EFFECTIVE IMPLEMENTATION OF THE
DESIGN-BUILD DELIVERY SYSTEM ON
TRANSPORTATION PROJECTS

Project 08-05
August 2008

Midwest Regional University Transportation Center
College of Engineering
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<td>The use of design-build project delivery systems today is popular for delivering commercial, industrial, and institutional construction projects and is increasingly used on transportation projects. While some states have used design-build to deliver transportation projects for over a decade, others have little to no experience with this method and have not yet established any legislation to use design-build. Design-build has been shown to shorten the duration of a project as compared to the design-bid-build traditional delivery method, together with increasing cost certainty and without sacrificing quality. While these benefits make design-build a very attractive delivery system, its implementation is not always as easy. This report combines the knowledge from existing literature as well as Departments of Transportation (DOTs) from around the United States familiar with design-build to form an overview of the entire implementation process including: passing legislation, choosing appropriate projects, overcoming the barriers specific to design-build, selecting the best design-build team, and conditions for successful implementation. By being aware of the barriers to implementing design-build and how to best deal with them, Departments of Transportation can use this delivery method effectively, taking advantage of its benefits.</td>
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Effective Implementation of the Design-Build Project Delivery System on Transportation Projects

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Prepared for:

Midwest Regional University Transportation Center
August 30, 2008
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EXECUTIVE SUMMARY

The US highway system includes many roads that are now beginning to reach the end of their useful lives and will need to be reconstructed within the next few decades to meet the demand of a growing population in a competitive economy. For over a decade, state transportation agencies have worked to develop innovative project delivery approaches in order to produce projects with shorter durations, lower costs, and increased quality. One such delivery strategy is the design-build delivery system. In this approach, a single entity has absolute accountability for the design and construction of a facility. This is in contrast to the typical design-bid-build delivery system where the designer and builder are responsible under separate contracts.

While previous research has shown design-build to be a promising delivery approach with potential benefits over the typical design-bid-build approach, design-build is inherently a more complex process and can be difficult to implement. The Midwest Regional University Transportation Center (MRUTC) recognized the potential benefits of the design-build system and funded this study in order to assist state Departments of Transportation (DOT) in implementing design-build by documenting the impact of design-build on project quality, cost, and timeliness, as well as small businesses, recommending the appropriate level of design for design-build procurements, identifying barriers to implementation and offering suggestions on how to overcome project delivery issues, and recommending actions that state transportation agencies can take to best implement design-build.

The research was conducted in three phases. A literature review was conducted to find the impacts of using design-build on a transportation construction project. Surveys were sent to state DOTs familiar with design-build to find out how they originally implemented the delivery method and overcame the obstacles associated with utilizing it. Lastly, advisory panel meetings were held to gain the knowledge of members of the transportation construction community.

The research showed that design-build, when used correctly, will yield time and cost benefits without sacrificing quality. Design-build allows parallel processing of activities occurring on different portions of a project while design-bid-build keeps them sequential, it eliminates the need for a second procurement cycle by combining contracting for design and construction contracts, and it produces improved designs that are more constructible and require fewer design fixes through change orders.

Further impacts on small businesses and DOT workforces were researched. It was found that the percentage of design-build project costs going to small businesses was about the same on average as for design-bid-build projects, with only a very small reduction indicated for design-build projects. The survey results also indicated that design-build contracts spread more of the design work among sub-consultants than comparable design-bid-build contracts, which should be a positive feature for small business
enterprises. DOTs utilizing design-build showed few negatives effects from its use. While some DOT engineers found role changes from design work to project oversight, their core competencies did not change since, at most, design-build is used to deliver only ten percent of DOT projects. Furthermore, it was found that the overall DOT staff of DOTs using design-build did not decrease due to its use.

The benefits of the design-build delivery system remain unattainable until legislation is passed allowing its use. Getting the legislation “into the books” is what makes design-build a reality and is dependent on two interrelated processes – the writing of the legislation which includes word choice and which specific items to include and the approval process which needs to be done in a way that convinces the legislators and, at the same time, satisfies all groups or associations that have an interest in design-build legislation. Of the states that have passed design-build legislation, certain states include more stringent language explicitly stating their guidelines for the use of design-build while other states use broader language allowing more freedom in the use of design-build.

The process of getting the design-build legislation passed can be difficult and varies from state to state. There will be many interested parties from the industry including the Associated General Contractors of America (AGC), the American Road and Transportation Builders Association (ARTBA), and the American Council of Engineering Companies (ACEC) that will want their own specific language to be use in the legislation that will benefit them the most. In general, this process is one of communication and compromise.

While the design-build project delivery system is an attractive approach, there are several barriers to implementation including fear of change, lack of resources, creating new design-build documents, writing a good request for proposals (RFP) and scope, and managing quality and risk.

The barriers of fear of change, lack of resources, and the need to create new design-build documents are interrelated. It is important to remember that when state DOTs were formed, the delivery system used was design-bid-build. Therefore, the DOTs’ working and management philosophies were set up to delivery transportation projects using this delivery system. It is natural to feel trepidation when the standard way of doing business changes. The best strategies to overcome these barriers are leadership, education, and the use of outside counsel. With an organization as large as a DOT, perceptions of change are going to vary greatly (i.e. some people are willing to accept new ideas, others are not). With any change, champions are needed to implement new technology and practices.

Education can take the form of formal training or communication with others who have already implemented design-build. Formal training options include researching design-build reports and attending university courses and design-build workshops or conferences. Communication can be with other owners, but it may be beneficial to also talk with anyone involved on a design-build project whether their experience was positive.
or negative. It would be more beneficial to an owner of a prospective project to talk with those involved on a project similar in size and scope.

Writing a good RFP including a thorough scope is one of the most important success factors on a design-build project. For the design-build approach to be used successfully, the owner must clearly define the needs and requirements of the project so that the design-build teams submitting proposals understand the requirements. It is imperative that the owner issues comprehensive scope-of-work information including detailed space and equipment requirements, site surveys, soil borings, outline specifications, budget parameters, and scheduling requirements. There is only one chance on a design-build project for the owner to identify the work’s scope and project requirements. Any changes to the specifications after the contract is signed will result in time and cost changes on the project. Therefore, it is recommended that owners spend double the time and money that they would otherwise expect to spend on a design-bid-build project.

On a design-build project, the quality of a completed facility is essentially defined by the quality of the design. A quality management plan is of greater importance on a design-build project than a design-bid-build project and should be established prior to awarding the design-build contract. In general, it is a good strategy for the project owner to be specific in its requirements of the design-builder’s personnel as well as the past experiences of the design-build teams. A high quality design-build team is the first step to a high quality design-build project, and by being specific in its RFP, an owner will minimize its chances of soliciting the wrong team. The quality issues do not end with the selection of a design-build team. Consequently, an articulated quality management plan detailing all the quality control and quality assurance responsibilities throughout the life of the project should be adopted. Since the design is the main determinant of a quality facility many owners decide to remain involved in the design process by retaining the responsibility for design QA. In general, those best able to manage the quality should be given the responsibility.

Risk is an inherent part of the construction industry and will be present on every project, design-build or otherwise. In general, there are three strategies involved in risk management – eliminating risk, transferring risk, or accepting risk. The most important risk management strategy is to assign risk to those who can best manage it. There are currently standardized design-build contracts available to owners looking to use design-build that assign risk based on proper risk management strategies.

