DESIGN-BUILD AND CM AT RISK-

COMPARATIVE ANALYSIS FOR OWNER DECISION MAKING

BASED ON CASE STUDIES AND PROJECT SURVEYS

A Thesis

by

SOON ROCK PARK

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2011

Major Subject: Construction Management

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Approved by:

Chair of Committee,	José L. Fernández-Solís
Committee Members,	Zofia K. Rybkowski
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ABSTRACT

Design-Build and CM at Risk- Comparative Analysis for Owner Decision Making Based on Case Studies and Project Surveys. (May 2011)

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Chair of Advisory Committee: Dr. José L. Fernández-Solís

Currently, many researchers and stakeholders believe that effective delivery systems for construction projects are key to improving project quality and value in the construction industry. Therefore, it is important that owners use the best project delivery system because there are significant consequences due to differences in contracting processes and roles and responsibilities among contracting parties. For that reason, this research aims to compare the efficiency of Design-build with that of CM at Risk, as two methods used to select or deny expectations, specifically through quantitative and qualitative analysis. In order to do that, the researcher identified performance data and benefits, drawbacks, and success factors of Design-build and CM at Risk through survey and case projects and also analyzed performance data collected from two case projects. Consequently, owners will be able to understand characteristics, differences, and success factors of two different Project Delivery Systems based on the comparative study. Furthermore, this research could be used to develop a decision support system for owners to select an appropriate Project Delivery System.

DEDICATION

This work is dedicated to my beloved parents, Mr. Kiyoung Son, and also my dear girlfriend, Mi Jung Lee. Without their caring support, patience and love, it would not have been possible for me to complete this work.

ACKNOWLEDGEMENTS

First, I would like to express the deepest appreciation to my committee chair, Dr. Fernández-Solís, and my committee members, Dr. Rybkowski and Dr. He, for their guidance and support throughout the course of this research.

Thanks also go to my friends and colleagues and the department faculty and staff for making my time at Texas A&M University a great experience.

Finally, thanks to my parents for their encouragement and to my girlfriend for her patience and love.

NOMENCLATURE

CMAR	Construction Management- At- Risk
DB	Design-Build
DBB	Design-Bid-Build
ENR	Engineering New Record
GMP	Guaranty Maximum Price
IPD	Integrated Project Delivery
NCTM	National Center for Therapeutics Manufacturing
PDS	Project Delivery System
RFP	Request For Proposal
TAMU	Texas A&M University
TIPS	Texas A&M Institute for Preclinical Studies

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CHAPTER I

INTRODUCTION

To improve project quality and value, the significance of effective delivery methods for construction projects has recently increased. Traditionally, the Design-Bid-Build (DBB) method was used for several centuries. However, as design and construction specialization increased, this conventional method became unacceptable to many clients in the 1970s and 80s. After the early 1980's, Design-Build (DB) and Construction-Management at Risk (CMAR) were introduced (Konchar & Sanvido, 1998). Since the early 1990's, the use of the DB delivery method has increased. In 1996,DB was used in over half of the 50 U.S. states and accounted for over 24% of the $286 billion of nonresidential construction (Tarricon, 1996). More recently, the Integrated Project Delivery (IPD) method emerged in the early 1990s. IPD is a project delivery method that integrates people, systems, business structures and practices into a process to reduce waste and optimize efficiency through all phases of design, fabrication and construction (AIA, 2008). Thus, in order to improve efficiency in construction, a variety of delivery methods have been developed over decades.

According to Engineering New Record (ENR), DB and CMAR have become the most

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popular among these delivery methods (ENR, 2010). Several previous studies compared DB and CMAR regarding overall construction activities. However, little research has focused on specific activities such as building foundations, excavations etc. regarding efficiency between DB and CMAR.

It is important that owners use the best project delivery method because there are significant consequence due to differences in contracting processes and roles and responsibilities among contracting parties. Therefore, the primary objective of this research is to compare the efficiency of DB with that of CMAR, as two methods used to select or deny expectations, specifically through quantitative and qualitative analysis.

The performance data in this research use two different building projects: the Texas A&M Institute for Preclinical Studies (TIPS) and the National Center for Therapeutics Manufacturing (NCTM). They used the same geotechnical engineering company under similar geophysical soil conditions, but they used two different foundation types. Thus, to compare between DB and CMAR, based on performance data (cost, scheduling, and productivity), this research analyzes costs and scheduling regarding foundation types that used a different project delivery system in a similar environment. In the future, this research can be used to develop a decision support system for owners as they choose between DB and CMAR.

CHAPTER II

LITERATURE REVIEW

Introduction of Project Delivery System

Project Delivery System Defined

The Associated General Contractors of America (AGC) defines project delivery system as "the comprehensive process of assigning the contractual responsibilities for designing and constructing a project. A delivery method identifies the primary parties taking contractual responsibility for the performance of the work. The delivery method process includes: (1) Definition of scope and requirement of a project, (2) Procedures, actions, and sequences of events, (3) Contractual requirements, obligations, and responsibilities of the parties, (4) Interrelationships among the participants, (5) Mechanisms for managing time, cost, safety, and quality, and (6) Forms of agreement and documentation of activity" (AGC, 2004).

The Trend of PDS in the United States

Traditionally, the Design Bid Build method has been used in public and private projects in the United States and all state codes authorize public agencies to use it in their projects. After the early 1980's, Design-Build (DB) and Construction-Management at

Risk (CMAR) were considered two alternatives to this traditional method (Karmran, 2008). In order to compare the project delivery system regarding DB and CMAR, this study includes a literature review of the top 100 firms for DB and CMAR in the U.S. based on 2010 Engineering New Record (ENR).

Currently, CMAR and DB possess equivalent market shares. Revenue from projects done on a CMAR basis from the top 100 firms in The Figure 2.1 was $89.34 million in 2009, down 13.5% from $103.34 billion in 2008. Among the ENR Top 100 Design-build Firms, revenue was down as well, although not as drastically. It fell 8.4% in 2009 to $89.43 billion, from $97.60 billion in 2008. Thus, currently, DB and CMAR hold main parts of the construction market (ENR, 2010).

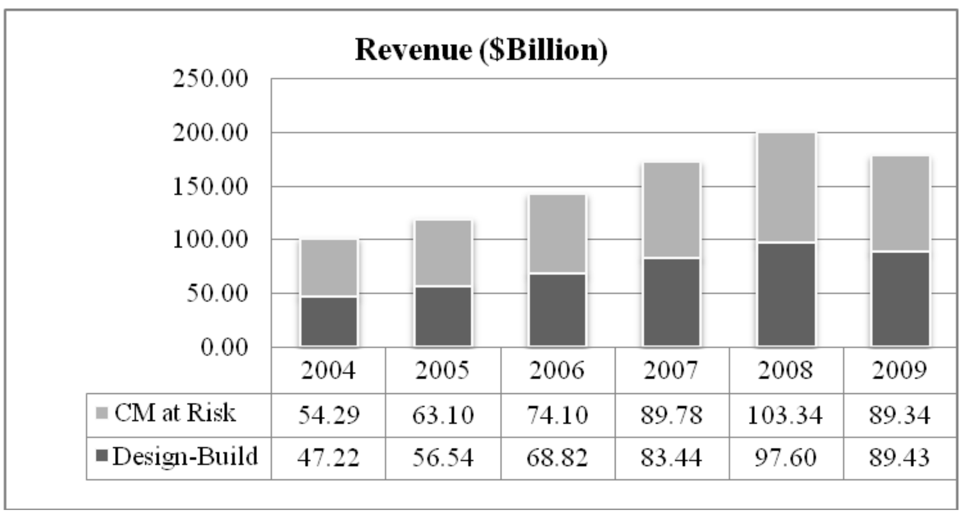

Figure 2.1: Revenue from Projects done on ENR Top 100 DB and CMAR Firms

The following figure 2.2 presents the percentage of annual revenue according to projects done on ENR Top 100 DB and CMAR Firms.

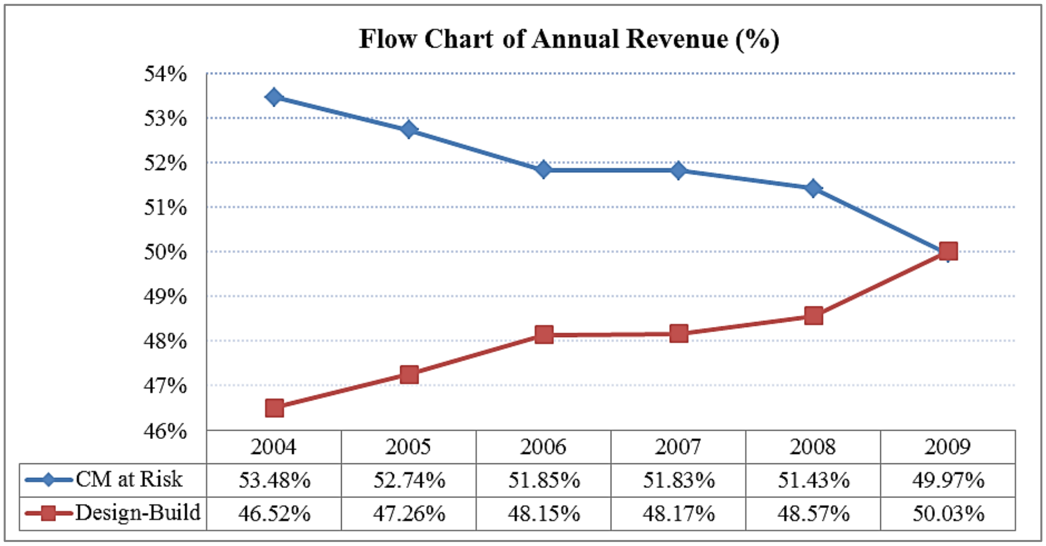

Figure 2.2: Flow Chart of Annual Revenue (%) from Projects done on ENR Top 100 DB and CMAR Firms

Project Delivery Systems: Design-Build & CM at Risk

Design-build

The Design-build method of project delivery has been employed on numerous projects. This delivery method requires the owner to have a clear understanding of the project goals and the aesthetic and functional construction details. (Kwak & Bushey, 2000)

In the Design-build, the owner contracts with a single entity, the architect builder, for both design and construction services. The Design-build entity can be led by either a designer or a builder and can consist of any number of people like following The Figure 2.3. In addition, Design-build requires an explicit understanding of the roles and responsibilities of the Design-build team. Single source contracting has gained popularity in recent years in both the private and public sectors. (AIA & AGC, 2006)

