Construction delivery methods in the United States Air Force

by

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Abstract

This report analyzes construction delivery method use in the United States Air Force (USAF) and determines which methods prove to be more effective and efficient and which construction delivery methods should be pursued. The construction delivery methods undergoing analysis are design-bid-build (DBB), design-build (DB), construction manager at risk (CMAR), and integrated project delivery (IPD). A literary review of previous studies on the aforementioned construction delivery methods, particularly regarding studies performed within the United States (US) federal government and US military branches is presented. The benefits for each construction delivery method is discussed, as well as the common obstacles and problems with each one. A survey was conducted in which 145 contracting officers in the USAF responded, and the survey results are analyzed and compared to those found in the literary reviews. Two major conclusions drawn from the literary review and survey are that DB should be used over DBB in most cases, and IPD should be examined as a viable USAF construction delivery method candidate. With the literary review, DB is seen as superior to DBB in almost every regard, and the surveyed contracting personnel tended to favor DB over other construction delivery methods. For higher complexity or large projects DBB can offer more control but sacrifices timeliness. IPD has data that suggests it can be a construction delivery method that is better than DB and DBB but currently cannot legally be used for USAF construction contracts because the Federal Acquisition Regulation (FAR) restricts it. DB should be defaulted to as the go to construction delivery method if the project is a viable candidate and there are not extenuating factors that suggest another method be used. It should be explored what parts of IPD can be implemented for now, while larger legislative changes to the FAR are made at the congressional level.

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Dedication

To my father, Todd Giefer, and mother, Diane Giefer, and for my late grandfather, Eugene Fladung.

Preface

The basis for this research on construction delivery methods within the USAF stemmed from my general interest as an architectural engineering major and my personal interest as a future officer in the USAF.

I am an analytical person, so being able to perform a survey allowing me to analyze data for trends greatly appealed to me. If the data can show that there is support for trying or putting more emphasis into a certain construction delivery method, or conversely a lack of support for a currently favored construction delivery method, I hope that this research can be useful in promoting change within the federal government regarding restrictions on the types of construction delivery methods currently allowed through the Federal Acquisitions Regulation (FAR). If possible, I hope information discovered would lend itself to helping future members of the USAF and perhaps increase the overall efficiency and effectiveness of the contracting and construction field, particularly in the military where stricter regulations can hinder operations.

Chapter 1 - Introduction

The United States of America (US) construction sector has lagged behind virtually all other sectors regarding productivity growth since 1964 (Garcia, 2014). While the construction industry is continually trying to meet the demands of project cost, quality, and time (Chan, 2002), it has exhibited a negative productivity growth for the past two decades whereas all other nonfarm industries have shown positive productivity growth and are trending towards additional growth (Garcia, 2014). The construction industry has not been without improvements to tools and technology, so it can be assumed that other factors are contributing to the lack of progress and the general stagnation in the construction sector. Military spending greatly impacts the construction industry, so it is in the government's interest to investigate these potential factors. One factor that has been identified is that the procurement systems, of which construction delivery methods play an important role, appear to be outdated or at the very least may not be as efficient as they could be. This report will analyze the different construction delivery methods for United States Air Force (USAF) projects to identify viable alternatives or improvements to the construction delivery methods currently in use.

Inside the US military and the federal government, added regulations retard the construction process and inhibit growth, specifically the Federal Acquisition Regulation (FAR). The FAR is a document containing the principle set of rules for the FAR System regarding government procurement and is codified in Chapter 1 of Title 48 of the Code of Federal Regulations. The FAR system governs the acquisition process by which executive agencies of the US federal government acquire goods and services by contract with appropriated funds and regulates the activities of government personnel in carrying out that process. It therefore applies to construction contracting in the USAF and to the USAF contracting officers responsible for awarding construction contracts. In order to better understand the USAF procurement process and how it impacts construction delivery methods, 145 USAF contracting officers were surveyed to obtain their opinions on construction delivery methods and what they believe the best steps forward to enhance productivity to the procurement process would be while working within the constraints of the FAR.

Report Layout and How Analysis Will be Conducted

Firstly, in chapter 2 terms are explained and the construction delivery methods in the survey are explained in detail so as to prevent confusion regarding what each method entails.

In chapter 3, a literary review will look over previous research done on construction delivery methods, focusing particularly on research done on construction delivery methods in the US federal government and its military branches. Most of the existing research reviewed dealt with construction delivery methods in the military involving the United States Navy (USN) and United States Marine Corps (USMC). Both the USN and USMC also fall under the FAR, which applies likewise to the USAF. There are more strict regulations that apply to some branches of the military and not to others, such as the USN and USMC supplements to the FAR. However, the USAF does have its own supplemental restrictions, and none of the regulations go as far as to explicitly outlaw the use of construction delivery methods that are already restricted by the FAR.

Chapter 4 will cover an analysis of a survey that was conducted amongst the contracting career field in the USAF which includes 145 respondents that provided their feedback as to the construction delivery methods currently used and why, as well as other pertinent information.

Chapters 5 and 6 will analyze the data generated from this survey and that data will be cross analyzed against the previous reports and studies discovered during the literary review to see if there are any significant similarities or differences.

Chapter 7 will conclude the body of the report by summarizing any significant findings.

Chapter 2 - Construction Delivery Methods

Four different construction delivery methods are being analyzed in this report: Design-Bid-Build (DBB), Design-Build (DB), Construction Manager at Risk (CMAR), and Integrated Project Delivery (IPD). Within this chapter, the explanation for why these four methods are selected out of all possible construction delivery methods is presented. The background information necessary to understand each construction delivery method, including their general definition, advantages, disadvantages, and history is explained. Lastly, other less used methods that are legal for use under the FAR are briefly defined and why they were not included in this research is addressed.

Design-Bid-Build:

Definition:

Design-Bid-Build (DBB), also known as the traditional method, is a project delivery method used in the construction industry in which the owner commissions an architect or engineer to prepare drawings and specifications under a design services contract, and separately contracts for at-risk construction by engaging a contractor through competitive bidding or negotiation. DBB involves three phases: design, bidding, and construction. In the design phase, the owner retains an architect to design and produce bid documents (contract documents), including construction drawings and technical specifications that provide the project specifics that meet the owner's needs. In the bidding phase, the contract documents are bid upon by competing general contractors. In the construction phase, the project is physically constructed, typically through subcontractors hired by the winning general contractor (Brookwood, 2011). Figure 2.1 indicates a simplified diagram depicting the hierarchy of a DBB contract/project.

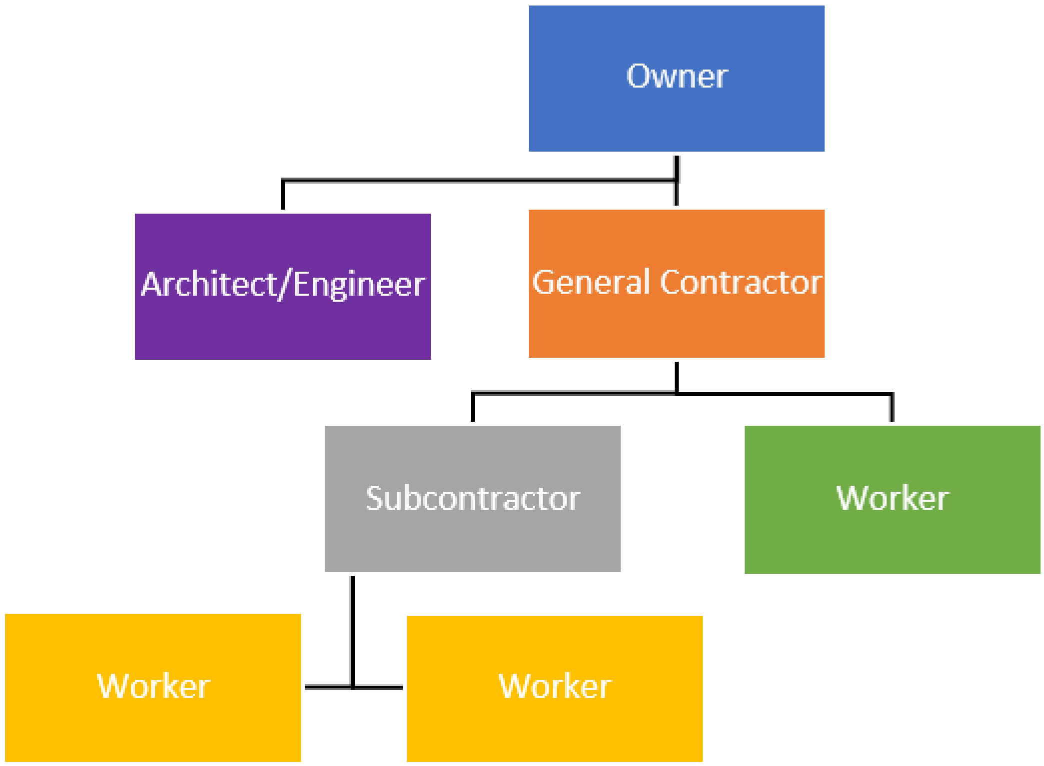

Figure 2.1 DBB Construction Delivery Method

Advantages:

Being considered as the traditional contract method, DBB has well-established legal and contractual precedents which help avoid confusion for both the owner and contractor as to what is expected from each party (Beard et al., 2001). Theoretically, the bidding phase allows for the owner to obtain the lowest reasonable price for construction depending on the completion and coordination of the contract documents (Beard et al., 2001). The owner has complete control over the design of the project since meetings and submittals, drawings and specifications, occur at different stages (typically 30%, 60%, and 90%) of design completion for review and comment (Webster, 1997; Department of the Air Force, 2000). The architect gives the owner professional design advice in a not-at-risk relationship (Beard et al., 2001). Established legal findings exist for allocating risk and responsibility, as well as an established procedure for licensing architects and engineers (A/E) and construction firms (Beard et al., 2001). The contractor assumes all construction risks, such as weather costs, labor disputes, material cost increases, and other external factors (Rosner, 2008). The project is fully defined at the end of the design phase, with 100% complete drawings, specifications, and cost estimates (Cushman & Loulakis, 2001). The sealed bid packages are based on price, not on subjective metrics (Rosner, 2008).

Disadvantages:

The owner acts as the arbiter between the designer and constructor and bears the risk for the adequacy of design. Any disagreements between the designer and constructor must be remedied by the owner (Beard et al., 2001). The owner funds change orders for design conflicts. Increased costs reduce the contingency funds and could potentially lead to litigation (Cushman & Loulakis, 2001; Rosner, 2008). Little shared vision or goal between the contracted entities exists since the designer typically focuses on the accuracy and quality of the product with the constructor focusing on the cost and schedule management (Beard et al., 2001; Cushman & Loulakis, 2001). The focus on an initial low bid does not consider past performance, environmental practices, concern for life cycle performance, and other best-value selection criteria, meaning the initial low bid may not be the final best value. Best value criteria can be used instead. The USAF tends not to use best value criteria because it is more difficult to create and apply best value criteria than it is to evaluate for the lowest cost, technically feasible option. The price is not certain until a construction bid is received, which is typically done on the 100% design package (bids at 90% or 95% design package is allowed in the USAF but is not commonly practiced). If the bids are over the budget, then the project must be redesigned, or the scope must be revisited (Beard et al., 2001). The constructor is not involved in the design process, which therefore lacks construction input from the winning bidder (Beard et al., 2001;

Cushman & Loulakis, 2001). The linear structure does not allow for overlap of phases, meaning DBB takes longer than other construction delivery methods (Beard et al., 2001; Cushman & Loulakis, 2001). The prevalence of disputes between the constructor and designer over design clarity, errors, omissions, construction quality, time delays, and other project related issues is well documented (Beard et al., 2001). Contractors can 'low bid' by counting on profits obtained by submitting change orders resulting from omissions and errors (Rosner, 2008). The contractor may need more staff because they are not the ones that provided the design, so more architects, engineers, and inspectors are required to review the drawings, specifications and inspect the construction to make sure it complies with design (Rosner, 2008).

History:

Although DBB is considered the traditional method, the Design-Build (DB) method goes back to ancient times, making it technically the "traditional" method of the construction delivery methods instead of DBB. Most of the construction projects in the ancient world were built by individuals called master builders (Beard et al., 2001), who were responsible for the entire project, from design through construction (Cushman & Loulakis, 2001). Up until the Renaissance, DB was far and away the best, if not the only, construction delivery method available. Starting with the Renaissance and culminating in the Industrial Revolution, the difference between designers and builders was defined and distinguished and DBB became the predominate construction delivery method. The American Society of Civil Engineers and Architects (ASCE) was founded in 1852 to assist in easing this distinction. When the American Institute of Architects (AIA) was founded in 1857 the "and Architects" was removed from ASCE's name (Beard et al., 2001). The DBB method dominated the construction industry for most of the first half of the 1900s; however, DBB underwent a high level of scrutiny in the 1960s and 1970s because increasing project complexity necessitated a higher level of coordination than was previously needed between designers and contractors for these technically complex projects (Cushman & Loulakis, 2001).

The Miller Act of 1935 protected the federal government from contractors that lacked capital to finish projects, further making the DBB method the preferred method, since the cost was known with the initial bids (Beard et al, 2001). The 1947 Armed Services Procurement Act established procurement procedures for the military and the Federal Property and Administrative Procedures Act of 1949 followed for civilian agencies and federal public works. Both directed federal agencies to use negotiation procedures for A/E services and separate competitive bid procedures for construction, which made DBB the preferred method (Loulakis, 2003). DBB was preferred in the USAF until the Clinger-Cohen Act of 1996 finally authorized the unlimited use of DB for federal use, amending the Defense Authorization Act of 1996 and the 1996 Federal Acquisition Reform Act (Beard et al., 2001; Loulakis, 2003).

Design-Build:

Definition:

Design-Build (DB) is a project delivery method used in the construction industry where the design and construction services are contracted to a single entity known as the DB contractor. The DB contractor is a combination of the architect/engineer and general contractor used in the Design Bid Build (DBB) method (see the previous section for the definition of DBB). The purpose of this combination is to consolidate responsibility for both design and construction into a single point, as well as allow for the overlap of the design and construction phases of projects and the omission of the bid phase. The DB contractor performs the design, contracts subcontractors and is fully responsible for the delivery of the project, ideally allowing for reduced risks and overall costs (Cushman & Loulakis, 2001). Figure 2.2 provides a simplified diagram of the hierarchy of a DB contract/project showing the owner, who commissions the architect/engineer and the general contractor under one contract who then contract subcontractors or self-performs construction through workers.

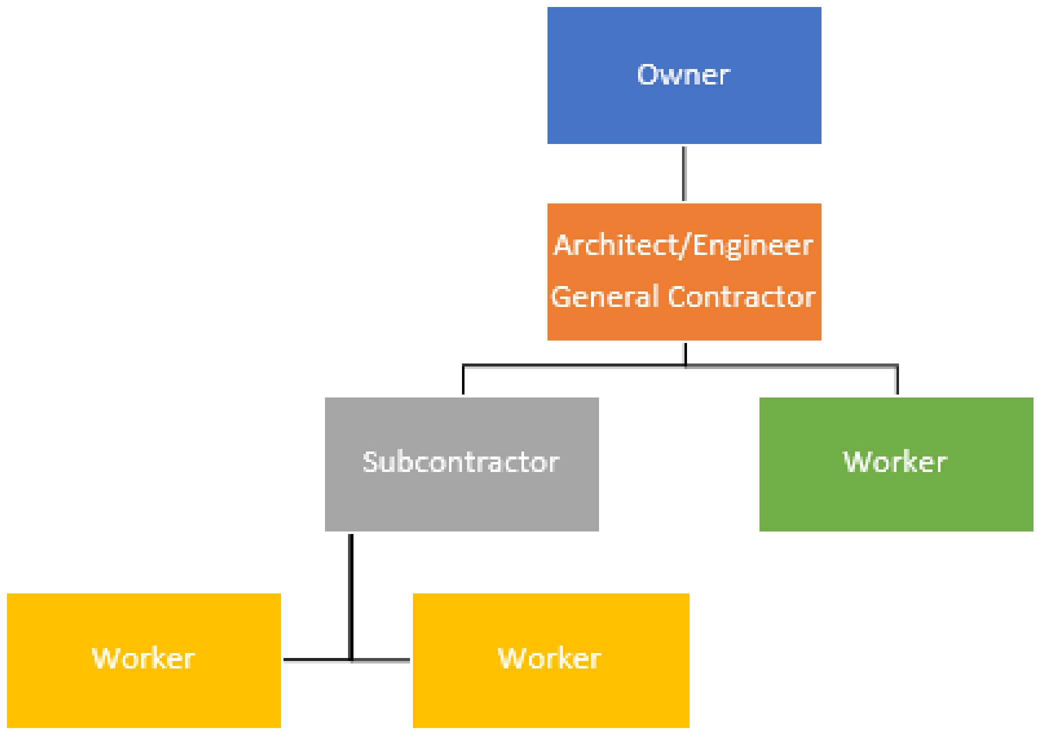

Figure 2.2 DB Construction Delivery Method

Advantages:

The combination of the designer and builder into a sole entity creates a single source of responsibility for both the design and construction services for the project. The responsibility for errors and omissions, faulty performance, and coordination of problems are consolidated to the design-build contractor (Mouritsen, 1993; Beard et al., 2001; Cushman & Loulakis, 2001). Owners avoid most claims and litigations due to the complete responsibility of the DB contractor. In addition, DB omits a bidding phase, allowing material and equipment procurement as well as site staging to begin before the design documents are complete, thus shortening the project's overall schedule (Mouritsen, 1993; Beard et al., 2001; Cushman & Loulakis, 2001). The combined DB allows for cost savings because estimates are coordinated through the DB contractor, and costs are known at proposer selection (Department of the Air Force, 2000; Beard et al., 2001; Cushman & Loulakis, 2001). Value engineering and constructability that occur through each phase of the project result in a more cost-effective delivery method (Mouritsen, 1993; Department of the Air Force, 2000; Beard et al., 2001; Cushman & Loulakis, 2001).

Construction input is given from commencement of design from the builder due to the overlapping design and building phases. This allows for design errors, omissions, and defects to be quickly identified and resolved, resulting in a higher quality final product (Webster, 1997; Beard et al., 2001; Cushman & Loulakis, 2001). DB is performance based, where the contractor is told what the owner wants, instead of specifications based, where the contractor is told how to do the work to meet the owner's requirements (Mouritsen, 1993; Department of the Air Force, 2000; Beard et al., 2001). This encourages innovation, with proposers evaluating different solutions to select the best approach which will meet the owner's/client's goals. The DB method does not require as many architects, engineers, and inspectors, thus reducing the amount of personnel required as well as the administrative burden, because the same entity designs and constructs the project. Using the DB delivery method allows personnel to have multiple roles and the owner does not need to manage separate contracts (Mouritsen, 1993, Department of the Air Force, 2000; Cushman & Loulakis, 2001).

Disadvantages:

Although being a popular delivery method alongside DBB, owners and practitioners might be unfamiliar with DB because they have not used it at all or are still unaccustomed to the method (Beard et al., 2001; Cushman & Loulakis, 2001). Inexperienced teams might need to hire experienced professional owner's representative because the management team lacks the experience required (Department of the Air Force, 2000; Rosner, 2008). From the owner's perspective, if the owner does not have adequate staffing, it is difficult to develop and present their needs clearly to a DB team (Rosner, 2008). As stated in the advantages, DB is based on performance and not specifications. Owner's need to be comfortable with qualifications-based proposals instead of the DBB approach of bidding on completed design documents (Beard et al., 2001). Because DBB is the more traditional method and its contractual paperwork has existed for the longest time of the construction delivery methods, in some cases its separate design and construction contracts are still used for DB, which complicates the DB process (Beard et al., 2001).

The industry was originally wary of DB and as a result put higher premiums on insurance and bonding, but premiums have decreased since (Beard et al., 2001; Rosner, 2008). Owners are not as involved in the design review process and place project risk on the contractor. Owners that are not willing to embrace the required trust level for DB to work effectively, will instead cause reduced effectiveness, increased cost, and a delay in the process (Cushman & Loulakis, 2001). Without the separation of designer and constructor, the designer's interests are no longer tied to the owner's needs (Mouritsen, 1993). This means that the owner's advocate in the designer is lost. The omission of the bidding phase means that the owner might not get the lowest price (Rosner, 2008).

History:

The history of the DB method goes back to ancient times, making it technically the "traditional" method of the construction delivery methods instead of DBB. The pyramids, Parthenon, Coliseum, and essentially all the construction projects in the ancient world were built by individuals called master builders (Beard et al., 2001). The master builder was responsible for the entire project, from design through construction (Cushman & Loulakis, 2001). Up until the Renaissance, DB was far and away the best, if not the only, construction delivery method available. In the Renaissance, architects began to separate themselves from builders, making the builders bid on the architects for their services and designs, creating the DBB method. DB fell by the wayside until the mid-1900s, where a resurgence has been seen due to the involvement required in modern-day projects. The AIA formed the 1975 Design-Build-Bid Task Force to clarify roles of professionals for the new system, and the first version of standard DB contract documents became available in 1985 (Beard et al., 2001). The Design Build Institute of America (DBIA) formed in 1993 (Cushman & Loulakis, 2001). The need for close collaboration between the designer and builder has again made DB one of the most heavily favored construction delivery methods.

As far as DB's history within the USAF, originally procurement law only allowed for projects to be done with DBB. With the resurgence of DB in the 1960s and 1970s in the civilian sector, the Department of Defense (DoD) began experimenting with the method to see if it was worthwhile. This required a change in procurement law. The DoD first permitted the use of DB in 1967 for Military Family Housing (MFH), and 30 MFH projects were completed by 1972 (Mouritsen, 1993). The United States Army (USA) experimented first with DB outside of MFH in 1982 and then 1984, with projects delivered earlier than the DBB method and within budget (Buckingham, 1989). The Military Construction Authorization Act of 1986 allowed each branch of military a maximum of three DB projects annually until 1990 (Department of the Air Force, 2000). Pilot projects were authorized from 1986 to 1996 for the USAF. The Clinger-Cohen Act of 1996 finally authorized the unlimited use of DB for federal use, amending the Defense Authorization Act of 1996 and the 1996 Federal Acquisition Reform Act (Beard et al., 2001; Loulakis, 2003).

Construction Manager at Risk:

Definition:

Construction Manager at Risk (CMAR) is a delivery method which entails a commitment by a construction manager to deliver the project within a guaranteed maximum price (GMP) which is based on construction documents and specifications at the time of the GMP (Haltenhoff, 1999). The CMAR acts as a consultant and provides design, engineering, and construction services to the owner in the design and construction phases, provides construction services (if not subcontracted), and manages and controls project costs in order to not exceed the GMP, because any costs that exceed the GMP that are not change orders are the financial liability of the CMAR (Haltenhoff, 1999). The CMAR typically will give the owner a GMP prior to receiving complete bid documents. By doing so the CMAR assumes the risk of bids being higher since the CMAR is contractually bound to deliver the project per the contract documents as defined in his GMP (Haltenhoff, 1999). Figure 2.3 depicts a simplified diagram of the hierarchy of a CMAR contract/project.

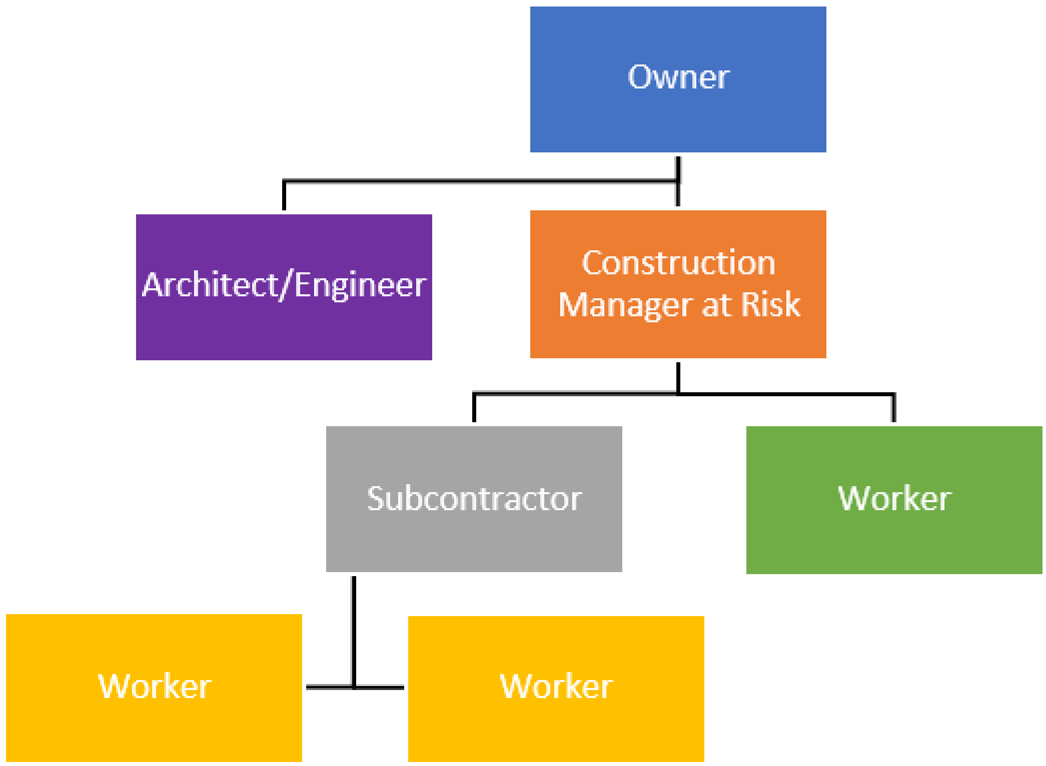

Figure 2.3 CMAR Construction Delivery Method

Advantages:

The owner has a higher level of cost control from the beginning of the project. A successful CMAR project usually involves hiring the CMAR prior to the architect and then having the CMAR assist in selecting the architect (Campbell County, n.d.)). During the design process, the CMAR provides cost estimates at key phases. If these are in line with the established budget, then the architect continues the design. If not, the CMAR, architect, and owner assess the cost estimate and make design changes to achieve budget alignment (Campbell County, n.d.). The CMAR is the owner's advocate and manages the project with the owner's interests which takes the burden off the owner having to manage and coordinate the project. Therefore, the owner's risk is limited because of the CMAR giving a GMP that they are highly incentivized to abide by because they are responsible for covering overages (Strang, 2002).

Constructability and value to the owner are afforded by value engineering expertise provided by the CMAR, who hires personnel that can provide the highest quality product at the lowest price to stay within the GMP (Campbell County, n.d.). Because the CMAR gives the GMP prior to bidding, the owner is not required to select the lowest bid. A thorough prequalification process minimizes quality and performance issues with low bidders and leads to low long-term costs, higher quality, and fewer claims (Strang, 2002). The CMAR's main purpose is not to construct the project but to manage the construction, and this management focus helps add value to the project because the CMAR is looking to keep construction costs down while achieving the criteria specified by the design (Campbell County, n.d.; Strang, 2002).

Disadvantages:

The architect may or may not heed feedback from the CMAR during the design phase, resulting in conflict much like that which could develop between the architect and contractor in a DBB method (Campbell County, n.d.). The CMAR method is better for larger projects because it can provide preconstruction services, pre-qualification of subcontractors, reduced risk for the team members, less litigation, better schedule adherence, higher quality, and better budget control, so CMAR may not be the best method for smaller scale projects because there are no justifiable benefits to offset the higher initial cost of this method (Craven, 2017; Muter, 2014). During the early stages of the project before the GMP is established, ambiguity concerning the scope of work included under the GMP may occur. Because of its separate contract with the designer, the owner is potentially financially liable for exclusions and inconsistencies in the contract documents depending on how well the contract is written (Craven, 2017).

History:

The Construction Management Association of America (CMAA) was established in 1982 to set standards for managing construction projects (CMAA, 2019). CMAR is a relatively new construction delivery method. Many consider CMAR to be a variation of DB. CMAR is commonly referred to by the USAF as Design-Build+ and is essentially a form of design and construction that retains all advantages and flexibility of DB. It allows for use of performance specifications and a low level of design much like DB, so that the contractor has flexibility in their execution of the project because they are not following a predetermined design. It allows the flexibility of award to the contractor offering best value instead of lowest bid. The CMAR in this case is referred to as the DB+ contractor (Department of the Air Force, 2007).

Integrated Project Delivery:

Definition:

Integrated Project Delivery (IPD) is a team-based approach method that involves the owner, architect, engineers, contractor, and subcontractors working together throughout the design and construction phases in a highly collaborative relationship where the team shares both the risk and the rewards. The intention of IPD is to increase transparency/communication, save time, and create a shared accountability. Figure 2.4 depicts a simplified diagram of the IPD contract/project hierarchy. The chain of command is different from other construction delivery methods due to IPD being a team-based approach rather than a contract-based approach.

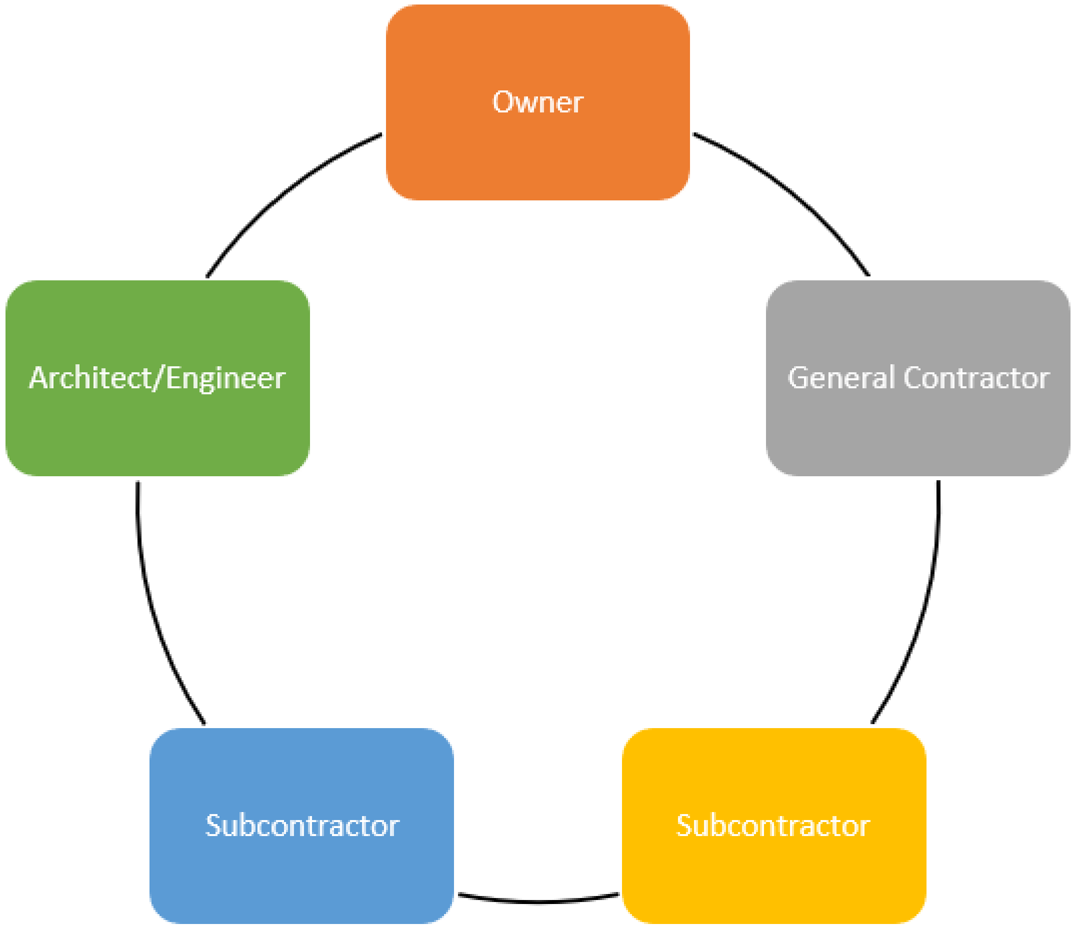

Figure 2.4 IPD Construction Delivery Method

Advantages:

With IPD, the owner is given the ability to make sound judgments that assist in transforming their vision into reality, all within budget. IPD removes traditional boundaries where the owner, architect and builder are separate parties. It eliminates layers of complexity that add time and cost because it aligns all parties' interests, which helps ideas flow more freely, and lessens the stress of decision making because all parties want the same thing (Langmade, 2018). Unique cost sharing arrangements allow shared savings. For example, the mechanical contractor can assist with structural steel design so that it accommodates for the mechanical equipment, instead of the typical approach where equipment is shoehorned into the building around the steel (Singleton, 2010). The more the owner saves, the more the contracted company makes (because the project price is fixed, any discrepancies are absorbed by the contractor, whether positive or negative), and added incentives lower project costs (The American Institute of Architects, 2007). Team members share ideas, costs, and profits without hidden agendas (such as the structural steel design being designed so it is cheaper but as a result the mechanical contractor must design a more expensive solution to fit), so design information is more readily accessible, allowing more informed decisions and ultimately a better product (The American Institute of Architects, 2007; Singleton, 2010). With the owner, architects, engineers, and contractors all involved in the design process from start to finish, owner priorities are less likely to get lost in translation because they are involved during the entire design and construction process and therefore, thoroughly informed (The American Institute of Architects, 2007).

