Owner's Guideline for Project Delivery Method Selection

by

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ABSTRACT

Many public agencies and/or private owners have no standards that help them to select the most suitable delivery method for their capital projects; hence, in some cases, this results in selecting the inappropriate project delivery method. This adversely impacts the project performance and leads to many negative consequences; starting with schedule growth, cost overrun, and may end up in an epic failure of the project. This research mainly focuses on developing a guideline to help owners make the decision on selecting the most appropriate delivery method for their capital projects. This research goes through three stages: Stage 1 - An extensive literature review of past research is conducted to conclude the selection factors considered in the decision-making process and the decision analysis technique and the project delivery methods; Stage 2 - This stage includes building up the selection model and setting out its guidelines; Stage 3 - This is the final stage of the research thread and includes the validation of the selection model through applying this model on some case study projects by industry practitioners, then evaluating the final results. The owner's guideline for project delivery method selection, developed within this research, is designed to help owners increase the project success likelihood by selecting the suitable project delivery methods during the pre-construction phase (planning phase of the project life cycle).

ACKNOWLEDGMENTS

I hereby extend my gratitude to all my committee members and special thanks to Prof. Wylie Bearup and my committee chair, Prof. Kenneth Sullivan, who never hesitate to lend me a hand whenever I need during my study journey at Arizona State University (ASU). Also, I'd like to take this time to thank Abdulla Al Ghurair Foundation for Education in Dubai, UAE for their financial support which grants me the opportunity to pursue my master's degree at Arizona State University (ASU).

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CHAPTER 1

INTRODUCTION

1.1. Problem Statement

Selection of the suitable project delivery method is critical for the project success as by definition, project delivery method is the system designed to achieve the satisfactory completion of a construction project from conception to occupancy (Construction Management Association of America, 2012). However, many public agencies and private owners have no standards that guide them in making the decision on selecting the suitable delivery method for their capital projects. As a result, this gives rise to many negative consequences, such as project schedule growth (delay), cost overrun, etc., and may end up in an epic failure of the project. This highlights the importance of having a guideline to help project owners make the right decision on project delivery method selection.

1.2. Research Objective

As previously mentioned, selection of the appropriate project delivery method is crucial for the project success. This fact is the motivation for this research. This research aims to develop a guideline to help public agencies / private owners select the most convenient project delivery method for their capital projects. As result, project owners can use this guideline, during the project planning phase, to select the suitable project delivery method. Therefore, they can avoid many future issues and increase the project success likelihood. Another aim of this research is to raise the awareness over the Public Private Partnership (P3) as an available finance mechanism, which can help in solving the problem of lack of funds, especially for public agencies / owners.

1.3. Research Methodology Summary

This research consists of a methodology, which is comprised of the following three main stages:

- Stage (1): This is the stage of data collection, which includes conducting an extensive literature review of past research and peer-reviewed published research articles to conclude the selection factors considered in the decision-making process and the decision analysis technique and the project delivery methods. The literature review conclusion is the basis for this research, which is used when developing the selection model in Stage 2.
- Stage (2): In this stage, after examining the past literature review and defining the influential selection factors in the decision-making process and the decision analysis technique, the selection model will be developed considering the literature review conclusion.
- Stage (3): This is the final stage in which the previously developed selection model will be validated through applying this selection model on some case study projects, then comparing the outcome to the actual results by industry practitioners, i.e., comparing the proposed project delivery method by the selection model with the actual delivery method used for the project and giving remarks and feedback by industry practitioners.

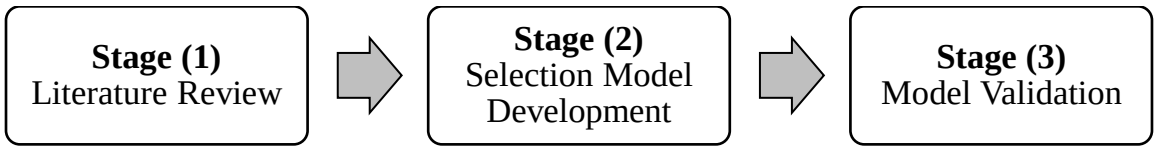


Figure 1: Research Methodology

1.4. Research Scope

This research scope includes developing a guideline that help owners in making decision on selecting the most suitable project delivery method for their projects. However, it seems that this guideline is inclusive for all types of projects, the research is based on a group of assumptions and bound by a set of limitations for the purpose of developing this research, as shown below:

1.4.1. Assumptions

- The data collection required for this research, is mainly based on the literature review of past research and peer-reviewed published articles and it shall be considered inclusive and presented without bias.
- The feedback and remarks received from industry practitioners about the final selection model, shall be used for the model validation (Yin, 2003) and (Touran, et al., 2009b).

1.4.2. Limitations

- This selection guideline is designed for infrastructure projects with a focus on highway, road, and bridge projects.
- This selection guideline considers only the project delivery methods, prevalent in Arizona State which are Design-Bid-Build (DBB), Design-Build (DB), Construction Management at Risk (CMR), Job Order Contracting (JOC) and Design-Build-Finance-Operate-Maintain (DBFOM). DBFOM is a variation of the DB delivery method which benefits from the Public Private Partnership (P3) mechanism.
- Selection factors used for the development of this guideline are aligned with the applicable laws and regulations in the State of Arizona.

CHAPTER 2

LITERATURE REVIEW

This chapter gives a review of the past literature, related to the area of decision making on selecting the most appropriate project delivery methods by owners for capital projects. This is the first step to establish the guideline required to help public and private owners in making the right decision of selecting the suitable delivery method for their projects. The literature review provides information about the currently used project delivery methods and selection factors and the decision analysis technique which will be a solid base to consider while developing the guideline.

2.1. Project Delivery Methods Characteristics

This section of the literature review gives an overview of the characteristics of the common project delivery methods, highlighting the key parties involved in the project and their roles and responsibilities, in addition to the advantages and disadvantages of each delivery method. It is very important to educate the project owners on the characteristics of each project delivery method and keep them aware of the advantages and disadvantages of each project delivery method so that the project owners can select the suitable delivery method for the project, according to each project characteristics, as selection of the appropriate delivery method facilitates the project success (Oyetunji & Anderson, 2001).

2.1.1. Design-Bid-Build (DBB)

Design-Bid-Build (DBB) is the traditional project delivery method that is widely used in public and private projects in the United States (Ghavamifar & Touran, 2008). As shown in **Figure 2**, the Design-Bid-Build (DBB) delivery method adopts sequential phases to

deliver the project that start with selection of the architect / engineer who prepares the design, then the design stage, and afterwards, the bidding phase and selection of the contractor, and ultimately, the construction phase.

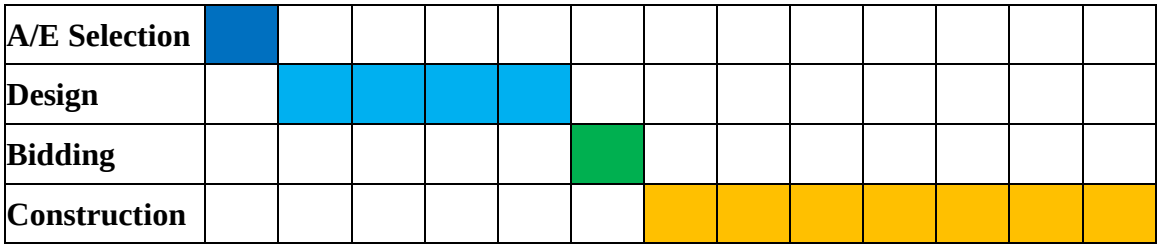


Figure 2: Design-Bid-Build (DBB) Phases

Accordingly, the Design-Bid-Build (DBB) has three prime roles in the project delivery process, which are owner, architect, and contractor. Therefore, the owner has to sign two separate contracts, which are owner - architect and owner - contractor (Joint Committee of AIA and AGC of America, 2011). The first contract is to appoint an architect / engineer to prepare the design and help in the bidding process and construction administration while the second contract is for hiring a general contractor to perform the construction work. Consequently, there is no formal relationship between the architect and contractor, as shown in **Figure 3**.

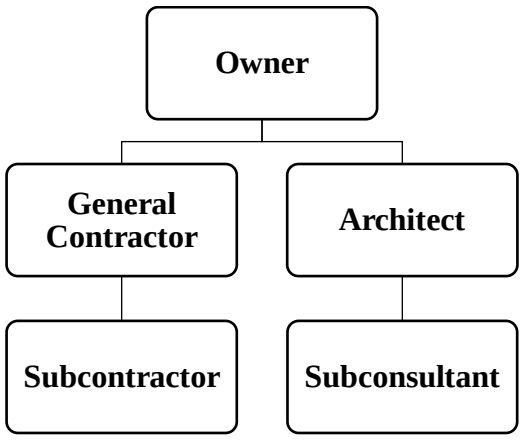


Figure 3: Design-Bid-Build (DBB) delivery method hierarchy

The Design-Bid-Build (DBB) has some advantages and disadvantages. (Touran, et al., 2009b) stated several advantages of the DBB delivery method. The DBB is applicable to work on projects of all sizes, and it is using the low bid selection method that awards the project to the lowest satisfactory bid so the owner can benefit from cost saving. Moreover, DBB provides better control over the project and single point responsibility for construction besides using design at the time of project award before the start of construction, which allows for stakeholders' input and better owner's control of lifecycle cost through review of performance specifications and maintenance issues in designs. Additionally, (Rojas & Kell, 2008) added some benefits that DBB allows freedom on contractor selection. On the other hand, (Touran, et al., 2009b) mentioned some DBB disadvantages, such as constructability advice and contractor innovations are not available in the design phase. Consequently, this results in change orders, claims, cost growth, and schedule growth in the construction phase due to the design conflict issues. Moreover, DBB has a longer schedule due to its linear nature, and it typically requires a higher level of owner involvement and bigger owner's staff, accordingly.

Ultimately, knowing the pros and cons of the delivery method and its characteristics gives a better understanding of the delivery method and when to select it. Therefore, the following below data about DBB characteristics are summarized from (Joint Committee of AIA and AGC of America, 2011):

- Three prime players: owner, architect, builder.
- Two separate contracts: owner-architect, owner-builder.
- Final contractor selection based on lowest responsible bid or total contract price.
- Three linear phases: design, bid, build.

- Well-established and broadly documented roles.
- Carefully crafted legal and procedural guidelines.
- The lowest responsible bid that provides a reliable market price for the project.
- Construction planning based on completed documents.
- Complete specifications that produce clear quality standards.

2.1.2. Design-Build (DB)

Design-Build (DB) is the oldest delivery method in the construction industry. The practice goes back in history for centuries, as many large cathedrals of Europe were built by master builders who were roughly equivalent to today's DB contractors (Ghavamifar & Touran, 2008). Design-Build (DB) is an alternative project delivery method, which is currently widely used to deliver highway and bridge projects in United States because of its favorable delivery speed (Minchin Jr., Li, Issa, & Vargas, 2013). As shown in **Figure 4**, the Design-Build (DB) delivery method takes on concurrent or sequential phases to deliver the project that begin with finalizing the preliminary design and defining the performance requirements by the owner. Then selection of the design-build entity (EPC contractor), which completes the detailed design, often simultaneously, with the project construction.

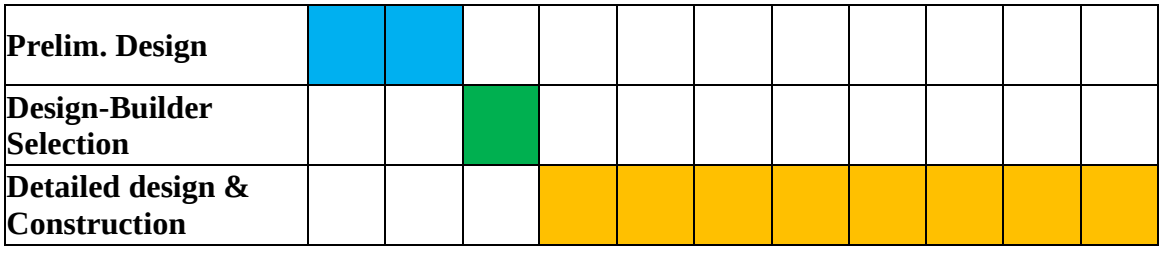


Figure 4: Design-Build (DB) Phases

The Design-Build (DB) has two prime roles in the project delivery process: owner and design-build entity (EPC contractor). Therefore, the owner has to sign one contract, which is the owner and design-build entity (EPC contractor) (Joint Committee of AIA and AGC of America, 2011). This single contract provides the owner with a single point of contact and responsibility for the design and construction, as shown in **Figure 5**.

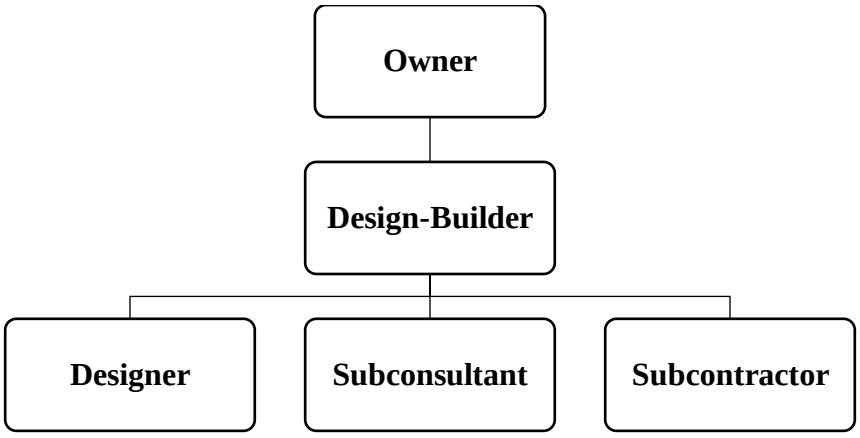


Figure 5: Design-Build (DB) delivery method hierarchy

However, the Design-Build (DB) is one of the most common project delivery method; it has some disadvantages besides its advantages. According to (Touran, et al., 2009b), the DB delivery method has several advantages. The DB is applicable to work on projects of all sizes with better performance than other delivery methods on large and complex projects due to having a single point of contact and responsibility. The DB provides the best value to the owner, as the design-builder is selected based on qualifications. Moreover, the DB has a less cost growth and financial risk to the owner by comparison with other delivery methods, especially when using the GMP contract. Also, the DB has a better control over project schedule and usually delivers the project faster than other delivery methods. Another advantage from the owner's perspective is that the DB eliminates the owner's design risk and transfers all the design and construction risk to

the design-build contractor. On the other hand, (Touran, et al., 2009b) listed some DB disadvantages, such as the DB deprives the owner of the checks and balances of having a 100%-complete design prior to start of construction. Also, the rapid nature of the DB delivery method requires much of the owner's effort in design and construction review to make sure of meeting the preliminary design and performance specifications.

To develop a better understanding of the DB delivery method, the (Joint Committee of AIA and AGC of America, 2011) has summarized the main characteristics of DB delivery method as follows:

- Two prime players: owner, design-build entity.
- One contract: owner to design-build entity.
- Final design-builder selection may be based on any of the following: Direct Negotiation, Qualifications Based Selection, Best Value: Fees or Total Project Cost.
- Overlapping phases: design and build
- Overall project planning and scheduling are performed by the design-build entity prior to mobilization.

