB) projects and other projects not currently using a form of prequalification or modified bidding procedure, this tool may be useful in improving the field of candidates from which to select design consultants and contractors.

How to Use It

Prequalification processes are in use at many STAs across the country, but they require some care in their crafting to ensure that they are not excessively exclusive and don't overly impede requirements to procure contractors on a low-cost basis. If prequalification procedures may be useful, STAs should determine which facets of a contractor's or a designer's prior experience are worth evaluating in considering them for future projects.

The use of bidding procedures which add quality-based components are relatively easy to incorporate. However, unless proper weight is given to the various components (price, schedule, special constraints, overall approach, etc.), this approach may end up emphasizing the wrong aspect of a project. If project managers are truly interested in encouraging innovative and high-quality approaches to a project's challenges, the weighting of the various bid components must reflect that desire.

Examples

George Sellar Bridge Project (WSDOT)

WSDOT used an alternative quality management approach in procuring a contractor to add an additional eastbound lane to the SR285 George Sellar Bridge in Wenatchee, Washington. On that project, WSDOT was originally envisioning several total bridge closures to raise the portals at either end, but wanted to keep these to a minimum. To emphasize the need for a high-quality approach to this problem, WSDOT used an A+B+C bidding process to procure the general contractor on this DBB project. The "total" bid of each contractor was found by adding their bid price to the number of days multiplied by a price per day and the number of full bridge closures multiplied by a price per bridge closure. As a result, all of the prospective bidders proposed zero total bridge closures, and the winner of the project ultimately delivered the project with zero total closures.

Oregon Department of Transportation (ODOT)

ODOT also uses a form of this tool in their prequalification procedures. In addition to administrative requirements, a contractor must be prequalified to build a project based on its type or class before the contractor can bid on the project. ODOT also requires its design consultants and contractors to fill out evaluations of themselves and other project parties at the end of every project. These ratings are then tracked by ODOT and used to as a prequalification factor for future work. Contractors or consultants who score too low are prevented from participating on certain projects in the future. To date, ODOT has not used this tool to prevent the participation of any parties, but the capability exists to do so.

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B.4 Quality-Based Selection System

Proper procurement is a vital part of assembling an effective project team that can produce a final product. In the traditional procurement approach, cost is commonly the only factor considered in procuring a contractor to build the project. This can make it difficult for an agency to know what type of quality and factors other than favorable cost that the selected contractor is capable of bringing to the project. Alternative project delivery methods can involve the selection of multiple team members in one procurement (e.g., designer and builder), or they may require that the contractor be selected before the price is known (e.g., CMGC). Therefore, an optional approach in team member selection is to require specifically defined quality factors from bidding contractors.

Compatible QAOs

Deterministic, Assurance, Variable, Oversight, Acceptance

What Is It?

Quality-based selection is a process in which the RFP and the associated bid evaluation process consider quality aspects when evaluating proposals or bids. This can be a best-value procurement approach where quality; cost; and possibly other factors such as contractor qualifications, reviewing past quality performance, and design alternatives are evaluated in the selection process. The agency then selects the contractor that provides the best combination of all of the factors.

"Best-value procurement is a process where price and other key factors are considered in the evaluation and selection process to minimize and enhance the long-term performance and value of construction" (Scott et al. 2006). In terms of quality, the agency includes in the RFP specific parameters for quality that contractors must include in their submittal. The quality parameters have to be measureable and project specific, not management specific (Anderson and Russell 2001). Examples of quality parameters are past quality performance and experience, quality capabilities, proposed project-specific QMS and corresponding quality management team, and proposed innovative quality solutions (Scott et al. 2006, Anderson and Russell 2001).

Why Use It?

For some projects, the evaluation of responsible low bids is not enough to select a responsible contractor. In addition to cost, other factors, such as quality, can be required in the RFP. This process of including quality as a factor in selecting a contractor enhances the potential project quality. It also signals to contractors that the agency is quality-focused in addition to focused on keeping the project within budget.

The selected contractor is then held to the proposed quality requirements. This places the risk of performing to the level of quality required by the agency on the contractor. The agency is then only responsible for oversight and verification of adherence to the proposed quality aspects, which reduces the amount of resources and time needed for quality management.

What Does It Do?

Quality-based selection provides the agency with a quality factor in evaluating received bids. The advantage of including a quality parameter or parameters in the RFP is the ability to consider a contractor's potential quality performance before awarding the contract (Scott et al. 2006).

When to Use It

Quality-based selection of contractors would be useful on particularly complex or innovative projects requiring exceptionally high levels of quality or on unique projects not commonly performed. The agency must consider the selection process prior to the development of an RFP as contractors must be informed of the quality requirements of their proposals and the scoring criteria associated with those requirements. The process then continues to the evaluation stage in which quality characteristics (past performance, planned approaches, etc.) are factored into the scoring. Agencies must also include contract language requiring contractors to follow through with the quality-related portions of their proposals after they have signed the contract.

How to Use It

To use this tool accurately, RFP development by the agency is critical. The RFP may include sections describing contractor quality requirements such as submitting information on the design and construction quality managers, describing the overall quality management plan, providing ISO 9000 or similar quality management training, and any other appropriate quality aspects necessary for the project. The agency must specifically define in the RFP what the agency requires in terms of quality.

Once the agency receives proposals from contractors, the agency evaluates each submission according to its scoring process and criteria, including, at a minimum, cost and quality components. An evaluation process needs to be developed by the agency prior to issuance of the RFP. This evaluation process is necessary to quantify or score the quality information so that the evaluation of all contractor submissions is performed in an equivalent manner. Agencies may want to evaluate the quality scoring of proposals independently to prevent the appearance of bias.

The bidding contractor that provides the best combination of quality requirements and total cost (in addition to other scoring categories) is selected as the contractor for the project. In some instances, the bidder with the lowest cost may not be the selected contractor due to a lack of quality requirements in their bid.

Tips

- The development of the RFP is critical in requiring quality aspects in bids. Lack of proper instructions and requirements in the RFP could make the quality portion of proposals confusing to contractors and essentially useless to the agency.
- The agency has to develop a process for evaluating the quality portion prior to the release of the RFP. This process then should be included in the RFP so that contractors know how the agency will evaluate their quality information.
- Quality requirements of the contractor, such as a proposed QMP, have to be monitored during design and construction

to make sure the contractor is adhering to the quality requirements and the proposed quality aspects from the contractor's proposal.

Examples

I-15 Widening and Beck Street Bridge Project (UDOT)

The Utah Department of Transportation (UDOT) utilized a technique of quality-based selection of contractors for the I-15 Widening and Beck Street Bridge Project. On this project, UDOT had specific quality requirements developed early on in the project. UDOT then developed and issued an RFP that required contractors to submit specific information for a design quality manager, a construction quality manager, and an overall quality management plan for the duration of design and construction. The agency evaluated the quality aspects in each of the bids and then reviewed the cost portion of the bids. The selected design builder proposed the best combination of cost and quality management. Once the design builder was on board, the agency was in charge of oversight and monitoring of the quality aspects proposed by the design builder to make sure the design builder was adhering to those aspects.

I-595 Express Corridor Project (FDOT)

The Florida Department of Transportation (FDOT) required contractors to submit quality information in their bids for the I-595 Express Corridor Project. This was a PPP project, the first of its kind for FDOT. Therefore, certain quality requirements had to be a part of the RFP in the selection of a concessionaire process. The bidding concessionaires had to include specific information for a design quality manager, construction quality manager, and all other quality management staff proposed for this project. The RFP also requested a description of proposed quality management plans for design and construction.

Once the concessionaire was selected based on quality, cost, and other important factors that FDOT required as part of the contract, the selected firm was required to provide a quality assurance (QA) plan for both design and construction for review by FDOT. For this project, the selected firm provided and performed the overall QA, the design quality control (QC) and design acceptance plans, and the construction QC and construction acceptance plans.

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B.5 Use of Warranties

Once a project is complete, the final product requires maintenance and repairs so that it remains at a high level of operation. In the traditional method, the STA is the party that performs the maintenance and repair of a completed project, which puts the risk of contractor performance on the agency. If a contractor performs poorly, the project quality could suffer, which could result in a higher probability of needed repair and maintenance during the life of the project. Additional maintenance requires additional materials and agency resources. One way to alleviate this performance risk and potential for additional maintenance is with the use of warranties.

Compatible QAOs

Deterministic, Assurance, Variable, Oversight, Acceptance

What Is It?

Warranties and warranty contracting is a process where the selected contractor is held responsible for all maintenance and repair work that occurs during the specified warranty period (Bayraktar et al. 2004). This process provides some freedom to the selected contractor in choosing materials and techniques for a project as long as those chosen align with the best approach and still meet the agency's requirements. The contractor then warrants the project and performs work on any defects that occur during the warranty period due to materials or performance of the contractor.

Warranties can be an evaluation factor in a best-value procurement procedure where the agency develops specific warranty criteria and presents the criteria in the RFP. The agency then evaluates submitted proposals based on a previously derived procedure to review each proposal in terms of warranty.

Why Use It?

The use of warranties helps to reduce the amount of agency resources required on a highway project (Anderson and Russell

2001). This is because the agency can limit its inspection process and the resources associated with it during construction, and, during the warranty period of the project, the agency does not have to provide maintenance and repair. Warranties reduce the performance risk for the agency and increase the performance risk for the contractor. The contractor is able to control performance risk more effectively than the agency since the contractor is performing the actual construction work (Anderson and Russell 2001).

Quality improvement is the major anticipated advantage of using warranties on highway construction projects (Bayraktar et al. 2004). This is because the contractor has the incentive to perform at a high level of quality during construction so that it can reduce the potential for repairs and maintenance during the warranty period (Hancher 1994). Using warranties also increases the contractor's freedom to use innovative construction technologies and methods on their projects (Bayraktar et al. 2004).

What Does It Do?

Warranties provide the agency with increased product quality, lower the maintenance and overall life-cycle costs of a project, protect the agency from early project failures, and reduce the amount of site inspections needed (Anderson and Russell 2001, Thompson et al. 2002, Bayraktar et al. 2004). Essentially, the use of warranties places the risk of quality performance on the contractor in that the contractor will want to produce a high-quality project so that less warranty work occurs after the project is complete.

When to Use It

Warranties are useful for almost any type of project. It is common for most projects to include a warranty that covers defective materials and workmanship over a period of 1 year (Hancher 1994). However, this tool is useful in instances where warranty of materials, workmanship, and performance is needed for a period longer than 1 year. Warranties can also be used in instances where the agency wants to reduce the resources needed for site inspections and future maintenance.

The agency has to decide if warranties are to be a part of a project early in the life of a project (Thompson et al. 2002). This allows the agency to develop warranty criteria that are then included in the RFP. From there, contractors provide warranty provisions in the submitted proposal. The contractor can then be selected based on warranty information, cost, and possibly other factors pertinent to a particular project. Once the agency selects the contractor, the warranty provisions presented in the proposal become a part of the contract.

How to Use It

Warranties need to be included in the contract between the agency and the contractor. Typical elements of warranty contracts are the description of the warranty, the duration of the warranty, bonding requirements, maintenance, conflict resolution, contractor responsibilities, agency responsibilities, performance indicators, requirements for corrective action, basis of payment, and insurance coverage (Thompson et al. 2002).

At the completion of the project, the warranty period begins. From this point to the end of the warranty period, if any materials, workmanship, or performance defects arise, the contractor is responsible for repairing or replacing the defective work. This is done on an as-needed basis, and any work performed, materials used, and associated costs are the responsibility of the contractor.

Tips

- Warranties are useful for a variety of projects. However, in terms of highway projects, warranties are used most commonly for paving and pavement-marking projects.
- It is important to describe the warranty specifically in the contract to avoid possible conflict during the warranty period.

Example—Wisconsin Department of Transportation Warranty Program (Anderson and Russell 2001, Thompson et al. 2002, Scott et al. 2011)

The Wisconsin Department of Transportation (WisDOT) was one of the first state highway agencies to utilize warranties and has been doing so since 1994, mostly on pavement projects. Since that time, WisDOT has realized several advantages to using warranties in contracts. First, WisDOT acknowledged a reduction in inspection and quality assurance personnel on warranty projects, but increased resources for annual inspections during the warranty period. Also, in terms of actual inspections and testing, WisDOT realized that eliminating the duplicative testing used on traditional projects also reduced the contractor's quality control testing. This saves time and resources for the contractor and ultimately WisDOT.

WisDOT views warranty projects and associated specifications as a means of payment to the contractor so that the contractor takes on a specified, reasonable risk. It was very important to WisDOT that the risk assumed by the contractor is reasonable. The warranty provides a guarantee to WisDOT that the contractor will complete the project correctly and maintain it properly for the term of the warranty.

The contractor then has the freedom to select materials, mix designs, techniques, and a quality control program.

In terms of bonds, WisDOT requires a warranty bond be in place for the entire duration of the warranty period. This helps WisDOT ensure that any remedial actions that need to take place do take place. However, WisDOT has worked to try and keep warranty bonds reasonable so that more contractors are able to bid warranty work.

Finally, the overall quality of the warranty projects has not suffered in any way for WisDOT projects. WisDOT utilizes distress threshold performance metrics to measure the overall quality of a pavement project. Two measurements, international roughness index (IRI) and the pavement distress index (PDI) were recorded for warranty and non-warranty projects. Both measurements are based on an inverse scale, with lower values indicating better measurements. For WisDOT, the IRI and PDI values were lower for warranty projects than non-warranty projects.

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B.6 Requirements Management—Verification

Requirements management (RM) is a defined methodology included in the systems engineering body of knowledge. The approach is used extensively in organizations and on projects where the risk and impact of failure could be high, such as in aerospace and public rail transit. As the complexity of transportation project delivery increases, RM is a tool that helps project delivery teams to manage these projects to successful completion.

Compatible QAOs

Deterministic, Assurance, Variable, Oversight, Acceptance

What Is It?

RM is an approach that covers the (1) development, (2) communication, (3) fulfillment, and (4) verification of requirements for a scope of work to be completed. The intent of a systematic RM program is to establish, with a measured level of confidence, the degree to which the completed work within a defined scope is conforming to governing requirements. Requirements are an expression of a facility's owner or end user's expectations and needs. A good requirement can be very simply defined as a "clearly communicated parameter." There are a number of attributes that define a good requirement, such as verifiable, clear and concise, necessary, and traceable. The verification of requirements is typically performed using established statistical sampling methodologies and review, inspection, and testing of the completed work. As a result of this verification effort, a measured level of confidence can be determined based upon the anticipated risk of the fulfillment of each defined requirement.

Why Use It?

Why use an RM approach to develop requirements? Owners of facilities typically best know the needs and expectations for a specific scope of work. These owners may or may not be able to express these needs and expectations in a format that will allow a designer or builder to deliver a scope of work that will appropriately fulfill the needs and expectations. Using a proven and systematic approach to developing requirements can contribute to successful project delivery. Developing and standardizing good requirements will lower the cost of developing future scopes of work.

Why use an RM approach to communicate requirements? Clarity in defining requirements will lower the risk associated with completing a scope of work. If requirements are poorly presented to the entity tasked with completing the work, the risk of having the work done incorrectly and having to perform rework is high. The higher the risk, the higher the proposed cost to complete the work. Clearly communicating requirements will lower the proposed cost to complete a defined scope of work.

Why use an RM approach to fulfill requirements? When a designer or builder clearly understands what is expected to be completed, the probability of fulfilling the defined requirements increases.

Completing work correctly the first time and avoiding rework is a recipe for success for all involved. Projects that involve rework are never as good as those that were done right the first time. Performing rework is an unnecessary drain on resources that lowers profit and has a negative impact on schedule. Performing work right the first time saves both money and time.