IPD places value in shortening the design and construction process, creating a better-quality end-product through collaboration of the parties, and lessening risk for all parties involved (The American Institute of Architects, 2007). It skips unnecessary steps such as contracting separate parties because the IPD team is already composed of all necessary parties needed to complete a project, and overlaps processes, such as the design and construction phases (much like DB). The high amount of collaboration also reduces the number of change orders (Integrated Project Delivery Collaborative, n.d.; Cheng et al., 2018). During construction, labor and rental equipment can be shared which reduces cost (The Integrated Project Delivery Collaborative, n.d.). Increased collaboration and shared risk produce high quality design and construction because the architect plays a major role in integrating design input from all parties (who communicate design plans amongst themselves first), instead of designing the project by themselves (Lee, 2013). Like DBB, the owner and architect have direct contract and communication regarding issues of quality and design. However, there is greater flexibility and faster delivery without loss of cost control because within the IPD method there is more continuity and communication regarding parties' preferences and objectives throughout the design and construction phases which catches discrepancies quickly, so they can be solved efficiently. This ensures an early determination of project costs and deliverables during the design development phase, which in turn ensures a cost-effective design (The American Institute of Architects, 2007; Friedlander, 2017). The IPD benefit of focus on an early design is supported by the research of Patrick MacLeamy who developed the MacLeamy curve shown in Figure 2.5. MacLeamy stated an architectural project becomes more difficult to change the more developed it becomes, and his curve advocates shifting design effort forward in the project and frontloading it, reducing the cost of design changes (The American Institute of Architects, 2007).

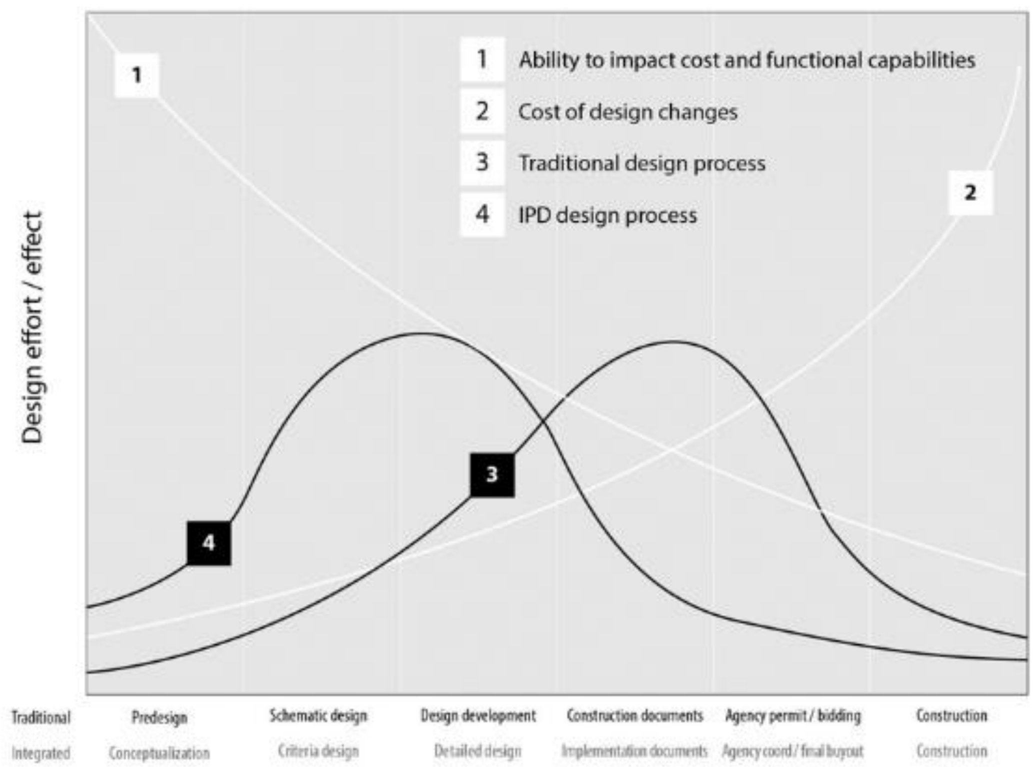

Figure 2.5 The MacLeamy Curve (The American Insitute of Architects, 2007)

Since little to no adversity between architect and contractor happens, IPD method has fewer claims and disputes than DBB with avoidance of low bidding where the contractor wins project bidding below actual cost and then counts on change orders and claims to make a profit (Friedlander, 2017). Like CMAR, a single point of responsibility exists for the project with the project team accepting responsibility for functional problems which reduces liability and minimizes claims (Friedlander, 2017). The team can negotiate a price rather than rely on competitive bidding (The American Institute of Architects, 2007).

Disadvantages:

Trust is not automatic and using IPD will not automatically make team members trust each other. The design/construction team needs to work on developing good relationships between contractors, owners, architects, and engineers. Unfortunately, some project owners find it difficult to secure financing for IPD projects, as lenders are not always familiar with this new design/construction contract approach. In addition, designers and contractors may be unfamiliar with IPD and refuse to participate on projects (Contractors Insurance, 2016). IPD requires the design/construction team to cooperate to a higher level than other delivery methods; on occasion, parties may be required to pass tasks they normally perform to other responsible parties on the team, such as acquiring labor or equipment that will be shared (Integrated Project Delivery Collaborative, n.d.; Stencil & Powell, 2018). The design/construction team must understand the overall project's goals to a higher degree than other delivery methods. High functioning team members within each discipline need to be flexible, knowledgeable, and always available, understanding the scope of the entire project and not just their area of expertise so that they can communicate quickly to adjust for discrepancies with other parties' designs or offer suggestions of their own (Stencil & Powell, 2018). Ensuring documentation (construction documents, addenda, change orders, contracts, etc.) and information (permits, reports, individual party responsibilities, etc.) are readily available throughout the design and construction process through an open environment requires additional work and time from key parties (Stencil & Powell, 2018). IPD is best for repetitive projects because of their assembly line nature which garners improved results by maintaining a consistent team and offering incentives for increased outcomes from project to project. It is also well-suited for complex projects because of the intense focus required for proper planning, innovation and results, or for large projects that benefit from strong party alliances and processes as the parties work together over a long amount of time (Stencil & Powell, 2018).

History:

IPD is one of the youngest construction delivery methods. The construction industry has suffered from productivity decline since the 1960s and when compared to other non-farm industries', construction labor productivity is the only non-farm industry that has failed to increase labor productivity over the last 50 years (Chan, 2014). This is partially attributed to projects falling behind schedule or going over budget, and to adverse relations that can develop between the owner, general contractor, and architect (Barbosa et al., 2017). IPD is designed to solve these problems. The concept of IPD was trademarked in 2000 and sponsored by the AIA in 2007. Since then, this approach has gained traction from many architecture, engineering, and construction (AEC) firms (Luu, 2017).

Alternative Construction Delivery Methods

Other construction delivery methods are allowed in the USAF; these are covered in the Project Managers' Guide for Design and Construction, coded as C-1 through C-7. C-1 is DBB, C-2 is two-step DB (which is the traditional DB method), and C-5 is CMAR which the USAF calls DB+ (Department of the Air Force, 2007). The survey for this report did not include the other methods (C-2, C-3, C-4, C-6, and C-7) because they are all variations of DB and assumed to be grouped with the traditional DB method. The other methods grouped with DB are:

C-3 One-Step DB – In the one step variation, the request for proposal (RFP) is usually based on performance specifications and a general description. Proposals are detailed and evaluated on technical merit and cost. This type of delivery method should also be utilized only when well established industry standards and materials are available and control after contract award is not desired or necessary. Potential vendors must be willing to risk higher costs to compete (Department of the Air Force, 2007).

C-4 Bridging Design Build – The bridging variation of DB involves a detailed description of the project from the USAF's perspective and utilizes preliminary design drawings and specifications. This provides the DB contractor with latitude in the final detailed development of the design and in the execution of working drawings. The USAF must approve specific design packages for compliance with standards in the RFP before releasing the contractor to build. This method offers greater USAF control, but all requirements must be thoroughly communicated to facilitate a successful project delivery using this method. The project can be more complex than for C-3 or C-6 and potential vendors have lower cost risk (Department of the Air Force, 2007).