2.1.3. Construction Manager at Risk (CMR)

Construction Manager at Risk (CMR) is an alternative project delivery method in which a contractor is introduced early during the project design phase to help the owner with managerial duties and also to increase the feasibility and constructability of the design (Ghavamifar & Touran, 2008). As shown in **Figure 6**, the Construction Manager at Risk (CMR) delivery method has overlapping or sequential phases to deliver the project that start with the selection of an architect / engineer who prepares the design, simultaneously

or earlier to the selection of a CMR. Afterwards, the design stage begins in overlapping with the construction stage in which the architect prepares the design, while the CMR provides pre-construction services, such as preparing project schedule, providing design review services (constructability and biddability review), and preparing the project cost estimate and the GMP package. Finally, the CMR contractor executes the construction works as soon as a certain amount of the design is finished, and the project is well-defined.

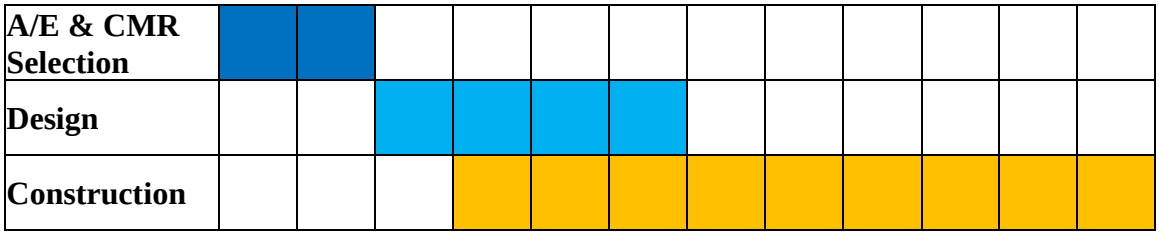


Figure 6: Construction Manager at Risk (CMR) Phases

According to (Joint Committee of AIA and AGC of America, 2011), the Construction Manager at Risk (CMR) has three prime roles in the project delivery process: owner, architect, and CMR. Accordingly, the owner signs two separate contracts during the pre-construction phase (design phase), owner - architect and owner – CMR, and signs another contract with the CMR for execution the construction works during the construction phase. During the design phase, the owner hires an architect to prepare the design and employs a CMR to provide pre-construction services, as discussed above. As soon as a significant amount of the design is finalized by the architect and the GMP package is prepared by the CMR, the owner signs a GMP contract with the CMR to perform the construction works. **Figure 7** illustrates the relationship among the three prime roles in the CMR delivery method and highlights that there is no contractual relationship between the architect and the CMR in any stage of the project.

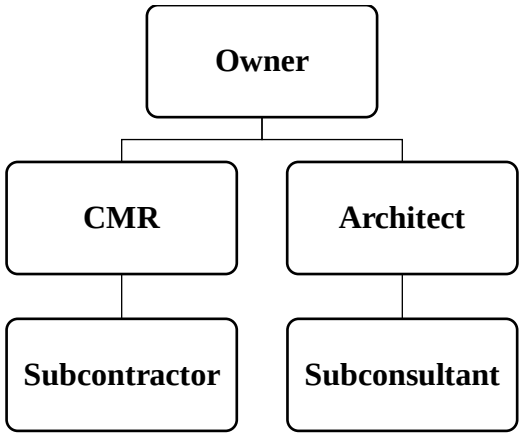


Figure 7: Construction Manager at Risk (CMR) delivery method hierarchy

As discussed before, any project delivery methods have advantages and disadvantages. According to (Touran, et al., 2009b), the CMR delivery method has several advantages. CMR is applicable to work on projects of all sizes and provides the best value to the owner, as the CMR is selected based on qualifications or best value. Also, CMR allows for early involvement of the contractor, during the design phase, to provide pre-construction services, such as design review (constructability and biddability review), value engineering, project scheduling and cost estimate. That way, the owner can eliminate any future issues due to design conflicts, hence less schedule growth and better cost saving. Also, the CMR transfers all the financial risk to the contractor, as the GMP contract puts a cap on the project cost; for example, in case of exceeding this limit, the contractor alone incurs this extra cost. Furthermore, CMR is facilitating the project fast-tracking due to the overlapping of design and construction, but it is still slower than the DB delivery method. Besides previous mentioned advantages, (Rojas & Kell, 2008) added that having the architect and the CMR in one team during the design phase enhances the spirit of cooperation and eliminates the adversarial relationships. With that being said, (Touran, et al., 2009b) stated some disadvantages of the CMR delivery method, such as the owner

usually needs a well-versed staff to manage the design development and the contractor's inputs during the design phase in addition to negotiating the prices under GMP contract.

Ultimately, for better understanding of the CMR delivery method, the (Joint Committee of AIA and AGC of America, 2011) has stated the main characteristics of CMR:

- Three prime players: owner, architect, CM at-Risk.
- Two separate contracts: owner to architect, owner to CM at-Risk.
- Final provider selection based on Qualifications Based Selection or Best Value: Fees.
- Hiring of the CM at-Risk during the design phase.
- Establishment of a guaranteed maximum price.
- Overlapping phases: design and build.
- Preconstruction services offered by the CMR such as: constructability review.

2.1.4. Job Order Contracting (JOC)

Job Order Contracting (JOC) is an alternative project delivery method in which a single contract for multiple, small projects (typically termed delivery, job, or task orders) of a similar technical scope for which the actual scope, timing, cost, and work orders are not quantified at the time of award (Francom, Ariaratnam, & El Asmar, 2016). An example of this is when a qualified contractor(s) is put on standby to perform construction services to be determined in the future (Rueda-Benavides & Gransberg, 2014). As shown below in **Figure 8**, the Job Order Contracting (JOC) delivery method has phased stages to deliver the project that start with the selection of a contractor(s), based on qualifications or best value. Further, the qualified contractor(s) is put on standby in a ranked list for future needs.

Thereafter, the qualified contractor(s) is awarded a contract for the job as soon as a need for the work arises. The job scope may include services, such as design, pre-construction services, operations, maintenance, renovation, and construction.

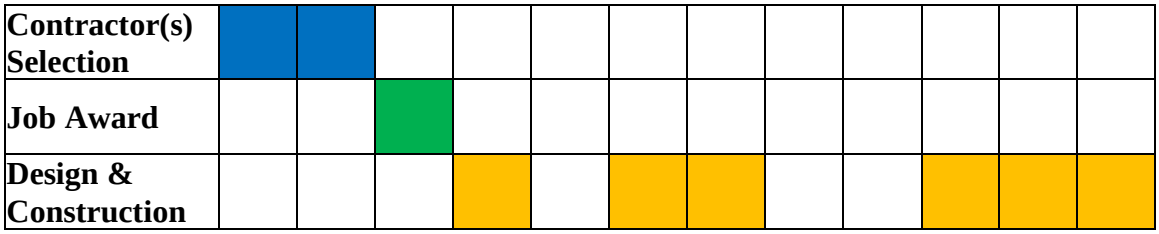


Figure 8: Job Order Contracting (JOC) Phases

According to (Gransberg, Benavides, & Loulakis, 2015), the Job Order Contracting (JOC) has two prime and one secondary roles in the project delivery process; owner, contractor (prime players) and architect (secondary player), as shown below in **Figure 9**. Hence upon award, the owner signs only one contract with the qualified contractor, as in most cases, the contractor takes over the design preparation as a design-builder or there is an already hired architect by the owner, to prepare the design. Further, (Rueda-Benavides & Gransberg, 2014) have defined three models through which JOC is usually offered:

- Single work order - two step selection (RFQ then RFP): A single contract is awarded to a single contractor who performs the desired services on demand.
- Single award - one step selection (IFB): A single contract is bidded out and awarded to a single contractor based on best value.
- Multiple award - two step selection (RFQ then RFP): A single contract is bidded out and a pool of qualified contractors is shortlisted based on qualifications, then the contract is awarded to the shortlisted contractor whose offer is the lowest price.

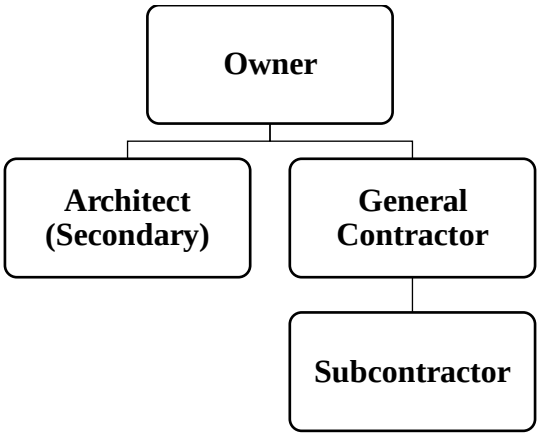


Figure 9: Job order contracting (JOC) delivery method hierarchy

However, the Job Order Contracting (JOC) is gaining popularity due to its advantages; it still has some drawbacks. (Gransberg, Benavides, & Loulakis, 2015) provided some of these disadvantages, such as JOC requires experienced staff who are familiar with the JOC procedures and usage of the unit price book. Moreover, it lacks development of detailed estimates and schedules at contract level, i.e., the pricing model (unit prices), which is set up front may lead to higher cost due to uncertainty borne by contractor. On the other hand, (Rueda-Benavides & Gransberg, 2014) listed some advantages of the JOC, such as JOC provides better funding flexibility and less pre-construction / overhead cost. Also, it ensures best value to the owner, as the contractor is selected based on qualifications or best value. Moreover, it produces high quality product as it gives an incentive to the contractor to maintain highest owner satisfaction to stay qualified for future work. Additionally, it provides fast project delivery and is well suited for routine and repetitive work.

To give a holistic overview of the Job Order Contracting (JOC), (Gransberg, Benavides, & Loulakis, 2015) formulated the main characteristics of the JOC that can be summarized in the following:

- Two prime players and one secondary: owner, contractor (prime players) and architect (secondary player).
- One contract: owner to contractor, upon award.
- Final provider selection based on Qualifications Based Selection or Best Value.
- Standby contract process where work is accomplished over time on an as-needed basis.
- Using of the unit price book that includes unit prices set up upfront for construction.

2.1.5. Public Private Partnership (P3)

Public Private Partnership (P3) is an innovative approach that has recently evolved due to the lack of public fund amid a growing demand for public infrastructure facilities. This public fund shortage contributed to the emergence of the P3 project. By FHWA definition, Public Private Partnership (P3) is an integrated approach where a public agency enters a contractual agreement with a private sector entity to deliver a project (service or facility) within a specific period. Under this agreement, the private sector entity is solely responsible for the design, construction, finance, operations, and maintenance of the facility for a specified concession period (Federal Highway Administration (FHWA), 2016). According to (Federal Highway Administration (FHWA), 2016), Public Private Partnership (P3) comes in different delivery models, such as Design-Build-Finance (DBF), Design-Build-Maintain (DBM), Design-Build-Operate-Maintain (DBOM), and Design-Build-Finance-Operate-Maintain (DBFOM). However, the focus of this research is on the Design-Build-Finance-Operate-Maintain (DBFOM) exclusively. The Design-Build-Finance-Operate-Maintain (DBFOM) is similar to the Design-Build (DB) delivery method in terms of project phases and their sequence, although the DBFOM extends beyond

construction, as it includes the project operation. The Design-Build-Finance-Operate-Maintain (DBFOM) delivery method also follows a concurrent or sequential phase to deliver the project that begin with completion of the preliminary design by the owner, then selection of the private partner that takes over the detailed design and construction, then ultimately, the project operation and maintenance. **Figure 10** illustrates the typical phases of the DBFOM and their sequence.

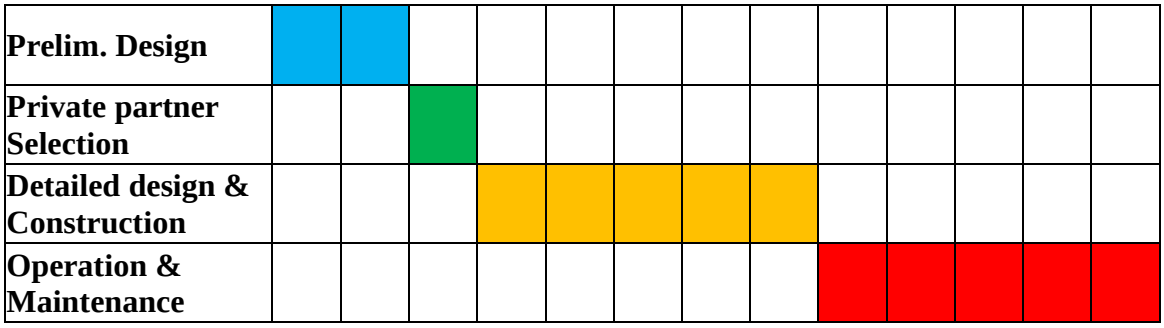


Figure 10: Design-Build-Finance-Operate-Maintain (DBFOM) Phases

Likewise, the Design-Build (DB) delivery method and the Design-Build-Finance-Operate-Maintain (DBFOM) have two prime roles in the project delivery process, public owner, private partner so the public owner signs one single contract, public owner and private partner that bundles together the responsibilities of detailed design, construction, financing, maintenance and operation (Federal Highway Administration (FHWA), 2016). **Figure 11** below, shows the typical organizational structure of DBFOM delivery method.

There is a growing trend in United States to use the Public Private Partnership (P3) approach to deliver the public capital projects because of its advantages. (Federal Highway Administration (FHWA), 2016) defined some of these advantages. DBFOM provides public owner with all the potential benefits of the DB method such as: project acceleration and having the private partner as a single point of contact and responsibility.