The Federal Highway Administration summarized the conditions that increase the overall quality of a design-build project, when present. The table with the results is presented below.
### Conditions Affecting Overall Project Quality

<table>
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<tr>
<th>Project/Contract Characteristic</th>
<th>Overall Sponsor Satisfaction</th>
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<tr>
<td></td>
<td>Lower</td>
</tr>
<tr>
<td>Procurement Method</td>
<td>Low Bid</td>
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<tr>
<td>Project Type</td>
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<tr>
<td>Project Size</td>
<td>Smaller</td>
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<tr>
<td>% of Design Completed at Award</td>
<td>Higher</td>
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The table shows that larger, more complex projects lead to a better overall satisfaction with the design-build delivery method. In addition to the type and size of the project, the percentage of preliminary design completed prior to the awarding of the design-build contract as well as the selection process used to determine the winning design-build team greatly affect the outcome of the design-build project. Preliminary design should be as low as possible to allow the design-builder the most room for innovation. Furthermore, the design-builder should be selected using the “Best Value” approach, which is the most objective method of selecting a design-build team.

By being aware of the barriers to implementation of design-build projects and the best practices and conditions for successful implementation presented in this paper, the owner of a transportation project now has a better understanding of the implementation process of such projects using the design-build delivery system. This can assist him in making the decision that will maximize the project’s benefits.
1.0 Introduction
The US highway system includes many roads that are now beginning to reach the end of their useful lives and will need to be reconstructed within the next few decades to meet the demand of a growing population in a competitive economy. When the majority of the highway system was constructed in the 1960’s and 1970’s, the only project delivery system being utilized was the traditional design-bid-build system. In the design-bid-build delivery system, a project is delivered in three separate phases – design, bidding, and construction. First, the owner designs with its own forces or signs a contract with an architecture/engineering firm to design a facility. After the design is complete, it is made available to contractors to bid on. The bidding stage is complete when the owner selects a contractor. The third phase is the actual construction of the facility.

![Figure 1 – Contractual Agreements in Design-Bid-Build](image)

Today, delivery of states’ improvement programs using traditional design-bid-build processes threatens the regions’ abilities to compete economically with others. Also, as projects become more integrated into political decisions, methods for accelerating delivery become more critical.

According to the Design-Build Effectiveness Study (2006) published by the Federal Highway Administration (FHWA), “Since 1990, a number of transportation agencies have been experimenting with a wide variety of innovative project delivery strategies aimed at lowering the costs and time to produce highway construction and rehabilitation projects, while maintaining or improving project quality.” One such delivery strategy among several that has been gaining recognition steadily over the past decade is the
design-build delivery system. The concept of design-build is not new. It is based off the Master Builder construction approach that has been used since the Mesopotamian civilization around 1800 BC. In this approach, a single entity has absolute accountability for the design and construction of a facility. This entity, which consists of a designer and a contractor, is held responsible by the owner under one contract, and both designer and contractor are involved in the project from the start. As shown in Figure 3, the major benefit of this method is that the design phase and the construction phase overlap because the design-build team selection occurs very early in the project, and construction can begin before the final design is complete; sometimes as soon as the preliminary design is done, depending on the project. This implies theoretical time savings. While it has been employed more often in vertical construction, design-build has been used effectively in transportation construction (Gransberg and Molenaar 2007).

Figure 2 – Contractual Agreements in Design-Build

Figure 3 – Design-Build vs. Design-Bid-Build Timelines (Dr. Keith Molenaar, University of Colorado at Boulder)
The majority of the design-build transportation projects have come from just a few state Departments of Transportation (DOT), namely the Florida DOT, Michigan DOT, Ohio DOT, and Pennsylvania DOT. However, more than half of the other state DOTs have some experience utilizing design-build, yet much of this experience is limited. In addition the FHWA has published its Design-Build Effectiveness Study and reported to the US Congress on the design-build delivery system and passed rules regarding its use. If employing design-build yields cost and time benefits, and quality is not compromised as previous research has shown, then there should be reasons for why this project delivery method has not been utilized by more DOTs and in greater amounts. While design-build has been convincingly shown through previous research to produce benefits, there is a significant list of issues that must be dealt with in order to successfully implement it.

Figure 4 – States’ Experiences with Design-Build (Federal Highway Administration 2006)

1.1 Forms of Design-Build
There are essentially two different ways to get the design-build delivery process underway in regards to the team selection.
1.1.1 AE/Contractor Selected as One Entity

Many design firms and contractors team up with each other to form one entity for the sole purpose of utilizing the design-build delivery system. This was done, originally, in order to ensure competence to owners looking for an alternative to the traditional design-bid-build delivery method in vertical construction and to setup an efficient and viable economic scheme for the two companies. Now with increased use of design-build in transportation construction, design firms and contractors specialized in transportation construction have begun to do the same thing. So when the owner, typically the DOT, looks to select a team for a project, it looks at the strengths and weaknesses of the single entity comprised of the partnered design firm and contractor as opposed to pairing up the two separately.

The partnership defined above can further be clarified into either a joint, contractor-led, or designer-led entity. A joint entity is one where the design firm and the contractor are around the same size in terms of employees and earnings. In a joint entity, the design firm and the contractor look to find the best counterpart possible, which is oftentimes the most successful and largest firm that is willing to partner with the other; although, characteristics other than employment size and company worth are sometimes taken into account. Such characteristics include the location of the companies and how a design firm’s particular design philosophy fits with the contractor’s strengths and resources.

A contractor-led entity is one where a larger contractor picks up a smaller design firm and partners with it. In this partnership, the design firm benefits because they get absorbed into the contractor, opening up the possibility for larger projects and, thus, larger profits that they might not have been able to get otherwise. The contractor benefits because the design firm becomes an in-house design team. The in-house design team will then design with the strengths and the resources of the contractor in mind thus minimizing costs.

A designer-led entity is rare and typically occurs when an A/E firm creates a sister corporation to be its construction division. The construction company uses the same
employees and workspace as the A/E firm but allows the A/E firm to enter into a design-build contract with the owner of a project. After the contract is signed, the A/E firm’s construction company subcontracts out 100% of the construction work to a general contractor, who, essentially, becomes the real design-build teammate. All the construction work goes through the A/E firm’s construction company to the general contractor who is free to further subcontract out the work (Friedlander 1996).

1.1.2 Selecting the Design Firm and Contractor Separately
Instead of selecting an already partnered entity, an owner might want to select the design firm and the contractor separately and then partner them into one entity. This might be advantageous if the owner is very knowledgeable of both the scope of the project as well as the strengths and weaknesses of the potential design firms and contractors. A knowledgeable owner can then make sure it selects the absolute best design firm and contractor for the project.

1.2 When to Use Design-Build
While it would be true to state that design-build can be used to deliver any project that design-bid-build can deliver, some projects may be better suited for design-build than others. Design-build might be best used on the following projects:

- Innovative projects
- Complex projects (with complex designs and/or complex staging and traffic control)
- Projects where acceleration is critical (emergencies)
- Packaged projects (several smaller projects combined into a larger program)

1.3 Purpose
This paper intends to show the impacts of utilizing design-build, to list the barriers to implementing design-build as well as offering best practices to overcome these barriers, to describe the legislation that accompanies it, and to list the conditions that increase the success probability of a design-build project.
1.4 Scope
This paper targets state DOTs that are looking to implement design-build. It will help the DOT understand the impacts of using design-build, create the necessary legislation, overcome the barriers to implementation of design-build, and identify the best practices for successful implementation.

1.5 Research Methodology
A literature review was conducted to find the impacts of using design-build on a transportation construction project. Surveys were sent to state DOTs familiar with design-build to find out how they originally implemented the delivery method and overcame the obstacles associated with utilizing it. Furthermore, an advisory panel meeting was held to gain the knowledge of members of the transportation construction community.