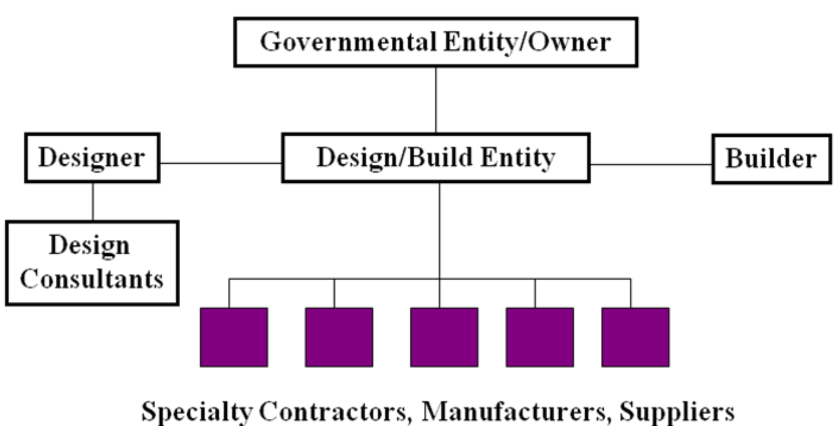

Figure 2.3: Design-Build-Relationships among Parties

CM at Risk

The CM at Risk method is based on team building between the owner, the design architect/engineer, and the contractor construction manager from the beginning of the project conceptual design through the final construction and operation or occupancy of the facility. (Kwak & Bushey, 2000)

In this method, the owner has a separate contract with the CM at Risk (construction manager) and another directly with the architect/engineer as shown The Figure 2.4. The construction manager, referred to as the CM at Risk, typically provides essential preconstruction services, holds the trade contracts, takes responsibility for the performance of the work, and guarantees the construction costs and schedule. The CM at Risk also serves as the general contractor assuming the risk of the performance, either by its own crews or by specialty contractors and suppliers. (AGC, 2004)

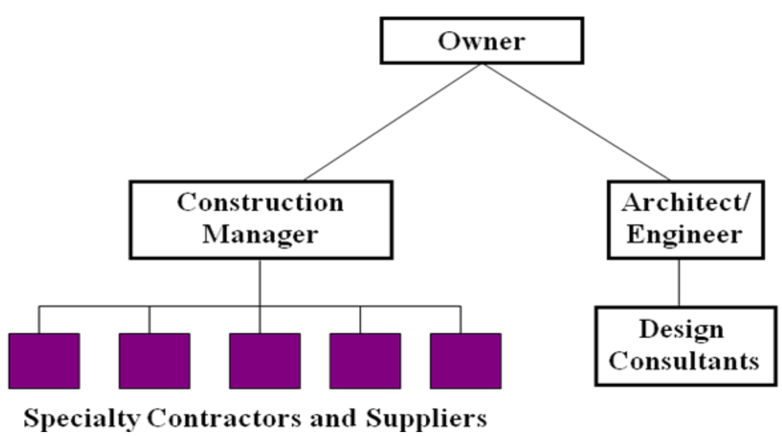

Figure 2.4: CM at Risk-Relationships among Parties

Previous Research: Characteristics, Benefits & Drawbacks

Konchar and Sanvido (1998), this research presents results of a research study that empirically compared the cost, schedule, and quality performance of U.S building projects that used construction management at risk, Design-build, and Design-Bid-Build project delivery systems. This research verified the data through the use of nonresponse sampling techniques, and built multivariate linear regression models for cost and schedule metrics using certain amount of response, explanatory, and interacting variables.

Ibbs et al. (2003), he points out that design/build has become one of the popular project delivery methods in the construction industry. In this research, a comprehensive analysis of 67 global projects from the Construction Industry Institute's database indicates that Design-build projects may not provide all the benefits to project performance. The study found timesaving was a definitive advantage of Design-Bid-Build project delivery, however, the positive effects of cost and productivity changes were not convincing. Based on the results of the research, the project management expertise and experience of the contractor may have a greater impact on project performance outcomes than focusing on project delivery strategy only.

Hale et al. (2009), he compares the performance of Design-build and Design-Bid-Build in order to identify which project delivery method is advanced regarding time and cost.

In this research, two samples of projects with each of the two delivery methods were used to provide a meaningful comparison because they include buildings of the same typology delivered using similar design models. Project duration, project duration per bed, project time growth, cost growth and cost per bed were statistically compared. Based on the results of the analysis, DB projects were proven superior in performance in almost every measure through the hypothesis that DB projects are superior to DBB projects regarding time and cost was tested.

The Table 2.1 demonstrates particular studies that compare CMAR with DB regarding differing construction activities. However, little research has focused on specific activity such as foundation, excavation etc. The case studies in this research have a different Project Delivery System (DB and CMAR), the same geotechnical engineering company, and similar geophysical soil conditions, but they have used two different foundation types. Thus, this research identifies cost and scheduling through applying a different project delivery system in a similar environment.

Table 2.1: Matrix of Prior Research based on Research Methods to Comparative Work regarding PDS

	Literature Search on Comparative Work Regarding Project Delivery Systems	Bender, W.J.(2004)	Debella, D.C.(2006)	Garvin, M. J.(2003)	Ghavamifar, K.(2008)	Gibson, G. E.(2008)	Greco, A.(2006)	Hale, D.R.(2009)	Henry, E.(2001)	Hyun, C.T.(2008)	Ibbs, C.W.(2003)	Konchar, M(1998)	Kwak, Y.H.(2000)	Ling, F.Y.Y.(2004)	Minchin, R. E. Jr.(2010)	Pakkala, P.(2002)	Park, M.S.(2009)	Pen~a-Mora, F(2001)	Puerto, C.L.(2008)	Ritchie, W.D.(2004)	Rojas, E.M.(2008)	Rosner, J.W.(2009)	Smith, V.R.R.(2009)	Thomas, S.R.(2002)	Touran, Ali.(2008)	Touran, A.(2009)	Uhlik, F.T.(1999)	Walewski, J.(2001)	Yates, J. K.(2003)
1	Collection of data and Data analysis		✔			✔		✔	✔	✔		✔		✔				✔			✔	✔	✔	✔					
2	Statistical Analysis		✔					✔		✔	✔	✔		✔	✔						✔			✔	✔				
3	Analysis of Case Study	✔				✔	✔		✔	✔			✔	✔		✔		✔		✔					✔	✔			
4	Reviewing previous research			✔							✔		✔			✔	✔	✔							✔	✔		✔	✔
5	Survey		✔		✔		✔				✔				✔		✔												✔
6	Interview					✔				✔						✔									✔	✔		✔	
7	Analysis of Project Performance metric													✔															
8	DB vs. CMAR (Both are dealt with)				✔							✔	✔		✔			✔					✔		✔		✔		
	Criteria for the comparison																												
a	Cost	✔	✔				✔	✔	✔		✔	✔		✔							✔	✔	✔	✔	✔		✔		
b	Time (Schedule)	✔	✔				✔	✔	✔		✔	✔		✔								✔		✔	✔		✔		
c	Quality Performance											✔		✔										✔			✔		
d	Others		✔				✔	✔								✔			✔					✔					
e	Legal Status				✔																		✔					✔	
f	Preference														✔	✔	✔												
g	Work Element						✔		✔																				
h	Project Process												✔																
i	Potential Strengths			✔																									
j	Risk																			✔									
k	Potential Conflicts																	✔											
l	Design Performance									✔																			

Characteristics of Design-build & CM at Risk

In the following table 2.2, characteristics of two different delivery methods are identified. (AIA & AGC, 2006)

Table 2.2: Characteristics of DB and CMAR from Literatures

Design-Build	CM at Risk
Continuous execution of design and construction	Three prime players: owner, architect, CMr
Two prime players: owner, design-build entity	Two separate contracts: owner-architect, owner- CMr
Overlapping phases: design and build (fast track)	Overlapping phases: design and build (fast track)
Carefully crafted legal and procedural guidelines for public owners	Construction manager hired during the design phase
Some construction-related decisions after the start of the project	Preconstruction services offered by the constructor
Overall project planning and scheduling by the design-build entity prior to mobilization	Specific contractual arrangement determines the roles of players
Either cost or solution as the basis for selection of the design-build entity	Clear quality standards produced by the contract's prescriptive specifications

Benefits & Drawbacks of Design-build & CM at Risk

Many authors and researchers (Songer & Molenaar, 1997, Fisk, 2000, Kwak & Bushey, 2000, Beard et al., 2001, Tenah, 2001, Pakkala, 2002, Rojas & Kell, 2008, Del Puerto et al., 2008, and AIA, 2008) have identified advantages (benefits) and disadvantages (drawbacks; risks; concerns) of Design-build project delivery system and CM at risk. They are presented in Table 2.3 and 2.4.

Table 2.3: Advantages and Disadvantages of DB from Literatures

Design-Build	
Advantages (Benefits)	Disadvantages (Drawbacks/ Risk/ Concerns)
Allows Owner to control guaranteed maximum price at an early stage of the project and control project cost during construction (Songer & Molenaar, 1997) (Fisk, 2000) (Beard et al., 2001) (Tenah, 2001) (AIA, 2008) (Rojas, 2008)	Design-builder must guarantees cost at a very early stage of the project (Fisk, 2000) (Beard et al., 2001) (Tenah, 2001) (AIA, 2008)
Design-build er has control over the design and the cost of the project (Songer & Molenaar, 1997) (Fisk, 2000) (Beard et al., 2001) (AIA, 2008)	Decisions made by the design-builder are based on the initial costs rather than life cycle costing (Fisk, 2000) (Beard et al., 2001) (Tenah, 2001) (AIA, 2008)
The total cost of the project is lower than other systems especially a similar design-bid-build project (Songer & Molenaar, 1997) (Fisk, 2000) (Beard et al., 2001) (Tenah, 2001) (AIA, 2008) (Rojas & Kell, 2008)	Substantial financial burden by the Designer in the development of the proposal (Fisk, 2000) (Beard et al., 2001) (Tenah, 2001) (Pakkala, 2002)
The product is delivered in a shorter time frame (Songer & Molenaar, 1997) (Del Puerto et al., 2008) (AIA ,2008) (Rojas & Kell, 2008)	Owners have less control over design process than with other PDSs and owners perceive the loss of control over the design and during construction (Fisk, 2000) (Beard et al., 2001) (Tenah, 2001) (AIA, 2008)
Reduces administration time from reduced claims and issues resolutions (Songer & Molenaar, 1997) (Fisk, 2000) (Beard et al., 2001) (Tenah, 2001) (Rojas & Kell, 2008)	Requires increased Owner skill level on front-end work (preparation of RFP) (Beard et al., 2001) (Tenah, 2001) (AIA 2008)
Fast tracking: The total amount of time from inception to completion is reduced (Molenaar, 1997) (Songer & Molenaar, 1997) (Fisk, 2000) (Beard et al., 2001) (Tenah, 2001) (AIA, 2008)	Design-builder demands quick decisions by Owners (Fisk, 2000) (Tenah, 2001) (AIA, 2008)
Improved constructability and enhanced product and process quality (Songer & Molenaar, 1997) (Beard et al., 2001) (Fisk 2000) (Tenah, 2001) (AIA, 2008) (Del Puerto et al., 2008)	DB meets the performance criteria through the cheapest material and minimum design (Fisk, 2000) (Beard et al., 2001) (Tenah, 2001)
Designer and builder are working on the same team and partnering with the designers and sub-contractors will help produce a superior product resolutions (Songer & Molenaar, 1997) (Beard et al., 2001) (Fisk, 2000) (Tenah, 2001) (AIA, 2008)	Less checks and balances. No third party to act as a watchdog for the Owner (Fisk, 2000) (Beard et al., 2001) (Tenah, 2001)
Less change orders (error and omissions are the Design-builder's responsibility) (Songer & Molenaar, 1997) (Beard et al., 2001) (Fisk, 2000) (Tenah, 2001) (AIA, 2008)	Lack of project definition prior to contract award (Quality of the RFP) (Fisk, 2000) (Beard et al. ,2001) (Tenah, 2001) (AIA, 2008)