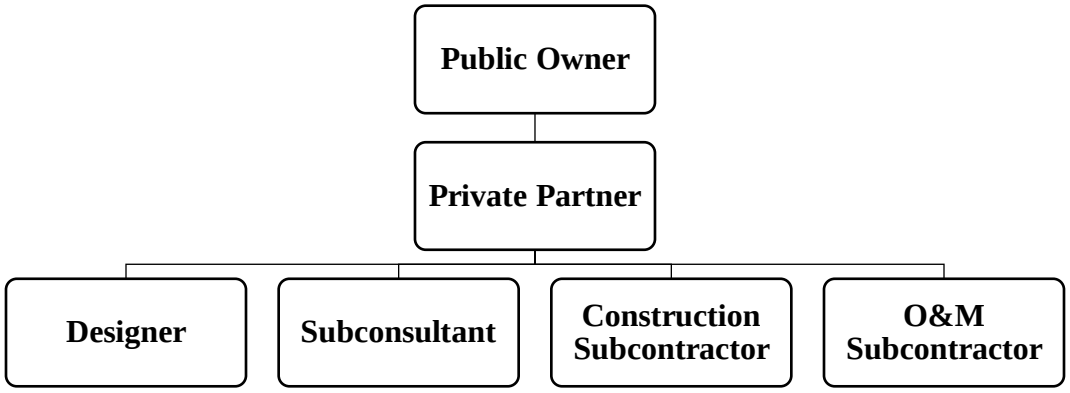


Figure 11: Design-Build-Finance-Operate-Maintain (DBFOM) delivery method hierarchy

Additionally, bundling the operation of project with the design, construction, and finance adds lifecycle benefits to the public owners as this bundle of responsibilities stimulates the private partner to apply cost-saving, life-cycle costing principles to align the project design with long-term maintenance needs, and hence, better quality and service. Furthermore, DBFOM transfers the project financial risk to the private partner and provides owners with access to new sources of financing, including private sector equity besides eliminating the issue of shortage of required funds for capital projects. Also, (Touran, et al., 2009b) added that having the private partner as a single point of contact and responsibility for the project, makes the DBFOM viable to work on large and complex projects. Moreover, it provides better control over project schedule and budget like the DB delivery method. Therefore, DBFOM have less schedule and cost growth than other delivery methods. Further, it eliminates the owner's risk design errors and omissions in construction, operations, and maintenance besides transferring them to the private partner. (Zhang, 2006) stated that the selection of the private partner is based on best value methodology. That way, the public owner gets the maximum benefits. Also, (Antillon, Garvin, Molenaar, & Javernick-Will, 2018) explained that bundling together the project

lifecycle tasks under a single contract this provides better project team collaboration and less adversary relation. On the other hand, (Federal Highway Administration (FHWA), 2016) pointed out some disadvantages of DBFOM, such as requirement of owner's experienced staff to oversee the financial, legal, and technical issues over the length of the contract period. Some enabling legislation is required to undertake a P3 in certain states. Further, (Zhang, 2005) defined other disadvantages, such as the complicated contractual arrangements between project participants (Public owner and Private partner) and the broad range of uncertainties and risks associated with the long-term P3 contract. In the same context, (Touran, et al., 2009b) noted some disadvantages, such as DBOM can necessitate large peaks in owner staffing requirements to oversee the project over its lifecycle. Furthermore, the owner losses the advantage of having a complete design prior to start of construction due to the project rapid schedule; thus, this requires much of the owner's efforts in design and construction reviews.

As previously mentioned, each project delivery method has its characteristics that distinguishes it from other delivery methods. The main characteristics of the DBFOM below are adapted from the (Federal Highway Administration (FHWA), 2016) and (Zhang, 2005).

- Two prime players: Public owner, Private sector entity.
- One contract: Public owner to Private sector entity.
- Private sector entity selection is based on Best Value.
- Overlapping phases: design and build
- Overall project planning and scheduling are performed by the private sector entity.
- Project is financed by the private sector fund.

- Private sector entity is repaid through the following three payment methods;
  i. **Real toll**: The private sector partner maintains the right to collect toll revenues during the concession period with the risk that toll proceeds may not meet forecasted levels.
  ii. **Availability payment**: The public owner retains all toll revenue risk if the facility is tolled. The sponsor pledges availability payments to compensate the private sector partner for its role in designing, constructing, operating, and maintaining the facility for a set time period during which it receives fixed annual payments. If the facility isn't tolled, the public owner makes the availability payments to the private partner from public funds.
  iii. **Long-term Lease**: The public owners leases existing publicly financed toll facilities to a private partner who pledges to operate and maintain the facility for the concession period at certain service standards, in exchange for an upfront lease payment (i.e., a concession fee). The private partner then has the right to collect tolls on the facility for the concession period.

2.2. Project Delivery Method Selection Framework

Project Delivery Method is the process by which a construction project is comprehensively designed and constructed for an owner including project scope definition, organization of designers, constructors and various consultants, sequencing of design and construction operations, execution of design and construction, and closeout and start-up (Touran, Gransberg, Molenaar, & Ghavamifar, 2011). Therefore, selection of the suitable project delivery method is critical for the project success as it defines the framework of

project execution to achieve the project owner's objectives. Moreover, the project delivery method defines the roles and responsibilities of all parties involved in the project (Oyetunji & Anderson, 2001). Additionally, the decision made on selection of a project delivery method for a project impacts all phases of execution of the project and greatly impacts the efficiency of project execution (Oyetunji & Anderson, 2006). However, the owners usually choose the project delivery method because they usually are used to it and not because of its appropriateness and suitability with the project condition (Pishdad & Beliveau, 2010). This fact about the criticality of choosing the suitable project delivery method for the project is the motivation behind the ongoing research whether to develop a new selection tool or refine an existing one.

As previously mentioned, the quest to develop a reliable selection framework, is ongoing to provide more improvement to the existing selection tools or develop a new approach. Notable works in this area are accomplished by (Alhazmi & McCaffer, 2000), who developed a project procurement system selection model. This model integrates the techniques of the analytic hierarchy process and Parker's judging alternative technique of value engineering into multi-criteria multi-screening system considering six groups of criteria; project characteristics, market attributes, contractor and architect/engineer (A/E) needs, categories of client, client design organization, and the local design and construction regulations. This model consists of four screening levels and proposing three main categories of project delivery methods comprising twelve procurement systems (project delivery methods) which are evaluated using six groups of criteria. The selection process of the proposed model goes through the following four screening stages:

- **First Screening - Feasibility Ranking**: It includes selecting a set of evaluation criteria from the six main groups of criteria for evaluating the feasibility of twelve procurement systems where each project delivery method is scored on a scale from 0 to 5.
- **Second Screening - Evaluation by Comparison**: It includes comparing each delivery method by listing the advantages and disadvantages of each.
- **Third Screening - Weighted Evaluation**: This step consists of two stages, which are the criteria weighting process (paired comparisons) and matrix evaluation. This step is for identifying the optimum procurement systems relative to the criteria considered to be influential in the selection process.
- **Fourth Screening - Analytic Hierarchy Process (AHP)**: This step requires running a computer model using the Expert Choice version 9.0 software. The process goes through four steps: problem hierarchy, pairwise comparisons, construction of overall priorities rating with AHP (synthesis) and evaluation of the consistency of judgment.

Table 1 and **Table 2** show the three main categories of project delivery methods, as well as the twelve procurement systems (project delivery methods) in addition to the evaluation criteria (selection factors) considered in the screening process.

Table 1: Project Delivery Methods proposed by (Alhazmi & McCaffer, 2000)

Separated and Cooperative Procurement Methods	Integrated Procurement Methods	Management Oriented Procurement Methods
Traditional method	Design and Build	Management contracting
Two stage tendering	Package deals	Design and manage
Negotiation method	Turnkey	Construction management
Serial contracts	Develop and construct	
Cost reimbursable contracts		

Table 2: Selection Factors proposed by (Alhazmi & McCaffer, 2000)

Evaluation Criteria		
Categories of Client	Market Attributes	Contractor and A/E needs
• Public client • Public experienced primary client • Public experienced secondary client	• Availability of local & international contractor • Availability of local & international A/E firms • Project package size	• Local & international contractors acceptable profit • Contractor expectation • Client expectation
Project Characteristics	Client Design Organization	Local design & construction regulations
• Project type • Project cost • Time constraints • Degree of flexibility • Degree of complexity • Payment method • Design & construction integration • Project funding method	• In-house design team • outside design team • Combined teams	• Construction methods • Awarding procedures

It is worth mentioning that the model, proposed by (Alhazmi & McCaffer, 2000), entails a group of obstacles, such as the process is found to be complex, lengthy, time consuming, and requires a certain computer software to run the developed model to get the final results. Also, the proposed model doesn't consider all the available project delivery methods, especially the delivery methods which consider the public-private partnership (P3) mechanism.

Another notable attempt by the project delivery and contract strategy research team 165 (Construction Industry Institute, 2001) in that the research team has developed a tool

to help owners select the project delivery method for their project. The tool focuses on the owner's project objectives and the project execution environment and incorporates a quantitative assessment of twelve project delivery methods and twenty selection factors categorized into 3 groups: cost related factors, schedule related factors, and other factors for the decision making process, as shown below in **Table 3** and **Table 4**.

Table 3: Project Delivery Methods proposed by CII Research Team

#	Project Delivery Methods
1	Traditional Design-Bid-Build (DBB)
2	Traditional (DBB) with Early Procurement
3	Traditional (DBB) with Project Manager
4	Traditional (DBB) with Construction Manager
5	Traditional (DBB) with Early Procurement and CM
6	CM @ Risk
7	Design-Build or EPC
8	Multiple Design-Build or EPC
9	Parallel Primes
10	Traditional (DBB) with Staged Development
11	Turnkey
12	Fast Track

Table 4: Selection Factors proposed by CII Research Team

#	Factors Category	Selection Factors
1	Cost Related Factors	Control cost growth
2		Ensure lowest cost
3		Delay or minimize expenditure rate
4		Facilitate early cost estimates
5		Reduce risks or transfer risks to contractor(s)
6	Schedule Related Factors	Control time growth
7		Ensure shortest schedule
8		Promote early procurement
9	Other Factors	Ease change incorporation
10		Capitalize on expected low levels of changes
11		Protect confidentiality
12		Capitalize on familiar project conditions
13		Maximize Owner's controlling role
14		Minimize Owner's controlling role
15		Maximize Owner's involvement
16		Minimize Owner's involvement
17		Capitalize on well-defined scope
18		Efficiently utilize poorly defined scope
19		Minimize number of contracted parties
20		Efficiently coordinate project complexity or innovation

In addition to the selection factors and the project delivery alternatives, the research team has considered other two variables for the selection process:

- **Relative Effectiveness Values**: They are scores on a scale from 0 to 100 that represent the performance level of each project delivery method relative to the others, with respect to each selection factor.
- **Compensation Approaches**: They define how the contractors and architect / Engineer will be paid in return to their services. The selection tool includes default compensation

approach for each project delivery alternative; however, this default approach can be changed according to the owner's convenience.

Also, the research team has considered three techniques for the decision analysis process and assessing the combined effects of the variables:

- Analytic Hierarchy Process (AHP)
- Multi-Attribute Utility Theory (MAUT)
- Simple Multi-Attribute Rating Technique with Swing Weights (SMARTS)

Ultimately, it is worth mentioning that the research team has developed a selection model using Microsoft Excel software to facilitate the utilization of the tool by the owners. The procedures of the selection model go through three simple steps:

- **First step** is providing rank and preference score for the relevant selection factors based on the project objectives and conditions, then the three project delivery alternatives with highest aggregate scores are selected for further review.
- **Second step** is reviewing the default compensation approach associated with each of the three project delivery alternatives, for the owner's convenience.
- **Third step** is deciding which project delivery method shall be selected for the project.

It can be concluded that the tool developed by the (Construction Industry Institute, 2001) has a couple of advantages, e.g., the process is seamless, simple, and the decision analysis is based on a sound technique. Moreover, the research team has developed a model using Microsoft Excel software to facilitate using the developed technique. However, the tool has a limitation that the infrastructure projects data aren't considered while developing this tool. Therefore, this selection tool may not be suitable for infrastructure projects. Also,

the developed tool doesn't consider all the available project delivery methods, especially the delivery methods which consider the public-private partnership (P3) mechanism.

Another trial accomplished by (Touran, Gransberg, Molenaar, Bakhshi, & Ghavamifar, 2009a) who developed a project delivery method selection framework for airport projects. The developed selection process includes a two-tiered project delivery selection framework that may be used to select the most appropriate method for the project. Tier 1 is an analytical delivery decision approach that is designed to help the owner understand the characteristics of each project delivery method and decide which delivery method is the appropriate one, according to the project goals and project critical issues. Tier 2 uses a weighted-matrix delivery decision approach that allows owner to prioritize their objectives to select the suitable delivery method for the project. The objective prioritization is based on the selection factors, which are formed by combining the project goals and the project critical issues.

The notable fact about this selection framework is that (Touran, Gransberg, Molenaar, Bakhshi, & Ghavamifar, 2009a) have developed a list of pertinent issues rather than a list of selection factors. Also, they considered only three delivery project methods for the selection framework. **Table 5** and **Table 6** illustrate the project pertinent issues and the project delivery methods considered in this selection framework.

Table 5: Project Delivery Methods proposed by (Touran, et al., 2009a)

#	Project Delivery Methods
1	Design-Bid-Build (DBB)
2	Design-build (DB)
3	Construction Manager at Risk (CMR)

Table 6: Project Pertinent Issues proposed by (Touran, et al., 2009a)

	Pertinent Issues for airport projects
Project-level Issues	
1	Project size/complexity
2	Schedule compression
3	Schedule growth control
4	Early cost precision
5	Cost control
6	Risk management/allocation
7	Lifecycle costs
8	Maintainability
Airport-level Issues	
9	Airport experience/staff capability
10	Airport control of project
11	Security
12	Control of impact on passengers and operations
13	Third-party stakeholder input to design and construction
Public Policy/Regulatory Issues	
14	Competition and local talent
15	DBE/small business impacts
16	Legal and statutory constraints
17	Sustainability and LEED certification
Other Issues	
18	Adversarial relationships
19	Construction claims

Following the same manner, (Touran, et al., 2009b) developed a project delivery method selection framework for transit projects. Unlike, the previous selection framework of (Touran, Gransberg, Molenaar, Bakhshi, & Ghavamifar, 2009a), this selection process includes three-tiered project delivery selection framework, instead of two tiers. It is worth mentioning that (Touran, et al., 2009b) followed the same methodology of (Touran, Gransberg, Molenaar, Bakhshi, & Ghavamifar) for developing Tier 1 and Tier 2 selection framework. Tier 1 is a qualitative approach that allows the owner to select the project

delivery method, based on its advantages / disadvantages and its suitability to achieve the project goals and overcome the project critical issues. Tier 2 is a weighted-matrix approach that allows the owner to quantify the effectiveness of each delivery methods by comparing each delivery method against set of selection factors which are formed by combining project goals and project pertinent issues. The addition to this selection framework is Tier 3, optimal risk-based approach, which uses principles of risk analysis to evaluate delivery methods and provide a quantitative analysis-based decision to select the suitable project delivery method. Further, (Touran, et al., 2009b) introduced additional project delivery method; Design-Build-Operate-Maintain (DBOM), besides the three project delivery methods, which were used by (Touran, Gransberg, Molenaar, Bakhshi, & Ghavamifar, 2009a). It deserves to be mentioned that the Design-Build-Operate-Maintain (DBOM) delivery method is a variation of the DB delivery method which considers the public-private partnership (P3) mechanism (Federal Highway Administration (FHWA), 2016). **Table 7** and **Table 8** summarize the project pertinent issues and the project delivery methods, considered in the selection framework.