Why use an RM approach to verify requirement conformance? Verifying that the requirements are being appropriately fulfilled is a way of depicting value for money. Work that is of higher risk and of critical nature should be the focus of verification rather than work of lower risk and less critical in impact. By understanding the risk priority, efficiencies can be gained in the verification of requirements of higher risk. The cost of verification can be reduced, with minimal loss in confidence, through the systematic collection of data associated with performance of completed work.

What Does It Do?

Systematic RM provides a way for owners to clarify their expectations and then communicate those expectations in a format that will lower the perceived risk of completing a scope of work. Systematic verification of requirements provides a data-driven method of evaluating the observed performance of competed work and the ability to focus remedial efforts on those areas of less-than-acceptable performance.

When to Use It

RM can be applied at several points in the development and delivery of a project. The most benefit will be gained by applying the methodology as early in the process as possible. Planning a project with an RM focus can include establishing a defined set of requirements. Communicating the requirements with an RM focus can occur through use of a simple spreadsheet or database, depending upon the complexity of the requirement set. Verifying requirements and collecting data on the level of conformance can be performed as the work is completed and used to facilitate final acceptance and project closeout.

How to Use It

A form of RM can be used on any project or type of project delivery that has requirements that need to be fulfilled and verified. Simple scopes of work can be accommodated through simple MS Excel spreadsheets that delineate requirements and associated attributes. More complex scopes of work and delivery methods require more robust tools to manage larger volumes of requirements and collected verification evidence. The more complex projects also need more sophisticated project management tools, such as schedule and budget management tools.

When performed correctly, RM will reduce risk and cost, improve communications among all parties, improve the level of confidence in the quality of completed work, and facilitate focusing on lower performing areas of the work.

Tips

- RM is a data-driven approach in which more good data will result in a higher level of confidence. A significant effort should be directed to understanding what data are needed, collecting only the needed data, collecting the data quickly, analyzing the data for trends, and then graphically depicting the results of the analysis.
- RM and the resulting performance measurement rely on the collection of observations of conforming work as well as any observation of deficient work. Traditional verification efforts typically only report deficient observations (nonconformance reports), which does not allow for a true evaluation of performance.

Examples

TREX Project (Colorado Department of Transportation and Denver RTD)

The $1.2 billion design-build contract used an RM program to verify that the design and construction of the light rail lines and the highway reconstruction were completed in conformance with contract requirements. The database of requirements was developed from Colorado Department of Transportation and Regional Transportation District (RTD) standards and from the requirements included in the technical provisions. Agency and general engineering consultant staff were trained to highlight and extract requirements from the contract documents. These staff members then performed scheduled audits of the design packages and construction activity to capture objective evidence that the requirements were being fulfilled. Analysis of the verification data was presented in monthly reports and other special reports, as requested by management. The status of the closeout of the project was monitored through a dashboard that connected the requirement verification data with fulfillment of conditions for acceptance. The TREX Quality Oversight Audit Program was registered to ISO 9000 and won the International Road Federation Global Excellence Award in the category of Quality Management.

Intercounty Connector Project (Maryland State Highway Administration)

The $2.4 billion Intercounty Connector project was a new alignment toll highway covering over 18 miles that was completed through three mega design-build contracts that were undertaken simultaneously. The general engineering consultant team assisting the Maryland State Highway Administration in the oversight of the project used an RM program to manage the collection and analysis of the large volume of verification data that was generated by this complex and complicated project. The three separate DB contracts were generally uniformly structured with only site-specific modification to accommodate environmental and situational needs. The RM program was used to capture all requirement verification evidence, all quality-related documents generated by each of the three DB teams, and all the results of material sampling and testing. The project had a significant emphasis on environmental impact mitigation measures, and all commitments were included in the RM program and tracked through to resolution and closure. This project won a number of project management awards including the Design-Build Institute of America Project of the Year and the International Road Federation Global Excellence Award in the category of Quality Management.

Columbus Crossroads Project (Ohio Department of Transportation)

This $200 million design-build project used an independent quality firm to verify that the design and construction efforts were completed in conformance with contract requirements. The independent quality firm was a member of the proposing design-build team, but was contractually bound to report all findings equally to the Ohio Department of Transportation and the design builder. The independent quality firm used a RM program to identify the key requirements identified in the technical provisions, Ohio DOT standards and manuals, City of Columbus standards and applicable AASHTO standards. As the design and construction work was completed, the independent quality firm captured objective evidence that the applicable requirements were being fulfilled. To bring efficiency to the construction inspection effort, each of the construction-related requirements were risk profiled to ensure that the highest risk requirements were the focus of verification efforts. All data collected by the independent quality firm as well as applicable and validated data from the contractor's QC efforts were analyzed and reported monthly to both the Ohio Department of Transportation and the DB team. All field data collected by the independent quality firm were with global-positioning-system (GPS)-enabled, ruggedized electronic tablets that contained all applicable design documents and all contract requirements. Verification data were uploaded daily into the central independent quality firm database for approval and analysis. Project closeout was monitored through a dashboard that depicted the progress of fulfilling the conditions for acceptance that applied each of the elements of work.

B.7 One-On-One Procurement Meetings with a Focus on Quality

One-on-one meetings during procurement allow proposers to discuss issues with the agency and obtain clarification regarding the RFP and any Alternative Technical Concepts (ATCs) from the proposer.

Compatible QAOs

Acceptance, Oversight, Assurance

What Is It?

A one-on-one meeting is an opportunity for proposers to meet with the agency, discuss concerns, and gain clarifications relating to project details. Additionally, the proposer is able to discuss their own ATCs with the agency; however, the agency will not discuss any ATCs from other proposers. While similar meetings may be included as part of an industry review of an RFP (Tool B.2), these meetings are used expressly for communication purposes and do not provide proposers with an opportunity to modify the RFP.

Why Use It?

The agency implements this tool to provide proposers with a better understanding of the project RFP. Furthermore, it allows the agency to gain insight into the proposer's train of thought. A one-on-one meeting also provides the opportunity to discuss project complexities and establish good communication practices, which will be valuable throughout the project. Meetings such as these provide a forum for sharing ideas that may improve the quality or design of the project.

What Does It Do?

The primary function of a one-on-one meeting is to facilitate the discussion of issues and ATCs prior to the submittal of the proposals. The proposers should not view these meetings as an opportunity to gain commitments from the agency or to achieve an unfair advantage over the other proposers. Similarly, the agency should not provide any proposer with information during a one-on-one meeting that is not made available to the other proposers. One-on-one meetings are not considered during the evaluation of proposals.

When to Use It

One-on-one meetings take place after releasing the RFP and before proposers submit their proposals. The agency sets the meeting date and all participants attending, either by telephone or in person, are identified. One-on-one meetings facilitate discussions and highlight ambiguities or areas of miscommunication, making them particularly valuable on complex projects.

How to Use It

Prior to initiating one-on-one meetings, the agency must develop specific ground rules that govern what the meetings are, how the meetings will take place, and when the meetings will occur. The project agency instigates one-on-one meetings during the procurement phase, and the attendance of proposers is mandatory. Additionally, all attendees must sign an acknowledgement of the ground rules for conducting the meetings prior to the one-on-one meeting. The agency reserves the right to disclose to all proposers any issues discussed during a one-on-one meeting, unless the disclosure reveals confidential information related to the proposer's ATCs or business strategy.

Examples

T.H. 61 Hastings Bridge Project (MnDOT)

The Minnesota Department of Transportation (MnDOT) conducted one-on-one meetings for the Hastings Bridge Project. The meetings with proposers for this CMGC project were used to discuss ATCs. The proposers were able to incorporate one or more accepted ATCs into their proposal once the agency accepted it at the meeting. The pre-approved ATCs were known as pre-approved elements (PAEs). MnDOT was careful to not coach the proposers through the PAE process, but rather provided evaluations of each ATC. MnDOT also ensured that the individuals evaluating the PAEs were not the same people evaluating received proposals.

I-15 Widening and Beck Street Bridge Project (UDOT)

UDOT held one-on-one meetings with proposers for the I-15 widening project from 500 North to I-215 in Utah. The meetings conducted during the procurement phase were a valuable form of communication as the project had a very tight budget. These meetings along with discussions between UDOT and the design builder during the preconstruction phase enabled the project team to review ways to reduce the project cost. Additionally, the meetings provided an opportunity for the project team to discuss a particularly complex bridge involved in the project that required individual attention.

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B.8 Contractor Involvement in Establishing and Streamlining Quality Control Standards

Transportation agencies develop extensive manuals and standard specifications detailing QC and acceptance processes on their projects in order to ensure that project quality standards are met. However, because construction projects are each unique, some standard requirements may not apply or may not be well suited for a particular project. Allowing for changes to quality standards may result in more efficient quality management programs, which still meet project goals and requirements.

Compatible QAOs

Deterministic, Assurance, Variable, Oversight, Acceptance

What Is It?

This tool recognizes the unique nature of every construction project and the value that contractors can add to quality management processes by streamlining sampling frequencies and requirements where appropriate.

Why Use It?

The purpose of this tool is to streamline quality control aspects of projects where appropriate without sacrificing overall quality and still meeting the goals of the project. This should result in a more efficient and less costly quality management program.

What Does It Do?

The use of this tool essentially opens up the state transportation agency to considering alterations to its traditional specifications and testing requirements. While the agency typically applies these standards to every project, adopting the approach of this tool would mean an agency is willing to consider adjusting some project-specific quality specifications when opportunities arise and the contractor presents clear reasons to do so.

When to Use It

Contractor-proposed, alternate quality standards/specifications can be used on projects with prescriptive, not performance-based, quality specifications and are particularly useful in dealing with innovative or uncommon situations. The flexibility afforded by this tool is useful in instances where materials are used in a non-traditional manner.

How to Use It

This tool can be used formally or informally. Used formally, this tool would involve the addition of contract language allowing for the use of contractor-proposed alternatives to quality specifications, only if sufficient justification is provided and documented. In order to use this tool informally, the agency and the contractor must establish a close working relationship in which both parties operate in good faith and recognize that the decision to approve or deny a project-specific specification ultimately resides with the agency.

Tips

Agencies can experiment with the use of this tool informally first by asking contractors to point out areas of perceived inefficiency or "overkill" in the quality management programs on the projects they are constructing to see if valuable feedback is available and contractors are interested in suggesting alternatives.

Example—Willamette River Bridge Project (ODOT)

ODOT successfully used this tool on their Willamette River Bridge Project, where I-5 crosses the Willamette River. On that project, the close relationship between the CMGC and ODOT resulted in several CMGC proposed alternatives to ODOT's standard quality specifications.

In one case, hot-mixed asphaltic cement (HMAC) was to be used to pave the trails in the parks surrounding the project in order to meet the needs of the local park agencies. The typical ODOT HMAC specification required development and submittal of project-specific mix designs and optimum rolling procedures designed to provide the highest quality results on major paving jobs. In this case, those specifications would have added costs for very little return, as the demand on bike path pavement is so much less than the demand on Interstate highway pavement, which the specifications were written for. The costs of the submittals and testing, when applied to the very small quantities needed for the bike paths, resulted in extremely high prices for the pavement. After the CMGC made their case for the alteration, ODOT was able to write a "minor hot mix asphalt" specification that was more in line with what the local park agencies used on their bike path projects, meeting the needs of the project and its stakeholders at a reduced cost.

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B.9 Alternative Technical Concepts

The ATC process involves reviewing ATCs prior to the submittal of proposals in order to ensure that they do not conflict with the project design and construction requirements. Allowing proposers to submit ATCs for review encourages innovation and creativity, avoids potential delays associated with design, and achieves the best-value solution for the public.

Compatible QAOs

Assurance, Variable, Oversight, Acceptance

What Is It?

An ATC is an alternative concept developed by a proposer, which is better than or equal to the basic configuration in quality or effect, as judged by the agency. The ATC process enables proposers to present innovative alternatives for the design and construction of a project. The agency then reviews the ATCs before proposers submit proposals. The agency reviewing the ATCs provides an indication of whether the ATC is acceptable or not. If the agency considered an ATC acceptable, the proposer who presented the ATC is able to include it in their proposal.

Why Use It?

This tool enables the agency to obtain a preview of proposals prior to formal submission, while still ensuring that the proposers maintain their advantages through confidentiality. Similarly, the proposers are able to gain insight into the agency's needs and expectations. The ATC process is beneficial because it allows the design and construction quality criteria to be clarified and renegotiated, if necessary, potentially enhancing the quality of the final project. Finally, ATCs allow the agency to obtain the best value for the public (FDOT 2011).

What Does It Do?

The ATC process provides the opportunity for proposers to submit innovative and creative ideas as alternatives to the basic configuration for a project. The agency is able to consider these ATCs as part of the selection decision. ATCs are beneficial because they avoid potential design-related delays and conflicts while providing a best-value solution for the project.

When to Use It

The agency should implement the ATC process prior to the submittal of proposals. It is particularly useful on projects where the agency desires innovation in the design or where there are high risks involved.

How to Use it

The RFP should describe the ATC process and inform proposers of the one-on-one meetings required to review ATCs prior to submitting their proposal. The agency then does not allow changes to the contract requirements in a proposal, except through an ATC. Once an ATC has been submitted, the agency reviews it. The agency typically only approves an ATC if the concept has been used elsewhere under comparable circumstances. The agency must be careful not to coach the proposer through the review and may respond with one of the following statements (responses used by MnDOT):

- The ATC is acceptable for inclusion in the Proposal.
- The ATC is not acceptable for inclusion in the Proposal.
- The ATC is not acceptable in its present form, but may be acceptable upon the satisfaction, in the Agency's sole discretion, of certain identified conditions which must be met or clarifications or modifications that must be made.
- 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.

After evaluation, proposers are able to include all of their approved ATCs in their proposal. At no point prior to the proposal is it acceptable for the agency to share details of one team's ATCs with any other proposing team. Additionally, some agencies choose to ensure that the personnel evaluating ATCs are not the same as those evaluating the proposals.

Example—T.H. 61 Hastings Bridge Project (MnDOT)

MnDOT implemented an ATC process, known as a PAE process, on the Hastings Bridge Project. Geotechnical issues were a major quality challenge for this project; therefore, MnDOT desired innovation for the foundation of the north approach. The PAE process was successful in providing MnDOT with a design solution for the north approach, which involved column-supported fill. This innovative concept, presented as an ATC, saved the project $100 million.

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B.10 External Contractor Panel Input

Constructability is an important feature of quality plans. However, constructability can be easily forgotten by designers working with pen and paper rather than physical materials with real dimensions. Designs for which the construction process has not been adequately considered may prove infeasible to build and/or difficult to bid responsibly. Constructability is a facet of design that must be considered in a clear, rational manner, preferably utilizing the construction knowledge of experienced professionals. When project factors preclude involving the construction contractor during the design phase, the advice and input from practicing constructors can still be utilized in the form of an external contractor panel review.

Compatible QAOs

Deterministic, Assurance, Variable

What Is It?

An external contractor review of designs can be an important tool used by agencies to not only reduce design errors, but also improve the overall quality of the plans produced for their projects. While many agencies utilize internal design reviews to consider constructability issues, input from practicing construction professionals, with current knowledge of available means, methods, and necessary equipment, is often more valuable.

Why Use It?

External contractor reviews of project designs can be used for several reasons. First, a general constructability review can determine whether a project is buildable as designed or whether the design provides sufficient information to accurately estimate the cost of building the project as designed. Secondly, external contractor reviews can address specific feasibility questions from designers regarding one or more design alternatives. In this case, external reviews are conducted to explore the impact of a particular design decision. Regardless of the reason, reviews should lead to higher quality plans that require fewer adjustments later on and lead to fewer construction errors.

What Does It Do?