Table 2.4: Advantages and Disadvantages of CMAR from Literatures

CM at Risk	
Advantages (Benefits)	Disadvantages (Drawbacks/ Risk/ Concerns)
Early cost commitment: Pricing & Cost model are developed along with design (Beard et al., 2001) (Tenah, 2001) (Pakkala, 2002) (AIA, 2008)	Managerial role of contractor adds more cost to the project's total design budget. This cost may be offset by the savings resulting from improved design and constructability (Fisk, 2000) (Beard et al. 2001) (Tenah, 2001) (AIA, 2008)
Provides opportunities for time and cost savings (Kwak & Bushey, 2000)	Sometimes difficult to manage all phased packages with costs, changes & schedule (Kwak & Bushey, 2000) (Pakkala, 2002)
Provides a Guaranteed Maximum Price (GMP) (Pakkala, 2002)	Linear process, which may cause some time delays (Fisk, 2000) (Beard et al., 2001) (Tenah, 2001) (AIA, 2008)
Complex scheduling & Clear schedule (AIA, 2008)	Fast tracking difficult to control with Designer & Construction manager (Pakkala, 2002)
Reduce the time for construction through fast track delivery and reduces the real time required to complete the project from conception to completion (Kwak & Bushey, 2000) (Fisk, 2000) (Beard et al.,2001) (Tenah, 2001)	Designer & builder still have separate contractual relationships with the owner and can be a source of conflict (Fisk, 2000) (Beard et al., 2001) (Tenah, 2001) (AIA, 2008)
Contractor identify long lead items early to avoid scheduling delays (Fisk, 2000) (Beard et al., 2001) (Tenah, 2001) (AIA, 2008)	Owner needs to have sufficient expertise to manage both contractor and designer (AIA, 2008)
Contractor review of the documents reduces error and omissions (Beard et al., 2001) (Tenah, 2001) (Pakkala, 2002)	Potential philosophical disconnect (AIA, 2008)
Team building through partnering is a key element in the project's success (Kwak & Bushey, 2000)	Some duplication of administration and more paperwork for client (Pakkala, 2002)
Provide the opportunity to be flexible for the implementation of supplemental technology (Kwak & Bushey, 2000)	Contractor must be comfortable being directly responsible to the owner (Fisk, 2000) (Beard et al., 2001) (Tenah, 2001)

Problem Statement

Many research studies, regarding comparisons between a traditional project delivery system such as DBB with alternative PDS's such as DB, CMAR, IPD, describe stakeholders' expectations regarding the benefits of alternative PDS's. They present the information as if this new delivery system will resolve all the challenges encountered in the traditional PDS. However, the researcher believes that the use of DB and CMAR delivery systems is required to validate the realities of their characteristics, benefits, and drawbacks according to literature reviews. Thus, through a careful comparison, stakeholders can understand characteristics, differences, and success factors of two different PDS's. In addition, they will be able to select the appropriate PDS according to the comparison between DB and CMAR, based on quantitative and qualitative analysis.

For this issue, the researcher identified benefits, drawbacks, and success factors of DB and CMAR through the literature review and conducted a survey with several practitioners. Participants were asked about their experiences related to this issue, and the performance data collected from two different building projects were analyzed.

Summary

This chapter presented a detailed review of the literature. The main purpose was to highlight the current status of the DB and CMAR project delivery systems in the literature, identify a method for comparing them, and finally identify advantages (benefits) and disadvantages (drawbacks; risks; concerns) of DB and CMAR through reviewing literature. In Chapter 3, based on the literature, the researcher will describe and identify the method for data collection and analysis of data.

CHAPTER III

RESEARCH METHODOLOGY

Literature Review of the Research Methodology: Survey

Data Collection Method for Survey

This section describes the specific steps for collecting data for this research, based on the literature review. It includes the survey process and the method used to evaluate the performance of each project. Based on previous research and literature (Konchar & Sanvido, 1998, Swarup, 2010), it was determined that both qualitative and quantitative methods to compare the two case projects and project delivery systems were appropriate.

Figure 3.1 illustrates the conceptual framework used in this research. The survey was divided into two phases. The first phase was a survey of the two case projects' performance and the second phase evaluated the characteristics of project delivery systems for each project. The following sections describe the two phases of the survey.

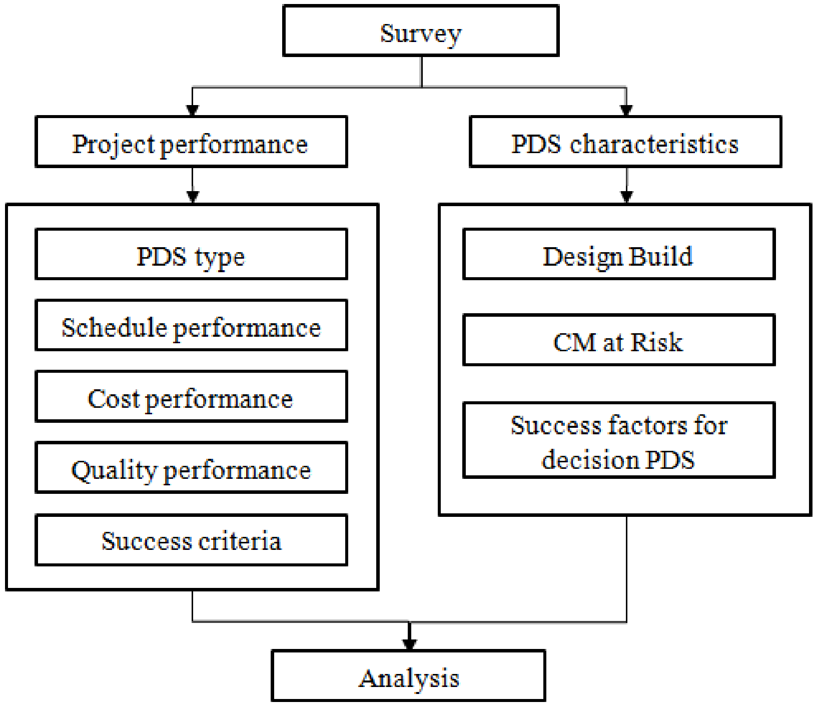

Figure 3.1: Conceptual Framework of Research

The researcher identified three main objectives for this research. First, the two building projects selected were the Texas A&M Institute for Preclinical Studies (TIPS) and the National Center for Therapeutics Manufacturing (NCTM). Also, the owner of both projects is the Texas A&M (TAMU) System. From each project, four main participants were selected: owner, project manager, superintendent, and BIM manager. All the participants selected by the researcher were crucial to the project as they were deeply involved in the process and therefore, could provide keen insights. The surveys were conducted individually as semi-interviews, to gather more profound information from individuals.

Phase I: Project performance

For Phase I of the survey, seven project performance metrics were used to describe the performance of the delivery system based on previous research and literature (Korkmaz et al., 2010, Lapinski et al., 2006, Pulaski, 2005, and Magent, 2005). The following table 3.1 is the form for collecting data regarding cost and schedule performance; the following paragraphs define each performance metric.

Table 3.1: Performance Survey Form

Variable		#1 project(CMAR)	#2 project(DB)
Cost	Unit Cost		
	Cost Growth		
	Intensity		
Schedule	Construction Speed		
	Delivery Speed		
	Schedule Growth		
Quality	Foundation performance		

• Cost measures

Costs were limited to the design and construction and did not include land acquisition, extensive site work, and process or owner costs. Cost measures included unit cost, project cost growth and intensity.

1) *Unit cost*, the first metric, was measured to indicate the relative cost of a building for its given area. It was represented by the formula.

Unit Cost ($/SF) = [Final Project Cost / Area] / Index

Where:

Final Project Cost was the final design cost plus the final cost of construction. A cost index was essential to make accurate comparisons of projects built in different cities in different years.

2) The second metric, *Cost Growth*, provided an indication of the growth of project costs. It was defined by the formula:

*Cost Growth (%) = [(Final Project Cost – Contract Project Cost) / Contract Project Cost] * 100*

Where:

Contract Project Cost was the design contract cost plus the construction contract cost.

3) The final cost metric, *Intensity*, indicated the unit cost of design and construction work put in place in a building per unit time. It was defined by the formula:

Intensity ((\$/SF)/Month) = [(Unit Cost) / Total Time]

Where:

Total Time was the period from the as built design start date to the as built construction end date.

• Schedule measures

Three schedule metrics defined the time taken by the construction team and the owner to deliver the building. Schedule measures included construction speed, delivery speed and schedule growth.

1) *Construction speed* was the rate at which the construction team built the building. It was defined by the formula.

Construction Speed (SF/Month) =

[Area / ((As Built Construction End Date – As Built Construction Start Date)/ 30)]

2) *Delivery speed* was the rate at which the project team designed and built the building. It was defined by the formula:

Delivery Speed (SF/Month) = [Area / (Total Time / 30)]

3) *Schedule growth* was the percentage by which the schedule grew over the life of the project. It was defined by the formula:

*Schedule Growth (%) = [(Total Time – Total As Planned Time) / Total As Planned Time]*100*

Where:

The Total as planned Time was the period from the planned design start date to the planned construction end date.

• Quality measures

Quality was defined as the degree to which the project met expected quality requirements. Individual quality scores, based on a maximum of 5, were used. Foundation quality measures reflected the performance of the foundation, and were measured as the averages of the scores.

• Success criteria

The final step of project performance is for participants to describe the success factors from their projects. These parts were used to decide effective project delivery systems during building construction.

Phase II: Rating performance of PDS characteristics

Numerous authors and researchers (Songer & Molenaar, 1997, Fisk, 2000, Kwak & Bushey, 2000, Beard et al., 2001, Tenah, 2001, Pakkala, 2002, Rojas & Kell, 2008, Del Puerto et al., 2008, and AIA, 2008) have articulated advantages and disadvantages of both DB and CMAR. These are presented in Table 2.3and 2.4. Furthermore, many researchers (Konchar & Sanvido, 1998, Mahdi & Alreshaid, 2005, and Touran, 2009) refer to crucial success factors for selecting a project delivery system. They are presented in Table 3.2.

Phase II consisted of two sections: (1) rating each enumerated advantage or benefit according to its relative importance in achieving the project's success, as well as rating each disadvantage or drawback, according to the need to addressed it in order to improve each project delivery systems; (2) rating the enumerated success factors in terms of their relative importance in encouraging people to select a PDS.