Table 7: Project Delivery Methods proposed by (Touran, et al., 2009b)

#	Project Delivery Methods
1	Design-Bid-Build (DBB)
2	Design-build (DB)
3	Construction Manager at Risk (CMR)
4	Design-Build-Operate-Maintain (DBOM)

Table 8: Project Pertinent Issues proposed by (Touran, et al., 2009b)

	Pertinent Issues for transit projects
Project-level Issues	
1	Project Size
2	Cost
3	Schedule
4	Risk Management
5	Risk Allocation
6	LEED Certification
Agency-level Issues	
7	Agency Experience
8	Staffing Required
9	Staff Capability
10	Agency Goals and Objectives
11	Agency Control of Project
12	Third-Party Agreement
Public Policy/Regulatory Issues	
14	Competition
15	DBE impacts
16	Labor Unions
17	Federal/State/Local Laws
18	FTA/EPA Regulations
Lifecycle Issues	
19	Lifecycle Costs
20	Maintainability
21	Sustainable Design Goals
22	Sustainable Construction Goals
Other Issues	
23	Construction claims
24	Adversarial relationships

In the same context, another remarkable work, done by (Cherkos, Jha, & Singh, 2020) who identified selection factors and developed a conceptual framework for the selection of a suitable P3 model based on the project characteristics. (Cherkos, Jha, & Singh) have

identified twelve selection factors that influence the selection process of P3 delivery model, these selection factors are summarized below:

- Data availability to predict future macroeconomic risks during construction, maintenance, and operational stages.
- Private sector interest in construction and maintenance risks.
- Government preference to transfer O&M risks in an integrated way.
- Project commercial viability.
- Certainty of traffic revenue.
- Private sector traffic risk-taking preference.
- Private sector financial capacity.
- Lender's preference.
- Public sector capital support.
- Public sector financial capacity for semi-annuity (traffic revenue risk preference).
- Alignment of the project with the main objectives of the road sector policy.
- Adequacy of the country environment (political, legal, and institutional framework) to the contractual and organizational arrangements required to the project.

However, the holistic view of all factors impacting the project success is much needed, the gap analysis conducted by (Pishdad & Beliveau, 2010) showed that the existing selection tools are mainly developed around the "macro pieces" of the project delivery methods tools such as: organizational structure (delivery method), contract type and selection method. However, there are "micro pieces" should be incorporated into the selection tools such as: task assignment, risk allocation/mitigation, contractual reinforcement, and process management.

CHAPTER 3

RESEARCH METHODOLOGY

This research takes on a methodology that passes through three stages; stage (1): data collection, stage (2): development of project delivery method selection model, stage (3): validation of the project delivery method selection model. **Figure 12** below illustrates the workflow and methodology sequence of this research.

- **Stage (1) - Data Collection**: the data required for this research are collected through conducting an extensive literature review of past research and peer-reviewed published research articles to conclude the selection factors considered in the decision-making process as well as the decision analysis technique and the project delivery methods.
- **Stage (2) - Selection Model Development**: the project delivery method selection model is developed based on the conclusion of the literature review of stage (1).
- **Stage (3) - Selection Model Validation**: The validation of the developed model is through applying this selection model on some case study projects by industry practitioners who evaluate the outcome to assess the effectiveness of the selection model to solve the problem (Yin, 2003), (Phillips, 1984) and (Touran, et al., 2009b).

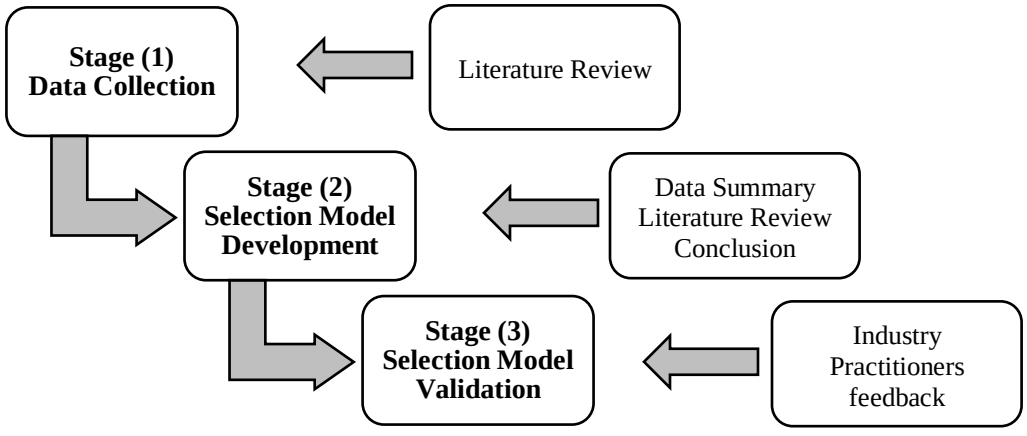


Figure 12: Research Workflow and Methodology Sequence

3.1. Data Collection

The data required for this research are collected via conducting an extensive literature review of past research and peer-reviewed published research articles that addressed the topic of developing a project delivery selection model for owners. The objective of the literature review is to conclude the selection factors considered in the decision-making process and the decision analysis technique and the employed project delivery methods. After conducting the literature review (data collection), the conclusion of literature review (data summary) is used as a basis for developing the selection model in the following stage.

3.2. Data Summary

The section contains an executive summary of the literature review findings that are concluded in stage (1), Data Collection. This literature review conclusion shall be the basis for developing the project delivery selection model and it addresses three main points; common project delivery methods used by owners, decision analysis technique employed in the decision-making process, and the influential selection factors considered in the process.

3.2.1. Project Delivery Methods

There are several types of project delivery methods currently available to the owners in the United States (Touran, Gransberg, Molenaar, & Ghavamifar, 2011). However, this research considers only the available project delivery methods in state of Arizona for the development of the selection model. As such, only the following project delivery methods are employed in the selection model;

- Design-Bid-Build (DBB)

- Design-Build (DB)
- Construction Management at Risk (CMR)
- Job Order Contracting (JOC)
- Public Private Partnership (P3): Design-Build-Finance-Operate-Maintain (DBFOM)

3.2.2. Decision Analysis Technique

The decision analysis technique is critical component in the selection model, as it is the tool that facilitates the design-making process. Couple of analysis techniques were discussed in the literature review such as: Analytic Hierarchy Process (AHP), Multi-Attribute Utility Theory (MAUT), Simple Multi-Attribute Rating Technique with Swing Weights (SMARTS), Analytical Decision Approach (Qualitative Approach), Weighted-Matrix Decision Approach, and Optimal Risk-Based Approach. Accordingly, the Weighted-Matrix Decision Approach is used as a decision analysis technique for the selection model because of its simplicity, seamlessness, and moreover, the decision analysis is based on a sound rationale. **Table 9** illustrates a sample of the proposed weighted matrix.

Table 9: Sample of Weighted Matrix

Selection Factor	Factor Weight	Project Delivery Method									
		DBB		DB		CMR		JOC		DBFOM	
		Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Factor 1											
Factor 2											
Factor 3											
Total Score											

3.2.3. Selection Factors

Selection factors are the most influential component of the decision-making process, as they are considered the evaluation criteria against which the different project delivery methods are assessed. Therefore, after thorough examination of past literature, the important selection factors are defined, then refined by eliminating redundant factors, compiling relevant factors together, and introducing new selection factors to constitute the final selection factors. Eventually, a list of five major categories of selection factors comprising twenty-eight factors is developed, as shown in **Table 10**.

Table 10: Selection Factors

#	Selection Factor Category	Selection Factor
1	Project Characteristics	Control cost growth
2		Ensure lowest cost
3		Facilitate early construction cost estimates
4		Control time growth
5		Ensure fastest schedule
6		Promote early procurement
7		Efficiently utilize poorly defined scope
8		Efficiently utilize well-defined scope
9		Efficiently coordinate design and construction (complexity)
10		Ensure high quality project
11	Owner’s Agency	Maximize owner's controlling role
12		Maximize owner's involvement in pre-construction
13		Minimize owner’s risk for design error and omission
14		Minimize owner’s pre-construction / overhead cost
15	Public Regulation	No statutory authorization required

Table 10: Selection Factors - Continued

#	Selection Factor Category	Selection Factor
16	Project Finance & Lifecycle	Reduce / transfer financial risks to contractor(s)
17		Provide external project fund
18		Optimize Lifecycle Costs
19		Transfer operation & maintenance cost to contractor
20		Ensure sustainable goals in design
21	Other Factors	Minimize number of contracted parties
22		Reduce construction claims
23		Reduce change orders
24		Reduce adversarial relationships
25		providing pre-construction services by contractor
26		contactor selection based on qualifications or best value
27		Provide single point of responsibility for project
28		Fast project award for small tasks (< $2M)

CHAPTER 4

RESULTS

This chapter addresses the second and third stages of the research methodology, which include the development of the selection model and the validation of the developed model. The first section of this chapter explains the steps of the project delivery method selection model while the second section addresses the validation of the selection model through applying it on some case study projects by industry practitioners.

4.1. Project Delivery Method Selection Model

The project delivery method selection model, developed within this research, is designed to help owner selects the most suitable project delivery method for the project by going through a set of steps that ultimately end up to defining the appropriate project delivery method, the procurement selection method, and the contracting compensation type. It is worth mentioning that to effectively use this selection model, the owner should be aware of the characteristics of each project delivery method and the advantages and disadvantages of each, which are collectively discussed in Chapter 2, Literature Review. The project delivery method selection model is developed based on the literature review conclusion summarized in the Data Summary section in Chapter 3, Research Methodology. The project delivery method selection process consists of five steps: Step 1 - Define project key information; Step 2 - Define selection factors and their weights; Step 3 - Select project delivery method; Step 4 - Determine the selection method; Step 5 - Select the contracting compensation type. **Figure 13** illustrates the workflow of the project delivery method selection process.

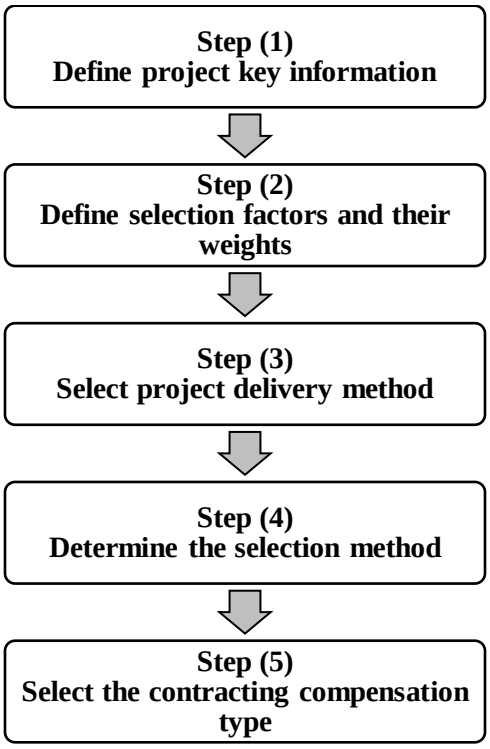


Figure 13: Workflow of Project Delivery Method Selection Model

4.1.1. Step (1): Define project key information

In this step, the project owner studies the project scope thoroughly to define the project key information, which will be used in the following stages. The information that needs to be extracted, is shown below:

- **Project Title**:
- **Location**:
- **Sector**: Public / Private
- **Work Type**: New construction / Repair & Maintenance
- **Project Duration**:
- **Project Urgency**: Urgent delivery / Normal delivery
- **Project Budget**:

- **Project Fund Source**: Internal Fund / External Fund
- **Scope Status**: Defined / Undefined
- **Design Status**: Completed / In-progress / Not Started
- **General Remarks**:

4.1.2. Step (2): Define selection factors and their weights

Based on the project goals, the project owner starts picking out the selection factors that have maximum influence on the project success from the selection factors, described in **Table 10**. Afterwards, the project owner starts defining the weight of each selection factor in order from highest to lowest with respect to its influence on project success using 100 total points, where the highest points refer to the most important factor. The project owner should take into consideration the following when defining the factors' weight:

- Choosing at least four selection factors.
- Avoiding equal weighting of factors.
- Avoid giving a factor weight of less than five points.
- The total factor weights should be equal to 100 points.

4.1.3. Step (3): Select project delivery method

In this step, the weighted score of each project delivery method is captured, which facilitates the decision-making on selecting the appropriate project delivery method. The project owner starts to prioritize the project objectives by defining the weight of each selection factor to such project objective, as discussed in step 2. As soon as the selection factor weights are defined, the selection model automatically calculates the total weighted score of each project delivery method by multiplying the factor weights (project owner's

input) by each project delivery method score (selection model's default built-in scores). The default built-in scores are already scores populated into the model, which are collected via conducting an extensive literature review of past research and peer-reviewed published research articles that addressed the project delivery method performance with respect to each project objective (selection factor) defined in the model; e.g., (Molenaar & Franz, 2018) have conducted a research to evaluate the performance of project delivery methods in the U.S. building construction industry with respect to cost performance, schedule performance and delivery speed. Further, the Research Team DCC-06 of Construction Industry Institute (CII) has prepared (An Owner's Manual for Selecting a Project Delivery System, 2021) that examined the performance of major four project delivery methods in 96 construction projects, which included a rating of each project delivery method's performance with respect to 11 project factors, such as project size, project cost, schedule, and risk allocation, etc. All such information has been analyzed and used to populate the selection model with the default score of each delivery method regarding its performance relative to project objectives (selection factors). The scoring scale, used in evaluating the delivery methods, consists of four categories: high, medium, low, and not applicable. Thereafter, the four scoring categories have been converted to numerical scores to facilitate the quantitative assessment, where high = 10 points, medium = 6 points, low = 3 points and not applicable = 0. Ultimately, the selection model provides total weighted score for each project delivery method which the project owner considers while making the decision of selecting the appropriate delivery method. **Table 11** below, shows the selection factors and scores of each project delivery method with respect to its performance against project objectives (selection factors).

Table 11: Performance Score of Project Delivery Methods

#	Selection Factor Category	Selection Factor	Factor Weight	Project Delivery Method									
				DBB		DB		CMR		JOC		DBFOM	
				Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
1	Project Characteristics	Control cost growth		3		10		6		6		0	
2		Ensure lowest cost		6		10		3		6		3	
3		Facilitate early construction cost estimates		3		6		10		6		6	
4		Control time growth		3		10		6		6		10	
5		Ensure fastest schedule		3		10		6		6		10	
6		Promote early procurement		3		10		10		6		10	
7		Efficiently utilize poorly defined scope		10		3		6		6		3	
8		Efficiently utilize well-defined scope		6		10		10		10		10	
9		Efficiently coordinate design and construction (complexity)		3		10		10		6		10	
10		Ensure high quality project		6		6		10		10		10	
11	Owner's Agency	Maximize owner's controlling role		10		3		10		3		3	
12		Maximize owner's involvement in pre-construction		10		3		10		3		3	
13		Minimize owner's risk for design error and omission		0		10		0		3		10	
14		Minimize owner's pre-construction / overhead cost		3		3		3		10		3	
15	Public Regulation	No statutory authorization required		10		3		3		10		3	
16	Project Finance & Lifecycle	Reduce / transfer financial risks to contractor(s)		6		10		3		3		10	
17		Provide external project fund		0		0		0		0		10	
18		Optimize Lifecycle Costs		6		3		6		0		10	
19		Transfer operation & maintenance cost to contractor		0		0		0		0		10	
20		Ensure sustainable goals in design		6		3		6		0		10	

Table 11: Performance Score of Project Delivery Methods - Continued

#	Selection Factor Category	Selection Factor	Factor Weight	Project Delivery Method									
				DBB		DB		CMR		JOC		DBFOM	
				Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
21	Other Factors	Minimize number of contracted parties		6		10		6		10		10	
22		Reduce construction claims		0		10		6		6		10	
23		Reduce change orders		0		10		6		6		10	
24		Reduce adversarial relationships		0		10		6		6		10	
25		providing pre-construction services by contractor		0		6		10		6		6	
26		contactor selection based on qualifications or best value		3		10		10		10		10	
27		Provide single point of responsibility for project		0		10		0		6		10	
28		Fast project award for small tasks (< $2M)		0		0		0		10		0	
Total Score													

4.1.4. Step (4): Determine the selection method

Following to selecting the project delivery method in the previous step, the owner determines the selection method through which the contractor is selected, and the project is awarded. The selection model considers three types of selection methods: low bid, qualifications-based selection, and best value. The project owner shall choose the selection method, which is compatible with the project delivery method, selected in step 3, and also suit the project objectives and conditions; for example, if the design-build (DB) method is selected for a federally funded complex project, which requires a high qualified contractor, the selection method that is based on qualifications or best value shall be the right option. However, the best value selection method shall be employed in such case because the qualification-based selection method, which disregards price, isn't federally acceptable. **Table 12** illustrates the selection methods and their characteristics to help the owner in selecting the appropriate selection method.