This tool provides project designers—whether in house or consultants—with the chance to directly address experienced construction professionals unrelated to the project and prospective bidders with their concerns and questions. Even if the design team has already conducted an internal constructability review, the tool opens the designs up for additional improvements. The additional review may cover the same topics addressed by the internal review, or the external reviewers may find entirely new opportunities to improve constructability.

When to Use It

While every project might benefit from the input of construction professionals, the added time and effort required to conduct an external design review, though minimal, means that external design reviews should be used on projects with characteristics outside of the norm: exceptional space or schedule constraints, projects with multiple alternatives under consideration, particularly technical projects, and so forth.

Although external reviews take place prior to advertising a project for bids, project teams have a wide time frame in which to conduct such reviews. When these reviews are conducted during the design phase, they will affect the value and the information gained in the review. Seeking the advice of an external contractor panel early in design can allow for a better alternatives analysis and decision process as well potentially preventing designs from heading toward expensive or difficult-to-construct options. Reviews conducted after substantial designs have been generated can better identify specific issues that can be resolved before construction begins.

The use of an external contractor panel to review designs is not compatible with CMGC, DB, or PPP delivery methods as each of these methods already includes a contractor during the design process.

How to Use It

STAs have experimented with various methods for implementing external contractor reviews of a design while maintaining a fair and competitive bidding process. Two of the primary processes involve using a panel, either one that is assembled for a specific project or a standing panel.

For a project-specific panel, panel participants can be selected in various ways, through publicly posting invitations for comment and review during an open meeting, identifying contractors interested in participating through local Association of General Contractors (AGC) chapters, soliciting the input of contractors outside of the local region not likely to bid on the project, using local contractors with intimate knowledge of the region, requiring a minimum of two contractors to participate on each review, and not informing contractors of which ideas were selected for incorporation into the design (Dunston, Gambatese, and McManus 2005). These methods can be used for project-specific panels where contractors are given time to review the current designs and either allowed free rein to comment or directed through a series of questions and concerns generated by the designer.

Alternatively, a standing panel can be used that meets at regular intervals and has rotating seats of agency staff and regional contractors. This method, employed by WSDOT, is used to eliminate claims of impropriety and relies on open meetings where designers from several projects can come with their questions or concerns for review. Contractors who sit on the panel are still allowed to bid on projects they have considered and meeting minutes are publicly posted for anyone to review.

While the project-specific and standing-panel methods are organized differently, both can be used to improve the buildability and bid-ability of quality designs.

Tips

- The use of construction contractors interested in bidding on a project can sometimes generate the most specific, useful recommendations, but requires the greatest diligence to ensure a fair bidding process. In contrast, a standing panel or the use of contractors not likely to bid on a project may be best at reducing claims of a non-competitive or unfair bidding process, but may produce less specific information.

- An effective implementation of external contractor reviews requires the buy-in not only of the agency, but of the professionals who will participate as well. Getting local chapters of the AGC, the American Council of Engineering Companies (ACEC), or their local equivalent on board with the process may help ensure participation and reduce the potential for complaints.
- Consult the contracting, design, and legal communities when setting up a new process that may be perceived as having an impact on the bidding process.

Example—George Sellar Bridge Project (WSDOT)

The addition of another eastbound lane to the George Sellar Bridge in Wenatchee, Washington, involved complex traffic control operations to keep the bridge open during construction. Project managers took their questions to a joint AGC/WSDOT panel for assistance in drafting a traffic control plan that could adequately maintain a daily traffic load of 60,000 vehicles. In addition, designers asked the panel to suggest a preferred alternative for the various portal modifications under consideration. As a result, the panel made specific recommendations regarding the use of a quick-change movable ("zipper") traffic barrier to rapidly change lane configurations in between daytime and nighttime construction shifts and recommended one of several portal modification alternatives based on a number of project factors.

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B.11 Independent Party Design Review

Typically, the STA performs verification reviews during the development of a project design. This is done to ensure that the proper quality is being provided to the agency. In some instances, the agency is not equipped to perform reviews or is not able to provide an objective review. Therefore, the agency can use an independent party to review the design.

Compatible QAOs

Deterministic, Assurance, Variable, Oversight

What Is It?

Independent party review is a process where the agency hires a third-party firm to provide quality inspections and verification reviews during design. The independent review team involves a qualified consultant that can provide objective design reviews that are not biased by the contractual relationship that exists between the designer and the agency. Independent party review provides another avenue for agencies to use for reviewing the design.

Why Use It?

There are instances where an agency may not have the necessary resources or expertise to provide complete and thorough design reviews when the agency does not perform the design in house. In these cases, it would be beneficial to the agency to hire a third-party, independent review consultant to perform design reviews in place of the agency. This would place design review responsibilities on the hired independent party, while the agency retains control of how the reviews occur.

What Does It Do?

This tool helps to reduce the resources and time needed by an agency for a project. Since the independent party performs the design reviews, the agency can reduce the staff requirements and can eliminate the time needed for each review. Also, an independent review consultant may possess additional expertise that can take the design reviews to an advanced level. Having a more qualified team perform reviews of complex and specialty projects can reduce the technical requirements risk for the agency.

When to Use It

Third-party independent reviews are used successfully on specialty projects or in instances where the agency lacks the necessary resources and time to meet specific design milestones. Independent reviews are very useful for situations where the agency lacks the expertise needed to perform an accurate review (Capers et al. 2011).

How to Use It

The agency needs to decide before design begins whether design reviews can be accomplished internally. This decision should be based on determining whether fair reviews are possible and whether agency resources are available. If it is decided that the agency cannot provide an objective review of the design or that the needed resources will not be available, then a third party can be hired to conduct reviews.

The third-party independent review team conducts the reviews based on the process and requirements developed by the agency. This includes reviewing the design for all required quality aspects developed by the agency prior to starting design. In addition, the independent review team will provide reviews at all specified intervals agreed to by the agency and the design team. Essentially, the third-party review team provides reviews based on the direction issued by the agency.

Tips

This is an advantageous tool in instances where the agency cannot perform fair reviews. The independent third-party reviewer will help to decrease the biases and in turn help the design team reach the goals required by the agency.

Example—Willamette River Bridge Project (ODOT)

ODOT used a unique structure for design reviews on the Willamette River Bridge Project. For one, this project included a third-party joint venture hired by ODOT. This entity, called the Oregon Bridge Delivery Partners (OBDP), helps ODOT manage its multi-billion dollar bridge infrastructure program, which includes the Willamette River Bridge. One of the responsibilities of the OBDP was to provide quality control reviews during design and construction. During construction, ODOT and OBDP worked together to perform construction inspections and testing. However, during design, OBDP functioned independently from ODOT so that they could provide an objective review of the design. Note also that the CMGC delivery method was used for this project. This meant that the contractor was involved in the design process.

Based on the setup of the project, the design review process included several reviews: internal design team reviews, agency reviews, contractor reviews, and OBDP reviews. This setup was burdensome due to the numerous reviews, but it was very beneficial in producing complete and high-quality design. In order to have a meaningful impact on the design, the contractor conducted constructability reviews on a regular basis. In addition, the design team regularly performed technical requirement reviews. Also, ODOT wanted to have a direct role in reviewing technical aspects of design due to the complexity and high profile of the project. Finally, OBDP was responsible for providing input and commentary on design at key milestones. OBDP then issued the final design disposition for each key design milestone, acknowledging that all comments were accurately responded to, but ODOT was ultimately in charge of accepting the design deliverables.

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B.12 Over-the-Shoulder Agency Review

During the design phase of a project, reviews take place to verify quality and adherence to the agency's design criteria. When utilizing alternative project delivery methods, specifically DB, more quality aspects become the responsibility of the contracting firm. If the agency decides to assign design and construction QC and acceptance responsibilities to the design builder, the agency will still need to perform quality oversight. One tool for the agency to use in performing quality oversight is the over-the-shoulder agency review.

Compatible QAOs

Variable, Oversight, Acceptance

What Is It?

The over-the-shoulder agency review, also called an oversight review, is a process of informal design review that the STA performs during the design of a project, without stopping the design process to prepare a formal submittal (Gransberg, Datin, and Molenaar 2008). These types of design review mainly assess whether the contractor is properly meeting the design requirements and design criteria of the contract. In addition, these reviews can also address whether the design quality management plan activities are occurring in accordance with the agency-approved, contractor-developed, quality management plan as well as overall project quality requirements (Gransberg, Datin, and Molenaar 2008).

Why Use It?

When the agency decides to assign quality responsibilities to the contractor, the agency still performs the QA role. To properly perform QA, the agency needs tools or procedures that assist with QA. In terms of design QA, the agency can use over-the-shoulder reviews, which ensure that the design is progressing according to the contract requirements without the need to prepare a specific design submittal package and provide agency input to the design where it will be both desired and helpful (Gransberg, Datin, and Molenaar 2008). Once the contractor requests an over-the-shoulder review, the contractor continues forward with design, which helps to keep design on schedule. Additional monitoring and reviews during design can help to increase the contractor's adherence to required criteria, increase the quality of the design, and, in turn, increase the quality of the constructed project.

What Does It Do?

Over-the-shoulder design reviews allow the design team an opportunity to walk the agency reviewers through all the design assumptions made, constraints realized, and solutions developed prior to formal design submittals. If used properly, over-the-shoulder reviews can be effective at saving time, eliminating later frustration, and providing an open forum where meaningful exchanges of ideas and options can occur. This helps to improve quality since issues that affect design criteria and project quality can be reviewed and addressed before the construction phase. Over-the-shoulder design assists the agency with overall QA activities.

When to Use It

This tool is most effective when it is used to check specific design criteria. Certain projects may have strict or difficult performance and design criteria. To make sure that the contractor is adhering properly to these criteria, the contractor requests an over-the-shoulder review by the agency. This allows the contractor to present a specific portion of the design in an informal review that verifies certain aspects of the design and is not a complete design document review or formal design submittal.

How to Use It

The agency must decide early in the planning phase whether informal monitoring should take place during design. If over-the-shoulder reviews will be used, the agency includes a statement in the RFP issued to bidders indicating the ability to request informal, over-the-shoulder reviews. Then, during design, the agency will perform reviews of the ongoing design as well as monitor and audit the design quality management plan when requested by the contractor. Additionally, the agency must determine how many reviews the contractor is allowed and what amount of agency time and resources should be allocated to this task.

Finally, the contract must also contain information on the over-the-shoulder review process. This informs the contracting firm of how the over-the-shoulder review process will work. This information should address when the reviews will take place and what the steps are in requesting and performing an over-the-shoulder review. In most cases, over-the-shoulder design reviews should only take place on design aspects that are on the critical path (Gransberg, Datin, and Molenaar 2008).

Tips

- An over-the-shoulder review is a helpful tool when the agency is confident that it can internally review design on an ongoing or informal basis.
- The purposed of this tool is mostly to address adherence and inclusion of criteria in the design. The tool is not for constructability review, as that should take place between the design entity and construction entity of the DB firm.

Examples

T.H. 61 Hastings Bridge Project (MnDOT)

MnDOT implemented over-the-shoulder agency reviews for design of the T.H. 61 Hastings Bridge Project. This DB project, utilizing the Oversight QAO, had significant performance criteria that needed to be met to address the unstable soils that are present at the site of the bridge. For example, the north approach of the bridge had a performance criterion stating that no more than 2 inches of settlement within 3 months of the embankment construction was allowed. This criterion was included in the project because the previous bridge had to be raised by jacking on several occasions during its lifespan due to differential settlement, and MnDOT wanted to avoid this problem with the new bridge.

Because of the complexity of the design and the high-level performance criteria of this project, MnDOT completed design reviews (in addition to the internal DB firm reviews) using the over-the-shoulder review process to verify that the correct design was being furnished based on the strict performance criteria.

I-15 Widening, Beck Street Bridge Project (UDOT)

UDOT utilized over-the-shoulder agency reviews during the development of the design for the I-15 Widening and Beck Street Bridge Project. This was a DB project where UDOT could participate in design reviews and was allowed to comment as requested or as it deemed necessary. The reviews took place with the contractor's design quality manager (DQM), the design staff, and the agency.

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B.13 In-Progress Design Workshops

In-progress design workshops are meetings of the designer, the contractor, and the agency that take place throughout the design process to discuss and verify design progress. This tool encourages communication among the project parties and mitigates future misunderstandings or conflicts while enhancing design quality through knowledge sharing.

Compatible QAOs

Variable, Oversight

What Is It?

Throughout the design phase, the state transportation agency or the contractor is able to request a meeting with the designer in order to discuss the progress of the design. These in-progress design workshops are intended to assist the designer and/or the contractor in resolving design issues and questions.

Why Use It?

In-progress design workshops ensure that the project team has a consistent understanding of the project assumptions and expectations. This tool allows issues to be resolved early in the project, before they carry through the project process. Furthermore, the workshops provide an opportunity to enhance the quality of the project and enable the agency to review design information.

What Does It Do?

In-progress design workshops provide a forum for the relevant project parties to review and discuss design details. This tool establishes communication between project parties at a time when decisions have a large impact on the quality of a project. All parties involved in the project are able to align their understandings of the project and assign future corrective actions if needed.

When to Use It

This tool is implemented at any stage during the design phase of a project. It is best suited to projects delivered using alternative project delivery methods in which the designer and the contractor are contractually obligated to coordinate with one another.

How to Use It

The agency or the contractor requests an in-progress design workshop at least 5 days prior to the workshop date. This enables the contractor and/or the designer to submit drawings or other documents for review during the workshop. The agency may choose to limit the number of in-progress design workshops held per week due to resource restraints. The agency should keep a written record of following details:

- A list of the workshop participants.
- A description of the items covered.
- Identification of discrepancies and comments.
- A report on past and planned corrective actions.
- Identification of follow-up action items.

Example—T.H. 61 Hastings Bridge Project (MnDOT)

MnDOT used in-progress design workshops on the Hastings Bridge Project. The DB project involved replacing the existing two-lane bridge over the Mississippi River with a new four-lane bridge. Contractor-driven, in-progress design workshops were held throughout the design process to address specific issues, such as the pier design and the arch design. These workshops were vital in keeping the design on schedule.

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B.14 Discipline Task Force

As the name suggests, a discipline task force is a group of individuals focused on one specific discipline. Discipline task forces are formed to ensure coordination across project disciplines.

Compatible QAOs

Deterministic, Assurance, Variable, Oversight, Acceptance

What Is It?

Each discipline task force focuses on a specific discipline of work and includes designers, key construction personnel, and the agency's experts. Task forces meet weekly to discuss the discipline and to plan phased action items as necessary. The meeting minutes from each task force meeting are recorded. Individuals should be involved in more than one discipline task force in order to ensure consistent cross-discipline coordination.

Why Use It?

The primary purpose of discipline task forces is to provide consistency and improve coordination across all project disciplines. Additionally, regular meetings on specific topics aid in management and communication among all parties, as well as enhancement of project quality.

What Does It Do?

This tool ensures that attention is given to every aspect of the project. Furthermore, implementing discipline-specific meetings ensures that any necessary action is taken in a timely manner.

When to Use It

Discipline task forces could apply to projects of any delivery method. It is feasible for discipline task forces to hold meetings during any phase of a project. Additionally, there is potential for new task forces to form throughout the project as the need arises.

How to Use It

A discipline task force requires creating a team of appropriate individuals representing each necessary party on a project, who can meet regularly to discuss their discipline and responsibilities in relation to the project. These individuals need to have the knowledge and authority to be able to address issues relating to the discipline. Similarly, they need to be able to coordinate with other discipline task forces to provide consistency across project disciplines.

Example—T.H. 61 Hastings Bridge Project (MnDOT)

Discipline task forces were utilized for the Hastings Bridge Project owned by MnDOT. The core disciplines involved in the bridge replacement project were roadway, drainage, structures, traffic, and utilities. Other disciplines included Intelligent Transportation Systems, geotechnical design, and quality.

