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# Performance Measures for Alternative Project Delivery Methods on Highway Transportation Projects

Alan J. Therrien

University of Colorado at Boulder, atherrien7@gmail.com

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# **Performance Measures for Alternative Project Delivery Methods on Highway Transportation Projects**

By

Alan J. Therrien

B.S., University of Vermont, 2015

A thesis submitted to the Faculty of the  
Graduate School of the University of  
Colorado in partial fulfillment of the  
requirements for the degree of

Master of Science

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This thesis entitled:  
Performance Measures for Alternative Project Delivery Methods on Highway  
Transportation Projects

Written by: Alan J. Therrien  
has been approved for the Department of Civil, Environmental, and Architectural  
Engineering

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Chair: Keith Molenaar

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Paul Goodrum

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Cristina Torres-Machi

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Date

The final copy of this thesis has been examined by the signatories, and we  
find that both the content and the form meet acceptable presentation  
standards of scholarly work in the above mentioned discipline

IRB protocol # 18-0530

## **Abstract**

Therrien, Alan J. (M.S., Civil, Environmental, and Architectural Engineering)

*Performance Measures for Alternative Project Delivery Methods on Highway Transportation Projects*

Thesis directed by Professor Keith Molenaar.

The use of alternative project delivery methods such as Design-Build (D-B) and Construction Manager/General Contractor (CM/GC) is becoming an effective solution for state transportation agencies to deliver highway construction projects. These delivery methods have been introduced to increase efficiency and innovation, while decreasing costs and schedule durations. Studies have explored the benefits of D-B and CM/GC delivery methods, but they have not explored how to best measure the performance of these projects when viewed in aggregate as a program. Through a survey of 41 transportation practitioners across the country, this study addresses that need by identifying 6 performance measures that state transportation agencies can use to gauge the success of the alternative project delivery method projects, and programs as a whole. These performance measures are; (1) Proposals from Qualified Contractors, (2) Milestone Dates, (3) Construction Duration, (4) Total Project Cost, (5) Project Cost at Award, and (6) Accepted Alternative Technical Concepts. These measures utilize data from the preconstruction phase, construction phase, or both. This gives state transportation agencies the ability to analyze each phase, and identify improvements. The use of these performance measures will allow state transportation agencies to identify strengths and weaknesses within their alternative project delivery method programs, and lead to improvement when delivering these projects.

## **Acknowledgements**

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## Chapter 1: Introduction

State transportation agencies across the country are beginning to utilize more alternative project delivery methods such as design-build (D-B) and construction manager/general contractor (CM/GC) (Gransberg and Molenaar 2008, Sullivan et al. 2017). This is in part due to the proactive position taken by the federal government to improve the nation's transportation systems. "Congress declares that it is in the national interest to promote the use of innovative technologies and practices that increase the efficiency of construction of, improve the safety of, and extend the service life of highways and bridges." (Moving Ahead for Progress in the 21<sup>st</sup> Century (MAP-21) 2012). Implementing alternative project delivery methods on highway construction projects is one step taken by state transportation agencies to accomplish the objectives stated in MAP-21. D-B and CM/GC project delivery methods were highlighted as innovative practices in the Federal Highway Administration (FHWA) Every Day Counts program, where training and support for these alternative project delivery methods was provided to state transportation agencies to help with their initial implementation and growth of the programs (FHWA 2018c).

Since state transportation agencies first began using D-B and CM/GC delivery methods in the 1990s and 2005 respectively, more and more states have adopted their use. This is in part due to the FHWA introducing the Special Experimental Project No. 14 – Alternative Contracting in 1990, which allowed state transportation agencies to evaluate these non-traditional contracting techniques (FHWA 2017b). By the end of 2014 the number of state transportation agencies delivering D-B projects grew to 35, and the number delivering CM/GC projects grew to 17 (FHWA 2018a). As these alternative project delivery method programs continue to grow, it is important to measure and analyze their performance.

Many state transportation agencies currently measure performance at the organizational level and project level, as seen in the Virginia Department of Transportation's *Performance Reporting System for Projects and Programs* Dashboard (VDOT 2007). Performance measures at these levels are important to the success of state transportation agencies, but as the use of D-B and CM/GC delivery methods continues to grow, so does the need to implement alternative project delivery method specific performance measures. The Washington State Department of Transportation (WSDOT) identified this need as well in their Review of WSDOT's Implementation of Design-Build Project Delivery (WSDOT 2016). Developing these performance measures will allow agencies to grow their programs if they are currently performing well, or implement corrective actions if the programs are performing poorly.

Identifying and developing these unique performance measures will fill the need for defining success of alternative project delivery method projects, and the programs as a whole. The scope of each alternative project delivery method project is unique, but it is important to establish performance measures that can be used interchangeably in order to compare the projects and view them in aggregate as a program.

State transportation agencies use a variety of terms to describe project delivery methods that differ from the traditional Design-Bid-Build (D-B-B) method. These terms include innovative contracting methods, innovative project delivery methods, alternative contracting methods, and alternative project delivery methods. For consistency, this research uses the term alternative project delivery methods when referring to D-B and CM/GC delivery methods.

Alternative project delivery method projects function quite differently from D-B-B projects throughout all phases. Because of this, alternative project delivery methods are contracted and executed differently, typically by a specially trained group of staff members. A

program is a group of related projects managed in a coordinated manner to obtain benefits not available from managing them individually (Project Management Body of Knowledge 2017). For this research, the group of staff members and all their associated D-B and CM/GC projects will be referred to as an alternative project delivery method program.

The central function of any performance measurement process is to provide regular, valid data on indicators or performance outcomes (Venner 2003). Similarly, the FHWA states that “performance measurement is the use of statistical evidence to determine progress toward specific defined organizational objectives” (FHWA 2018d). For this research, the purpose of performance measures are to accomplish these defined objectives.

## **1.1 Literature Review**

A preliminary literature review was conducted to identify existing research and studies around the topics of alternative project delivery methods and performance measures in highway design and construction. The literature consisted of journal articles and reports from researchers, as well as guidance manuals produced by state transportation agencies.

### *1.1.1 Alternative Project Delivery Methods*

The literature review revealed that there has been much research regarding alternative project delivery methods, specifically D-B and CM/GC. One area of emphasis for this research has been their corresponding procurement methods (El Asmar et al. 2010; Migliaccio et al. 2010). For example, Gransberg and Senadheera (1999) described three methods to advertise and award D-B projects for state transportation agencies, low-bid, adjusted score, and best value. Gransberg and Shane (2013) investigated the use of a best-value procurement method for CM/GC projects on state transportation agency projects. The procurement process is a critical phase when implementing an alternative project delivery method, and it can differ greatly from

traditional D-B-B procurement. Therefore it has been researched thoroughly to ensure effective utilization by state transportation agencies.