Table 12: Selection method Characteristics

	Low Bid	Qualifications Based Selection	Best Value
Project Delivery Method compatibility	DBB	CMR, DB, JOC, DBFOM	CMR, DB, JOC, DBFOM
Selection Criteria	Lowest responsible bid	Qualifications only	Qualifications and Price
Process Steps	One-step process by issuing Invitation For Bid (IFB)	One-step process by issuing Request For Qualifications (RFQ)	Two-step process; 1st step: issuing RFQ to obtain qualification statement 2nd step: issuing RFP to obtain financial proposal
Evaluation Method	Used exclusively with DBB with a sole focus on price of responsive bids	Focus on qualifications only	Focus on total value (qualifications and price)
Federally Acceptable Method	Yes	No, as price isn't considered in contractor selection	Yes

4.1.5. Step (5): Select the contracting compensation type

Ultimately, this is the last step in the project delivery method selection model where the project owner selects the contracting compensation type that defines how the contractor is paid for the services he offers. The selection model considers three types of the contracting compensation methods: fixed price or lump sum, guaranteed maximum price (GMP), and cost reimbursable. The selection model defines the common contracting compensation approaches for each delivery method along with other possible compensation alternatives that can be used. **Table 13** shows the common contracting compensation types for each project delivery method together with the other possible compensation alternatives.

Table 13: Contracting Compensation Methods

	DBB	DB	CMR	JOC	DBFOM
Common Contracting Compensation Method	Fixed Price / Lump Sum	Fixed Price / Lump Sum	Guaranteed Maximum Price (GMP)	Fixed Price based on unit price book	Fixed Price / Lump Sum
Contracting Compensation Alternatives	N/A	1. Guaranteed Maximum Price (GMP)	1. Fixed Price / Lump Sum 2. Cost Reimbursable	N/A	N/A

4.2. Model Validation

The model validation is the last stage in the research methodology. The project delivery selection model is validated through submitting the selection model to industry practitioners to collect their feedback on the selection model after applying it on some case study projects. The main objective of gathering the industry practitioners' feedback is to evaluate the effectiveness of the proposed selection model to solve the problem and to

determine if there are any shortcomings in its processes in terms of steps simplicity, selection factors, and factor scores, etc. Comparing the outcomes of the selection model to the actual methods used for the project isn't the main objective of asking for the industry practitioners' feedback. However, holding this comparison is required, it shall be by no means considered as the sole factor to judge the effectiveness of the selection model because by doing so, this gives the full credit to the actual methods used for the project while overlooking the fact that the actual delivery method and selection method and compensation type, employed by project owner, aren't necessary to be the best options for the project. For the sake of collecting feedback from industry practitioners, the project delivery method selection model is transformed into a Microsoft Excel spreadsheet to facilitate usage of the selection model and a feedback survey is developed to collect the industry practitioners' feedback, refer to **Appendix B**. Ultimately, the industry practitioners are categorized into four groups, as shown below, and the selection model spreadsheet as well as the feedback survey are submitted to them to gather their remarks.

- Public owners
- Private owners
- PM consultants
- Subject matter experts

4.2.1. Analysis of Feedback Survey Outcomes

Responses were received from forty-two industry practitioners comprising public owners, private owners, PM consultants, and subject matter experts. The survey respondents had a wide range of experience spanning from 10 years up to 30 years of

professional work, mostly, in construction of infrastructure and building projects. The captured feedback was analyzed to define the strength points of the selection model and the weakness points that needs improvement. **Table 14** below, shows the analysis outcomes.

Table 14: Analysis of The Feedback Survey Outcomes

Model Component	Feedback			
	Public Owner	**Private Owner**	**Project Management (PM) Consultant**	**Subject Matter Expert**
Selection Factors	**Strength Points:** • Comprehensive factors that cover most of the owner's objectives. **Weakness Points:** • Lack of clear guidance for defining the factor weights. • Revising some project delivery methods score.	**Strength Points:** • Comprehensive factors that cover most of the owner's objectives. **Weakness Points:** • Definition of some selection factors isn't too clear to understand.	**Strength Points:** • Comprehensive factors that cover most of the owner's objectives. **Weakness Points:** • Lack of clear guidance for defining the factor weights. • The viewpoint which the selection factors are addressing, is not clear.	**Strength Points:** • Comprehensive factors that cover most of the owner's objectives. **Weakness Points:** • Revising some project delivery methods score.
Selection Method	**Weakness Points:** • The model doesn't provide clear direction to choose the selection method.	No drawbacks are reported in the feedback survey.	No drawbacks are reported in the feedback survey.	**Weakness Points:** • The model doesn't provide clear direction to choose the selection method. However, it is usually dictated by statutes and regulations.
Contracting Compensation Type	**Weakness Points:** • The model doesn't provide clear direction to choose the contracting compensation type.	No drawbacks are reported in the feedback survey	No drawbacks are reported in the feedback survey.	**Weakness Points:** • The model doesn't provide clear direction to choose the contracting compensation type. However, it is usually dictated by statutes and regulations.

Table 14: Analysis of The Feedback Survey Outcomes - Continued

Model Component	Feedback			
	Public Owner	**Private Owner**	**Project Management (PM) Consultant**	**Subject Matter Expert**
Overall Model	**Strength Points:** • 82% of the participants found the model simple and easy to use. • 93% of the participants found the selection factors, defined in the model, covering most of the project objectives. • 82% of the participants found the model efficient and reliable to use. **Weakness Points:** • 18% of the participants found the model a bit difficult to use. • 7% of the participants found the selection factors, defined in the model, not covering all the project objectives they were looking for. • 18% of the participants were neutral regarding the model efficiency and reliability.	**Strength Points:** • 71% of the participants found the model simple and easy to use. • 100% of the participants found the selection factors, defined in the model, covering most of the project objectives. • 71% of the participants found the model efficient and reliable to use. **Weakness Points:** • 29% of the participants found the model a bit difficult to use. • 29% of the participants were neutral regarding the model efficiency and reliability.	**Strength Points:** • 92% of the participants found the model simple and easy to use. • 85% of the participants found the selection factors, defined in the model, covering most of the project objectives. • 46% of the participants found the model efficient and reliable to use. **Weakness Points:** • 8% of the participants found the model a bit difficult to use. • 15% of the participants found the selection factors, defined in the model, not covering all the project objectives they were looking for. • 54% of the participants were neutral regarding the model efficiency and reliability.	**Strength Points:** • 100% of the participants found the selection factors, defined in the model, covering most of the project objectives. • 100% of the participants found the model quite efficient and reliable to use. **Weakness Points:** • 100% of the participants found the model a bit difficult to use.

4.2.2. Model Improvement

Based on the analysis outcome of the feedback survey responses, which points out the model weakness points, the following below modifications are performed to remedy such drawbacks. These modifications are incorporated to the final project delivery method selection guideline enclosed in **Appendix A**.

a. Selection Factors:

The analysis of the feedback survey responses highlighted four weakness points. Therefore, the following modifications are performed to remedy the drawbacks.

- **Lack of clear guidance for defining the factor weights**

Drawback Description: Since the whole model is driven by the input of the selection factor weights, it is a good practice to have a clear guidance for defining the selection factor weights to get consistent results from the model.

Improvement Action: to develop a clear guidance for defining the selection factor weights, there are already existing recommendations, mentioned in **section 4.1.2**. However, a reference scoring scale is adapted from (Saaty, 1990) and integrated to the model step 2: Define selection factors and their weights, as shown below in **Table 15**.

Table 15: Selection Factor Reference Weights

Factor Weight	Priority Definition
100	Extreme priority
80	Very high priority
60	High priority
40	Moderate priority
20	Low priority
10, 30, 50, 70, 90	Intermediate values between two adjacent judgments.

- **Revising some project delivery methods score**

Drawback Description: Based on the received feedback from the survey participants, some scores related to CMR and DBFOM delivery methods are required to be revised for a more reliable output of the model.

Improvement Action: The project delivery method scores, defined by the survey participants, are revisited and adjusted, as shown below.

Original Scores						
#	Selection Factor	Project Delivery Method				
		DBB	DB	CMR	JOC	DBFOM
		Score	Score	Score	Score	Score
1	Control cost growth	3	10	6	6	0
2	Minimize owner's risk for design error and omission	0	10	0	3	10

Adjusted Scores						
#	Selection Factor	Project Delivery Method				
		DBB	DB	CMR	JOC	DBFOM
		Score	Score	Score	Score	Score
1	Control cost growth	3	10	6	6	10
2	Minimize owner's risk for design error and omission	0	10	6	3	10

- **Definition of some selection factors aren't too clear to understand**

Drawback Description: Based on the received feedback from the survey participants, the wording of some selection factors isn't too clear to understand.

Improvement Action: The selection factors, which are reported vague, are rephrased to convey a sound clear meaning, as shown below.

Original Wording	Modified Wording
Reduce / transfer financial risks to contractor(s)	Transfer financial risks to contractor(s)

- **The viewpoint which the selection factors are addressing, is not clear**

Drawback Description: Some survey participants give the feedback that they have a confusion about which standpoint the model is representing while addressing the selection factors, i.e., the model is representing the owner's viewpoint, the contractor's viewpoint, or the project management consultant's viewpoint.

Improvement Action: To eliminate such confusion, a statement which emphasizes that the model is adopting the owner's standpoint, is clearly mentioned in the model instruction.

b. Selection Method:

The analysis of the feedback survey responses pointed out one weakness point. Therefore, the following modifications are performed to remedy this drawback.

- **The model doesn't provide clear direction to choose the selection method**

Drawback Description: The feedback received from the survey participants points out that the model doesn't provide clear steps / instructions to guide the model user to choose the suitable selection method.

Improvement Action: To make the process more simple and easier to understand, a flowchart for the model step 4: Determine the selection method, is developed and attached to the final project delivery method selection guideline enclosed in **Appendix A**. **Figure 14** is a flowchart, which illustrates the workflow of the model step 4: Determine the selection method, for choosing the suitable selection method eventually.

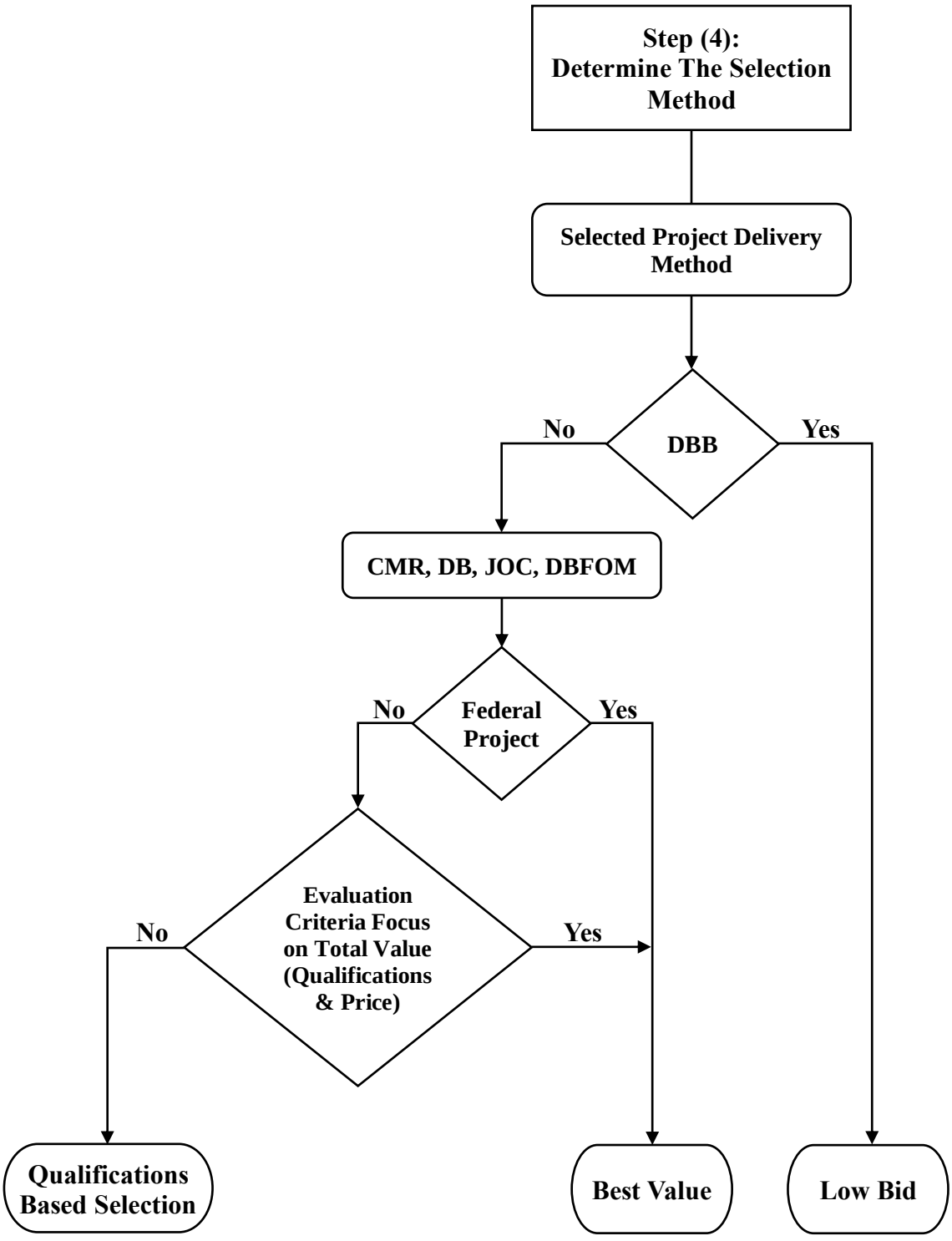


Figure 14: Flowchart of Model Step (4)

c. Contracting Compensation Type:

The analysis of the feedback survey responses highlighted one weakness point. Therefore, the following modifications are performed to remedy this drawback.

- **There is no clear direction to choose the contracting compensation type**

Drawback Description: The feedback received from the survey participants points out that the model doesn't provide clear steps / instructions to guide the model user to select the appropriate contracting compensation type.