1.6 Organization
The impacts of using design-build can be found in Section 2. It looks at the effects of design-build on project duration, cost, and quality. Other topics such as design-build’s effect on small businesses and public workforces are also examined. Section 3 describes what to include in design-build legislation and how to get that legislation passed. Section 4 gives the barriers to implementing design-build and the best practices to overcome these barriers. Section 5 presents the conditions that increase the probability of a successful design-build project and details the design-build team selection process. Finally, a conclusion can be found in Section 6.
2.0 Impacts of Using Design-Build

There are many impacts upon using design-build. These impacts have been researched extensively, and the results of many studies are presented below. Before using design-build, it is important to get familiar with its the benefits it can offer, as well as its disadvantages. Figure 5, below, shows the relative importance of the different factors considered by the DOT when deciding whether to use design-build. Following Figure 5, Table 1 shows the benefits and concerns of the major parties involved in a transportation construction project.

![Figure 5 - Relative Importance of Factors Considered in Deciding Whether to Use Design-Build (Scale: 1 – Unimportant; 6 – Extremely Important) (Federal Highway Administration 2006)](image)

<table>
<thead>
<tr>
<th>Client improvements</th>
<th>Architect/engineer benefits</th>
<th>Contractor benefits</th>
<th>Designer benefits</th>
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<tr>
<td>Foster innovation solutions</td>
<td>Reduces total project delivery time</td>
<td>Single source of responsibility</td>
<td>More control over in-place project quality</td>
</tr>
<tr>
<td>Loss of independent professional consultant</td>
<td>Lowered number of formal change orders</td>
<td>Reduces clarity of liability</td>
<td>Improves designer business performance</td>
</tr>
<tr>
<td>Lack of flexibility to respond to changing client needs</td>
<td>Lowered total project costs</td>
<td>Reduces response time to change requests</td>
<td>Reduces claims</td>
</tr>
<tr>
<td>System's design and construction needs</td>
<td></td>
<td></td>
<td>Improves interdisciplinary design decisions</td>
</tr>
<tr>
<td>Substandard materials</td>
<td></td>
<td></td>
<td>Rewards innovation</td>
</tr>
<tr>
<td>Inspection services</td>
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*(a) Benefits*

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<tr>
<th>Limitation of design/build as a project delivery method</th>
<th>Need for determination of project requirements</th>
<th>Reluctance, resistance, initial early difficulty in joining a (joint venture) construction team</th>
<th>Impact of changes Liability</th>
</tr>
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<tbody>
<tr>
<td>Inability to shift responsibility for errors and omissions</td>
<td>Increased obligation to owner</td>
<td>Complexity of design/build may make organizing and assigning roles within design/build entity difficult</td>
<td>Extended warranties</td>
</tr>
<tr>
<td>Costly bid preparations that involve several alternatives that may not mature into contract</td>
<td></td>
<td>Costly bid preparations that involve several alternatives that may not mature into contract</td>
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*(b) Concerns*
2.1 Impact on Time

From Figure 5, it is clear that the main reason that the DOT would be interested in using design-build is the perceived impact on the duration of a project. In design-build, the fact that the contractor is involved from the onset of the project yields many time saving benefits to the owner. It allows parallel processing of activities occurring on different portions of a project while design-bid-build keeps them sequential, it eliminates the need for a second procurement cycle by combining contracting for design and construction contracts, and it produces improved designs that are more constructible and require fewer design fixes through change orders (Federal Highway Administration 2006).

In order to quantify the perceived time saving of using design-build, the Federal Highway Administration gathered data from a number of actual design-build projects and found that there was an average drop of 1 percent between planned and actual total project duration. The study also looked at differences in project duration between design-bid and design-bid-build by comparing data from similar projects that used the two different delivery approaches. The results showed a 9 percent difference in total project duration and a 13 percent difference in construction phase duration with the design-build projects having the shorter durations. Personnel involved on the projects were surveyed and perceived that design-build projects take more time to set up and procure, but once awarded, require less time for the contracting agency to administer in comparison to similar design-bid-build projects.

The results found in The Design-build Effectiveness Study are not uncommon. “In its experience with its first ten DB projects, the Maryland State Highway Administration found it reduced the average time for design and construction by approximately one year, as compared to the traditional design-bid-build method” (Science Applications International Corporation 2003). In response to a survey question on the time impact of using design-build given in 2007, the Minnesota DOT (MNDOT) wrote:
On our $238 million TH 212 project, design was completed within approximately 12 months. It would have taken several years to complete the design using our traditional approach. On our ROC 52 project, design was estimate[d] to take 30 months using design-bid-build, but was reduced to 12 months with design-build. ROC 52 was opened 2 years ago[,] if this job was a traditional design-bid-build project it would still have several years of construction remaining. On TH 10/32, the design and construction of an interchange was completed in one-year, compared to 2-years using our traditional approach.

It is undeniable that when used correctly, the design-build delivery approach yields significant time benefits.

2.2 Impact on Cost

The MNDOT put the trouble of quantifying the cost impact of using design-build versus design-bid-build in the following 2007 survey response:

It is impossible to compare the costs of design-build to design-bid-build contracts. There may be costs of design-build that do not occur in design-bid-build (co-housing, quality management, design), but these costs may be offset by items such as inflationary savings by starting construction earlier, allowing more cost-effective designs that match the contractors assets, lower cost growth, and fewer change orders. The only way to compare it would be to have side-by-side identical projects, but even then you are subject to market conditions that would impact the bid of both projects.

While it may be difficult to directly compare the cost impact of design-build in respect to design-bid-build projects, certain inferences can be made about cost savings from the standpoint of time savings. A report from the Science Applications International Corporation (2003) states:

With respect to design-build projects, the conventional wisdom is that the dollar cost to the owner appears to be about the same as conventional approaches, but that design-build projects open to the public much sooner. Time, of course, is money and therefore this suggests that indeed there is a considerable saving to the
public in the form of user cost benefits due to significant schedule accelerations resulting from this outsourcing method.

User benefit due to time savings is not the only impact on the costs of a project utilizing the design-build delivery approach. Research has shown that projects using design-build have increased cost certainty compared to those using design-bid-build. “In its experience with its first ten DB projects, the Maryland State Highway Administration found it consistently produced final products with less than 1% in change orders – significantly less than its design-bid-build program as a whole (Science Applications International Corporation 2003). Project cost certainty/early cost establishment is very important to public infrastructure projects as it effectively impacts the number of capital projects an agency can award in a given year within its established budget. For instance, an early study of the FLDOT first series of DB projects found that these projects were awarded at a 4.5% premium above low bid but only experienced 2% cost growth. Whereas, Florida DOT DBB projects experienced 8.5% cost growth from the low bid award price. Thus, there was a marginal 2% cost savings on the DB projects. Another important aspect is the effect on the Florida DOT’s ability to manage its capital improvements budget. Under the traditional system, it would have to set aside 8.5% of each project’s authorized budget to pay for cost growth due to quantity overruns and change orders. Its DB experience would require it to only set aside 2%. Thus, is could award a greater percentage of its authorized budget which presumably would result in a larger number of total infrastructure projects being built in a given fiscal year and a more efficient use of available capital (Gransberg and Villarreal 2002).

2.3 Impact on Quality
The impact of using design-build on the quality of a facility is the most troublesome impact to compare to design-bid-build because the major studies comparing design-build to design-bid-build used subjective criteria when evaluating the difference. Therefore, the results of these studies depend on the surveyed owners’ perceptions and not necessarily on the actual quality.
While it is subjective in nature, owner satisfaction with the outcome and process of project delivery is one of the primary ways to measure the quality of different approaches. Out of 61 owners surveyed on the change in quality between design build and design-bid-build delivery systems, the mean and median responses were 0% and the standard deviation was 2.1% (Federal Highway Administration 2006). Hence, there was no notable change in the quality from this study.