The researcher focused on limited issues that have been frequently pointed out by previous researchers in relation to characteristics of PDS's. The researcher conducted the surveys face-to-face to avoid trivial or essential mistakes, and to provide sufficient instructions to participants. The respondents were asked to grade the previously identified advantages, disadvantages, and success factors by using an importance scale of 1-7, with (1) for "strongly disagree" and (7) for "strongly agree." A Delphi study was applied to rate the advantages, disadvantages, and success factors according to their weight and to identify the respondents' viewpoint of these factors.

Table 3.2: Success factors for decision PDSs

Success factors for decision Project Delivery Systems
Reduce/compress/accelerate project delivery period (Mahdi, 2005) (Touran, 2009)
To incorporate the quality performance of the delivery (Konchar & Sanvido, 1998)
Encourage innovation (Konchar & Sanvido, 1998)
Establish project budget at an early stage of design development (Konchar & Sanvido, 1998)
Project schedule and cost performance (Touran, 2009)
Project cost savings (Konchar & Sanvido, 1998) (Mahdi & Alreshaid, 2005) (Touran, 2009)
Risk management - identifying, quantifying, and allocating risks; facilitated regulations (Mahdi & Alreshaid, 2005) (Touran, 2009)
Get early construction contractor involvement (Touran, 2009)
Flexibility needs during construction phase; ease of change (Touran, 2009)
Incorporate the quality performance of the delivery methods, like difficulty of facility start up, number and magnitude of call backs, and operation and maintenance costs (Konchar & Sanvido, 1998)
Allowance of competitive bidding (Mahdi & Alreshaid, 2005)

Delphi Study

Phase II of the survey contained three lists for the Delphi study. The first was a comprehensive list of advantages and benefits, the second was a list of disadvantages and drawbacks, and the last was a list of success factors for PDS decision. These lists were used to develop the basis for Phase II of the survey, according to the Delphi study. A Delphi study was performed to rate the advantages, disadvantages, and success factors according to their weights and to identify which item was most important, in the participants' opinion.

Loveridge (2001) defines a Delphi study as a systematic method for eliciting and collecting informed judgments on a particular topic through the circulation of a set of carefully designed questionnaires, giving feedback to respondents between circulation rounds to allow the respondents to modify their later opinions, should they wish to, taking account of the earlier responses as a whole.

The researcher rated the advantages, disadvantages of each DB and CMAR project delivery, and comprehensive success factors by applying a 7-point scale with (1) for "strongly disagree" and (7) for "strongly agree." Figure 3.2 illustrates an example in the Delphi study. The researcher believes that the Delphi study is the most appropriate approach since it helps obtain participants' ideas and decisions simply and quickly.

Section 1. Advantages & Disadvantage of PDSs

The following list was compiled from literatures reviewed.
Please rate each of the following advantages or benefits according to its relative importance in achieving success of a project.
Furthermore, Please rate each of the following disadvantages or drawbacks according to its need to be addressed to improve each of project delivery systems

Please use the following scale:

☐	☐	☐	☐	☐	☐	☐
1	**2**	**3**	**4**	**5**	**6**	**7**
Strongly Disagree	**Disagree**	**Conditionally Disagree**	**Neutral**	**Conditionally Agree**	**Agree**	**Strongly Agree**

Figure 3.2: Example of 7-point Scale Delphi study

Overview of the Research Methodology

The primary objective of this study is to compare the efficiency of DB with that of CMAR through quantitative and qualitative analysis. In order to do that, first, a literature review was conducted regarding the current status of DB and CMAR in U.S. and then previous research was analyzed for comparisons between DB and CMAR.

Second, for the quantitative analysis, bid information and actual construction performance information, such as numbers and costs of change orders, actual scheduling, and actual construction cost of the TIPS and NCTM projects, were collected.

Third, to analyze the efficiency of DB and CMAR, based on the collected data, performance metrics are suggested in this study. The performance metrics consist of unit costs, cost growth, time growth and change order rates. Fourth, the performance metrics of two building projects, which include unit cost, cost growth, time growth and change order rates, were analyzed.

Fifth, for the qualitative analysis, the survey included owner representatives, project managers, superintendents, and BIM managers. Survey contents consisted of benefits, preferences, drawbacks, risk, quality, success factors, and limitations between DB and CMAR.

Sixth, based on quantitative and qualitative analysis, the two delivery methods were compared and improvements were suggested. The following figure 3.3 presents the methodology diagrams for this study.

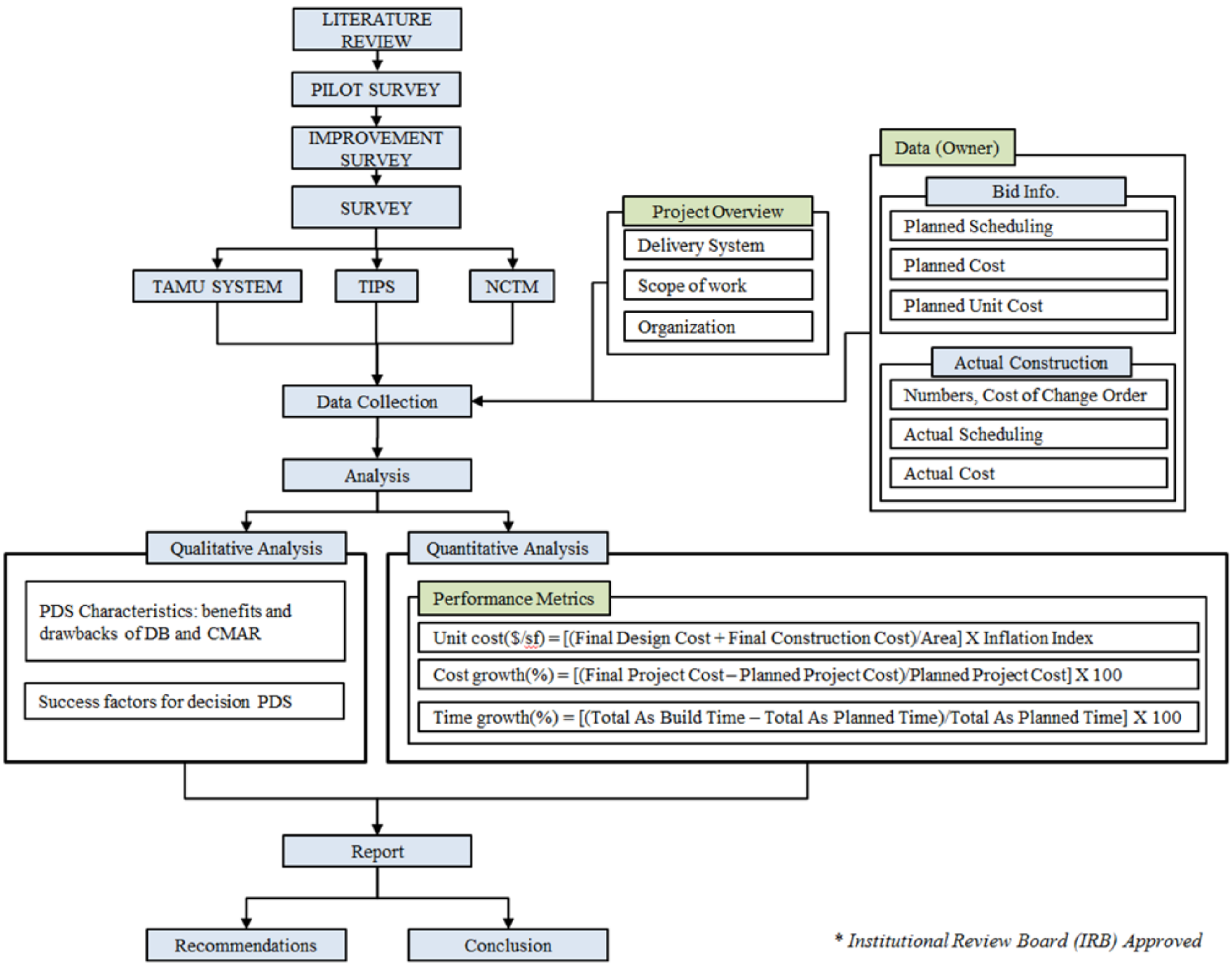

Figure 3.3: Research Methodology Diagram

Summary

This chapter covered in detail the qualitative and quantitative methodologies used in this research. The next two chapters will present the detailed components and the survey analysis.

CHAPTER IV

SURVEY I – PILOT SURVEY

Overview of Pilot Survey

This section presents the findings of a preliminary survey referred to as the pilot survey. The lessons learned from the feedback of respondents are also provided in detail in this chapter.

The researcher conducted the pilot survey with nine participants in face-to-face meetings before surveying the participants involved in the projects. This pilot survey included both project performance and characteristics of project delivery systems. The respondents consisted of professors, master's program students, and PhD students. The same questions were used for all participants. The pilot survey's data will be summarized separately and will be included in the interpretation and findings discussion.

Objective

The main purpose of the pilot survey was to obtain a better understanding and evaluation for creating the subsequent survey. In other words, the pilot survey was designed to obtain critical feedback and also discover any deficiency in order to improve the final survey. For the pilot survey, the researcher asked participants to pretend to be owners, project managers, or design professionals. After conducting the pilot surveys, the researcher focused on the exploratory investigation collecting feedback and constructed a process of data analysis from the pilot survey to obtain a better understanding of the data prior to the subsequent survey.

Lessons Learned

The respondents provided lessons learned regarding the composition and content of the pilot survey.

A summary of participants' feedback follows:

- One of the nine respondents suggested that the data collection method was very significant for successfully gathering information. A personal relationship with the respondent was significant in the data collection: since the respondent already knew the researcher, the data was shared willingly. The structured interview was successful as many respondents reactions could be documented, unlike when using other quantitative measures such as a survey. Moreover, contacting different case project participants for different sections of the project helped minimize survey completion time, improved the participants' willingness to participate, and decreased the number of non-response questions due to lack of knowledge in the area.
- One of the nine respondents pointed out that as the case projects followed the guidelines of the TAMU System, most data was well documented. Since the rest

of the information requested was intended to be more opinion than fact, the respondent felt comfortable in responding.

- Three of the nine respondents pointed out some terminology choices and problem contexts needed to be modified for a clearer understanding in the questionnaire.
- Two of the nine respondents suggested that the researcher should consider reducing the number of questions, such as lists of advantages, disadvantages and success factors. Then, participants would be able to focus more on the survey.
- One of the nine respondents pointed out the literature citations in questions regarding advantages, disadvantages, and success factors of PDS should be removed, since these citations could bias the responses.

CHAPTER V

SURVEY II – DESIGN-BUILD vs. CM at RISK

Overview

This research offers a direction for creating a decision support system that can help owners select the most appropriate project delivery method. This is accomplished by identifying project performance and conducting a survey with project practitioners, according to the literature review. Based on the previous chapter, this chapter is divided into two sections: 1) analysis of project performance; and 2) analysis of PDS characteristics, based on the survey. The chapter starts by reviewing the case projects regarding project performance. After analyzing project performance, the second section identifies PDS characteristics for selecting the most appropriate PDS.

