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Center for Innovative Finance Support

ACM Evaluation Methodologies in the United States [and Select International Practices]

Summary Report October 24, 2018





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This summary report documents research on the alternative contract departments of transportation (DOTs) and select international agen of the practice in use of ACMs in each of the 50 State DOTs in ord determine the most appropriate ACM for a given project. The infor for in-depth case studies based on onsite interviews. This formed the agencies in the evaluation and selection of ACMs by incorporating the Federal Highway Administration and State DOTs.				A literature redocument and on contained is sis for develop	eview was conducted on d develop an understand in this report was used to bing a suite of tools that	the current state ing of how they o select agencies will assist public		
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ACRONYMS AND ABBREVIATIONS

ACM alternative contracting methods

ACRP Airport Cooperative Research Program
ADOT Arizona Department of Transportation

APD alternative project delivery

ASCE American Society of Civil Engineers

ATC alternative technical concepts

BOT build-operate-transfer

BOOT build-own-operate-transfer

Caltrans California Department of Transportation
CDOT Colorado Department of Transportation
CM/GC construction manager/general contractor

CM@R construction manager at-risk
CMAR construction manager at-risk

CMR construction manager at-risk/construction management at-risk

DB design-build

DBB design-bid-build

DBM design-build-maintain

DBOM design-build-operate-maintain

DBF design-build-finance

DBFM design-build-finance-maintain

DBFOM design-build-finance-operate-maintain

DEA data envelopment analysis

DOT department of transportation

DRB dispute resolution board

DS design-sequencing

DSS decision support system

FDOT Florida Department of Transportation

FHWA Federal Highway Administration

GMP guaranteed maximum price

HfL Highways for Life

HMA hot-mix asphalt

HPTE High-Performance Transportation Enterprise

ID/IQ indefinite quantity/indefinite delivery.INDOT Indiana Department of Transportation

ITD Idaho Transportation Department

JOC job order contracts

KPI key performance indicators

LD liquidated damages

MnDOT Minnesota Department of Transportation

NCHRP National Cooperative Highway Research Program

NCR noncompliance reports

NTP notice to proceed

NYSDOT New York State Department of Transportation

O&M operations and maintenance P3 public-private partnership

PDA Project Development Agreement that includes the environmental phase.

PDSM Project Delivery Selection Matrix

PPP public-private partnership

QBS qualifications-based selection

RFP request for proposals
SME subject matter experts

TCRP Transit Cooperative Research Program

TxDOT Texas Department of Transportation

UDOT Utah Department of Transportation

VDOT Virginia Department of Transportation

VfM value for money

VTrans Vermont Agency of Transportation

WSDOT Washington State Department of Transportation

Executive Summary

As outlined in Task Two of the Task Order for "Tools and Technical Assistance for Evaluation of Alternative Contracting Methods," this report documents the current state of the practice in the selection and evaluation of alternative contracting methods (ACMs) for State departments of transportation (DOTs). In conducting the research, many trends of the current state of the practice were revealed.

The most notable trend found was that DOTs choose ACM delivery for three primary reasons: to accelerate the schedule, to reduce risk through enhanced schedule and cost certainty, and to address complexity through collaboration (i.e., teamwork). It is understood that accelerating the schedule may increase the delivery cost even with a new ACM delivery method. These three benefits can be used as the basis for identifying and reporting effective practices.

Effective selection practices used by DOTs vary greatly, both historically and currently. These can range from simply choosing the ACM that best fits the project's specific characteristics and constraints based on engineering judgment to graduated selection tools starting with engineering judgment and ending with a quantitative risk analysis. It is important to note that, based on the literature, the research, and the DOT interviews performed for this task, the typical DOT is satisfied with an ACM selection process that is fundamentally based on professional judgment. It is even more notable that this is true among DOTs with mature ACM programs and experience from which to draw professional judgment. Tools that involve a quantitative component, however, help to eliminate the perception of bias in the selection process.

Measuring the success of ACMs has proven to be a more difficult task, as effective practices for performance measurement were tougher to find. Direct comparisons of ACMs to each other or to traditional design-bid-build (DBB) are difficult to make. Leading efforts to date proving the success of ACMs include the shadow project comparison by the California DOT (Caltrans) comparing ACMs to similar DBB projects let in the same time frame, the time and cost savings related to ACM delivery as documented by Caltrans and the Washington State DOT in alternative technical concept (ATC) data collected, and the Utah DOT effort to develop a cost index to relate ACM contract cost to DBB costs.

Existing ACM selection methodologies rely significantly on user judgments. Few forecast project outcomes as a consequence of a particular ACM, and their output is not easily validated. In fact, international ACM selection methodologies have warned against such a tool. Instead, the suite of tools should incorporate semi-quantitative methods with room for professional judgment on ACM performance data when choosing the most suitable ACM for a project. Consequently, these issues need careful consideration as the scope and features of the ACM toolset are defined in subsequent tasks.

Executive Summary 1

Chapter 1. Introduction

Purpose

The Federal Highway Administration (FHWA) has long championed initiatives to improve quality and performance in all aspects of transportation asset management and project delivery—including design, construction, financing, operations, and maintenance. As part of this effort, FHWA has been a leader in promoting innovation in the development, use, and evaluation of alternative project delivery and procurement methods for highway development and management. In return for Federal support, FHWA has asked agencies to report on outcomes, particularly in terms of the ability to save time, reduce costs, or improve quality and performance. Many State departments of transportation (DOTs) have complied, creating an unconsolidated database of tools and methodologies used around the country to evaluate alternative project delivery systems.

With the increased use of alternative delivery systems, FHWA is renewing its efforts to assess their effectiveness and to further develop guidelines for their use. Practitioners have recognized that alternative project delivery is not appropriate for all project scenarios. It is often difficult to pinpoint and attribute the root causes for project success or failure; therefore, guidance in selection of the proper project delivery tool is needed. As such, FHWA has issued a Task Order to develop "Tools and Technical Assistance for Evaluation of Alternative Contracting Methods."

The intent of this Task Order is to develop a suite of tools that will build on the reporting of innovative contracting to date and assist public agencies in the evaluation and selection of alternative contracting methods (ACMs). These newly developed tools will incorporate and expand on tools and processes already developed by FHWA and State DOTs, filling in gaps where they exist and enhancing current capabilities.

As outlined in Task Two of the Task Order for "Tools and Technical Assistance for Evaluation of Alternative Contracting Methods," the first necessary step is to document the current state of the practice in a report. This includes the following:

- Identifying agencies that have developed methodologies for evaluation of ACMs.
- Identifying which ACMs are evaluated for different types of projects.
- Providing a brief description of the methodologies identified.
- Summarizing the state of the practice for analyzing and evaluating ACM options.

The results of the research are then evaluated in this report to identify promising methodologies that can be incorporated into the ACM evaluation tools to be developed under this project and locate those agencies that could be good candidates for pilot testing of the ACM evaluation tools.

Approach

The approach to the research was taken with the purpose of the report in mind. An exhaustive effort to determine the current state of the practice in the evaluation and selection of ACMs was conducted. While this research was nationwide, some international studies were also included. Even though the intent of the research was to uncover methodologies used for infrastructure

projects, a full range of project types and ACMs were included in the study. Key factors in the evaluation and selection of ACMs were noted, and DOTs with formal processes were documented and discussed in detail. Other notable methodologies outside of DOTs were also documented if they were perceived to be pertinent to the overall effort. Some attempt at looking for literature findings internationally and in other related fields for other methodologies to document has been included in the process.

As the first step in the Task Order, the results of this research report will be instrumental in the development of the final suite of analytical ACM evaluation tools. These tools will provide project owners with systematic analytical processes to identify, evaluate, and select feasible ACM options for their projects. The results of this report will also be key in identifying owners that will provide good testing grounds for the developed methodologies to ensure the result is a product that is practical and useful to the end user.

Chapter 2. Review of ACM Literature and Professional Practice

Introduction

In the 20th century, the project delivery options in the United States evolved to rely on a single system, design-bid-build (DBB) (Miller et al., 2000). Over roughly the last 30 years, however, many public owners have rediscovered the potential value of other delivery approaches, such as design-build (DB), construction manager/general contractor (CM/GC), and a variety of options that are considered public-private partnerships (P3s), such as design-build-operate-maintain (DBOM) and design-build-finance-operate-maintain (DBFOM). Arguments for these choices include opportunities to bring relevant knowledge into the delivery process at the right time, to accelerate delivery time frames, to leverage private sector expertise and capital, to predict operational funding requirements, and to realize life-cycle cost reductions through the integration of delivery activities and private sector efficiencies that are honed in competitive markets. Indeed, many within the engineering, procurement, and construction community in the United States have recognized the limitations of DBB, and they are using or considering other options.

With the re-emergence of multiple project delivery methods or ACMs, many public owners need guidance about which ACMs are suitable for a given project. Interest in a methodology for selecting ACMs is not new. As the contemporary utilization of such methods began to increase in the late 1980s and early 1990s, literature about methodologies began to appear. Gordon (1994) introduced one of the earliest frameworks that suggested practitioners consider project drivers, owner drivers, market drivers, and risk allocation to identify feasible ACM options and procurement method options. Since then, additional methodologies have appeared in the literature and practice.

Hence, the focus in this chapter is on documenting the current state of knowledge and practice through review of ACM literature and reports, search of DOT websites, and interviews with key personnel in DOTs across the United States.

Literature, Report, and Website Review

Approach

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The desk research to identify and review published literature and reports as well as State DOT websites was a multifaceted effort. The focus was on the identification and review of *methodologies* to evaluate both ACMs and procurement methods. For the purposes of this report, ACMs are defined as in NCHRP Synthesis 504 as "viable delivery options for highway construction projects to accelerate project delivery, encourage the deployment of innovation, and minimize unforeseen delays and cost overruns. These options include DB, CM/GC, P3s, and other innovation techniques." Here, a methodology is defined as a systematic process to identify a feasible set of ACMs or procurement methods for an owner to consider for a given project. Material found that examined ACMs or procurement methods for other purposes was also documented.

¹ In both literature and practice, ACMs are also referred to as project delivery methods or project delivery systems.

The review involved the following activities:

- General Search: Keywords provided by the team's subject matter experts (SMEs) were synthesized (see Appendix B) and used to search the following sources: Google Scholar, Engineering Village, the American Society of Civil Engineers' Civil Engineering Database, and Transport Research International Documentation (TRID), which combines the Transportation Research Board's Transportation Research Information Services and the Organisation for Economic Cooperation and Development's International Transport Research Documentation databases. From these sources, relevant published papers and reports were identified.
- **Identification of Known Sources:** The team's SMEs identified known sources of information about ACMs; these were inventoried and reviewed.
- Targeted Review of International Sources: Reports and guidelines published by Australia, Canada, and the World Bank related to P3s were reviewed for their relevance to the objectives of this project.
- **DOT Website Search and Review:** Websites from all 50 State DOTs, Washington DC, and Puerto Rico were reviewed to identify content related to ACM guidelines, manuals, or methodologies. The site search involved determining if the department had divisions or units for alternative contracting/delivery and/or P3s. If so, then these respective pages were reviewed for content; if not, then a site's search engine was employed using keywords such as "innovative contracting" or "public-private partnerships." Content that was potentially relevant was extracted from the site and then assessed for relevance. The results are summarized in Appendix B.

Outcomes

Two themes emerged as a consequence of the material reviewed. First, the overall literature identified fell into two *general* categories.

- Category 1 papers, reports, or guides that provide or propose a methodology to select an ACM or a procurement method. Papers or reports that covered general factors or guidelines for decision makers to consider in the selection decision were also included in this category.
- Category 2 papers, reports, or guides that provide a comparison of two or more ACMs or procurement methods based on performance of an observed set of projects. This category also includes material that characterizes ACMs by discussing advantages or disadvantages of ACMs generally or focusing on a specific ACM (such as DB or CM/GC). These documents are summarized in Appendix B.

Interestingly, these categories are consistent with the findings of Touran et al. (2009), who completed a similar review roughly a decade ago.

Second, ACM papers, reports, or guides tend to focus on either non-P3s or P3s with respect to the *scope of ACMs* covered. In other words, the vast majority of the material reviewed focused on ACMs such as DBB, DB, and/or CM/GC (non-P3s) *or* on ACMs such as DBOM and DBFOM (P3s). Hence, ACM selection methodologies or guidance documents found were not comprehensive in scope. This is not surprising since P3s are typically considered as a distinct branch of ACMs.

ACM Methodologies

Overview of Category 1 Material

Despite the renewed interest in ACMs, the literature, reports, and guides found in Category 1, which document methodologies in the form of frameworks or guidelines, were far outnumbered by the same material uncovered in Category 2 (comparisons and characterizations). Table 1 presents the ACM methodologies identified as a result of the review. The table includes those sources that provided a framework for ACM selection as well as those that presented guidelines for public agencies to consider. The sources are differentiated by those from program (e.g., NCHRP) or agency (e.g., FHWA) sources or academic (e.g., archival journal) sources.²

² Notwithstanding the potential value of the academic sources, the principal focus of the interim report is on those from agency/report sources since it is easier to observe whether these are being used by practitioners.

 $\label{lem:continuous} \textbf{Table 1. Overview of ACM methodologies identified.}$

No.	Source	Year	Title	Type	Summary/Synopsis
Prog	ram/Agency Literature			T	
1	Texas Department of Transportation (TxDOT) (Khwaja et al)	2018	Innovations in Project Delivery Method Selection Approach in the Texas Department of Transportation	Framework	Presents a decision support tool developed for TxDOT to select between DBB and DB. Note: Also described in a 2016 presentation titled "TxDOT Alternative Delivery Support Tool."
2	Colorado Department of Transportation (CDOT)	2017	P3 Management Manual	Guidelines	This manual provides a framework for both High-Performance Transportation Enterprise (HPTE) and the Colorado Department of Transportation (CDOT) for the development, implementation, and oversight of P3 projects.
3	Washington State Department of Transportation (WSDOT)	2016	Project Delivery Method Selection Guidance	Framework	Presents process and selection matrix for determining a project delivery method
4	World Bank ¹	2016	Public-Private Partnerships in Infrastructure Toolkit	Framework & Guidelines	An array of tools from agency certification to P3 fiscal risk assessment intended to support agency decision-making and implementation for infrastructure delivery and P3s.
5	World Bank (Marcelo et al)	2016	An Alternative Approach to Project Selection: The Infrastructure Prioritization Framework	Guidelines	This paper provides an overview of existing approaches to project selection and propose an alternative approach to prioritization – the Infrastructure Prioritization Framework.
6	Infrastructure Ontario	2015	Assessing Value for Money	Guidelines	This VfM ² Guide provides greater information and insight about IO's use of best practices, as well as provides further transparency about VfM for various stakeholders through a review and assessment of IO's historical Alternative Finance and Procurement project experience.

¹International source ²Value for money

No.	Source	Year	Title	Type	Summary/Synopsis				
Prog	Program/Agency Literature								
7	Infrastructure Ontario (MMM Group)	2015	DBFM Highway Projects	Guidelines	This report examined risk matrix features for a wide range of civil infrastructure projects. While there are many common risks inherent in these projects, each sub-sector has its own unique characteristics and risks that have been identified and considered in this report.				
8	The Commonwealth of Pennsylvania	2015	Providing for Public Private Transportation Partnerships (Implementation Manual and Guidelines)	Guidelines	This document provides guidance regarding Public Private Transportation Project development and implementation in the Commonwealth of Pennsylvania. This guidance applies to both solicited and unsolicited transportation projects across all modes including multi- modal and intermodal.				
9	World Bank	2014	Public-Private Partnerships Reference Guide Version 2.0	Guidelines	Provides information about P3s as well as an overview of methods for identifying and appraising potential P3 projects found across many countries.				
10	Colorado DOT (CDOT) (Molenaar et al)	2014	Guidebook for Selecting Alternative Contracting Methods for Roadway Projects	Framework	Presents a decision support approach to select a project delivery method, procurement procedures and payment provisions.				
11	Virginia DOT (VDOT)	2017	PPTA Implementation Manual and Guidelines	Guidelines	Provides details on P3 activities within the VDOT P3 project delivery process, addressing both roles and responsibilities for solicited and unsolicited projects.				
12	FHWA	2013	P3-SCREEN Supporting Guide FHWA Office of Innovative Program Delivery	Framework	P3-SCREEN is a checklist to assist public agencies in assessing the appropriateness of delivering a planned transportation project as a public-private partnership.				
13	FHWA	2013	P3-VALUE 2.1 Concept Guide, User Guide and Analytical Tool	Framework	Guide explains how to utilize the P3-VALUE 2.1 Analytical Tool to understand the processes and considerations that go into a rigorous quantitative analysis of P3 procurement options for transportation projects.				

No.	Source	Year	Title	Type	Summary/Synopsis
14	Indiana DOT (INDOT))	2013	Public-Private Partnership Program (Implementation Guidelines)	Guidelines	Document is resource for the private sector and stakeholders of the P3 Program to assist in delivering needed projects that provide value to the State of Indiana. It outlines Indiana's objectives for its P3 Program, presents the project delivery guidelines, and provides additional considerations affecting the P3 process.
15	New York State DOT (NYSDOT)	2012	Project Delivery and Procurement Selection Matrix	Framework & Guidelines	Presents a process and checklists for determining a project delivery method.
16	Idaho Transportation Department (ITD)	2012	Project Delivery Method Evaluation Matrix	Framework & Guidelines	Presents a matrix to investigate the opportunities and risks of alternative contracting methods. It also provides guidance and consistency in evaluating the suitability of alternative contracting methods and subsequent nomination of projects.
17	Arizona DOT (ADOT)	2011	ADOT P3 Program Guidelines	Guidelines	Purpose is to document a clear, consistent, efficient, and transparent process for ADOT's interaction with the private sector related to its management of innovative project delivery contemplated by the governing statutes.
	Transit Cooperative		A Guidebook for the Evaluation of Project Delivery Method (Tier 1, Tier 2, and Tier 3)		Tier 1 provides a framework to define project goals and examine the advantages and disadvantages of each delivery method within the context of these goals.
18	Research Program (TCRP)	2009		Framework	Tier 2 involves a Weighted-Matrix Delivery Decision Approach to further examine delivery methods.
	(Touran et al)				Tier 3 will generally be used only when the completion of the Tier 1 and Tier 2 approaches does not yield a project delivery decision and when a formal risk management process for the project is already in place.

No.	Source	Year	Title	Type	Summary/Synopsis
19	California DOT (Caltrans) (Trauner Consulting)	2008	Alternative Procurement Guide	Framework & Guidance	Presents a process and worksheet-based scoring system for selecting a project delivery method; also provides guidance about various delivery methods.
20	Australian Government (Dept. of Infrastructure and Regional Development)	2008	National Public Private Partnership Guidelines (Volume 1: Procurement Options Analysis)	Framework & Guidance	Procurement Options Analysis is designed to shortlist and select the appropriate procurement methodology that best achieves the procurement objectives, including decision-making rationale for selecting the procurement method.
21	Minnesota DOT (MnDOT)	Unknown	Project Delivery Selection Matrix	Framework & Guidelines	Presents a formal approach for selecting project delivery methods for MnDOT projects. The document describes the project delivery methods and provides an outline of the process, instructions, and evaluation worksheets.
22	Vermont Agency of Transportation (VTrans)	Unknown	VTrans Alternative Contracting Decision Matrix	Framework & Guidelines	Presents a formal approach for selecting project delivery methods for VTrans projects.
Acad	lemic Literature				
23	Hosseini et al	2016	Selection Criteria for Delivery Methods for Infrastructure Projects	Guidance	Provides selection criteria for project delivery selection in general along with specific criteria for large infrastructure projects. This paper also provides literature review of the models used for project delivery selection.
24	Tran et al	2015	Risk-Based Project Delivery Selection Model for Highway Design and Construction	Guidance	Compares DBB, DB, and CM/GC project delivery methods through risk-based modeling to identify cost differences that would affect the selection of a project delivery method.
25	Qiang et al	2015	Factors governing construction project delivery selection: A content analysis	Guidance	Identifies various factors affecting project delivery selection. Firstly, factors are determined from previous studies. Content analysis and T test were performed to compare importance of factors.

No.	Source	Year	Title	Type	Summary/Synopsis
26	Liu et al	2014	Which Owner Characteristics Are Key Factors Affecting Project Delivery System Decision Making? Empirical Analysis Based on the Rough Set Theory	Guidance	Primarily aimed at the owner's characteristics; researched the key factors affecting the decision making of the project delivery system.
27	Ghavamifar	2009	A Decision Support System for Project Delivery Method Selection in the Transit Industry	Framework & Guidance	Provides a decision support system (DSS) which is multi- objective and knowledge-driven (supported No. 8).
28	Sillars	2009	Development of Decision Model for Selection of Appropriate Timely Delivery Techniques for Highway Projects	Framework	Focuses on selection of project delivery techniques with timely delivery as the main purpose. Multi criteria decision analysis was used in this paper along with expert opinion.
29	Molenaar & Yakowenko (American Society of Civil Engineers)	2007	Alternate Project Delivery, Procurement and Contracting Methods for Highways	Guidance	Comprehensive and objective presentation of methods that government agencies can use to improve the efficiency and effectiveness of public-sector project delivery.
30	Zhang	2005	Criteria for Selecting the Private-Sector Partner in Public-Private Partnerships	Guidance	Facilitates the formulation of a multi-criteria best-value source selection methodology for P3 projects in general and the development of both objective and subjective evaluation criteria to select the right private-sector partner for a particular P3 project.
31	Mahdi and Alreshaid	2005	Decision Support System for Selecting the Proper Project Delivery Method using Analytical Hierarchy Process (AHP)	Guidance	Presents a multi-criterion decision-making methodology using the analytical hierarchy process is provided to help owners in selecting a project delivery method.
32	Miller et al	2000	Toward A New Paradigm: Simultaneous Use of Multiple Project Delivery Methods	Guidance	Focuses on shifting from the current trend toward a new model that supports simultaneous use of multiple project delivery methods.
33	Gordon	1994	Choosing Appropriate Construction Contracting method	Framework	Uses three groups of drivers, the risk-allocation analysis, and the commodity versus service analysis to select an ACM.

No.	Source	Year	Title	Type	Summary/Synopsis
34	Crosslin	1991	Decision-Support Methodology for Planning and Evaluating Public Private Partnerships	Framework	Presents a structured methodology, including quantitative simulation models for financial planning, evaluation, and cost justification.

The sources in Table 1 that are methodologies and not purely guidance documents were further assessed based on the following:

- **Purpose** Identifies the main objective of the methodology. For example, this could indicate that it is a screening tool.
- Scope Identifies the ACMs considered by the methodology. For example, some may only cover DBB and DB while others may be broader.
- **Approach** Describes the general process followed. For example, this might include user judgment.
- **Decision basis** Indicates the basis for decision-making whether qualitative and/or quantitative.

Table 2 presents these details about the identified ACM methodologies separated into program/agency or academic source.

Table 2. Details of identified ACM methodologies.³

No.	Source	Title	Purpose	Scope	Approach	Decision Basis
Prog	ram/Agency					
1	TxDOT	Innovations in Project Delivery Method Selection Approach in TxDOT	ACM Selection	DBB and DB	User Input and Judgment into Model	Qualitative & Quantitative
3	WSDOT	Project Delivery Method Selection Guidance	ACM Selection	DBB, DB, and CM/GC	User Input and Judgment into Scoring Matrix	Qualitative & Quantitative
4	World Bank	Public-Private Partnerships in Infrastructure Toolkit	P3 Preparation and Implementation	Р3	Various Tools for Public Agencies to Use for P3s	Qualitative & Quantitative
10	CDOT	Project Delivery Selection Matrix for Highway Design and Construction	ACM Selection	DBB, DB, and CM/GC	User Input and Judgment into Adjectival Matrix	Qualitative
12	FHWA	P3-SCREEN	Screen P3 Candidates	Р3	User Input and Judgment into Spreadsheet	Qualitative (Heuristic)
13	FHWA	P3-VALUE 2.1	Introduce VfM	Р3	User Input into Model	Quantitative
15	NYSDOT	Project Delivery and Procurement Selection Matrix	ACM Selection	DBB, DB	User Input and Judgment	Qualitative

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³ This table only includes a few representative P3 methodologies since guideline documents for P3 assessment and implementation are more common; however, the report can be modified to include additional discussion of P3 evaluation.

No.	Source	Title	Purpose	Scope	Approach	Decision
16	ITD	Project Delivery Method Evaluation Matrix	ACM Selection	DBB, CM/GC, DB	User Input and Judgment	Basis Qualitative
		A Guidebook for the Evaluation of Project Delivery Method - Tier 1	ACM Selection	DB, DBB, CM/GC, DBOM	User Input and Judgment	Qualitative
18	TCRP	A Guidebook for the Evaluation of Project Delivery Method - Tier 2	ACM Selection	DB, DBB, CM/GC, DBOM	User Input and Judgment	Qualitative & Quantitative
		A Guidebook for the Evaluation of Project Delivery Method - Tier 3	ACM Selection	DB, DBB, CM/GC, DBOM	User Input and Judgment with Simulation	Qualitative & Quantitative
19	Caltrans	Alternative Procurement Guide	ACM Selection	DBB, DB, Design- Sequencing, CMR ¹	User Input and Judgment into Scoring System	Qualitative & Quantitative
20	Australian Government	National Public Private Partnership Guidelines (Volume 1: Procurement Options Analysis)	ACM Selection	Alliancing, P3, CM, Other	User Input and Judgment	Qualitative
21	MnDOT	Project Delivery Selection Matrix	ACM Selection	DBB, CM/GC, DB	User Input and Judgment	Qualitative
22	VTrans	VTrans Alternative Contracting Decision Matrix	ACM Selection	DBB, CM/GC, DB	User Input and Judgment into Scoring System	Qualitative & Quantitative

No.	Source	Title	Purpose	Scope	Approach	Decision Basis
Acad	lemic					
28	Sillars	Development of Decision Model for Selection of Appropriate Timely Delivery Techniques for Highway Projects	ACM Selection	DBB, DB, CM/GC, BOT ²	User Input into Model	Qualitative & Quantitative
33	Gordon	Choosing Appropriate Construction Contracting method	ACM Selection	MP, GC, DB, T, CM, BOT ¹	User Input and Judgment	Qualitative
34	Crosslin	Decision-Support Methodology for Planning and Evaluating Public- Private Partnerships	ACM Evaluation	Р3	User Input and Judgment into Model	Quantitative

NOTES:

Number corresponds to identifier in Table 1.

Generally, the methodologies for ACM assessment require that users consider the following broad categories to determine the appropriate ACM for a given project:

- Owner characteristics
- Project characteristics
- Design characteristics
- Regulatory issues
- Market or service provider characteristics
- Risk
- Life-cycle issues

Table 3 shows the frequencies of these categories in the methodologies from select agencies or programs.

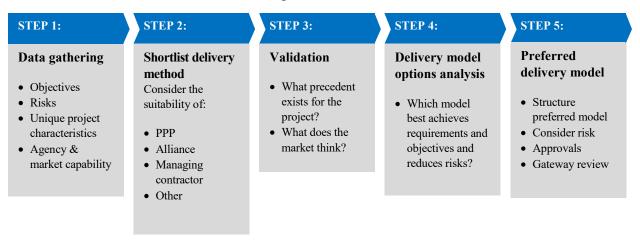
¹Construction manager at-risk

²Build-operate-transfer

Table 3. Frequencies of identified categories in program/agency documents.

No.	Sou	rce	Owner Characteristics	Project Characteristics	Design Characteristics	Regulatory Issues	Market/ Service Provider Characteristics	Risk	Life-
			Characteristics	Characteristics	Characteristics	Issues	Frovider Characteristics		Cycle Issues
1	TxD	ОТ	X	X	X	X		X	X
3	WSI	OOT	X	X	X			X	
10	CD	OT	X	X	X			X	X
12	FHV	VA	X	X	X	X	X	X	X
	(Scre	een)							
13	FHV	VA		X	X			X	X
	(Val								
15	NYSI	DOT	X	X	X			X	
16	IT	D	X	X	X		X	X	X
		Tier	X	X	X	X	X	X	18
		1							10
18	TCRP	Tier	X	X	X	X	X	X	X
10	ICKI	2							
		Tier			X			X	X
		3							
19	Caltı	rans	X	X	X				X
20	Austr	alian	X	X	X	X			X
	Go								
21	MnD	TOC	X	X	X		X		
22	VTr		X	X	X			X	
No	No. of sources		12	13	14	5	5	11	10
	referencing the								
cat	tegory (o	ut of							
tota	al 14 sou	rces)							

Only representative guidelines and methodologies that consider P3s were reported in Tables 1-3. One of these was Australia's Procurement Options Analysis guidelines (Australia Department of Infrastructure and Regional Development 2008), which is their starting point for ACM consideration and is one of the few methodologies that considers P3 and non-P3 options. An overview of this framework is shown in Figure 1.



Source: Australia Department of Infrastructure

Figure 1. Overview of Australia's procurement options analysis guidelines.

As shown, it involves five steps and relies on various tools to support it. For instance, the shortlisting done in Step 2 is supported by the checklist shown in Figure 2. In Australia, a Managing Contractor approach is comparable to a CM/GC approach in the United States. National Cooperative Highway Research Program (NCHRP) Synthesis 466 provides additional details about the alliancing approach.

Category	PPP	Project Alliance, Managing Contractor	Other			
Scale						
Project value over [\$100] million?	>	>	>			
If not, can service be bundled to exceed this threshold?	>	n/a	n/a			
Scope and Outputs						
Scope and outputs can be defined clearly	>	×	>			
Scope likely to change significantly prior to project completion and the potential change cannot be satisfactorily provided for in the specification	×	•	>			
Whole-of-Life Opportunities						
Services can be bundled together to create a long- term operational/maintenance opportunity	~	×	×			
Risk						

Category	PPP	Project Alliance, Managing Contractor	Other
A significant proportion of the material risks can be defined, allocated and potentially transferred to a private party	>	×	*
Unquantifiable risk that could have a material impact on project cost and objectives	×	>	×
Government is best-placed to manage material risks, with the cost of transferring the risk prohibitive	×	•	>

Source: Australia Department of Infrastructure. A v denotes that the characteristics are suited to the delivery model

Figure 2. Australia procurement options analysis checklist for Step 2.