C-6 Design Build (Turnkey) – A turnkey project establishes a fixed price, usually based on a written RFP with no sketches or drawings. USAF personnel prepare the RFP defining the minimum design requirements and the DB teams submit design concepts along with price proposals and qualification packages. This form of acquisition is usually selected for repetitive type construction projects such as housing, temporary living facilities (TLFs), and like structures.

This type of contracting has the highest level of risk for the contractor and often involves a significant amount of money for preparation of each proposal. It may include a requirement for the contractor to complete land acquisition to achieve the final facilities (Department of the Air Force, 2007).

C-7 Design Build (Fast Track) – The Fast Track delivery method is a form of DB, in which construction begins before working drawings and specifications are complete, and work is based on multiple bid packages for each phase of work, with all contracts managed by the USAF. This delivery method offers the highest potential for reduced acquisition time and cost. Disadvantages are that it is more complex, and time consuming to administer and requires greater construction management skills. In addition, a potential for higher costs and schedule risks exists. The best application for C-7 is for bona fide emergencies where time savings carries high premiums. The work must also be divisible into discrete packages (Department of the Air Force, 2007).

Chapter 3 - Literature Review

The most predominate construction delivery methods in the construction industry are DB and DBB, and they are also the only two legal construction delivery methods for use by USAF contracting per the FAR. CMAR is referred to by the USAF as Design-Build+, and is considered a form of design and construction that retains all of the advantages and flexibility of DB. For this reason, previous studies on DB and DBB were selected for review, specifically studies within the branches of the US military, preferably within the USAF. Rosner 2008 document, *An Analysis of the Design-Build Delivery Approach in Air Force Military Construction* analyzes DB in the USAF. Hale et al. 2009 study, *Empirical Comparison of Design/Build and Design/Bid/Build Project Delivery Methods* presents a comparison of DB and DBB regarding USN BEQs. Allen 2001 document, *Comparison of Design-Build to Design-Bid-Build as a Project Delivery Method* also compares DB and DBB, using data from USN MILCON projects.

While IPD is not usable as a construction delivery method in the US military per the FAR, it is a fast-growing method that has demonstrated immense potential. For this reason, previous studies on IPD potential in the US military were selected for review. Both Singleton 2010 document, *Implementing Integrated Project Delivery on Department of the Navy Construction Projects* and Lee 2013, *Implementation of Integrated Project Delivery on Department of Navy Military Construction Projects* investigate the potential of implementing IPD for use in USN construction projects.

An Analysis of the Design-Build Delivery Approach in Air Force Military Construction

Overview:

Rosner 2008 document, *An Analysis of the Design-Build Delivery Approach in Air Force Military Construction,* examines the DB construction delivery method in USAF military construction. It is a comparison between the performance of the DB construction delivery method with the "traditional" approach that USAF MILCON had favored previously in the DBB construction delivery method. Data was gathered from the Automated Civil Engineer System – Project Management Module (ACES-PM) regarding 835 MILCON projects (278 DB, 557 DBB) from the fiscal years 1996-2006. This data was analyzed to see if the DB method resulted in better cost performance, better schedule performance, fewer modifications, increased performance level regarding cost and schedule measures, and for what types of facilities DB was the better construction delivery method option. The following assumptions were made: Data was gathered on 100% complete projects from continental US locations and excluded military family housing projects. The eight performance metrics defined by the study were unit cost, cost growth, schedule growth, construction speed, modifications per million dollars, current working estimate/programmed amount (CWE/PA) ratio, construction timeline, and total project time. Results were described as statistically significant if the probability-value was less than 0.05, and highly significant if less than 0.01. In addition, projects were grouped in two-year increments and by category codes for facility types. This study, *An Analysis of the Design-Build Delivery Approach in Air Force Military Construction,* was not able to investigate the causality of the results, just the numbers since no documentation was given for cause of modifications, all modifications were assumed to be a result of a negative case. ACES-PM data measures project timeline from notice to proceed date to beneficial occupancy date. DB projects include design and construction time, while DBB include only construction time thus the results are skewed in favor of DBB.

Results and Findings:

Rosner 2008 document, *An Analysis of the Design-Build Delivery Approach in Air Force Military Construction*, found that the DB construction delivery method has better performance in six of eight metrics analyzed, with significant results for cost growth and number of modifications per million dollars, whereas DBB performed better regarding construction timeline and total project time. DB demonstrated improvement over time in four metrics (cost growth, modifications per million dollars, construction timeline, total project time) while DBB showed improvement in two areas (cost growth, modifications per million dollars). A facility-type analysis showed that DB was best suited for seven of the nine facility types (types include airfield pavements, operations, maintenance, corrosion control, storage, administration, dormitory, fitness center, and child development center).

Conclusion:

Rosner 2008 document, *An Analysis of the Design-Build Delivery Approach in Air Force Military Construction*, concluded that the studies and reports compiled were qualitative and gave anecdotal support for the DB construction delivery method. It was concluded that the study provided empirical evidence that the DB construction delivery method provided an advantage to the traditional method of DBB that USAF MILCON employed.

Empirical Comparison of Design/Build and Design/Bid/Build Project Delivery Methods

Overview:

Hale et al. 2009 study, *Empirical Comparison of Design/Build and Design/Bid/Build Project Delivery Methods*, compares the performance of DBB and DB to determine if one project delivery method is superior regarding time and cost. Similar military buildings were used to identify two samples of projects delivered with each of the two delivery methods (both USN Bachelor Enlisted Quarters (BEQs)). One sample included 39 DBB projects while the other sample was 38 DB projects. The study was limited to measuring cost and schedule performance of the 77 Naval Facilities Engineering Command (NAVFAC) projects for BEQs delivered from fiscal year 1995 to fiscal year 2004 through the MILCON process. A hypothesis was constructed that DB projects are superior to DBB projects regarding time and cost. Cost per bed with other costs, cost per bed, cost growth, project duration, fiscal year duration, project start duration, project duration per bed, fiscal year duration per bed, project start duration per bed, and time growth were statistically compared to test this hypothesis.

Result and Findings:

Hale et al. 2009 study, *Empirical Comparison of Design/Build and Design/Bid/Build Project Delivery Methods*, performed an empirical analysis of USN DB and DBB contracts. First, a literary review of multiple sources was conducted. A study by Michael Roth in 1995 compared six DBB and six USN DB childcare facilities built through the MILCON process. Roth found that the DB construction delivery method significantly reduced costs associated with design and construction, and cost growth was also decreased. However, this is a small sample and a test run when DB was still new to the USN. Ibbs et al (2003) concluded that DB projects outperformed DBB projects with respect to time, but the results associated with cost were not statistically convincing. Hale et al. (2009) stated the skill of the project management team and experience of the contractor had greater impacts on the project performance than the construction delivery method. Hale et al. (2009) indicated that other studies have shown time savings can be achieved by using the DB construction delivery method (Songer & Molenaar 1996; Bennett et al. 1996; Konchar & Sanvido 1998; Molenaar et al. 1999). Konchar and Sanvido concluded DBB projects were more likely to have changes in their schedules than DB projects and concluded the DB construction delivery method showed cost benefits. Bennett et al. (1996) agreed with these findings. Uhlik and Eller (1999) suggested a shift to DB would decrease the time to design and build new facilities, with the overall cost also being reduced. Warne (2005) stated that DB projects had better price certainty and a majority of them were completed ahead of schedule. The Federal Highway Administration (FHwA) compared DB and DBB highway projects in 2006 and its study showed that DB projects had higher cost growth but lower schedule growth in comparison to DBB projects. Shrestha et al. (2007) compared DB and DBB highway projects with cost higher than $50 million, and its study showed that DB projects had lower cost growth but higher schedule growth in comparison to DBB projects. All these research findings are compiled in Table 3.1.

Hale et al (2009) used statistical analysis on the samples to determine whether one construction delivery method was better than the other. The confidence level for the analysis was set at 95%, with the null hypothesis saying the means of the DB and DBB samples would be equal. The p-value would have to be 0.05 or less for the null hypothesis to be false. The results of the analysis are shown in Table 3.2.