Characteristics of Respondents

The researcher identified three main groups of respondent for this research. First, the two building projects selected were the Texas A&M Institute for Preclinical Studies (TIPS) and the National Center for Therapeutics Manufacturing (NCTM). Also, the owner of both projects is the Texas A&M (TAMU) System. From each project, five main participants were selected: construction manager (owner representative), project manager, project engineer, superintendent, and BIM manager. All the participants selected by the researcher were crucial to the project as they were deeply involved in the process and therefore, could provide keen insights. The surveys were conducted individually as semi-interviews, to gather more profound information from individuals. Table 5.1 represents information of respondents' responsibility according to the TIPS and NCTM project, and owner representatives in each project.

Table 5.1: Matrix of Information regarding Respondent's Responsibility

	TIPS (DB)				**NCTM (CMAR)**				
Players	PM (Builder)	PM (Arch.)	PE	CM (TAMU)	PM	PE	Supt.	BIM	CM (TAMU)
A	✔								
B		✔							
C			✔						
D				✔					✔
E					✔				
F						✔			
G							✔		
H								✔	
I				✔					✔

Characteristics of Case Projects

To understand how PDS fosters construction innovation and improves overall project delivery, this research uses two case projects, the TIPS and NCTM projects. This section provides general information about the case projects in order to show how the performance data is used in the matrix for comparison between these two projects.

Texas A&M Institute for Preclinical Studies (TIPS) Project

The TIPS project is a new building at Texas A&M University in College Station, Texas. This project was designed and built by the Design-builder, as part of a joint venture for this project.

TIPS adopted DB PDS with a Lump Sum contract for the Architect / Designer and a GMP contract for the Design-builder. Building gross square footage totaled 114,000 SF and total project budget for design and construction cost was $41 million. In addition, this project's total duration including the design phase was 29 months, from March 2007 to August 2009.

National Center for Therapeutics Manufacturing (NCTM) Project

The NCTM project was also for a new building at Texas A&M University in College Station, Texas. This project is being built with one of the top general contractors in the U.S. and adopted CMAR PDS with a GMP contact for this project.
The building's gross square footage totaled 153,000 SF and total project budget for design and construction cost was $37 million. In fact, this project is still ongoing, with the construction phase occurring from April 2010 to now. However, this project's planned construction end date is August 2011, according to the RFP.

A summary of the information regarding the case projects are presented in the following table 5.2.

Table 5.2: Summary of Information regarding Case Project

Case #	Project	PDS	Project Contract Amount (Original / Actual)	Project Total SF	Completion Date (Original / Actual)
1	Texas A&M Institute for Preclinical Studies (TIPS)	DB	$41.1 million / $40.6 million	114,000 SF	24 months / 29 months
2	National Center for Therapeutics Manufacturing (NCTM)	CM AR	$37 million / $41 million	153,00 SF	23 month / Not complete

Data Analysis: Phase I - Project Performance and Phase II: Rating Performance of PDS Characteristics

Analysis of Phase I - Project Performance

This section provides the results of each project, applying CMAR and DB individually. The analysis was conducted based on the contract documents of each project and surveys for owners and project managers. There are three measures in the analysis: cost, schedule, and quality. Each project is analyzed and then compared in this section.

Project cost performance

Budgeted cost, contract award and final cost were requested from each project. Contract award amount and final costs were most critical to this research. Contract costs represent the amount agreed upon at the time the contract was signed. Final cost includes changes or modifications to the contract (Konchar & Sanvido, 1998). The owner was contacted to verify the accuracy of the estimates. The following questions are related to cost performance:

1) What are the following total project costs?
2) Are you satisfied with the cost performance?
3) What percentage of final construction cost was the design fee?

Approximately what percentage of cost growth was related to external factors?

Project 1: Texas A&M Institute for Preclinical Studies (TIPS)

Table 5.3 represents data from the TIPS project according to DB. Based on the survey, the costs consisted of budget, contract award and final cost of each phase.

Table 5.3: Cost Data of TIPS Project

Stage / Cost	Design Costs	Construction Costs	Total Project Costs
Budget	$2,600,000	$38,608,505	$41,208,505
Contract Award	$2,600,000	$38,608,505	$41,208,505
Final Cost	$2,600,000	$38,000,000	$40,600,000

1) Unit cost

The total projected costs in the TIPS budget were $41,208,505and the final costs were $40,600,000 (see Table5.2). Based on the cost performance formula, the unit cost ($/sf) was 359.3 $/sf.

2) Cost growth

Cost growth provides an indication of the growth of project costs. Based on the cost performance formula, the cost growth (%) was -1.5%.

3) Intensity

Intensity indicates the unit cost of design and construction work put in place in a building per unit time. The intensity of this project was 12.4 $/sf/month.

Project 2: National Center for Therapeutics Manufacturing (NCTM)

Table 5.4 represents data from the NCTM project according to CMAR. Based on the survey, the costs consisted of budget, contract award and final cost of each phase.

Table 5.4: Cost Data of NCTM Project

Stage / Cost	Design Costs	Construction Costs	Total Project Costs
Budget	$3,259,206	$33,939,720	$37,198,926
Contract Award	$3,013,501	$33,939,720	$36,953,221
Final Cost	$3,509,337	$37,541,289	$41,050,626

1) Unit cost

The total projected costs of the NCTM budget were $37,198,926 and the final costs were $41,050,626 (see Table 5.2). Based on the cost performance formula, the unit cost ($/sf) was 266.8 $/sf.

2) Cost growth

Cost growth provides an indication of the growth of project costs. Based on the cost performance formula, the cost growth (%) was 11.1%.

3) Intensity

Intensity indicates the unit cost of design and construction work put in place in a building per unit time. The intensity of this project was 9.9 $/sf/month.

Cost Comparison between TIPS Project (DB) and NCTM Project (CMAR)

Table 5.5 represents the cost comparison between the TIPS and NCTM projects. The unit cost of the TIPS project was $92.5 higher than the NCTM project. However, in cost growth, the NCTM project was higher than the TIPS project. This indicates that the TIPS project saved final project costs over the original budget. Also, the TIPS project was slightly higher than NCTM in intensity.

Table 5.5: Cost Comparison between TIPS and NCTM Project

Cost measures	TIPS (DB)	NCTM (CMAR)
Unit cost	359.3 $/sf	266.8 $/sf
Cost growth	-1.5%	11.1%
Intensity	12.4 $/sf/month	9.9 $/sf/month

Project schedule performance

Schedule information was collected by asking participants to list as planned and as built dates for each project. These included the design start or notice to proceed date, the construction start or notice to proceed date and the construction end date, defined by substantial completion (Konchar & Sanvido, 1998). Dates were given in mm/dd/yy format.

Project 1: Texas A&M Institute for Preclinical Studies (TIPS)

Table 5.6 represents data from the TIPS project according to DB. Based on the survey, the schedule consisted of design start, construction start and construction end date.

Table 5.6: Schedule Data of TIPS Project

Item	As Planned (mm/dd/yy)	As Built (mm/dd/yy)
Design Start Date (Notice to proceed)	3/2007	3/2007
Construction Start Date (Notice to proceed)	12/15/07	2/15/08
Construction End Date (Substantial Completion)	4/2009	8/2009

1) Construction speed

As earlier mentioned, construction speed is the rate at which a construction team builds a building, in sf/month. The construction speed of the TIPS project was 5,947sf/month.

2) Delivery speed

Delivery speed provides the rate at which a project team designs and builds a building. The delivery speed of the TIPS project was 3,896 sf/month.

3) Schedule growth

Schedule growth provides overall the period from design phase to construction phase. It can help to identify how fast a project is finished. The TIPS project schedule growth was 16% based on the schedule performance formula.

Project 2: National Center for Therapeutics Manufacturing (NCTM)

Table 5.7 represents data from the NCTM project according to CMAR Based on the survey, the schedule consisted of design start, construction start and construction end date.

Table 5.7: Schedule Data of NCTM Project

Item	As Planned (mm/dd/yy)	As Built (mm/dd/yy)
Design Start Date (Notice to proceed)	9/27/2009	9/27/2009
Construction Start Date (Notice to proceed)	4/5/2010	4/12/2010
Construction End Date (Substantial Completion)	8/22/2011	8/22/2011(Estimated)

1) Construction speed

As earlier mentioned, construction speed is the rate at which a construction team builds a building, in sf/month. The construction speed of the NCTM project was 9,223 sf/month.

2) Delivery speed

Delivery speed provides the rate at which a project team designs and builds a building. The delivery speed of the NCTM project was 3,897sf/month

3) Schedule growth

Schedule growth provides overall the period from design phase to construction phase. It can help to identify how fast a project is finished. The NCTM project schedule growth was 0% based on the schedule performance formula.

Schedule comparison between TIPS project (DB) and NCTM project (CMAR)

Table 5.8 represents the case project schedule comparison between TIPS and NCTM. From the schedule data, the overall schedule growth of the TIPS project is 16% higher than NCTM. In delivery and construction speed, however, the NCTM project was faster than the TIPS project. This indicates that the NCTM project spent less time on project completion than did TIPS on the same time scale.

Table 5.8: Schedule Comparison between TIPS and NCTM Project

Schedule measures	TIPS (DB)	NCTM (CMAR)
Construction speed	5,947 sf/month	9,223 sf/month
Delivery speed	3,896 sf/month	6,617 sf/month
Schedule growth	16%	0%

Project quality performance

In quality performance, four questions asked the respondents to rate the quality of each project. Responses were recorded as low, medium or high, with low representing the worst quality. This provided information on whether or not the projects met or exceeded expectations. One question asked the respondents how many change orders occurred. This provided information about whether or not there were time delays and cost growth. The four questions are as follows:

1) Are you satisfied with the cost performance?
2) Did the quality of results in construction meet your expectations?
3) Did the quality of site layout meet your expectations?
4) Number and magnitude of change orders within first year.

Quality Performance comparison between TIPS project (DB) and NCTM project (CMAR)

Table 5.9 represents the quality performance comparison between the TIPS and NCTM projects. From the survey data, the respondents in the TIPS project were more satisfied with their project's cost performance than were the NCTM respondents. Moreover, in the quality of results in construction and site layout, notably, the respondents in the TIPS project were more satisfied regarding the quality of results in construction performance and site layout than were those from NCTM. In the measure of change orders within their first year, the TIPS project had one change order while NCTM had no change orders within the first year. This indicates that the TIPS project might spend more time or costs in order to take care of change orders.

Table 5.9: Quality Performance Comparison between TIPS and NCTM Project

Quality measures	TIPS (DB)	NCTM (CMAR)
Are you satisfied with the cost performance?	5	3.5
Did the quality of results in construction meet your expectations?	5	3.25
Did the quality of site layout meet your expectations	5	4
Number and magnitude of change orders within fist year.	1	0

Analysis of Phase II: Rating Performance of Characteristics PDSs

This section examines the advantages and disadvantages of each delivery method and the success factors for selecting a PDS, based on the survey. The purpose of this section is to help owners clearly understand project delivery methods for their projects and to determine the PDS in terms of specific goals for each project.