Aside from research on each individual procurement method, a comparison of D-B and CM/GC delivery methods to the traditional Design-Bid-Build (D-B-B) delivery method has also been thoroughly researched. When comparing the performance of D-B-B projects to alternative project delivery methods, the most common metrics include cost, schedule, and quality (Goftar et al. 2014; Sullivan et al. 2017), however contractor performance and value contribution are also metrics that have been used (Ellis et al. 2007). Gransberg et al. (2003) studied the performance of 88 federal building projects constructed using the D-B and D-B-B delivery methods, and found that D-B projects performed better than D-B-B projects in metric categories of cost and time growth. Tran et al. (2017) studied 139 pairs of D-B-B and D-B highway projects build by the Florida Department of Transportation organized into five work types. Similar to Gransberg et al. (2003), metrics of cost growth and schedule growth were used for comparison and showed that D-B delivery performed better than D-B-B delivery. The FHWA TechBrief concluded that alternative project delivery methods are resulting in 40 to 60 percent schedule savings compared to D-B-B, and the point of cost certainty is accelerated as well (FHWA 2018a). Alleman et al. (2016) compared D-B-B, D-B, and CM/GC delivery methods on 291 small highway construction projects in the United States, which revealed the use of alternative project delivery methods should not only be limited to projects with large contract values.

Aside from procurement and performance, other aspects of alternative project delivery methods have also been researched. These topics include; delivery selection (Tran et al. 2012), risk (Farnsworth et al. 2016), and tools to help delivery projects (West et al. 2012).

Metrics have been used to compare the performance of alternative project delivery methods to the D-B-B delivery method, but no research was found that used metrics to measure the performance of alternative project delivery method programs when viewing projects in aggregate. It has been proven that D-B and CM/GC delivery can out-perform D-B-B delivery, but how can the improved performance of D-B and CM/GC delivery be proven?

### *1.1.2 Performance Measurement*

Performance measures in transportation construction have also been studied in depth, as further development of performance measures is needed in all aspects of the highway transportation industry in order to move towards a much needed performance-based management system (Molenaar and Navarro 2011). NCHRP Report 551 (2005) studied the use of performance measures in transportation asset management and identified 10 categories of metrics; preservation, accessibility, mobility, operations and maintenance, safety, environmental impacts, economic development, social impacts, security, and delivery. This shows the use of metrics in transportation construction to measure performance at the organizational level, but no such performance measures were identified at the program level for alternative project delivery methods.

Many state transportation agencies have already identified the need for performance measurement at the organizational level, and have developed systems to document these measures and their data as seen in Table 1.1.

Table 1.1: Organizational Performance Measurement Systems

State Transportation Agency	Performance Measurement System
Alaska Department of Transportation	Performance Dashboard
California Department of Transportation	Performance Measurement System (PeMS)
Colorado Department of Transportation	Annual Performance Plan
Georgia Department of Transportation	Performance Management Dashboard
Idaho Transportation Department	Performance Measures Dashboard
Minnesota Department of Transportation	Annual Transportation Performance Report
North Carolina Department of Transportation	Organizational Performance Dashboard
South Carolina Department of Transportation	Organizational Performance Dashboard
Utah Department of Transportation	Dashboard and Strategic Direction
Virginia Department of Transportation	Performance Reporting System for Projects and Programs
Washington State Department of Transportation	The Gray Notebook

These performance measurement systems include categories such as; safety, mobility, finance, condition, and customer satisfaction. This shows the use of metrics by state transportation agencies to measure performance at the organizational level, but no such performance measures were identified at the program level for alternative project delivery methods.

To learn more about how state transportation agencies are implementing alternative project delivery methods and using performance measures, their available documentation was analyzed. By reviewing state transportation agency websites, it was found that 24 agencies have guidebooks or manuals specifically for D-B, CM/GC, or both. These states are listed in Table 1.2.

Table 1.2: State Transportation Agencies with Alternative Project Delivery Method Manuals

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• Alaska	• Illinois	• North Carolina
• Arizona	• Louisiana	• Ohio
• Arkansas	• Maryland	• Pennsylvania
• California	• Michigan	• Tennessee
• Colorado	• Minnesota	• Utah
• Washington D.C.	• Montana	• Vermont
• Georgia	• Nevada	• Virginia
• Idaho	• New York	• Washington

Searching these guidebooks and manuals revealed the following about current performance measurement:

- Project-specific performance measures are listed in RFPs
- Contractor past performance is considered for selection
- Performance measures are used for incentives/disincentives related to cost, schedule, safety, design innovations and others
- Project performance is often related to meeting quality specifications

In all cases, performance measures seemed to be determined on a project-by-project basis. They are currently used to measure the performance of individual projects, not the alternative project delivery method program as a whole.

Some of the previously mentioned performance measurement systems somewhat measure program performance, such as the Virginia Department of Transportation (VDOT) *Performance Reporting System for Projects and Programs* Dashboard (VDOT 2007). One function of this dashboard is to view the performance of all VDOT construction projects in aggregate, and report their ability to complete the development and delivery phases on time and on budget. This view of all projects within the construction program is beneficial, but categorizing the alternative project delivery method projects separately and using performance measures specifically for D-B and CM/GC projects would add even more value.

WSDOT identified the need for more program level performance measures in their Review of WSDOT's Implementation of Design-Build Project Delivery (WSDOT 2016). One of their recommendations on program development and management included, "Develop a framework for monitoring performance, capturing lessons-learned, and fostering a culture of continuous improvement." Like many state transportation agencies, WSDOT does not currently have a formal system for tracking the performance of their alternative project delivery method programs, but they recognize the need and are moving towards implementing a system in the future.

## **1.2 Point of Departure**

Current alternative project delivery method literature does not give enough attention to identifying and developing performance measures for alternative project delivery method programs. Alternative project delivery methods such as D-B and CM/GC have been studied in depth, specifically regarding their procurement methods and benefits over D-B-B. Performance measurement has also been studied within state transportation agencies, but this has mostly been directed at the organizational and project levels. Establishing performance measures within alternative project delivery method programs will allow state transportation agencies to identify specific aspects of their delivery method processes in need of improvement, and enable them to push towards programs that are operating more effectively.

After identifying this need, three research questions were developed to address the lack of current alternative project delivery method program performance measures.

Central Question: *How can state transportation agencies measure the performance of their alternative project delivery methods such as D-B and CM/GC at the program level?*



Sub Question 1: *What measures can state transportation agencies use to determine the performance of their alternative project delivery method programs during the preconstruction phase?*

Sub Question 2: *What measures can state transportation agencies use to determine the performance of their alternative project delivery method programs during the construction phase?*

### **1.3 Research Method**

To answer the questions posed for this research, a qualitative approach was chosen. The lack of existing data for alternative project delivery method performance measures discourages a quantitative approach. Before an analysis of performance measure data can take place, the performance measures themselves must be identified. An initial list of potential performance measures was developed through literature reviews, phone interviews, and reviews of publicly available state transportation agency documents. Documentation from state transportation agencies with mature alternative project delivery method programs were targeted for collection. This collection continued until no new performance measures were being identified in the literature, indicating the data set was complete and saturation had been reached (Bowen 2008).