Table 3.1 Findings of Studies Done on DB and DBB

Researchers	Methods	Sample Size	Project Types	Project Size	Major Findings
Roth (1996)	DB DBB	6 6	Navy child care facilities	N/A	Cost growth for DB was lower than that for DBB.
Songer and Molenaar (1996)	DB DBB	108 N/A	Industrial, building, and highways	N/A	Reduced cost and shortened duration were the top ranked factors for selected DB method.
Konchar and Sanvido (1998)	DB DBB	155 116	Industrial and buildings	N/A	Unit cost was 6% and cost growth was 5.2% less in DB. Schedule growth 11.4% less in DB.
Molenaar et al. (1999)	DB DBB	104 N/A	Industrial, buildings, and highways	N/A	59% of DB projects were with 2% or better of the established budget.
Ibbs et al. (2003)	DB DBB	24 30	Buildings	$5M to $1B	Cost growth for DB was 7.8% higher than that for DBB
Warne (2005)	DB DBB	21 N/A	Highway projects	$83M to $1.3B	76% of DB projects were finished ahead of schedule
FHwA (2006)	DB DBB	11 11	Highway projects	$5M to $20M	Cost growth for DB was 3.8% higher than that for DBB. Schedule growth for DB was 9% lower than that for DBB.
Shrestha et al. (2007)	DB DBB	4 7	Highway projects	$50M to $1.3B	Cost growth for DB was 9.6% lower than that for DBB. Schedule growth for DB was 5.2% higher than that for DBB.

Table 3.2 Single Factor ANOVA for Cost and Schedule Performance Metrics

Metric	Unit	DB mean	DBB mean	F-value	p-value	F-critical
Cost per bed with other costs	$K/bed	56.0	58.0	0.097	0.756	3.968
Cost per bed	$K/bed	53.1	56.4	0.317	0.575	3.968
Cost growth	%	2.0	4.0	6.738	0.011	3.968
Project duration	Days	667	1398	55.650	<0.001	3.968
Fiscal Year duration	Days	864	1026	8.801	0.004	3.968
Construction start duration	Days	667	771	5.779	0.019	3.968
Project duration/bed	Days	2.6	7.0	20.726	<0.001	3.968
Fiscal Year duration per bed	Days	3.6	5.1	4.375	0.0040	3.968
Construction start duration per bed	Days	2.6	3.7	4.711	0.033	3.968
Time growth	Days	76.4	193.8	11.450	0.001	3.968

Total adjusted barracks project cost was obtained by multiplying the total barracks project cost by the September 2004 index and then dividing by the respective midpoint of construction index, and cost per bed was obtained by then dividing the total adjusted barracks project cost by the total number of beds. Cost per bed with other costs includes the cost of the BEQ construction along with other types of work included in the project. These other costs included a variety of non-typical costs (demolition, dewatering, special architectural features, etc.) that were removed to obtain an accurate cost per bed value. Means of cost/bed with other costs and cost/bed are statistically not different, but evidence indicates that both are lower for DB projects than DBB projects. The significance test conducted on cost growth shows a p-value of 0.011, meaning the null hypothesis is rejected with statistical certainty, which confirms a difference in sample means. All of the schedule-related performance metric mean differences for the DB and DBB projects were statistically significant. Since all p-values were less than 0.05 the null hypothesis can be rejected with almost statistical certainty. Project duration, fiscal year duration, construction start duration, project duration per bed, fiscal year duration per bed, construction start duration per bed, and time growth for a DB project are lower than those of a DBB project.

Conclusion:

Hale et al. (2009) concluded that DB projects proved to be superior in performance in every measured factor (cost/bed with other costs, cost/bed, cost growth, total project duration, fiscal year duration, project start duration, project duration per bed, fiscal year duration per bed, project start duration per bed, and time growth) with statistical significance in eight of the ten factors measured (cost growth, total project duration, fiscal year duration, project start duration, project duration per bed, fiscal year duration per bed, project start duration per bed, and time growth). The DB construction method is thus superior to the DBB construction delivery method when used on building projects. The sample data shows that DB projects will take less time to complete and have less time and cost growth. While statistical significance was not found, Hale et al. (2009) concluded the data seemed to indicate that DB projects may be less expensive to build.

Comparison of Design-Build to Design-Bid-Build as a Project Delivery Method

Overview:

Allen 2001 document, *Comparison of Design-Build to Design-Bid-Build as a Project Delivery Method*, evaluates the difference between the DBB and DB construction delivery methods. NAVFAC had used both the DBB and DB construction delivery methods for the decade prior to Allen's study. The most recent four years before the thesis, 1998-2001, saw an increase in the use of the DB construction delivery method. This study compares cost, schedule, and quality attributes of the two types of construction delivery methods and was completed using data from 110 MILCON projects. This study used MILCON projects from the financial information system database from FY 1996-2000. The research is aimed at helping an owner better select the construction delivery method best suited to their facility goals and criteria.

Allen 2001 wanted to ascertain if the DB construction delivery method was superior to DBB when managing USN BEQ construction projects. This was deemed the primary issue for the subsidiary questions which included investigating what type of homogenous construction projects were representative of NAVFAC, Southwest Division and analyzing the comparative quality performances, comparative cost growths, and comparative schedule growths of projects using the DBB construction delivery method versus the DB construction delivery method.

Results and Findings:

Allen 2001 document, *Comparison of Design-Build to Design-Bid-Build as a Project Delivery Method*, found that the decision to use the DB construction delivery method or DBB delivery method comes after a full analysis in the advanced planning stage of the needs and requirements of the facility. DB is chosen when importance is put on execution because it is believed that DB will ensure execution of 100% of project dollars each FY because a single contract is awarded quicker than the two contract actions required by the DBB process. DB is also selected because contingency funds on MILCON projects, for all intents and purposes is non-existent and DB is seen as satisfying a mission for delivering a project with zero contingency dollars while the DBB process historically experiences several change orders to the contract. DB is typically chosen if speed of delivery is ranked most important, and as of 2000, NAVFAC stated that DB is the procurement strategy of choice.

Allen 2001 presented three key metrics: cost, schedule, and performance, and explained which metrics used within the construction industry she would use to capture these key metrics. Cost Performance/Cost Growth (CG) measures the percentage increase of construction contract amount from award price to the total final price. Schedule Performance or Time Growth (TG) measures the increase or decrease in a contract's life. Engineer's Estimate (EE) or estimated program amount are on the 1391 funding authorization and the Award Cost (AC). NAVFAC programs/authorized projects are based on the EE from the 1391 funding authorization. Award Growth (AG) is the difference in value of the EE and AC.

Other indices were included and based on the concepts of earned value and dollar placement. Earned value measures the speed with which a contractor earns the full contract amount. Dollar placement is the average earned value over a specific portion of a project's life cycle. Earned value is normally not applied to NAVFAC design contracts, but the concept can be extended as a means of measuring the design contract performance in terms of cost and time index. Three metrics related to dollar placement were: Design placement (DP) is the average daily cost of the design contract; Construction placement (CP) is the average rate at which the construction contractor earns value over the entire period of the construction contract; and design-construct placement (DCP) is the sum of the design contract and the construction contract divided by the total time between the start of the design contract and the completion of the construction contract.

The final set of metrics is based on the cost to furnish a single unit of capacity in a given class of facilities. The scope of study for this thesis was limited to BEQs, and the most appropriate measurement was deemed cost per square foot of the finished facility. Delay costs were analyzed individually for BEQ projects if the code or description defined the change as a delay. The metric including delay costs was DCP. Time elapsed in calendar days was captured by the TG metric, while liquidated damages from the contractor's failure to complete the contract within the specified time were accounted for in the CG metric. The rate of change orders was analyzed as a percentage of CG for the BEQs.

Quality measurements are defined as the degree to which the facility meets the expected facility requirement, with a maximum score of 10 on a subjective scale rating. The measurement compared actual performance against the facility user or owner's expectation of the BEQ, with quality surveys collected for family fitness centers and day care centers. The facility maintenance or performance measure was based on the difficulty of facility startup, the number and magnitude of call backs, and the operation and maintenance costs required for the building. This measurement is the turnover quality (TQ) of the facility. A maximum score of 30 was possible. System quality (SQ) measured the performance of the envelope, roof, structure and foundation; the interior space and layout, and environmental systems and whether or not they met, exceeded, or did not meet owner expectations. A maximum score of 30 was possible. Equipment quality (EQ) was the quality of the process equipment in the facility. The process equipment and layout had a maximum score of 10.

For analysis, Allen divided the projects into vertical and horizontal classifications based on how they were classified within MILCON. Eighty-nine vertical projects (32 DB, 57 DBB), and 21 horizontal projects (4 DB, 17 DBB) were examined.