The key outputs of the second phase (PDS characteristics) consist of two sections. The first section is a comprehensive list of benefits (advantages) and drawbacks (disadvantages) of both a CMAR and DB, and the second section is a list of success factors for a PDS. These lists were used to outline the basis for the Delphi study. As mentioned in the previous chapter, the respondents were asked to grade the beforehand identified advantages, disadvantages, and success factors by using an importance scale with (1) for “strongly disagree” and (7) for “strongly agree.”

Design-build

Advantages & disadvantages of design-build

Tables 5.10 and 5.11 present the rankings of DB’s advantages and disadvantages, respectively. The researcher used the mean value to rank the advantages and disadvantages identified by respondents in the second phase of the survey.

Table 5.10: Ranking of Advantages regarding DB according to Delphi Study

No.	Description	Mean
A6	Fast tracking: The total amount of time from inception to completion is reduced	6.00
A8	Designer and builder are working on the same team and partnering with the designers and sub-contractors will help produce a superior product resolutions	6.00
A4	The product is delivered in a shorter time frame	5.78
A7	Improved constructability and enhanced product and process quality	5.33
A1	Allows Owner to control guaranteed maximum price at an early stage of the project and control project cost during construction	5.22
A9	Less change orders (error and omissions are the Design-build er's responsibility)	5.11
A2	Design-builder has control over the design and the cost of the project	4.89
A5	Reduces administration time from reduced claims and issues resolutions	4.78
A3	The total cost of the project is lower than other systems especially a similar design-bid-build project	4.56

Table 5.11: Ranking of Disadvantages regarding DB according to Delphi Study

No.	Description	Mean
D6	Design-builder demands quick decisions by Owners	5.56
D1	Design-builder must guarantees cost at a very early stage of the project	5.00
D2	Decisions made by the design-builder are based on the initial costs rather than life cycle costing	4.67
D5	Requires increased Owner skill level on front-end work (preparation of RFP)	4.44
D9	Lack of project definition prior to contract award	4.00
D4	Owners have less control over design process than with other PDSs and owners perceive the loss of control over the design and during	3.78
D3	Substantial financial burden by the Designer in the development of the proposal	3.56
D7	DB meets the performance criteria through the cheapest material and minimum design	3.11
D8	Less checks and balances. No third party to act as a watchdog for the Owner	2.78

According to the results of the Delphi study, respondents rated the following as the top 3 advantages and disadvantages of the Design-build project delivery system:

1) Advantages (benefits)

- Designer and builder are working on the same team; partnering with designers and sub-contractors will help produce a superior product resolutions
- Fast tracking: the total amount of time from inception to completion is reduced
- The product is delivered in a shorter time frame

2) Disadvantages (drawbacks)

- Design-builder demands quick decisions by owners
- Design-builder must guarantee cost at a very early stage of the project
- Decisions made by the design-builder are based on initial costs rather than life cycle costing

Construction management at risk

Advantages & disadvantages of CMAR

Tables 5.12 and 5.13 present the rankings of CMAR’s advantages and disadvantages, respectively. The researcher used the mean value to rank the advantages and disadvantages identified by respondents in the second phase of the survey.

Table 5.12: Ranking of Advantages regarding CMAR according to Delphi Study

No.	Description	Mean
A3	Provides a Guaranteed Maximum Price (GMP)	6.11
A6	Contractor identify long lead items early to avoid scheduling delays	5.89
A1	Early cost commitment: Pricing & Cost model are developed along with design	5.67
A4	Complex scheduling & Clear schedule	5.67
A5	Reduce the time for construction through fast track delivery and reduces the real time required to complete the project from conception to completion	5.56
A2	Provides opportunities for time and cost savings	5.44
A8	Team building through partnering is a key element in the project’s success	5.44
A7	Contractor review of the documents reduces error and omissions	5.33
A9	Provide the opportunity to be flexible for the implementation of supplemental technology	5.22

Table 5.13: Ranking of Disadvantages regarding CMAR according to Delphi Study

No.	Description	Mean
D6	Owner needs to have sufficient expertise to manage both contractor and designer	5.89
D2	Sometimes difficult to manage all phased packages with costs, changes & schedule	5.44
D8	Some duplication of administration and more paperwork for client	5.44
D5	Designer & builder still have separate contractual relationships with the owner and can be a source of conflict	5.11
D9	Contractor must be comfortable being directly responsible to the owner	5.11
D3	Linear process, which may cause some time delays	4.78
D4	Fast tracking difficult to control with Designer & Construction manager	4.78
D7	Potential philosophical disconnect	4.44
D1	Managerial role of contractor adds more cost to the project's total design budget. This cost may be offset by the savings resulting from improved design and constructability	4.11

According to the results of the Delphi study, respondents rated the following as the top 3 advantages and disadvantages of the CMAR project delivery system:

1) Advantages (benefits)

- Provides a Guaranteed Maximum Price (GMP)
- Contractor identifies long lead items early to avoid scheduling delays
- Early cost commitment: pricing & cost model are developed along with design.

2) Disadvantages (drawbacks)

- Owner must have sufficient expertise to manage both contractor and designer
- Sometimes difficult to manage all phased packages with costs, changes & schedule
- Some duplication of administration and more paperwork for client

The table on page 55 presents a summary of the rank for the advantages and disadvantages of Design-build and CM at Risk project delivery system.

Success factors for PDS decision

Table 5.14 shows the ranking of the success factors for PDS decision. The researcher used the mean value to rank the success factors identified by respondents in the second phase of the survey.

Table 5.14: Ranking of Success Factors for Decision PDS according to Delphi Study

No.	Description	Mean
S5	Project schedule and cost performance	6.11
S8	Get early construction contractor involvement	6.11
S1	Reduce/compress/accelerate project delivery period	5.89
S4	Establish project budget at an early stage of design development	5.56
S6	Project cost savings	5.56
S7	Risk management - identifying, quantifying, and allocating risks; facilitated regulations	5.00
S2	To incorporate the quality performance of the delivery	4.89
S10	Incorporate the quality performance of the delivery methods, like difficulty of facility start up, number and magnitude of call backs, and operation and maintenance costs	4.89
S3	Encourage innovation	4.78
S11	Allowance of competitive bidding	4.56
S9	Flexibility needs during construction phase; ease of change	4.22

According to the results of the Delphi study, respondents ranked the following as the top three success factors for a project delivery system decision:

- Project schedule and cost performance
- Get early construction contractor involvement
- Reduce/compress/accelerate project delivery period

CHAPTER VI

RESEARCH FINDINGS

Overview

This chapter presents the findings of the survey and compares crucial findings between DB and CMAR project delivery systems through a detailed data analysis. The findings highlight a number of issues that should be addressed by the owner and players involved in each case project to make their experience more successful and identify the gap between expectations and the realities of both DB and CMAR PDS. The researcher summarizes the qualitative and quantitative findings in this chapter based on the analysis of the survey in the previous chapter.

Summary of Main Findings

The survey was designed and improved, according to crucial literature related to comparative studies of PDS's and the lessons learned from the pilot survey. In the previous chapter, the researcher presented the data analysis according to project cost performance, schedule performance, quality performance, and characteristics of each PDS. Based on the data analysis of the survey results, this section summarizes the research findings collected from both qualitative and quantitative points of view. Moreover, the researcher presents respondents' survey comments regarding the PDS.

Cost Performance

This research has demonstrated that among the performance data related to cost, there is a significant difference between the DB and CMAR projects. The TIPS (DB) project might have more efficient and effective construction management in respect to cost since its cost was -1.5% even though it had $92.5 higher unit cost than the NCTM (CMAR) project. On the contrary, cost growth on the NCTM project increased a great deal, to 11.1% over the original cost estimate.

It is important to note that even though there was no significant difference in the amount of total final construction cost, the geographical region was the same for both case projects, and there were controlled same owner systems, the DB project still enjoyed a cost advantage. The results of the survey revealed that design costs on the DB project, estimated at 6.8% of the final construction cost amount, was not changed in the final price, but the design cost on the CMAR project, estimated at 8% of the contract award construction cost, increased by 1.3%, to 9.3% of final construction costs. This indicates that increased design costs on the CMAR project directly affected the final project cost. Essentially, the DB project delivery system provides more value for the money with the inclusion of design services in the contract award amount.

Schedule Performance

This research has shown that the TIPS (DB) project experienced greater project schedule growth (16%) than the NCTM (CMAR) project, based on the data analysis in the previous chapter. It was also demonstrated that the construction and delivery speed on CMAR were greatly faster than the DB project. However, it must be noted that these differences are remarkably significant. In fact, the increased project schedule growth on DB projects originally seems counter to most other previous studies, which believe that DB enables fast-track delivery and saves time.

Quality Performance

Through the data analysis of the survey, for quality performance, the comparison of the TIPS (DB) and NCTM (CMAR) projects reveals that there are no significant differences in terms of satisfaction with the quality performance. Furthermore, in terms of change orders, the DB project had one change order and the CMAR project had no change orders within the first year.

Summary of PDS Characteristics

Table 6.1 shows the summary of PDS characteristics and success factors collected from respondents in the second phase of the survey

Table 6.1: The Summary of PDS Characteristics and Success Factors

PDS	Advantages	Disadvantages
DB	Designer and builder are working on the same team and partnering with the designers and sub-contractors will help produce a superior product resolutions	Design-builder demands quick decisions by Owners
	Fast tracking: The total amount of time from inception to completion is reduced	Design-builder must guarantees cost at a very early stage of the project
	The product is delivered in a shorter time frame	Decisions made by the design-builder are based on the initial costs rather than life cycle costing
CMAR	Provides a Guaranteed Maximum Price (GMP)	Owner needs to have sufficient expertise to manage both contractor and designer
	Contractor identify long lead items early to avoid scheduling delays	Sometimes difficult to manage all phased packages with costs, changes & schedule
	Early cost commitment: Pricing & Cost model are developed along with design. Also, Complex scheduling & Clear schedule	Some duplication of administration and more paperwork for client
Success factors for decision Project Delivery System		
Project schedule and cost performance		
Get early construction contractor involvement		
Reduce/compress/accelerate project delivery period		

Written Respondents Comments

The respondents provided the following written comments for project success criteria based on their valuable experience. Moreover, the Facilities Planning and Construction Department in the TAMU System as owner representative offered the following comments for characteristic of DB and CMAR.

Project success criteria

1. Completed project on schedule and in budget
2. Met clients' expectations and subcontractors satisfaction
3. Met facility functions as programmed
4. Applied valuable information management technology such as BIM, resource allocation control system, indicated outcome report, etc.
5. Used state funds efficiently and appropriately

Expectations of DB and CMAR

Table 6.2 presents the expectations of DB and CMAR, as provided by the Facilities Planning and Construction Department in the TAMU System.