A qualitative research approach involves the researcher collecting emerging data with the intent of developing themes from the data (Creswell 2003), which is how the top-rated performance measures were identified. The research approach consisted of four primary tasks: (1) literature review, reviewing existing documentation for performance measurement within state transportation agencies; (2) develop initial performance measure list, utilizing the information from the first task to document existing applicable performance measures and developing new performance measures; (3) data collection, distribute a questionnaire to a variety

of transportation practitioners; and (4) synthesis of performance measures, synthesizing final results to identify the top-rated performance measures.

The survey data collected through task 3 was analyzed using appropriate statistical methods to produce the results of task 4. The transportation practitioners who participated in the questionnaire were selected based on their involvement with alternative project delivery methods within state transportation agencies, and further filtering was conducted based on their experience working with D-B and CM/GC projects.

#### **1.4 Thesis Format**

This thesis follows the “journal paper” format. Chapter 2 is a stand-alone paper that will be submitted to an academic journal. As a result, the chapter has its own abstract, introduction, background, methodology, results, discussion, and conclusion sections. In this format, there will inevitably be some degree of overlap. The final chapter in this thesis discusses the research contributions, limitations, and potential future research.

## **Chapter 2: Performance Measures for Alternative Project Delivery Methods on Highway Transportation Projects**

### **2.1 Abstract**

The use of alternative project delivery methods such as Design-Build (D-B) and Construction Manager/General Contractor (CM/GC) is becoming an effective solution for state transportation agencies to deliver highway construction projects. These delivery methods have been introduced to increase efficiency and innovation, while decreasing costs and schedule durations. Studies have explored the benefits of D-B and CM/GC delivery methods, but they have not explored how to best measure the performance of these projects when viewed in aggregate as a program. Through a survey of 41 transportation practitioners across the country, this study addresses that need by identifying 6 performance measures that can be used by state transportation agencies to gauge the success of the alternative project delivery method projects, and programs as a whole. These performance are; (1) Proposals from Qualified Contractors, (2) Milestone Dates, (3) Construction Duration, (4) Total Project Cost, (5) Project Cost at Award, and (6) Accepted Alternative Technical Concepts. These measures utilize data from the preconstruction phase, construction phase, or both. This gives states the ability to analyze each phase, and determine where improvement is needed. The use of these performance measures will allow state transportation agencies to identify strengths and weaknesses within their alternative project delivery method programs, and lead to improvement when delivering these projects. It is important for these delivery methods to not only out-perform traditional delivery methods such as Design-Bid-Build (D-B-B), but to also reach their maximum potential as programs develop.

### **2.2 Introduction**

State transportation agencies across the country are beginning to utilize more alternative project delivery methods such as design-build (D-B) and construction manager/general

contractor (CM/GC) (Gransberg and Molenaar 2008, Sullivan et al. 2017). This is in part due to the proactive position taken by the federal government to improve the nation's transportation systems. "Congress declares that it is in the national interest to promote the use of innovative technologies and practices that increase the efficiency of construction of, improve the safety of, and extend the service life of highways and bridges." (Moving Ahead for Progress in the 21<sup>st</sup> Century (MAP-21) 2012). Implementing alternative project delivery methods on highway construction projects is one step taken by state transportation agencies to accomplish the objectives stated in MAP-21. D-B and CM/GC project delivery methods were highlighted as innovative practices in the Federal Highway Administration (FHWA) Every Day Counts program, where training and support for these alternative project delivery methods was provided to state transportation agencies to help with their initial implementation and growth of the programs (FHWA 2018c).

Many state transportation agencies currently measure performance at the organizational level and project level, as seen in the Virginia Department of Transportation's *Performance Reporting System for Projects and Programs* Dashboard (VDOT 2007). Performance measures at these levels are important to the success of state transportation agencies, but as the use of D-B and CM/GC delivery methods continues to grow, so does the need to implement alternative project delivery method specific performance measures. The Washington State Department of Transportation (WSDOT) identified this need as well in their Review of WSDOT's Implementation of Design-Build Project Delivery (WSDOT 2016). Developing these performance measures will allow agencies to grow their programs if they are currently performing well, or implement corrective actions if the programs are performing poorly.

Identifying and developing these unique performance measures will fill the need for defining success of alternative project delivery method projects, and the programs as a whole. The scope of each alternative project delivery method project is unique, but it is important to establish performance measures that can be used interchangeably in order to compare the projects and view them in aggregate as a program.

State transportation agencies use a variety of terms to describe project delivery methods that differ from the traditional Design-Bid-Build (D-B-B) method. These terms include innovative contracting methods, innovative project delivery methods, alternative contracting methods, and alternative project delivery methods. For consistency, this research uses the term alternative project delivery methods when referring to D-B and CM/GC delivery methods.

Alternative project delivery method projects function quite differently from D-B-B projects throughout all phases. Because of this, alternative project delivery methods are contracted and executed differently, typically by a specially trained group of staff members. A program is a group of related projects managed in a coordinated manner to obtain benefits not available from managing them individually (Project Management Body of Knowledge 2017). For this research, the group of staff members and all their associated D-B and CM/GC projects will be referred to as an alternative project delivery method program.

The central function of any performance measurement process is to provide regular, valid data on indicators or performance outcomes (Venner 2003). Similarly, the FHWA states that “performance measurement is the use of statistical evidence to determine progress toward specific defined organizational objectives” (FHWA 2018d). For this research, the purpose of performance measures are to accomplish these defined objectives.

## 2.3 Background and Industry Need

State transportation agencies are selecting alternative project delivery methods because of their benefits over the traditional (D-B-B) delivery method. Some of these benefits are highlighted in the FHWA Every Day Counts program, and include; fostering innovation, improved design quality, accelerated project delivery, improved design quality, improved cost control, and risk mitigation (FHWA 2017a; FHWA 2018b).

Since state transportation agencies first began using D-B and CM/GC delivery methods in the 1990s and 2005 respectively, more and more states have adopted their use. This is in part due to the FHWA introducing the Special Experimental Project No. 14 – Alternative Contracting in 1990, which allowed state transportation agencies to evaluate these non-traditional contracting techniques (FHWA 2017b). By the end of 2014 the number of state transportation agencies delivering D-B projects grew to 35, and the number delivering CM/GC projects grew to 17 (FHWA 2018a). With the increased use of alternative project delivery methods, much research has already been conducted on D-B and CM/GC delivery. One focus of research has been their corresponding procurement methods, as Gransberg and Senadheera (1999) described methods to advertise and award D-B projects for state transportation agencies, and Gransberg and Shane (2013) investigated the use of a best-value procurement method for CM/GC projects. A comparison of these methods to the traditional D-B-B delivery method has also been studied, as Gransberg et al. (2003) studied the performance of 88 federal building projects constructed using D-B and D-B-B delivery. Alleman et al. (2016) also compared D-B, D-B-B, and CM/GC delivery methods while analyzing 291 small highway construction projects in the United States. Even though all this research has been conducted on D-B and CM/GC delivery very little exists on measuring the performance of the delivery methods themselves, not just the performance on individual projects.