Like methodologies in the United States, each step is supported by qualitative and quantitative techniques. If P3 is considered the most suitable method, then P3 assessment techniques including value for money (VfM) studies are employed. Infrastructure Australia has published standards for P3 assessment, which Australian States can supplement (and most do). For instance, Partnerships Victoria has its own framework as well as a requirements document (Partnerships Victoria Requirements 2016) that supplements the national processes prescribed by Infrastructure Australia for P3 assessment and implementation.

Details of selected methodologies are presented in Appendix A (including an overview of the Partnerships Victoria Framework).

Summary of ACM Methodologies

Tables 2 and 3 describe multiple methodologies from agency or program sources.⁴ Below are highlights:

- The scope of ACMs considered by these methodologies is limited; generally, the methodologies consider non-P3 methods or P3 methods. Exceptions are Transit Cooperative Research Program (TCRP) Report 131 and Australia's Procurement Options Analysis Guide; TCRP Report 131 considers DBB, DB, CM/GC and DBOM whereas the Procurement Options Analysis Guide contends to evaluate most ACMs.
- Eight were found in State DOTs. Many of these are based on or utilize techniques developed by Molenaar et al. (2014), which is the basis of CDOT's approach. Hence, these approaches to ACM selection are qualitative since they use checklists or worksheets that help guide user judgments; consequently, the quality of the decision depends heavily on the competency and experience of the personnel involved.

⁴ For this discussion, TCRP Report 131 is considered a distinct source even though its three tiers are considered unique in Table 3.

- Other methodologies have some limited quantitative dimensions to them since they
 employ weighting and scoring of factors. Still, these are very dependent on user
 judgments.
- User inputs generally consider various factors; broadly, Table 3 illustrates that owner characteristics, project characteristics, design characteristics, risk and life-cycle issues are the categories of factors most frequently considered.
- None of the non-P3 methodologies are data-driven; the methodologies do not employ inputs that forecast or predict outcomes such as quantifying the influence of an ACM on a project's capital cost, operating cost, or schedule.
- P3 methodologies typically have qualitative and quantitative elements to them. First, decision-makers typically complete a qualitative assessment of drivers and factors to screen project candidates for suitability for delivery by P3 (FHWA's P3-Screen tool formalizes such a process). Once a project is considered a candidate for P3, then a quantitative VfM analysis is conducted (FHWA's P3-Value 2.1 is illustrative of such methods). Guidelines for such analyses are generally published by jurisdictions actively pursuing P3s. Both also rely substantially on user input and judgment; VfM methods have the potential to be data-driven; however, it is unclear whether many jurisdictions in the United States have reliable data for such purposes.

Category 2: Comparison and Characterization Documents

Literature, reports, and guidance in Category 2 (comparisons and characterizations) are listed in Appendix B. While they are not covered here, they are captured for their potential relevance as the scope of the ACM Evaluation Toolset becomes clearer. These documents include guidebooks for CM/GC implementation or incorporation of ATCs in procurement.

Category 1: Procurement Method Methodologies

Very few studies have focused on methodologies for selecting a procurement approach, although some of the ACM assessment methodologies (e.g., CDOT Guidebook and Caltrans Alternative Procurement Guide) did include consideration of the procurement approach. Aside from these, NCHRP Report 561 *Best-Value Procurement Methods for Highway Construction Projects* is one of the most comprehensive guides to selecting and using alternative methods for procuring service providers. It explains and provides conceptual as well as case examples of four basic elements of best-value procurement:

- Parameters for evaluation such as price or qualifications.
- Evaluation criteria for the parameters being considered such as lowest price.
- Rating systems ranging from satisficing to direct point scoring.
- Award algorithms such as price + time (A+B) or weighted criteria.

Interviews with Key Personnel

Approach

In addition to the literature review, interviews with key personnel have also been conducted to assess the state of the practice. As a part of this effort, contact was made to all 50 States as well as the District of Columbia and Puerto Rico to request time for a brief phone call. The goal of the

initial contacts was to determine key introductory information from each State in order to inform the decision of which States to use for more detailed case studies.

Information obtained in the initial phone discussions includes the following:

- Whether the State has statutory authority to use ACMs.
- Which types of ACMs they have authority to use.
- Which ACMs they have used to deliver projects.
- What type of process they use to determine whether to use an ACM.
- Whether any tools or guidelines are utilized in deciding which ACM to use and details about this process (including how it was developed and how long it has been in practice).
- Whether any type of process is utilized to evaluate the effectiveness of the project delivery method decision.

States' willingness to participate further in the project efforts was also gauged during these initial contacts. In order to make participation easier on the agencies, the initial contact calls were meant to last no longer than 30 minutes. The overall goal of these contact calls was to ascertain the state of the practice in each agency. This information served as a means of comparison against the methodologies found in the literature review and aided in selection of States to participate in future case studies.

It should be noted that while initial requests were made to all State agencies, during the time of the screening calls, Hurricane Florence impacted several States on the eastern coast. Due to these unforeseen circumstances, States affected by Florence were not sent secondary contact requests.

Outcomes

Contact was initiated with all 50 State DOTs as well as the District of Columbia and Puerto Rico at the end of August and into early September. Of these agencies, contact was made with approximately half, and calls were completed with 20. The interviews indicated that many States do have statutory authority to utilize ACMs. Of the responses gathered, almost 91 percent of States indicated having statutory authority to use ACMs, while the remaining 9 percent of States do not. Unpacking the authority is important; while DOTs have broad authority, it is also checked by legislative approval.

A detailed breakdown of statutory authority by State, based on the desktop research, is provided in Table 4.

Table 4. State statutory authority for ACM use.

		•	
State/Territory/District	DB ¹	CM/GC ²	P3 ³
Alabama	L	В	В
Alaska	В	В	L
Arizona	В	В	В
Arkansas	В	L	L
California	L	В	В
Colorado	В	В	В
Connecticut	В	В	L
Delaware	В	В	В
Florida	В	В	В
Georgia	В	В	В
Hawaii	В	В	N
Idaho	В	В	N
Illinois	N	В	В
Indiana	L	L	L
Iowa	N	L	N
Kansas	L	N	N
Kentucky	В	В	L
Louisiana	В	В	В
Maine	В	L	В
Maryland	В	В	В
Massachusetts	В	L	В
Michigan	В	В	N
Minnesota	В	В	L
Mississippi	L	В	В
Missouri	В	N	L
Montana	В	N	N
Nebraska	В	N	N
Nevada	В	В	L
New Hampshire	L	L	В
New Jersey	L	N	N
New Mexico	L	В	N
New York	L	N	N
North Carolina	В	В	L
North Dakota	N	L	В
Ohio	В	В	В
Oklahoma	N	В	N
Oregon	В	В	В
Pennsylvania	L	N	L
Rhode Island	В	В	N
South Carolina	В	N	В
South Dakota	В	N	N
Tennessee	В	В	L
1 0111103500	ט	ט	ப

State/Territory/District	DB^{I}	CM/GC ²	P3 ³
Texas	В	В	L
Utah	В	В	В
Vermont	L	В	N
Virginia	В	В	В
Washington	В	В	В
West Virginia	В	В	В
Wisconsin	N	N	В
Wyoming	L	В	N
District of Columbia	В	В	В
Puerto Rico	В	В	В

Table Legend

B = Broad authorization

L = Limited or project-specific authorization

N = None

Sources

¹Design-Build Institute of America (DBIA 2018 update)

²Associated General Contractors of America (AGC)

Of the project delivery methods utilized, the interviews revealed that many States rely on use of DB as well as DBB. Some States are using CM/GC, indefinite delivery/indefinite quantity (IDIQ), and P3, however many contacts indicated that P3 contracts are handled in a unique division of the State agency, which is separate from DB, DBB, and the like. Figure 3 shows the types of project delivery methods inquired about as well as whether the State has utilized its authority to deliver projects using the method.

³National Conference of State Legislatures (NCSL reports 2010 and 2014 and 2016 updates)

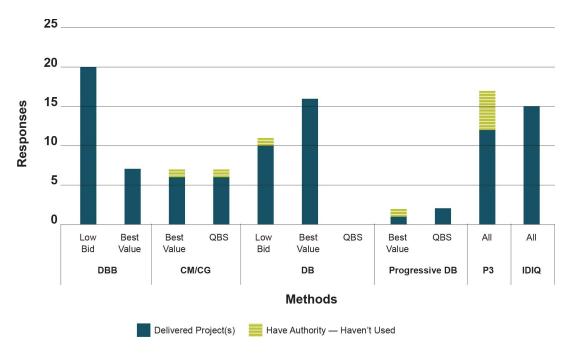


Figure 3. Project delivery method use recorded during calls to States.

Another observation gleaned from this data collection is that while all States interviewed stated that their agency utilized a tool to select which project delivery method to use, many States did not have a formal evaluation process to assess the effectivness of their decisions. Many reported engaging in "lessons learned" reviews or workshops after project completion, however the focus is often not on the initial decision of which ACM or other method was selected. While they may analyze how the project went, they are often not analyzing whether the method selected was indeed the best method nor if this method performed as expected or as indicated by their tools and guidelines. Additionally, many States expressed interest in a standardized evaluation method or guideline being one outcome of this project effort.

While some States did report having mature ACM programs, many still reported using intuition when making project delivery method decisions. Even States with tools to aid in the selection of a delivery method are primarily using DB, DBB, and CM/GC. Additionally, many States have strong preferences toward the method or methods where they already have experience or have had success in past projects.

Some States reported that they have or are able to obtain statutory authority to use many or all ACM methods, but feel they cannot justify certain methods such as P3 due to costs or project size. Of the States utilizing tools, many are based off the tool developed in Colorado, which uses a comprehensive decision matrix to aid in selecting a project delivery method. States using some form of this tool expressed that, for the tool to best fit their agency, it was streamlined or altered. Information collected during these intial screening contacts was synthesized into a spreadsheet for analysis of quantitative trends, such as which methods are most widely utilized and the percentage of States with authority to use ACMs. Qualitative trends gleaned were summarized by the research team and compared against literature review results.

State of Practice Summary

The following summarizes the state of practice as a consequence of the literature, interviews, and website review:

- ACM selection methodologies or guidance documents found were not comprehensive in scope; the vast majority either focused on DBB, DB, and CM/GC (non-P3 alternatives) or DBOM and DBFOM (P3 alternatives). A few exceptions were found such as the methodology by Gordon (1994) and the approach in TCRP Report 131.
- Many of the ACM methodologies identified that consider non-P3 options are similar
 in structure and have used the Caltrans Alternative Procurement Guide or the CDOT
 Guidebook (Molenaar et al. 2014) as their basis. They rely significantly on user
 judgments and inputs and are generally qualitative frameworks—although they
 incorporate some limited quantitative features through scoring or weighting.
 Consequently, the quality of the decision depends heavily on the competency and
 experience of the personnel involved.
- The non-P3 methodologies identified do not forecast or predict outcomes, such as quantifying the influence of an ACM on a project's capital cost, operating cost, or schedule.
- P3 methodologies employ qualitative screening tools to determine if a project is a P3 candidate, whereas subsequent tools tend to focus on quantitative VfM techniques that rely on user inputs as well as various assumptions and analytical techniques to compare a P3 option to a Public Sector Comparator. Many guideline documents for screening P3s and VfM analyses are available domestically and internationally; this interim report only highlighted a limited sample.
- Survey information collected for NCHRP Synthesis 473, *Indefinite Delivery/ Indefinite Quantity Contracting Practices*, showed that at least five State DOTs are using DB-ID/IQ contracts and that some agencies have also combined ID/IQ contracting with CM/GC project delivery.

Chapter 3. Making the ACM Selection Decision

Determining Project ACM Potential

When deciding to choose an alternative delivery approach, the agency must first remember that ACMs are not a "magic bullet" that will guarantee reduced cost and schedule or enhanced quality for any specific project. While the research has shown modest improvements in each of those categories, the results come from the statistical analysis of large populations of ACM projects, which necessarily include ACM projects that finished late, overran their budgets, and experienced quality issues. Thus, attempting to attribute historical *average* project performance to a future project will rarely be accurate. On the other hand, the agency must guard against being overly influenced by anecdotal information on ACM projects that may not have been overly successful from a project delivery standpoint. It is not uncommon for an agency to experiment with a given ACM and have a bad experience, which creates an agency bias against ever trying that approach again. Most project delivery shortcomings are not a direct function of the project delivery method but rather of other underlying issues in the project planning and development process that would have occurred even if the project was delivered using a traditional means.

Additionally, an agency that is trying an ACM for the first time also has to reckon with the fact that it is on the lowest point of the learning curve with respect to the given ACM and mistakes are likely to be made that must be turned into lessons learned and fed back into the project development process for future ACM projects. In the end, regardless of project delivery method, the project must still be designed, constructed, and put into operation. Experience has shown that complex infrastructure projects will encounter issues during the delivery process. The contract structure in place for the project will govern how these issues are addressed, but the project team is still responsible for ensuring that the final project performs as intended.

Therefore, the project team making the ACM selection decision must ensure that it focuses on the characteristics of the specific project. Both experience and research have shown that each project has a project delivery method that will, most likely, prove better than others to meet its needs. In many, if not most, cases the traditional DBB method is completely adequate. Thus, the selection of an ACM becomes a three-part process. First, the agency should identify the reasons why DBB is not optimum for the particular project. In most cases, this is a function of the need to compress the project delivery period. Once the agency has satisfied itself that there are achievable benefits available through ACMs, it must then decide which ACM will furnish the greatest probability of success given the constraints in which the project must be delivered. Lastly, the agency must examine its internal procurement culture and identify both preferences and biases that will need to be addressed by the project delivery method, as well as agency personnel ACM experience with each potential ACM for which the agency has the necessary enabling legislative authority.

Once a list of potential ACMs that appear to be suitable for the project is developed, the agency conducts a risk analysis to determine the specific ACM that will provide the most attractive risk profile. This usually begins with a qualitative risk assessment using some form of subjective

evaluation. If a clear best choice does not emerge from the initial assessment, then a more formal analysis of risk is in order and could advance to the point where sophisticated risk analysis tools such as Monte Carlo simulations are used to determine the best ACM candidate. Examples of this process are found in TCRP Report 131, A *Guidebook for the Evaluation of Project Delivery Methods* (Touran et al. 2009a) and Airport Cooperative Research Program (ACRP) Report 21, A *Guidebook for the Selecting Airport Capital Project Delivery Methods* (Touran et al. 2009b). The ACRP project delivery method selection tool is also available as an on-line tool.

ACM Selection Factors

There is no "optimum" or "default" ACM that fits all projects. An agency needs to select an ACM that best furnishes the means to achieve project-specific objectives. This argues for a full toolbox of project delivery tools and for an agency to work toward surmounting artificial legal, regulatory, and policy barriers that prevent it from picking the best ACM for each project. Table 5 contains a list of project delivery issues by category that need to be considered in the ACM selection decision. There are four major categories:

- 1. **Project-level issues:** Issues specific to the given project.
- 2. **Agency-level issues:** Issues that deal with agency-specific items, which include agency preferences and biases and ability to resource the given ACM with current workforce constraints.
- 3. **Public policy/regulatory issues:** Issues that constrain the ACM selection decision and may require external approval to use a given ACM for which the agency does not currently have authority.
- 4. **Life-cycle/sustainability issues**: Issues related to each ACM's long-term, post-construction performance potential. While life-cycle issues apply to all ACMs, they are particularly prominent when P3 is being considered for a particular project.

Project-Level Issues	Agency-Level Issues	Public Law/Policy/ Regulatory Issues	Life-Cycle/ Sustainability Issues
 Project size Risk management/ allocation Schedule control Cost control Complexity Funding/financing 	 Agency experience/staff capability Agency control of project Agency goals and objectives Agency preferences Agency biases Third-party stakeholder/ community input 	 Competition Disadvantaged Business Enterprise/small business impact Legal constraints Environmental/regulatory constraints Protest potential Adversarial relationships Claims avoidance Debt amortization rules to follow 	 Life-cycle cost Maintainability Operability Sustainability Hand-back criteria Future expansion

Table 5. Project delivery issues.

Project-Specific ACM Selection Factors

The agency, legal, and life-cycle issues are usually viewed as constraints on the ACM selection decision. Thus, the project-specific issues become the areas in which the agency has latitude to

optimize the ACM selection. The following is a list of project-specific factors that are typically considered in the decision process:

- The need to compress the project delivery schedule.
- Project location.
- Technical complexity of the project's design.
- Opportunity to innovate in the design, construction, and life-cycle elements.
- Agency desire to transfer key risk elements.
- Project budget control requirements.
- Available funding/financing.
- Level of third-party interface requirements.
- Project type (typical agency project versus a first-of-a-kind project).
- Project environmental constraints.
- Project technical content.
- Project traffic control requirements.
- Public preferences for aesthetics, setback distances, and community development.

Other Common Factors

Other key factors found in the literature that influence the ACM selection decision are as follows:

- Need for immediate improvements to the transportation infrastructure.
- Design is technically complex, difficult to define at early stages, subject to change and/or has several alternative solutions that require analysis before making a design decision.
- Cost risk and schedule risk are elevated by the need to coordinate with external stakeholders such as resource agencies, utility owners, railroads, etc.
- The project is sequence or schedule sensitive.
- Need to develop a highly constructible final design.
- A desire to encourage innovative design and construction means and methods.
- Non-typical risk allocation distribution.
- Early construction contractor involvement.
- Facilitate value analysis and value engineering.
- Requirement to reduce/compress/accelerate project delivery period.
- Flexibility needs during construction.
- Establish project budget at an early state of design development.
- Provide a mechanism for follow-on operations and/or maintenance.
- Highly constrained budget.
- Desire to compete different design solutions through the proposal process.
- Presence of innovative financing.
- Requirement for highly qualified construction contractors.

Current ACM Selection Methodologies

The use of a formal selection methodology to rationally compare viable ACM candidates against the specific requirements of a highway project is not standard across the 52 DOTs covered in this

study. In most cases, those with ACM authority do not have mature ACM programs and can be best characterized as being on the early portion of the learning curve, where they are experimenting with each ACM but have neither the time nor the experience to have institutionalized the ACM selection decision within their agency. A recent survey of 46 DOTs regarding ACM staffing needs (Tran et al. 2018) found that while 43 States reported having the authority to use at least one ACM, only 21 can be classified as having mature ACM programs based on having delivered more than 15 DB projects. As a result, current ACM selection decision methodologies can be classified as falling into three general categories:

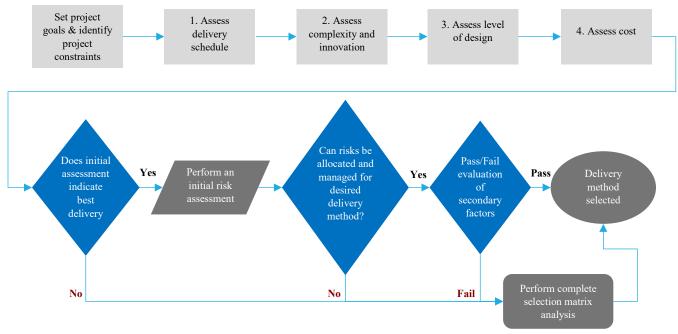
- Ad Hoc: No specific methodology is specified or in use by the agency. ACM type is selected based on the professional judgment of the agency.
- Qualitative: The agency has a published protocol for evaluating the strengths and weaknesses of each candidate ACM in the context of a specific project. However, the comparisons are subjective, and the output is generally in adjectival rather than numeric form.
- Quantitative: The agency has a published protocol for evaluating the costs, risks, and opportunities associated with each candidate ACM using some form of expected value based on historic cost data as well as an expected project duration based on past experience data with typical delay. The output can take a number of forms ranging from a probability density function that permits a statistical level of confidence to be associated with possible outcomes to a life-cycle cost.

Review of Current DOT ACM Selection Tools

The majority of DOTs, including Minnesota, Nevada, and Virginia, that have a formal ACM selection decision-making tool have based their specific approach on the process developed for the Colorado DOT by the University of Colorado (Molenaar et al. 2012). This process, entitled the Project Delivery Selection Matrix (PDSM), was disseminated as part of the FHWA Every Day Counts 2 initiative. It was expanded as part of Transportation Pooled-Fund Study, TPF-5(260). The PDSM is a qualitative decision-making tool based on a comprehensive series of predeveloped forms that include selection factors organized in the following seven categories:

- Delivery schedule
- Complexity and innovation
- Level of design at the time of procurement
- Cos^{*}
- Staff availability and experience
- Level of oversight and control
- Competition and contractor experience

Figure 4 is a flow chart for the PDSM method. It shows the sequence of actions taken by the agency during a PDSM workshop that is convened to review each project, its ACM potential, and the agency's project goals and objectives.



Source: Molenaar et al. 2012

Figure 4. PDSM approach flowchart.

The workshop consists of assessing each potential ACM in terms of opportunities and obstacles using checklists provided in the tool's guidebook. Figure 5 is an example of one of those checklists. Table 6 is an example of how the results are summarized and used by the agency to select the project delivery method.

Design-B	Bid-Build
Opportunities	Obstacles
□ Schedule is more predictable and more manageable □ Milestones can be easier to define □ Projects can more easily be "shelved" □ Shortest procurement period □ Elements of design can be advanced prior to permitting, construction, etc. □ Time to communicate/discuss design with stakeholders	 ☒ Requires time to perform linear design-bid-construction process ☐ Design and construction schedules can be unrealistic due to lack industry input ☐ Errors in design lead to change orders and schedule delays ☐ Low bid selection may lead to potential delays and other adverse outcomes
Design	
Opportunities	Obstacles
 ☑ Potential to accelerate schedule through parallel design-build process ☐ Shifting schedule risk to DB team ☐ Encumbers construction funds more quickly ☐ Industry input into design and schedule ☐ Fewer chances for disputes between agency and design-builders ☐ More efficient procurement of long-lead items ☐ Ability to start construction before entire design, ROW, etc. is complete (i.e., phased design) 	 □ Request for proposal development and procurement can be lengthy □ Undefined events or conditions found after procurement, but during design can impact schedule and cost □ Time required to define technical requirements and expectations through RFP development can be lengthy □ Time required to gain acceptance of quality program □ Requires agency and stakeholder commitments to an expeditious review of design
Construction Manage	r/General Contractor
Opportunities	Obstacles
 ☑ Ability to start construction before entire design, ROW, etc. is complete (i.e., phased design) ☐ More efficient procurement of long-lead items ☐ Early identification and resolution of design and construction issues (e.g., utility, ROW, and earthwork) ☐ Can provide a shorter procurement schedule than DB ☐ Team involvement for schedule optimization ☐ Continuous constructability review and VE ☐ Maintenance of Traffic improves with contractor inputs 	 ☑ Potential for not reaching GMP and substantially delaying schedule ☑ GMP negotiation can delay the schedule ☐ Schedule-driven goals may drive up cost ☑ Designer-contractor-agency disagreements can add delays ☐ Strong agency management is required to control schedule

Source: Molenaar et al. 2012

Figure 5. PDSM opportunities and obstacles checklist example.

Table 6. Example PDSM summary.

Project Delivery	Method Opportuni	ty/Obstacle Summary	
Evaluation Factors	DBB	DB	CM/GC
Primary Evaluation Factors			
1. Delivery Schedule	X	++	-
2. Project Complexity & Innovation	NA	+	+
3. Level of Design	NA	++	+
4. Cost	NA	++	+
5. Perform Initial Risk Assessment	NA	Risks can be properly allocated	NA
Secondary Evaluation Factors			
6. Staff Experience/Availability (Owner)	NA	Pass	NA
7.Level of Oversight and Control	NA	Pass	NA
8. Competition and Contractor Experience	NA	Pass	NA
++ Most appropriate; + Appropriate; - Least a	appropriate; X Fatal	flaw; NA Not applicable	

Source: Molenaar et al. 2012

Figure 6 is a flow chart that comes from the California DOT (Caltrans) Alternative Procurement Guide (Trauner 2008). It illustrates a less detailed approach that is used by Caltrans and other DOTs, including Montana, Utah, and Florida. It shares the same structure as the CDOT tool but relies on the professional judgment and experience of the agency to determine the appropriate project, agency, legal/policy, and life-cycle factors that will be considered in the selection decision.

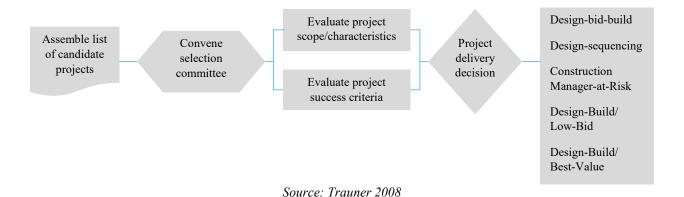


Figure 6. Caltrans four-step approach to project delivery selection.

Transit Cooperative Research Program (TCRP) Report 131 A Guidebook for the Evaluation of Project Delivery Methods (Touran et al. 2009a) details a three-tiered method that encompasses all three categories. The same approach was modified by its authors for application for airport capital ACM projects and published as ACRP Report 21 (Touran et al. 2009b). It is of note that the Texas DOT has adopted the TCRP version as an ACM selection tool for highway projects. Both the TCRP and ACRP tools have been in use since their inception and have been successfully implemented by transit agencies and airports across the Nation.

The thrust of this ACM selection methodology is a graduated comparison of possible ACMs that moves from completely qualitative to very quantitative until a clear best option is identified. The idea is that if the most appropriate ACM is clear after the initial qualitative assessment, then there is no reason to invest additional time and resources to populate the quantitative risk models.

The TCRP methodology is briefly reviewed in the following paragraphs to provide the reader with an overview of a specific ACM selection tool that covers the spectrum of most possible approaches to rationally making this decision for most projects. The following figures and tables furnish a graphical description of the proposed process. Full-size copies of the tables shown in the figures are contained in Appendix A. Table 7 provides a synopsis of each step in the process. It shows the graduated commitment of effort and resources inherent to the TCRP tool. One can see that there are three opportunities to stop the process if a particular ACM clearly becomes the best alternative. Experience in the field with this process has shown that if it proceeds past Tier 1, transit agencies will often carry two ACMs through to the end until one method emerges as the preferred approach. This is partially because the Federal Transit Agency requires a top-down risk analysis to be conducted with all of its grant projects, and the third tier of the TCRP process fulfills this administrative requirement.

Tier Action Outcome Create Project Description List of key project factors and characteristics 1 2 **Define Project Goals** Document objectives for success 3 Review Go/No-Go Decision Points Eliminate nonviable options 4 Review ACM Advantages/Disadvantages Qualitative comparison of possible ACMs 5 Choose Most Appropriate ACM Selection Decision - If no clear choice - go to Tier 2 6 **Document Results** Record rationale, etc. **Define Selection Factors** List of project/agency factors germane to project 2 Weight Selection Factors Relative importance of each factor in decision 2 3 Score ACMs Subjective score assigned by agency Choose Most Appropriate ACM Selection Decision - If no clear choice - go to Tier 3 5 **Document Results** Record rationale, etc. 1 Risk allocation matrix Preliminary risk analysis 2 Choose Most Appropriate ACM If no clear choice – go to step 3 3 Monte Carlo simulation - Expected Assign probability distributions and values to each 3 Cost/Schedule Impact risk factor-run simulation Choose Most Appropriate ACM Selection Decision

Table 7. TCRP three-tiered ACM selection decision process.

The Tier 1 process is shown in Figure 7 and begins with the development of a technical description of the project, listing its key elements of scope as well as other legal and regulatory requirements. Next, the agency documents the project goals, which embody the definition of project success. The goals are specific and extend beyond the usual budget, schedule, and quality goals that are in force for all public projects. Step 3 involves excluding those ACMs from further consideration that are not viable options for the given project. The process is simply a go/no-go decision. For example, if the required completion date is immutable and there is not enough time to complete the design before advertising the construction contract, then DBB would be dropped at this point as not viable.

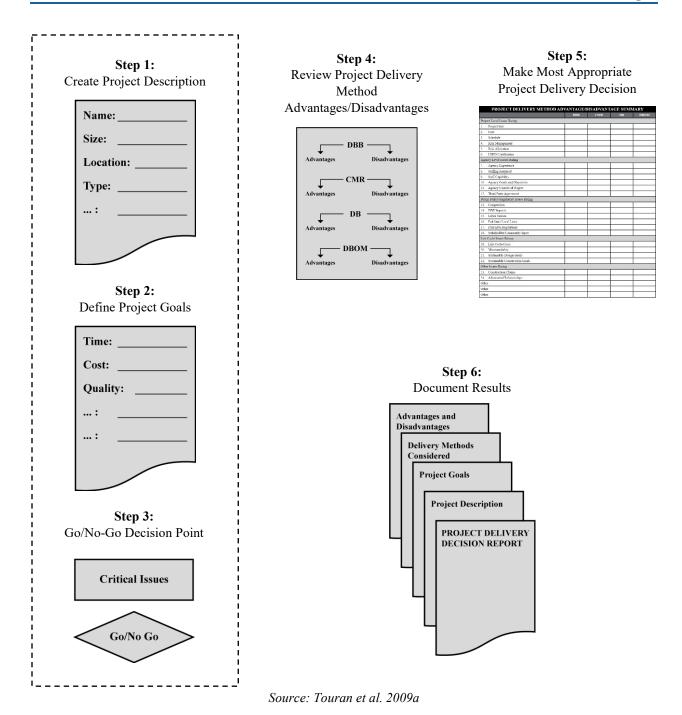


Figure 7. TCRP Tier 1 ACM selection assessment.

Step 4 involves walking through a list of possible advantages and disadvantages of each ACM in 24 critical areas that are provided in tabular form in the TCRP tool's guidebook (See Appendix A for the details). Potential advantages and disadvantages are assessed in the context of the project's requirements and constraints.

"Variations in the project characteristics, the people involved, and the processes in use by the agencies (the "three Ps") will determine if these potential issues are actual advantages or

disadvantages for a particular project. Step 4 asks the agencies to consider these actual advantages and disadvantages and rate each project delivery method as 'most appropriate, appropriate, least appropriate, or not applicable' for each of the 24 issues" (Touran et al. 2009a). The TCRP guidebook contains a standardized form for the rating, as well as the format for documenting comments and rationale.