Improvement Action: To make the process more clear and easier, a flowchart for the model step 5: Select the contracting compensation type, is developed and attached to the final project delivery method selection guideline, enclosed in **Appendix A**. **Figure 15** is a flowchart, which illustrates the workflow of the model step 5: Select the contracting compensation type, to select the appropriate contracting compensation type.

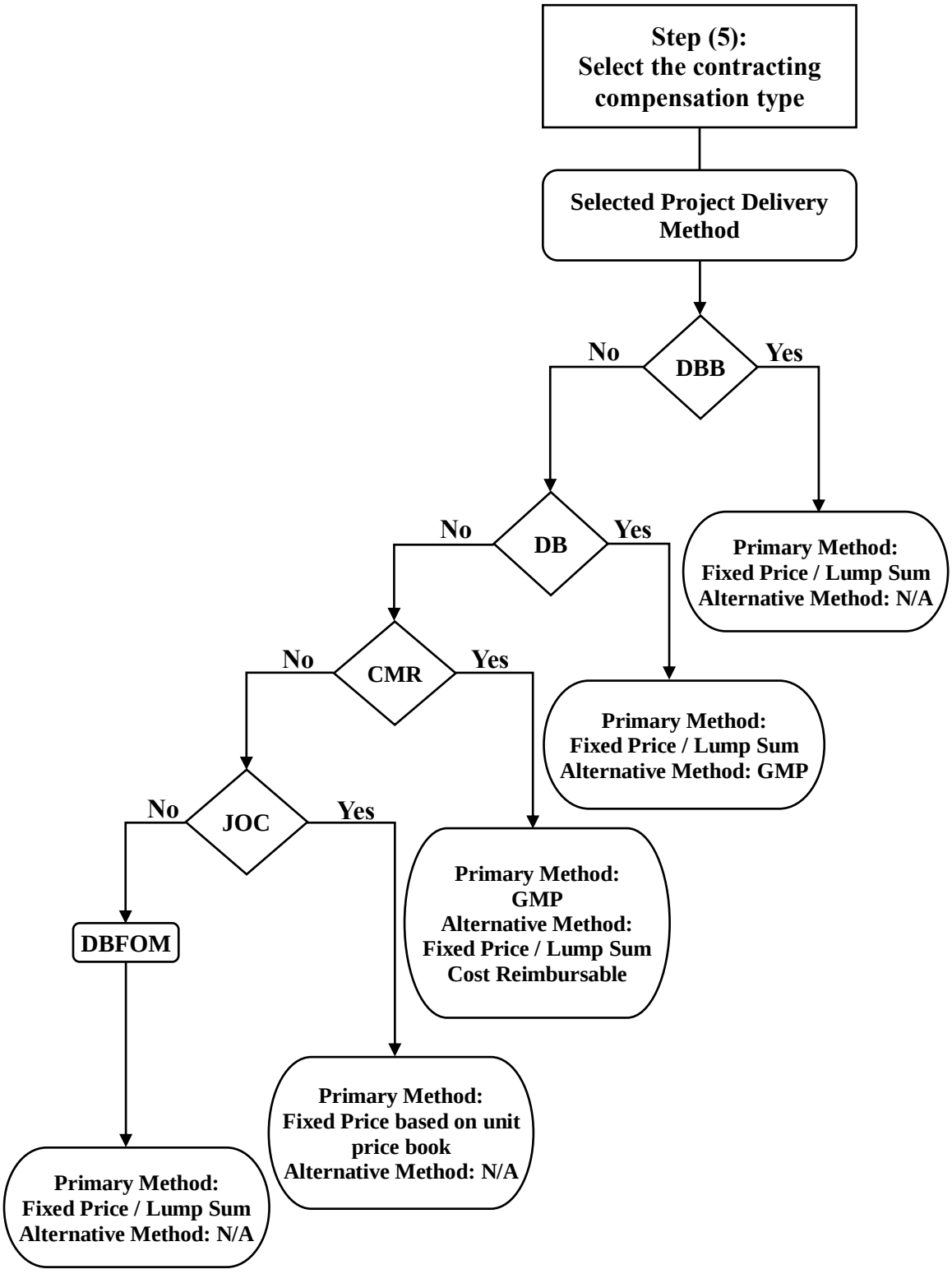


Figure 15: Flowchart of Model Step (5)

CHAPTER 5

CONCLUSION

This chapter provides a holistic overview of this research including a summary of the research methodology, the knowledge contribution of this research, and ultimately, the recommendations for future work on the research topic.

5.1. Summary of Research

Selection of the project delivery method is crucial for the project success. However, many public agencies and private owners have no standards that guide them in making the decision on selecting the suitable delivery method for their projects which results in many subsequent problems. This fact is the main motivation for this research to develop a guideline to help owners with the project delivery method selection. For this purpose, a research methodology is designed of three stages: (1) data collection, (2) selection model development, and (3) selection model validation. The data collection stage is the basis for developing the selection model in the following stage and is meant to collect the research required data through conducting an extensive literature review of past research and peer-reviewed published research articles to conclude the selection factors considered in the decision-making process and the decision analysis technique and the project delivery methods. The selection model development stage includes creating the whole model steps based on the literature review conclusion. The selection model validation stage is meant to evaluate the overall reliability and efficiency of the selection model in terms of workflow simplicity, selection factors inclusion, and factor scores accurateness. Therefore, a feedback survey is submitted to industry practitioners to collect their feedback on the

selection model after applying it on some case study projects. Ultimately, the captured feedback is analyzed to define strength and weakness points, then performing the required modifications to improve the model.

5.2. Research Conclusion

The owner's guideline for project delivery method selection, developed within this research, is designed to help owners to increase the project success likelihood by selecting the suitable project delivery method. This research makes contributions through developing a comprehensive guideline which helps owners, during the planning phase, to set a plan for the whole project delivery system including selecting the project delivery method, determining the selection method, and choosing the contracting compensation type. This research develops a comprehensive list of selection factors which addresses most of the project owners' objectives. Additionally, this research examines the performance of five project delivery methods (DBB, DB, CMR, JOC, DBFOM) against a set of project objectives (selection factors), then quantifies their performance by providing numerical scores. Moreover, this research introduces the option of the DBFOM delivery method, which is a variation of the DB delivery method that uses the Public Private Partnership (P3) finance mechanism, to raise the awareness over the P3 mechanism, which can help in solving the problem of lack of funds, especially for public agencies / owners.

Further, this research transformed the project delivery method selection model into a Microsoft Excel spreadsheet to make it simple to use and easy to be tailored to fit each agency's objectives while giving quick and reliable outcomes.

Finally, the feedback received from the survey participants showed that 82% of the public owners, 71% of the private owners and 92% of the PM consultants found this selection model simple and easy to use. Also, 93% of the public owners, 100% of the private owners and 85% of the PM consultants found the model selection factors covering most of the project objectives. Additionally, 82% of the public owners, 71% of the private owners and 46% of the PM consultants found the selection model efficient and reliable to use.

5.3. Recommendations for Future Work

This research develops a guideline for selection of the project delivery method considering only five project delivery methods, authorized in Arizona State, which are Design-Bid-Build (DBB), Design-Build (DB), Construction Management at Risk (CMR), Job Order Contracting (JOC), and Design-Build-Finance-Operate-Maintain (DBFOM). Accordingly, future research can expand this research to include additional project delivery methods, such as the integrated project delivery (IPD) method. Also, this research develops a project delivery method selection guideline for infrastructure projects with focus on highway, road, and bridge projects. Moreover, the validation of the developed selection model was through gathering feedback from forty-two industry practitioners who tested the model mainly on transportation projects (highways, roads, bridges) so that additional future studies can be performed to expand this research to cover buildings, water, and wastewater capital projects. Further, future studies can expand this research by investigating the owner's level of comfort or familiarity with a certain project delivery method as an influential factor in selecting the project delivery method.

REFERENCES

Alhazmi, T., & McCaffer, R. (2000). Project Procurement System Selection Model. Journal of Construction Engineering and Management, ASCE, 126(3), 176–184.

Antillon, E. I., Garvin, M. J., Molenaar, K. R., & Javernick-Will, A. (2018). Influence of Interorganizational Coordination on Lifecycle Design Decision Making: Comparative Case Study of Public-Private Partnership Highway Projects. Journal of Management in Engineering, ASCE, 34(5), 05018007.

Bowers, D., Bhargava, R., & Anderson, S. (2003). Characteristics Of Integrated Project Delivery And Contract Strategies. The University of Texas at Austin. Austin, TX: Construction Industry Institute.

Cherkos, F. D., Jha, K. N., & Singh, A. (2020). Framework to Select Public–Private Partnership Modalities. Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, ASCE, 12(4), 04520034.

Construction Industry Institute. (2001). Owner's Tool for Project Delivery and Contract Strategy Selection. The University of Texas at Austin. Austin, TX: Construction Industry Institute.

Construction Industry Institute. (2003). Owner's Tool for Project Delivery and Contract Strategy Selection User's Guide 2nd Ed. The University of Texas at Austin. Austin, TX: Construction Industry Institute.

Construction Industry Institute. (2021). An Owner's Manual for Selecting a Project Delivery System. The University of Texas at Austin. Austin, TX: Construction Industry Institute.

Construction Management Association of America. (2012). An Owner's Guide to Project Delivery Methods. Construction Management Association of America (CMAA).

El-Sayegh, S. M. (2008). Evaluating The Effectiveness of Project Delivery Methods. Journal of Construction Management and Economics, Taylor & Francis , 23, 457-465.

Federal Highway Administration (FHWA). (2016). Guidebook on Financing of Highway Public-Private Partnership Projects. Washington, DC: U.S. Department of Transportation.

Federal Highway Administration (FHWA). (2016). Report on Highway Public-Private Partnership Concessions in the United States. Washington, DC: U.S. Department of Transportation.

Francom, T., Ariaratnam, S. T., & El Asmar, M. (2016). Cost Performance of Job Order Contracting (JOC) Applied to Wastewater. Pipelines 2016 (pp. 64-70). Kansas City, MO: ASCE.

Ghavamifar, K., & Touran, A. (2008). Alternative Project Delivery Systems: Applications and Legal Limits in Transportation Projects. Journal of Professional Issues in Engineering Education and Practice, ASCE, 134(1), 106-111.

Gransberg, D. D., Benavides, J. A., & Loulakis, M. C. (2015). NCHRP Synthesis 473: Indefinite Delivery/Indefinite Quantity Contracting Practices - A Synthesis of Highway Practice. Washington, D.C.: National Cooperative Highway Research Program.

Joint Committee of AIA and AGC of America. (2011). Primer on Project Delivery (2nd ed.). Washington, DC: The American Institute of Architects (AIA) and the Associated General Contractors of America (AGC).

Minchin Jr., R. E., Li, X., Issa, R. R., & Vargas, G. G. (2013). Comparison of Cost and Time Performance of Design-Build and Design-Bid-Build Delivery Systems in Florida. Journal of Construction Engineering and Management, ASCE, 139(10), 04013007.

Molenaar, K., & Franz, B. (2018). Revisiting Project Delivery Performance. Austin, TX: Construction Industry Institute (CII) and Charles Pankow Foundation.

Oyetunji, A. A., & Anderson, S. D. (2001). Project Delivery and Contract Strategy. The University of Texas at Austin. Austin, TX: Construction Industry Institute.

Oyetunji, A. A., & Anderson, S. D. (2006). Relative Effectiveness of Project Delivery and Contract Strategies. Journal of Construction Engineering and Management, ASCE, 132(1), 3-13.

Phillips, L. D. (1984). A theory of requisite decision models. Acta Psychologica, Elsevier, 56(1-3), 29-48.

Pishdad, P. B., & Beliveau, Y. J. (2010). Analysis of Existing Project Delivery and Contracting Strategy (PDCS) Selection Tools with a Look Towards Emerging Technology. The 46th Annual International Conference . Boston, MA: Associated Schools of Construction.

Rojas, E. M., & Kell, I. (2008). Comparative Analysis of Project Delivery Systems Cost Performance in Pacific Northwest Public Schools. Journal of Construction Engineering and Management, ASCE, 134(6), 387-397.

Rueda-Benavides, J. A., & Gransberg, D. D. (2014). Indefinite Delivery - Indefinite Quantity Contracting Case Study Analysis. Journal of the Transportation Research Board, National Academies, No. 2408(3), 17-25.

Saaty, T. L. (1990). How to make a decision: The Analytic Hierarchy Process. European Journal of Operational Research, 48(1), 9-26.

Touran, A., Gransberg, D. D., Molenaar, K. R., & Ghavamifar, K. (2011). Selection of Project Delivery Method in Transit: Drivers and Objectives. Journal of Management in Engineering, ASCE, 27(1), 21-27.

Touran, A., Gransberg, D. D., Molenaar, K. R., Bakhshi, P., & Ghavamifar, K. (2009a). A Guidebook for Selecting Airport Capital Project Delivery Methods. Washington, D.C.: Federal Aviation Administration.

Touran, A., Gransberg, D. D., Molenaar, K. R., Ghavamifar, K., Mason, D. J., & Fithian, L. A. (2009b). A Guidebook for the Evaluation of Project Delivery Methods. Washington, D.C.: Federal Transit Administration.

Yin, R. K. (2003). Case Study Research: Design and Methods (3rd ed.). California, USA: SAGE Publications.

Zhang, X. (2005). Criteria for Selecting the Private-Sector Partner in Public-Private Partnerships. Journal of Construction Engineering and Management, ASCE, 131(6), 631-644.

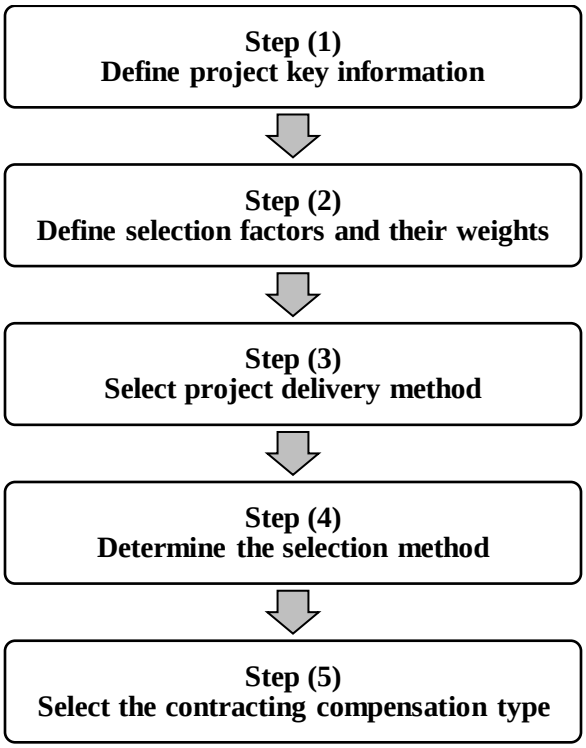
Zhang, X. (2006). Factor Analysis of Public Clients' Best-Value Objective in Public–Privately Partnered Infrastructure Projects. Journal of Construction Engineering and Management, ASCE, 132(9), 956-965.