As these alternative project delivery method programs continue to grow, it is important to measure and analyze their performance. It is important to measure the performance of D-B and CM/GC projects against D-B-B projects, but it is also important to measure their performance internally within the program to ensure their continued improvement. Washington State Department of Transportation (WSDOT) identified the need for more program level performance measures in their Review of WSDOT's Implementation of Design-Build Project Delivery (WSDOT 2016). One of their recommendations on program development and management included, "Develop a framework for monitoring performance, capturing lessons-learned, and fostering a culture of continuous improvement." Like many state transportation agencies, WSDOT does not currently have a formal system for tracking the performance of their alternative project delivery method programs, but they recognize the need and are moving towards implementing a system in the future.

## **2.4 Research Questions**

Current alternative project delivery method literature does not give enough attention to identifying and developing performance measures for alternative project delivery method programs. Establishing performance measures within alternative project delivery method programs will allow state transportation agencies to identify specific aspects of their delivery method processes in need of improvement, and enable them to push towards programs that are operating more effectively. After identifying this need, three research questions were developed to address the lack of current alternative project delivery method program performance measures.

Central Question: *How can state transportation agencies measure the performance of their alternative project delivery methods such as D-B and CM/GC at the program level?*

Sub Question 1: *What measures can state transportation agencies use to determine the performance of their alternative project delivery method programs during the preconstruction phase?*

Sub Question 2: *What measures can state transportation agencies use to determine the performance of their alternative project delivery method programs during the construction phase?*

## **2.5 Research Approach and Results**

The research approach consisted of four primary tasks: (1) literature review, reviewing existing documentation for performance measurement within state transportation agencies; (2) develop initial performance measure list, utilizing the information from the first task to document existing applicable performance measures and developing new performance measures; (3) data collection, distribute a questionnaire to a variety of transportation practitioners; and (4) synthesis of performance measures, synthesizing final results to identify the top-rated performance measures.

### *2.5.1 Literature Review*

A thorough literature review of existing documentation from state transportation agencies was conducted to identify existing performance measures. It was revealed that many state transportation agencies have already identified the need for performance measurement at the organizational level, and have developed systems to document these measures and their data as seen in Table 2.1.



Table 2.1: Organizational Performance Measurement Systems

State Transportation Agency	Performance Measurement System
Alaska Department of Transportation	Performance Dashboard
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Idaho Transportation Department	Performance Measures Dashboard
Minnesota Department of Transportation	Annual Transportation Performance Report
North Carolina Department of Transportation	Organizational Performance Dashboard
South Carolina Department of Transportation	Organizational Performance Dashboard
Utah Department of Transportation	Dashboard and Strategic Direction
Virginia Department of Transportation	Performance Reporting System for Projects and Programs
Washington State Department of Transportation	The Gray Notebook

These performance measurement systems include categories such as; safety, mobility, finance, condition, and customer satisfaction. This shows the use of metrics by state transportation agencies to measure performance at the organizational level, but no such performance measures were identified at the program level for alternative project delivery methods.

To learn more about how state transportation agencies are implementing alternative project delivery methods and using performance measures, their available documentation was analyzed. By reviewing state transportation agency websites, it was found that 24 agencies have guidebooks or manuals specifically for D-B, CM/GC, or both. These states are listed in Table 2.2.

Table 2.2: State Transportation Agencies with Alternative Project Delivery Method Manuals

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Searching these guidebooks and manuals from the state transportation agencies revealed the following about current performance measurement:

- Project-specific performance measures are listed in RFPs
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In all cases, performance measures seemed to be determined on a project-by-project basis. They are currently used to measure the performance of individual projects, not the alternative project delivery method program as a whole.

Some of the previously mentioned performance measurement systems somewhat measure program performance, such as the Virginia Department of Transportation (VDOT) *Performance Reporting System for Projects and Programs* Dashboard (VDOT 2007). One function of this dashboard is to view the performance of all VDOT construction projects in aggregate, and report their ability to complete the development and delivery phases on time and on budget. This view of all projects within the construction program is beneficial, but categorizing the alternative project delivery method projects separately and using performance measures specifically for D-B and CM/GC projects would add even more value.

### *2.5.2 Develop Initial Performance Measure List*

Since there were very few performance measures for alternative project delivery methods found in the literature review, it was necessary to develop more. While conducting the previous task to identify performance measures, it was revealed that many state transportation agencies utilize the Project Delivery Selection Matrix (PDSM) developed by Tran et al. (2012), or a similar version. This group of state transportation agencies includes; Colorado, Minnesota, California, South Carolina, Texas, Georgia (Version), North Carolina (Version), Washington State (Version), Idaho (Version), and Nevada (Version).

The original PDSM was designed to assist state agencies in evaluating and selecting the most appropriate delivery method for their highway construction projects. The PDSM evaluates the 3 most fundamental delivery methods of D-B-B, D-B, and CM/GC based on the following eight categories/selection factors:

1. Delivery Schedule
2. Complexity and Innovation
3. Level of Design
4. Initial Project Risk Assessment
5. Cost
6. Staff Experience/Availability
7. Level of Oversight and Control
8. Competition and Contractor Experience

Since these eight categories were identified as being the most appropriate for evaluating the use of alternative project delivery methods, it was determined for this research that it would serve as a suitable outline for developing alternative project delivery method performance measures. Since these are the criteria being used to select an alternative project delivery method,

they should also be used to measure the performance of these methods to determine their success or failure.

State transportation agencies such as the Colorado Department of Transportation (CDOT) and the Minnesota Department of Transportation (MnDOT) also document their use of the PDSM on individual projects. These documents contain the detailed objectives for each project, and the justifications for each delivery method selection. Some of these completed PDSMs were reviewed, and when possible the objectives stated for an individual project were converted into performance measures that could be used on any alternative project delivery method project. For example, a CDOT project (SH92 Stengel's Hill) had the objective of "Construction Completed by December, 2016". This is very specific, however a performance measure such as "Milestone Dates" could track the project's ability to meet desired milestones such as this. Understanding the percentage of milestone dates that are achieved using each delivery method could help state transportation agencies have more confidence in their ability to achieve them, or implement changes to ensure they are achieved more frequently.

The completion of this task resulted in an initial list of 32 performance measures being identified. This list represented the categories presented in the Project Delivery Selection Matrix (Tran et al. 2012), and common project objectives identified by state transportation agencies.

### *2.5.3 Data Collection*

After the initial list of 32 performance measures were identified, it was necessary to distribute a questionnaire to a variety of transportation practitioners to identify the top-rated performance measures. The list of potential participants consisted of transportation practitioners familiar with the alternative project delivery methods of D-B and CM/GC within state transportation agencies. The list was generated from information on state transportation agency

websites, the Design Build Institute of America Transportation Conference contacts list from the past 3 years, and recommendations from other transportation practitioners. The questionnaire was then distributed to 183 potential participants through email, representing 40 different state agencies, Washington D.C., and the FHWA.

The questionnaire presented the 32 performance measures organized into six categories of; (1) delivery schedule, (2) project complexity and innovation, (3) level of design, (4) cost, (5) qualified contractors, agency staff, and agency resources, and (6) other potential performance measures. The full list of performance measures and their definitions can be seen in Appendix A.