Moving on to Step 5, a detailed comparative analysis of each of the viable ACMs is conducted using a standard set of forms found in the TCRP guide. The comparisons are not numeric. The agency must assign one of four adjectival ratings to each ACM in each category. Symbols are used to simplify the analysis. They are as follows:

- – Most appropriate
- Appropriate
- O Least appropriate
- **X** Not applicable

Once complete, the agency rolls up the ratings and selects the most appropriate ACM *if there is a clear leader*. If there is, the process ends with the Step 6 completion of documentation. If the decision is not clear then the agency moves on to Tier 2, which is shown in Figure 8.

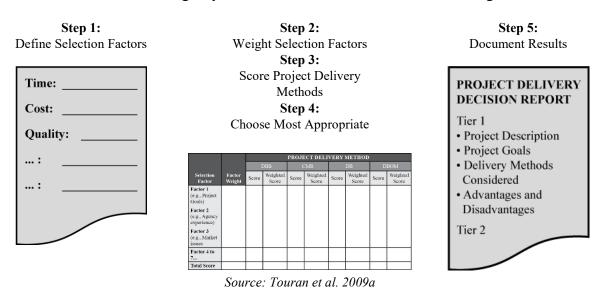


Figure 8. TCRP Tier 2 ACM selection assessment.

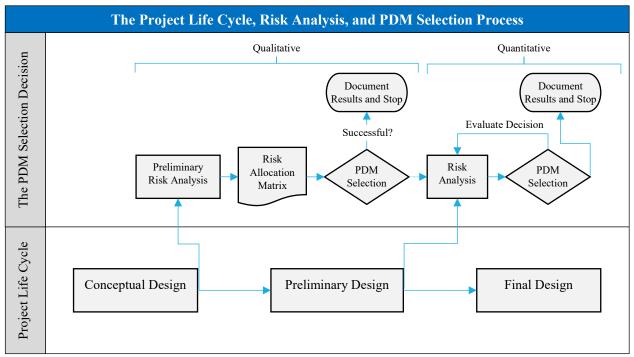
Step 1 of Tier 2 is to develop a list of factors that must be considered in the ACM selection decision. These factors are listed above in the ACM Selection Factors section. With the selection factors identified, the agency then assigns a relative weight to each proportionate to its perceived importance to project success. The factors and weights are then used to populate the weighted-matrix template (Table 8). In Step 3 the agency scores each factor, multiplies it by its weight, and sums of the total weighted score for each ACM. Again, if there is a clear choice, the process ends by documenting the rationale behind the choice of that ACM. If not, it proceeds to Tier 3.

Table 8. Weighted-matrix template.

					Project Deliv	ery Met	hod		
Selection Factor	Factor	DBB			CMR	DB		DBOM	
ractor	Weight	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Factor 1 (e.g., project goals)									
Factor 2 (e.g., agency experience)									
Factor 3 (e.g., market issues)									
Factor 4 to n									
Total Score									

(Touran et al. 2009a)

Figure 9 is an overview of the Tier 3 ACM selection process. It consists of two major stages. First, a preliminary risk analysis is conducted and used to populate a risk allocation matrix for each viable ACM. Table 9 is an example of that process and shows the qualitative ratings assigned to each risk factor. Next, the last off-ramp in the process is reached and the most appropriate ACM is selected if there is a clear choice. If not, the process moves on to a formal top-down risk analysis involving simulations and the development of a probability density function for each competing ACM.



Touran et al. 2009a

Figure 9. TCRP Tier 3 ACM selection assessment.

Table 9. Example of risk allocation matrix.

Risk Factor	DBB		DB		
	Responsible Rating		Responsible	Rating	
Permits/Approval	Owner	+	Constructor/Owner	-	
Different Site Conditions	Owner	0	Constructor/Owner	+	
Design Defects	Owner	-	Constructor	+	
Quality Assurance/Quality Control	Constructor/Owner	0	Constructor	+	
Exchange Rate Risk	Owner	-	Owner	-	
Other risk factors					

(Touran et al. 2009a)

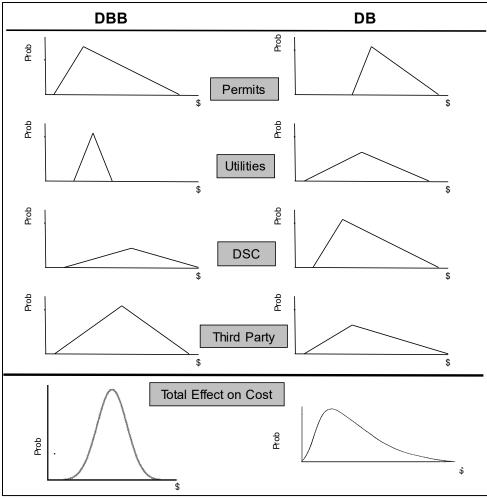
Figure 10 shows the concept of the last stage. The ranked risk factors from the matrix are transferred into the risk modeling process. Each factor is assigned a range of values in accordance with past experience and estimates of potential impact on cost and schedule.



Source: Touran et al. 2009a

Figure 10. TCRP Tier 3 ACM selection – quantitative approach.

Figure 11 shows the conceptual process where each risk factor is assigned triangular distributions defined by the best possible, most likely, and worst possible outcome values. These are then input in a project cost model for each ACM in the analysis. A Monte Carlo simulation is run, and the range of expected values and corresponding levels of statistical confidence is produced, allowing the agency to compare the candidate ACMs. The hypothetical example shown in Figure 11 would indicate that DB would be preferred over DBB due to the shape of its probability distribution being skewed toward a lower expected cost.



Source: Touran et al. 2009a

Figure 11. TCRP Tier 3 ACM selection assessment – quantitative approach to compare delivery methods on a basis of risk-adjusted expected cost.

Summary

The state of the practice in the development and implementation of ACM selection tools has been detailed in the previous sections. In summary, the prevalent approach seems to be the use of a qualitative analysis of project, agency, legal/policy, and life-cycle factors to compare each viable ACM in the context of a given project. In many cases, the comparison is restricted to looking only at DBB and DB.

Chapter 4. ACM Selection and Evaluation Tools

DOT ACM Selection Processes

Chapter 3 contains a description of not only DOT ACM selection processes but also ones developed for the transit and airport transportation sectors. It found that there were three categories of selection processes (ad hoc, qualitative, and quantitative) as well as those, like the TCRP method, that combined all three in graduated a process designed to identify the appropriate ACM with the minimum practical level of effort by the agency. This section will evaluate the advantages and disadvantages of each category.

Ad Hoc ACM Selection

The Ad Hoc category is reserved for those agencies that have not formalized their ACM selection process in some written document. In most cases, it is employed by agencies new to ACM implementation. One would expect that as these organizations gain ACM experience, they will formalize the ACM selection process. The advantages and disadvantages of the Ad Hoc approach are as follows:

- Advantages It is the simplest approach and as such provides the agency with the following benefits:
 - o Minimal resource requirements.
 - o Selection decision can be made expeditiously.
 - o Maximum flexibility to use professional judgment.
 - o Facilitates experimental use of ACMs.
- Disadvantages The following are those aspects of Ad Hoc selection that may not add value to the ACM selection process:
 - o Potential lack of consistency between projects and between sub-entities within the agency.
 - o Relies purely on professional judgment.
 - o Little transparency of the process, making it susceptible to political accusations of restricted competition, favoritism, and bid protest.
 - Lack of agency ACM experience makes the decision susceptible to perceived preferences and biases based on knowledge found from other agencies.
 - o Risk assessment may be incomplete due to lack of a decision-making structure.

Before proceeding, it must be noted that most agencies with mature ACM programs started with an Ad Hoc selection process. Two notable exceptions to this rule are the California and New York State DOTs. Both had developed a documented process for selecting the most appropriate ACM prior to receiving enabling legislative authority to use ACMs. In both cases, this prescient investment in capturing and codifying lessons learned from other DOTs paid dividends in the implementation of their initial set of ACM projects. Hence, this finding leads to a recommendation that agencies without formal ACM selection processes follow the Caltrans and NYSDOT example by investing the resources to develop an initial ACM selection process prior to implementing their first ACM projects.

Qualitative ACM Selection

The research found that most ACM selection methods fall into this category. These methods rely on a list of project and agency characteristics that describe the salient elements that should be considered if applicable to the project under analysis. In many cases, the evaluation of project and agency factors is followed by a qualitative risk analysis where each ACM under consideration is rated either on its own merits or on a comparative basis with other ACMs. The second method essentially identifies which among the candidates is the best and worst option; whereas, the first type of rating merely assigns an adjectival description to each ACM for each factor. Thus, in the first system, two ACMs can receive equal ratings in the same selection factor, but in the second system, each will have a different rating. There is no evidence as to which rating system is superior and the literature appears to support a conclusion that both have been equally successful when used.

The qualitative ACM selection decision category has the below listed advantages and disadvantages.

- Advantages The primary benefit accrued by moving from an ad hoc to a qualitative method is found in the greater level of detail to which each ACM is assessed. Others are as follows:
 - Increased consistency between projects and between agency sub-entities in their ratings.
 - Since the method is checklist based, the chance that an important factor will unintentionally be omitted from the process is reduced.
 - Provides an ability to evaluate outcomes of previous decisions and to revise or fine-tune the process based on important lessons learned.
 - o Provides a consistent set of documentation for justifying the ACM selection decision to external stakeholders.
 - o Provides data to identify trends in project characteristics that associate themselves with particular ACMs.
 - Increased transparency of the process through the publication of the decisionmaking criteria.
- Disadvantages The disadvantages of the qualitative process are few and mainly related to resource requirements as shown below.
 - o Increased level of personnel involvement in the decision-making process.
 - o Reduced ability to make ACM selection decision quickly.
 - Potential from external stakeholders to criticize the process as missing key factors or being arbitrary.

Quantitative ACM Selection

The use of a quantitative ACM selection process requires two major elements to be available. First, the agency must have the historic data to populate the risk model. If this is not available, the process can be carried out using expert opinions, but in the end, that merely reduces the accuracy and authority of the outcomes. In the strictest sense, without historic data driving the results, the quantitative analysis is based on qualitative input and is no longer a quantitative evaluation, but rather a much more complicated qualitative assessment. The second element is the resources, including time, to be able to develop the models needed for the risk analysis.

Therefore, the complexity of the ACM selection decision should be great enough to justify the time and the expense. Lastly, it should be noted that none of the existing ACM selection tools attempt to predict relative performance for each candidate ACM, merely to compute each candidate's probability of successfully achieving cost and time constraints.

The FHWA Office of Innovative Program Delivery P3 Toolkit contains a series of spreadsheets (e.g., P3 SCREEN, P3 EFFECTS, and P3 VALUE 2.1) that provide quantitative inputs for expected cost, schedule, and quality enhancements from the use of P3 when compared to DBB. However, the literature does not indicate whether this tool has been validated in the field with actual P3 projects, and as such, should be considered a promising concept requiring further research. It, like all such quantitative tools, will only be as good as the input data available to drive the output.

The quantitative ACM selection decision category has the below listed advantages and disadvantages.

- Advantages The major benefit associated with the quantitative method is the ability to compute a result that involves all identifiable costs and risks into a single graphic output: the probability density function. The quantitative method has all the advantages of the qualitative method listed above plus the following:
 - o Ability to associate statistical levels of confidence with each candidate ACM.
 - o Increased fluency with the project's sensitivity to specific risks.
 - The potential to update the risk model as risks are retired and use that information for fine-tuning future analyses.
 - Ability to conduct a forensic analysis after the project is completed to identify inaccuracies in the model to continuously improve future uses of the system.
- Disadvantages The quantitative method has all the disadvantages of the qualitative method listed above plus the following:
 - The numerical output may lend a sense of false precision that might unintentionally have an adverse impact on subsequent project delivery decisions.
 - o The utility of the output is limited by the quality of the input data.

Agencies must be careful not to over-populate the risk models with trivial risks that do not affect the bottom-line but do add unnecessary noise that might mask the actual sensitivities of important risk factors.

Graduated/Combination ACM Selection Tools

The TCRP tool reviewed in detail in Chapter 3 is an example of the graduated approach to ACM selection. As previously stated, its underlying principle is to minimize the effort necessary to make the decision and contains three off-ramps that are used to end the analysis if one ACM becomes a clear leader. Thus, this approach's major benefit is the optimization of the decision-making effort. It also has the advantage of providing documentation at each stage to justify the selected ACM. Because of its nature, many of the disadvantages associated with the three categories that relate to resource requirements are eliminated. The approach is completely flexible and allows the agency to make decisions as rapidly as it needs while still ensuring a coverage of important issues due to its checklist-based system for determining model input. The

system's greatest advantage is the completeness of its evaluation building from a simple go/no-go assessment to a quantitative analysis of risk.

DOT ACM Evaluation Tools

For purposes of this report, the difference between an ACM evaluation tool and an ACM selection tools is the perspective. The selection tool is applied *ex ante*, whereas an ACM evaluation tool is applied *ex post*. Therefore, the evaluation tool is used to compare the difference between the pre-award expectations that led to the selection of a particular ACM and the post-construction actualities of project performance. Unfortunately, there are few examples of rigorous ACM evaluation tools. Most of the available information is anecdotal and related to project performance at the program level, not on how the decision to deliver a project using a specific ACM versus another impacted its performance.

Nevertheless, there are some examples from DOTs that provide a framework for the development of ACM evaluation tools. The most thorough ACM evaluation tool was developed by Caltrans (Dongo et al. 2014). The system was developed to furnish quantitative feedback to the California Legislature regarding the performance of a series of projects delivered using design-sequencing (DS), a newly authorized ACM. DS differs from traditional DBB project delivery in that the construction contract is awarded to the low bidder based on an initial bid package where the design has been advanced to roughly 30-percent completion, permitting construction to proceed before design is complete to achieve an accelerated delivery schedule without using DB project delivery. In the Caltrans case, DB was not authorized and, unlike most DOTs, Caltrans is expressly prohibited from outsourcing design services, except in a few specific cases.

Caltrans ACM Evaluation Tool

The Caltrans DS method operates on the concept of design and bidding a series of packages. Figure 12 provides an example of the process. The post award phase of DS project delivery is similar to CM/GC because it allows the successful contractor to work with the in-house designers to incorporate innovative designs and construction methods to improve delivery.

	Initial Bid Package @ 100% Complete		I olete		Sequence II @ 30% Complete		
Bid Item	Complete	Bid Item	Complete	Bid Item	Complete		
Utility Plans	100%	Utility Plans	100%	Utility Plans	100%		
Construction Area	100%	Construction Area	50%	Construction Area	30%		
Signs		Signs		Signs			
Electrical Plans	100%	Electrical Plans	50%	Electrical Plans	10%		
Highway Planting	100%	Highway Planting	30%	Highway Planting	3%		
Plans Details &		Plans Details &		Plans Details &			
Quantities		Quantities		Quantities			
Sign Plans, Details	100%	Sign Plans, Details 5%		Sign Plans, Details	3%		
& Quantities		& Quantities		& Quantities			
TOTAL	100%	TOTAL	47%	TOTAL	30%		

Source: Caltrans 2008

Figure 12. Example of 30-percent complete plan showing all packages.

Caltrans' DS legislation required a report to the Legislature evaluating the performance of the DS contracts. The agency conducted a comparative analysis of DS projects with similar DBB projects (called "shadow projects") awarded in the same year (Craggs et al. 2008). When design-sequencing project was identified, Caltrans selected two or three similar DBB projects to compare with it. The pilot program consisted of six DS projects and nine shadow projects. Once all projects were closed out, comparative financial, schedule, and contract administration analysis conducted based on a predetermined plan. During project execution and closeout, the necessary data was collected to support the evaluation plan. Table 10 shows the details of the performance criteria evaluated in accordance with the plan.

Table 10. Caltrans DS versus DBB project performance criteria.

Performance Area	#	Criteria	Data Collection Method
Schedule	1	Projected time savings versus actual time savings	Delivery of projects will be compared to their baseline schedule.
	2	Measure time from PA&ED (or programming date) to CCA date	Time frame to delivery project once the Environmental Document is completed.
Cost	3	Final Contract allocation for design-sequencing projects compared to traditional projects	Compare closeout costs to the initial project's allocation.
	4	Quantify time savings by adjusting with the construction cost index and calculate user costs	Evaluate time savings and adjust for inflation. Congestion cost savings due to opening the facility earlier.
	5	Capital Outlay Support costs for design-sequencing and traditional projects	Collect and evaluate support costs (i.e., PID, Design, R/W support, and Const. support).
Contract Administration	6	Notices of potential claims versus actual claims (DS vs. DBB), number of CCOs and magnitude of CCOs	Number of potential claims and actual claims (DS vs. DBB), number of CCOs, total cost of CCOs.
	7	Number, magnitude, and type of CCOs	Evaluate number of CCOs, total cost of CCOs, and type of CCOs.
	8	Impacts on small businesses engaged in the highway development industry	Collect data on Disadvantaged Business Utilization
	9	Asses the low bid versus the Engineer's Estimate for design-sequencing projects	The contractor's low bid will be evaluated against the Engineer's Estimate.
PA&ED = Project a acceptance; CCO =		oval and environmental document; C ntract change order	CCA = Construction contract

Source: Craggs et al. 2008

The Caltrans plan shown in Table 10 provides a framework for ACM evaluation that can easily be generalized to all types of ACMs. The processes major strength is the conscious selection of shadow DBB projects that are delivered in the same timeframe. The *ex-ante* tool is designed to feed the ex post analysis and the sample population is controlled to projects that are individually comparable. The weakness in other studies is the fact that the comparison is made on available historic data that was not collected specifically for this type of analysis. Table 11, Table 12, Table 13, and Table 14 illustrate the results of the evaluation for each of the performance areas designated in the evaluation plan.

 $Table\ 11.\ Schedule\ performance\ comparison.$

EA	Co-Rte-PM	Work Description	Original Contract Days	Actual No Days Worked	CCO Days	Projected Time Savings (months)	Actual Time Savings (months)	Time Increase/ Decrease Due to CCO %1	Overall Time Increase/ Decrease % 2
		D	esign-Sequen	cing Project	s				
03-2A860	SAC-51-8.0	Add Connector Lane	680	712	22	12	18	3%	5%
04-25901	SOL-80-R10.3	Stabilize Landslide	525	525	0	6	0	0%	0%
07-19100	LA-405-37.0	Add Auxiliary Lane	370	399	26	5	10	7%	8%
04-25371	ALA-680-M	Construct HOV Lane	240	298	69	7	0	29%	24%
04-2285U	CC-680-15.6	Widen Highway for HOV	650	530	123	14	0	19%	-18%
07-0533U	LA-210-R34.9	Soundwalls	360	499	0	10	-2	0%	39%
		Average	471	494	40	9	4	8%	5%
			Shadow	Project					
03-3696U	SAC-50-16.1	Widen Freeway	305	302	4	NA	0	1%	-1%
12-08620	ORA-405-5.9	Widen Existing Highway	471	416	0	NA	2	0%	-12%
07-06174	LA-134-0.0	Soundwalls	330	435	45	NA	-4	14%	32%
07-49061	LA-405-16.0	Soundwalls	320	488	207	NA	-6	65%	53%
03-44820	ED-50-40.0	Storm Damage Restoration	80	256	88	NA	-3	110%	95%
07-1069U	LA-10-28.0	Widen Freeway and Bridges	900	981	105	NA	-3	12%	9%
08-4047U	SBD-15-R137.0	Rehabilitate Roadway	380	383	3	NA	0	1%	1%
04-19530	SON-01-26.4	Storm Damage Repair	160	160	83	NA	-3	52%	0%
07-00230	LA-101-14.9	Soundwalls	525	601	36	NA	-3	7%	14%
		Average	386	436	63	NA	-2	16%	13%
		viding the CCO days by the original contra							
² Percentage	e (%) obtained by di	viding the difference between the Actual n	umber of days	worked and the	e original cont	ract days by the	original contra	ict days.	

Table 12. Cost growth comparison.

EA	Co-Rte-PM	Work Description	Final Construction Cost	Bid Amount	Increase/ Decrease
		Design-Sequencing	Projects		
03-2A860	SAC-51-8.0	Add Connector Lane	\$4,949,923	\$4,405,515	12%
04-25901	SOL-80-R10.3	Stabilize Landslide	\$7,603,316	\$7,272,661	5%
07-19100	LA-405-37.0	Add Auxiliary Lane	\$6,226,905	\$5,139,078	21%
04-25371	ALA-680-15.6	Construct HOV Lane	\$24, 524, 087	\$20, 654,321	19%
04-2285U	CC-680-15.6	Widen Highway for HOV	\$48,152,396	\$31, 954, 607	51%
07-0533U	LA-210-R34.9	Soundwalls	\$5,278,878	\$4,900,698	8%
		Average	\$16,122, 584	\$12,387,813	30%
		Shadow Proje	ects		
03-3693U	SAC-50-16.1	Widen Freeway	\$7,306,670	\$7,153,283	2%
12-08620	ORA-405-5.9	Widen Existing Highway	\$6,759,802	\$6,000,435	13%
07-06174	LA-134-0.0	Soundwalls	\$7,167,975	\$6,044,444	19%
07-49061	LA-405-16.0	Soundwalls	\$6,936,784	\$5,550,708	25%
03-44820	ED-50-40.0	Storm Damage Restoration	\$11,225,753	\$8,975,560	25%
01-1096U	LA-10-28.0	Widen Freeway & Bridges	\$45,028, 538	\$41,558,440	8%
08-4047U	SBD-15-R137.0	Rehabilitate Roadway	\$49,243,692	\$43,683,368	13%
04-19530	SON-01-26.4	Storm Damage Repair	\$3,077,909	\$2,975,661	3%
07-00230	LA-101-14.9	Soundwalls	\$5,726,319	\$5,257,373	8%
		Average	\$15,830,382	\$14,133,252	12%
¹ Percentage	(%) obtained by div	viding the difference between t	he final cost and bio	d amount by the bid	amount

Table 13. Quantified time savings.

			California	a Construct	tion Index		Potential	
EA	Co-Rte-PM	Work Description	Actual RTL	DBB RTL	%	Bid Amount	Savings	
		Design-Se	quencing P					
03-2A8604	SAC-51-8.0	Add Connector Lane	141.6	175.5	19%	\$4,405,515	\$850,980	
04-259014	SOL-80-R10.3	Stabilize Landslide	141.6	183.3	23%	\$7,272,661	\$1,654,501	
07-191004	LA-405-37.0	Add Auxiliary Lane	132.3	141.6	7%	\$5,139,078	\$337,524	
04-253714	ALA-680-M	Construct HOV Lane	152.0	167.5	9%	\$20,654,321	\$1,911,295	
04-2285U4	CC-680-15.6	Widen Highway for HOV	129.5	188.2	31%	\$31,954,607	\$9,966,713	
07-0533U4	LA-210-R34.9	Soundwalls	129.5	175.5	26%	\$4,900,698	\$1,284,513	
		Average	137.8	171.9	19%	\$12,387,813	\$2,677,588	
RTL = Ready	to List		•	•	•			

Table 14. Bid price and contract change order analysis.

EA	Co-Rte-PM	Work Description	Engineer's Estimate	Increase/ Bid Decrease		Final Construction	Increase/ Decrease	CCO & Supplemental		
LA	Co-Rie-FM	work Description	(EE)	Amount	% EE to Bid	Construction	% Bid to Final	Num ber	Cost	%
			Desig	gn-Sequencing	Projects					
03-2A860	SAC-51-8.0	Add Connector Lane	\$6,243,088	\$4,405,515	-29%	\$4,949,923	26%	43	\$574,155	12%
04-25901	SOL-80-R10.3	Stabilize Landslide	\$8,206,000	\$7,272,661	-11%	\$7,603,316	8%	15	\$486,586	6%
07-19100	LA-405-37.0	Add Auxiliary Lane	\$7,266,062	\$5,139,078	-29%	\$6,226,905	17%	35	\$1,127,697	18%
04-25371	ALA-680-M	Construct HOV Lane	\$23,265,222	\$20,654,321	-11%	\$24,524,087	-5%	48	\$4,774,301	19%
04-2285U	CC-680-15.6	Widen Highway for HOV	\$40,250,000	\$31,954,607	-21%	\$48,152,396	-16%	117	\$19,920,858	41%
07-0533U	LA-210-R34.9	Soundwalls	\$6,190,000	\$4,900,698	-21%	\$5,278,878	17%	43	\$358,826	7%
		Average	\$15,236,729	\$12,387,813	-19%	\$16,122,584	-5%	50	\$4,540,404	28%
				Shadow Proje	cts					
03-3696U	SAC-50-16.1	Widen Freeway	\$7,140,000	\$7,153,283	0%	\$7,306,670	-2%	43	\$576,277	8%
12-08620	ORA-405-5.9	Widen Existing Highway	\$9,007,000	\$6,000,435	-33%	\$6,759,802	33%	47	\$744,199	11%
07-06174	LA-134-0.0	Soundwalls	\$9,003,000	\$6,044,444	-33%	\$7,167,975	26%	42	\$1,382,355	19%
07-49061	LA-405-16.0	Soundwalls	\$6,968,000	\$5,550,708	-20%	\$6,936,784	0%	53	\$1,481,646	21%
03-44820	ED-50-40.0	Storm Restoration Damage	\$5,536,006	\$8,975,560	62%	\$11,225,753	-51%	34	\$3,074,739	27%
07-1069U	LA-10-28.0	Widen Freeway & Bridges	\$49,261,962	\$41,558,440	-16%	\$45,028,538	9%	104	\$3,998,837	9%
08-4047U	SBD-15-R137	Rehabilitate Roadway	\$46,482,000	\$43,683,368	-6%	\$49,243,692	-6%	68	\$3,015,522	6%
04-19530	SON-01-26.4	Storm Damage Repair	\$4,571,681	\$2,975,661	-35%	\$3,077,909	49%	14	\$156,234	5%
07-00230	LA-101-14.9	Soundwalls	\$5,225,000	\$5,257,373	1%	\$5,726,319	-10%	38	\$722,208	13%
		Average	\$15,910,517	\$14,133,252	-11%	\$15,830,382	1%	49	\$1,683,557	11%

Utah DOT CM/GC ACM Evaluation Tool

Like Caltrans, Utah DOT was asked to track the performance of its CM/GC program and provide facts regarding its ability to furnish value for money to the State. Additionally, the agency received permission to use CM/GC via the FHWA SEP-14 program, which also required the reporting of project performance information. Table 15 contains the details of the performance of the six CM/GC project included in their 2012 report. To arrive at these numbers, UDOT conducted an estimate before advertising for the CM/GC contractor. That number was then designated the anticipated project price.

During the preconstruction phase, the contractor was required to provide cost and time information for each of its suggested design and constructability changes. If those were accepted, the actual cost of those pay items was tracked until the project's guaranteed maximum price was established. For those contractor-suggested improvements that remained in the final design, the estimated cost savings was recorded and shown in Table 15.

It must be noted that this evaluation is not an *ex-post* evaluation like the one previously described for the Caltrans DS program; however, it does provide a measure of value against the actual preconstruction fee paid to the CM/GC contractor for these services. Later research, which included UDOT CM/GC projects, found that the average CM/GC preconstruction fee to be between ½ and ½ percent of construction costs (West et al. 2012). Thus, UDOT could show an estimated direct savings of 6 percent that flowed from an investment of ½ percent: a 12 to 1 benefit cost ratio.

Estimated Direct Project Description Anticipated Project Price Savings¹ \$4,700,000 Atkinville Interchange \$42,084,814.57 I-15 Bridge Reconstruction \$9,032,135.05 \$240,000 \$116,425,488.79 \$4,000,000 I-80 Reconstruction (Phase 2) Riverdale Road (Phase 3) \$41,748,562.31 \$3,260,000 Virgin River Trail \$1,296,518.74 \$180,000 Southern Parkway - River Rd to Airport \$14,024,172.74 \$1,400,000 \$13,780,000 Total \$224,611,692.20 **Savings as a Percent of Anticipated Price:** 6% 1 - Estimated Direct Savings are based on proposed innovations, and savings recognized during design.

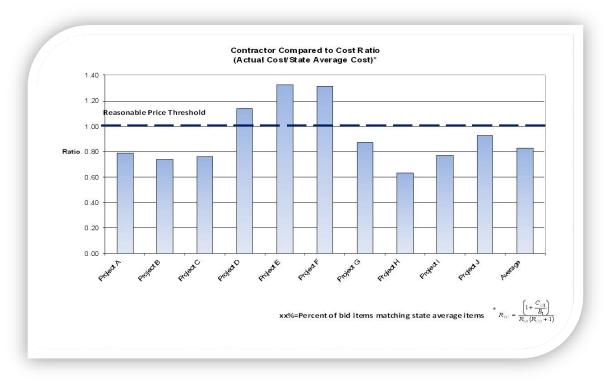
Table 15. UDOT SEP-14 CM/GC performance report.

Source: Alder 2012

The second aspect of the UDOT CM/GC evaluation effort came from an audit conducted by the State Auditor's Office. Questions had been asked as to whether the pricing obtained in negotiated GMPs was competitive with those received during low-bid DBB projects (Park 2012). To answer the question, the auditors developed a model that compared CM/GC actual costs to an index that represented the State average costs on a pay item unit price basis for DBB projects.

Figure 13 is the result of that comparison. It shows that for the 10 projects included in the audit, 7 out of 10 were judged to have been less costly, and the average cost was roughly 82 percent of the cost of DBB projects. The audit found that while the initial low-bid price appeared to be less

than the CM/GC GMP in most cases, the actual costs when construction was complete were more, validating the estimated savings UDOT found at the end of preconstruction.



Source: UDOT

Figure 13. Utah DOT CM/GC cost versus State average DBB costs.

The use of the index of statewide construction costs as the benchmark against which to compare final ACM costs is an excellent ACM evaluation tool and worthy of future research to develop a standardized methodology for use outside of Utah.

WSDOT and Caltrans ATC ACM Evaluation Tools

The last examples of DOT ACM evaluation tools come from the Washington State DOT (WSDOT) and Caltrans. In both cases, they are evaluations of the DOT alternative technical concept (ATC) program used in conjunction with their DB projects. Table 16 and Table 17 illustrate the output from the evaluations. In both cases, the agency had prepared a plan in advance detailing the data to be collected. WSDOT restricted its evaluation to the percentage of savings realized from the value of the engineer's estimate at the time of award of the DB contract.