In *Selecting Project Delivery Systems* (1999), Sanvido and Konchar compared design-build, design-bid-build, and construction management at risk. They surveyed a number of owners regarding their satisfaction in seven categories in order to compare the quality between the delivery systems. The categories used were ease of startup; lack of call backs; low operation and maintenance cost; quality of envelope, roof, structure, and foundation; quality of interior space and layout; quality of environment; and quality of process equipment and layout. Contrary to the study by the FHWA, they found that quality, on average, was higher in every category when using design-build.

Again, it is important to keep in mind that these results are subjective in nature. Design-build seems to have the potential of increasing the overall quality of project compared to design-bid-build, but design-build inherently is a harder system to implement with regards to quality assurance. So if strategies are not employed to specifically manage risk, there remains the possibility of decreased quality.

### 2.4 Impact on DOT Workforce

In 2007, a paper entitled *The Impacts of Design-Build on the Public Workforce* by Gransberg and Molenaar explored what, if any, impact utilizing design-build had on the DOT workforce. The paper's authors surveyed all state DOTs that have utilized design-build in order to look at potential changes in the size and roles of the DOT professional engineering workforce after implementing design-build as well as the possibility of the DOT losing the skills and expertise to conduct essential functions in-house, or to effectively check, evaluate or approve the work of external sources.
The study found that none of the DOTs reduced its professional engineering workforces due to the use of design-build. Furthermore, the roles of the engineers remained mostly the same. When there was a role change, it was found that, typically, “the design staff and construction staff shifted from full-time traditional tasks to oversight of the design-builders’ design and construction tasks. In most cases the workload stayed roughly the same or increased” (Gransberg and Molenaar 2007).

The issue of the DOT losing the skills and expertise to conduct essential functions in-house, or to effectively check, evaluate or approve the work of external sources centers around the perception that when utilizing design-build, the professional engineering staff performs less of the design and construction engineering itself and, instead, contracts out the work. The fear was found to be unwarranted for several reasons. First, from the information presented above, the roles of the engineering workforce do not typically change when using design-build. Therefore, the skills developed should not change. Second, it was found that only about ten percent of all the construction projects from DOTs familiar with design-build are delivered using design-build (Gransberg and Molenaar, 2007). Thus, according to Gransberg and Molenaar, the traditional professional engineering workforce is required to deliver the remaining ninety percent of the projects using traditional contracting methods. It is in these projects delivered using traditional delivery systems that the DOT engineering workforce, especially entry-level engineers, can develop their core competencies. This skill set then can be applied to utilizing design-build in the future.

2.5 Impact on Small Businesses

The advent of design-build project delivery has raised concerns by some that small firms may be unable to participate on design-build teams, particularly as the design-build team lead or prime contractor, due to the increased functional scope and scale of many design-build contracts, more stringent qualification requirements, and/or higher bonding requirements (Federal Highway Administration 2006).
The Federal Highway Administration (2006) distributed a design-build program survey among a number of contracting agencies. Agency respondents to the survey indicated that the percentage of design-build project costs going to small businesses was about the same on average as for design-bid-build projects, with only a very small reduction indicated for design-build projects. The survey results also indicated that design-build contracts spread more of the design work among sub-consultants than comparable design-bid-build contracts, which should be a positive feature for small business enterprises.

3.0 Legislation

The benefits of the design-build delivery system remain unattainable until legislation is passed allowing its use. Getting the legislation “into the books” is what makes design-build a reality and is dependent on two interrelated processes – the writing of the legislation which includes word choice and which specific items to include and the approval process which needs to be done in a way that convinces the legislators and, at the same time, satisfies all groups or associations that have an interest in design-build legislation and its application in transportation projects such as the Associated General Contractors of America (AGC), the American Road and Transportation Builders Association (ARTBA), and the American Council Of Engineering Companies (ACEC) among others.

These processes can take a long time as the legislative language is continually revised until the greatest number of stakeholders is satisfied. Furthermore, it is important to note that, while there have been many states that have already passed legislation allowing the use of design-build, no two states have the exact same legislation. Certain states include more stringent language explicitly stating their guidelines for the use of design-build while other states use broader language allowing more freedom in the use of design-build. The latter of the two allows more options for the particular state DOT on when to use design-build and is more dependent on the judgment of the DOT to select a project that will most benefit from its use. At the same time, the potential of a DOT to select an inappropriate project to be delivered using design-build increases as the language used in
the legislation becomes broader; this assumes that the writers of the legislation are familiar with design-build, its benefits, and the types of projects that design-build should be used on.

The Wisconsin DOT (WisDOT) summarized the status of design-build legislation around the United States in its unpublished *Design-Build Workgroup Final Report* from October of 2004. While there certainly has been progress in developing design-build legislation in states since 2004, the report does give a good idea of how the legislation ranges and what certain states chose to include in their legislation. After the information from the summary is presented, an outline adapted from the Arizona DOT’s (AZDOT) and the Minnesota DOT's (MNDOT) legislation will be given showing the items that are commonly included in more detailed legislation.

The WisDOT report states legislation is limited to “brief assignments of authority” in Arkansas, Delaware, Maryland, New Hampshire, New Jersey, Ohio, Washington, and Wisconsin. Of these states, Arkansas, Louisiana, and Wisconsin legislation permit pilot projects rather than establish permanent procedures. Other states opt for “detailed codified requirements” which are frequently contained in separate rules developed by the states’ transportation agencies.

In general, design-build legislation usually identifies the number of projects the DOT is authorized to use design-build on and sets a minimum value, maximum value, or both on design-build projects. The number of projects can be limited in a number of ways. The number of design-build projects can be explicitly stated in the legislation as either a number of projects in a year or, if the legislation is not permanent, a number of pilot projects over the lifetime of the temporary legislation. The number of design-build projects can also be limited by setting a maximum number of projects based on a percentage of either total projects or total spending by the DOT in the fiscal year. When limiting the use of design-build based on project value, states usually set a minimum value on projects of around $50 million. This is because design-build’s benefits are more fully realized on larger projects. Some states, however, also set a maximum value on
design-build projects of around $5 million. This is done more often on pilot projects so that potential problems are minimized. Maximum values are also established in order to give smaller design firms and contractors the opportunity to participate on design-build projects.

In all state legislation, laws on the design-build team selection process are included. This can range from simply stating that the DOT will receive solicited and unsolicited proposals to detailing the two-phase Request for Qualifications (RFQ) plus Request for Proposals (RFP) team selection process that most states with design-build legislation use. For those states that use this selection process, further legislation is oftentimes included on the review committee, the use of short listing, and how the winning team is selected (“Best Value,” low-bid, etc.).

Below is a list showing the main items included in more detailed design-build legislation:

- **Definitions** – Terms such as “design-build,” “design-builder,” “emergency,” etc. are often defined at the very beginning of the design-build legislation.
- **Design-build generalities** – Next comes a range of legislation concerning the state’s use of design-build in general. This section may include the following:
  - The number of projects that can be undertaken
  - The minimum or maximum value of potential projects
  - Whether the right-of-way acquisition is included in the estimated cost of the project
  - If the department is responsible for right-of-way acquisition prior to team selection process
  - Whether the department is responsible for preparation and acquisition of environmental documents
  - The potential team selection processes
  - Whether the department has to report on its use of design-build and the reasons of its use to a higher state authority every set amount of time
  - Who has the final determination authority to use design-build
• Design-build criteria – Next is a section on the minimum basis for determining when to use design-build. The criteria may include:
  o The extent to which it can adequately define the project requirements in a proposed scope of the design and construction desired
  o The time constraints for delivery of the project
  o The capability and experience of potential contractors with the design-build method of project delivery or similar experience
  o The suitability of the project for use of design-build in the areas of time, schedule, costs, and quality.
  o The capability of the department to manage the project, including the employment of experienced personnel or outside consultants
  o The capability of the department to oversee the project with persons who are familiar with design-build
  o The lack of ability and availability of any current state employee to perform the services called for by the contract
  o Other criteria the department deems relevant

• Licensing requirements – This sections basically states that the design-build team selected must employ a licensed designer, and that all contractors who work on the project must be licensed. Also included in this section can be a subdivision on liability detailing the responsibilities of the design-builder to the state.