In order to identify the top-rated performance measures, the following three questions were asked for each category.

Question 1: *Does your state transportation agency currently track the following performance measures on alternative project delivery method projects?*

Question 2: *How accurate would the following performance measures be at reflecting the performance of an alternative project delivery method program?*

Question 3: *How available is the data required for the following performance measures?*

The purpose of question 1 was to gain a better understanding of the current practices within state transportation agencies. This identified the performance measures that were currently being tracked, but not used to formally evaluate the performance of the overall program. This question was presented in multiple choice format, with selection options of “yes”, “no” and “unsure”.

Question 2 and question 3 were generated based on what was determined to be the most important aspects of a good performance measure for alternative project delivery method programs. The ability of the data to accurately represent the performance, and the availability of

the required data. After each questions, the performance measures were presented with a sliding bar for scoring on a Likert-type scale, ranging from one to six. Participants were also given the option to check “unsure” if they were not familiar with the performance measure or did not understand.

For question 2, an “Inaccurate” performance measure would not at all represent the performance of an alternative project delivery method program. An “Accurate” performance measure would effectively represent the performance of an alternative project delivery method program. For question 3, data that is “Unavailable” could not be obtained or used. Data that is “Readily Available” is currently collected and easily obtainable.

The use of a Likert-type scale to produce a score for each performance measure was determined to be more effective than simply ranking the performance measures. This is because an ordinal or ranking scale provides no information about the intervals between the points (Oppenheim 1992). One performance measure could have scored far higher than the next closest performance measure, but the use of a ranking scale would not allow this to be known. Using a Likert-type scale with a scoring system allows for the performance measures to be ranked, and allows the difference in scoring between each performance measure to be known.

The range of scoring from one to six for the Likert-type scale was chosen for two reasons. The first reason was because although there may be no optimal number of responses for a scale, the amount of information that can be processed by participants is typically in the range of five to nine points. Giving participants more options would not necessarily increase the accuracy of the responses, it would more likely create more confusion (Miller 1955). The second reason for selecting a range of scoring from one to six was because an even number of response options eliminates a rating at the middle of the scale, or “neutral”. Participants are forced to

select a side of the scale. The use of the “unsure” response choice is meant for participants that do not understand the question or performance measure, not for those that are unsure about their opinion.

The final portion of the survey consisted of questions intended to gain more background information about the participants. This information included the state transportation agency they work for, the number of years they have worked on D-B and CM/GC projects, and the number of D-B and CM/GC projects they have worked on.

#### *2.5.4 Synthesis of Performance Measures*

The data from the questionnaire was synthesized by generating a total score for each performance measure, from each participant. The total scores were calculated by summing the scores obtained during questions 2 and 3, with each question being given an equal weight. For both questions, the lowest possible score, or most negative response, was one, and the highest possible score, or most positive response, was six. This resulted in total scores for each performance measure to potentially range from 2 to 12. The total scores for each performance measure, from each participant, were then analyzed and used to calculate a final score for each performance measure. The median score was chosen to represent the final score because descriptive statistics recommend the median to represent central tendency (Boone and Boone 2012), and median statistics is much less sensitive to being biased by outliers (Chen and Ratra 2011). These median scores were used to identify the top rated performance measures, which could then be categorized as those used during the preconstruction phase, construction phase, or all phases of the project.

## **2.6 Analysis of Responses**

### *2.6.1 Demographics of Respondents*

The questionnaire was distributed to 183 transportation practitioners across the country who have experience working with D-B or CM/GC highway transportation projects for state transportation agencies. Of the 183 distributed questionnaires, 44 complete responses were returned, resulting in a response rate of about 24%. Of these 44 complete responses, 3 were eliminated because they did not meet the criteria of completing at least 1 D-B or CM/GC project in their career. This resulted in a total of 41 responses being analyzed for this research

These 41 responses represented 19 different state transportation agencies across the country, with the FHWA Eastern Federal Lands Highway Division (FHWA-EFLHD) also being represented. In March of 2015 the FHWA released the Every Day Counts-2 Final Report which identified that 22 states, Washington D.C., and Federal Lands Highway had made D-B, or CM/GC, or both, a standard project delivery practice (FHWA 2015). Of these 22 states, 12 are represented in this research. The other 7 state transportation agencies represented in this research had completed or were currently in the “Demonstration” phase as of 2015.

Due to the varying ages of alternative project delivery method programs within state transportation agencies, practitioners with a wide range of experience contributed to this research. As previously mentioned, only those who had completed at least one D-B or CM/GC project were included in this data. The experience with these delivery methods ranged from 1 year to 28 years, and 1 project to 30 projects. The average experience with D-B was approximately 8 years, completing 9 projects, and the average experience with CM/GC was approximately 3 years completing 2 projects. CM/GC is still not practiced in many states, and very new in others, therefore the experience was less than that of D-B.



### 2.6.2 Findings

The findings of this questionnaire resulted in the identification of the six top-rated performance measures for alternative project delivery methods. These results can be seen in Table 2.3.

Table 2.3: Top-Rated Performance Measures

<b>Performance Measure</b>	<b>Project Phase</b>	<b>Total Score</b>	<b>Percentile</b>
Proposals from Qualified Contractors	Preconstruction	10	100 <sup>th</sup>
Milestone Dates	Construction	10	100 <sup>th</sup>
Construction Duration	Construction	10	100 <sup>th</sup>
Total Project Cost	All Phases	10	100 <sup>th</sup>
Project Cost at Award	Preconstruction	9.5	84 <sup>th</sup>
Accepted Alternative Technical Concepts	Preconstruction	9.5	84 <sup>th</sup>

These six performance measures received the highest total scores, and were therefore identified as top-rated. The total scores of the initial 32 performance measures ranged from 6 to 10, with a median score of 8. The Median Absolute Deviation (MAD) value for the total scores was calculated to be 1.48, revealing that all performance measures with a total score of 9.48 and higher were greater than one MAD above the median. The only six performance measures that fit this criteria are those identified in Table 2.3. All of these performance measures also had a minimum response rate of 93%, meaning at most only 3 respondents were unsure about the performance measure's definition, accuracy, or availability.

### 2.6.3 Proposals from Qualified Contractors

The data for this performance measure is collected in the preconstruction phase, and is defined as the number of qualified contractors submitting proposals for each D-B or CM/GC project. This performance measure would fall into the category of "competition and contractor

experience” within the Project Delivery Selection Matrix (Tran et al 2012). When using this selection matrix, this is one of the factors that is considered when choosing between D-B-B, D-B, or CM/GC. It is meant to evaluate the level of competition and experience among contractors available to the state transportation agency. More competition among contractors could result in lower contract prices, and more experience will produce a better overall product. One practitioner commented, *“The contractors and consultants are currently tracked in-line with our regular D-B-B ratings. It doesn’t really fit well at all. We could use something better.”* This shows the need to also develop a unique criteria for qualified contractors using alternative project delivery methods. Tracking this performance measure and implementing changes to increase the number of proposals from qualified contractors could improve the overall quality of the alternative project delivery method program.