Table 16. WSDOT ATC program 2009–2012.

Contract Name	# Proposers	Proposer	ATCs Submitted	ATCs Approved	Engineer's Estimate (millions)	Winning Proposal Amount	Apparent Savings (Loss)	Percent Savings from EE
I-405, NE 8TH		A	5	5				
ST TO SR 520	2	В	2	2	01751	0107.5	ф <i>с</i> л <i>с</i>	20.60/
- Braided Ramps Interchange	3	С	4	4	\$175.1	\$107.5	\$67.6	38.6%
I-405, NE		A	1	1				
195th St to SR	4	В	3	3	\$30.0	\$19.3	\$10.7	35.8%
527 - Auxiliary Lane		С	2	2				
I-5 ET ALL,		A	5	3				
Active Traffic	2	B**	1	0	\$37.9	\$34.6	\$3.5	9.2%
Management System		С	8	3	, , , ,		*	
SR 520		A	11	6				
Pontoon	3	В	5	4	\$600.0	\$367.3	\$232.7	38.8%
Construction		С	1	1				
SR 520,		A	27	15				
Eastside Transit	3	В	24	13	\$422.1	\$306.3	\$115.8	27.4%
and HOV Project		С	27	13				
SR 99, Bored		A	8	4		\$1,089.		
Tunnel Alternative	2	В	18	14	\$1,056.9	7	(\$32.8)	-38.6%
		A	9	7	\$18.6		\$4.1	38.6%
I-5, Joe Leary		В	4	0		\$14.5		
Slough to Nulle	5	С	5	3				
Road Paving		D	0	0				
		Е	3	3				
SR 520		A	17	12				
Evergreen Point Floating	3	В	18	4	\$640.8	\$586.5	\$54.3	8.5%
Bridge and Landings	3	С	62	27	ψο 10.0	ψ300.3	ψ3 1.3	0.570
US 2, Rice		A	1	0				
Road - Safety	3	В	9	3	\$2.75	\$2.17	\$0.58	21.1%
Improvements I-405, NE 6th		С	1	0				
to I-5 Widening & Toll Lanes	4	*	*	*	\$249.9	\$155.5	\$94.4	37.8%
SR 9/SR 92 - Intersection Improve.	3	*	*	*	\$3.90	\$3.35	\$0.55	37.8%
TOTALS			281	152	\$3,238.1	\$2,686. 6	\$551.5	17.0%

Source: Adapted from Carpenter 2012

Caltrans chose a different point of comparison. The agency had offered stipends for partial payment of proposal preparation costs to the unsuccessful bidders on its DB projects. Its evaluation was to compare the value of approved ATCs that were eventually incorporated into the final constructed project to the total cost of the stipends. Table 17 shows that it spent \$3.32 million on stipends and accrued a savings of \$142.5 million through ATCs.

Table 17. Caltrans ATC program summary.

	#/Value of ATCs											
Project	# Propose	DBr	# Sub	Sub (\$M)	# App	App (\$M)	# In Pro	In Pro (\$M)	# On Proj	On Proj (\$M)	Stipend (\$K)	Winner (\$M)
SM 101		A B	0	\$0 \$0	0	\$0 \$0	0	\$0 \$0	0	\$0 \$0	\$0 \$25	010
Ramp	3	C	0	\$0	0	\$0	0	\$0	0	\$0	\$25	\$10.6
Meter			0	\$0	0	\$0	0	\$0	0	\$0	\$50	
Fre 180 Braided Ramps	5	A	1	\$1.6	0	\$0	0	\$0	0	\$0	\$0	\$40.7
		В	0	\$0	0	\$0	0	\$0	0	\$0	\$0	
		С	2	\$1.2	0	\$0	0	\$0	0	\$0	\$25	
		D	6	\$4.9	0	\$0	0	\$0	0	\$0	\$25	
		Е	2	\$2.0	2	\$2.0	0	\$0	0	\$0	\$25	
			11	\$9.7	2	\$2.0	0	\$0	0	\$0	\$75	
LA		A	5	\$9.5	3	\$8.8	1	\$7.8	1	\$7.8	\$0	\$46.2
I-10/	4	В	9	\$13.3	4	\$6.9	4	\$6.9	0	\$0	\$65	
I-605		C	5	\$1.5	2	\$1.5	2	\$1.5	0	\$0	\$65	
Inter-		D	8	\$8.3	5	\$6.2	5	\$6.2	0	\$0	\$0	
change			27	\$32.6	14	\$23.4	12	\$23.4	1	\$7.7	\$130	
	6	A	5	\$3.6	1	\$1.3	1	\$1.3	1	\$1.3	\$0	\$71.9
		В	4	\$2.2	4	\$2.2	1	\$0.7	0	\$0	\$75	
I-805 N		C	6	\$1.3	6	\$1.3	3	\$0.9	1	\$0.7	\$75	
HOV/BR		D	2	\$2.6	1	\$0.8	1	\$0.8	0	\$0	\$0	
T		Е	4	\$7.7	4	\$7.7	4	\$3.8	0	\$0	\$75	
		F	0	\$0	0	\$0.0	0	\$0	0	\$0	\$0	
			21	\$17.4	16	\$13.3	10	\$7.4	2	\$1.9	\$225	
	d 4	A	38	\$251.3	22	\$119.0	18	\$108.2	18	\$108.2	\$0.00	\$649.5
Gerald		В	17	\$44.6	9	\$35.9	0	\$0	0	\$0	\$1,000	
Desmond		C*	19	\$56.2	9	\$31.2	0	\$0	0	\$0	\$0	
Bridge		D	37	\$401.9	13	\$179.9	0	\$0	0	\$0	\$1,000	
			111	\$754.0	53	\$366.0	18	\$108.2	18	\$108.2	\$2,000	
I-15/		A	10	\$49.3	9	\$28.4	8	\$24.6	8	\$24.6	\$0.0	_
I-215		В	2	\$8.8	2	\$8.9	1	\$8.6	0	\$0	\$250	
Devore	4	С	14	\$68.4	7	\$38.6	7	\$38.6	0	\$0	\$250	\$208.2
Inter-		D	10	\$26.9	6	\$22.5	6	\$22.5	0	\$0	\$250	
change	4.4	•	36	\$153.5	24	\$98.4	22	\$94.3	8	\$24.6	\$750	01.005
TOT	44	20	16	\$967.3	109	\$502.8	62	\$232.2	29	\$142.5	\$3,230	\$1,027

*Design-builder chose to not submit a final proposal.

DBr = Design-builder; Sub = Submitted; App = Approved; Pro = Proposal; Proj = Project; M = millions; Project; M

K = thousands; TOT = total

Source: Adapted from Tritt 2013

Again, the WSDOT and Caltrans evaluation processes furnish the foundation for the development of similar ACM evaluation tools. The use of multiple benchmarks as seen in the two ATCs systems provides an opportunity for a DOT to demonstrate ACM value for money in ways other than cost and time savings.

ACM Project Performance Metrics

Overview

The previous section contained a number of project performance metrics, including award growth, cost growth, time growth, and number of change orders. The major consideration when selecting an ACM project performance metric is the aspect of project performance that the agency desires to measure and the purpose for collecting that information. In this study, the focus is on making the ACM selection decision via a comparative analysis of potential options. Therefore, it can be argued that the agency needs metrics that will test the decisions made and allow it to revise its decision-making model as well as add or delete ACM evaluation tools. That would lead one to seek metrics that measure the costs and benefits of selected ACMs in a manner that permits them to be compared to the same measures for DBB projects. Further, ACMs that extend beyond the design and construction period, such as DBOM or DBFOM, will logically need similar metrics to also assess and compare life-cycle activities such as service provision, operations, and maintenance. Hence, the performance metrics should flow out of the ACM selection tool to determine whether the various factors included in the decision were adequate and whether the expected benefit of using a given ACM was realized for each factor in the process.

This section will first briefly review the common categories of project implementation performance metrics applicable primarily to a project's design and construction phase, defining each and indicating its strengths and weaknesses for application on typical highway construction projects delivered using ACMs. Subsequently, the review will consider metrics for operations or service phase performance, which illustrates the limitations of such metrics. Consequently, the challenge for developing the ACM selection tool will be to identify measures that are both informative and pragmatic.

Types of metrics

Project performance metrics generally fall into three categories:

- Relative: Relative metrics are expressed as a percentage and as a result are independent of the size of a project. This allows the cost engineer to directly compare the performance of small projects with the performance of large projects. The cost and time growth metrics discussed above are typical examples of relative metrics.
- Static: Static metrics are discreet numerical measures that do not change with time. They are project size dependent and can only be used to compare projects that are roughly the same size. Cost per square foot of constructed area and charge days per lane-mile of highway are examples of static metrics.
- Dynamic: Dynamic metrics vary with time and are also project-size dependent. These metrics can be a function of both cost and time, with some including cost, time, and a function of physical size.

To be used to evaluate the effectiveness of various ACMs, the analyst must consider their limitations before choosing a set to measure ACM project performance. Additionally, the reason for the measurement of project performance must be known and metrics selected that are best adapted to satisfy the need for specific performance information. Lastly, while it is possible to

craft metrics that include a measure of non-numerical performance for areas such as quality and safety, the output from such metrics must be carefully assessed to ensure that inferences made do not overstate the given metric's utility.

Relative Project Implementation Performance Metrics⁵

Three common relative metrics are time growth, cost growth, and award growth. Others, such as dispute cost percentage, average cost growth due to liquidated damages, and average time growth due to liquidated damage days, are less widely used but have been shown to be both valuable and reliable for providing performance information to the agency (Gransberg et al. 1996). For instance, if the agency were seeking to measure the impact of enhanced collaboration and integration brought by ACMs, the change in dispute percentages would be an appropriate metric.

Time Growth

The literature has consistently shown that agencies' primary reason for choosing ACM delivery is to accelerate or compress the delivery schedule (Molenaar et al. 2014; Dongo et al. 2014; Craggs et al. 2008). Thus, measuring the ACM's ability to reduce schedule increases after contract award is a primary factor of interest and directly relates to the reason for assessing ACM performance. Time growth is defined as the change in time between the final contract time and the original contract time and is expressed as a percentage. Time growth can be either positive or negative. It is important to remember that time growth also changes with any changes in the project's scope. If time growth is positive, the project finished late; whereas, a negative time growth value indicates that the project finished ahead of schedule.

$$Time Growth = \frac{Final contract time - Original contract time}{Original contract time}$$
eqn 1

Where: Time Growth (percent) – Change in contract time.

Final contract time (days) – The number of days between the contract award date and the actual completion date.

Original contract time (days) – The number of days between the contract award date and the contract completion date.

Cost Growth

Cost growth is the change in cost between the original contract cost and final contract cost, expressed as a percentage. Cost growth can be positive or negative. In most cases, positive cost growth indicates that scope changes that increased the cost of the project were made during the contract period. In unit price contracts, positive cost growth can also be due to actual quantities

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⁵ Certainly, the scope of several of the implementation performance metrics presented could be expanded to include the operations or service phase; for instance, the "cost growth" metric could be broadened to include the final life-cycle contract cost and the original life-cycle contract cost.

being higher than the engineer's estimated bid quantities, or it can also be the result of unbalanced unit prices. Unbalanced unit prices can occur when contractors artificially inflate or deflate the actual unit prices for competitive reasons they see as an advantage in preparing their overall bid price. Neither of these two cases indicates that the pre-award scope was inadequate. Negative cost growth is typically the result of a reduction in the project's scope of work after award due to owner-directed scope deletions, value engineering changes, or over-estimated quantities.

$$Cost Growth = \frac{Final contract cost - Original contract cost}{Original contract cost}$$
 eqn 2

Where: Cost Growth (percent) – Change in contract cost.

Original contract cost (\$) – The amount at which the contract was awarded.

Final contract cost (\$) – The actual final contract amount including changes, claims, and quantity variations.

Award Growth

Award Growth is defined by the difference between the contract amount at award and engineer's pre-award estimate expressed as a percentage. Positive award growth indicates that the owner under-estimated the project's cost and may be in danger of having an inadequate contingency to complete the project. Negative award growth indicates that the owner's estimate was high. Award growth is a measure of the owner's understanding of the construction market.

Award Growth =
$$\frac{\text{Original contract } \cos t - \text{Engineer's estimate}}{\text{Engineer's estimate}}$$
 eqn 3

Where: Award Growth (percent) – The change in estimated contract cost from the pre-award estimate and the award amount.

Original contract cost (\$) – The amount at which the contract was awarded.

Engineer's estimate (\$) – The estimated cost prior to contract award.

Average Percent Increase per Change Order

The average percent increase per change order measures incremental cost growth. A contract with no change orders has no scope-related cost growth. When the average percent increase per change order is large, it indicates an issue with the contract documents and provides a means of assessing their quality (Gransberg et al. 1996). As the average percent increase per change order increases, the probability that design errors were present in the contract document also increases. This would indicate that regardless of the project delivery method, a flawed design will require change orders and result in cost growth. This metric is described by the following equation:

Number of Change Orders

Average Percentage of Additional Days Granted

The average percentage of additional days granted is included in the overall time growth equation; however, additional days granted move the contract completion date and come into play when liquidated damages are calculated. Additional days are typically granted for issues such as owner directed changes, compensable delays, and other events covered in the contract. In weather-sensitive highway construction, there is often a clause that determines whether a day of work is charged based on the timing of a specific interruption such as rain. Typically, the day is charged if the contractor had worked over half its schedule shift before the disruption occurred, which is often open to interpretation when the overall complexity of the project production system is considered. In the end, the average percentage of additional days granted can be used as an indicator of the agency's willingness to reduce time pressure on the contractor. Hence, agency policy rather than strict technical events can and will influence the value this metric and must be kept in mind as its results are evaluated.

Average Percentage of Additional Days Granted = <u>Additional Days Granted</u> eqn 5
Original Contract Time

Average Liquidated Damages as a Percentage of Total Cost

Average liquidated damages as a percentage of total cost is a means to measure the impact of ACM employment on those projects with schedule issues as indicated by the imposition of liquidated damages (LD). When new ACMs are introduced, focus tends to be on those projects that go well. If an ACM program is to become truly institutionalized, it must also produce positive results in those projects that have problems. Measuring LDs on projects that finish late is an objective metric with which to compare ACM projects to traditional projects. The metric is calculated using the following formula:

Average Liquidated Damages as a Percentage of Total Cost = Liquidated Damages Cost eqn 6

Total Contract Cost

Average Liquidated Damage Days as a Percentage of Total Time

Average liquidated damage days as a percentage of total time is intended to measure the effect of LD days on the overall contract period. Again, comparing this parameter between the two types of projects should give us the ability to quantify the impact of ACM implementation on project performance. This parameter is computed as follows:

Average LD days as a percentage of total time = Number of Days of LDs

Total Days Allowed + Additional Days Granted

eqn 7

Percent of Projects with Liquidated Damages

The percentage of projects with LDs is a direct measure of the agency's willingness to impose LDs. Additionally, it provides an indicator of contractor ability to prosecute the projects as they were originally planned and bid. A difference in this indicator between ACM and traditional projects will provide a means to explain the value of ACM delivery on projects that do not finish as expected. This metric is calculated by the following formula:

Percentage of Projects with LDs = <u>Number of Projects with LD's</u>
Total Number of Projects

eqn. 8

Percentage of Projects with Deducts

A deduct is defined as a change order which reduces the contract amount and is typically the result of a reduction in project scope. This metric measures the agency's ability to properly scope the project. It also may indicate the ability of the agency's cost estimation system to properly value project scope and allocate adequate contingencies to cover realized risks. This parameter is calculated by dividing the number of projects that had negative cost growth by the total number of projects.

Percentage of Projects with Deducts = <u>Number of Projects with Negative Cost Growth</u> eqn. 9

Total Number of Projects

Claims Cost as a Percentage of Original Cost

The term "construction claim" has a variety of technical definitions that are specific to each DOT's procurement vernacular. In general, claims are contractor assertions that a specific item of work that must be performed is outside the scope of the contract. Typically, claims initially surface as contractor requests for a compensable change order and morph into a claim when the owner rejects the change order request. Negotiations ensue and if a settlement is reached, the contract is increased by the amount of the settlement. For purposes of defining this metric, no standard definition will be offered. Agencies that choose to adopt it are encouraged to establish their own definition. For example, the Texas DOT defines claims as "contract disputes that are settled above District Level (Cacamis and El Asmar 2013) whereas, the Montana DOT uses the term to describe contractual issues that are resolved in the courts (Pinto-Nunez et al. 2018). Hence, this relative metric is one that cannot be compared between agencies and as such, has value only to the agency that provides its unique definition. The literature cites the increased collaboration inherent to ACMs as having the benefit of discouraging claims (Lopez et al. 2008; DBIA 2009; Lahdenperä 2012). Therefore, analysis of ACM project performance relative to claims experience permits the agency to validate one purported benefit of adopting ACMs. Claims cost as a percent of original cost is determined as follows:

Claims cost as a percent of original cost = <u>Total Cost of Claims</u> Original Contract Cost

eqn 10

Where: Total Cost of Claims – The amount attributed to the cost of resolving claims based on the agency's definition.

Dispute Cost as a Percentage of Original Cost

Some DOTs differentiate between claims and disputes and again, this metric will conform to the using agency's definition and cost attribution system. A common example is found in many large DB projects where a dispute resolution board (DRB) is empaneled for the life of the contract and has specific binding and nonbinding authority to resolve disputes on a routine basis. Therefore, this metric might be used to compare ACM projects with DRBs and ones without. Disputes cost as a percentage of original cost is calculated as follows:

eqn 11

Where: Total Cost of Disputes – The amount attributed to the cost of resolving disputes based on the agency's definition.

Static Implementation Metrics

Static metrics are a function of project size, and as such, comparisons can only be made between similarly sized projects, and static metrics do not vary with time. Some DOTs differentiate between claims and disputes and, again, this metric will conform to the using agency's definition Most are based on the elements of construction cost; however, it is also instructive to include functions of design cost when measuring ACM performance since most ACMs involve contractor design involvement. A poorly developed design will manifest its deficiencies during the construction process. A study for the Oklahoma Turnpike Authority found that the agency's ability to control cost and time growth in DBB projects correlated to the level of investment in the design process (Gransberg et al. 2007). Thus, a life-cycle approach to project performance metrics is in order, measuring the project's progress from concept to ribbon cutting. The following sections detail the static metrics identified in this study.

Design Unit Cost

Design unit cost determines the average cost per some physical measure of project size. The physical parameter can be a linear unit (i.e. linear foot, lane-mile, etc.), unit of constructed area (square-foot of bridge deck, square-yard of paved surface, etc.) or a volumetric unit for (cubic meter, cubic yard, etc.) depending on the nature of the project. This metric provides a factor for comparing different projects and different ACMs. It is usually used as supporting information to explain potential values in other metrics, such as cost growth, time growth, or disputes experience. This value is obtained by dividing the design cost by the size.

 $Design Unit Cost = \underline{Design Cost}$ Size

eqn 12

Where:

Design Unit Cost (\$/unit)

Design Cost (\$) – The amount spent on design.

Size (unit) – The project-specific physical measurement(s) of interest.

Construction Unit Cost

Construction unit cost determines the average cost per project physical size measure. It is the measure obtained by dividing the final construction cost by the size.

Construction Unit Cost = $\underline{\text{Construction Cost}}$

eqn 13

Size

Where: Construc

Construction Unit Cost (\$/unit)

Final Construction Cost (\$)

Size (unit)

Design-Build Cost

Design-Build Cost is the sum of design cost and final construction cost, which measure the total amount of the design and construction contract.

Design-Build Cost = Design Cost + Final Construction Cost

eqn 14

Design-Build Unit Cost

Design-Build unit cost determines the average cost on a project for unit designed and built which is obtained by dividing the Design-Build cost by the size.

 $Design-Build Unit Cost = \underline{Design-Build Cost}$ Size

eqn 15

Dynamic Implementation Metrics

Dynamic metrics like static metrics are size dependent, but unlike static metrics, dynamic metrics are a function of time. Dynamic metrics are typically a combination of cost and time parameters and may include functions of project size. Because they are time dependent, dynamic metrics can be used to measure project performance efficiency (Gransberg and Villarreal 2002). Again, both the design and construction phases of a project can be measured and used to give the analyst an idea of how efficiently the work is proceeding. The common unit for dynamic metrics

is dollars per unit time. The Army Corps of Engineers calls the resulting term "placement" which it uses to measure construction progress against an agency standard (Gannon et al. 2012). This type of metric is used in earned value analysis and, as a result, it is also called earned value.

While the formulas are identical, there is a subtle difference between the purposes of placement and earned value. Placement is a retrospective metric and looks backward to compare a given project against a specific standard. Earned value is a prospective metric and the output is used to predict probable project outcomes, such as the final cost at completion (Vargas 2003). Earned value analysis output is used to compute cost and schedule performance indices, which in turn are input values for predicting final project costs and time. Earned value performance indices can be used in a retrospective manner that allows projects of similar size to be compared. Intensity metrics are the third type of dynamic metric. These combine cost, time, and project size into a single computed factor. Thus, the following sections will detail both the placement metrics and intensity metrics, as well as earned value indices, as possible ACM performance metrics.

Placement Metrics

Design placement is defined as the average cost per day of a design contract. It is obtained by dividing the design contract cost by the design contract time.

$$\begin{aligned} \text{Design Placement} &= \underline{\text{Design Cost}} \\ &\quad \text{Design Time} \end{aligned}$$

eqn 16

Construction placement is the measure obtained by dividing the construction cost by the construction time; therefore, construction placement measures the average rate at which the contractor earns value over the entire period of a construction contract. The effective and efficient construction management is obtained with a high value in construction placement.

eqn 17

Design-Build placement is the total amount obtained with the sum of design cost and construction cost divided by the total time period between the start of the design and the completion of the construction contract.

eqn 18

Intensity Metrics

Intensity metrics combine cost, time and project size into a single measurement. Its purpose is to furnish a measure of how fast the project is being delivered in financial terms. Intensity was first used to measure ACM project performance by the seminal study by Konchar and Sanvido (1998) and has continued to be included in the literature to this day. The metric is computed by dividing the unit cost of interest by its corresponding time period. When used as an ACM project

performance metric, the intensity provides an indication of the project team's capacity to deliver the project. Hence, if placement metrics measure efficiency, intensity metrics measure effectiveness. Intensity can take the same three forms as placement using the following equations.

$$\frac{\text{Design-Build Intensity} = \underline{\text{Design-Build Unit Cost}}}{\text{Design-Build Time}} \qquad \qquad \text{eqn 21}$$

Where: Intensity (\$/unit/day)

Earned Value Indices

Earned value theory seeks to measure project cost and schedule performance in financial terms. Hence, its underlying assumption is that the analyst can measure how well the project is proceeding with regard to its planned schedule by following the actual amounts being paid to the contractor and comparing those to the project's planned payment schedule, sometimes referred to as cash flow schedule (Vargas 2003). Two key elements of earned value analysis are the cost performance index and the schedule performance index. These indices are the ratio of actual payments to date to planned payments to date. These indices are computed as shown below.

The above performance indices provide a measure of how well the project team is executing its project management plan for the given project. If the resultant index is less than unity, then there are performance issues; if it is greater than unity, then project performance is exceeding expectations. The ideal project would have cost and schedule performance indices that equal 1.00. Hence, following the change in these metrics allows the analyst to determine if corrective actions taken during project delivery are having a positive or negative effect. They can also be used as static metrics to compare performance between ACM and traditional.

Operations or Service Phase Metrics

This section considers metrics for assessing operations and service phase performance. It first describes DOT approaches to assess such outcomes at a programmatic level, and then it provides

examples of project-level metrics being implemented in P3 arrangements. Next, it presents other related FHWA initiatives that may support evaluating operations and service phase performance. Finally, the material covered is summarized, emphasizing its usefulness for developing an ACM selection framework and tools.

Programmatic Measures

Operations or service phase metrics are used by DOTs at a programmatic level. Generally, the intent of such metrics is to gauge how well an agency is fulfilling user or customer needs and expectations. Quite a few agencies have "dashboards" in place to track specific programmatic areas for this purpose. For instance, the Virginia DOT (VDOT) has an online system (dashboard.virginiadot.org) that monitors two major areas: highway and VDOT performance. Within the highway area, the dashboard reports on performance, safety, condition, and finance, while in the VDOT performance area it reports on VDOT management, citizen survey results, and projects. Table 18 provides further information about the specific metrics used.

Area	Metric	Description
Highway	Performance	Percentage of congestion-free travel on
		interstates.
Highway	Safety	Highway deaths since the beginning of the
		year.
Highway	Condition	Percentage of pavement and bridges meeting
		target condition thresholds and percentage of
		lane miles with fair or better ride quality.
Highway	Finance	Variance of year-to-date planned versus
		actual expenditures.
VDOT Performance	VDOT Management	Information about VDOT's management
		performance measures.
VDOT Performance	Citizen Survey Results	Ratings of overall citizen satisfaction with
		VDOT.
VDOT Performance	Projects	Percentage of projects in development and in
		delivery that are on time and on budget.

Table 18. Overview of VDOT's dashboard.

Obviously, systems like VDOT's dashboard encompass far more than operations and service performance; however, they represent key dimensions and outcomes for an agency, and these tend to influence the performance measures put in place in long-term contracts such as P3s. This tendency was observed in a report that examined performance measurement and key performance indicators in domestic and international P3s – *Key Performance Indicators in Public-Private Partnerships: A State-of-the-Practice Report* (Garvin et al. 2011). In the report, a central theme presented was the alignment of broad agency goals with performance measures in P3 projects. While practice had yet to achieve complete alignment, many agencies using P3s were evolving and working toward this objective. Certainly, long-term contracts offer the opportunity to link agency objectives with project-level outcomes through key performance indicators (KPIs).

Project-Level Metrics

Scope and Structure of Metrics in P3s

P3s typically employ a variety of metrics to assess project operations and service outcomes as well as P3 contractor performance. These metrics can be grouped into broad categories such as the following:

- Usage
- Customer Service
- Asset Management
- Availability and Service
- Financial Outcomes

In P3 projects, basic financial metrics are some of the easier ones to monitor, and public agencies, equity investors, and lenders will follow different ones. For instance, public agencies may track the present value of any subsidies, budgetary or contingent commitments to the project; this provides them a sense of the current magnitude of any long-term monetary obligations. Equity investors are most interested in the project's equity rate of return or the equity internal rate of return (IRR), where the latter gives an indication of the minimum equity rate of return for a project at a given point in time. Finally, lenders monitor various coverage ratios, such as the annual debt service coverage ratio (DSCR) or the loan life coverage ratio (LLCR). These ratios allow lenders to assess a project's capacity to repay debt and are usually expected to range from 1.15 to 1.40, depending on a project's characteristics. FHWA's *Financial Structuring and Assessment for Public-Private Partnerships: A Primer* provides further details about these metrics.

Typically, P3 projects use an overall life-cycle management approach to monitor project outcomes, and KPIs are implemented within this broader management system to gauge whether specific requirements are being met (Nguyen and Garvin 2018). Financial metrics KPIs, though, are very indicative of a P3 project's operations and service performance. For instance, the Capital Beltway Express P3 in Virginia has 34 measurement criteria in the following nine main categories:

Tolling

- Transactions
- Cross-reads
- Signage
- Privacy
- Transactions

Communications

Public information

Customer service

Project management

• Project plans

Operations

- Incident management
- Information sharing
- Systems control
- Work zone management

Inspection

• Qualification of inspection

Maintenance

• Performance requirements

Level of service

• Degradation of the facility

Contract administration obligations

- Discrimination
- Subcontracting
- Suspension of tolls
- Permit fee
- Updates to financial model
- Refinancing
- Operations and maintenance contractor
- Maintenance budget
- Department access and inspection

Performance is evaluated against each of these criteria using a performance points system that identifies breaches or failures by the P3 contractor as well as different "cure periods" for each KPI. A cure period essentially defines the time frame that the contractor has to remedy the breach or failure and when and how performance points are assessed if the breach is not remedied. The employment of KPIs in conjunction with a performance points system is very common in U.S. highway P3s (Nguyen and Garvin 2018). Table 19 depicts representative KPIs and cure periods in the Capital Beltway Express Project.

Table 19. Sampling of KPIs in the Capital Beltway Express P3 Project.

Heading	Subheading	Breach or Failure	Category	Cure period	Max points
Tolling	Transactions	The Concessionaire transmits duplicate transactions or incorrect toll amounts to the Customer Service Center (to be determined on a per transmission basis).	С	None	5
Communica- tions	Public information	The Concessionaire issues information to the public or in press releases whether through variable message signs or other means that is factually incorrect.	С	None	5
Customer service		The Concessionaire fails to respond within 7 days to customer inquiries and complaints about the HOT lanes where contact details of customers have been provided, whether the complaint is received directly from customers, the customer service center, or from the Department.	A	2 days	5
Project management	Project plans	The Concessionaire fails to produce, review, and, if necessary, update the following plans during the operating period in accordance with the agreement including but not limited to: (1) the Concessionaire Management Plan; (2) the Hazardous Substances Management Plan; (3) the Communication, Public Outreach, and Community Education Plan; (4) the Life-Cycle Maintenance Plan; and (5) the Operation and Maintenance Plan.	A	30 days	5
Operation	Work zone management	The Concessionaire fails to meet requirements of I&IM 241 relative to work zone safety, management, maintenance of traffic, and diversion routes for regular maintenance during operations.	В	60 minutes	5
Inspection	Quality of Inspection	The Concessionaire fails to identify material defects in the inspection reports, Life-Cycle Maintenance Plan, or work currently undertaken.	С	None	5
Maintenance	Performance requirements	The Concessionaire fails to meet the performance requirements for each asset in cycles adopted in the industry for each asset.	A	30 days	5
Level of service	Degradation of the facility	The Concessionaire fails to appropriately manage the dynamic tolling mechanism to ensure the level of service of the HOT Lanes Project does not become degraded as required by law. In addition and to be measured separately, upon receiving notice of a problem	В	7 days	5

Heading	Subheading	Breach or Failure	Category	Cure period	Max points
		with the dynamic tolling mechanism, the Concessionaire fails to submit a rectification plan to the Department for approval.			
Contract administration obligations	Sub- contracting	The Concessionaire fails to include provisions in all of its subcontracts requiring its subcontractors to refrain from discrimination.	С	None	5

Source: adapted from Garvin et al. 2011

Linkage to Agency Requirements

The KPIs used in the Florida I-595 Express Lanes P3 are also illustrative of how P3 project data can be linked to agency-wide standards or systems. Table 20 is an excerpt from the KPI tables in the P3 agreement. The measurements for the raveling and/or delaminating of the friction courses for the running surfaces are tied to online specifications. These items will change over time and the P3 project will therefore be aligned with such elements in the overall FDOT network. Similarly, the Intelligent Transportation System (ITS) KPIs are linked to the State's ITS program.