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B.15 Formal Partnering with Regulatory Agencies

Permit requirements from regulatory agencies can be difficult and time consuming to obtain. Part of the reason for this is that there is often insufficient communication between project parties who are applying for permits and the permit-granting agency. By forging a more open relationship between project parties and regulatory agencies, the permitting process can be streamlined. The spirit of cooperation and collaboration will help the team to more effectively interpret the permitting requirements, as opposed to potentially disagreeing about the interpretation of requirements.

Compatible QAOs

Deterministic, Assurance, Variable, Oversight, Acceptance

What Is It?

Partnering with regulatory agencies involves having open and honest communication among regulators, the STA, and the party applying for a permit (e.g., contractor, design builder, or concessionaire). The purpose of the communication is to explain the ramifications of alternatives to meet permit requirements in real time, rather than a back-and-forth exchange of permit applications, review, and denials.

Why Use It?

The purpose of partnering with regulatory agencies is twofold. First, it helps regulators understand what effects their proposed changes to contractor work plans will actually have. This is crucial, as contractors sometimes have a better understanding of the ramifications of various construction options than the regulators reviewing the plans. This exchange of information is crucial to helping regulators understand that while there may not be a perfect solution, the proposed solution is optimal and fulfills not just the letter, but also the spirit of the applicable regulations. Second, by encouraging a dialogue between regulators and contractors, streamlining the permitting process itself can save valuable time in the project schedule.

What Does It Do?

Partnering and the associated dialogue establish a working relationship between contractors (who develop construction means and methods) and regulators (who evaluate construction means and methods for permit compliance). By opening the process up to explanation and allowing contractors to address the concerns and alternatives of regulators, the back-and-forth submission of permit proposals and permit denials can be avoided. By removing this tedious step from the process, permits can be obtained faster and regulators can be assured that the best measures possible are being taken to satisfy their regulations.

When to Use It

Encouraging dialogue between contractors and regulators should be done with care and is not warranted for every project. However, on projects involving contractors with a demonstrated commitment to fulfilling their obligations and providing high-quality solutions rather than the lowest-cost ones, partnering between the two parties can be very successful at streamlining the process and satisfying regulators' concerns.

This technique is well suited to project delivery methods in which the contractor has intimate knowledge of the design—such as in CMGC, DB, and PPP—and is a part of the project team during the permitting process.

How to Use It

State highway agencies can initiate the use of this tool by first evaluating the contractor and the contractor's willingness to work directly with regulators to develop the optimal, although not necessarily the lowest-cost, permitting solution. Having established that the project builder is willing to put in the extra effort necessary to establish a positive dialogue with regulatory agencies, agency personnel can schedule and host meetings of all three parties in which regulators can discuss their concerns with contractor plans and contractors can explain or modify their proposed work plans.

Tips

- While this technique can be used for DBB projects, permits are often secured prior to the selection of a contractor on DBB projects. As a result, the use of this tool on such projects may not be possible as construction means and methods will not have been developed prior to the permitting process.
- The use of this tool requires the buy-in of both contractors and regulators, which may not always be possible. Explaining that the goal of the process is to develop optimal solutions and to streamline the process may help.

Example—Willamette River Bridge Project (ODOT)

ODOT and its CMGC used this technique with great success on the Willamette River Bridge Project in Eugene, Oregon. The CMGC was part of the early phases of design and was actively involved in applying for project permits. The CMGC had an extensive history of in-water work and fine-tuned the design of their work platform to minimize its impact on the river and the environment despite the increased cost of doing so. As a result, the CMGC—with ODOT at its side—was able to walk environmental regulators through the design, explain why it was an optimal solution and why the options proposed by the regulators would trade reductions in certain impacts for increases in others, and alleviate any concerns the regulators had. The result was a significant reduction in the permitting process and an excellent working relationship among ODOT, the CMGC, and the various environmental regulatory agencies on the project.

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B.16 Formal Team-Partnering/Goal-Setting Process

Highway projects include precise objectives and goals that are developed by the agency during the planning and development of a project. These goals are then presented to contractors in the form of criteria, specifications, and designs in the invitation for bid (IFB) or RFP. In some instances, there is a discrepancy between the agency's and the selected contractor's understandings of and expectations for these goals. This can have a significant impact on project quality. To establish a common understanding of project goals and to ensure that the contractor understands what the agency wants, team-partnering and goal-setting sessions can be used.

Compatible QAOs

Deterministic, Assurance, Variable, Oversight, Acceptance

What Is It?

A team-partnering/goal-setting process is a tool where the participation of a selected contractor (and/or subcontractor) is requested in partnering and goal-setting sessions. This is done to establish a positive working relationship between the agency and the contractor, to review the agency's goals and objectives, and to ensure that the contractor understands the goals set by the agency. These sessions allow the contractor to provide recommendations to the agency.

Why Use It?

This is an important tool for the agency to use in establishing a working and trusting relationship as well as in creating a shared understanding of the goals and objectives set for a particular project. This is essential as more quality responsibilities shift from the agency to the contractor because more trust between the parties is necessary to help ensure the success of the project. The partnering and goal-setting sessions can clarify any disconnects or discrepancies in the parties' understandings of what is to be achieved on the project. Also, the contractor can make suggestions to the agency on how to achieve quality goals effectively throughout the project.

What Does It Do?

Team-partnering and goal-setting sessions help to create an effective relationship between the agency and the contractor that is critical as responsibility for quality shifts away from the agency. Team partnering and goal setting establish a common understanding of project goals between the agency and the contractor, assist with ensuring that the agency and contractor are in alignment with their expectations, and help to avoid disagreements or misunderstandings later on in the project.

When to Use It

This tool is very useful in instances where the agency transfers quality responsibilities to the contractor. When the agency transfers quality responsibilities such as quality control and quality acceptance to the contractor, a higher level of trust needs to exist between the agency and the contractor. To create this superior level of trust, team-partnering exercises are very beneficial and establish a better foundation for the working relationship than ad hoc or informal processes might.

The team-partnering and goal-setting process should be developed by the agency prior to selecting a contractor. Then, once the contractor is selected, the agency and contractor need to establish team-partnering and goal-setting procedures before any construction begins. This is helpful for avoiding any issues that could arise during construction that were not addressed prior to breaking ground.

How to Use It

This tool is used most effectively when the agency develops the partnering and goal-setting process before the contractor is selected because then the agency may require partnering and goal setting as part of the RFP or contract. The selected contractor must then fully participate in the team-partnering program the agency establishes and must attend goal-setting sessions to discuss and develop a mutual understanding of the project goals. The goal-setting sessions should also be used as an open forum in which the contractor can make suggestions about how the goals will be achieved.

Tips

Partnering and goal setting can be essential tools for other factors beyond quality. They open up communication between parties and build a relationship that helps prevent conflict and mistrust later on in the project.

Examples

I-595 Express Corridor Project (FDOT)

FDOT implemented team-partnering exercises for the I-595 express corridor improvements project, a PPP project. Partnering was an essential part of that project in light of the new delivery method being used and the tight schedule that was established for the project. At the highest level, partnering exercises took place between FDOT and the concessionaire to establish a mutual understanding of goals, an understanding of each party's role, and the expectations of the project.

Other partnering exercises included sessions between the CEI and the OCEI. This was done to gain a better understanding of how these two individuals responsible for ensuring the quality of the project would work together throughout the duration of the project.

Finally, partnering exercises were required between the design builder entity of the concessionaire firm and each of its subcontractors. This was done to make sure that all parties had a mutual understanding of the goals and expectations regarding quality, schedule, and budget. These partnering exercises also helped to establish a working relationship between the design builder (who was new to working in south Florida and did not know the local subcontractors) and the subcontractors in the south Florida area.

Mountain View Corridor Project (UDOT)

UDOT utilized team-partnering and goal-setting sessions on the Mountain View Corridor Project. That project used a CMGC delivery method and included construction of a new highway, transit-way, and trail system in western Salt Lake and northwestern Utah counties. Due to the complexity, size, and varying scope of the project, UDOT initiated partnering and goal-setting sessions.

First, UDOT included in the RFP a requirement that all parties involved in the performance of the project—including UDOT, the selected architectural and engineer designers, the contractors, and all the subcontractors—meet on a regular basis. These meetings were used to establish and maintain open lines of communication thereby ensuring a relationship of trust and to develop effective team partnering among other administrative discussions.

Secondly, the selected contractor was required to participate in an initial goal-setting meeting with UDOT. This was used to review UDOT's goals, to ensure that the contractor understood these goals, and to provide the contractor with an opportunity to suggest how to accomplish each of the goals.

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B.17 Co-Location of Quality Management Personnel

Co-location involves all quality management personnel being located in the same place for the duration of the project. It allows for efficient collaboration and improved communication among these members of the project team.

Compatible QAOs

Deterministic, Assurance, Variable, Oversight, Acceptance

What Is It?

Co-location of the quality management personnel, as the name suggests, requires locating all quality management personnel at the same facility throughout the life of a project. This tool brings project resources together at one location, creating the opportunity for increased communication, improved project quality, greater efficiency, and enhanced project understanding.

Why Use It?

This tool is beneficial to the process of developing and implementing quality management plans. Work is completed more efficiently and with fewer communication-related delays. Additionally, co-location is important for understanding agency concerns and for receiving agency reviews in a timely manner.

When to Use It

Co-location is a useful tool for any project that requires collaboration between project team members. In particular, co-location is beneficial to complex projects that may require a great deal of regular communication in order to ensure that the project team has an understanding of the project. Obviously, co-location can occur for the whole duration of the project.

How to Use It

Co-location involves some or all of the project team, including quality management personnel, working in the same building. This requirement would be specified by the agency in the RFP.

Example—SH 130 Turnpike Project (TxDOT)

TxDOT used co-location for the SH 130 Turnpike Project due to the magnitude of the 49-mile tollway project. This co-location enabled an environment that enhanced the effectiveness and intensity of communication required for the large project (Migliaccio, Gibson, and O'Connor 2009). Additionally, "the quality assurance personnel were able to sort out any issues in reasonable time by visiting other project personnel, who are located in the same building." (Migliaccio, Gibson, and O'Connor 2009).

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B.18 No Low-Bid Requirement for Subcontractors

In order to use alternative project delivery methods like DB or CMGC, many STAs must file for an exemption from laws that require construction projects to be procured using a competitive low-bid process. When these exemptions are granted, clauses are sometimes added to the contracts requiring the design builder or CMGC to procure subcontractors on a low-bid basis. However, the inclusion of such clauses removes an important quality management tool from the contractor.

Compatible QAOs

Deterministic, Assurance, Variable, Oversight, Acceptance

What Is It?

This tool involves the inclusion or exclusion of certain clauses from a construction contract. One use of this tool would be to omit any clauses dictating the manner in which a contractor must procure subcontractors. On the other hand, using this tool would mean the inclusion of a clause specifically allowing contractors to award their subcontracts based on factors other than price.

Why Use It?

The use of this tool allows construction contractors to procure subcontractors with quality in mind. On projects that are broken up into phases or bid packages, allowing contractors to use the same subcontractors on multiple phases of a project (without running an additional bid competition) reduces learning curves and allows contractors to benefit from a more knowledgeable subcontractor.

What Does It Do?

Removing subcontractor procurement clauses from the contract allows contractors to retain subcontractors for the duration of projects that are broken up into separate work packages that might normally be bid out separately. As a result, the construction team is able to take advantage of lessons learned throughout the project rather than introducing multiple subcontractors with separate learning curves for each package. In addition, the contractor—often chosen on the basis of prior qualifications and/or quality management plans—is free to use subcontractors it has worked with in the past that understand and respect the contractor's quality management process.

When to Use It

This tool is especially useful on projects where there is a recurring need to perform similar types of complex or technical construction several times during construction. An example would be a large bridge project in which two or more complex spans must be produced in several phases. While each phase might typically require a separate subcontractor procurement process, this tool would remove the need for such repeat procurements.

How to Use It

To use this tool, a project team must decide before the procurement process has started not to require contractors or DB teams to obtain their subcontractors on a low-bid, competitive basis. The approval to include or remove clauses from the construction contract allowing this practice may require approval from legal authorities to ensure that it does not violate state or federal statutes.

Tips

It should be noted that the use of this tool does not remove the contractor's obligation to meet disadvantaged business enterprise percentage goals, but rather the tool allows the contractor to maintain a greater level of continuity in project team members, which can lead to an improvement in quality.

Example—Willamette River Bridge Project (ODOT)

The removal of competitive pricing requirements was particularly successful on ODOT's Willamette River Bridge Project, which consists of two similar, but not identical, long-span arch bridges. The CMGC on the project reported that being able to use the same subcontractors from the first bridge on the second bridge, rather than having to select a new low-bid subcontractor, allowed the project team to utilize lessons learned in the complex rebar installation process with great success.

As an example of a contract clause allowing subcontractor selection on the basis of factors other than the lowest bid, see the following from ODOT:

> STATE OF OREGON CMGC CONTRACT 9.1.1(c)—The CMGC may select Subcontractors to perform Construction Phase Services utilizing either a competitive bidding process or through negotiation, at CMGC's discretion.

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B.19 Use of Dual CEI/OCEI Roles

During construction, testing and inspections take place to measure and monitor the quality of work. This is done in a variety of ways, and one such method is the use of CEIs. A CEI is a hired independent engineering consultant used to inspect, test, and verify the quality of a project. When implementing this particular tool, there are two CEIs; one is hired by the constructing firm and one by the agency.

Compatible QAOs

Acceptance

What Is It?

A CEI is an entity that performs verification inspecting and testing. With the use of a CEI and an OCEI, there are two entities in charge of managing and accepting quality. The CEI is the entity hired by the contractor to handle day-to-day quality management (quality control) responsibilities. The agency-hired CEI (the OCEI) conducts audits with statistical sampling verification testing on the overall work performed by the contractor (quality acceptance).

Why Use It?

The use of both a CEI and an OCEI provides a check and balance of quality control and acceptance from the contractor side and the agency side of a contract. Use of both a CEI and OCEI prevents a contractor from producing low-quality work since a separate entity hired by the agency also manages quality. In addition, the CEI and OCEI essentially handle all of the quality management for the project, allowing the agency to focus resources on other important areas of the project.

What Does It Do?

The dual CEI/OCEI process helps to keep quality in check. The CEI performs the common construction quality control activities while the OCEI provides construction quality acceptance. The OCEI offers the agency a way to check a contractor's adherence to the quality provisions of the contract. With the two quality consultants on a project, both the contractor and the agency monitor quality so that quality does not suffer if there is a lack of quality incentives on a project.

When to Use It

Certain projects have attributes that make them candidates for the use of a CEI and OCEI. When a project lacks specific contract incentives or financial goals (such as cost plus contracts), the contractor may not emphasize quality as strongly as the agency would like. In this situation, the use of a CEI and OCEI requires the contractor to utilize a CEI, an independently hired consultant, who then must communicate and interact with the agency's hired OCEI. This process ensures that project quality meets agency requirements.

For this tool to be successful, the CEI and OCEI must be hired early in the project, at least before the beginning of construction. Both entities need be in place before construction starts so that quality during construction is managed properly from the very beginning. Once the CEI and OCEI are in place, it is best that they work together on quality management for the duration of the project construction.

How to Use It

As a quality management system (QMS) begins to take shape on a project, the use of a CEI and an OCEI for quality control and acceptance must begin early on. Once the decision is made, the contractor and agency select an independent engineering consultant to act as the CEI, and the agency selects an OCEI to represent its interests.

Once each consultant is in place, partnering exercises should take place between the OCEI and the CEI to improve the interactions that will take place between them. After construction begins and for the duration of the project, the CEI performs the construction quality control testing for the contractor and the OCEI performs quality acceptance for the agency.