#### *2.6.4 Milestone Dates*

The data for this performance measure is collected in the construction phase, and is defined as a comparison of achieved milestone dates to estimated milestone dates. These milestones could consist of road or bridge closures and openings, traffic switches, project phasing, and any other key dates identified by the project team. What the state transportation agency defines as an important milestone will change from project to project, but the goal will always be to meet these dates. One practitioner commented that the ability to meet milestone dates is one of the “most visible achievements” related to project schedule. Milestone dates are often an important aspect of project objectives, and tracking a delivery method’s ability to achieve these objectives would benefit the program and the agency.

### *2.6.5 Construction Duration*

The data for this performance measure is collected in the construction phase, and could have different definitions depending on the delivery method. In D-B delivery, the D-B team is able to start construction upon award and approval from the state transportation agency, which takes place prior to 100% design completion. Substantial completion is an appropriate measure for the end of construction, as this date reflects the point at which the public is able to benefit from the project (Crossett & Hines 2007). In CM/GC delivery, the work is typically divided up into construction work packages, therefore construction would officially start at the start of this first work package. Similar to D-B, substantial completion would be an appropriate end date for construction. Accelerated project delivery is one of the potential benefits of these delivery methods as described by the FHWA's Every Day Counts program (FHWA 2017a; FHWA 2018b), therefore performance should be measured based on some aspect of delivery schedule. Durations of other aspects of the project, such as the preconstruction phase, could be accelerated as well. However, construction has the largest impact on the traveling public, and is likely the phase agencies would like to accelerate the most, and have the most schedule certainty. Construction duration can be measured and evaluated based on the following aspects; comparison to similar projects, planned duration vs. actual duration, or percent growth. All of these data collection and measurement techniques would allow for performance trends to be identified, and targets set. Many respondents commented that data for durations such as construction are currently tracked to measure performance of individual projects, but the data is not viewed in aggregate to gauge program success.

### *2.6.6 Total Project Cost*

The data for this performance measure is collected throughout the duration of the project, and is defined as the sum of all costs associated with the project. This includes the cost to

produce the preliminary design, procure a contractor, contract amount, quality assurance, and any other associated costs. Improved cost control is another potential benefit of alternative project delivery methods identified by the FHWA's Every Day Counts program (FHWA 2017a; FHWA 2018b). Similar to measures associated with schedule duration, measures associated with cost can be analyzed as a planned cost vs. actual cost, percent growth, or compared to similar projects. There are many types of costs that can contribute to the total project cost, but if an agency is able to control the total cost, other associated costs are likely controlled as well. If this is identified as an area in need of improvement within an agency, then a more detailed look at all costs could reveal which factors are contributing to high or unpredictable costs. Again, many respondents commented that this measure is tracked for every project, but only used to measure the performance of that individual project.

#### *2.6.7 Project Cost at Award*

The data for this performance measure is collected in the preconstruction phase, and is defined as the cost of the project at award vs. the original engineer's estimate. According to the FHWA's "Guidelines on Preparing Engineer's Estimate, Bid Reviews, and Evaluation", the engineer's estimate should reflect the amount that the agency considers fair and reasonable for performance of the work (FHWA 2004). Underestimating project cost could cause delay's as the gathering of additional funds is required, and overestimating could result in the agency not recognizing a proposal that is too high. An agency's ability to consistently produce accurate estimates of project costs could increase the efficiency of procurement, and protect funds that can be used as contingency, or used on other projects.

### 2.6.8 Accepted Alternative Technical Concepts (ATCs)

The data for this performance measure is collected in the preconstruction phase, and is defined as the number of ATCs proposed by the D-B or CM/GC team and accepted by the state transportation agency. Research shows that ATCs can improve constructability, enhance innovation, shorten schedules, reduce risks, and ultimately save costs on a case-by-case basis (FHWA 2018a). With these potential benefits, state transportation agencies should be hoping to implement many ATCs, as long as they are of equal or better value of the originally proposed scope. One respondent commented, “*A good program should allow for innovation in the technical proposals, which would mean there is room for ATCs that save time and money. The RFP should not be so descriptive so as to limit innovation through ATCs.*” The Project Delivery Selection Matrix (Tran et al. 2012) identifies the need for applicability of new designs or processes to resolve complex and technical issues as a reason for selection alternative project delivery methods. If this is one of the main reason’s D-B or CM/GC was chosen, then ATCs should be encouraged by the state transportation agency. A high number of accepted ATCs could indicate that the project will experience these potential benefits, and could be used to gauge the quality of the overall proposal.

### 2.6.9 Other Potential Performance Measures

Table 2.3 showed the top 6 performance measures, with total scores of 9.5 and 10. If state transportation agencies would like to implement more performance measures, the second tier of performance measures based on total score are shown in Table 2.4.

Table 2.4: Second Tier Performance Measures

<b>Performance Measure</b>	<b>Project Phase</b>	<b>Total Score</b>	<b>Percentile</b>
Procurement Duration	Preconstruction	9	78 <sup>th</sup>
Overall Project Duration	All Phases	9	78 <sup>th</sup>
Change Orders	All Phases	9	78 <sup>th</sup>
Disputes	All Phases	9	78 <sup>th</sup>
Use of Contingency and Risk Pools	All Phases	9	78 <sup>th</sup>

These performance measures received the next-highest total score of 9, but were all within one MAD of the median. These performance measures also received high response rates (above 93%) with the exception of “use of contingency and risk pools”. This measure only received a response rate of 71%, indicating a larger number of respondents were unsure about its definition, accuracy, or availability. This performance measure could require more analysis to understand its lower response rate and to determine how effective it would be. The definitions of these performance measures and all performance measures presented in the questionnaire can be seen in Appendix A.

#### *2.6.10 Summary of Results*

Of the six top-rated performance measure, three utilize data from the preconstruction phase, two from the construction phase, and one from all phases of the project. The percent of respondent’s who’s agencies currently collect data for these measure range from 63% to 93%, indicating the majority of these agencies have the ability to utilize all of these performance measures. Respondents consistently commented that many of performance measures in question are only used on individual projects, they are not viewed in aggregate as an entire program. Or, the data is collected but it is not formally tracked or presented in a database available for analysis.

With the majority of this data currently being collected, it would take little change or additional effort to formally track and analyze these performance measures. Table 2.1 showed that many agencies have a formal performance measurement database for organizational level objectives, so utilizing this type of technology to alternative project delivery method programs could create significant benefits with little effort.

## **2.7 Discussion and Applications**

Now that the top performance measures for alternative project delivery method programs have been identified, they can be adopted by state transportation agencies and used to track program performance. Collecting the data required for each of these performance measures will allow state transportation agencies to identify areas of strength and weaknesses within their program, and work towards continuous improvement.

These performance measures should be used to collect data from individual projects, but they will be most useful when viewed in aggregate. Viewing the performance of a single project will allow project teams to gauge their success against targets or expected outcomes, but viewing the performance of the program as a whole will allow for performance trends to be identified. Achieving the objectives of each individual project is important, but improving programs and delivering the majority of projects more effectively and efficiently should also be the objective of state transportation agencies.