APPENDIX A

PROJECT DELIVERY METHOD SELECTION GUIDELINE

Instructions to Use the Project Delivery Method Selection Guideline:

- The goal of this selection guideline is to help public / private owners select the most appropriate project delivery method for their projects to increase the success likelihood of their projects.
- This selection guideline is adopting the Project Owner's standpoint in the whole of its processes and procedures.
- Description of selection guideline steps:



Selection Model Steps

1. **Step (1):** Project owner starts with studying the project scope to define the project key information, which will be used in next steps.
2. **Step (2):** Project owner picks out the selection factors that have maximum influence on the project success from the defined selection factors, then starts defining the weight of each selection factor by populating the column of "Factor

Weight". The selection factor weights shall be defined in order from highest to lowest with respect to its influence on project success using 100 total points, where the highest points refer to the most important factor. The following points should be considered while populating the factor weights:

a. Choosing at least four selection factors.

b. Avoiding equal weighting of factors.

c. Avoid giving a factor weight of less than five points.

d. The total factor weights should be equal to 100 points.

e. Follow the reference scoring scale for defining the selection factor weights:

Selection Factor Reference Weights

Factor Weight	Priority Definition
100	Extreme priority
80	Very high priority
60	High priority
40	Moderate priority
20	Low priority
10, 30, 50, 70, 90	Intermediate values between two adjacent judgments.

3. **Step (3):** After populating the selection factor weights, the total weighted score of each project delivery method should be calculated by multiplying the factor weights (project owner's input) by each project delivery method score (selection model's default built-in scores). Ultimately, the total weighted score (sum of weighted scores) should be calculated for each project delivery method so that the project owner can rank the project delivery methods and make his decision by selecting the project delivery method of highest score (rank).

4. **Step (4):** The owner determines the selection method through which the contractor is selected, and the project is awarded. The owner should select one of three available selection methods: low bid, qualifications-based selection, best value. The project owner can use the flowchart together with the table in step 4 to easily make a decision.
5. **Step (5):** This is the last step in the selection model where the project owner selects the contracting compensation type that defines how the contractor is paid for the services he offers. The selection model has defined the most common contracting compensation method for each delivery method along with other possible compensation alternatives that can be used. The owner should select one of four available compensation methods; fixed price or lump sum, guaranteed maximum price (GMP), cost reimbursable, and fixed price based on unit price book. The project owner can use the flowchart together with the table in step 5 to easily make a decision.

Selection Guideline Procedures:

Step (1): Define project key information

In this step, the project owner studies the project scope thoroughly to define the project key information, which will be used in the following stages. The information that needs to be extracted, is shown below:

- **Project Title**:
- **Location**:
- **Sector**: Public / Private
- **Work Type**: New construction / Repair & Maintenance
- **Project Duration**:
- **Project Urgency**: Urgent delivery / Normal delivery
- **Project Budget**:
- **Project Fund Source**: Internal Fund / External Fund
- **Scope Status**: Defined / Undefined
- **Design Status**: Completed / In-progress / Not Started
- **General Remarks:**

Step (2) & (3): Define selection factors and their weights & Select project delivery method

#	Selection Factor Category	Selection Factor	Factor Weight	Project Delivery Method									
				DBB		DB		CMR		JOC		DBFOM	
				Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
1	Project Characteristics	Control cost growth		3		10		6		6		10	
2		Ensure lowest cost		6		10		3		6		3	
3		Facilitate early construction cost estimates		3		6		10		6		6	
4		Control time growth		3		10		6		6		10	
5		Ensure fastest schedule		3		10		6		6		10	
6		Promote early procurement		3		10		10		6		10	
7		Efficiently utilize poorly defined scope		10		3		6		6		3	
8		Efficiently utilize well-defined scope		6		10		10		10		10	
9		Efficiently coordinate design and construction (complexity)		3		10		10		6		10	
10		Ensure high quality project		6		6		10		10		10	
11	Owner's Agency	Maximize owner's controlling role		10		3		10		3		3	
12		Maximize owner's involvement in pre-construction		10		3		10		3		3	
13		Minimize owner's risk for design error and omission		0		10		6		3		10	
14		Minimize owner's pre-construction / overhead cost		3		3		3		10		3	
15	Public Regulation	No statutory authorization required		10		3		3		10		3	
16	Project Finance & Lifecycle	Transfer financial risks to contractor(s)		6		10		3		3		10	
17		Provide external project fund		0		0		0		0		10	
18		Optimize Lifecycle Costs		6		3		6		0		10	
19		Transfer operation & maintenance cost to contractor		0		0		0		0		10	
20		Ensure sustainable goals in design		6		3		6		0		10	

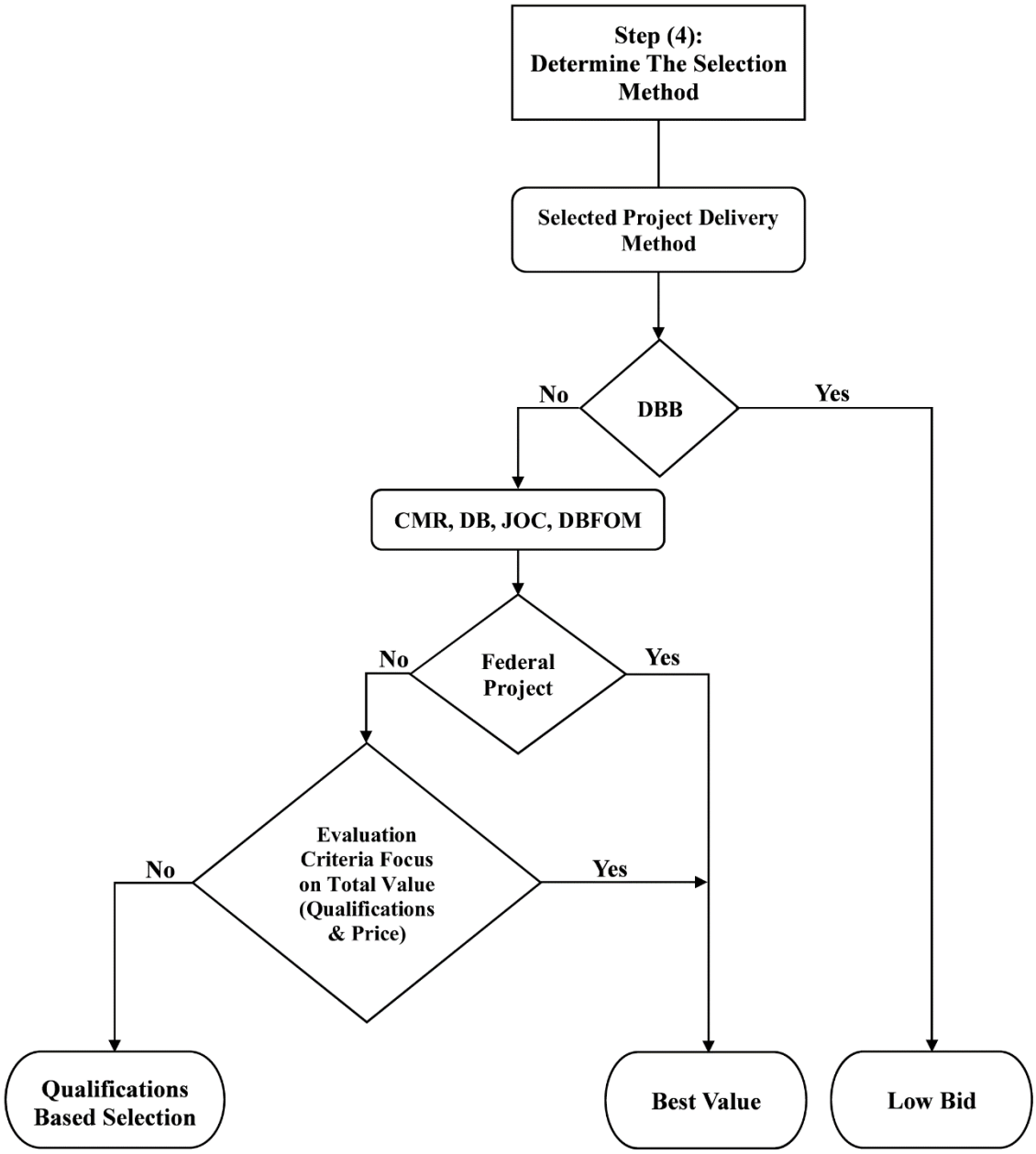
Performance Score of Project Delivery Methods

#	Selection Factor Category	Selection Factor	Factor Weight	Project Delivery Method									
				DBB		DB		CMR		JOC		DBFOM	
				Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
21	Other Factors	Minimize number of contracted parties		6		10		6		10		10	
22		Reduce construction claims		0		10		6		6		10	
23		Reduce change orders		0		10		6		6		10	
24		Reduce adversarial relationships		0		10		6		6		10	
25		providing pre-construction services by contractor		0		6		10		6		6	
26		contactor selection based on qualifications or best value		3		10		10		10		10	
27		Provide single point of responsibility for project		0		10		0		6		10	
28		Fast project award for small tasks (< $2M)		0		0		0		10		0	
Total Score													

Selection Factor Reference Weights

Factor Weight	Priority Definition
100	Extreme priority
80	Very high priority
60	High priority
40	Moderate priority
20	Low priority
10, 30, 50, 70, 90	Intermediate values between two adjacent judgments.

Step (4): Determine the selection method

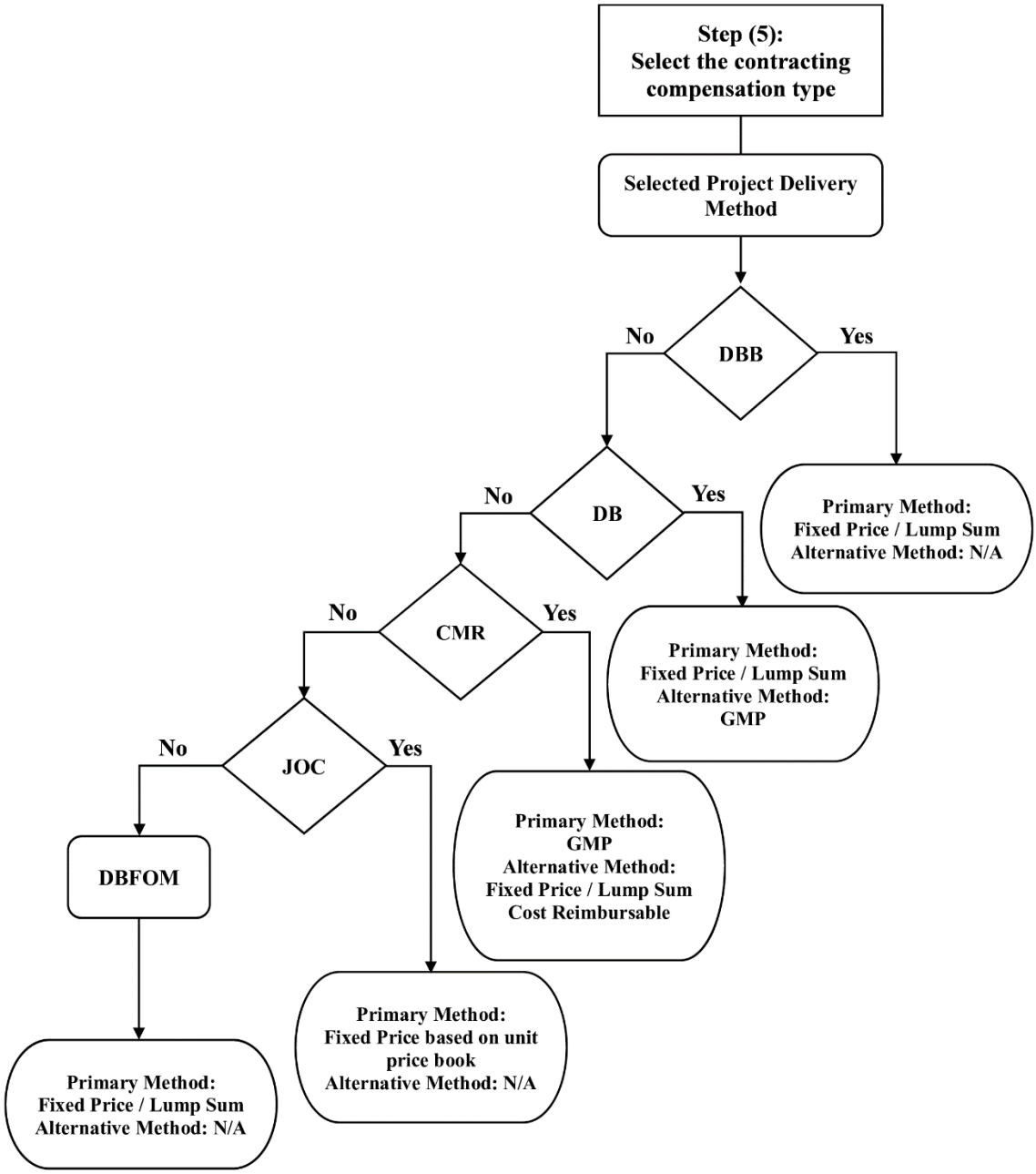


Flowchart of Model Step (4)

Selection method Characteristics

	Low Bid	Qualifications Based Selection	Best Value
Project Delivery Method compatibility	DBB	CMR, DB, JOC, DBFOM	CMR, DB, JOC, DBFOM
Selection Criteria	Lowest responsible bid	Qualifications only	Qualifications and Price
Process Steps	One-step process by issuing Invitation For Bid (IFB)	One-step process by issuing Request For Qualifications (RFQ)	Two-step process; 1st step: issuing RFQ to obtain qualification statement 2nd step: issuing RFP to obtain financial proposal
Evaluation Method	Used exclusively with DBB with a sole focus on price of responsive bids	Focus on qualifications only	Focus on total value (qualifications and price)
Federally Acceptable Method	Yes	No, as price isn't considered in contractor selection	Yes

Step (5): Select the contracting compensation type



Flowchart of Model Step (5)

Contracting Compensation Methods

	DBB	DB	CMR	JOC	DBFOM
Common Contracting Compensation Method	Fixed Price / Lump Sum	Fixed Price / Lump Sum	Guaranteed Maximum Price (GMP)	Fixed Price based on unit price book	Fixed Price / Lump Sum
Contracting Compensation Alternatives	N/A	1. Guaranteed Maximum Price (GMP)	1. Fixed Price / Lump Sum 2. Cost Reimbursable	N/A	N/A

APPENDIX B

FEEDBACK SURVEY

All the information you provide for this survey shall be kept confidential to protect your interests and the interests of your company. All the information collected by this survey shall be used for the sole purpose of research at Arizona State University.

The goal of this survey is to collect the feedback of the construction industry practitioners about a project delivery method selection model which is basically developed to help public and private owners select the most appropriate project delivery method for their projects to increase the success likelihood of their projects.

Instructions:

Before filling out this feedback survey, you should first check out the project delivery method selection model.

Survey Questions:

Please answer the following questions based on your experience of using the Project Delivery Selection Model

1) Which is of the following best describe your professional background? *

- ☐ Public Owner
- ☐ Private Owner
- ☐ Project Management (PM) Consultant
- ☐ Subject Matter Expert
- ☐ Other:……..