Table 20. Example KPIs from I-595.

Element Category	Required Task	Minimum Performance Requirements	Cure Period	Interval of Recurrence	
Highway Rur	nning Surfaces: Pa	vement			
Category 1 Pavement (0-3 years	Maintain Flexible Pavement at acceptable level	Meet the performance requirements set forth in Division II, Section 6 of the Technical Requirements for the following:			
Substantial Completion)	of safety for traveling public	Rutting to be maintained less than a depth of 0.25 inches.	90 days	Every 5 days	
		Ride to be maintained at Ride Number (RN) greater than 3.5.	90 days	Every 5 days	
		Settlement/Depression maximum depth of 0.5 inches.	7 days	Daily	
		Cumulative length of cracking > 30 feet for Cracks > 0.125 inches in a 1/10 th miles lot.			Every 5 days
		Raveling and/or Delamination of the Friction Course as defined and determined by the Department in accordance with the examples displayed at www.dot.state.fl.us/specificationsoffice/pavement.htm or its successor.	90 days	Every 5 days	
		Potholes and Slippage Area(s) cannot be greater than 0.5 square feet in area and 1.5 inches deep.	24 hours	Hourly	
Intelligent Tr	ansportation Syst	ems			
ITS Operations	Monitor time required for roadway clearance	I-595 EXPRESS LANES Quarterly Average Roadway Clearance Duration (in minutes) must be no more than 90% of FDOT District Four's ITS Performance Measures published quarterly on www.smartsunguide.com .	0	N/A	
	Monitor time required for incident clearance	I-595 EXPRESS LANES Quarterly Average Incident/Event Clearance Duration (in minutes) must be no more than 90% of FDOT District Four's ITS Performance Measures published quarterly on www.smartsunguide.com .	0	N/A	

Comparable Approaches from International P3s

Australia's EastLink P3 also employed KPIs, and its KPIs were developed in the target areas of customer service, road maintenance, landscape and environment, and tolling accuracy. Any performance shortfalls by the concessionaire would be recorded as "KPI points" and converted into financial penalties, up to \$17 million annually. These amounts would be paid not to the State, but to road users since they were the ones inconvenienced by the performance lapses. These toll credits would be distributed to motorists in proportion to their use of the facility during the corresponding KPI year. Table 21 depicts KPIs from each of the project's major performance areas.

Table 21. Excerpts from EastLink KPIs.

No.	KPI Description	KPI Bench- mark	KPI Points	Assessment Period
1.	A Quarterly KPI Report, containing the information required by the Deed, is submitted within 20 Business Days after the end of each Quarter.	100%	Report submission: 21-60 Business Days after the end of each Quarter = 50 points >60 Business Days after the end of each Quarter = 100 points	Quarterly
2.	The number of incoming calls must not exceed 96% of the inbound telephone line capacity during any consecutive period of more than 5 minutes on any day. This KPI is limited to one breach per day. This KPI will not be breached in circumstances where the excess was caused by errors or omissions by external telecommunications service providers.	100%	100 points every day KPI Benchmark is not met	Monthly
3.	Applications for Accounts, additional Tags and adding or removing Vehicle LPNs from an Account, must be responded to in accordance with all requirements of this Deed and any relevant Customer Contract within 5 Business Days of receipt by ConnectEast at the first customer service centre facility where such application is received. KPI applicability is from in-house receipt, to out the door shipments / mail responses. The ConnectEast document management system will be used to measure compliance. Tag dispatch lead times will be measured by the Tolling System as the elapsed time between receipt of the Tag order and time of physical dispatch to the Customer.	99.9%	10 points for every occurrence outside KPI Benchmark	Monthly
4.	All events which will trigger financial transactions for a Customer (other than transactions the subject of KPI numbered 7) must be applied to the Customer's Account within 2 Business Days of the event except where this KPI Benchmark cannot be met because of:	99%	1 point for every occurrence outside KPI Benchmark	Monthly

	 (a) recovery from Tolling System outage, in which case the applicable time period may be extended by no more than 3 Business Days; or (b) where the Customer's Account has not been created at the time of the event triggering the financial transaction, in which case the financial transaction shall be applied to the Customer's Account within 2 Business Days of its creation. 			
5.	Customer Complaints that have not been resolved must be escalated to a senior level within the customer services staff, within 7 Business Days of the Customer Complaint being received by ConnectEast.	99%	10 points for every occurrence outside KPI Benchmark	Monthly
6.	ConnectEast must not suspend a Customer's Account or take action in relation to offences such as instituting or progressing enforcement procedures until ConnectEast, acting reasonably, considers the Customer Complaint to be resolved. Example: If two complainants out of 1,000 have action taken against them while their Customer Complaints are active, the penalty will be 10 points. This KPI excludes enforcement action taken by the enforcement agency that is beyond the reasonable control of ConnectEast.	99.9%	10 points for every occurrence outside KPI Benchmark	Monthly
7.	At least one staffed, convenient full-service product delivery channel must be open 24 hours a day, seven days a week. This KPI will exclude delays caused by an emergency situation.	100%	10 points for every closure	Monthly
8.	Accounts must not be overcharged, even in the event of detection system 'failed or missed' transactions. This KPI does not apply in the following cases: • Errors or omissions by other Toll Road Service Providers • Errors caused by VicRoads or by any authorised provider of interstate vehicle registration information (including where VicRoads' or relevant interstate authority's data files are incorrect or incomplete)	100%	10 points for every occurrence outside KPI Benchmark	Monthly

For KI	• Fraud, errors, or omissions by the Customer The above 3 cases would be excluded in the numerator and denominator for calculating this KPI Benchmark. Pl's 9 and 10, 'Incidents' are rounded down to the neare.	st 10 and do not	include incidents caused	l by an act or
	Percentage of incident response events, in a traffic lane, for which the required response time (10 minutes) was achieved. Example: There are 105 incidents recorded in a month, but the Operator fails to respond to 22 of those incidents within 10 minutes. The KPI points for that month would be: {22 - [10% of 100 (105 rounded down)]} x 10 = 120 points.	90%	10 points for every occurrence outside KPI Benchmark	Monthly
10.	Percentage of incident response events, in an emergency stopping lane, for which the required response time (15 minutes) was achieved. Example: There are 167 incidents recorded in a month, but the Operator fails to respond to 24 of those incidents within 15 minutes. The KPI points for that month would be: {24 - [10% of 160 (167 rounded down)]} x 10 = 80 points.	90%	10 points for every occurrence outside KPI Benchmark	Monthly
11.	Perform planned maintenance inspections and activities in accordance with Appendix D10 (Planned Maintenance Schedule) to the Project Scope and Project Requirements for those activities or inspections for which the scheduled interval is less than six months based upon a rolling Quarterly period, with monthly reporting.	95% of inspections to be undertaken within scheduled time frame.	10 points for every occurrence outside KPI Benchmark	Monthly
12.	Road Condition - Meet Pavement Performance Measures as set out in Appendix D9 (Code of Maintenance Standards) to the Project Scope and Project Requirements.	100%	10 points for every occurrence outside KPI Benchmark	Annually

13.	Landscaping - Meet the intervention standards set out in Appendix D9 (Code of Maintenance Standards) to the Project Scope and Project Requirements for Asset Element: Landscaping.	95%	5 points for every occurrence outside KPI Benchmark	Monthly
14.	Availability of Tunnels - Each tunnel must be open between 05:00 and 22:00.	100%	10 points per hour for every occurrence outside KPI Benchmark	Monthly
15.	Lane availability (Freeway, other than Tunnels) - All Freeway lanes must be open, except when closed for permitted maintenance between 20:00 and 05:00 or between 09:00 and 15:00.	100%	10 points per lane per hour for every occurrence outside KPI Benchmark	Monthly
16.	Freeway Lane Closures (not applicable to tunnels) - The Concessionaires and/or Operator may not close two or more lanes in any Freeway section north of Thompson Road for a period of more than 5 hours except between 22:00 and 05:00 or between 09:00 and 15:00.	100%	10 points per hour for every hour or part thereof beyond the first 5 hours	Monthly

KPI's 17 to 19 relate to the availability of Tolling Roadside Equipment (as defined in the Operation and Maintenance Agreement). Note, for the purposes of those KPI's:

- (a) Period P1 = Monday to Saturday 06:00 to 20:00; Period P2 = times other than P1
- (b) Rectify/Replace timing commences from time notification/alarm is received in the Traffic Control Room or is otherwise notified.

17.	Rectify/Replace defective transceiver or image capture camera within KPI Benchmark.	2 hours during period P1. 4 hours during period P2.	10 points for every occurrence outside KPI Benchmark	Monthly
18.	Rectify/Replace defective classification device or overview camera within KPI Benchmark.	4 hours	10 points for every occurrence outside KPI Benchmark	Monthly
19.	Rectify/Replace defective controller in technical shelter within KPI Benchmark (where the 2 complete gantries associated with the technical shelter/controller are out of action).	4 hours	10 points for every occurrence outside KPI Benchmark	Monthly

20.	The Concessionaires may not exceed the conditions of the air quality license. Example: The Concessionaires are notified by the EPA that there is a breach of the Operation EPA License conditions relating to air quality. The KPI Points will be 10 for each breach that is notified to the Concessionaires by the EPA.	100%	10 points for every occurrence outside KPI Benchmark	Monthly
21.	Meet water quality measurement in accordance with Appendix S6 (Environmental Requirements), Table S6.9.1 (Objectives, Performance Criteria and Minimum Procedural Requirements) and Appendix D17 (Environmental Management Plan) to the Project Scope and Project Requirements.	95%	5 points for every occurrence outside KPI Benchmark	Monthly

Source: Victoria 2004

Other FHWA Initiatives

FHWA has two initiatives underway that may support the development of an ACM selection tools. In 2017, a conceptual design for an online source of data about major surface transportation projects was presented in a discussion paper (Binder et al. 2017). The paper described issues related to collecting information about major projects and proposed various types of project data for collection. The paper suggested that the information source should focus on DB and DBFOM projects. The information proposed for collection is comprehensive in scope ranging from an implementing agency's policies, to project procurement, to operations and maintenance. Information about operations and maintenance would include 11 data elements, such as traffic related data, pavement condition thresholds, annual pavement maintenance, preservation and rehabilitation costs, and annual financial performance metrics. Currently, a team is working on developing the proposed information source.

In addition, FHWA is developing a tool called P3-EFFECTS. The intent of this tool is to assist decision-makers in quantitatively estimating the impacts of ACMs (such as DB and DBFOM) on cost, schedule, and quality compared to DBB. Specifically, the tool considers how specific drivers and factors produce desired effects (Volpe 2018). Figure 14 depicts the relationship between the tool's drivers, factors, and effects.

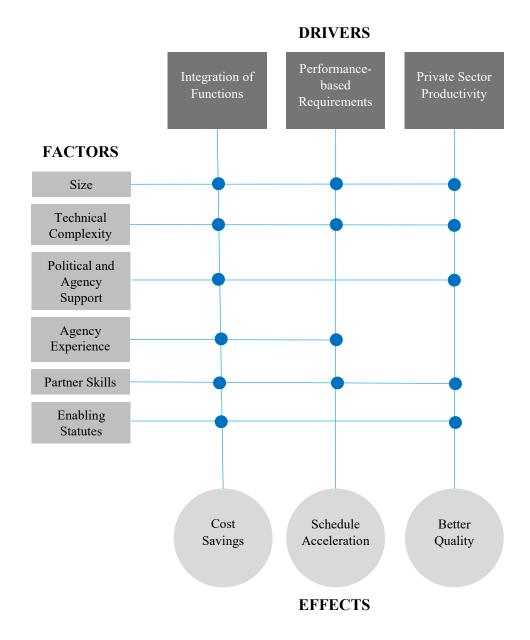


Figure 14. Overview of drivers, factors, and effects in P3-EFFECTS tool.

Currently, the tool relies on user inputs and expert judgment to generate ranges of cost savings, schedule acceleration, and improved quality for a P3 delivery compared to DBB, and it is still under development.

Summary

In general, awareness of the need and benefits of gauging overall agency performance is increasing among State DOTs (Garvin et al. 2011). P3s offer the means to translate overall agency performance goals into tangible performance measures at the project level. Existing research and practice has illustrated mechanisms for this purpose. The KPIs used in P3s emphasize metrics in the operations and service phase of projects, since output specifications rather than prescriptive specifications are widely viewed as a driver of P3 benefits. While

instructive in terms of their scope and structure, the KPIs being used in P3s are specifically designed to both incentivize and monitor a P3 contractor's performance in a particular project. Alone, they do not provide an indication of whether a P3 produces better outcomes, such as improved asset management or service availability, compared to another delivery option. Over time, the collection of such project-specific performance data across a range of project types and delivery approaches, if it were available, could be useful to assess how well a particular ACM compares to another in terms of operations and service provision as well as implementation. Yet, data of this sort is not readily available.

Consequently, the two ongoing FHWA initiatives to develop the Online Information Source for Major Transportation Projects and P3-EFFECTS are intended to enhance understanding of the influence of ACMs on project-level outcomes such as cost, schedule, and quality. The Online Information Source could support empirical analyses of the influence of ACMs on project outcomes, while P3-EFFECTS is intended to provide estimates of such impacts. However, both efforts are still in their formative stages, so it is unclear at this point how to incorporate these endeavors into the development of ACM selection tools. At this time, the existing FHWA P3-VALUE 2.1 Tool does provide a means to forecast relevant project-level outcomes for a public sector comparator (PSC) such as DBB and a P3 such as DBFOM based on user inputs and a calculation engine. Its structure and transparency potentially support enhancing the tool for inclusion in the ACM selection toolset.

Interpreting ACM Project Performance Metrics

There is no single metric that provides the all-knowing evaluation of project performance. The types of projects delivered using ACMs are normally more complex than those using traditional delivery for no other reason than ACM projects are typically executed at a faster pace, employing procurement and project management practices that are often new to the project delivery team. Therefore, it is important that the agency develop its own project performance dashboard that consists of a variety of the above detailed metrics, as well as a consistent protocol for interpreting their output. There are two primary methods with which to infer meaning when assessing a suite of project performance metrics:

- 1. Discreet value analysis
- 2. Relative value analysis

Discreet Value Analysis

This approach merely consists of comparing the actual numbers that are computed for the metrics in the analysis suite. It relies on the direct comparison and, depending on the metric, the value with the highest or lowest value is judged to be the best. For example, when using cost growth as a metric, the desired value is a low as possible and negative values are seen as better than positive values. Therefore, a project with a construction cost growth of +4% would be judged less successful than a similar project whose cost growth was +2%. On the other hand, earned value metrics with values greater than 1.0 indicate successful project performance; whereas, those with values less than 1.0 have project performance problems.

The major benefit to discreet value analysis is its simplicity and ease of communication of comparative output. Its major disadvantage is that many of the above metrics are not independent of each other. This is especially true when dynamic metrics are included in the suite. For instance, a project that is progressing ahead of its schedule will have higher costs than what was expected if it were on schedule. This might cause the higher costs to be interpreted as showing the project to be over budget. Another possible problem comes when two projects are being compared and the input data is not uniform. A good example would be to compare a DBB project where the design was outsourced to a DB project, where the design was advanced to 30 percent before awarding the DB contract. Since the design-builder did not start from zero design, adding the DBB design cost to its corresponding construction does not provide an "apples-to-apples" comparison with the cost of the DB contract.

Relative Value Analysis

Relative value analysis uses the difference between the measures of discreet value as the primary comparator between two projects' performances. Thus, the fact that the cost per square foot of bridge deck of one project is less than another is less important to the interpreter than the percentage difference of the two. In this approach, the analyst focuses on the delta and uses it as an additional measure to deepen the understanding of actual project performance.

Other Project Performance Metrics

No evaluation of highway project delivery is complete without considering safety and quality performance analysis. Unfortunately, these areas, while receiving intense scrutiny during project execution, are not often included in the suite of ACM project performance metrics. Thus, there is very little information in the record from which to draw potential effective practices. For example, NCHRP Project 19-10, American Association of State Highway and Transportation Officials (AASHTO) Partnering Handbook, was charged with quantifying the quality and safety benefits accrued by implementing partnering (Gransberg et al. 2017). However, after completing a comprehensive literature search and a survey of all 52 DOTs, it found no data being collected in a manner that permitted project-by-project evaluation of the change in quality and safety performance between partnered and non-partnered projects. This is an area where further research would be highly beneficial.

Safety Performance Metrics

Table 22 comes from an ongoing research project sponsored by the National Metrics Advisory Committee, a body that tracks 223 metrics that relate to safety and health performance (Gittleman 2017). This project is specifically related to construction safety. The table lists 15 metrics that have been used in the construction safety literature. Many of them are not suitable for ACM performance evaluation, but they are included here to demonstrate the wealth of potential metrics that can be adopted and adapted for use in the ACM area.

Table 22. Example safety performance metrics.

Metric	Metric Description	Important	Likely to Use
1	Percent supervisors meeting goals/scorecard	3	1
2	Percent above or below industry rate for recordable case rate	5	2
3	Number of safety violations observed	1	5
4	Number of safety suggestions and problems solved	2	3
5	Number employees reporting unsafe practices or conditions	2	3
6	Percent of all potential exposures have been qualitatively assessed	5	4
7	Percent of closure for corrective action plans	4	4
8	Percent improvement in trend analysis results	4	2
9	Number of near misses reported	3	5
10	Number of work-related hospitalizations	1	1
11	Competent persons selected and trained for tasks	1	5
12	Workforce turnover	4	2
13	Employees involved in accident investigation	5	3
14	Employees exercising stop work authority	3	1
15	Evaluation of training effectiveness	2	4

Source: Gittleman 2017

Two commonly used metrics are the number of labor hours without a lost time accident and the number of reportable accidents. These outcomes can then be combined as demonstrated in the

previous sections with measure of cost, time, and size to produce performance metrics that will permit a reasonable comparative analysis. For example, a major national highway construction company uses reportable accidents per million dollars of construction cost as one of its internal key performance indicators (Lopez del Puerto et al. 2013).

Quality Performance Metrics

While the literature is rife with information regarding the measurement of construction quality, it is nearly silent with respect to quality-related ACM performance metrics. Molenaar and Navarro (2011) found that the Georgia DOT established a number of key performance indicators for its West Point I-85 Interchange DB project. Those KPIs are as follows:

- Pavement sound intensity testing results: Highways for Life (HfL) goal of 96.0 dB(A) or less for all paved surfaces.
- Pavement smoothness HfL goal of 43.8 in/mi (international roughness index) or less for all paved surfaces.
- Smoothness index of 900 or less for new construction.
- Smoothness index of 1,025 or less for corrective work.
- Profile index of 30 in/mi or less for bridge approaches.
- Hot-mix asphalt (HMA) concrete thickness measurements.
- HMA concrete spread rates.

The Panama Canal Expansion DB project also developed a number of quality-related performance metrics. One that proved particularly useful was the number of noncompliance reports (NCR) per unit of constructed product. For instance, one quality KPI for portland cement concrete was the number of NCR per 1000 cubic meters in place. The agency then tracked this over time using relative value analysis with success be defined as a downward incremental change over time (Tapia et al. 2017).

Chapter 5. Findings

This chapter summarizes the findings of the research to date and identifies areas where additional work is required. However, before jumping into the details, it is interesting to note that the team has developed a sense from the literature, the research, and the DOT interviews that the typical DOT is satisfied with an ACM selection process that is fundamentally based on professional judgment. This is particularly true among DOTs with mature ACM programs and a reasonable foundation of experience from which that professional judgment can be drawn. It is also important to note that most formal ACM selection processes were developed to determine whether a single ACM is more attractive than DBB delivery, with DB being the most used ACM in the procurement toolbox.

Analysis of Historical NCHRP Surveys

To test this notion, Dr. Gransberg consolidated the survey responses received from the 19 NCHRP ACM research projects completed over his 24 years of research. The database includes over 400 individual responses from all 50 DOTs and the District of Columbia Department of Transportation to survey questions seeking to gain information on the reasons DOTs chose to use ACMs. The delivery methods sampled were DBB, CM/GC, DB, P3, ID/IQ, and ATCs. While each research survey had its own focus, every survey included a list of potential reasons for using an ACM rather than DBB delivery. The top seven reasons are shown in Table 23 along with the number of responses collected for each ACM.

The reader should understand that Table 23 is not a rigorous scientific experiment, but merely the summation of individual DOT perceptions recorded since 2001. No effort has been made to determine if the responder is qualified by experience to respond, which is beyond the scope of this project and probably impossible without revisiting every individual survey. However, it does reflect the perceptions of working-level DOT project managers with regard to the value added by ACM delivery and those project characteristics that lead them to select a specific ACM.

Table 23. Consolidated results of 19 surveys from NCHRP ACM research projects (2001 to 2017)

Selection Reason	Overall	CM/GC	DB	Р3	ID/IQ	ATC
Compuess sobodulo	386	121	306	120	59	57
Compress schedule	95%	100%	100%	100%	100%	100%
Schedule certainty	384	120	304	118	58	57
Schedule certainty	95%	99%	99%	98%	98%	100%
Cost containts	160	121	154	60	32	29
Cost certainty	39%	100%	50%	50%	54%	51%
Complex project	306	115	305	115	50	54
requirements	75%	95%	100%	96%	85%	95%
Early contractor	151	52	145	120	29	21
involvement	37%	43%	47%	100%	49%	37%
TOL 1	120	50	109	45	59	7
Third-party issues	30%	41%	36%	38%	100%	12%
Flexibility during	126	46	114	45	11	57
construction	31%	38%	37%	38%	19%	100%

Table 23 makes a decent departure point for discussing the findings to date of this research. The first two reasons are the most frequently cited, and both are related to schedule. Completing the project as quickly as practical (Compress Schedule) and achieving enhanced schedule certainty seem to continue to be the primary reasons for not using DBB project delivery. The yellow cells with thick borders show instances where the value for a given ACM does not align with the overall trend. Only in CM/GC does cost certainty rank as high as schedule factors. DOTs feel that complex project requirements are a good reason for DB delivery. P3 is selected if early contractor involvement is needed. ID/IQ appears to be well suited to projects with third-party issues, and projects that require flexibility during the construction phase appear to benefit from ATCs. Therefore, while not scientific, the trend is clear. DOTs choose ACM delivery for three primary benefits:

- Ability to accelerate the delivery schedule.
- Enhanced schedule and cost certainty; i.e. better control over risk.
- Furnish a mechanism to better address project complexity though integration and collaboration.

Those three benefits could be rephrased as speed, certainty, and teamwork. The information covered in the previous four chapters independently validates the result of this simple analysis. Thus, these three benefits can be used as the basis for identifying and reporting effective practices.

Defining Effective Practices

One of the commonly misused terms in the ACM research literature is "best practices." (Michaelson, and Stacks 2011). The description of what some find as a best practice almost always elicits the response: "according to whom?"

Michaelson and Stacks (2011) proposed that a best practice must meet two objective criteria, allowing the analyst to differentiate a best practice from a practice that an author asserts to be sound. Their definition is, "A method or technique that has *consistently* shown *results superior* to those achieved with other means and that is used as *a benchmark*." Accardo (2015) offers a complimentary definition for an effective practice: "Research-based practices identified through high quality quantitative study, but not yet meeting the strict criteria needed to become a benchmark."

Thus, the term "effective practice" is appropriate for this report for two reasons. First, this report is restricted to a review of the literature and practice found in DOT ACM documentation. Therefore, it is possible to satisfy the criterion of "practices identified through quantitative study." Secondly, since less than half the DOTs in the United States can be described as having mature ACM programs, establishing a national benchmark is impossible, which is consistent with Accardo's second criterion.

Effective Practices for Making the ACM Selection Decision

Synthesizing the information found in Chapters 2 and 3 leads to the following list of potential effective practices.

- Choose the ACM that best fits the project's specific characteristics and constraints.
- Include four types of issues in the ACM selection analysis:
 - Project-level issues
 - Agency-level issues
 - Public policy/regulatory issues
 - Life-cycle/sustainability issues
- Based on the project issue analysis, choose the level of effort appropriate to identify the best ACM for the given project by progressively adding more detail and rigor until a clear choice is available. The following are the four levels, in order of ascending effort:
 - 1. Professional judgment alone a single ACM is clearly superior to DBB.
 - 2. Qualitative analysis of project requirements more than one ACM appears viable, as does DBB.
 - 3. Qualitative risk analysis one or more ACMs appear viable, as does DBB, and risk profile can be used as the decision criterion.
 - 4. Quantitative risk analysis one or more ACMs appear viable, as does DBB, and the qualitative risk profile does not provide a clear choice.
- The CDOT PDSM, Caltrans Alternative Procurement Guide, and the TCRP three-tiered approach have all been successfully implemented by more than one DOT for selecting CM/GC and DB projects.
- The TCRP three-tiered approach and the FHWA P-3 Toolkit have been successfully used for P3 projects.

Effective Practices for Developing ACM Project Performance Measures

The research was less successful in uncovering effective practices for ACM performance measurement. Nevertheless, it did identify a large number of performance metrics that are available for use as required.

Table 24 consolidates those metrics detailed in Chapter 4. This table does include illustrative operations and service phase KPIs actually in place in selected P3 projects. Further, several of the metrics focused on the implementation phase (design and construction) could be expanded to include the operations or service phase; for instance, cost metrics could consider life-cycle cost growth or life-cycle cost per unit. However, using life-cycle metrics requires careful definition of the life-cycle period and life-cycle cost components.⁶

Surprisingly, there was little information on safety and quality performance measurement in the context of ACM delivery. Given the plethora of metrics designed to measure both safety and quality on construction projects, it appears that a DOT could certainly develop its own ACM safety and quality metrics by selecting among those that are related to the ACM delivery process.

Given that ACMs are chosen when the agency has a need for speed, it would seem logical that the implementation of ACM safety and quality metrics would be critical to evaluating the effectiveness of ACMs to accelerate delivery without degrading either safety or the quality of the constructed product.

Metric Type	Relative	Static	Dynamic
	Time Growth Average percentage of additional days granted Average liquidated damage	Additional days granted Days of LDs Schedule Performance	
Time	days as a percentage of total time Percentage of projects with LDs	Index	Design Placement
	Cost growth Award Growth Average Percent Increase Per Change Order Average liquidated damages as a percentage of total cost	Design Unit Cost Construction Unit Cost Design-Build Cost Design-Build Unit Cost	Construction Placement Design-Build Placement Design Intensity Construction Intensity Design-Build Intensity
Cost	Percentage of Projects with Deducts Claims cost as a percent of total cost Dispute Cost as a Percentage of Original Cost	Cost Performance Index	
	Expected cost index		

Table 24. ACM performance metrics.

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⁶ Similarly, separate metrics for operations and maintenance (O&M) cost could be included.

Metric Type	Relative	Static	Dynamic
	Reportable accidents per	Labor hours without a	
Safety	million dollars of construction	lost time accident	
-		Reportable accidents	
		Pavement smoothness	
Quality	NCRs per unit		Change in NCRs per unit over time
Financial		NPV of public payments	
		Equity Rate of Return	
		Equity IRR	
		Annual DSCR	
		LLCR	
Operations and Service		1	T
Highway Safety		$A = N*10^8 /$	
		L*365*AADT	
		Where:	
		A = accident rate N = number of accidents	
		with victims	
		L = length of highway	
		under management (km)	
		AADT = Average	
		Annual Daily Traffic	
		The accident rate is	
		compared with the	
		previous year's rate; an	
		increase results in a	
		penalty while a decrease	
		results in a bonus of up	
		to 5% of the annual	
		service payment.	
Roadway Clearance		Quarterly average	
		roadway clearance (in	
7 11 01		minutes).	
Incident Clearance	Percentage of incident	Incident/event clearance	
	response events in a traffic	duration (in minutes).	
	lane where required response time was achieved.		
Pavement Quality	time was achieved.	Ride maintained at RN	
1 avenient Quanty		greater than 3.5.	
Lane Availability		All freeway lanes must	
		be open, except when	
		closed for permitted	
		maintenance.	
Customer Service	Number of incoming calls	Customer complaints not	
	must not exceed 96% of	resolved within 7	
	inbound telephone line	business days are	
	capacity during any	escalated to senior staff.	
	consecutive period of more		
	than 5 minutes on any day.		

As far as ACM evaluation methodologies are concerned, three effective practices were observed.

- The shadow project comparison used by Caltrans and in the FHWA P3 Toolkit furnish the ability to compare ACMs to similar DBB projects let in the same time frame.
- The capture of time and cost savings specifically related to ACM delivery as seen in the ATC data collected by Caltrans and WSDOT provides a means to quantify the increased value for money related to ACM delivery.
- The development of a cost index to relate ACM contract costs to traditional contract costs as used by UDOT furnishes a direct comparison in a simple visual format to articulate the relative change wrought by implementing CM/GC. This approach can easily be extended and applied to all ACMs.

Alternatively, the determination of operations and service phase or life-cycle performance outcomes for ACMs remains a challenge. While P3 projects have comprehensive and rigorous performance measurement systems, these systems were designed for their particular projects rather than comparability among projects. Further, availability of data remains problematic, so existing tools that forecast outcomes of interest such as P3-Value 2.1 will be evaluated for applicability to the ACM selection toolset.

Potential ACM Methodologies for Further Investigation and Refinement

Appendix A contains the details of the most promising ACM selection and evaluation tools identified at this writing. The methodologies are grouped into two categories: Non-P3 methodologies and P3 methodologies. The TCRP ACM methodology is the only one that potentially bridges those two categories as it includes DBOM in its protocols. While not always considered a P3 delivery method, DBOM is the only one found that extends beyond construction completion and is commonly used in P3 delivery as DBOM-Finance.