• Two-phase procedure – This section states that if the agency determines that the design-build delivery method will be used, the department will establish a two-phase procedure for awarding the design-build contract.

• Technical Review Committee – This section establishes the minimum number of individuals, along with their qualifications, that will make up the committee that will review the qualifications and proposals of the potential design-build teams. Legislation prohibiting a review committee member from having financial interest in any of the potential design-build teams is also included.

• Contents of RFQ – May including the following:
  o The minimum qualifications of the design-builders necessary to meet the requirements for acceptance
o A scope of work statement and schedule
o Documents defining the project requirements
o The form of contract to be awarded
o The selection criteria for compiling a short list and the number of firms to be included on the short list
o A description of the RFP requirements
o The maximum time allowed for design and construction
o The department’s estimated cost of design and construction
o Requirements for construction experience, design experience, financial, personnel, and equipment resources available from potential design-build teams and their experience in other design-build projects

• Evaluation – This section states how the evaluation process will be handled and how the short listing will be done.

• Contents of RFQ – May including the following:
  o The scope of work, including programmatic, performance and technical requirements, specifications and functional and operational elements for the delivery of the completed project
  o A description of the qualifications required of the design-build team and the selection criteria
  o Copies of the contract documents that the successful proposer will be expected to sign
  o The maximum time allowable for design and construction
  o The road authority’s estimated cost of design and construction
  o The requirement that a submitted proposal be segmented into two parts, a technical proposal and a price proposal
  o The requirement that each proposal be in a separately sealed, clearly identified package and include the date and time of the submittal deadline
  o The requirement that the technical proposal include a critical path method; bar schedule of the work to be performed, or similar schematic; design plans and specifications; technical reports; calculations; permit requirements; applicable development fees; and other data
The requirement that the price proposal contain all design, construction, engineering, inspection, and construction costs of the proposed project

The date, time, and location of the public opening of the sealed price proposals

Other information relevant to the project

- Design-build award – In this section, information on how the department will award the design-build contract is included. Information includes computations and announcement information.

- Stipulated fee – This section details how the short listed design-build teams will be paid for their proposals. Stipulated fees are commonly two-tenths of one percent of the department’s estimated cost of design and construction.

- Alternative process for certain contracts – This section may be included for the potential use of design-build on projects with substantially lower costs (projects with estimated costs less than $5 million). In the section, an alternative process, which is less complex than the aforementioned selection process is made available for the department to use.

- Low-bid design-build process – A section making a low-bid selection process available for the department to use may also be included in the legislation. This section usually refers back to the two-phase selection process and states that if a team meets all the technical criteria then their price proposal can be considered in the low-bid process.

The process of getting the design-build legislation passed can be difficult and varies from state to state. There will be many interested parties from the industry including the AGC, ARTBA, and ACEC that will want their own specific language to be use in the legislation that will benefit them the most. In general, this process is one of communication and compromise. Communication is necessary to get the thoughts of the interested parties, and compromise is necessary as to not alienate those in the industry. As for wording of the legislation, the outline presented above can serve as a guide, but it may be necessary to solicit the help of outside consultation or establish an “Innovative Contracting” unit within the department whose members will be able to focus all their time and efforts on
not only establishing the best design-build legislation but to also make sure that the
design-build program in the department will be as effective as possible long after the
legislation has been passed.

At the MN/DOT, the push for design-build legislation started with their AGC members.
The bigger contractors saw great potential in design-build, but even before legislation
was pursued, the MN/DOT and representatives from the AGC spent a lot of time visiting
other states to learn about design-build. Initially, the MN/DOT and the AGC were each
pursuing separate bills. At some point in time, the MN/DOT and the AGC began
working together and came up with language that they both could agree on. It took
several months of negotiating, but having both parties agree at the legislative hearings
helped. Without having both parties united, the legislation would have never passed.
While the negotiating was taking place, the MN/DOT established an Innovative
Contracting Initiative unit, which is now part of their Construction and Innovative
Contracting Office. This unit's charge was to pursue DB legislation with the industry and
to implement design-build. They also hired a General Engineering Consultant (GEC)
that helped them establish their design-build program and provided expertise on design-
build contracting. While the contracts were being developed, the MN/DOT held several
workshops with the AGC. Since the legislation has been passed, the MN/DOT has
continued to communicate regularly with the AGC and the ACEC and feels that that is
one of the key to a successful design-build program (Lynch personal, 2008).

4.0 Overcoming the Barriers to Implementation
While the design-build project delivery system has been shown to produce many benefits
under the right circumstances, it is not easy to implement, and can result in poor
performance if not used properly. Below are the most common barriers to implementing
design-build that an owner may face. Each idea is presented, followed by the best
practices to overcome the particular hurdle.
4.1 Fear of Change

The main delivery system since the start of the modern construction era has been design-bid-build, and until the last few decades it was essentially the only delivery system (Federal Highway Administration 2006). It is important to remember that when state DOTs were formed, the delivery system used was design-bid-build. Therefore, the DOTs’ working and management philosophies were set up to delivery transportation projects using this delivery system. It is natural to feel trepidation when the standard way of doing business changes. Fahmy and Jergeas (2004) interviewed 5 public owners who claimed that the idea of a single identity is relatively new to most owners, and that the possibility of misunderstandings exists. In a number of survey results from 2007, several state DOTs said they felt some sense of uneasiness when using design-build for the first time. Caltrans explains their experience with the fear of change in the following:

Design-build requires a new mindset in order to be successful, especially for a Department like Caltrans that has done 90 percent of the design work on our projects historically. The primary motivation for resistance is fear of change. We are facing a lot of resistance from our employees because they see design-build as a threat to their jobs. Local contractors are resistant to this change because they fear large out-of-state contractors coming in and taking these projects.

The keys to overcoming a fear of change are leadership and training. In a survey response, the MNDOT wrote:

With any organization, culture changes need to occur with any shifts in delivery or modifications in a system. With an organization as large as a DOT, perceptions of change are going to vary greatly (i.e. some people are willing to accept new ideas, others are not). With any change, champions are needed to implement new technology and practices. With design-build and our other innovative practices, several champions implemented these changes.

Furthermore, two of the state DOTs surveyed said that they provided training discussing, in detail, the new processes involved in utilizing design-build to the department staff, groups outside the DOT, and contractors.
4.2 Lack of Resources

Tied to the idea of a fear of change of using design-build is the potential lack of resources to implement design-build. All those surveyed by the authors of this report believed that they, originally, lacked some of the resources to successfully implement design-build at their organization. Resources include budget, knowledge, and experience. For the Pennsylvania DOT (PennDOT), the lack of knowledge and experience eventually became a non-issue. As knowledge was gained, it was transferred to other employees, and experience was gained by the staff as more design-build projects were undertaken (Lynch personal 2007). While this scenario is likely for any DOT that uses design-build long enough, it implies that before the knowledge and experience was gained the potential of problems coming up with design-build may have been higher.

Preemptive strategies can be used to overcome this issue. In their paper, *Ten Critical Principles for Successful Design-Build Projects* (2006), which summarized the results of surveys with professionals with design-build experience, Jergeas and Fahmy offered some broad strategies. They believe that owners should “Be prepared to have an open mind, flexibility, cooperation, and trust” when implementing design-build and to “Pay special attention to education and training.” Survey respondents suggested formal training and communication with others who have already implemented design-build. Formal training options include university courses and attending design-build workshops or conferences. Communication can be with other owners, but it may be beneficial to also talk with anyone involved on a design-build project whether their experience was positive or negative. It would be more beneficial to an owner of a prospective project to talk with those involved on a project similar in size and scope.