Tips

- Specifications and drawings must be detailed for the CEI to be able to perform proper testing and inspections of the construction work. Lack of specifications leaves a gap in the design, and the CEI has no guidelines to follow.
- Partnering exercises would help to establish a relationship between the contractor's CEI and the agency's OCEI. Refer to Tool B.16 for more information on team partnering.

Example—I-595 Express Corridor Project (FDOT)

FDOT implemented dual CEI/OCEI roles for the I-595 express corridor improvements project. On that project, the role of the concessionaire CEI was to provide daily quality control activities by adhering to the specifications and design provided in the contract. Then, to make sure that the concessionaire was performing work at the level of quality detailed in the contract, FDOT also hired a construction consultant to act as the OCEI. The OCEI audited the quality testing and inspections performed by the CEI to make sure that the concessionaire was adhering to the specifications and design provided in the contract.

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B.20 Innovation in Witness and Hold Points

During construction, there are certain stages, or points, when inspection, testing, and verification may need to take place. This is done at critical points where specific aspects such as checking technical quality requirements, safety requirements, and proper completion have taken place so that the next activity or activities can proceed. These critical points during construction are called witness and hold points.

Compatible QAOs

Variable, Oversight, Acceptance

What Is It?

A hold point is a mandatory verification point beyond which a process cannot proceed without authorization by the agency (Chung 1999). Hold points are commonly assigned to critical aspects of the work that cannot be inspected or corrected at a later stage as they will no longer be accessible. The final inspections or tests at a certain phase of construction (e.g., underground work) where no further work is allowed to progress without acceptance by authorized personnel is a hold point.

A witness point is an identified point in the work process where the agency may review, witness, inspect, or undertake tests on any component, method, or process in the work being performed (Chung 1999). The presence of authorized agency personnel (i.e., the witness) is suggested during a witness point inspection or test. When a witness point arises, the contractor notifies the agency. At that point, the agency can choose to inspect or not inspect. In either case, the succeeding activity may proceed.

Why Use It?

At certain points during construction, a critical aspect of the project is complete and needs thorough inspection and testing as the next activity will be covering or enclosing that particular work, and it will be very difficult to perform rework once it is covered or enclosed (e.g., subsurface grading and preparation for a paving project). The agency then makes use of witness and hold points to monitor the verification activities of the contractor (Chung 1999).

What Does It Do?

The use of hold and witness points allows the agency to instill inspections for work that is overly critical to the project. It allows the agency to either witness a test or inspection (witness point) or to provide permission for work to proceed (hold point). This helps the agency to verify the work and to keep the contractor's work at the required level of quality.

When to Use It

During construction, the contractor is required to implement a quality management plan that includes a witness and hold procedure. Then the agency and contractor agree to specific points when inspections and testing will occur during construction.

How to Use It

For this tool to be effective, witness and hold points have to be established before construction work begins. The agency and the contractor create an inspection and testing procedure that both parties agree to that will be put in place during construction. Once all specific points are identified, each has to be defined as either a witness point or a hold point. Hold points should include all overly critical points in construction where the agency must grant permission to proceed forward with construction activities. All other points can be designated witness points, where the agency will be present for an inspection, but permission to proceed is not required.

For the contract, the agency must provide information to the contractor on the agency's inspection and testing procedure and how the witness and hold point process will work. Specifically, the agency should provide the sequence of activities involved in the process, specify the checks or tests to be performed and the acceptance criteria, indicate the hold and witness points for which verification of quality is a prerequisite to the succeeding work, and identify the authority that provides approval for each hold point (Chung 1999).

Tips

- For this tool to be most effective, the Instructions to Proposers (ITP) must be discretely defined so that the contractor understands the inspection and testing requirements of a project.
- Innovative practices in using witness and hold points can be developed to make the ITP process more efficient.

Example—I-595 Express Corridor Project (FDOT)

FDOT implemented witness and hold points during construction of the I-595 express corridor project. This PPP project was the first of its kind in Florida. Therefore, innovative and new techniques had to be established for the overall QAO.

Two major procedures of the quality system that affect all project work are the witness and hold procedure and the testing and sampling requirements (TSR) procedure, initiated by subcontractors, inspected by the design builder QC, and verified by the Consultant Construction Engineering and Inspection (CCEI). The witness and hold point procedures followed the traditional method, but included a few innovative and technological ideas.

For one, all work and materials used to advance the project were recorded and regulated by multiple parties (contractor's QC staff, CCEI, and OCEI). This helped to validate the concessionaire's work internally and externally. Then, for electrical inspections and testing, all requests for witness and hold points were made electronically. The process included email requests that are then converted to text messages so that field personnel can receive the request if email is unavailable. Both of these innovative ideas have helped to produce efficient testing and inspection procedures on the I-595 corridor project.

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B.21 Continuous Internal Process Audit

QC procedures are developed prior to beginning work. Then, as the work occurs, the necessary parties utilize the proper QC procedures to check the work. Once QC testing and inspections are complete, an audit of the QC procedure can take place to verify that the agency is following the QC procedures correctly.

Compatible QAOs

Acceptance

What Is It?

A quality system (or process) audit is an independent and documented process for obtaining evidence on various aspects of quality performance and then evaluating this evidence objectively to determine whether established criteria have been met (Juran and Godfrey 1999; Hoyle 2009). Auditing provides the agency with assurance that a specific aspect of performance is being met (Juran and Godfrey 1999). According to the Institute of Internal Auditors (IIA), continuous auditing is a method used to perform control and risk assessments on a high-frequency basis (n.d.). Essentially, a continuous internal process audit is a procedure where each party that is part of a project team performs audits of its quality control procedures on a regular basis.

Why Use It?

Specific QC procedures developed prior to the start of a project help an agency to perform the correct QC for the work the agency completes. Yet, there are times when the QC procedures are complex and/or for special or uncommon work. In these cases, it is beneficial for the organization to perform continuous internal audits of the QC processes.

What Does It Do?

Internal process audits help the agency to verify that the project QC procedures were followed correctly and completely (UDOT 2011). This additional verification provides internal assurance that the work that a party completes is performed using QC procedures developed prior to beginning of the project.

When to Use It

Continuous internal process audits should be used to audit QC procedures once the work is complete, and necessary testing and inspections have occurred. Audits can also occur before each review meeting and, specifically for the agency, before advertisement and procurement or releasing documents for construction.

How to Use It

Each organization that is part of the project team (agency, design team, contractor, etc.) has to provide an auditor to perform the internal process audit (UDOT 2011). This auditor then performs audits on the work that that organization performed and *only* the work that it performed.

Once specific QC procedures are completed, QC inspection and/or testing documentation is submitted to the agency. The auditor then verifies whether the submitted documentation is complete and that the proper QC procedures were followed. If deficiencies are determined during the review, the auditor returns the documentation with comments to the agency individuals who originally submitted the QC documents. If no issues are found in the audit, then the auditor signs off on the QC documentation and work goes forward.

Tips

It is beneficial for the agency to use this tool as well as encourage or require all contracted parties to utilize this tool.

Example—I-595 Express Corridor Project (FDOT)

FDOT required a continuous internal process audit for the I-595 Express Corridor Project. This was the first time that the PPP project delivery method was used by FDOT for any project. The contract called for a concessionaire team to design, build, finance, operate, and maintain the project for 30 years after completion of construction. This put the responsibility for quality on the concessionaire as ultimately it was in the concessionaire's best interest to provide high quality to minimize future operation and maintenance costs. This meant that the overall quality management plan had to be adjusted for PPP. In this case, the Acceptance QAO was used.

In the Acceptance QAO, FDOT was responsible for independent assurance and had an OCEI to perform these duties. The concessionaire team was then responsible for all other elements of quality management. This was accomplished with a mandatory requirement from FDOT for direct auditing by the OCEI, who was hired by FDOT, and direct auditing by the CEI, who was contracted under the concessionaire.

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B.22 Real-Time Electronic Quality Management Information

Real-time electronic management of quality management information (and other project documents) was the most frequently utilized tool observed in the case studies examined for this guidebook. The benefits and uses of such systems are many and various.

Compatible QAOs

Deterministic, Assurance, Variable, Oversight, Acceptance

What Is It?

While listed as a single tool, in reality, electronic management of the quality management process can look very different depending on the needs of the project and agency. At a minimum, such a system should allow for the uploading and organizing of daily reports for review and submission to the necessary team members. The reports can then be referenced and their submission verified later if needed. Some systems incorporate recording devices for inspectors to use in the field, which can then automatically upload checklists and inspection results. Other systems provide statistical analysis and decision tools, integrated databases, and administrative tools for use at an enterprise/agency-wide level. In addition, utilizing a central location for all QC tests and a system to flag failed tests can be very useful on large projects where non-complying sections of work may not be fixed immediately.

Why Use It?

The benefits of an electronic data management system (EDMS) vary based on the scope of the system and the level at which project participants utilize it. The primary benefits are organizing large volumes of information and providing a clear record of submission, receipt, and approval of everything from daily reports to QC tests performed by a third party. Deploying a system to the field in the form of handheld devices streamlines the inspection process and ensures that every item of work is checked so that any incomplete reports can be flagged for review.

What Does It Do?

The use of software (and some hardware devices) to manage quality management provides several advantages. First, it organizes project documents in a centralized location for later reference. This is vital on large transportation or infrastructure projects where large volumes of information and reports are generated daily or weekly. Second, this tool provides users with access to information they are authorized to view and alter via the Internet or an intranet. Third, the tool tracks non-compliance issues and ensures that all areas of concern are followed up on and closed out. Finally, electronic management of quality management information is customizable. For the most part, if project managers can imagine a type of functionality and justify the expenditure to acquire it, software and hardware companies can find a way to develop it.

When to Use It

As projects grow in size and complexity, the use of an electronic information management system also becomes valuable. While these systems provide the organization and standardization needed by projects spanning long time periods and large geographic distances, they can also be useful on smaller projects when they are set up to contribute information to a large database that the agency can use in future decisions.

How to Use It

The implementation of electronic management of quality management information requires varying levels of commitment from an STA's staff depending on the types of information to be captured and the level of functionality required. A simple system would provide a central location for depositing and organizing electronic files with varying levels of access for different project team members and might only exist for the life of the project. More complex, enterprise-level systems would require the buy-in of agency upper management in procuring the necessary equipment and software development services, of field inspectors to use the systems to their full potential, of contractors and designers to use the system, and of the agency as a whole to use information gleaned from one project as part of a database of knowledge for future projects.

Examples

SH 130 Turnpike Project (TxDOT)

TxDOT used a particularly comprehensive EDMS on their SH 130 Turnpike Project, completed in 2008. The Electronic Laboratory Verification Information System (ELVIS) was a web-based EDMS developed to support the construction quality assurance program. ELVIS supported the input of 43 different field and laboratory test results as well as their correlation with the results of agency verification testing. ELVIS provided a wide range of data-management, project-management, and deficiency-monitoring functions as well as statistical analysis and enterprise-level management tools. The system was credited with large reductions in the number of non-conformance reports generated as well as a significant reduction (18.7% to 4.6%) in the amount of uncorrected material deficiencies (Yuan, Fu, and Raba 2006).

Portland Transit Mall Revitalization (TriMet)

The Portland Transit Mall Revitalization Project included the installation of a light rail line along the entire length of the Portland Transit Mall. This CMGC project, managed by TriMet transit agency, utilized electronic collection and reporting of quality control systems. This allowed the TriMet resident engineer to streamline the reporting process and provided easy access to a searchable database of reports for later reference that included field reports and laboratory testing results.

United States Army Corps of Engineers (USACE)

The USACE uses a contract administration program known as the Resident Management System (RMS), of which the Quality Assurance System (QAS) and the contractor-accessible Quality Control System (QCS) are components. This comprehensive system provides project management and control functionality for all aspects of construction. The QCS allows contractors to exchange daily QC reports, material test results, and correspondence with USACE personnel and allows them to "perform quality control activities more consistently" (USACE 2011).

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B.23 Financial Incentives/ Disincentives for Quality

The use of financial incentives to speed project delivery is well established in the highway construction industry. Less common is the use of financial incentives (or disincentives) for quality management purposes. This tool can be a cost-effective way to elicit performance from contractors, design builders, or CMGCs that goes above and beyond the established minimum levels of quality.

Compatible QAOs

Deterministic, Assurance, Variable, Oversight

What Is It?

Financial incentives and disincentives for quality are composed of appropriate contract clauses defining incentive terms as well as the necessary mechanisms for comparing a contractor's performance to the incentive criteria and awarding earned incentives or withholding payment as part of a disincentive.

Why Use It?

Incentive clauses are one way that STAs can increase the level of quality on their projects without needing to revise their quality standards or define an optimum allocation of resources toward quality. By incentivizing contractors to exceed quality minimums, STAs can let contractors allocate their resources toward earning quality incentives in the most cost-effective manner possible, resulting in increased levels of quality for minimum increases in cost.

Disincentives are useful in motivating contractors to address the concerns of an STA and to address non-compliance issues in a timely manner. By establishing the right to charge contractors for their failure to address shortcomings quickly in the contract, STAs can demonstrate their commitment to the timely resolution of unsatisfactory work without needing to confront contractors through the dispute process. Disincentives can also be used to encourage high-quality work by essentially "charging" contractors for substandard work.

What Does It Do?

Incentives essentially provide a bonus to the contractor for performing at a high-quality level. When a contractor has the ability to increase income on a project by performing, the project will benefit from the increased care in performance.

Disincentives essentially provide a charge to the contractor for not performing at the level of quality required by the agency. In this case, the contractor loses income on a project. Contractors do not like to lose income; therefore, the contractor will try to perform at a high level of quality consistently or repair the deficient work as quickly as possible.

When to Use It

Incentive clauses should be used when project managers have a clear idea of which aspects of a project's quality they would like to see maximized. When project managers are unsure of their priorities, it may be difficult to accurately award incentives when they are earned.

Disincentive clauses should be used when project managers have specific quality or procedural concerns. If ride quality, dimensional tolerances, and so forth are particularly important to a project, managers may consider using disincentives in conjunction with incentives to encourage the production of high-quality work. Disincentives can also be useful when project managers want to discourage certain behaviors such as delaying the correction of substandard work or failing to meet schedule deadlines.

How to Use It

The use of incentives/disincentives requires several key components. First, the contract clauses related to their use must clearly spell out the purpose of the incentives/disincentives, the targeted type of performance or behavior, the criteria for evaluating the contractor's performance, the value of awards or disincentives, and the source of the money for the incentive award pool or where disincentive fines will come from. Second, STAs must provide some means of evaluating the priorities laid out in the contract against a contractor's performance using pre-defined criteria. Finally, there must be some mechanism for transferring award funds from the incentive pool to the contractor and for withholding payment from or levying charges against the contractor for disincentives.

Tips

Award funds do not need to be dedicated solely to schedule or quality incentives but can instead be pooled together along with incentive programs (safety, environmental compliance, community relations, etc.). This general incentive fund can be filled entirely with agency funds or can be partially filled with contractor funds. In the second scenario, the money "belongs" to the contractor and is theirs to lose or win depending on performance.

Examples

T.H. 61 Hastings Bridge Project (MnDOT)

On the Hastings River Bridge Project, MnDOT used financial disincentives to ensure that the contractor promptly dealt with non-compliance issues. Subject to MnDOT's determination, the contractor could be assessed a $100/hour monetary deduction for failure to facilitate satisfactory progress or completion of the work. Hourly charges could be applied during periods when MnDOT determined that the contractor had not satisfactorily responded to a documented non-compliance. No charge was to be assessed if the contractor corrected the deficiency within 1 hour of written notification from MnDOT.