Candidate Case Study DOTs

The work to date has furnished the necessary foundation for selecting candidate case study DOTs. The following protocol is proposed:

- Mature ACM program completed more than 10 DB projects.
- ACM program includes more than one ACM (not including variations on DBB such as cost-plus-time / A+B bidding).
- ACM program has been institutionalized by the development of standard guidance in the form of manuals, guidebooks, policy documents, etc. containing ACM selection and/or evaluation methodologies.
- Project performance data is available for both ACM and DBB projects on a program basis.

Table 25 contains the current DOTs that satisfy the criterion as having a mature ACM program and how they relate to the other case study selection criteria. Finding of performance data in the literature provides an indication that the DOT has collected this data in a manner that would be accessible to the research team without a great deal of effort.

Table 25. List of candidate case study DOTs.

Mature Program > 10 DB	More than One ACM	Documentation Found	Performance Data in Literature	Possible ACM Case Study	Remarks
AZ	X	X		All	
CA	X	X	X	All	Limited P3
CO	X	X		All	Moderate P3
FL	X		X	All	Extensive P3
GA	X	X X		DB, P3, ATC	Limited P3
IN		X		P3, ATC	Moderate P3
KY	X X			DB, ATC	
ME	X			DB, CM/GC,	
				ATC	
MD	X	X		All	Limited P3
MA	X	X		All	Limited P3
MI	X X	X		All	Limited P3
MN	X	X	X	All	Limited P3
MO	X X	X		DBB-ATC, DB	
MT	X	X		DB, CM/GC	
NC	X	X		DB, P3, ATC	Limited P3
NY	X	X		DB, ID/IQ	
ОН	X	X		DB, P3, ATC	Limited P3
OR	X	X		DB, CM/GC	
PA	X	X		DB, P3	Limited P3
SC		X		DB	
TX	X	X		DB, P3, ATC	Extensive P3 ¹
UT	X	X	X	DB, CM/GC, ATC	
VA	X	X		DB, P3	Extensive P3
WA	X	X	X	All	Limited P3

¹Recent legislative actions may limit P3 implementation in future

Before the final selection is made, direct coordination is necessary to ensure that the DOT is both willing and able to support the case study data collection effort. Additionally, given the finding that most ACM methodologies are applicable to either P3 or non-P3 projects, it seems logical to target those DOTs with mature P3 programs for a case study. It is anticipated that the final selection will be made in the face-to-face meeting in October.

Summary of Emerging Findings

The following are high-level observations made during this effort that have not been discussed thus far in this report.

Literature Review

- ACM selection methodologies or guidance documents found were not comprehensive in scope. The vast majority either focused on DBB, DB, and CM/GC (non-P3 alternatives) or DBOM and DBFOM (P3 alternatives). A few exceptions were found, such as the methodology by Gordon (1994) and the approach in TCRP Report 131.
- Many of the ACM methodologies identified that consider non-P3 options are similar in structure and have used the Caltrans Alternative Procurement Guide or the CDOT Guidebook (Molenaar et al. 2014) as their basis. They rely significantly on user judgments and inputs and are generally qualitative frameworks—although they incorporate some limited quantitative features through scoring or weighting. Consequently, the quality of the decision depends heavily on the competency and experience of the personnel involved.
- The non-P3 methodologies do not forecast or predict outcomes, such as quantifying the influence of an ACM on a project's capital cost, operating cost, or schedule.
- P3 methodologies typically employ qualitative screening tools to determine if a project is a P3 candidate, whereas subsequent tools tend to focus on quantitative VfM techniques. FHWA's P3-Screen and P3-Value tools are illustrative of these methods.

State Call Observations Summary

- States with mature ACM programs tend to use intuition when making method decisions.
 - Even if States are using tools, they are primarily using DB, DBB, and CM/GC.
 - o Many States have strong preference toward the method(s) where they already have the most experience and success.
 - Some States have authority to use other (or in some cases all) methods, but cannot justify or do not want to use methods such as P3.
 - Many States developed their tool by streamlining Colorado's tool, which is quite comprehensive; and many States use Colorado's tool as a discussion guide for working groups to decide on project delivery methods.
- While many States do "lessons learned" reviews after projects, their focus is often not on how the use of the ACM compared to other methods, nor on whether the ACM performed the way their tool expected it to.
 - o Not much review on the initial decision to use an ACM vs. other methods.
 - Many States are interested in an aspect of our tool to be a way to formally evaluate the ACM decision versus other options deemed viable for the project.
- Staffing levels and expertise are factors in steering toward certain ACMs, especially if projects must be delivered quickly.

Next Steps

The review of international ACM selection methodologies contained an interesting review of lessons learned on this topic in the Australian *Procurement Options Analysis Guide*. It reads as follows:

"There is no prescribed approach or methodology for delivery model selection...

However, a number of tools are available for comparing models and identifying the most suitable for a particular project. A semi-quantitative assessment may assist in selecting the preferred delivery model. There are various quantitative methods available and new methods may be developed. The essence of quantitative analysis is to quantify the rationale behind delivery model selection decisions. No matter how solid mathematically, a model based on incorrect or illogical assumptions will be of little use. Some departments have developed approaches (assessment matrices, weighted tables and other tools) which reflect their particular project requirements.

When using a decision support tool –

- Avoid formulae or methodologies that conceal their logic or fail to demonstrate the reasoning involved.
- Ensure sufficient intellectual expertise is available to analyse [sic] options from first principles.
- Ensure that the tool is appropriate—there is no decision support tool that fits all projects.
- Do not rely on the assessment of a single tool.
- Compare the result arrived at by applying the tool with an analysis from first principles—does the result withstand scrutiny from a first-principles analysis and a check against another analytical method?"

This quotation stands as a warning against developing "black boxes" whose output has not been empirically validated. However, it does encourage the use of "semi-quantitative methods" where professional judgment is used to temper the interpretation of available ACM performance data when used to identify the most suitable ACM for a given project. Therefore, the problem then becomes redefined as how to make available data support the objectives of the ACM selection methodology.

Appendix A: Details of ACM Methodologies

An overview and details of sample of ACM methodologies identified in Task 2 are provided in this Appendix, separated into ones that consider non-P3 ACMs and ones that consider P3 ACMs. They are presented alphabetically by agency.

Non-P3 Methodologies

Colorado Department of Transportation

Overview

The Colorado Department of Transportation (CDOT) uses the methodology developed by Molenaar et al. (2014) as described in the *Guidebook for Selecting Alternative Contracting Methods for Roadway Projects*. This methodology guides owners in the selection of DB, DBB, and CM/GC. It has four elements:

- 1. Set project goals.
- 2. Select a delivery method.
- 3. Select a procurement procedure.
- 4. Select a payment provision.

Set Project Goals

Establishing the goals and objectives for the project is the first step, and worksheets are available to guide this process. The "Project Attributes" worksheet is shown in Figure 15.

Project Attributes
Project Name:
Location:
Estimated Budget:
Estimated Project Delivery Period:
Required Delivery Date (if applicable):
Source(s) of Project Funding:
Project Corridor:
Major Features of Work – pavement, bridge, sound barriers, etc.:
Major Schedule Milestones:
Major Project Stakeholders:
Major Obstacles (as applicable):
With Right of Way, Utilities, and/or Environmental Approvals:
During Construction Phase:
Main Identified Source of Risk:
Safety Issues:
Sustainable Design and Construction Requirements:

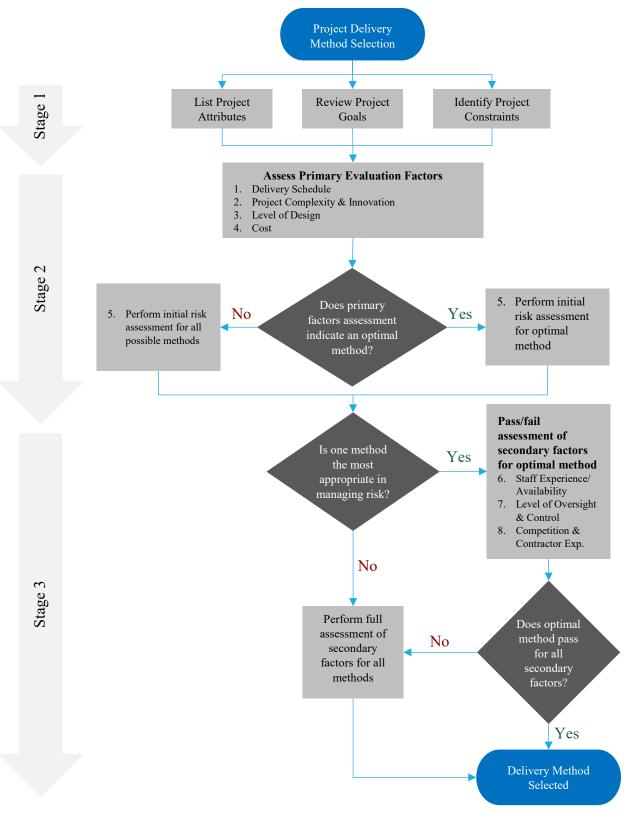
Source: Molenaar et al. 2014

Figure 15. Colorado DOT project attributes worksheet.

Select Delivery Method

To select between DBB, DB, and CM/GC, a three-stage process requiring user judgments is followed where the five primary factors of delivery schedule, project complexity and innovation, level of design, cost, and risk assessment are considered; secondary factors of staff experience, level of oversight and control, and competition and contractor experience are assessed if necessary.

Figure 16 shows the staged process. Users complete worksheets and checklists to assess each factor that aids in completing the delivery summary sheet shown in Figure 17



Source: Molenaar et al. 2014

Figure 16. Process for selecting delivery method.

PROJECT DELIVERY METHOD OPPORTUNITY/OBSTACLE SUMMARY

Primary Selection Factors	D-B-B	CM/GC	D-B
1. Delivery Schedule	-	-	++
2. Project Complexity & Innovation	+	+	+
3. Level of Design	++	++	+
4. Cost	+	+	++
Perform Initial Risk Assessment	+	-	++

Se	econdary Selection Factors	D-B-B	CM/GC	D-B
6.	Staff Experience/Availability (Agency)	NA	NA	PASS
7.	Level of Oversight and Control	NA	NA	PASS
8.	Competition and Contractor Experience	NA	NA	PASS

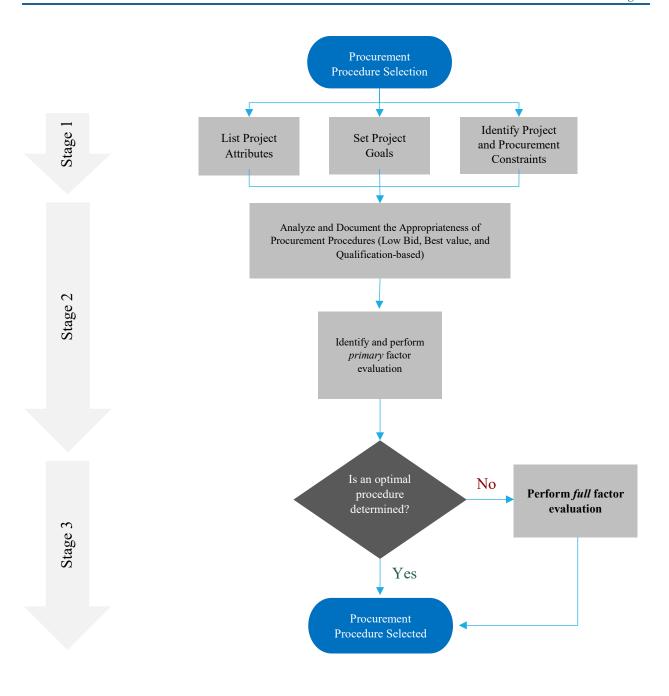
	Rating Key			
++	Most appropriate delivery method			
+	Appropriate delivery method			
-	Least appropriate delivery method			
Χ	Fatal Flaw (discontinue evaluation of this method)			
NA	Factor not applicable or not relevant to the selection			

Source: Molenaar et al. 2014

Figure 17. Example delivery method summary worksheet.

Select Procurement Procedure

Similarly, selecting the procurement procedure follows a three-stage process that considers eight factors ranging from delivery schedule to level of design to competition and contractor experience against three common procurement procedures: low-bid, best-value, and qualifications-based selection (QBS). The process is depicted in the flowchart in Figure 18; again, users complete worksheets and checklists that support completing the selection summary sheet shown in Figure 19.



Source: Molenaar et al. 2014

Figure 18. Process for procurement method selection.

PROCUREMENT PROCEDURES OPPORTUNITY OBSTACLE SUMMARY

Evaluation Factors	Evaluate this Factor? (Circle One)	Low Bid	Best Value	Qualifications- Based
Delivery Schedule	Yes No	NA	NA	NA
Project Complexity and Innovation	Yes No	+	++	NA
Level of Design	Yes No	-	++	NA
Cost	Yes No	+	++	NA
Assessment of Risk	Yes No	-	++	NA
Staff Experience and Availability	Yes No	NA	NA	NA
Level of Oversight and Control	Yes No	NA	NA	NA
Competition and Contractor Experience	Yes No	-	++	NA

Rating Key

- ++ Most appropriate procurement procedure
- + Appropriate procurement procedure
- Least appropriate procurement procedure
- X Fatal Flaw (discontinue evaluation of this procedure)
- NA Factor not applicable or not relevant to the selection

Source: Molenaar et al. 2014

Figure 19. Example procurement method summary worksheet.

Select Payment Provision

The final stage is the selection of payment provisions. Checklists are provided for users to assess: lump sum, unit price, and cost reimbursable/guaranteed maximum price (GMP). Additional payment provisions or conditions such as incentives or warranties are also supported by checklists for user input.

Idaho Transportation Department

Overview

The Idaho Transportation Department (ITD) considers three major project delivery methods: DBB, CM/GC, and DB. ITD has users evaluate various factors to determine a delivery method for a given project.

Evaluation Approach

ITD has adopted an evaluation matrix that considers several factors to decide on a suitable project delivery method. These factors are as follows: (1) Complexity and Innovation, (2) Delivery Schedule, (3) Level of Design, (4) Risk, (5) Agency Factors, (6) Market Factors and (7) Third Party Coordination. Factors are considered separately in worksheets such as the one shown in Figure 20 for "Complexity and Innovation," and users must decide whether a delivery method is one of the following:

- M Most appropriate
- A Appropriate
- L − Least appropriate
- X Not Applicable

Finally, the results are summarized, as shown in Table 26, to aid users in making the delivery method decision.

Factor 1: Complexity and Innovation

Project complexity and opportunity for innovation reflect the likelihood that the project scope will allow for new designs or processes to achieve the project's purpose and need.

DESIGN-BID-BUILD				
Opportunities	Risks			
 Agency can have more control of complex issues Project development and design opportunities can be researched and implemented as project develops Value Engineering opportunities during design 	 Limited opportunity for constructability input Limited flexibility for design/construction solutions Opportunities limited to agency/designer input Contractor may implement different methods Change orders inherent in process 			

CONSTRUCTION MANAGER/GENERAL CONTRACTOR			
Opportunities	Risks		
Better review and inclusion of project solutions Early team integration and increased opportunity for innovation due to the diversity of the project team Constructability reviews and Value Engineering inherent in collaborative design process	 Pre-construction services fees for contractor input Clearly defined cost bidding and negotiating process Customization can add cost or time Additional administration can be necessary for project development phase If Guaranteed Maximum Price (GMP) 		
Take advantage of materials constraints and availability	negotiations break down with initial contractor, DBB is fallback plan.		

DESIGN- BUILD				
Opportunities	Risks			
 Innovation inherent in process Single point of responsibility Design can be customized/optimized to contractor means and methods and technical strengths Opportunity for innovation with Alternate Technical Concepts (ATC) prior to contract award 	 Final design details unknown at time of award Project constraints can be difficult to define Goals and expectations need to be well-defined in order to ensure an acceptable outcome Project unknowns have more impact (e.g. differing site conditions) 			

Complexity & Innovation Summary

		DBB	CMGC	DB
		Opportunity/Risk	Opportunity/Risk	Opportunity/Risk
1.	Complexity-Innovation			

M. Most appropriate delivery method Key:

A. Appropriate delivery method
L. Least appropriate delivery method

X. Not Applicable

Notes and Comments:

Source: Idaho Transportation Department 2012

Figure 20. Factor assessment worksheet for complexity and innovation.

Table 26. Summary of factor assessments by delivery method.

Factors	DBB	CM/GC	DB
	Opportunity/Risk	Opportunity/Risk	Opportunity/Risk
Complexity and Innovation			
Delivery Schedule			
Level of Design			
Risk			
Agency Factors			
Market Factors			
Third Party Coordination			

Texas Department of Transportation

Overview

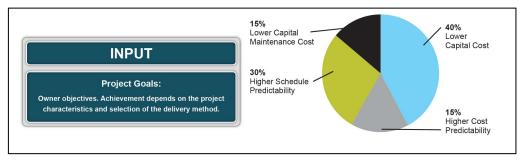
The Texas Department of Transportation (TxDOT) has developed a methodology with support from the Center for Transportation Research at the University of Texas-Austin. The methodology considers DBB and DB.

Identification of project goals and characteristics

The key component of the approach requires users to identify project goals and characteristics; these are expectations of TxDOT with respect to project success.

Input to Methodology

Project goals and the project characteristics are treated as "input." The project goals are defined as dependent variables such as meeting target duration, quality, and safety. The project characteristics are implementation factors inherent to project as shown in Figure 21.



Lower capital cost	1 3
	lowest reasonable; the budget available is
	tight.
Higher cost predictability	The project must be completed within the
	budget. The agency wants to avoid cost
	growth.
Higher schedule predictability	The project must be completed within the
	target schedule. The agency wants to avoid
	schedule growth.
Lower capital maintenance costs	The agency is concerned about minimizing
	the maintenance costs during the life cycle of
	the project.

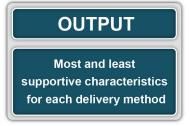
Source: Khwaja et al. 2018

Figure 21. Overview of input parameters.

- Safety and Quality are always considered target objectives.
- Target duration can be met with any Delivery Method and the proper incentives.

Output from Methodology

Using the input, the methodology displays most and least supportive characteristics of each delivery method, as shown in Figure 22.



Design – Build Delivery Method (Most Suitable)		
Most Supportive Characteristics	Least Supportive Characteristics	
The project will benefit from the introduction of	The agency is better equipped than the contractor	
innovative methodologies early in the	to manage third party issues.	
planning/design phase.		
The project requires the benefit of designer-	Prescriptive project requirements for methods,	
contractor integration to reduce coordination	materials, and/or procedures limit contractor	
challenges.	innovation in terms of alternatives.	
Early completion will add significant extra value	For this project, alternative delivery methods shall	
for key project stakeholders.	create incremental agency efforts and expenses	
	that are expected to be greater than the savings in	
	capital expenses.	

Design – Bid – Build Delivery Method (Least Suitable)		
Most Supportive Characteristics	Least Supportive Characteristics	
The project has well-known site conditions that	Completion date of ROW acquisition is highly	
won't cause significant field changes.	uncertain.	
The agency is better equipped than the contractor	Utility relocations have not been completely	
to manage third party issues.	identified and are likely to result in important	
	changes in the design, cost, and/or schedule of the	
	project.	
The project will benefit from the introduction of	The project includes permits requiring	
innovative methodologies early in the	coordination and regulator approval during th	
planning/design phase.	design and/or construction phases of the project.	

Source: Khwaja et al. 2018

Figure 22. Output from methodology.

Final Recommendation

The final output of the methodology presents a recommended delivery method, supported by a combination of bar charts and heat maps shown in Figure 23. This information is presented in five zones:

- Zone 1: Gives the final recommendation.
- Zone 2: Shows the difference in scores for the two delivery alternatives.
- Zone 3: Presents a bar chart combined with a heat map, showing the score obtained by each delivery method in each of the four goals.
- Zone 4: Displays the weighted average of the four goals' scores.
- Zone 5: Presents the recommended delivery method's most and least supportive characteristics.

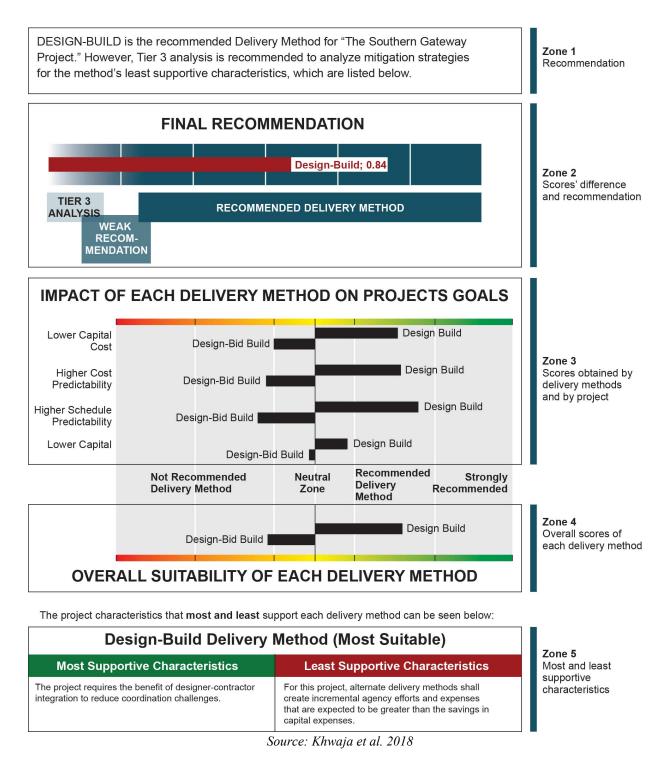


Figure 23. Recommendation and supporting information.

Vermont Agency of Transportation

Overview

The Vermont Agency of Transportation (VTrans) uses a decision matrix methodology to select ACMs – DBB, DB, and CM/GC. The approach starts with users answering four fundamental questions to determine whether to consider a method other than DBB (DB or CM/GC) as shown in Table 27.

Table 27. Initial binary questions to decide whether to consider ACMs.

Question	Description	Answer
1	Does the project have the appropriate scale to consider alternative delivery?	Yes or No
2	Will means and methods have a significant influence on cost and schedule?	Yes or No
3	Is procurement schedule a significant driver of the project?	Yes or No
4	Are there technical complexities on the job?	Yes or No

Decision Matrix

If users decide that ACMs should be considered, then VTrans uses a decision matrix that has two components: technical and process, for further assessment. Each factor has a weight (0-10) assigned and a score (1-3) for each method.

Selection of Method

Users then weight each factor and score each method against the factor where "3" represents most advantageous and "1" represents least advantageous. Once each factors are weighted and scored, a total score for each method is found, which supports determination of the delivery method by VTrans. An example matrix is shown in Figure 24.

	Weight (0-10)	Item	DBB	DB	CMGC
	10	Overall Project Schedule	1	3	1
	10	Overall Construction Cost	3	3	1
	10	Permitting Risk	3	1	3
	10	Design Innovation Potential	1	3	2
<u>₹</u>	10	Means and Methods (Construction)	1	3	2
	10	Design Control	3	1	3
TECHNICAL	Weight (0-5)	Item	DBB	DB	CMGC
<u> </u>	5	Early Construction Work Potential	1	3	2
	5	ROW Risk	3	1	3
	5	Railroad Risk	1	2	3
	5	Utility Risk	1	2	3
	5	Geotechnical Risk	2	1	3
	5	Traffic Management Mobility Impacts	2	1	3
	Weight (0-10)	Item	DBB	DB	CMGC
	10	Timing for Obligation of Construction	1	3	1
S		Funds			
S Ш	Weight (0-5)	Item	DBB	DB	CMGC
PROCESS	5	VTrans Alternative Contracting Staff	3	2	1
		Availability			
	5	Public Involvement/Outreach	2	2	3
	5	Contractor Qualifications	1	2	3
	Total		210	250	250

Source: VTrans

Figure 24. Example decision matrix for ACM selection.

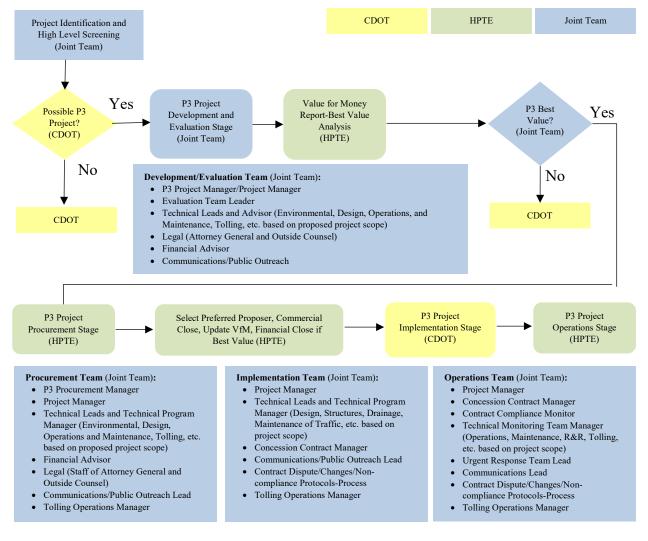
P3 Methodologies – United States

Colorado: High-Performance Transportation Enterprise

Overview

Colorado: High-Performance Transportation Enterprise (HPTE) is a government-owned business that is a separate division within the Colorado Department of Transportation (CDOT). HPTE was specifically charged by legislation (Colorado's FASTER Act) to seek opportunities for P3s to complete surface transportation projects through any available means of financing that allow efficient completion of projects.

CDOT's *P3 Management Manual* (2017 Update) provides guidance for this purpose. The manual covers a number of subjects related to P3s, and Figure 25 depicts its overall process for P3 consideration and implementation.



Source: CDOT 2017

Figure 25. Overview of HPTE's P3 process.

Project Identification and Screening

HPTE considers projects in the Statewide Transportation Plan, Regional Transportation Plans, and the Statewide Transportation Improvement Program, as well as others in CDOT's planning process. Candidates are first screened against high-level criteria:

- Size of project.
- Challenging project funding.
- Project complexity or uniqueness.
- Project is broken up into multiple projects (rationale for break up).
- Environmental review process is underway or cleared.
- Project risks.

Those considered as possible P3 projects are then subject to a prioritization process that assesses project readiness, relative benefits to the traveling public, and funding status.

Project Development and Evaluation

Possible P3 projects then move into a development and evaluation stage. A key step in this stage is the initial Value for Money (VfM) analysis. This analysis includes:

- Creating a Public Comparator that models the project based on a traditional delivery approach.
- Developing a P3 delivery that models the project based on a P3 delivery approach(es) as defined by HPTE's P3 Project Team.
- Comparison of the Public Comparator with the P3 delivery approach(es) to determine which provides best value.

This initial VfM is updated prior to selecting the preferred proposer and prior to financial close.

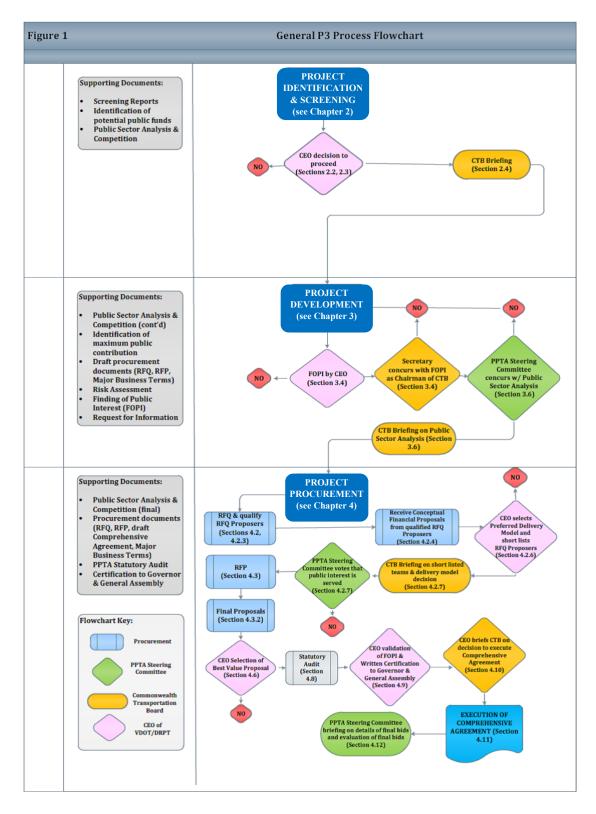
Virginia DOT

Overview

The Virginia Department of Transportation (VDOT) Office of Public Private Partnerships is authorized to pursue public and private collaborations to develop and operate qualifying transportation facilities under the Public-Private Transportation Act of 1995 as amended (PPTA). VDOT's *PPTA Implementation Manual and Guidelines for the Public-Private Transportation Act of 1995* (2017 update) explains the P3 process in the State, which is depicted in Figure 26.

Project Identification and Screening

Projects considered for P3 delivery will go through a qualitative and quantitative screening process. The qualitative screening criteria, shown in Figure 27, determine the desirability and suitability of the project. The quantitative criteria, shown in Figure 28, determine the feasibility of the project. Notably, the quantitative process described in the 2017 update is a departure from the prior process followed in Virginia.



Source: VDOT 2017

Figure 26. VDOT's P3 process.