In general, the MNDOT will often contact other state DOTs with experiences with new practices and inquire about lessons learned. When they originally implemented the design-build system, along with contacting other DOTs, they retained the expertise of consultants who were familiar with design-build (Lynch personal 2007). Caltrans believed that when they gain permanent legislation to deliver projects using design-build,
they will lack the expertise to optimize the process. They envision obtaining the expertise through the use of consultants (Lynch personal 2008).

4.3 Creating New Design-Build Documents
Along with overcoming a fear of change and lack of resources, it is necessary to create new design-build documents before an owner can successfully implement design-build. After years of using standardized contracts and paperwork, it may be difficult to readily change contracts and start dealing with different paperwork. In order to overcome this issue, the Pennsylvania DOT had the designers and contractors work with them in developing the paperwork for selection and implementation (Lynch personal 2007). In order to make progress developing design-build documents, Caltrans hired a consultant to assist in preparing some of the processes and procedures necessary to put out a design-build contract (Lynch personal 2008). The MNDOT solicited assistance from a national consultant with experience assembling design-build contracts. Furthermore, they worked very closely with the contracting industry on developing the contract language through industry reviews of draft RFPs (Lynch personal 2007).

The MNDOT design-build contract is set up differently from their design-bid-build contract. It is set-up in several parts: Book 1 - Contract - General conditions; many are similar to traditional contract. However, Book 1 addresses issues that are not covered by their traditional methods (e.g. transfer of risk). Book 2 - Project Requirements - Addresses exactly what the contractor is required to do on each specific project. Book 3 - Applicable Standards - Addresses standards that need to be followed (design, management, construction). Traditional design-bid-build projects don't prescribe any design standards since the designs are 100% complete (Lynch personal 2007).

4.4 Writing a Good RFP/Scope
Writing a good RFP including a thorough scope is one of the most important success factors on a design-build project. In a 2007 survey response, the FLDOT attested to this by saying that “the key to design-build is writing a clear, defined, and well written
scope.” There is only one chance on a design-build project for the owner to identify the work’s scope and project requirements. Any changes to the specifications after the contract is signed will result in time and cost changes on the project (Fahmy and Jergeas 2004).

For the design-build approach to be used successfully, the owner must clearly define the needs and requirements of the project so that the design-build teams submitting proposals understand the requirements. It is imperative that that the owner issues comprehensive scope-of-work information including detailed space and equipment requirements, site surveys, soil borings, outline specifications, budget parameters, and scheduling requirements (Tenah 2000). Furthermore, “The owner must clearly articulate the ‘given needs’ for design and construction quality in the DB project RFP” (Gransberg and Molenaar 2004).

Jergeas and Fahmy (2006) identified preparing an adequate RFP as one of the critical principles for successful design-build projects. Their research showed that a clear and comprehensive RFP is necessary to deliver a project that meets the owner’s and user’s needs. One owner that they interviews stated that, “The RFP is the core of the design-build process.” A strategy that can be used to develop a good RFP and scope is to communicate the project’s needs in terms of concrete, measurable results. Furthermore, it is important to spend a lot of time in developing the scope of work. One respondent interviewed by Jergeas and Fahmy advised owners, “to spend double the time and money you would otherwise expect to spend on a design-bid-build” scope of work.

4.5 Quality Management
According to Gransberg and Windel (2008), on a design-build project, the quality of a completed facility is essentially defined by the quality of the design. They go on to state that, “the importance of design quality management in DB projects can probably not be overemphasized.” A quality management plan is of greater importance on a design-build project than a design-bid-build project and should be established prior to awarding the design-build contract (Gransberg and Molenaar 2004).
On a design-bid-build project, the designer is under a separate contract with the owner. The designer is in direct communication with the owner throughout the design process, and the owner is directly able to influence the quality of the design. Furthermore, on a design-bid-build project, the owner is provided with checks and balances. The owner of a project typically retains the designer to review the contractor’s performance during the construction phase (Tenah 2000). However, in design-build, the design is completed after the awarding of the design-build contract. Therefore, the owner cannot influence the quality of design nearly as much as in design-bid-build.

While the literature review on the impact of design-build on the quality of a project seems to show that quality does not decrease when design-build is used, there is debate on the issue with certain characteristics inherent to design-build given as proof or disproof of its effect on quality. Fahmy and Jergeas (2004) conducted interviews with 20 industry professionals (5 public owners, 5 general contractors, 5 designers, 2 lawyers, 1 claim consultant, 1 specification writer, and 1 bonding and insurance agent). The designers interviewed believed that “The potential for professional conflict of interest increases because the designer is employed by or in partnership with the design-builder” and not the owner. The owners reaffirmed this by stating that “Design decisions usually are inappropriately influenced by the builder, who is in most cases not familiar with design issues. In many cases, the builder may pressure designers to reduce quality criteria or design standards to minimum levels to maximize profit.” The general contractors believed otherwise and stated, “Single-point responsibility is an inherent quality motivator. The builders know that they cannot blame poor quality on the designers because the design-builder is responsible for both the design and the building.”

In 2008, the Transportation Research Board (TRB) published a paper entitled *Quality Assurance in Design-Build Projects*. They performed an extensive literature review on quality issues and surveyed a number of DOTs. Their research confirmed that quality issues are present beginning in the procurement phase and remain throughout the design, construction, operation, and maintenance phases. The quality issues include the classic
design and construction issues present in design-bid-build as well as concerns over the quality of the design-builder’s personnel, the quality of the past experience of the various firms that make up the design-builder’s team, and the quality of the plans that will be used to implement quality management practices after the design-build contract is awarded (TRB 2008).

While it is important to understand where and why quality issues may arise, it is more important to recognize that strategies exist to minimize their detrimental effects on quality. In general, it is a good strategy for the project owner to be specific in its requirements of the design-builder’s personnel as well as the past experiences of the design-build teams. A high quality design-build team is the first step to a high quality design-build project, and by being specific in its RFP, an owner will minimize its chances of soliciting the wrong team. In 2004, Gransberg and Molenaar reported on owner’s design and construction quality management approaches on design-build projects. They listed the following possible quality management approaches that can be used during the team selection process:

- Quality by qualification: The RFP requires past performance and/or personnel qualifications.
- Quality by evaluated program: The RFP requires the design/builder to submit a proposed QM (quality management) program of its own design in the proposal, and the owner competitively evaluates it.
- Quality by specified program: The RFP requires the design/builder to submit a proposed QM program that complies with an owner-specified program in the proposal, and the owner verifies this compliance.
- Quality by performance criteria: The RFP requires the design/builder to submit a proposed technical solution that is responsive to owner-furnished technical performance criteria, and the owner competitively evaluates it.
- Quality by specification: The RFP requires the design/builder to submit proposed technical solutions that were responsive to the owner’s prescriptive technical specifications, and the owner verifies this compliance during the design submittal process.
- Quality by warranty: The RFP requires some type of performance warranty of maintenance bond.

The quality issues do not end with the selection of a design-build team. Consequently, an articulated quality management plan detailing all the quality control and quality assurance responsibilities throughout the life of the project should be adopted. Since the design is the main determinant of a quality facility many owners decide to remain involved in the design process by retaining the responsibility for design QA (TRB 2008). In general, those best able to manage the quality should be given the responsibility. Table 2, below, shows the possible quality management organizations.