In order to effectively compare D-B and CM/GC projects against one another, more categorization should be established. For example, when using performance measures related to schedule durations or costs, the values will vary drastically depending on the size and complexity of the projects. It is recommended that projects be organized into categories of non-complex,

moderately complex, and most complex as defined in NCHRP Report 574 (2007). These complexity definitions for roadway projects can be seen in Table 2.5.

Table 2.5: Complexity Definitions

Non-Complex	<ul style="list-style-type: none"> <li>• Maintenance betterment projects</li> <li>• Overlay projects, simple widening without right-of-way (or very minimum right of way take), little or no utility coordination</li> <li>• Non-complex enhancement projects without new bridges (e.g., bike trails)</li> </ul>
Moderately Complex	<ul style="list-style-type: none"> <li>• 3R and 4R projects which do not add capacity</li> <li>• Minor roadway relocations</li> <li>• Certain complex (non-trail enhancement) projects</li> <li>• Slides, subsidence</li> </ul>
Most Complex	<ul style="list-style-type: none"> <li>• New highways; major relocations</li> <li>• New interchanges</li> <li>• Capacity adding/major widening</li> <li>• Major reconstruction (4R; 3R with multi-phase traffic control)</li> <li>• Congestion management studies are required</li> </ul>
<p>Note: “3R” = Resurfacing, Restoration, Rehabilitation  “4R” = New Construction/Reconstruction</p>	

Only analyzing projects within the same category will allow for more accurate comparisons and trend analysis, as projects with similar complexities will most likely be executed in similar manners. Categorizing projects by total project cost could also allow for more accurate comparisons.

Compiling the data from these performance measures in a database will allow state transportation agencies to view their performance trends from project to project, and year to year. Tracking this data and comparing it to changes in procedure for delivering these project will allow agencies to identify the impact those changes have had.



## **2.8 Limitations of Research**

Although this research has identified the top performance measures for alternative project delivery method programs, it has not discussed how state transportation agencies can set or reach their targets for these performance measures. Each state transportation agency will need to decide for themselves what goals should be set with regards to these performance measures, and how long until the goals are achieved.

The identification of performance measures allows state transportation agencies to gauge their own success, but further research will need to be done to determine the most effective ways to realize improvement. Specifically, if an alternative project delivery method program is not performing well, what changes must be made in order to reach the target levels of the performance measures? This need is true for all performance measures, as highlighted in the Performance Measures to Improve Transportation Systems and Agency Operations report by the Transportation Research Board (2000). “Performance measurement is a means to an end, but not an end itself. Clarity is needed about the purpose, the true driving forces, the intended audience, and the use of the information.” Identifying performance measures is the first step, but achieving objectives and seeing improvement could require cultural and procedural changes at the organizational level.

## **2.9 Conclusions**

Through the distribution of a questionnaire to state transportation practitioners across the country, this research identified the top-rated performance measures for alternative project delivery methods to be; (1) Proposals from Qualified Contractors, (2) Milestone Dates, (3) Construction Duration, (4) Total Project Cost, (5) Project Cost at Award, and (6) Accepted Alternative Technical Concepts. Indicators for these performance measures could be determined

based on comparisons to similar projects, actual values vs. expected values, or for those related to cost and schedule percent growth could be used. The use of performance measures in state transportation agencies is not a new concept. This research found that many state transportation agencies have established performance measures for organizational objectives regarding safety, mobility, finance, etc., and for objectives relating to all construction projects such as cost and schedule growth. However, the use of performance measures specific to alternative project delivery methods is almost non-existent. This need is recognized by state transportation agencies, but formal data collection and reporting systems have not yet been developed. The top-rated performance measures identified in this research were determined to be the most important factors when considering alternative project delivery method performance, and it is hoped that state transportation agencies use these performance measures to realize improvement and achieve their objectives within their alternative project delivery method programs.

## **2.10 Acknowledgements**

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## Chapter 3: Conclusions

The use of performance measures in state transportation agencies is not a new concept. This research found that many state transportation agencies have established performance measures for organizational objectives regarding safety, mobility, finance, etc., and for objectives relating to all construction projects such as cost and schedule growth. However, the use of performance measures specific to alternative project delivery methods is almost non-existent. This need is recognized by state transportation agencies, but formal data collection and reporting systems have not yet been developed.

This study builds on and contributes to previous research that has been conducted on alternative project delivery methods, and performance measurement in transportation agencies. Literature such as; Goftar et al. (2014), Sullivan et al. (2017), Gransberg et al. (2003), and Tran et al. (2017), have all studied the performance of alternative project delivery methods compared to the traditional D-B-B method, but no research was found which studied the performance of these projects at a program level. This research fills that need and allows for more future research on the topic to be done as well.

Delivery methods such as D-B and CM/GC are becoming increasingly popular with state transportation agencies throughout the country because of their benefits over the D-B-B method. It is important that these alternative project delivery methods continue to out-perform the D-B-B method, but it is also important that they continue to improve over time. As state transportation agencies continue to deliver projects using these methods, more data will become available and more analysis can take place to identify performance trends over time.

The top-rated performance measures identified in this research were determined to be the most important factors when considering alternative project delivery method performance. It is

hoped that state transportation agencies use these performance measures to realize improvement and achieve their objectives within their alternative project delivery method programs.

### **3.1 Discussion**

The questionnaire for this research study was distributed to 183 transportation practitioners across the country, and 44 completed responses were returned for a response rate of approximately 24%. This questionnaire did provide excellent data from a variety of states, however even more responses would have improved the quality even more. Responses from the remaining 10 states that have made D-B, CM/GC, or both standard project delivery methods would also increase the quality of the responses.

Distributing a questionnaire was an effective method to conduct this research, however given the proper time and available resources conducting workshops with these transportation practitioners could have provided even more insight and reliable data. A workshop could be utilized to develop the initial list of performance measures, and the identification of the top-rated performance measures. A workshop setting would allow for more structure, more conversation, and it would give participants a chance to explain the reasoning behind their answers. This type of explanation would not only provide valuable insight, but it could produce a higher degree of consensus among participants. Without the discussion and explanation available in a workshop setting, it is difficult to claim with a high degree of certainty that all participants interpreted the questions and performance measures in the same manner. A questionnaire requires less time and effort for the respondents and is therefore likely to have a higher participation rate than a workshop, but a workshop may provide data that is more accurate, and of higher quality.

### 3.2 Future Research

Although this research has identified the top performance measures for alternative project delivery method programs, it has not discussed how state transportation agencies can set or reach their targets for these performance measures. Each state transportation agency will need to decide for themselves what goals should be set with regards to these performance measures, and how long until the goals are achieved. As more agencies adopt this practice, more data will become available to share with one another, and compare results. For example, an alternative project delivery method program that has been operating for 15 years is likely to be more efficient than a program in its first or second year, but data could still be shared to gain a better understanding of how long this growth and improvement could take, and what are some realistic starting objectives for the program. For a very young program, similar data from D-B-B projects could potentially be used to set objectives for the alternative project delivery method projects until the program has become more developed. To start seeing trends and patterns in the data it could take several years and upwards of 15 D-B or CM/GC projects for an agency to be able to accurately set their own objectives based on past performance.