I-15 Widening and Beck Street Bridge Project (UDOT)

UDOT established an incentive program on the project to widen I-15 near Beck Street to provide the design builder with the opportunity to earn "Incentive Awards" for superior performance in certain key areas of the project. UDOT developed the program to encourage and reward consistent excellence in achievement of the technical specifications, workmanship, and the administrative program requirements. The design builder could only earn the awards through clear and consistent superior performance over the term of the contract. UDOT capped the incentive fund at $1.2 million, and scope expansion would not increase the fund. However, scope reductions could reduce the fund. The agency's goal was for the design builder to perform in a manner that allowed for the maximum possible award. The agency predefines and weights the various incentive criteria for each incentive period appropriately to ensure high-quality performance in areas most critical to the agency.

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B.24 Contractor-Controlled QC Testing

While the concept of contractors performing their own QC testing is not new, some transportation agencies still require that the contractor hire a third-party, independent, material testing and inspection laboratory to perform the actual tests and inspections required for the project. With the removal of this requirement, contractors receive greater schedule flexibility, and project costs can decrease without sacrificing the level of quality on the project.

Compatible QAOs

Deterministic, Assurance, Variable, Oversight, Acceptance

What Is It?

This tool removes restrictions placed on contractors that force them to retain an independent laboratory for QC testing and inspection.

Why Use It?

While construction projects are planned, and given sections of work are scheduled to be completed at certain times, those plans and schedules are not always kept or met. While schedules can be adjusted to make up for lost time, the inclusion of third-party inspectors and materials testing labs can greatly complicate efforts to reschedule work or take advantage of a faster than anticipated rate of progress. Allowing contractors to utilize their own directly employed personnel for QC testing and inspection ensures that contractors will always have someone on hand to perform QC functions when needed. This schedule flexibility itself can save some projects money, but further savings are realized by removing the overhead and profit costs of independent laboratories.

What Does It Do?

Allowing contractors to perform QC functions using their own personnel simplifies scheduling, reduces costs, and maintains equivalent levels of quality when compared to requiring a third party to perform the same functions. Allowing contractor-controlled QC testing is done by removing contract clauses that require the use of independent laboratories or independent inspectors or inserting clauses that present contractors with the option to use their own personnel provided certain conditions are met.

When to Use It

This tool is compatible with all five possible QAOs because contractors are always responsible for construction QC functions on their projects. However, removing requirements for contractors to retain an independent laboratory to perform those functions should only be done when three conditions can be met. First, the contractor must have the capability and capacity to perform the types and volume of testing and inspection necessary. Second, the contractor must be able to demonstrate that removing the requirement for an independent, third-party firm will result in improved schedule performance and/or reduced costs for the contractor and agency. Finally, the agency must establish a prior relationship with the contractor or have some way of verifying the contractor's reputation for delivering high-quality projects.

How to Use It

The actual implementation of the tool itself is straightforward: it involves removing clauses from a project contract or standard specifications for a project that require a contractor to retain a third-party independent laboratory to perform QC inspection and testing. The removed material must be replaced with a clause that establishes acceptable certification bodies or levels that inspectors and technicians directly employed by the contractor need to have. The addition of this clause involves an understanding of the types of inspections and tests that must be performed and the certifications necessary to perform them.

Tips

Rather than removing clauses that require independent QC inspectors and technicians outright, agencies may consider inserting language in the contract or specifications presenting the option to the contractor to self-perform QC functions provided that certain conditions are met and that the contractor can demonstrate the benefits of performing QC itself.

Example—Portland Transit Mall Revitalization (TriMet)

TriMet typically requires that contractors hire an outside, independently certified laboratory to perform QC testing. On TriMet's South Corridor Light Rail Extension Project however, the agency allowed the contractor to use directly employed inspectors and technicians to do the QC testing. TriMet's willingness to do this was based in part on the reputations for quality and integrity of both parties in the contracting joint venture and in part on TriMet's requirement that all inspectors and technicians be nationally certified to perform the needed inspections and testing. This decision saved the contractor money and streamlined the scheduling process by removing the inherent scheduling complications that occur when dealing with an independent firm without sacrificing quality.

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B.25 ISO 9000 Training Sessions

Many alternative contracting strategies that highway projects utilize allow the agency to pass along quality responsibilities to the contractor. In these instances, the agency is in a position to oversee and verify quality, but the contractor handles most of the formal quality tasks. This helps to decrease quality responsibilities for the agency and reduces the resources needed for a project. Yet, since the agency has little or no part in most quality activities in this setup, the agency needs a way ensure that the selected contractor can meet the quality, cost, and delivery requirements (Hoyle 2009). One way to accomplish this is providing quality management training for all individuals and associated firms involved with constructing the project.

Compatible QAOs

Acceptance

What Is It?

ISO 9000 is a set of standardized requirements for a QMS that assist with managing quality. The International Organization of Standardization (ISO) maintains the standards. The ISO 9000 requirements provide a common foundation for instilling a quality culture in organizations that embrace eight quality principles (Miron, Rogers, and Kopac 2008).

ISO 9000's quality management objective is to "break down communication barriers, change paradigms, and ensure that every department in an organization knows how its work affects other processes or areas in the organization. Aligning a quality management system with the organization's current management system facilitates planning, allocating resources, defining complementary objectives, and evaluating the organization's overall effectiveness" (Miron, Rogers, and Kopac 2008, Hoyle 2009).

Why Use It?

When the agency places most of the quality management responsibilities on the selected contractor (i.e., Acceptance QAO), it reduces the quality management responsibilities of the agency. Therefore, the agency needs fewer resources to carry out quality management responsibilities. However, the agency must still be confident that the contractor is meeting the required level of quality. One way to assist in this process is to require the contractor to provide ISO 9000 quality management training to the contractor's employees, which includes training internal personnel and the subcontractors contracted under the selected contractor. Requiring quality management training for all involved in constructing the project helps the contractor to achieve the level of quality that the agency expects.

What Does It Do?

This tool provides the agency with a way to require a specific level of quality and a common understanding of the quality management system when the agency is not assuming most or any of quality management responsibilities on a project. The tool requires the contractor to train all involved with building the project in ISO 9000 quality management principles.

When to Use It

This tool is most effective for projects that put more of the QAO responsibilities on the contractor. In the Acceptance QAO, the agency monitors and accepts the work based on quality, while the contractor performs the rest of the project quality responsibilities. This "hands off" approach by the agency means that a large amount of trust needs to be established between the agency and the contractor so that the agency can trust that the contractor will meet to the level of quality required by the project.

Actual training of contractor and subcontractor personnel may occur at many different times throughout the duration of a project depending on when those personnel are actually involved in the project.

How to Use It

To use this tool properly, the agency must require contractually that the contractor utilize ISO 9000 quality management principles and provide ISO 9000 training for all of its staff and the subcontractors that are involved with the project.

The agency must then enforce the ISO 9000 training. To accomplish this, the agency might consider assisting the contractor with the training. Alternatively, the agency can require bidding contractors to have ISO-9000-certified individuals on the project team. Another approach that an agency can use is to hire an ISO-9000-certified team to provide the ISO 9000 training or require the contractor to hire this consultant team.

The ISO 9000 consultant can provide proper training to make sure that all involved in the project have a common understanding of the quality expected on the project. The cost of hiring the consultant may be offset by the cost savings realized when an entire team has the same understanding of quality goals and objectives.

Tips

Refer to the Section B.25 bibliography for additional information on ISO 9000 quality management. ISO 9000 is not commonly used on U.S. transportation projects, but it is an internationally accepted system that has a record of providing successful quality management.

This tool can be used in the same manner as other QMSs that the agency may be more familiar with, such as the advanced quality system (AQS) approach developed by the FHWA. Refer to Miron, Rogers, and Kopac (2008) for more information on the AQS approach.

Example—I-595 Express Corridor Project (FDOT)

FDOT established ISO 9000 training for the I-595 Express Corridor Project. This highway reconstruction and improvement project was FDOT's first PPP project. Therefore, FDOT had to adjust the QAO to match the PPP method. For this project, the Acceptance QAO was utilized, making the development of the QMS and the provision of the associated staff the responsibility of the concessionaire.

The concessionaire selected for the project had experience internationally with PPP projects and several team members held ISO 9000 certifications in Europe. This experience and knowledge of ISO 9000 proved useful on the project in reducing the learning curve associated with managing the full QMS for the project. However, the concessionaire had limited knowledge of local subcontractors and their experience related to the PPP delivery method and quality management in general.

As a result, the concessionaire trained the 160+ subcontractors on the project QMS. This helped to develop the subcontractors' knowledge of PPP and ISO 9000 requirements and additionally helped to develop a working relationship between the concessionaire and the subcontractors. It should be noted that ISO 9000 was not required for this project, and the requirements were only used as reference material by the concessionaire due to the ISO certifications held by several team members.

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B.26 Project-Specific Quality Management Team Training

Agencies implement quality training of their personnel to emphasize the importance of high-level project quality. The extent of the training corresponds to the scope and complexity of the project, along with the education and experience of the personnel.

Compatible QAOs

Deterministic, Assurance, Variable, Oversight, Acceptance

What Is It?

All quality management personnel receive project-specific training necessary to achieve quality and technical requirements relating to their activities and, more importantly, understand how the project quality control plan will be executed on the given project. The requirements are specified in the contract documents and in the project quality control plan. If the quality management personnel are performing an activity that requires certification, then the certification will be received after proper training.

Why Use It?

Training for quality management personnel is specified in order to emphasize the importance of quality as well as to highlight the concept that quality is best achieved when the work is installed the first time. Finally, mandatory training for quality management personnel encourages the exchange of quality-related information among the project team members and reduces non-compliance.

What Does It Do?

Training for quality management personnel provides individuals with the necessary skills and knowledge to achieve a suitable level of quality in project activities, as specified by contract documents. Training ensures the establishment of high quality from the beginning of the project and establishes that personnel responsible for achieving quality are qualified to do so.

When to Use It

This tool can be used on any project at any time throughout the project whether implemented by the agency or the contractor.

How to Use It

Each quality management personnel member receives training necessary to satisfy the quality and technical requirements of a project, as specified by construction documents for the element of work to be performed. All personnel receive training on the project quality control plan and their specific roles from the design builder's quality manager. The extent of the training received by each quality management personnel member depends on their education and experience and the scope of the work. Quality management personnel are responsible for the quality of the work.

Example—Mountain View Corridor Project (UDOT)

UDOT has used quality management personnel training for the Mountain View Corridor Project. Quality management personnel are expected to have the necessary education, training, and certifications for their discipline. Furthermore, any individual who has an impact on quality through performing an activity is required to be familiar with the contract document specifications.

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APPENDIX C

Highway Project Quality Assurance Organization Selection Guide

C.1 Objective

This quality assurance organization (QAO) selection guide assists STAs in the assignment of project quality assurance (QA) roles through the selection of the most applicable project QAO. Ideally, selection will begin early in the project development process. At the latest, it should occur before the procurement of design or construction contracts begins. This guide provides the basic definitions for the project QAO selection tool, includes instructions on the use of the tool, and presents a demonstration of the tool on a project for illustration. This appendix also includes the selection factor definitions, the factor appropriateness ratings, and all blank forms required to apply the tool. Electronic versions of these forms are available for download by searching for *NCHRP Report 808* on the TRB website.

C.2 Definitions

An understanding of a few basic quality terms and the fundamental QAOs is necessary to ensure an accurate implementation of the selection tool. Definitions for the basic quality terms and the fundamental QAOs follow. Please review the following definitions of quality terms prior to completing the selection of a project QAO:

- **Quality Management (QM).** The totality of the system used to manage the ultimate quality of the design as well as the construction encompassing the quality functions described below as QA, QC, independent assurance, and verification (Gransberg, Datin, and Molenaar 2008).
- **Quality Assurance Organization (QAO).** The assignment of the roles and responsibilities associated with the quality management of a project from concept through completion.
- **Quality Assurance (QA).** All those planned and systematic actions necessary to provide confidence that a product or facility will perform satisfactorily in service (*Transportation Research Circular E-C137* 2009).
- **Quality Control (QC).** Also called "process control," those QA actions and considerations necessary to assess and adjust production and construction processes so as to control the level of quality being produced in the end product (*Transportation Research Circular E-C137* 2009).
- **Acceptance.** The process of deciding, through inspection, whether to accept or reject a product including what pay factor to apply (*Transportation Research Circular E-C137* 2009).

C.3 Fundamental QAOs

The definition for each of the QAOs is provided below. Table C1 summarizes the quality roles and responsibilities in each QAO, and Figure C1 provides a spectrum of the QAOs and the associated level of control the agency has over the quality of the project.

- **Deterministic QAO.** The traditional approach to quality within the highway industry. The agency retains responsibility over all project quality roles, responsibilities, and activities.
- **Assurance QAO.** The agency is responsible for all aspects of quality except for design and construction QC.
- **Variable QAO.** Design and construction take different approaches to quality. For example, the STA may assign both design phase QC and acceptance to an outside party, while the construction phase QC only may be assigned to an outside party. This approach was found on design-build (DB) projects.
- **Oversight QAO.** The agency takes on an oversight role by assigning design QC, design acceptance, construction QA, and construction acceptance to outside parties.
- **Acceptance QAO.** The agency is responsible only for verification testing and final acceptance. All other quality roles and responsibilities are assigned to the concessionaire. This variation was found only in public-private partnership (PPP) arrangements.

Table C1. Summary of roles and responsibility assignments for each QAO.

QAO	Design Acceptance	Design QC	Construction Acceptance	Construction QC	Project Acceptance
Deterministic	Agency	Agency	Agency	Contractor	Agency
Assurance	Agency	Designer	Agency	Contractor	Agency
Variable	Designer	Designer	Agency	Contractor	Agency
Oversight	Designer	Designer	Contractor	Contractor	Agency
Acceptance	*Concess	Concess	Concess	Concess	Agency

*Concess = Concessionaire

C.4 Project QAO Selection Tool

The QAO selection tool can assist STAs in selecting the most appropriate QAO for a project by rating the appropriateness of the five fundamental QAOs according to the categories of project selection factors. The definitions for the 10 selection factors can be found in Section C.6.

The tool uses a three-step process (see Figure C2): identifying barriers to QAO adoption, preparing a selection factor profile, and through analysis of the selection factor profile in conjunction with selection factor category/QAO appropriateness ratings, selecting the most appropriate QAO. The steps are discussed in more detail in the following sections.

Step 1: Identifying Barriers to QAO Selection

Barriers are regulations or policies that either prevent the use of an alternative QAO or dictate that a specific QAO be used on a project. Possible barriers include—but are not limited to—federal, local, or funding regulations; political issues; and agency policies. It is important to identify these barriers at the beginning of a QAO selection process because it is very likely that if barriers exist, the QAO selection process will begin and end at this step. For example, when a specific QAO is required, that QAO must be selected.

Step 2: Preparing the Project QAO Selection Factor Profile

The goal of the second step is to prepare a project QAO selection factor profile. The selection factor profile identifies which category of each selection factor applies to the project being analyzed. The information in the selection factor profile will be used in Step 3 to identify the appropriateness ratings for each selection factor that applies to the project.

For some selection factors, such as project size or project delivery method, it is easy to identify which category applies. However, identifying the correct category for selection factors such as the amount of quality responsibility the agency wants to shift to other project participants requires that the project goals be established and understood so that the correct selection factor category can be determined. Establishing the project goals will also provide the user with further understanding of the motivation for the project and why the project might need to diverge from the agency's default project QAO. A complete understanding of the project goals will ensure that the agency is making a fully educated decision. Once the goals are established, the user can complete the project QAO selection factor profile form included as Figure C5.