Table 2 – Possible Quality Management Organizations (TRB 2008)

<table>
<thead>
<tr>
<th>Type</th>
<th>Design QA</th>
<th>Design QC</th>
<th>Construction QA</th>
<th>Construction QC</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
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<td>DBr</td>
<td>DBr</td>
<td>DBr</td>
<td>DOT oversight of design and construction</td>
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<tr>
<td>Type 2</td>
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<td>DOT or 3rd</td>
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<td>DBr</td>
<td>DOT and 3rd party share construction QA</td>
</tr>
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<td>DBr and DOT</td>
<td>DBr</td>
<td>DBr</td>
<td>DOT and DBr share construction QA</td>
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<td>3rd party QA; DBr QC</td>
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<td>3rd and DBr and DOT</td>
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<td>QA is shared; DBr QC</td>
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<td>DOT</td>
<td>DBr</td>
<td>DBr or 3rd</td>
<td>DOT oversight of design</td>
</tr>
<tr>
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<td>DBr</td>
<td>DOT</td>
<td>DBr</td>
<td>DOT QA; DBr QC</td>
</tr>
<tr>
<td>Type 9</td>
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<td>DOT or 3rd</td>
<td>DBr or 3rd</td>
<td>3rd party is involved in construction QA or QC</td>
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<td>DBr</td>
<td>DOT and DBr share design QA only</td>
</tr>
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<td>DBr and DOT</td>
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<td>DOT and DBr share QA</td>
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<td>DOT</td>
<td>DBr</td>
<td>DBr construction QC only; traditional DBB QM</td>
</tr>
<tr>
<td>Type 14</td>
<td>DOT</td>
<td>DOT</td>
<td>DOT</td>
<td>DOT</td>
<td>Force account project done with DOT forces</td>
</tr>
</tbody>
</table>

Note: DBr = design-builder; DOT = department of transportation (i.e., the projects owner); 3rd = third party (independent firm retained to conduct QA and QC or independent assurance responsibilities); QM = quality management.

Gransberg and Molenaar (2004) concluded their report by offering the following recommendations:
• Owners procuring a DB project of any type should require both design and construction QM plans in the proposal. This permits the evaluation of each potential design/builder’s approach to project quality and will mitigate postaward disputes over quality issues during both the design and construction phases of the project.

• Owners should require quality-specific qualifications on both the design and construction members of the DB team. A strong record of quality performance and quality-specific individual credentials is a powerful method to manage the quality risks inherent to the DB process.

• The best warranty for a DB project may be to configure the project with a follow-on requirement to operate and maintain the project for some period after construction completion.

Still other strategies exist for managing quality including an auditing process. Participants in the International Transit Studies Program (2002) reported that projects utilizing design-build in Hong Kong, Bangkok, and Sydney each used a quality audit system. An audit process recognizes that it is impossible and unwise to inspect every detail of a project. The owner, instead, audits specific details to ensure that they meet contract requirements. An audit process enables the owner to make sure that contract requirements affecting quality are being met without being directly involved in the inspection process and duplicating the design-builder’s quality control and quality assurance work.

Financial incentives can also be used as a strategy to increase the potential of receiving a quality facility. On a 1996 highway project, the Arizona DOT paid incentives for superior performance of the public relations and quality management programs for exceeding pavement smoothness, material strength, and construction workmanship. Furthermore, the Arizona DOT contracted out the quality assurance function to a previously approved testing laboratory (Ernzen and Feeney 2002). A full look at the quality control and quality assurance roles and responsibilities are shown in Figure 6.
4.6 Risk Management

Risk is an inherent part of the construction industry and will be present on every project, design-build or otherwise. Risk management is defined by the Project Management Institute as “the art and science of identifying and responding to risk factors throughout the life of a project and in the best interests of its objectives.” In general, there are three strategies involved in risk management – eliminating risk, transferring risk, or accepting risk. The fundamentals of risk management according to the American Society of Civil Engineers (ASCE, 1980) are as follows:

- Risks belong with those parties best able to evaluate, control, bear the cost, and benefit from the assumption of risks.
• Many risks and liabilities are not to be totally assigned but may be shared.
• Every risk has an associated, unavoidable cost which must be assumed in the planning, designing, bidding, or construction of the work.

A report by Gurry and Smith (1995) entitled *Allocation of Risk in Design/Build Projects – The EJCDC Approach* summarized the Engineers Joint Contract Documents Committee’s (EJCDC) philosophy on risk allocation on design-build projects. The EJCDC is a joint undertaking of ASCE, the National Society of Professional Engineers, and the American Consulting Engineers Council. They created a number of documents specifically for design-build contracting that allocate risk according to the fundamentals presented above. The following is a summary adapted in their language from Gurry and Smith’s report on how the EJCDC believes specific risks should be allocated:

- The risk of inadequate drawings and specifications: This risk and its impact on construction costs rests with the design-builder. The owner must approve the drawings and specifications before they become contract documents, thereby providing a check on the final documents.
- The risk of substandard performance: To reduce the risk of poor performance or function of the completed project, it is the responsibility of the owner to clearly define any necessary performance guarantees to transfer that risk to the design-builder.
- The risk of delayed or inadequate site access: The owner is responsible for providing the site and access thereto to the design-builder, and will be responsible to compensate the design-builder for any delays to the project caused by lack of access.
- Funding and payment risks: Project funding is the responsibility of the owner. The owner should reduce the risks of running short of funds by budgeting contingency funds for unexpected changes in price to which the design-builder may be entitled under the changes provisions of the General Conditions.
- Risk of changes in laws and regulations: The General Conditions require that the design-builder abide by all laws and regulations. However, the owner assumes the risk for changes in laws and regulations not known or foreseeable at the time.
of receipt of proposals. The owner does retain the right to suspend work or terminate the agreement for convenience provided that the design-builder be compensated for related costs.

- Risks associated with means and methods of construction/safety procedures: These risks are the sole responsibility of the design-builder.
- The risk of differing site conditions: The owner should provide whatever subsurface data it used in preparing the conceptual documents. The design-builder is responsible for obtaining additional subsurface data.
- The risk of hazardous environmental conditions: The risk is assigned to the owner. The design-builder is also given the right to stop work (with possible compensation). An exception to this would be if the design-builder brought the hazardous materials to the site.
- Weather: Risks for abnormal weather or other acts of God are shared. The design-builder receives a time extension for any corresponding delays, but each party absorbs its own costs for such delays.
- Construction cost estimating and labor productivity: If a stipulated fee agreement is used, the design-builder accepts the risk. In a cost-plus agreement, the owner accepts the risk until the guaranteed maximum price is reached.
- The risk of design errors and omissions: Design professionals are sometimes expected to assume risks which greatly exceed any reward they could expect from the projects and over which they have limited involvement or control. In cases like these, the risks may be shared by the owner and design-builder.
- Risk of inadequate communications: An important element in reducing risk to a project is communication between the parties. There should be communication between the engineer and the owner, through or in the presence of the design-builder.
5.0 Best Practices/Conditions for Successful Implementation

The Federal Highway Administration summarized the conditions that increase the overall quality of a design-build project, when present. The table with the results is presented below.

Table 2 – Conditions Affecting Overall Project Quality (Federal Highway Administration 2006)

<table>
<thead>
<tr>
<th>Project/Contract Characteristic</th>
<th>Overall Sponsor Satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procurement Method</td>
<td></td>
</tr>
<tr>
<td>Low Bid</td>
<td>Best Value</td>
</tr>
<tr>
<td>Project Type</td>
<td></td>
</tr>
<tr>
<td>Road-Resurface/Renewal</td>
<td>Road-New/Widen and Rehabilitate/Reconstruct</td>
</tr>
<tr>
<td>Project Size</td>
<td></td>
</tr>
<tr>
<td>Smaller</td>
<td>Larger</td>
</tr>
<tr>
<td>% of Design Completed at Award</td>
<td></td>
</tr>
<tr>
<td>Higher</td>
<td>Lower</td>
</tr>
</tbody>
</table>

The table shows that larger, more complex projects lead to a better overall satisfaction with the design-build delivery method. In addition to the type and size of the project, the percentage of preliminary design completed prior to the awarding of the design-build contract as well as the selection process used to determine the winning design-build team greatly affect the outcome of the design-build project.