2) How many years have you overall involved in construction industry and in construction management specifically? *

Answer:……

3) Which construction market have you spent most of your time working in? *

	Less than 3 years	3-5 years	6-10 years	More than 10 years	N/A
U.S. Market	☐	☐	☐	☐	☐
Canadian Market	☐	☐	☐	☐	☐
European Market	☐	☐	☐	☐	☐
Middle East Market	☐	☐	☐	☐	☐
Australian Market	☐	☐	☐	☐	☐
Asian Market	☐	☐	☐	☐	☐
Other:…….	☐	☐	☐	☐	☐

4) How would you rate ease of using the selection model on a scale from 0 to 5 where 0 is the worst and 5 is the best? *

	1	**2**	**3**	**4**	**5**	
Very difficult	☐	☐	☐	☐	☐	Very simple

5) Do the selection factors, defined in the model, cover most of the project objectives and goals, you are seeking for? *

☐ Yes

☐ No

6) If your answer for the previous question was "No", What are the other project objectives you are looking for, but they aren't covered by the selection factors? *

Answer:……

7) How would you rate the selection factors inclusion in terms of covering the project objectives and goals you are seeking for, on a scale from 0 to 5 where 0 is the worst and 5 is the best? *

	1	2	3	4	5	
Very limited	☐	☐	☐	☐	☐	Very comprehensive

8) Please write down the output of the selection model, after applying it on your project Vs the actual results of your project: *

Please specify the Project Delivery Method

	Selection Model Output	Actual Result
Design-Bid-Build (DBB)	☐	☐
Design-Build (DB)	☐	☐
Construction Manager at Risk (CMR)	☐	☐
Job Order Contracting (JOC)	☐	☐
Design-Build-Finance-Operate-Maintain (DBFOM)	☐	☐
N/A	☐	☐

9) Please write down the output of the selection model, after applying it on your project Vs the actual results of your project: *

Please specify the Selection Method

	Selection Model Output	Actual Result
Low Bid	☐	☐
Qualification Based Selection	☐	☐
Best Value	☐	☐
N/A	☐	☐

10) Please write down the output of the selection model, after applying it on your project Vs the actual results of your project: *

Please specify the Contracting Compensation Type

	Selection Model Output	Actual Result
Fixed Price / Lump Sum	☐	☐
Guaranteed Maximum Price (GMP)	☐	☐
Cost Reimbursable	☐	☐
Fixed Price based on unit price book	☐	☐
N/A	☐	☐

11) Based on the output of the selection model, how would you rate the efficiency of the selection model on a scale from 0 to 5 where 0 is the worst and 5 is the best? *

	1	**2**	**3**	**4**	**5**	
Poor	☐	☐	☐	☐	☐	Excellent

12) Based on the output of the selection model, what are the drawbacks of the selection model in your opinion? *

Answer:……

13) If you have any recommendations for improving the selection model, please list them below:

Answer:……

14) General Remarks:

Answer:……

APPENDIX C

PROJECT DELIVERY METHOD SELECTION GUIDELINE EXAMPLE

Step (1): Define project key information

- **Project Title**: Pinnacle Peak Road (45th Avenue to 35th Avenue) - Street and Storm Drain Improvements
- **Location**: Phoenix, AZ
- **Sector**: Public
- **Work Type**: New construction
- **Project Duration**: 12 months
- **Project Urgency**: Normal delivery
- **Project Budget**: $12,736,382
- **Project Fund Source**: Internal Fund
- **Scope Status**: Defined
- **Design Status**: Completed
- **General Remarks: -** Project components:

    1) New storm drain pipe, catch basins and box culvert crossings.
    2) New sidewalk, curb, gutter and new street lighting.
    3) Landscaping improvements.
    4) Modernized traffic signals at 43rd Avenue and 39th Drive.

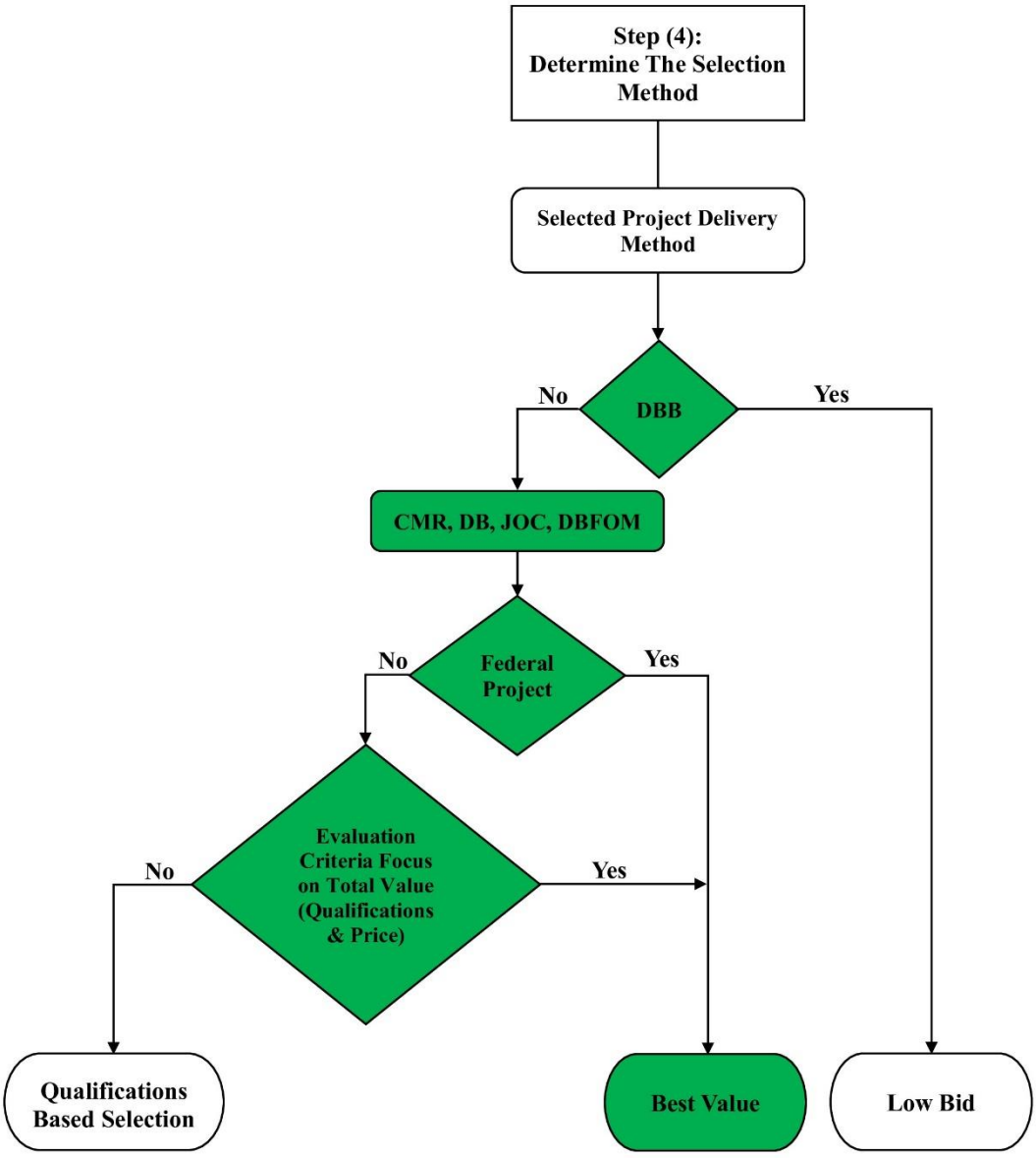
Step (2) & (3): Define selection factors and their weights & Select project delivery method

#	Selection Factor Category	Selection Factor	Factor Weight	Project Delivery Method									
				DBB		DB		CMR		JOC		DBFOM	
				Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
1	Project Characteristics	Control cost growth	24	3	72	10	240	6	144	6	144	10	10
2		Ensure lowest cost		6		10		3		6		3	
3		Facilitate early construction cost estimates		3		6		10		6		6	
4		Control time growth	15	3	45	10	150	6	90	6	90	10	150
5		Ensure fastest schedule		3		10		6		6		10	
6		Promote early procurement		3		10		10		6		10	
7		Efficiently utilize poorly defined scope		10		3		6		6		3	
8		Efficiently utilize well-defined scope		6		10		10		10		10	
9		Efficiently coordinate design and construction (complexity)		3		10		10		6		10	
10		Ensure high quality project	20	6	120	6	120	10	200	10	200	10	200
11	Owner's Agency	Maximize owner's controlling role	14	10	140	3	42	10	140	3	42	3	42
12		Maximize owner's involvement in pre-construction	10	10	100	3	30	10	100	3	30	3	30
13		Minimize owner's risk for design error and omission		0		10		6		3		10	
14		Minimize owner's pre-construction / overhead cost		3		3		3		10		3	
15	Public Regulation	No statutory authorization required		10		3		3		10		3	
16	Project Finance & Lifecycle	Transfer financial risks to contractor(s)		6		10		3		3		10	
17		Provide external project fund		0		0		0		0		10	
18		Optimize Lifecycle Costs	12	6	72	3	36	6	72	0	0	10	120
19		Transfer operation & maintenance cost to contractor		0		0		0		0		10	
20		Ensure sustainable goals in design		6		3		6		0		10	

#	Selection Factor Category	Selection Factor	Factor Weight	Project Delivery Method									
				DBB		DB		CMR		JOC		DBFOM	
				Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
21	Other Factors	Minimize number of contracted parties		6		10		6		10		10	
22		Reduce construction claims	5	0	0	10	50	6	30	6	30	10	50
23		Reduce change orders		0		10		6		6		10	
24		Reduce adversarial relationships		0		10		6		6		10	
25		providing pre-construction services by contractor		0		6		10		6		6	
26		contactor selection based on qualifications or best value		3		10		10		10		10	
27		Provide single point of responsibility for project		0		10		0		6		10	
28		Fast project award for small tasks (< $2M)		0		0		0		10		0	
Total Score					**549**		**668**		**776**		**536**		**602**

Selected Project Delivery Method: Construction Manager at Risk (CMR)

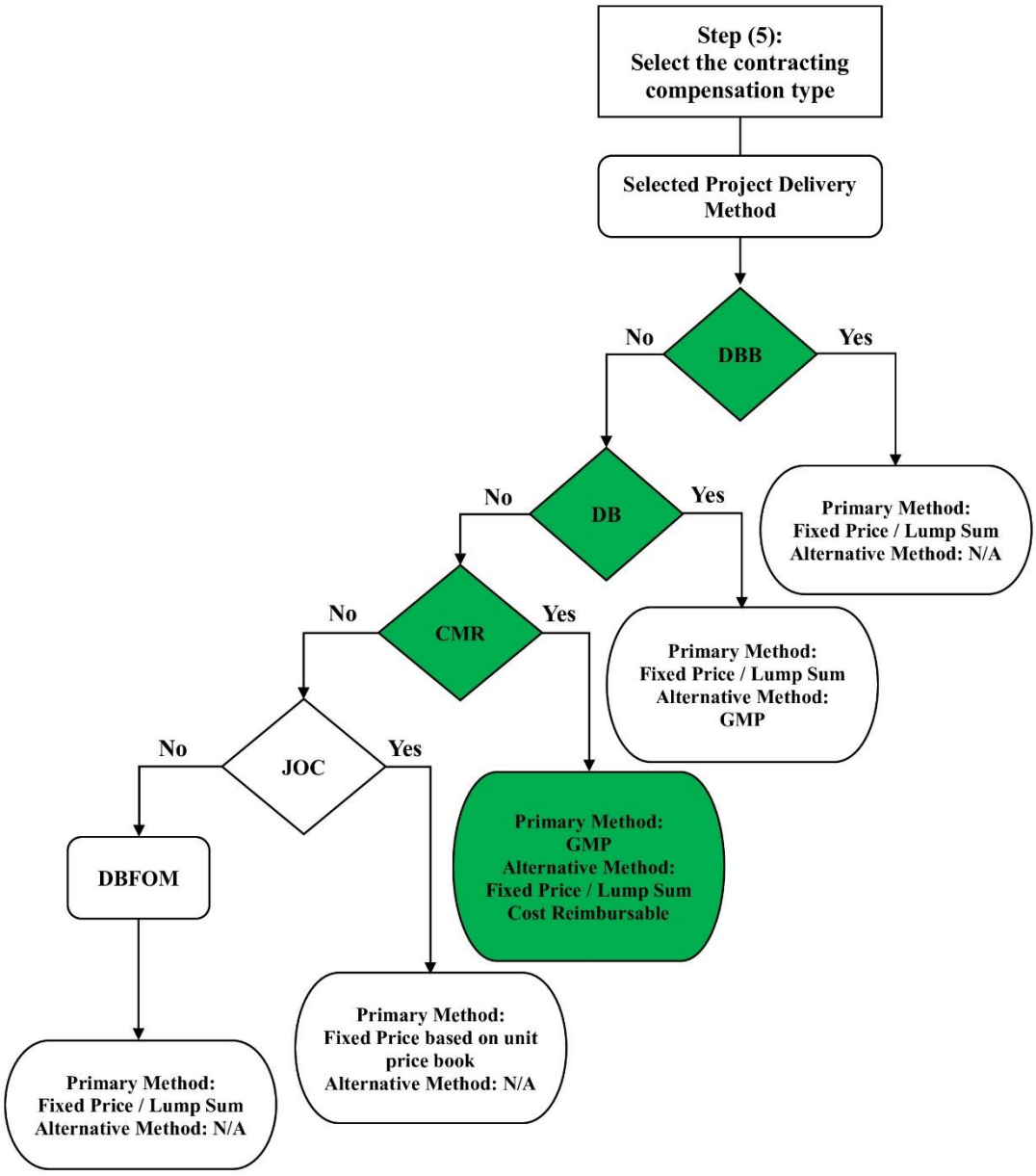
Step (4): Determine the selection method



	Low Bid	Qualifications Based Selection	Best Value
Project Delivery Method compatibility	DBB	CMR, DB, JOC, DBFOM	CMR, DB, JOC, DBFOM
Selection Criteria	Lowest responsible bid	Qualifications only	Qualifications and Price
Process Steps	One-step process by issuing Invitation For Bid (IFB)	One-step process by issuing Request For Qualifications (RFQ)	Two-step process; 1st step: issuing RFQ to obtain qualification statement 2nd step: issuing RFP to obtain financial proposal
Evaluation Method	Used exclusively with DBB with a sole focus on price of responsive bids	Focus on qualifications only	Focus on total value (qualifications and price)
Federally Acceptable Method	Yes	No, as price isn't considered in contractor selection	Yes

Selection Method: Best Value

Step (5): Select the contracting compensation type



	DBB	DB	CMR	JOC	DBFOM
Common Contracting Compensation Method	Fixed Price / Lump Sum	Fixed Price / Lump Sum	Guaranteed Maximum Price (GMP)	Fixed Price based on unit price book	Fixed Price / Lump Sum
Contracting Compensation Alternatives	N/A	1. Guaranteed Maximum Price (GMP)	1. Fixed Price / Lump Sum 2. Cost Reimbursable	N/A	N/A

Contracting Compensation Type: Guaranteed Maximum Price (GMP)