Table 6.2: The Expectations of DB and CMAR provided by Owner

PDS	Advantages	Disadvantages
DB	Single point of accountability for design and construction	No check and balance between architect and builder
	Enables fast-track delivery (construction begins before design is complete), saving time	Owner must select a team rather than the best architect and best builder
	Early GMP facilitates alternative financing methods	Design is completed after GMP is given
	GMP eliminates owner concern with cost overruns	Difficulty to control quality because DB team must only meet minimum criteria standards
CMAR	Construction firms selected by interview based on quality rather than low bid	Negotiate CM fee is not competitively bid
	Early CM involvement in estimating and constructability	Not suited for small projects
	Owner selects architect and CM separately and may be involved in selection of subcontractors	
	All work except CM fee is bid	
	Enables fast-track delivery (construction begins before design is complete), saving time	
	Good for large, complex projects	

Comparison between Realities and Expectations of DB and CMAR

Table 6.3 presents the comparison between the realities and the expectations of DB and CMAR in terms of time and cost, as provided by literature researches, TAMU System, and the findings from the case projects.

Table 6.3: The Comparison between Realities and Expectations of DB and CMAR

	Literature research		**Expectations of TAMU**		**Findings from case projects**	
Criteria	TIPS(DB)	NCTM(CMAR)	TIPS(DB)	NCTM(CMAR)	TIPS(DB)	NCTM(CMAR)
Time	-	-	-	-	+	-
Cost	-	-	-	-	-	+

According to literature researches and the expectations of TAMU system regarding DB and CMAR, both DB and CMAR not only enable to save time as a fast-track delivery, but also they enable to secure project cost against unexpected expense.

However, according to the results of cost and schedule performance from the two case projects, they revealed remarkable differences between the reality and the expectation of DB and CMAR.

First, while TIPS(DB) enables to save the project cost according to the expectations, the increased project schedule growth on TIPS(DB) projects originally seems to counteract to the most other previous studies and the expectations from TAMU system, which reveal that DB enables fast-track delivery and saves time. Second, for the

NCTM(CMAR) project, while it enables to save the project time, the fact that the increased project cost growth on NCTM(CMAR) project is in contrast with the most other expectations.

The researcher believed that there were undiscovered reasons or external variables that led to the project delay and an increased cost growth. Therefore, the researcher had additional meetings with each key player from the two case projects in order to discover particular reasons through an open-ended conversation.

In the following section, the researcher presents the reasons that lead to the project delay and the increased cost growth against the most other expectations.

Reasons of Differences between Reality and Expectation

In the previous chapter, the researcher presented the comparison between the reality and the expectations of DB and CMAR in terms of time and cost. Through the comparison, the researcher was able to come up with critical questions about significant differences between the reality and the expectation.

First, for what particular reason does the TIPS (DB) project reduce the total project cost while it prolongs the project duration? Are there possible external variables other than the results from the project performance data, or are there errors related to the project time management or unforeseen miscalculations during the initial construction phase?

Second, although the NCTM (CMAR) project has underwent accordingly as planned schedule, it revealed that there was somehow the cost growth. Is there inaccurate estimation of the cost, or is there difference between opinions between the contractor and TAMU system regarding the cost prior to the initiation of the construction?

In order to clarify the uncertainties, the researcher conducted open ended interviews with each of the targeted project managers from the two case projects and discovered significant reasons that may answer these questions. The research presents the findings from the interviews below.

TIPS (DB) project

First, during the consultation with TAMU system, due to TAMU's building regulation and standards, there were frequent changes in the design and the delay in initiation of the construction. Subsequently, it extended the substantial completion of the project. However, there was no delay in the construction phase and also secured the construction cost. The explanation for this is from the fact that the TIPS (DB) project cost less because the project returned $1.6M back to the TMAU system since there was no installation of the shielding material for the 7T MRI. In addition, there was only one change order during construction phase, so that the project was effectively managed according to the cost and time plan.

NCTM (CMAR) project

For the NCTM (CMAR) project, In fact, the project was initiated design development without knowing what the final product was to be produced and what equipment would be required to make it. Also, the cost for the PODs (Portable on Demand Storage) was not known at the design development phase. Furthermore, due to the TAMU's 100 year building requirement and standards, there were numerous limitations in the design and construction, and it caused 3% cost growth approximately. Therefore, an inaccurate estimation of the cost and some regulations might cause the project cost growth to be increased. However, the respondent agreed that using CMAR was thought to be the best project delivery system for a project with numerous unknowns at the initiation of a project.

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

Overview

This chapter presents contributions, limitations, and conclusions of this research. Furthermore, based on the amount of data collected and the results of the analysis performed in the previous chapters, related studies may discover other possible relationships in the future.

Contributions of the Research

This research accomplished its main goal of completing a comparative analysis of Design-build and CM at Risk Project Delivery Systems. The research was able to identify and confirm the gap and suggest ways to achieve positive project completion and owner satisfaction. The research holds several significant contributions for the academic field and the construction industry. The rest of this section presents detailed descriptions of the research contributions.

- This research allowed owners and practitioners to have a more comprehensive understanding of DB and CMAR. This understanding will help owners have more realistic expectations, thus improving and enhancing the outcome of DB and CMAR projects. This will have a direct impact on improving communication and understanding as well as improving final project results.
- The development of a clear understanding of PDS's roles to assist in properly introducing and implementing PDS to owner organizations.
- This research has identified the performance data based on RFP as a critical analysis for comparing two different PDS's. It also developed several guidelines for producing a clear report regarding a comparison among different PDSs through each performance metric.
- The opportunity to use a decision support criteria matrix comprised of certain guiding principles that will assist owners and other stakeholders in bridging the gap and in the proper delivery of projects.

Limitations of the Research

This section discusses five limitations of this research:

- Only limited respondents were included in the survey and only two case projects were studied.
- Several other potential variables may affect project performance in the case projects.
- Two case projects with different timelines were compared.
- Participant's knowledge and experience was based on self-assessment.
- Each respondent involved in the DB or CMR projects may hold biased opinions because of their position and interest.

Future Research

As the research continued, new questions and further research were revealed. The researcher identified numerous ideas for future research.

This research focused on only two building construction projects and only a few people for the survey. However, future research should study more case projects and include greater participation, in order to obtain and evaluate the performance data metric and PDS characteristic metric. This would allow future research to greatly reduce time to compare PDS with the current research.

Moreover, a clear understanding of PDS alternatives will help the TAMU System to add this information to their decision in the selection of future PDS's. Therefore, based on the performance data and PDS characteristic metrics in this research, future research would develop a decision support criteria matrix for PDS selection.

Conclusions

Currently, many researchers and stakeholders believe that effective delivery methods for construction projects are key to improving project quality and value in the construction industry. In terms of comparison between PDSs, previous research has focused on stakeholders' expectations regarding the benefits of a PDS, surmising that these delivery systems would be an essential way to resolve all challenges currently encountered in traditional PDS. However, this researcher believes that the use of DB and CMAR PDS's needs to be validated by matching the realities of the two PDSs', as based on literature reviews. Consequently, stakeholders will be able to understand characteristics, differences, and success factors of two different PDSs based on the comparative study. Furthermore, they will be able to consider selecting an appropriate PDS according to the comparison between DB and CMAR based on quantitative and qualitative analysis.

For this reason, the researcher identified performance data and benefits, drawbacks, and success factors of DB and CMAR through survey and case projects and also analyzed performance data collected from two case projects.

Therefore, based on the primary objective of this research, comparing the efficiency of DB and CMAR through quantitative and qualitative analysis the results of this research must be presented to the TAMU System to establish a selection guide for PDS. In the future, the researcher believes that this research could be used to develop a decision support system for owners to select an appropriate PDS.

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APPENDIX A

SURVEY QUESTIONNAIRE

Project Delivery System Survey

Construction Science Department
Texas A&M

Introductions

The main purpose of this survey is to compare two alternative project delivery systems that are emerging in recent years. (Design-Build and CM at Risk)

Upon receipt of your response, Texas A&M will number each copy, remove company identification, and remove project identification. The information you provide will be kept in strict confidentiality.

This survey is divided into two phases:

Phase I: Survey 1&2 of Projects Performance

Phase II: Rating performance of each alternative project delivery systems characteristics

Definitions

Design-build is an agreement between an owner and a single entity to perform both design and construction under a single design-build contract. Portions or all of the design and construction may be performed by the entity or subcontracted to other companies.

In the **CM at Risk**, the owner contracts with a design company to provide a facility design. The owner separately selects a contractor to perform construction management services and construction work in accordance with the plans and specifications for a fee. The contractor usually has significant input in the design process and generally guarantees the maximum construction price.

▪**Name:** ____________________ ▪**Date:** ____________________

▪**Title:** ____________________ ▪**Time:** ____________________

PHASE I. Project Performance

Section 1. Survey 1&2 of Projects Characteristics

Project name: **Project location:**

Phone number:

Company name:

Building gross square footage: ________sf

Progress Percentage of Completion: ________%

Section 2. Project Delivery System

Mark the appropriate oval for the project delivery system which best suits that used on your project
Furthermore, Mark the appropriate oval for the commercial terms used for the design-builder or designer and contractor: ***(If cost plus, please state fee type in blank provided)***

O **Construction Management at Risk**

Contractor	**O Lump Sum**	**O Cost Plus___Fee**	**O GMP**

O **Design – Build**

Design – Builder	**O Lump Sum**	**O Cost Plus___Fee**	**O GMP**
Architect / Designer	**O Lump Sum**	**O Cost Plus___Fee**	**O GMP**

*Based on Konchar & Sanvido, 1998; McWhirt 2007; Swarup 2010

Section 3. Project Schedule Performance

Please Provide the following schedule information: *__* Up to Foundation Work__*

Item	As Planned (mm/dd/yy)	As Built (mm/dd/yy)
Design Start Date (Notice to proceed)		
Construction Start Date (Notice to proceed)		
Construction End Date (Substantial Completion)		

If you are the Owner how satisfied are you with the schedule performance of the project?

O 1. (Did not meet) O 2. O3. (Met) O 4. O 5. (Exceeded)

Section 4. Project Cost Performance

What are the following total project costs? Indicate whether estimated (E) or actual (A). Please deduct all property costs, owner costs of installed process or manufacturing equipment, furnishings, fittings and equipment, or items not a cost of the building.

Stage / Cost	Design Costs	Construction Costs	Total Project Costs
Budget			
Contract Award			
Final Cost			

Please estimate the cost of site work (work done outside the footprint of the building) as the percent (%) of final construction costs: ________%

If you are the Owner, are you satisfied with the cost performance if any?

O 1. (Did not meet) O 2. O3. (Met) O 4. O 5. (Exceeded)

What percentage of final construction cost was the design fee? ________%

Approximately, what percentage of cost growth related to external factors? (e.g. weather, material delay, government regulations)?