5.1 Percentage of Preliminary Design Complete

In almost every DOT project there is some preliminary design with regards to right of way (ROW) acquisition and environmental compliances. It has been found, though, that the less preliminary design completed prior to the designer/contractor taking over, the better the project turns out (Federal Highway Administration 2006). One of the advantages of using design-build is the fact that there is more of an opportunity for
innovation from the designer/contractor. This opportunity decreases as more preliminary design is completed prior to awarding the contract. In a previously conducted study by the Federal Highway Administration (2006) regarding preliminary design in design-build projects, design averaged 27 percent complete prior to design-build contract award. For 81 percent of the reported projects, the percentage of design completion by design-build contract award was 30 percent or less.

5.2 Design-Build Team selection

The competency of the selected design-build team working on a project can be a very important factor in the project’s success. Therefore, the owner making the selection decision must take the necessary steps toward making the best possible evaluation of each team in order to select the best team. The traditional design-bid-build approach almost always uses a low bid competition method. However, in design-build, the selection method can be adapted to the owner’s specific goals and objectives, depending on the project. There are no design documents to abide by aside from the preliminary design completed by the DOT; therefore, a multitude of criteria should be evaluated to review a given proposal fairly since the lowest price proposal does not always deliver the best project. One such popular approach is the “Best Value” selection process. It takes into account the price and the cost of time, and adjusts the total price by dividing it by the “technical score” which is a quantification of several qualitative criteria. These criteria under consideration are aspects of the project that are important to the owner (e.g., past experience, safety record, quality of work, etc.), and are prioritized by specifying their contribution to the total score using higher weights for the most important criteria and lower weights for the less vital ones. The task of developing the selection criteria ultimately falls upon the owner of the project and needs to occur before the competitors submit proposals.

5.2.1 Selecting the criteria

Brainstorming a list of criteria from which to prioritize is necessary to ensure that no aspect of the project goes unnoticed. From this comprehensive list, the criteria that are the most relevant to the company, the type of contract, and the type of work are chosen. The following is a sample list of common criteria used in selecting a design-build team:
• Previous experience with the design-build partner
• Owner experience with either partner in the alliance
• Existence of employee training programs
• Workforce stability and turnover rate
• Safety record or “Experience Modification Rate” (EMR)
• References from other owners
• Performance guarantees
• Teamdepartmental integration approach
• Experience with this type and size of project
• Approaches to unique aspects of the project
• Experience Authority of Key Individuals
• Extent of Quality Control Quality Assurance
• Measures to Evaluate Performance in Construction
• Enhancement to the RFP
• Approach to involve stakeholders
• Geometric Enhancements
• Structural Enhancements
• Innovation of design and construction quality management plan
• Aesthetics
• Ease of Future Maintenance
• Public involvement and traffic mitigation

5.2.2 Quantifying the criteria
These criteria are qualitative, and it is a challenge to make a decision based on subjective criteria. The process, however, requires a quantitative evaluation. Qualitative comments serve no purpose in simplifying the selection process. A simple way to deal with this issue is to rate the proposal presenters based on a numeric scale. Different rating scales can be used; For instance, a criterion weighting 20 points out of the total 100 can be simply scored
over 20. Another example is a rating system ranging anywhere from one to five points used to assess the owner’s satisfaction with a team’s adherence to the criteria. Let us illustrate a rating system that uses a four-point scale. For each criterion, a “1” means that the team does not meet expectations at all, a “2” means that the team is below expectations, a “3” means that the team meets expectations and a “4” means that the team exceeds expectations represented by the specific criterion.

5.2.3 Assigning Levels of Importance
In addition to deciding on the criteria for selection, it is necessary to assign an importance level to each criterion. These weight percentages are decided on by the owner prior to the completion of the evaluations. This allows the weighting of each of the ratings given by the evaluators based on the criteria that are more or less critical to the success of the project. After a level of importance has been assigned to each criterion, the sum of the percentages should equal 100%. Consequently, a rating system is created for owner representatives to use in evaluating the alliance teams’ presentations.

5.2.4 Design-Build teams Solicitation, Presentations, and Evaluation
Once the criteria and their respective weights are decided on, the owner can proceed to the next step, which consists of inviting alliance teams to a presentation of the project. A limited number of bidders shortens the process time while still allowing for competition; it also allows the owner to perform a thorough evaluation, minimizing any risks involved in selecting a design-build team. The owner’s belief in the alliance teams’ qualifications to apply for the job, as well as knowledge of their performance capabilities, are main players in this pre-selection. These pre-selected potential alliances capable of performing on the project are solicited for work, and the selection criteria are sent to them to be used as guidelines for developing their designs.

Selected alliance teams may give presentations, hold phone conferences, host meetings, or provide another medium through which to present the owner with their approach to the project. It is at these presentations that owner representatives evaluate prospective alliances based on the criteria identified. Owner representatives should be given evaluation sheets
with the list of criteria and directions on how to rate each alliance. Once the evaluations are completed, they can serve as inputs for the Monte Carlo simulation. Based on these teams’ evaluations and their simulation, the project is awarded to the alliance team that optimizes the client’s requirements, not necessarily the lowest bidder.

5.2.5 Monte Carlo Simulation
Subjective evaluations are rarely quantified precisely, as bias can always be present in such evaluations, be it deliberate or unintentional. The evaluation model will consist of the criteria combined with their respective weights. Once the model is developed, and the teams evaluated, analyzing evaluations of each criterion to make the best final selection decision is very important to minimize the subjectivity involved in human selection and optimize the results of a group’s individual evaluations. The model, serving merely as an illustration of the problem, can heavily impact selection. As an example, consider a 10% versus a 20% weight for the factor “Experience with Owner”; this difference can greatly affect the selection results. The simulation runs several iterations, taking for each iteration a different point from the specified probability distribution for every weight. The calculated output will also be different for every run, and its distribution will be calculated. This assures the owner that the importance factors were not the only aspect of the analysis driving the results. Another form of bias could result from the inclinations of an evaluator, whether it was purposeful or just because assessing qualitative criteria is a tough task. Monte Carlo simulations - proven to be efficient when it comes to considering the effect of numerous factors on a specific output- can be an effective scientific tool to diminish biases entering into the evaluation of design-build teams. Use of this tool would complement the high performance of design-build project delivery systems and increase it further by ensuring that the selected alliance is the best one for the job, thus lowering project risks. Using this framework, what seemed to be a qualitative analysis was turned into reassuring quantitative analyses and results. The professional implications for the alliance selection methodology, with respect to increasing confidence in selecting the best project team, support the movement of a project toward financial success.
6.0 Conclusion

As many of the roads in our highway system will need to be reconstructed in the upcoming decades, delivering these projects in a cost and time effective way will turn out to be very important. The research has shown that the design-build delivery method yields many benefits when used properly; although, there is an increased list of hurdles to overcome in order for it to be successful. By being aware of the barriers to implementation of design-build projects and the best practices and conditions for successful implementation presented in this paper, the owner of a transportation project now has a better understanding of the implementation process of such projects using the design-build delivery system. This can assist him in making the decision that will maximize the project’s benefits.
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Lynch personal (2007) refers to information gained through distributed surveys to the PennDOT, MNDOT, and FLDOT.

Lynch personal (2008) refers to information gained through communication with Caltrans and MNDOT.