		Screening Criteria – Desirability and Suitability of the Project
I	Public Need	 Is the project part of the Statewide Transportation Plan, regional, and other local plans/programs? Is the project in Smart Scale?
		Is the project consistent with the overall transportation objectives of VDOT/DRPT?
		 Does the project address the needs outlined in the above plans including safety and security, system maintenance and preservation, mobility, connectivity and accessibility, environmental stewardship, economic vitality, coordination of transportation and land use, and program delivery? Does the project address other needs?
II	Public Benefits	 Does the project address other needs? Are there anticipated transportation benefits to the community, the region and/or the Commonwealth?
		Are there potential project benefits to the Affected Localities and their transportation system?
		Are there anticipated enhancements to the adjacent or existing transportation facilities?
III	Economic Development	 Are there anticipated enhancements to planned transportation facilities? Will the project enhance the Commonwealth's economic development
""	Economic Development	efforts?
		 Is the project helpful to attracting or maintaining competitive industries and businesses to the region, consistent with stated objectives?
IV	Market Demand for PPTA Delivery	If private sector feedback has been solicited, what is the level of interest that has been expressed?
	(Should this be deleted?)	(This measure applies to Solicited Projects only. The submission of an Unsolicited Proposal demonstrates market demand.)
V	Stakeholder Support	 What is the extent of public support or opposition for/to the project? What strategies are proposed during project development to involve Affected Localities and the general public? Affected public entities and concerned local, State, and/or federal officials?
		 Does the project have a transit component? Has there been coordination between VDOT and DRPT?
VI	Project Efficiencies (from a P3 project delivery process)	 Is the project sufficiently complex (in terms of technical and/or financial requirements) to effectively leverage private sector innovation and expertise?
		If the required public funding is not currently available, could using a P3 project delivery process accelerate project delivery?
		Would delivering the project under the P3 delivery process free up funding to apply to other transportation priorities within the Commonwealth?
VII	Legal Considerations	 Does the PPTA provide statutory basis for the development procurement and operation of the project? Is the project consistent with applicable State and federal statutes?
VIII	Legislative Considerations	 Is the project consistent with applicable State and rederal statutes? Is new legislation needed to complete the project? Will the project require General Assembly approval for tolls, user fees, or public funds? Are any other actions required from the General Assembly to complete the
		project?

Source: VDOT 2017

Figure 27. VDOT's qualitative screening criteria.

	Qua	alitative Project Screening Criteria – Feasibility of the Project
ı	Technical Feasil	
1	Project Approach	Is there sufficient information to determine the following information? a) Scope of the project b) Location of the project c) All proposed interconnections with other transportation facilities
		d) Affected Localities e) Alternatives for further evaluation
2	Proposed Project Schedule	 Does the project have any key constraints or assumptions? Is the proposed schedule for project completion clearly outlined and feasible?
3	Operation	Does the project include a plan to operate the facility?
4	Maintenance	Does the project include a plan to maintain this facility?
5	Life Cycle Management	 Does the project include a life cycle management plan? This may include a proposed term of concession for operation and maintenance, long-term performance management, inventory, and hand back.
6	Technology	Is the project based on proven technology?
7	Design Standards	Does the conceptual design appear to be consistent with the appropriate state and federal standards?
8	Environmental Standards	Is the proposed project consistent with applicable state and federal statutes and regulations? Consistent Consis
9	Federal, State, and Local Permits and Approvals	 Will the project require some level of federal involvement or oversight? Have the required permits and regulatory approvals been identified? Is there a reasonable plan and schedule for obtaining them?
10	Rights of Way	Does the project set forth the method by which all property interests required for the transportation facility will be secured and by whom?
11	Utilities	Does the project set forth the methods by which utility relocations will be identified and managed?
12	Land Use Impacts	Is the project compatible with local land use and comprehensive plans?
13	System Interface	Does the project provide continuity with existing and planned state and local facilities?
1	Financial Feasib	
'	Funding sources	 Is the preliminary financial plan feasible in that the sources of funding and financing can reasonably be expected to be obtained?
		 What is the level of private financial equity/debt within the preliminary financial plan? Are there public funds required and, if so, are the Commonwealth's financial responsibilities clearly stated?
		 Does the project have the revenue generation potential to partially or completely offset the public funding requirement?
2	Federal funding requirements	Is the project consistent with federal transportation agency programs or grants?
Ш		nalysis and Competition
	Code § 33.2- 3.1.1(B)	 What is the Public Sector Option? What is the maximum amount of public contribution? How can the risks of user-fee financing be mitigated? This information is based on assumptions on competing facilities, projected compensation for high usage of the facility by high-occupancy vehicles (HOV), or other considerations. Will VDOT/DRPT maintain/operate the facility itself, or will these responsibilities be transferred to the private sector?
		 Will public contributions be required to cover costs not covered by financing obtained for the project? Will funds to support non-user fee generating components of the project contribute to increased person throughput, reduction in congestion, improved safety and other expected benefits?
Ш	Risk Assessmer	nt
1	Risk Identification	Are there any particular risks unique to the project that have not been outlined above that could impair project viability?
2	Risk Allocation	 Would the P3 delivery process help transfer project risks and potential future responsibilities to the private sector on a long-term basis?
		Are there any project risks proposed to be transferred to VDOT/DRPT that are likely to be unacceptable?
		Would the P3 delivery process promote efficiencies through the most appropriate transfer of risk over the project lifecycle?

Source: VDOT 2017

Figure 28. VDOT's quantitative screening criteria.

P3 Methodologies – International

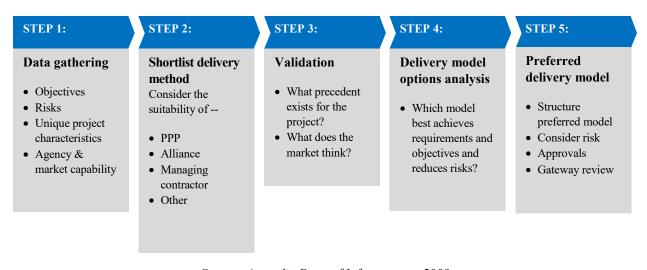
Australia

Overview

P3s in Australia are implemented at the State level but within an overall national policy framework. This framework includes multiple documents that describe the policy and provide guidelines for P3 implementation that include:

- National P3 Policy Framework
- National P3 Guidelines
- National P3 Detailed Guidance Material
 - Volume 1: Procurement Options Analysis
 - o Volume 2: Practitioners' Guide
 - Volume 3: Commercial Principles for Social Infrastructure
 - O Volume 4: Public Sector Comparator Guidance
 - o Volume 5: Discount Rate Methodology Guidance
 - Volume 6: Jurisdictional Requirements

P3s are considered among other delivery options (ACMs) in the Procurement Options Analysis guidelines. Figure 29 provides an overview of the process.



Source: Australia Dept. of Infrastructure 2008

Figure 29. Steps in procurement options analysis.

In Step 2, decision-makers consider the suitability of alternative delivery methods by considering various criteria and drivers of value relative to the delivery options as shown in Figure 30 to shortlist suitable methods. The guidelines do not prescribe any approach for Step 4 – Delivery Model Options Analysis, although they do discuss aspects for decision-makers to consider.

Interestingly, the guide advises the following when using a decision support tool:

- Avoid formulae or methodologies that conceal their logic or fail to demonstrate the reasoning involved.
- Ensure sufficient intellectual expertise is available to analyze options from first principles.
- Ensure that the tool is appropriate—there is no decision support tool that fits all projects.
- Do not rely on the assessment of a single tool." (Au Dept. of Inf. (2008). *Volume I Procurement Options Analysis*).

Once procurement options analysis is complete, if P3 is considered the most appropriate option, then VfM analysis is done to provide government agencies with a quantitative measure of the value for money it can expect from a P3 compared to public sector delivery.

Partnerships Victoria

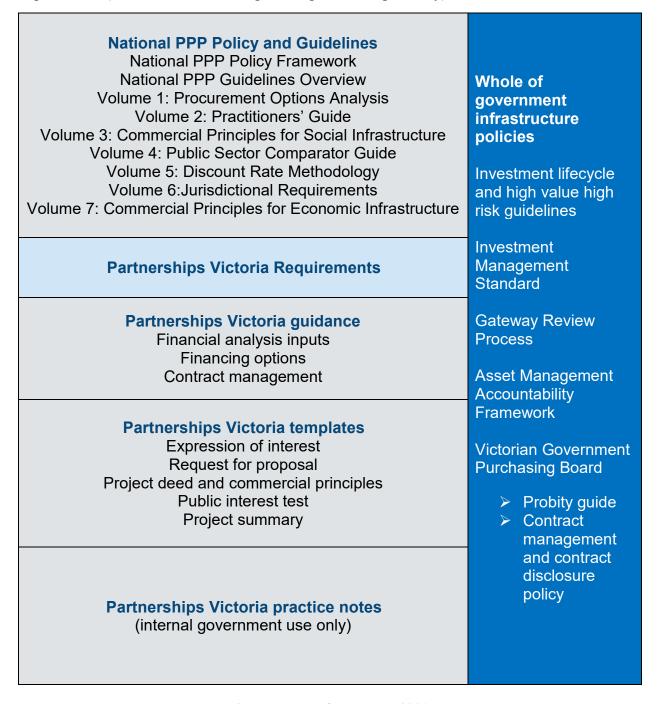
As mentioned, Australian States implement P3s in accordance with national policy guidelines. In Victoria, Partnerships Victoria establishes policy and guidelines to supplement national requirements. Figure 31 provides an overview of how Victoria's expectations, requirements, and guidance supplement national policy and guidelines. Projects must conform with Victoria's "whole of government infrastructure policies" as well as national and State P3 policy and guidelines.

ACM	When to use (e.g. suitability criteria)	Value for money drivers
PPP	 Complex and long-term infrastructure projects Outputs can be clearly defined and measured Scope for innovation Whole-of-life asset management is achievable and cost-effective Strong market interest Opportunities for appropriate risk transfer Opportunity for bundling contracts Significant service component Complementary commercial development 	 Sufficient scale and long-term nature Complex risk profile and opportunity for risk transfer Whole-of-life approach from integration of design, construction, operation, and maintenance over the life of an asset, in a single project package Innovation Appropriate third-party use of facilities, reducing net cost to government Efficiency of contract management
Alliance	 Complex and high-risk infrastructure projects The Solution is unclear or there is a significant likelihood of scope changes A high level of innovation is required Risks are unpredictable and best managed collectively, with costs of transferring risk prohibitive The owner can be closely involved and add value 	Cost of adversarial conduct, claims and disputes is eliminated (e.g. the "no blame" culture) Culture promotes innovation Integrated planning, design and construction process with early contractor and consultant involvement
Construct Only	The scope is defined and there is little likelihood of scope creep or wholesale changes to requirements Little incentive or need for innovation from the contractor It is desirable and there is sufficient time to complete design documentation before tendering Limited opportunity for bundling services/maintenance and creating whole-of-life efficiencies	Larger pool of potential ternerers which leads to increased competition Greater scope for competitive prices because of design certainty Contract value is set before construction starts
Design & Construct	The government's requirements are tightly specified before tender or do not change Government is best-placed to managed most project risks Limited opportunity for bundling services/maintenance and creating whole-of-life efficiencies	Single point of accountability for design and construction Fixed price contract Potentially, reduced overall project cost because the contractor has the opportunity to contribute construction experience into the design, resulting in innovation and efficiencies
Managing Contractor	Complex or high-risk projects with uncertain scope, risks or technology A degree of expert government input is available Early contractor involvement is beneficial	 Flexibility in delivery to manage uncertain risks Maximizing government input to manage risks where appropriate Managing contractor is incentivized to achieve cost and schedule targets

Source: Australia Dept. of Infrastructure 2008

Figure 30. Partnerships Victoria's suitability criteria for ACMs.

P3 delivery is required to be evaluated as an option against value-for-money drivers during planning of any capital expenditure over \$50 million, which can be triggered by bundling projects together. In effect, this means that a potential project must follow the national Procurement Options Analysis guidelines as well as Victoria's Investment Lifecycle and High Value Risk guidelines. As a project proceeds, it must follow both P3 and whole of life requirements (elements on left and right in Figure 31, respectively).



Source: Partnerships Victoria 2016

Figure 31. Overview of national and State (Victoria) requirements and guidelines.

Appendix B. Literature, Report, and Website Review Information and Summaries

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Table 28. Summary of Category 2 literature and reports.

Cc	Author	Year	Title	Summary
1	Tran et al.	2018	Staffing for Alternative Contracting Methods	This synthesis documents current practices in DOT staffing and organizational structure for ACMs. Information for this study was gathered through a literature review, a survey of State DOTs, a content analysis of manuals, guidelines, and templates at 21 agencies that have mature ACM programs, and structured interviews with eight selected DOTs.
2	Tran et al.	2018	Performance of Highway Design- Bid-Build and Design-Build Projects by Work Types	The study employed both parametric and nonparametric statistical tests to compare cost growth, schedule growth, and construction intensity metrics across the five project work types: new construction; reconstruction; resurfacing, restoration, rehabilitation (3R) projects; intelligent transportation systems (ITS)-related projects; and miscellaneous construction for 139 pairs of DBB and DB highway projects built by the Florida DOT.
3	Alleman et al	2017	Comparison of Qualifications- Based Selection and Best-Value Procurement for	Compares QBS and best-value procurement method for CM/GC project delivery method. For this study, 13 best-value and 16 QBS projects were selected. It found a

Cc	Author	Year	Title	Summary
			Construction Manager–General Contractor Highway Construction	variety of reasons why agencies select best-value or QBS procurement for CM/GC projects. Data was gathered from projects, interviews and literature
4	Chini et al.	2017	Industry Attitudes toward Alternative Contracting for Highway Construction in Florida	In Florida, the alternative contracting methods have become popular replacements for traditional practices based on low-bid acquisition. The Florida DOT (FDOT) adopted Alternative Contracting Program in the administration of highway construction projects. FDOT sought to evaluate the effectiveness of these methods compared with the traditional DBB system. The research team assessed the effective administration of alternative contracting methods. This report provides the results of the surveys, interviews, method reviews, and recommendations.
5	Macek et al.	2017	Public Transportation Guidebook for Small-and Medium-Sized Public-Private Partnerships (P3s)	This guidebook aims to broaden the literature on small-and medium-sized P3s by profiling successful initiatives across the country, and documenting lessons learned and best practices for other agencies. The findings of this research have been applied to produce a checklist for P3 initiatives, an interactive tool for identifying, evaluating, and screening opportunities for small-and medium-sized P3 initiatives.
6	Hosseini et al	2017	Sustainable Delivery of Megaprojects in Iran: Integrated	This study develops an integrated model of the main contextual factors that affect sustainable delivery of megaprojects in Iran. The inputs to

Cc	Author	Year	Title	Summary
			Model of Contextual Factors	the model are based on a comprehensive literature review affecting the "triple bottom line" of sustainability, as measured in economic, environmental, and social costs. Innovation diffusion theory and extralogical laws of imitation inform the theoretical points of departure.
7	Stewart et al.	2017	Applying Risk Analysis, Value Engineering, and Other Innovative Solutions for Project Delivery	This study includes a comprehensive review of current practices gathered through available documentation as well as extensive interviews with practitioners. Experience in other industries was included in the analysis, drawing on a broad range of practices to identify, build, and apply innovative analytical techniques for effective project delivery. Supplementing the written guide is a set of seven training videos.
8	Tran et al.	2017	Strategic Program Delivery Methods	This is a study of holistic approaches to maximizing the benefits of time and cost savings when delivering transportation programs, rather than delivering individual projects. A broader approach to delivering transportation programs might include combining winning strategies, taking an all-inclusive approach to project delivery, implementing a project management culture, improving delivery processes, and enhancing communication across the organization. A considerable amount of published research has focused on the process of selecting an optimal project delivery method, but there is

Cc	Author	Year	Title	Summary
				a lack of research that documents how implementing a variety of delivery methods strategically for a program of projects can improve the delivery of the entire program.
9	Alleman et al.	2016	The Use and Performance of Alternative Contracting Methods on Small Highway Construction Projects	Large, high-profile DB and CM/GC projects give the impression that alternative project delivery methods are only applicable to larger, more complex projects. A sample of 291 U.S. highway projects completed between 2004 and 2015, more than half of which are under \$20 million in final cost and the subsequent study provide empirical evidence of how alternative project delivery methods relate to small project successes, specifically design-build successes.
10	CDOT	2016	Design-Build Manual	DB is an alternative contracting method where design and construction services are included in a single contract. Using the DB approach, CDOT provides conceptual and preliminary designs and required performance results. The DB delivery method then requires construction firms to team with consultant design firms to work together to design and construct the improvements.
11	Francom et al	2016	Performance Analysis of Construction Manager at Risk on Pipeline Engineering and Construction Projects	The paper describes traditional methods for delivering water and wastewater pipeline engineering and construction projects via DBB. This paper examines alternative project delivery methods (APDM) such as construction manager-at-risk (CMAR) that have been introduced

Cc	Author	Year	Title	Summary
				to increase stakeholder integration and ultimately enhance project performance. A comprehensive study of CMAR project performance is done to develop a baseline of commonly measured performance metrics and to compare statistically the cost and schedule performance of CMAR.
12	Guo et al	2016	Civil Integrated Management: An Emerging Paradigm for Civil Infrastructure Project Delivery and Management	The purpose of this paper is to further define this vision and concept and establish an initial framework for Civil Integrated Management (CIM) implementation. An extensive amount of information was collected through two weeks of on-site visits to seven transportation agencies in the United States on their current CIM-related practices. The results obtained by qualitative research methods are expected to serve as a foundation for further investigation on CIM-related practices and to provide a roadmap for CIM implementation
13	Mostaan and Ashuri	2016	Challenges and Enablers for Private Sector Involvement in Delivery of Highway Public— Private Partnerships in the United States	The paper explains about the challenges and limitations of private sector involvement in financing and delivery of highway P3s in the United States. The implementation of existing P3 project delivery frameworks by the public sector has neglected the private sector's interests and has resulted in lack of alignment among public and private sector stakeholder institutions across P3 project planning, procurement, and administration. A structured and consistent interview protocol was

Cc	Author	Year	Title	Summary
				utilized to conduct interviews and document the study results.
14	Park and Kwak	2016	Design-Bid-Build (DBB) vs. Design-Build (DB) in the U.S. public transportation projects: The choice and consequences	This paper guides the owner to select and use DB or DBB to deliver projects and considers implementation consequences in terms of cost and schedule. The analyses of comprehensive data on public transportation projects in Florida reveal some misfits between theories and the reality. The authors suggested that DB seems advantageous to schedule control, while cost advantages of one method over the other is still inconclusive.
15	Tran et al	2016	A Hybrid Cross- Impact Approach to Predicting Cost Variance of Project Delivery Decisions for Highways	This journal article presents a hybrid cross impact analysis (CIA) approach to select a project delivery method. CIA is a method to predict future events by defining variables and analyze interactions between them. Three PDM are considered in this study – DBB, DB and CM/GC. The approach includes determining risk variables for three PDM mentioned above. An initial probability for each variable is determined and a factor analysis is performed afterwards.
16	VDOT	2016	P3 Value for Money Guidelines NOTE: These guidelines have been superseded by 2017 update.	The P3 Value for Money Guidelines (VFM Guidelines), a companion document to the PPTA Implementation Manual and Guidelines, were developed to assist the Virginia Office of Public-Private Partnerships and Responsible Public Entities (rpes) with the preparation of a VFM comparison of potential project delivery options.

Cc	Author	Yea	r Title	Summary
17	Scott et al.	201	Review of WSDOT's Implementation of Design-Build Project Delivery	Provides a basic overview of DB, including the benefits and challenges of DB compared to DBB delivery. Examines WSDOT's current use of DB project delivery for a representative cross-section of DB projects. Compares WSDOT's DB program with transportation industry best practices to determine what WSDOT is doing well, how WSDOT has improved its program over time, and what gaps exist in WSDOT's DB program that could be improved.
18	Ashuri and Mostaan	201	State of Private Financing in Development of Highway Projects in the United States	Highlights U.S. DOT and State DOT initiatives to leverage the shrinking financial resources and fulfill DOT's growing funding shortfalls. This involves the private sector in financing highway projects varies from State to State in several aspects. State DOTs pursue a wide range of objectives, use different procurement methods for project financing, and use different approaches to evaluate financial qualifications and proposals.
19	DBIA	201	Choosing a Project Delivery Method – A Design-Build Done Right Primer	method is one of the most important decisions made by every owner

Cc	Author	Year	Title	Summary
				influences ownership and impact of changes and modification of project costs.
20	Lin et al	2015	Framework Methodology for Risk-Based Decision Making for Transportation Agencies	This study develops a framework for risk-based decision making for the design, operation, and maintenance of various types of transportation facilities and entities. This framework is grounded in current practice and risk management theories and operationalizes a decision-making framework that is applicable at multiple levels in an organization.
21	Gransberg et al.	2015	Alliance Contracting— Evolving Alternative Project Delivery	The objective of this study is to identify and synthesize current effective practices that related to the use of alliance contracts around the world and discuss the procurement procedures that have been used to successfully implement alliance contracting on typical transportation projects.
22	Gransberg et al.	2015	Indefinite Delivery/Indefinite Quantity Contracting	This synthesis examines practices related to the use of ID/IQ contracting by transportation agencies for highway design, construction, and maintenance contracts. ID/IQ allows for the delivery of services or products that are not known at the time the contract is executed.
23	Qiang et al.	2015	Factors governing construction project delivery selection	This paper identifies various factors affecting project delivery selection. Factors are determined from previous studies. Content analysis and t-test were performed to compare importance of factors. Three main groups were identified:

Cc	Author	Year	Title	Summary
				internal project conditions, external project conditions, and project performance objective factors.
24	Gransberg et al.	2015	Alternative Technical Concepts for Contract Delivery Methods	The purpose of this synthesis is to document various methods by which transportation agencies have successfully implemented ATCs in the highway contracting process. The report identifies methods that promote transparency, consistency, and fairness of the evaluation process, while at the same time protecting the industry's right to confidentiality.
25	El-Mashaleh and Edward	2014	Concessionaire Selection Model Based on Data Envelopment Analysis	The purpose of this paper is to propose a concessionaire selection model that is based on data envelopment analysis (DEA). The paper explains and challenges of about the build-operate-transfer (BOT) project delivery approach that is gaining popularity because it offers public employers the advantages of delivering vital infrastructure projects while minimizing the need to secure financing. The challenge the authors mention is poor concessionaire selection. The strengths of the proposed DEA model include its ability to incorporate dozens of subjective and objective criteria and to accommodate any number of considered concessionaires. The proposed DEA model was practically illustrated based on a case that includes six competing concessionaires.

Cc	Author	Year	Title	Summary
26	Gransberg	2014	Applying Alternative Technical Concepts to Construction Manager—General Contractor Project Delivery	This paper presents four case studies where ATC were applied in CM/GC project delivery method. The CM/GC projects included a slope stabilization project in Michigan, a bridge in Oregon, the urgent, in situ foundation stabilization of a dam in Kansas, and a commuter rail project in Utah. The paper explains major ATCs that were taken into effect in all the four projects and the savings due to that. The paper also explains the advantages of using ATCs on CM/GC method as compared to other project delivery methods: DBB and DB.
27	Minchin et al.	2014	Guide for Design Management on Design-Build and Construction Manager/General Contractor Projects	This purpose of the guide is to assist agency staff responsible for management oversight of facilities developed using CM/GC and DB and other such alternative procurement strategies. Specifically, it provides guidance to State DOTs and other transportation agencies for design management under CM/GC and DB project delivery. The guidance is supplemented by case studies of projects successfully developed by several DOTs.
28	Shrestha and Mani	2014	Impact of Design Cost on Project Performance of Design-Bid-Build Road Projects	In this paper, the author describes about the DBB method and its implication on road projects. Using the DBB method, the quality of design has an impact on the construction performance. This paper analyzes a sample of 47 Clark County, NV, public road projects and 17 road projects of the Texas DOT. The sample includes projects completed between 1991 and 2009,

Cc	Author	Year	Title	Summary
				and cost more than \$3.43 billion in construction value. The analysis showed a significant negative correlation between the design cost percentage and the total cost growth of the project.
29	Tran and Molenaar	2014	Impact of Risk on Design-Build Selection for Highway Design and Construction Projects	This paper examines 39 generic risk factors related to the DB delivery selection process. These risks were identified through previous research and risk analysis workshops on transportation projects worth more than \$10 billion. To explore how these risks impact DB delivery selection, a questionnaire was developed to collect data from a national cross section of professionals with an average of 25 years of experience related to risk and project delivery methods in the transportation industry.
30	Doloi	2013	Empirical Analysis of Traditional Contracting and Relationship Agreements for Procuring Partners in Construction Projects	Traditional contracting is a primary method of procuring partners in delivering major construction projects. The relative benefits of relational agreements and its link to successful project delivery remain elusive among the construction professionals. This research aims to investigate the underlying attributes and factors critical to the success of relationship agreements in relation to traditional practices. A pilot study, a questionnaire was used among 150 participants from 43 selected projects. Standard statistical methods, i.e., factor analysis and multivariate regression analysis, were implemented.

Cc	Author	Year	Title	Summary
31	Minchin et al.	2013	Comparison of Cost and Time Performance of Design-Build and Design-Bid-Build Delivery Systems in Florida	This paper compares DBB and DB project delivery methods by performing statistical analysis on data from Florida DOT. Levene's test, the independent samples t-test, the Welch unequal variances t-test, and the Mann-Whitney U test were used.
32	Gransberg et al.	2013	A Guidebook for Construction Manager/General Contractor (CM/GC) Contracting for Highway Projects	The guidebook focused on identifying, analyzing, and understanding current models for CM/GC delivery and developing guidelines for agency implementation of this method. Recommendations were supported by a survey of State DOTs, content analysis of CM/GC solicitation documents, and case studies of CM/GC projects in multiple jurisdictions.
33	Asmar et al.	2013	Quantifying Performance for the Integrated Project Delivery System as Compared to Established Delivery Systems	This study compares the performance of IPD projects to projects delivered using the more traditional DBB, DB, and CMR systems, and showing statistically significant improvements for IPD.
34	Chasey et al.	2012	Comparison of Public-Private Partnerships and Traditional Procurement Methods in North American Highway Construction	This paper compares the cost- and schedule-overrun results of 12 completed large P3 highway projects in North America with DBB or DB as delivery method. P3 project performance data were collected through interviews with project executives, and then findings were used from previous studies of traditional projects for comparative benchmarking data.

Cc	Author	Y	Year	Title	Summary
35	Gransberg et al.	2	2012	Guidelines for Managing Geotechnical Risks in Design– Build Projects	This research developed a set of geotechnical risk management guidelines for DB transportation projects. Geotechnical uncertainty is always high in DB projects where foundation conditions are unknown at the time the contract is awarded and where the design-builder is expected to conduct the subsurface investigations necessary to complete the design after establishing the project contract price. The guidelines are based primarily on the data gathered by a survey of State DOTs, a second survey of both DOT and industry respondents with experience in DB geotechnical risk mitigation experience, and 20 case study projects.
36	Shrestha et al.	2	2012	Performance Comparison of Large Design- Build and Design- Bid-Build Highway Projects	This paper compares performance of DBB and DB project delivery methods. The performance criteria include cost, schedule, and change orders on highway projects. The data are analyzed by using a single factor ANOVA test and t-test assuming unequal variances. A correlation between inputs and performance outputs has also been presented.
37	Tran and Molenaar	2	2012	Critical risk factors in project delivery method selection for highway projects	This conference paper identifies 39 critical risk factors that affect the project delivery selection process. These factors were identified through major highway projects. After that, a survey was done to identify the most critical factors with respect to each project delivery method: DBB, DB, and CM/GC.

Cc	Author	Year	Title	Summary
38	Little	2011	The Emerging Role of Public- Private Partnerships in Megaproject Delivery	This article examines some of the reasons why megaprojects have become synonymous with poor cost and schedule performance and suggests that innovative project delivery methods, broadly termed PPP or P3, have the potential to improve project performance by better integration of the project delivery organization in the allocation and management of risk.
39	NCDOT	2011	Design-Build Policy & Procedures	This document establishes the DOT's process for selecting, procuring, and administering contracts that include preconstruction activities, including design and construction services of transportation facilities within one contract. The purpose of the DB process is to provide an alternative method of delivery for transportation projects, through which contractors and designers collaborate in design and other preconstruction activities to expedite construction, enhance innovation and constructability, and/or reduce costs.
40	VDOT	2011	Detail-Level Project Screening Report NOTE: Superseded by VDOT 2017 Implementation Guidelines	This report and recommendation is part of the screening process used by the VDOT Office of Public-Private Partnerships to assess the suitability and desirability of delivering a project under the Public-Private Transportation Act (PPTA) of 1995, as amended.
41	Gransberg and Shane	2010	Construction Manager-at-Risk	The synthesis identifies three different models for CMR project

Cc	Author	Year	Title	Summary
			Project Delivery for Highway Programs	delivery in use and effective practices and lessons learned that have been gleaned from the experiences of seven highway case studies and case studies from the airport, rail, transit, and building industries. Survey responses were received from 47 State DOTs regarding CMR experience. A formal content analysis of CMR solicitation documents from 25 transportation projects and 29 non-transportation projects from 17 States was also conducted. Finally, structured interviews were conducted with both agency and contractor personnel from the case study projects.
42	Ghavamifar	2009	A Decision Support System for Project Delivery Method Selection in the Transit Industry	This dissertation provides a decision support system (DSS) for selection of a project delivery method. It includes comparison of DBB, DB, CMR, and P3. The DSS developed in this dissertation is multi-objective and knowledge-driven.
43	Hale et al	2009	Empirical Comparison of Design/Build and Design/Bid/Build Project Delivery Methods	This paper compares DBB and DB project delivery methods. Project duration, project duration per bed, project time growth, cost growth and cost per bed were statistically compared. Two military building projects were chosen for the data.