The identification of performance measures allows state transportation agencies to gauge their own success, but further research will need to be done to determine the most effective ways to realize improvement. Specifically, if an alternative project delivery method program is not performing well, what changes must be made in order to reach the target levels of the performance measures? This need is true for all performance measures, as highlighted in the Performance Measures to Improve Transportation Systems and Agency Operations report by the Transportation Research Board (2000). “Performance measurement is a means to an end, but not an end itself. Clarity is needed about the purpose, the true driving forces, the intended audience, and the use of the information.” Identifying performance measures is the first step, but achieving

objectives and seeing improvement could require cultural and procedural changes at the organizational level. When data is being collected and formally tracked in a database, it will be much easier for programs to identify areas in need of improvement, implement changes, and analyze the impact of those changes on the performance measurement data. This information would also be very useful to other state transportation agencies, if a certain corrective measure has proved effective it could eliminate time and money spent on a trial and error process.

Additionally, future research could be conducted to determine why these performance measures were identified as the most effective. In the questionnaire participants were given the opportunity to provide comments and justify their responses, but not all elected to do so. Understanding the why behind these selections could help identify potential improvement methods, and identify more similar performance measures. The performance measures from this research that were not identified as being top-rated could also be studied further, to determine why they were not selected. Gaining more insight from experienced transportation practitioners on performance measurement for alternative project delivery methods would only enhance our understanding, and lead to more effective implementation.

### **3.3 Final Thoughts**

Looking back on the experience of pursuing my Master's degree, I'm very pleased I was able to experience the research process through completing a thesis. My original intention was to complete my degree requirements through only coursework, but I'm glad those plans changed. Conducting this research has not only drastically expanded my knowledge on the selected topic, but it has taught me useful skills related to critical thinking, problem solving, and expressing my thoughts through writing and discussion. The most significant takeaway from this experience was learning the importance of backwards planning. I found this research process to be much

more effective when I stopped and thought about my final product, and then worked backwards to complete the tasks that would get me there. This helped me avoid paths that at times looked effective, but would not result in the intended final product.

I'm very satisfied with the topic I selected to research as well. I feel that performance measures for alternative project delivery method programs is extremely interesting, and something that is needed in highway transportation construction projects. The feedback I received from members of state transportation agencies showed that this is a topic of interest to many people, and seen as an area of need. I believe my research will provide useful information to those interested in utilizing performance measures, and can be used to promote further research and investigation in the future.

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## **Appendix A: Initial Performance Measures and Descriptions**

### **Delivery Schedule**

Delivery schedule is the overall project schedule from scoping through design, construction, and opening to the public. (Measured as: duration compared to other projects, planned vs. actual, or % growth)

#### Performance Measures within this category

1. Overall project duration
  - Duration of project from concept to substantial completion
2. Production of Request for Proposals (RFP) duration
  - The time needed to complete all RFP documents for project advertisement
3. Procurement duration
  - For D-B – Duration from advertising date to award date
  - For CM/GC – Duration from advertising date to CM/GC selection
4. Response time to Alternative Technical Concepts (ATCs)
  - The time taken by the STAs to respond to ATCs proposed by the contractor or design team
5. Preconstruction services duration
  - For CM/GC – Duration from preconstruction award to GMP
6. Construction duration
  - For D-B – Duration from award to substantial completion
  - For CM/GC – Duration from start of the first construction work package to substantial completion
7. Milestone dates
  - Comparison of achieved milestone dates to estimated milestone dates (road/bridge closures and openings, traffic switches, project phasing, etc.)

### **Project Complexity and Innovation**

Project complexity and innovation is the potential applicability of new designs or processes to resolve complex technical issues

#### Performance Measures within this category

1. Proposed ATCs of equal or better value
  - The number of ATCs of equal or better value proposed by the contractor or design team
2. ATCs put into contract
  - The number of ATCs accepted by the STA and put into the contract
3. Cost savings
  - The estimated cost savings as a result of innovation, constructability, or value engineering by the D-B or CM/GC team
4. Schedule savings
  - The estimated schedule savings as a result of innovation, constructability, or value engineering by the D-B or CM/GC team
5. Life-cycle and maintenance savings
  - The estimated cost savings from innovation or value engineering to lower project life-cycle and maintenance operation costs

## **Level of Design**

Level of design is the percentage of design completed at the time of the project delivery procurement

### Performance Measures within this category

1. Design completion at procurement
  - The percent of design that is completed at project procurement
2. RFP clarification questions
  - The number of RFP clarification questions received by the state transportation agency and made public to all proposers that indicate project documents were incomplete or unclear.

## **Cost**

The financial process related to meeting budget restrictions, accuracy of cost estimation, and control of the project costs (Planned vs. actual, cost growth, % of contract)

### Performance Measures within this category

1. Total project cost
  - Sum of all costs associated with the project

2. Project cost at award
  - Cost of the project at award vs. original engineer's estimate
3. Procurement cost
  - Cost to produce RFP documents, and perform activities prior to award (Prelim design, ATC review process, cost validations etc.)
4. Cost to ensure design quality
  - Costs for STA to perform design reviews, ensure quality standards are met
5. Cost to ensure Construction Quality
  - Costs for STA to enforce the quality program and ensure construction quality standards are met
6. Incentive/Disincentive Payments
  - The need to pay or collect incentive or disincentive payments based on project quality, schedule performance, etc.

### **Qualified Contractors, Agency Staff, and Agency Resources**

The availability of qualified contractors, qualified agency staff, and agency resources required for a project.

#### Performance Measures within this category

1. Qualified contractors
  - The number of pre-qualified contractors for APDM projects
2. Proposals from qualified contractors
  - The number of qualified contractors submitting proposals for each project
3. Qualified STA staff
  - The number of qualified staff members within the STA (qualified can be defined as number of APDM projects worked on, number of years working with APDMs, or based on the completion of a training program)
4. Design review resources
  - The time and money the STA commits to performing design reviews (over-the-shoulder, discipline task force, in-progress design workshops etc.)
5. Cost validation resources

- The time and money the STA commits to validation of project costs (independent cost estimator, cost modeling approach, opinion of probable construction costs etc.)

## **Other Potential Performance Measures**

### Performance Measures within this category

1. Project quality
  - The number of materials failures, non-conformances, and necessary price reductions on the project
2. Mobility
  - The average time travel through project work zones
3. Project safety
  - The number of work zone incidents for both project staff and traveling public during a project
4. Change orders
  - The cost and schedule impacts resulting from change orders executed throughout the project
5. Disputes
  - The cost and schedule impacts resulting from disputes. A dispute is a disagreement that requires a resolution above the project level.
6. Initial contingency and risk pools
  - For D-B – The percent of contingency built into the contract
  - For CM/GC – The funds placed in agency and shared risk pools
7. Use of contingency and risk pools
  - For D-B – The percent of contingency used at contract completion
  - For CM/GC – The funds in agency and shared risk pools at contract completion