Section 5. Project Quality Performance

Mark the appropriate ovals to evaluate the quality of the building:

Are you satisfied with the cost performance?

O 1. (Low)	**O 2.**	**O3. (Medium)**	**O 4.**	**O 5. (High)**

Number and magnitude of call backs within fist year

O 1. (1 or 2)	**O 2.**	**O3. (5 or 6)**	**O 4.**	**O 5. (10 or more)**

Did the quality of foundation meet your expectations?

O 1. (Low)	**O 2.**	**O3. (Medium)**	**O 4.**	**O 5. (High)**

Did the quality of site layout meet your expectations?

O 1. (Low)	**O 2.**	**O3. (Medium)**	**O 4.**	**O 5. (High)**

Section 6. Project Success Criteria

Please list the criteria your organization uses to measure success and then mark the appropriate oval to rank each as it applied to your project:

1. ______________________________

O 1. (Poor)   O 2.   O3. (Average)   O 4.   O 5. (Excellent)

2. ______________________________

O 1. (Poor)   O 2.   O3. (Average)   O 4.   O 5. (Excellent)

3. ______________________________

O 1. (Poor)   O 2.   O3. (Average)   O 4.   O 5. (Excellent)

4. ______________________________

O 1. (Poor)   O 2.   O3. (Average)   O 4.   O 5. (Excellent)

5. ______________________________

O 1. (Poor)   O 2.   O3. (Average)   O 4.   O 5. (Excellent)

Mark the appropriate oval to rate the overall success of the project:

O 1. (Poor)   O 2.   O3. (Average)   O 4.   O 5. (Excellent)

PHASE II. Rating Performance of Characteristics

Project Delivery Systems

Section 1. Advantages & Disadvantage of PDSs

The following list was compiled from literatures reviewed.
Please rate each of the following advantages or benefits according to its relative importance in achieving success of a project.
Furthermore, Please rate each of the following disadvantages or drawbacks according to its need to be addressed to improve each of project delivery systems

Please use the following scale:

☐	☐	☐	☐	☐	☐	☐
1 **Strongly Disagree**	**2** **Disagree**	**3** **Conditionally Disagree**	**4** **Neutral**	**5** **Conditionally Agree**	**6** **Agree**	**7** **Strongly Agree**

Design-Build

Advantages
(Benefits)

Scale	Description
____	**Allows Owner to control guaranteed maximum price at an early stage of the project and control project cost during construction**
____	**Design Builder has control over the design and the cost of the project**
____	**The total cost of the project is lower than other systems especially a similar design-bid-build project**
____	**The product is delivered in a shorter time frame**
____	**Reduces administration time from reduced claims and issues resolutions**

______	**Fast tracking: The total amount of time from inception to completion is reduced**
______	**Improved constructability and enhanced product and process quality**
______	**Designer and builder are working on the same team and partnering with the designers and sub-contractors will help produce a superior product resolutions**
______	**Less change orders (error and omissions are the Design Builder's responsibility)**

Are there any other benefits or advantages that you would like to add to the above list? Please give rating for each item you add. Use (1) to (7) the scale

---

Disadvantages (Drawbacks/ Risk/ Concerns)

Scale	**Description**
______	**Design-builder must guarantees cost at a very early stage of the project**
______	**Decisions made by the design-builder are based on the initial costs rather than life cycle costing**
______	**Substantial financial burden by the Designer in the development of the proposal**
______	**Owners have less control over design process than with other PDSs and owners perceive the loss of control over the design and during construction**
______	**Requires increased Owner skill level on front-end work (preparation of RFP**
______	**Design-builder demands quick decisions by Owners**
______	**DB meets the performance criteria through the cheapest material and minimum design**
______	**Less checks and balances. No third party to act as a watchdog for the Owner**
______	**Lack of project definition prior to contract award (Quality of the RFP)**

Are there any other drawbacks or disadvantages that you would like to add to the above list? Please give rating for each item you add. Use (1) to (7) the scale

CM at Risk

Advantages
(Benefits)

Scale	Description
_____	**Early cost commitment: Pricing & Cost model are developed along with design**
_____	**Provides opportunities for time and cost savings**
_____	**Provides a Guaranteed Maximum Price (GMP)**
_____	**Complex scheduling & Clear schedule**
_____	**Reduce the time for construction through fast track delivery and reduces the real time required to complete the project from conception to completion**
_____	**Contractor identify long lead items early to avoid scheduling delays**
_____	**Contractor review of the documents reduces error and omissions**
_____	**Team building through partnering is a key element in the project's success**
_____	**Provide the opportunity to be flexible for the implementation of supplemental technology**

Are there any other benefits or advantages that you would like to add to the above list? Please give rating for each item you add. Use (1) to (7) the scale

Disadvantages (Drawbacks/ Risk/ Concerns)

Scale	Description
_____	**Managerial role of contractor adds more cost to the project's total design budget. This cost may be offset by the savings resulting from improved design and constructability**
_____	**Sometimes difficult to manage all phased packages with costs, changes & schedule**
_____	**Linear process, which may cause some time delays**
_____	**Fast tracking difficult to control with Designer & Construction manager**
_____	**Designer & builder still have separate contractual relationships with the owner and can be a source of conflict**
_____	**Owner needs to have sufficient expertise to manage both contractor and designer**
_____	**Potential philosophical disconnect**
_____	**Some duplication of administration and more paperwork for client**
_____	**Contractor must be comfortable being directly responsible to the owner**

Are there any other drawbacks or disadvantages that you would like to add to the above list? Please give rating for each item you add. Use (1) to (7) the scale

____

Section 2. Success factors for decision PDS

The following list was compiled from literatures reviewed.
Please rank each of the following success factors to its relative importance in encouraging you to select a project delivery system.

Scale	Description
______	Reduce/compress/accelerate project delivery period
______	To incorporate the quality performance of the delivery
______	Encourage innovation
______	Establish project budget at an early stage of design development
______	Project schedule and cost performance
______	Project cost savings
______	Risk management - identifying, quantifying, and allocating risks; facilitated regulations
______	Get early construction contractor involvement
______	Flexibility needs during construction phase; ease of change
______	Incorporate the quality performance of the delivery methods, like difficulty of facility start up, number and magnitude of call backs, and operation and maintenance costs
______	Allowance of competitive bidding

Are there any other success factors that you would like to add to the above list?

APPENDIX B

PERFORMANCE DATA AND ANALYSIS

PDS	#	**Respondents**									**Total**	**Mean**	**Rank**
		R 1	R 2	R 3	R 4	R 5	R 6	R 7	R 8	R 9			
DB	A6	5	6	5	6	6	6	7	7	6	54	6.00	1
	A8	6	5	7	6	5	6	7	7	5	54	6.00	1
	A4	6	6	5	4	5	6	7	7	6	52	5.78	3
	A7	5	5	6	7	4	5	5	6	5	48	5.33	4
	A1	6	6	5	5	4	5	6	5	5	47	5.22	5
	A9	3	4	6	6	6	4	6	6	5	46	5.11	6
	A2	3	4	7	6	5	5	5	5	4	44	4.89	7
	A5	4	4	6	6	2	6	5	6	4	43	4.78	8
	A3	4	5	3	4	4	4	6	5	6	41	4.56	9
	D6	6	7	4	4	6	6	7	5	5	50	5.56	1
	D1	6	6	5	6	6	4	3	4	5	45	5.00	2
	D2	6	7	4	5	6	6	2	2	4	42	4.67	3
	D5	6	6	5	5	6	3	3	2	4	40	4.44	4
	D9	4	3	4	5	4	6	4	4	2	36	4.00	5
	D4	5	4	6	5	5	3	1	3	2	34	3.78	6
	D3	2	2	4	4	6	4	2	4	4	32	3.56	7
	D7	3	3	4	4	2	4	4	1	3	28	3.11	8
	D8	2	1	5	5	2	4	1	3	2	25	2.78	9
CMR	A3	7	6	6	6	6	6	5	7	6	55	6.11	1
	A6	6	5	6	6	6	6	5	6	7	53	5.89	2
	A1	6	5	6	6	6	6	6	5	5	51	5.67	3
	A4	6	4	6	6	6	6	5	6	6	51	5.67	3
	A5	5	4	6	6	6	6	5	6	6	50	5.56	5
	A2	6	5	4	5	6	6	5	6	6	49	5.44	6
	A8	5	4	4	5	6	6	7	7	5	49	5.44	6
	A7	5	3	5	6	6	5	6	6	6	48	5.33	8
	A9	6	3	5	4	6	5	6	6	6	47	5.22	9
	D6	7	7	6	6	6	5	5	5	6	53	5.89	1
	D2	7	6	6	7	2	4	6	5	6	49	5.44	2
	D8	7	4	6	6	6	6	6	4	4	49	5.44	2
	D5	7	4	6	7	6	5	5	3	3	46	5.11	4
	D9	5	7	7	6	6	6	6	2	1	46	5.11	4
	D3	5	5	7	7	2	5	4	4	4	43	4.78	6
	D4	7	5	6	5	6	5	4	2	3	43	4.78	6
	D7	7	4	5	5	2	4	4	4	5	40	4.44	8
	D1	6	4	7	6	2	4	3	3	2	37	4.11	9

Success Factor	S5	7	6	6	6	6	6	7	6	5	55	6.11	1
	S8	7	7	7	6	6	4	7	6	5	55	6.11	1
	S1	7	6	5	5	6	7	6	6	5	53	5.89	3
	S4	7	5	6	5	6	5	6	6	4	50	5.56	4
	S6	5	4	7	7	6	6	5	6	4	50	5.56	4
	S7	7	5	6	6	6	3	3	5	4	45	5.00	6
	S2	5	6	6	5	6	4	5	5	2	44	4.89	7
	S10	6	4	5	5	6	5	4	4	5	44	4.89	7
	S3	5	4	5	6	6	2	6	5	4	43	4.78	9
	S11	6	3	5	5	6	3	5	4	4	41	4.56	10
	S9	5	3	5	5	6	3	3	4	4	38	4.22	11

APPENDIX C

TEXAS A&M UNIVERSITY
DIVISION OF RESEARCH AND GRADUATE STUDIES - OFFICE OF RESEARCH COMPLIANCE

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Human Subjects Protection Program — Institutional Review Board

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DATE: 04-Jan-2011

MEMORANDUM

TO: PARK, SOONROCK
77843-3578

FROM: Office of Research Compliance
Institutional Review Board

SUBJECT: Initial Review

Protocol Number:	2010-0947
Title:	Comparative study of Project Delivery System
Review Category:	Exempt from IRB Review

It has been determined that the referenced protocol application meets the criteria for exemption and no further review is required. However, any amendment or modification to the protocol must be reported to the IRB and reviewed before being implemented to ensure the protocol still meets the criteria for exemption.

This determination was based on the following Code of Federal Regulations:

45 CFR 46.101(b)(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior, unless: (a) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (b) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil

liability or be damaging to the subjects' financial standing, employability, or reputation.

Provisions:

This electronic document provides notification of the review results by the Institutional Review Board.

VITA

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