Cc	Author	Y	Zear	Title	Summary
44	Migliaccio et al.	20	009	Procurement of Design-Build Services: Two- Phase Selection for Highway Projects	This paper uses a case study approach to investigate the use of a two-phase process for selecting providers of highway DB services. Using two DB projects in central Texas as case studies, the writers analyzed project documentation and performed interviews with 37 project participants involved in procurement, including owner representatives and legal consultants. SH-130 tolled expressway and SH-45 SE tolled expressway were used as cases for this research. A process was developed that included activities to be performed between the delivery method decision and the contract execution.
45	Gransberg and Riemer	20	009	Performance- Based Construction Contractor Prequalification	The objective of this synthesis is to identify and synthesize current contractor performance-based prequalification practices based on construction quality, timely performance, safety record and other criteria.
46	Sillars	20	009	Development of Decision Model for Selection of Appropriate Timely Delivery Techniques for Highway Projects	This paper focuses on selection on project delivery techniques with timely delivery as the main purpose. Multi-criteria decision analysis has been used in this paper along with expert opinion. The project delivery methods considered were DBB, DB, CM/GC, and BOT. Procurement methods considered were low price, A+B, A+Q and qualifications only.
47	Sillars and O'Connor	20	009	Risk-Informed Transit Project Oversight	This paper presents an evolutionary process of integrating risk management into the Federal Transit Administration's new-start transit

Cc	Author	Year	Title	Summary
				project program. The paper presents research on a more holistic method for risk assessment and a better integration of risk management into standard project management practices.
48	Gransberg et al.	2008	Quality Assurance in Design-Build Projects	This report examines how State DOTs have successfully approached quality assurance for DB, including in procurement, design, construction, and post-construction operations and maintenance.
49	Rojas and Kell	2008	Comparative Analysis of Project Delivery Systems Cost Performance in Pacific Northwest Public Schools	This paper empirically compares cost growth performance of the CMR and DBB methods in Pacific Northwest public school projects.
50	Molenaar and Yakowenko	2007	Alternative Project Delivery, Procurement, and Contracting Methods for Highways	This publication provides a comprehensive and objective presentation of the use of alternative delivery, procurement, and contracting methods in the U.S. highway system.
51	Shreshta et al.	2007	Benchmarking of Large Design— Build Highway Projects	This paper compares DBB and DB project delivery methods through benchmarking to assess performance of large highway projects. Input factors that affect the project performance were identified and an input versus output analysis was done considering cost and schedule as the output. Four DB projects and 11 DBB projects were compared.
52	Kuprenas and Nasr	2007	Cost Performance Comparison of	The study compares costs for all phases (design, bid, and award;

Cc	Author	Year	Title	Summary
53	Abdel Aziz	2007	Two Public Sector Project Procurement Techniques Successful	construction; and total project cost) for DBB and in-house construction. The article examines two
	Abdel Aziz	2007	Delivery of Public-Private Partnerships for Infrastructure Development	approaches: a finance-based approach that aims to use private financing to satisfy infrastructure needs and a service-based approach that aims to optimize the time and cost efficiencies in service delivery. The implementation of PPPs, however, may suffer from legal, political, and cultural impediments. As per the article, the Federal Government enabled a number of acts to ease the impediments and promote PPPs for infrastructure development. Based on a detailed analysis of PPPs in the United Kingdom and British Columbia, Canada, this paper describes principles that would characterize the implementation of PPPs at the program level, i.e., whether the implementation is successful. The principles pertain to the: availability of a PPP legal framework and implementation units; perception of the private finance objectives, risk allocation consequences, and value-for-money objectives; maintenance of PPPs process transparency; standardization of procedures; and use of performance specifications. Guidelines for successful implementation are explained and discussed in the context of the U.S. PPP experience and impediments.

Cc	Author	Year	Title	Summary
54	Wardani et al.	2006	Comparing Procurement Methods for Design-Build Projects	This paper compares different procurement methods for DB project delivery. The procurement methods compared are sole source, qualifications-based, best-value, and low-bid selection. Data was collected through surveys from 76 DB projects in the United States. Data analysis indicates several important trends associated with different performance metrics and guidelines are provided for the owners to assist them in selecting the procurement method.
55	Mahdi and Alreshaid	2005	Decision support system for selecting the proper project delivery method using analytical hierarchy process (AHP)	This paper compares DBB, DB, and CM project delivery methods' costs. In this study, a multi-criterion decision-making methodology using the analytical hierarchy process is provided to help owners in selecting a project delivery method. An example of a real project is also provided.
56	Gransberg et al	2004	Analysis of Owner's Design and Construction Quality Management Approaches in Design/Build Projects	This paper explores and classifies current approaches to evaluating quality in DB proposals. This paper used a thorough content analysis of 78 RFPs for public DB projects with an aggregate contract value of over \$3 billion advertised between 1997 and 2002. It identifies the six owner approaches to articulating DB quality requirements in their RFPs. The six approaches are quality by qualifications, evaluated program, specified program, performance criteria, specification, and warranty.
57	Koppinen and Lahdenperä	2004	The Current and Future	This article describes ways to procure roads based on project size,

Cc	Author	Year	Title	Summary
			Performance of Road Project Delivery Methods	complexity, risks, timing, external factors, environmental issues, etc. To assist in the strategic selection of the most efficient project delivery methods, this research determined the performance of the following methods: DBB, Construction Management, DB, and Design-Build-Maintain (covering variations like DBOM, DBFO, Build Own Operate Transfer [BOOT], etc.). The advantages and disadvantages of different delivery methods are also discussed.
58	Zhang	2004	Improving Concessionaire Selection Protocols in Public/Private Partnered Infrastructure Projects	This paper presents a protocol for concessionaire selection that incorporates public procurement principles, a best-value selection approach, a competitive process, a multi-criteria prequalification, and tender evaluation methodology for a BOT project. Results have been presented through a survey of the factors identified.
59	Gransberg et al	2003	Project delivery comparison using performance metrics	This paper compares the performance of 88 building projects with 54 DBB and 34 DB project delivery projects. The performance metrics include time and cost.
60	Zayed, and Chang	2002	Prototype Model for Build-Operate- Transfer Risk Assessment	The importance of the BOT approach for project delivery was highlighted in this article. Compared with conventional project delivery methods, BOT sponsors expose themselves to a high risk, so that special attention must be paid to analyzing and managing risks. The BOT risk model presented is a

Cc	Author	Year	Title	Summary
				prototype evaluation model that introduced the BOT risk index.
61	Thomas et al.	2002	Measuring the Impacts of the Delivery System on Project Performance Design-Build and Design-Bid-Build	The aim of this study is to relate the impacts of the project delivery system to project outcomes and provide the construction industry a means by which to measure and evaluate the economic value of DB and DBB project delivery systems.
62	Molenaar and Gransberg	2001	Design-Builder Selection for Small Highway Projects.	This paper includes six case studies comparing the selection of a design builder across six highway projects in the U.S. The procurement methods include fixed price, one step, and two step. This paper offers guidance for State transportation authorities and highway engineers regarding the selection process.
63	Gransberg and Senadheera	1999	Design-Build Contract Award Methods for Transportation Projects.	This paper provides results of a survey conducted with 15 State DOTs to analyze the procurement methods used for DB project delivery method. Three main procurement methods were identified: low bid, adjusted score, and best value. These three methods are then compared, and their respective strengths and weaknesses have been provided.
64	Molenaar et al	1999	Public-sector design/build evolution and performance	Describes evolution and current trends in public sector DB and provides a foundation for developing uniform guidelines and practices. This paper defines the rapid evolution of public-sector DB and analyzes results from 104 completed projects, including owner experience, level of design completion, design/builder selection,

Cc	Author	Year	Title	Summary
				contract type, method of award, and process variations. The results provide insights/benchmarks for owners, designers, and builders into the changing public-sector procurement system.
65	Konchar and Sanvido	1998	Comparison of U.S. Project Delivery Systems	This paper compares performance (cost, schedule, and quality) of three project delivery systems: DBB, DB, and CMR. The results are presented for univariate comparisons and development of multivariate linear regression model on the data collected from 351 U.S. building projects.
66	Molenaar, K. and Songer	1998	Model for Public Sector Design- Build Project Selection	This paper presents analysis of 122 case studies and presents model for DB project selection. This study involves prediction modeling of performance criteria including include budget variance, schedule variance, conformance to expectations, administrative burden, and overall user satisfaction.
67	Retherford	1998	Project Delivery and the U.S. Department of State	The article emphasizes traditional versus nontraditional construction delivery methods in the United States. The paper describes guidelines for DB project delivery methods and ways to execute the projects in overseas environments, particularly U.S. embassies.
68	Hatush and Skitmore	1997	Criteria for contractor selection	This paper attempts to identify universal criteria for prequalification and bid evaluation, and the means by which different objectives can be accommodated to suit the requirements of clients and projects.

Cc	Author	Year	Title	Summary
69	Songer and Molenaar	1996	Selecting design- build: Public and Private Sector Owner Attitudes	Modern owners of constructed facilities are increasingly investigating a variety of alternative procurement methods. A fundamental understanding of owner attitudes about project delivery strategies required. This paper discusses results of research conducted to address owners' attitudes toward one specific alternative contracting method: DB. Several Primary DB selection factors identified and analyzed in the paper. Additionally, a comparison of private and public owner DB attitudes is documented.
70	Gordon	1994	Choosing Contracting Methods	The compatibility of several construction contracting methods with certain types of owners and projects is examined. Assessment of alternative contracting methods consists of scope, organization, contract, and award. There are six main organizations around which the contracting variations are created: general contractor, construction manager, multiple primes, DB, turnkey, and BOT. Choosing certain methods can decrease the project duration, provide flexibility for changes, reduce adversarial relationships, allow for contractor participation in design, provide cost savings incentives to the contractor, and provide alternative financing methods.

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Table 29. Keywords used for general website search.

Keywords representing nature of the tool	Keywords representing comparison or choice	Keywords representing Project Delivery Methods/ Procurements/ Payments/ Contracts	Keywords representing Sectors/Clients/ Stakeholders	Supplementary Keywords (can be used for a specific search)
Framework	Selection/ Select	Project Delivery	Infrastructure	Risk Analysis/Risk Transfer/Risk Allocation/ Risk Transfer/ Revenue Risk
Guidelines/ Guide/ Guidebook	Choice/ Choose	Project Delivery Methods	Highway/Highways	Bidding
Tool/ Support Tool	Comparison/ Compare	Contracting Methods/ Contracting Strategy	Roads/ Roadways/ Roadway Project	Benefit Cost Analysis/ Value Analysis/ Life-Cycle Cost Analysis/ Whole Life Costing/ BCA/ VA/ LCCA
Guidance	Determine	Delivery Methods	Federal Highways	Special Purpose Vehicle/ SPV
Factors	Decision/ Decide	Design Build/DB	Department of Transportation/DOT/DOTs	Grant/ Grants
Concept/ Concepts	Superior	Design Bid Build / Design-Bid-Build/DBB	State DOT/State DOTs	Payment Provision
Matrix	Better/Best	Construction Manager at risk/ CM at risk/ CMR/ CMAR/ CM@R	Owner/Owners/Client/Clients	Two Step Procurement
Practices	Preferred	Design Build Finance Operate Maintain / DBFOM	Federal Agency/Highway Agency/ State Transportation Agency/ STA/ STAs	Early Contractor Involvement/ ECI
White Paper	Alternative/ Alternate/ Options	Construction Manager/General Contractor (CM/GC)	Transportation	Hand Back Criteria

Keywords representing nature of the tool	Keywords representing comparison or choice	Keywords representing Project Delivery Methods/ Procurements/ Payments/ Contracts	Keywords representing Sectors/Clients/ Stakeholders	Supplementary Keywords (can be used for a specific search)
Toolkit	Innovative	Design Build Maintain/ DBM	Toll Roads	Public Sector Comparator
Specification	Evaluation	Design Build Operate Maintain/ DBOM	Roadway Construction Sector	Invitation for Bids/ IFB
Approach/ Approaches	Performance	Design Build Finance/ DBF		
Model/ Models	Quantitative	Design Build Finance Maintain/ DBFM		
Worksheet	Baseline	Public Private Partnership/ Public Private Partnerships/ P3/ P3s		
List	Conventional	Private Finance Initiative/ PFI		
	Traditional	Best Value Contracting		
	Integrated	Concession/ Concessions/ Concessionaire		
	Progressive	Project Development Agreement/ PDA		
	Qualification	Multi Prime Contracting		
	Holistic	Design Sequencing		
	Optimization/	Procurement/		

Keywords representing nature of the tool	Keywords representing comparison or choice	Keywords representing Project Delivery Methods/ Procurements/ Payments/ Contracts	Keywords representing Sectors/Clients/ Stakeholders	Supplementary Keywords (can be used for a specific search)
	Optimizing	Procurement Methods/ Procurement Procedures		
	Different	Low Bid Procurement		
	Appropriate	Best Value Procurement		
	Standard	Qualifications Based Procurement		
		Cost plus time Procurement		
		Sole Source Procurement		
		Job Order Contracting		
		Alternative Technical Concepts/ ATC		
		Additive Alternates		
		Alternate Design Procurement		
		Unit Price Payment		
		Lump Sum Payment		
		Cost Reimbursable Payment		
		Guaranteed Maximum		

Keywords representing nature of the tool	Keywords representing comparison or choice	Keywords representing Project Delivery Methods/ Procurements/ Payments/ Contracts	Keywords representing Sectors/Clients/ Stakeholders	Supplementary Keywords (can be used for a specific search)
		Price (GMP)		
		Contract Force Account		

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Appendix C. Project Delivery Method Comparison

Table 30. Comparison of five project delivery methods.

	Design-Bid-Build	Construction Manager/ General Contractor	Design-Build	Public-Private Partnerships	Alliance Contracting/ Integrated Project Delivery (IPD)
Essential Elements	 Traditional delivery system. Owner contracts separately for design and construction services. Bid based on complete (100%) plans and specifications. Owner retains high level of control and risk. Typically a unit priced contract, but could be a lump sum contract when there is little potential for changed conditions. ID/IQ, also called job order or task order contracting, a variant of the traditional DBB, provides for an indefinite quantity of supplies or services on an as-needed basis during a window of time based on agreed upon unit prices. The 	■ Owner engages a construction manager (CM) to act as a construction advisor during the preconstruction phase and as the general contractor (GC) during construction. The terms CM-at-Risk (CMR) and CM/GC have been used interchangeably by the industry, but the term CM/GC may be a better characterization for transportation projects where the CM may be selected based on a "best-value" process, and the GC typically selfperforms a greater proportion of the work. ■ Typically entails a preconstruction phase including design development (by designer) and constructability reviews, estimating, and scheduling services by the	 Combines design and construction under a single contract between the owner and a design-builder covering both the design and construction of a project. Design-builder can be an integrated services firm, a joint venture of the design and construction firms but in the highway sector is most likely a contractor led team. Also encompasses variants including: design-buildwarranty/maintain, design-buildoperate design-buildfinance progressive design-build Progressive design-build is a process whereby the owner then "progresses" 	 A developer takes part in financing project in return for ability to collect future revenues (e.g., tolls or availability payments), or pursue development rights. Developer responsible for integrated delivery – design, construction, and O&M for a specified duration. A P3 can occur as a result of solicited proposals or as a result of unsolicited proposals. A two-step or multi-step 	 An owner and one or more service providers (constructors, consultants, designers, suppliers, or a combination thereof) collaborate on the delivery of a project. Multi-party IPD agreement. Open book contract with target price. Shared Financial incentives/disincentives "Pain Share-Gain Share" encourage superior project performance and cooperation among the alliance partners. Fees tied to the final project outcome.

	Design-Bid-Build	Construction Manager/ General Contractor	Design-Build	Public-Private Partnerships	Alliance Contracting/ Integrated Project Delivery (IPD)
	work typically involves clearly defined, standardized, or repetitive work items.	CM followed by discussions to develop a mutually agreeable GMP. Transfer cost and schedule risk to CM. The GMP for CM/GC can be administered as a cost- reimbursable contract but for transportation projects is more often administered as a lump sum contract. Contingency and in some cases unit cost items can be added to address risk.	towards a design and contract price with the project team and issues early work packages to accelerate construction. Transfers design, cost, and schedule risk to design-builder. Typically, a lump sum contract but can be administered as costreimbursable with unit prices to a guaranteed maximum price or target price with shared contingency.	proposal process involving an RFI, a request for qualifications or a conceptual proposal followed by a detailed technical proposal followed by negotiation process to determine the terms of the partnership or the comprehensive development agreement.	
Applicability	 Projects where the owner needs to completely define the scope. Project scope can be best-defined using prescriptive specifications. Significant risks or third-party issues (ROW, utility, environmental) that can be best resolved or managed by the agency. 	 Projects where the owner wants to control the scope and design during the project development process, but also wants benefit of builder input during design. Projects with utility coordination issues, right-of-way requirements, third party risks or public involvement/controversy that the CM can assist with resolving. 	 Projects where the owner is able to define a scope of work but wants to provide an opportunity for innovation. Medium-to-large projects that are more complex in nature and that can derive benefit from innovation in design or construction. Projects having a high sense of urgency (due to natural disaster, 	 Projects where the owner desires to develop and refine the scope with the assistance of a developer. Available funding is not sufficient to complete the project. Tolls or investment 	 Projects where the owner desires to collaborate with industry partners to define the scope and share the risks. Complex, high-risk projects. Risks are unpredictable, inherent to the nature of the project (rather than due to inadequate planning, scoping, or time), and

	Design-Bid-Build	Construction Manager/ General Contractor	Design-Build	Public-Private Partnerships	Alliance Contracting/ Integrated Project Delivery (IPD)
		 Large projects with multiple phases and contracts. Staged construction is possible. Limited internal agency resources and expertise to manage complex project. Limited time or funding constraints. 	facility failures, or user impacts) that would benefit from an expedited project delivery. Projects having manageable public controversy and third-party issues or environmental issues.	opportunities are viable. New alignments or relief routes. Added capacity through managed or "HOT" lanes.	best managed collectively. Significant benefit derived from the involvement of partners in all aspects of project development and implementation.
Procurement Methods	 Qualified Low Bid. Task Order quantities/pricing. Cost +Time Bidding. Alternate Bids. Additive Alternates. Best Value. 	 QBS or Best-Value Selection. Selection criteria may include qualifications, experience, and possibly cost elements. 	 Qualified low bid. One/Two-step Best-Value (may include a competitive range with upset price and a BAFO process). QBS (DB to Budget). 	• QBS or Best- Value with competitive negotiations.	• QBS.
Advantages	 Applicable to a wide range of projects. Well established and easily understood. Owner retains design control. Provides the lowest initial price that responsible, competitive bidders can offer. No legal barriers in procurement and licensing. 	 Allows for contractor to influence innovation and constructability in the design phase. Facilitates common understanding of project goals between owner, designer, and contractor. Agency still retains significant control and influence over design. Time savings if fast-tracking early components of 	 Accelerate delivery by fast-tracking design and construction in phased packages. Streamline and enhance coordination through single-point responsibility for design and construction. Early contractor involvement to enhance constructability of plans. 	 Delivers projects much sooner than possible using public funds. Provides supplemental funding for projects for which other funding is otherwise unavailable. (For example: Private 	 Manage risks through sharing of responsibility and incentive for all participants to proactively mitigate risks. Early contractor involvement. Improved project outcomes through collaboration and "best-for-project" decision making.

	Design-Bid-Build	Construction Manager/ General Contractor	Design-Build	Public-Private Partnerships	Alliance Contracting/ Integrated Project Delivery (IPD)
	Well established legal precedents.	construction prior to complete design in phased packages. Allows for early risk identification and allocation. Reduces agency's general management and oversight responsibilities (but not quality assurance responsibilities). A not-to-exceed GMP, particularly with a shared savings contingency, provides an incentive for CM/GC to control costs and work within funding limits. Transparent costs if administered as an openbook contract.	 Allows for early identification and allocation of risks. Earlier schedule and cost certainty. Potential for innovation to reduce costs or enhance quality. Eliminate E&O changes. Streamlined payment. 	developers of shopping centers, sports arenas, or entertainment venues may benefit from a PPP for the development or reconstruction of roads and highways that will improve access to their developments.) Early contractor involvement and input in all aspects of project lifecycle.	 Reduced need for contract administration (i.e., inspection, dispute resolution) allows resources to be focused on achieving project objectives. Less adversarial. Transparent pricing of the project, including contingencies. Increased efficiency provided by a well-functioning team.
Risks/ Limitations	 Tends to yield base-level quality. Higher level of inspection/testing by the agency. Initial low bid might not result in ultimate lowest cost or final best value. Agency bears risk of design adequacy. Adversarial relationship among 	 Potential appearance of unfairness in the selection of the CM/GC firm as with all best-value or QBS selections or in self-performed work if the GC is not required to compete with subcontractors for the work. Potential for non-competitive prices if the agency does not use a process to assure adequate competition or 	 Tends to yield base-level quality. Higher level of inspection/testing by the agency. Initial low bid might not result in ultimate lowest cost or final best value. Agency bears risk of design adequacy. Adversarial relationship among the contracting parties. 	Potential appearance of unfairness in the selection of the CM/GC firm as with all best-value or QBS selections or in self-performed work if the GC is not required to compete with subcontractors for the work.	 Tends to yield base-level quality. Higher level of inspection/testing by the agency. Initial low bid might not result in ultimate lowest cost or final best value. Agency bears risk of design adequacy. Adversarial relationship among the contracting parties.

	Design-Bid-Build	Construction Manager/ General Contractor	Design-Build	Public-Private Partnerships	Alliance Contracting/ Integrated Project Delivery (IPD)
	the contracting parties. No incentives for contractors to provide enhanced performance (cost, time, quality, or combination thereof).	independent verification of pricing. If GMP timing is early for schedule savings, there is the potential for higher contingencies or disputes over incomplete design elements and what constitutes a change to the contract. Agency retains design liability. CM fees during preconstruction. If using an open book contract, added administrative burden related to invoicing.	No incentives for contractors to provide enhanced performance (cost, time, quality, or combination thereof).	 Potential for non-competitive prices if the agency does not use a process to assure adequate competition or independent verification of pricing. If GMP timing is early for schedule savings, there is the potential for higher contingencies or disputes over incomplete design elements and what constitutes a change to the contract. Agency retains design liability. CM fees during pre-construction. If using an open book contract, added administrative burden related to invoicing. 	No incentives for contractors to provide enhanced performance (cost, time, quality, or combination thereof).
Approvals		■ SEP-14 required.	 None at Federal level. 		■ SEP-14 required.

	Design-Bid-Build	Construction Manager/ General Contractor	Design-Build	Public-Private Partnerships	Alliance Contracting/ Integrated Project Delivery (IPD)
	SEP-14 for ID/IQ and Best Value.	State statutes may restrict or limit how it is implemented.	State statutes may restrict or limit how it is implemented.	 SEP-15 required only when project deviates from FHWA's ROW, financing, or other noncontracting policies. State statutes may restrict or limit how it is implemented. 	Statutory authority required.
Alternative Contracting Strategies	 QA specifications. Warranty or performance-based maintenance. Incentives/ disincentives for time or quality. Performance contracting. 	 Performance specifications. Performance contracting. Contingency with GMP. Incentives/ disincentives. Price-plus-time consideration in evaluation. 	 Performance specifications. Optional warranty or performance-based maintenance. Incentives/disincentives for time, quality, traffic, safety, etc. 	 Performance specifications for construction. Performance-based maintenance. 	 Performance specifications. Shared incentives/ disincentives. Optional warranty or performance-based maintenance.

Glossary of ACM Terms

- Alliance Contracting A commercial/legal framework between an owner-participant and one or more private-sector parties as service provider or non-owner participants for delivering one or more capital works projects. Also known as Alliancing.
- Alternative Contracting Methods (ACMs) Contracting methods—including design-build, construction manager/general contractor, and alternative technical concepts—to accelerate project delivery, encourage the deployment of innovation, and minimize unforeseen delays and cost overruns.
- Alternative Delivery Method (ADM) A wide array of methods used by public agencies to deliver transportation project improvements. These methods include construction manager/general contractor, design-build, design-build-operate-maintain, design-build-finance, design-build-finance-operate-maintain, fee services, long-term lease concessions, and operations and maintenance. Also known as alternative project delivery.
- Alternative Project Delivery (APD) A wide array of methods used by public agencies to deliver transportation project improvements. These methods include construction manager/general contractor, design-build, design-build-operate-maintain, design-build-finance, design-build-finance-operate-maintain, fee services, long-term lease concessions, and operations and maintenance. Also known as alternative delivery method.
- Best Value May be defined based on either the value of the product to be received (a 10-year warranty compared with a 3- or 5-year warranty) or the bidder's past performance based on some objective criteria. In general, the project award is based on a composite of price data and non-price factors.
- Bridge Bundling A defined set (or bundle) of bridges that are planned for preservation/preventive maintenance, rehabilitation, or replacement in a timely and efficient manner through a series of bridge bundling contracts with the support of various funding options and/or partnerships that may include a program completion time frame.
- Contract A mutually binding legal relationship obligating the seller to furnish supplies or services and the buyer to pay for them.
- Contracting Purchasing, renting, leasing, or otherwise obtaining supplies or services from non-Federal sources. Contracting includes a description of supplies and services required, selection and solicitation of sources, preparation and award of contracts, and all phases of contract administration.
- Construction Manager/General Contractor (CM/GC) The agency procures professional services on a qualifications or best-value basis from a construction manager during the design phase to offer suggestions on innovations, cost and schedule savings, and constructability issues. Upon completion of the design or individual design packages,

- the contractor and agency negotiate a price for the construction contract (often verified by an independent cost estimator), and then the construction manager acts as a general contractor to complete construction. The contract can employ a guaranteed maximum price administered on a cost-reimbursable basis, unit price, or lump-sum contract.
- Cost-Plus-Time Bidding (also referred to as A+B Bidding) Reduces construction time by making time a factor, in addition to cost, when awarding a contract. Under this method, each submitted bid consists of two components: the "A" component is the traditional bid for the contract items based on unit bid prices and quantities while the "B" component is the bidder's estimate of the time required to complete critical construction as defined in the contract. Calendar days are typically used to reduce the potential for disputes. For the purposes of determining the apparent low bidder, the B component is converted to a dollar value by multiplying the number of days by the daily road user cost identified in the contract.
- Design-Build (DB) A project delivery method that combines two, usually separate services into a single contract. With DB procurements, agencies execute a single, fixed-fee contract (lump sum) for both architectural/engineering services and construction. The DB entity—also known as a constructor—may be a single firm, a consortium, a joint venture or other organization assembled for a particular project. DB has been implemented using various procurement approaches, including qualified low bid and best value.
- Design-Bid-Build (DBB) The traditional delivery method where the agency contracts separately for design and construction services, the bid is based on complete (100 percent) plans and specifications, and design and construction occur sequentially. DBB is typically a unit-priced contract, but it can also include lump-sum items.
- Design-Build-Finance (DBF) A project delivery method where procurement is a single contract awarded for the design, construction, and full or partial financing of a facility. Responsibility for the long-term maintenance and operation of the facility remains with the project sponsor, but could be included in a separate agreement. This approach takes advantage of the efficiencies of the design-build approach and also allows the project sponsor to defer financing either completely or partially during the construction period.
- Design-Build-Finance-Operate (DBFO) Concessions whereby a single private consortium develops, builds, finances, and operates the road for a set number of years. See Design-Build-Finance-Operate-Maintain (DBFOM).
- Design-Build-Finance-Operate-Maintain (DBFOM) A concessions approach where the responsibilities for designing, building, financing, operating, and maintaining are bundled together and transferred to private sector partners.
- Design-Build-Operate (DBO) In a DBO project, a single contract is awarded for the design, construction, and operation of a capital improvement. Title to the facility remains with the public sector unless the project is a design-build-operate-transfer or design-build-own-operate project. On a public project, the operations phase is normally handled by

the public sector or awarded to the private sector under a separate operations and maintenance agreement. Combining all three phases into a DBO approach maintains the continuity of private sector involvement and can facilitate private-sector financing of public projects supported by user fees generated during the operations phase. See Design-Build-Finance-Operate-Maintain.

- Design-Build-Operate-Maintain (DBOM) An integrated procurement model that combines the design and construction responsibilities of design-build procurements with operations and maintenance. These project components are procured from the private sector in a single contract with financing independently secured by the public sector project sponsor. This project delivery approach is also known by a number of different names, including turnkey procurement and build-operate-transfer.
- Indefinite Delivery/Indefinite Quantity (ID/IQ) A type of contract that provides for an indefinite quantity of supplies or services during a fixed period of time.
- Job Ordering Contracting (JOC) A non-determinate location/non-determinate quantity-type contract. The heart of a JOC contract is a construction task catalog (CTC) consisting of hundreds of pre-priced work activities. The prices in the CTC are based on the estimated labor, equipment, and material costs to perform the work. All costs are based on local pricing (local prevailing wage rates, equipment costs, and local materials costs). Contractors bid a single adjustment factor that includes their overhead and profit and their risk assessment as to the prices in the CTC. The bidder submitting the lowest adjustment factor is declared the winner.
- Public-Private Partnership (P3) A contractual agreement between a public agency and a private entity that allows for greater private participation in the delivery of a transportation project (Federal Highway Administration, 2017c). P3s include any contractual arrangement in which the private sector takes on more risk. P3 goals may vary from raising funds from lease of an existing facility (brownfield) to constructing a brandnew facility (greenfield). P3s do not necessarily involve toll facilities. P3s traditionally include variations of design-build with one or more operate, maintain, and/or finance components (e.g., design-build-operate, design-build-finance-operate, design-build-finance-operate-maintain (DBFOM), availability-payment concession, and DBFOM concession) and could include other delivery methods such as construction manager/general contractor and alliancing.
- Procurement Method The means used to select a vendor (contractor, designer, or other service). These include low-bid, best-value, and qualifications-based selection. Other less common methods include adjusted low bid, sole source, and emergency selection.
- Project Delivery Method (PDM) The comprehensive process used by an agency to deliver a project, which includes planning, programming, design, construction, and consideration of required operations and maintenance. These methods include design-bid-build, indefinite delivery/indefinite quantity, design-build (DB), and public-private partnerships (P3s). P3s include DB with operate, maintain, and/or financing

- components, e.g., design-build-operate, design-build-finance-operate, design-build-operate-maintain, and design-build-finance-operate-maintain.
- Progressive Design-Build A variation of design-build that facilitates involvement of the design-build team during the earliest stages of the agency's project development, ensuring they are part of the project team developing design solutions (Design-Build Institute of America).
- Quality Assurance (QA) (1) All those planned and systematic actions necessary to provide confidence that a product or facility will perform satisfactorily in service; or (2) ensuring the quality of a product is what it should be.
 - QA addresses the overall process of obtaining the quality of a service, product, or facility in the most efficient, economical, and satisfactory manner possible. Within this broad context, QA includes the elements of quality control, independent assurance, acceptance, dispute resolution, etc. The use of the term QA/QC or QC/QA is discouraged; the term QA should be used. QA involves continued evaluation of the activities of planning, design, development of plans and specifications, advertising and awarding of contracts, construction and maintenance, and the interactions of these activities (TRB Circular E-C173, 2013).
- Quality Control (QC) Also called "process control." The system used by a contractor to monitor, assess, and adjust production or placement processes to ensure the final product will meet the specified level of quality. QC includes sampling, testing, inspection, and corrective action (where required) to maintain continuous control of a production or placement process (TRB Circular E-C173, 2013).

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