Step 3: Using the Project QAO Analysis Form to Select an Appropriate QAO

The final step of the QAO selection process is selecting the appropriate QAO based on a comprehensive analysis of the appropriateness ratings for each QAO that corresponds to the category of each of the project selection factors. In this step, the user transcribes the appropriateness ratings onto the project QAO analysis form from the project QAO selection factor profile form in Step 2. Appropriateness ratings for all categories of selection factors are included in Section C.7, and all forms are included in Section C.8.

Figure C1. Spectrum of QAOs and level of agency control over quality.

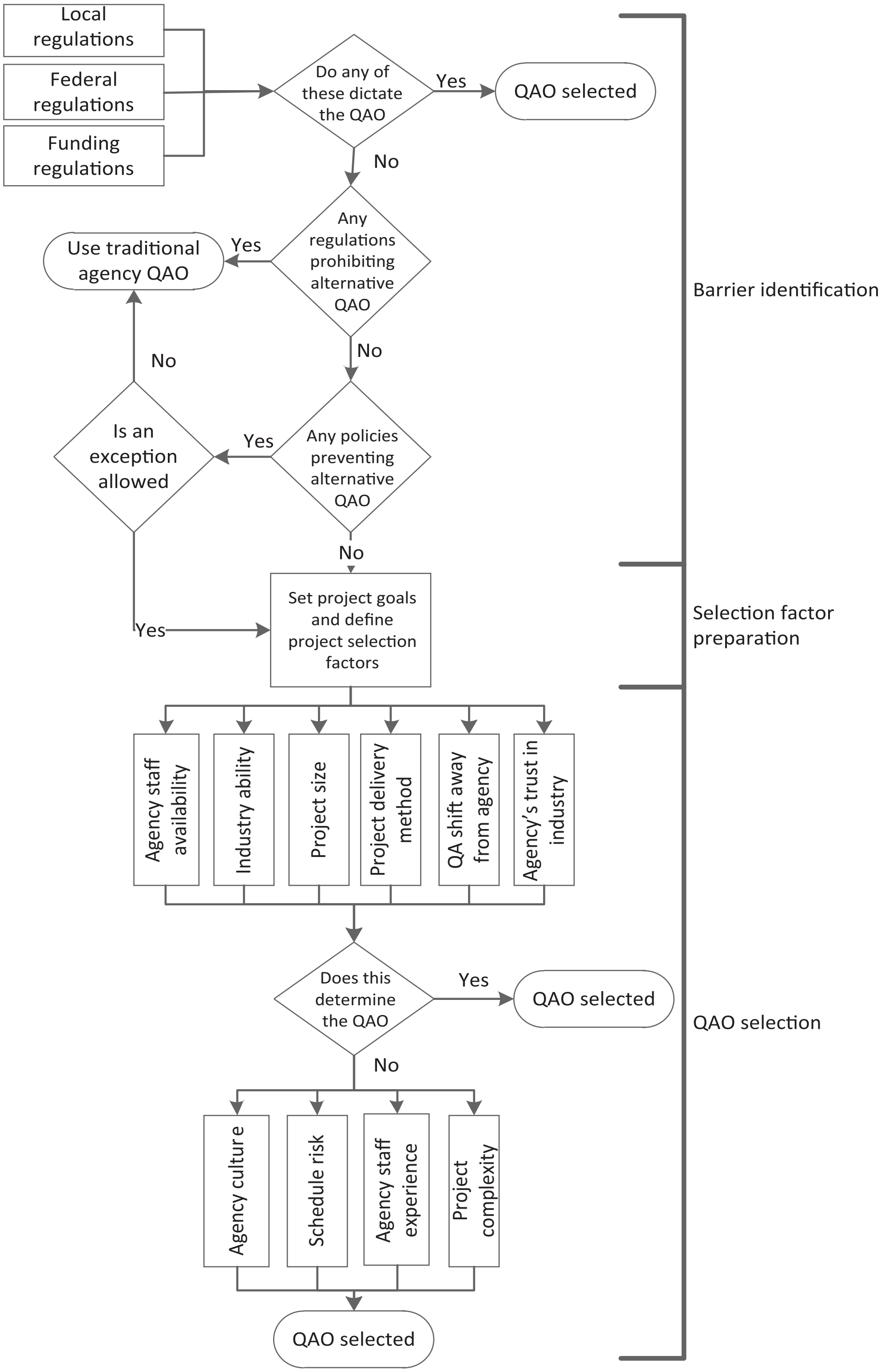

Figure C2. Project QAO selection flow chart.

The four ratings used to indicate the appropriateness of the factors are the following:

- Fatal flaw (denoted with ×)
- Least appropriate (–)
- Appropriate (+)
- Most appropriate (++)

The fatal flaw rating (×) indicates that, for that particular category of selection factor, the QAO has the potential to harm the success of the project. The fatal flaw rating effectively eliminates that QAO from further consideration. A least appropriate rating (–) indicates that, for the particular selection factor category, the QAO can work, but it is not the best option. If a QAO with a least appropriate rating is implemented, there may be extra measures needed to accommodate this particular selection factor. An appropriate rating (+) indicates that the QAO can work for that particular selection factor category—it neither harms nor improves the success of the project. Finally, the most appropriate rating (++) indicates that a project can be improved by the implementation of the associated QAO.

The project QAO selection analysis form is split into two separate sections: primary selection factors and secondary selection factors. The primary factors are all the selection factors that resulted in at least one fatal flaw rating during the NCHRP Project 10-83 research and testing. Secondary factors are the selection factors that did not result in a fatal flaw. Due to the diversity of the appropriateness ratings, primary factors have a more decisive role in project QAO selection. If the potential QAOs are not narrowed down to two options or fewer at the completion of the primary selection factors analysis, then the same process is used for the secondary selection factors. Also, if the potential QAOs are narrowed down to two or fewer in the primary factor analysis, the user can continue on to the secondary selection factors to further understand the potential QAOs, investigate the details of each project selection factor rating, and/or make a final selection of the project QAO.

This section has presented the three steps of the project QAO selection tool: barrier identification, selection factor preparation, and QAO selection. The following section demonstrates the use of the tool by presenting an implementation of the tool with an actual industry project.

C.5 Demonstration Project

A highway project in a state in the mid-section of the United States was selected to demonstrate and validate the project QAO selection process tool. The exact project location is not identified for reasons of anonymity in the research. The scope of the project was to construct a landmark river bridge(s); rehabilitate or replace approximately 4 miles of Interstate; improve traffic operations, geometrics, and safety; and add mainline capacity.

The budget for the DB project was approximately $230 million. The STA selected the DB method to achieve the project goals:

- Reduce/compress/accelerate project delivery period.
- Get early construction contractor involvement.
- Encourage innovation.
- Complete different design solutions through the proposal process.
- Address flexibility needs during the construction phase.

This STA has been very open to trying new delivery methods and does have a focus on shifting more quality responsibilities away from the agency. The agency has experienced staff reductions over the past decade and significant losses of expertise through retirements. The agency and the local contracting and engineering industry have built up high levels of mutual trust as a result of increasing use of alternative delivery methods in the state.

The first step of the project QAO selection tool is identifying barriers to the implementation of alternative project QAOs. The demonstration project is in a state that is leading the way in shifting quality responsibility away from the agency, and no state or local barriers preventing alternative QAO selection were identified. Also, no federal regulations pertain to this project that would prohibit the implementation of an alternative QAO. The agency itself is relatively progressive and encourages trying new processes and strategies that can improve projects and overall efficiencies. As such, no agency polices exist that prevent alternative QAO implementation. The result of the first step is that all project QAOs are still viable for this project.

The second step of the project QAO selection tool is completing the project QAO selection factor profile form. The project goals were already established, so the selection factor profile form was completed to show which category of each selection factor corresponded to the project (see Figure C3). The completed selection factor form is used in Step 3.

The third and final step in the project QAO selection tool is using the project QAO analysis form to select the project QAO. This form is completed by transcribing the appropriateness ratings for each QAO to the category of selection factor applicable to the project. The completed project QAO analysis form for the demonstration project is presented in Figure C4. In this case, the Deterministic, Assurance, and Variable QAOs had fatal flaw ratings in at least one of the primary selection factors and, as such, they were deemed inappropriate. This left two potential QAO options, Oversight and Acceptance. The secondary selection factors for these QAOs were analyzed to further understand the two possible QAOs so a final QAO decision could be made with confidence and the appropriate considerations.

Primary factor categories					
Agency staff availability	☒ Minimal	☐ Moderate	☐ Full		
Trust between agency and industry	☐ Low	☐ Moderate	☒ High		
Industry's ability to manage its own quality	☐ Low	☒ Medium	☐ High		
Project delivery method	☐ DBB	☒ DB	☐ CMGC	☐ PPP	
Project size	☐ <$10M	☐ $10M–$50M	☒ $50M–$500M	☐ $500M–$2B	☐ >$2B
Shift the quality responsibility from the agency	☐ None	☐ Some QC	☐ Some QA	☐ Some QC and Some Acceptance	☒ All
Secondary factor categories					
Project complexity	☐ Low	☒ Medium	☐ High		
Project schedule sensitivity	☐ Low	☐ Medium	☒ High		
Agency culture	☐ Traditional	☒ Moderate	☐ Progressive		
Agency staff experience	☐ <5 years	☐ 5–10 years	☒ 10–20 years	☐ >20 years	

Figure C3. Demonstration project QAO selection factor profile form.

Primary Selection Factors	Deterministic	Assurance	Variable	Oversight	Acceptance
Agency staff availability	x	–	+	++	++
Trust between agency and industry	+	++	++	++	++
Industry's ability to manage its own quality	+	+	+	+	+
Project delivery method	–	–	+	++	–
Project size	–	+	+	++	++
Shift the quality responsibility away from the agency	x	x	x	++	++
Tally of primary selection factor results	**x**	**x**	**x**	**++**	**++**
Secondary Selection Factors	**Deterministic**	**Assurance**	**Variable**	**Oversight**	**Acceptance**
Project complexity	n/a	n/a	n/a	+	+
Project schedule sensitivity	n/a	n/a	n/a	++	++
Agency culture	n/a	n/a	n/a	+	+
Agency staff experience	n/a	n/a	n/a	++	++
Tally of secondary selection factor results	n/a	n/a	n/a	++	++
Rating key: x Fatal Flaw – Least Appropriate + Appropriate ++ Most Appropriate					

Figure C4. Completed project QAO analysis form for the demonstration project.

The project delivery method selection factor can provide an example of how an appropriateness rating is determined. The project delivery method for the demonstration project is DB. The appropriateness ratings for each QAO for the DB category were transcribed onto the project QAO analysis form (see Figure C4) in the project delivery method row. Both Deterministic and Assurance QAOs are rated as least appropriate, but are not fatal flaws. Deterministic and Assurance QAOs can be used with DB on small, non-complex projects or when an agency has little experience with DB project delivery. This is not the case in this example. The Acceptance QAO can shift too much responsibility away from the agency in a DB project and, as a result, also has a least appropriate rating. The Oversight QAO is considered the best fit because the design builder is responsible for delivering both the design and construction of the project while the agency is responsible for clearly stating the requirements for the project and is not involved in the day-to-day management of project design or construction. The Oversight QAO allows the agency to ensure that the design builder is meeting the requirements of the project.

The project QAO selection tool indicated that the Oversight and Acceptance QAOs are the most appropriate for the project. Because projects and agencies are unique, in cases like this it is up to the agency to decide whether the Oversight or Acceptance QAO would be the best fit for the project. At the time this tool was developed, the demonstration project was already well into construction, so the tool could not be used to select the QAO for the project. However, the Oversight QAO, which is one of the options indicated by the QAO selection tool, was implemented for the demonstration project and was proving to be successful.

C.6 Factor Definitions

This section provides the definitions of the 10 QAO project selection factors:

- **Agency staffing ability.** The quantity of agency project staff available to be committed to the project as compared to traditional levels.
- **Trust between the agency and the industry.** The level of agency confidence that project decisions will be based on achieving the best results for the project, rather than the individual or specific company. This requires the agency and industry to overcome the long-standing adversarial paradigm of the project participants (designer, engineer, contractor, consultant, and agency).
- **Industry's ability to manage its own quality.** The local industry's level of competence in managing its own quality. The industry includes both the design and construction communities. Competence can be increased through experience, training, education, industry culture, or a combination of any of these.
- **Project delivery method.** The comprehensive process by which designers, constructors, and various consultants provide services for design and construction to deliver a complete project to the owner. While names can vary in the industry, and owners often create hybrid delivery methods, there are essentially three primary project delivery methods: DBB, CMGC, and DB.
- **Project size.** The total dollar value of the project's design and construction budgets.
- **Quality responsibility shifted away from the agency.** The amount of liability for the management of the project's quality that the agency wants to shift to another project partner (contractor, designer, engineer, design builder, construction manager/general contractor [CMGC], or concessionaire).
- **Project complexity.** The intricacy of a project's scope as compared to a typical project in the same locale—stemming from programming requirements, design constraints, construction methods, site conditions, budget and funding constraints, quality requirements, and so forth.
- **Project schedule sensitivity.** The vulnerability of the project schedule to changes due to delays, conflicts, and/or events outside of the designer's and/or contractor's control, such as coordination of observations, inspections, and/or testing performed by the agency.
- **Agency culture.** In this context, agency culture refers to the agency's attitude toward the implementation of change in project management techniques.
- **Agency staff experience.** The average number of years of experience of the agency staff committed to the project.

C.7 Factor Appropriateness Ratings Sheets

This section presents the factor appropriateness ratings sheets, which are based on expert input to the research process. Please refer to the final research report for NCHRP Project 10-83, published as *NCHRP Web-Only Document 212*, for a full explanation of the data collection and analysis method used to produce these ratings sheets. There are 10 "sheets" (presented as Tables C2 through C11), one for each selection factor. Each sheet presents ratings of different combinations of selection factor categories and QAOs.

Table C2 shows the appropriateness ratings for combinations of the five QAOs with the three categories (fully staffed, moderately staffed, and minimally staffed) of the availability of agency project staff selection factor:

- If a full staff is available for a project, as compared to typical past projects, the Deterministic QAO is appropriate because it requires a large staff to manage the day-to-day quality needs of the project: inspection, observation, materials testing, and so forth. The Acceptance QAO is rated as a fatal flaw in

Table C2. Appropriateness ratings of QAOs for various categories of agency project staff availability.

Selection factor category	Deterministic	Assurance	Variable	Oversight	Acceptance
Availability of agency project staff					
Fully staffed	++	+	+	+	x
Moderately staffed	–	+	+	+	–
Minimally staffed	x	–	+	++	++

this case because these resources will be underutilized due to the fact that the Acceptance QAO shifts the bulk of the quality responsibilities away from the agency.

- A moderately staffed project, as compared to typical projects, is best suited to the Assurance, Variable, and Oversight QAOs. Selecting which of these three to implement in a moderately staffed project is dependent on the goals and other requirements of the project.
- Deterministic and Acceptance QAOs are best suited for opposite extreme ends of the agency project staff availability spectrum.
- Acceptance and Oversight QAOs are both most appropriate for a project that has minimal staff, while the Deterministic QAO is a fatal flaw. A minimally staffed project doesn't allow agency project staff the time to manage the day-to-day quality needs of a project, which is exactly the use for both the Oversight and Acceptance QAOs.

Table C3 shows the appropriateness ratings for combinations of the five QAOs with the three categories (low, moderate, and high) of the trust between agency and industry selection factor:

- As the amount of quality responsibility shifts away from the agency, the amount of collaboration among all the project team members increases. This is directly reflected in the amount of trust that is needed between the agency and industry.
- The Acceptance QAO shifts the largest amount of quality responsibility away from the agency. Without trust between the agency and the industry, it is difficult to implement the Acceptance QAO, which is why it is a fatal flaw.
- All levels of trust are appropriate for the Deterministic QAO; however, it is the only one that is highly appropriate for a low level of trust because the agency is responsible for all elements of quality, requiring the rest of the project team to react to the agency.

Table C4 shows the appropriateness ratings for combinations of the five QAOs with the three categories (low, medium, and high) of the industry ability to manage its own quality selection factor:

- When shifting responsibility for quality away from the agency, it is critical that the party receiving the responsibility has the ability to successfully meet the responsibility. Ensuring this could require additional training, education, and/or resources on the part of the party receiving the new responsibility.
- The "industry" in this selection factor is meant to be the local design, consulting, and/or contracting community.
- Additional requirements or qualifications may need to be included in the RFP to ensure that the parties proposing on the project can manage the level of quality responsibility successfully.
- As the quality responsibility shifts away from the agency, the importance of succinctly stating the quality requirements in the RFP, specification, and contract documents increases.

Table C3. Appropriateness ratings of QAOs for various categories of trust between agency and industry.

Selection factor category	Deterministic	Assurance	Variable	Oversight	Acceptance
Trust between agency and industry					
Low	++	+	+	–	x
Moderate	+	+	+	+	+
High	+	++	++	++	++

Table C4. Appropriateness ratings of QAOs for various categories of industry ability to manage its own quality.

Selection factor category	Deterministic	Assurance	Variable	Oversight	Acceptance
Industry ability to manage its own quality					
Low	++	+	+	–	x
Medium	+	+	+	+	+
High	–*	+	+	++	++

*Considered in conjunction with the other factors as the research did not reach statistical significance on this rating.

Table C5 shows the appropriateness ratings for combinations of the five QAOs with the four categories (DBB, DB, CMGC, and PPP) of the project delivery method selection factor:

- As the amount of project responsibility shifts away from the agency—i.e., DBB to PPP—the amount of project quality responsibility shifts away from the agency, from the Deterministic QAO to the Acceptance QAO, allowing both the project responsibilities and the quality responsibilities to remain in sync.
- The fatal flaw rating corresponds to the implementation of the Deterministic QAO on a PPP project, because the Deterministic QAO requires the agency to retain all QA control. However, in PPP projects, almost all QA over the project shifts away from the agency to the concessionaire.
- DB shifts much of the project responsibility to the design builder at an early stage of the project. In order for the design builder to most effectively manage the quality of the work, the majority of the quality responsibilities need to be shifted as well; this is why the Oversight QAO is most appropriate.
- DB is least appropriate for the Deterministic and Assurance QAOs because the amount of project responsibility shifted to the design builder does not match the amount of quality responsibility that is shifted. However, the Assurance QAO has been used on DB projects because of the discomfort some agencies feel with transferring so much project and quality responsibility to one design builder. This can stem from an agency's inexperience in DB and/or alternative project QAOs.

Table C6 shows the appropriateness ratings for combinations of the five QAOs with the five categories (<$10M, $10M–$50M, $50M–$500M, $500M–$2B, and >$2B) of the project size selection factor:

- As project size increases, the appropriate QAOs shift from Deterministic toward Acceptance. As a project becomes larger in size the complexity increases, the need for agency resources increases, and the risk also increases. Increasing size most frequently requires the agency to shift some of the agency quality responsibility to other project participants.
- The Deterministic QAO is rated as a fatal flaw for projects over $500 million primarily because of the inherent complexity of such projects, the requirement for expertise outside of the agency, and the amount of risk on the project. Additionally, the Deterministic QAO is agency staff intensive. As a project grows in size, the demand for agency resources grows.

Table C5. Appropriateness ratings of QAOs for various categories of project delivery method.

Selection factor category	Deterministic	Assurance	Variable	Oversight	Acceptance
Project delivery method					
DBB	++	+	+	+*	–
DB	–	–	+	++	–
CMGC	–	+	+	++	+
PPP	x	–	–	+	++

*Considered in conjunction with the other factors as the research did not reach statistical significance on this rating.

Table C6. Appropriateness ratings of QAOs for various categories of project size.

Selection factor category	Deterministic	Assurance	Variable	Oversight	Acceptance
Project size					
<$10M	++	++	+	+*	–
$10M–$50M	++	++	+	+	+
$50M–$500M	–	+	+	++	++*
$500M–$2B	x	–	+	++*	++
>$2B	x	–	+	++*	++

*Considered in conjunction with the other factors as the research did not reach statistical significance on this rating.

- Acceptance is not appropriate for projects under $10 million. The primary reason is that these projects are "standard," and it would not be worth creating the infrastructure to support a non-standard Acceptance QAO. However, if the agency already has ability to implement the Acceptance model, has past experience with the Acceptance QAO, and has the infrastructure in place to manage the Acceptance QAO, there is nothing prohibiting the Acceptance QAO from being implemented on projects under $10 million.
- Assurance is not appropriate for projects over $500 million because it does not adequately meet the needs associated with the inherent complexity of such a project and the need to allocate risk to different parties on large projects.
- The Variable QAO is flexible and can be appropriate for all project sizes.

Table C7 shows the appropriateness ratings for combinations of the five QAOs with the five categories (all, some acceptance and some QC, some acceptance, some QC, and none) of the shifting quality assurance risk away from the agency selection factor:

- The categories of shifting the quality responsibility away from the agency essentially track exactly with the definitions of the fundamental QAOs. For example, by definition, the Deterministic QAO assigns all QA to the agency. It is the equivalent to shifting none of the quality risk away from the agency.
- The Deterministic, Assurance, and Variable QAOs still have the agency managing aspects of the day-to-day quality needs of the project. As a result, each of them is a fatal flaw if the agency desires to shift all quality responsibility.
- The Oversight and Acceptance QAOs shift, at a minimum, the day-to-day management of quality away from the agency; therefore, if the agency desires to shift none of the quality responsibility to other project team members, then each of these QAOs is a fatal flaw.
- Assurance and Variable QAOs shift at least some of the project quality responsibility away from the agency;

Table C7. Appropriateness ratings of QAOs for various categories of shifting quality assurance risk away from the agency.

Selection factor category	Deterministic	Assurance	Variable	Oversight	Acceptance
Shift quality responsibility away from the agency					
All	x	x	x	++	++
Some acceptance and some QC	–	–	++	++	+
Some acceptance	–*	–	+	++	+*
Some QC	+*	+	+	++	x
None	++	–	–	x	x

*Considered in conjunction with the other factors as the research did not reach statistical significance on this rating.

Table C8. Appropriateness ratings of QAOs for various categories of project complexity.

Selection factor category	Deterministic	Assurance	Variable	Oversight	Acceptance
Project complexity					
Low	++	+	+	+	+
Medium	+	+	+	+*	+
High	–	+	++	++	++

*Considered in conjunction with the other factors as the research did not reach statistical significance on this rating.

therefore, if an agency goal is to retain all quality responsibility, then the Assurance and Variable QAOs are less appropriate.

Table C8 shows the appropriateness ratings for combinations of the five QAOs with the three categories (low, medium, and high) of the project complexity selection factor:

- As project complexity increases, the amount of expertise needed from outside the agency tends to increase. As a result, the agency no longer has the expertise required to ensure project quality. As the complexity of a project increases, the most appropriate QAO shifts from Deterministic toward Acceptance.
- A low-complexity project is most appropriate for a Deterministic QAO because the expertise needed typically resides in the agency.
- A highly complex project will require more and more expertise from outside of the agency, resulting in the agency needing to be able to communicate the quality requirements effectively.
- If a project has only a few complex items, it may be that the QAO for those elements is different from QAO for the remainder of the project that is more along the lines of a typical project (such as special materials or a construction sequencing item).

Table C9 shows the appropriateness ratings for combinations of the five QAOs with the three categories (low, medium, and high) of the schedule sensitivity selection factor:

- Schedule sensitivity is not a decisive factor in the selection of a project QAO unless the schedule is highly sensitive to delays resulting from quality coordination issues among varying members of the project team.
- Schedule sensitivity specifically comes into play when work is being conducted around the clock, and there is no float in the schedule.
- Schedule sensitivity can be reduced if a good quality plan and communication plan has been agreed to among all parties involved in the day-to-day quality of the project (design and construction).

Table C10 shows the appropriateness ratings for combinations of the five QAOs with the three categories (traditional, moderate, and progressive) of the agency culture selection factor:

- Regardless of the project QAO, the agency provides the leadership for the project and ultimately dictates the culture of the project. The agency culture has to be aligned with the project QAO. The more alternative a project QAO is (as compared to the traditional Deterministic QAO), the greater the need for a progressive agency culture.

Table C9. Appropriateness ratings of QAOs for various categories of schedule sensitivity.

Selection factor category	Deterministic	Assurance	Variable	Oversight	Acceptance
Schedule sensitivity					
Low	+	+	+	+	+
Medium	–	+	+	+	+
High	–	+	+	++	++

Table C10. Appropriateness ratings of QAOs for various categories of agency culture.

Selection factor category	Deterministic	Assurance	Variable	Oversight	Acceptance
Agency culture					
Traditional	++	+	–	–	–
Moderate	+	+	+	+	+
Progressive	–	+	+	++	++

- The agency culture cannot be manifested by only a few of the project staff; it has to be instituted throughout the agency. If the project team is progressive but the executive level of the agency is traditional, it will be difficult for the project team to implement any alternative QAOs.
- A moderate culture indicates that the agency is not conversant in alternative QAOs but is willing to try new ideas tested out by other agencies. Because there is some acceptance of new ideas, a moderate culture is appropriate for all QAOs.

Table C11 shows the appropriateness ratings for combinations of the five QAOs with the four categories (<5 years, 5–10 years, 10–20 years, and >20 years) of the agency project staff experience selection factor:

- The most appropriate level of experience for all QAOs is 10 to 20 years. However, the experience is used in different ways across the different QAOs. The Deterministic QAO applies the experience to do more effective inspections whereas the Acceptance QAO applies the experience to create the quality requirement details, identify flaws in the quality plans, and resolve any quality issues that may arise.
- Fewer than 5 years of experience is not appropriate for the Oversight and Acceptance QAOs because both of these organizations require the agency staff to be well versed in quality for all elements of the project. This experience can only be achieved through time in the field.
- The experience levels shown in Table C11 represent the average for all of the agency staff. In general, there needs to be a combination of more experienced staff with less experienced staff, which is why the 10-to-20-year experience level is the most appropriate for all QAOs.
- The experience considered in this selection factor is primarily project or field experience. When shifting to a more alternative QAO, such as Oversight or Acceptance, this experience may need to be complemented with training on how to manage the quality process at a higher level, away from the day-to-day level of management.
- As the amount of quality responsibility shifts to other project participants, the role of the agency shifts toward a role of managing requirements. This shift can be difficult for some agency staff and can require additional training, education, and/or resources for them to successfully take on the new role.

Table C11. Appropriateness ratings of QAOs for various categories of agency project staff experience.

Selection factor category	Deterministic	Assurance	Variable	Oversight	Acceptance
Agency project staff experience					
<5 years	+	+	+	–	–*
5–10 years	+	+	+	+	+
10–20 years	++*	++	++	++	++
>20 years	+	+	++	++	++

*Considered in conjunction with the other factors as the research did not reach statistical significance on this rating.

Primary factor categories					
Agency staff availability	☐ Minimal	☐ Moderate	☐ Full		
Trust between the agency and the industry	☐ Low	☐ Moderate	☐ High		
Industry's ability to manage its own quality	☐ Low	☐ Medium	☐ High		
Project delivery method	☐ DBB	☐ DB	☐ CMGC	☐ PPP	
Project size	☐ <$10M	☐ $10M–$50M	☐ $50M–$500M	☐ $500M–$2B	☐ >$2B
Shift the quality responsibility away from the agency	☐ None	☐ Some QC	☐ Some Acceptance	☐ Some QC and Some Acceptance	☐ All
Secondary factor categories					
Project complexity	☐ Low	☐ Medium	☐ High		
Project schedule sensitivity	☐ Low	☐ Medium	☐ High		
Agency culture	☐ Traditional	☐ Moderate	☐ Progressive		
Agency staff experience	☐ <5 years	☐ 5–10 years	☐ 10–20 years	☐ >20 years	

Figure C5. Project QAO selection factor profile form.

Primary Selection Factors	Deterministic	Assurance	Variable	Oversight	Acceptance
Agency staff availability					
Trust between agency and industry					
Industry's ability to manage its own quality					
Project delivery method					
Project size					
Shift the quality responsibility away from the agency					
Tally of primary selection factor results					
Secondary Selection Factors	**Deterministic**	**Assurance**	**Variable**	**Oversight**	**Acceptance**
Project complexity					
Project schedule sensitivity					
Agency culture					
Agency staff experience					
Tally of secondary selection factor results					
Rating key: x Fatal Flaw – Least Appropriate + Appropriate ++ Most Appropriate					

Figure C6. Project QAO analysis form.

C.8 Project QAO Selection Tool Forms

Project QAO Selection Factor Profile Form

Figure C5 presents the project QAO selection factor profile form (an electronic version of this form is available for download by searching on *NCHRP Report 808* on the TRB website). Select the specific category for each selection factor that applies to your project. Factor definitions are included in Section C.6.

Project QAO Analysis Form

Using the category of each factor that applies to your project, look up the value for each factor in the factor appropriateness ratings sheets provided in Section C.7 (see Tables C2 through C11) and fill in the corresponding ratings in the project QAO analysis form shown in Figure C6 (an electronic version of this form is available for download by searching on *NCHRP Report 808* on the TRB website). If you are not able to select a project QAO using only the primary selection factors, then continue with the same process for the secondary selection factors.

C.9 Appendix C Bibliography

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Abbreviations, Acronyms, and Initialisms

ACEC	American Council of Engineering Companies
ADOT	Arizona Department of Transportation
AGC	Association of General Contractors
AQS	Advanced quality system
ASQ	American Society for Quality
ATC	Alternative Technical Concept
Caltrans	California Department of Transportation
CCEI	Consultant Construction Engineering and Inspection
CEI	Construction Engineering Inspector
CMGC	Construction manager/general contractor
DB	Design-build
DBB	Design-bid-build
DQM	Design quality manager
ECI	Early contractor involvement
EDC	"Every Day Counts"
EDMS	Electronic data management system
ELVIS	Electronic Laboratory Verification Information System
FDOT	Florida Department of Transportation
GDOT	Georgia Department of Transportation
GMP	Guaranteed maximum price
GPS	Global positioning system
HMAC	Hot-mixed asphaltic cement
IA	Independent assurance
IIA	Institute of Internal Auditors
IFB	Invitation for bid
IRI	International roughness index
ISO	International Organization of Standardization
ITP	Instructions to Proposers
MIDOT	Michigan Department of Transportation
MnDOT	Minnesota Department of Transportation
NSPE	National Society of Professional Engineers
OBDP	Oregon Bridge Delivery Partners
OCEI	Oversight Construction Engineering Inspector
ODOT	Oregon Department of Transportation
PAE	Pre-approved element
PDCA	Plan-Do-Check-Act
PDI	Pavement distress index

PDT	Project delivery team
PPP	Public-private partnership
RTD	Regional Transportation District
QA	Quality assurance
QAO	Quality assurance organization
QAS	Quality Assurance System
QC	Quality control
QCS	Quality Control System
QM	Quality management
QMS	Quality management system
RFP	Request for proposals
RFQ	Request for qualifications
RM	Requirements management
RMS	Resident Management System
RTD	Regional Transportation District (Denver, CO)
STA	State transportation agency
TQM	Total Quality Management
TSR	Testing and sampling requirements
TxDOT	Texas Department of Transportation
USACE	U.S. Army Corps of Engineers
UDOT	Utah Department of Transportation
WisDOT	Wisconsin Department of Transportation
WSDOT	Washington State Department of Transportation

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

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