Allen 2001 covered other literature and research to back her findings. In University of Florida study, of 11 completed DB Florida Department of Transportation (FDOT) projects and predicted time for DBB projects, all the DB projects resulted in performing better than the expected DBB results. The total DB project time was 35.7% less than that predicted for performing the projects as traditional DBB, and DB construction time was confirmed statistically greater than the DBB results at a 95% significance level. The actual DB design procurement times were considerably shorter than the normal design procurement time for non-DB design projects (54% less average design time). The change amount was -1.99 percent for DB projects and 8.78% for non-DB projects. The USN reported a 15% savings in DB project cost and a 12% reduction in facility delivery time over DBB projects. In a Pennsylvania State University study of 215 projects, an applied regression analysis was done for a schedule growth model, and the effects of a delivery system indicated DB to be 11.37% less than DBB, and 6.1% less for unit cost (square foot cost). The four major variables found included the procurement method, the level of new construction, the commercial terms, and the availability of a quality pool of contractors.

Allen 2001 also examined a University of Colorado Boulder (UCB) report which states the possibility to reduce the overall project delivery time is one of DB's most significant promises. The Utah Department of Transportation reduced I-15 project delivery time from 8-10 years to just 5 years by switching from DBB to DB.

In addition, Allen 2001 used a study of 209 DoD projects that showed DB projects have 33% fewer changes due to design deficiencies than projects procured through DBB. Analysis shows DB provides a delivery system that meets budget and schedule mandates, and in some areas provides better quality. The USA echoes this conclusion, stating that the Corps of Engineers (CoE) is using DB more and transitioning away from the DBB method. As of FY 2002, the USA was committed to executing 25% of stateside MILCON using DB, with plans to increase to 50% eventually.

Conclusion:

Allen 2001 document, *Comparison of Design-Build to Design-Bid-Build as a Project Delivery Method*, found that the award growth of horizontal DB projects was -20% with vertical DB and horizontal DBB having negative growths of -3% and -2% respectively, and vertical DBB at 3%. When looking at homogenous projects (family fitness centers, child care centers, BEQs) combined, the award growth for DB was -2% and 7% for DBB. Cost growth is higher for all DBB projects. The DB construction delivery method resulted in lower cost growth in all areas. For construction CG, the DBB method resulted in higher cost growth. The DB construction delivery method resulted in lower time growth of schedule growth than the DBB method. The DB construction delivery method resulted in higher DCP except for horizontal projects in which DBB performed better. The DB square foot costs are more variable than the DBB square foot costs. The survey questionnaire showed that DB outperformed DBB in two out of three areas for turnover process quality. DBB outperformed DB in three of four categories regarding system performance quality, but despite higher scores, actual remarks testified to poor quality materials and warranty problems.

The research provided conclusive evidence that DB is superior based on DB's outperformance of DBB in areas of cost growth, construction cost growth, award growth, and design-construct placement and should be used if the project is a viable candidate.

Implementing Integrated Project Delivery on Department of the Navy Construction Projects

Overview:

Singleton 2010 document, *Implementing Integrated Project Delivery on Department of the Navy Construction Projects*, explores IPD and its associated efficiency improvements and waste reductions that may directly benefit the NAVFAC and its employees and contractors, as well as the American taxpayer.

The paper focuses on how IPD can affect a project's operating system and discusses project organization and commercial terms. It uses literature review of academic papers, professional journal articles, and trade publications and a collective case study to demonstrate techniques and benefits and provides recommendations on which techniques of IPD can and should be integrated and discusses specific benefits applicable to the USN. Qualitative data was collected from the documents and reports of three IPD projects and presented, focusing on the IPD techniques employed on the projects that were successful. The three projects were chosen to provide a wide range of attributes such as public vs. private sector, "pure" IPD vs. partial implementation, and project complexity. The obvious legal ramifications of the FAR are briefly discussed, but this paper mainly covers what can be done without modifications to the FAR. The primary objectives are to create a list of IPD techniques that can benefit and be implemented on NAVFAC projects today by using best practices identified in the literature review, use case studies to demonstrate how and why the techniques should be implemented, and to develop a simple, easy-to-use criteria based upon easily identifiable project attributes that can be used to select IPD project candidates for NAVFAC. The decision-making tool used a simple numerical project scoring system that weighed selected project attributes, resulting in an overall project score that determines which NAVFAC projects could potentially implement select IPD techniques.

Results and Findings:

Singleton 2010 document, *Implementing Integrated Project Delivery on Department of the Navy Construction Projects*, indicates that major innovations in the past 20 years with the DB construction delivery method and partnering have helped reduce claims, change orders, and encourage schedule adherence (Killian & Gibson, 2005; Schmader, 1994) but have little effect on overall project duration and virtually no effect on cost (FHwA, 2006). They have had no effect on how projects are constructed in the field, including the use of labor, equipment, and materials. This area is where the project operating system domain comes into play, and one can determine the efficiency of the project operating system by measuring labor productivity (the amount of work being completed per man-hour). In a 40-year period from 1964 to 2003, productivity has gone down roughly 20% in the construction industry, while all non-farm industries have increased over 100%. This means that owners are getting less for their construction dollar now than they used to, even with advancements made in the past 40 years.

The problem identified with the project operating system is that the construction industry uses a “siloed” approach, where each entity involved in a project worries about their own interests, which may or may not align with those of the other entities and communicate only along contractual lines. This system is inefficient, wasteful, and contributes to low productivity rates. IPD was developed in conjunction with the Lean Construction Institute (LCI) and shares many attributes with lean construction, including maximizing value, and minimizing the waste of time, money, and materials. IPD was developed as a method to overcome the current operating system roadblocks in the construction industry with the added benefits of improving project organizations and commercial terms.

The FAR does not allow the government to participate in financial motivational techniques such as risk-sharing/profit pooling/contingency pooling (exceptions to the rule are seldom). It does not allow multi-party agreements or relational contracts and contains competitive bidding requirements for construction which makes hiring a construction contractor early in the design process difficult and time-consuming (not doing so exposes the government to contract award protests and claims if not done properly).

NAVFAC is concerned that IPD will increase administrative workload in administering a contract. NAVFAC has begun testing integrated teams, which is an IPD technique. This is done by using Early Contractor Involvement (ECI), where a general contractor is brought into the project during the design phase as a consultant and actively participates in the project design. Following the design phase NAVFAC has the option to award the construction of the project to the general contractor, provided the post-design project target price does not exceed the ceiling price that the contractor provided the government in their initial bid to become the CMAR.

The Pentagon Renovation (PenRen) Program began in 1996 with the first wedge of the Pentagon awarded as a DBB Firm-Fixed-Price (FFP) contract in 1998. An FFP contract provides a price that is not subject to any adjustment on the basis of the contractor's cost experience in performing the contract, placing the contractor at maximum risk and in a position of full responsibility for all costs (profit/loss). It was finished behind schedule and over budget. The PenRen program office studied the relationship between acquisition strategy and construction delivery and found FFP contracts strictly emphasize cost control but do nothing to positively affect the contractor's performance. With Wedge 1 renovation, contractors focused solely on constructing the building within their bid cost so that quality, resource management, project controls, and customer relations all suffered. Poor quality led to rework, poor resource management to wasted materials, equipment, and labor, poor project controls to poor productivity, and poor customer relations to unsatisfied customers not getting what they wanted. The government ended up footing the additional bill in the form of claims and change orders. The PenRen program office developed a new contracting vehicle that was a combination of Fixed-Price Incentive Fee (FPIF) and Fixed-Price Award Fee (FPAF). FPIF has additional incentives for the contractor if they are able to meet or exceed the specified performance criteria and penalties if they cannot. The FPIF aspect included target cost, target profit, and sharing arrangement for under runs and overruns, all determined at the outset of the project, with a ceiling price stipulated and the contractor defined with being 100% responsible for exceeding the price. FPAF has an additional amount of fee that may be added to the base amount of fee, based on judgmental measures of productivity, and that may be withheld if the contractor does not perform to the specified criteria. The FPAF aspect rewarded the contractor based on the customer's rating of non-cost criteria (safety, quality, timeliness, project controls, sustainability, resource management, etc.). The target profit on the FPIF side was set at $0, so the only way to make additional money was to complete the project below target cost. The FPAF side provided up to 10% profit, if the contract met required performance goals 100% of the time. The contractor only received a share of FPIF under runs or had the government pay for its share of overrun if they met the award fee performance goals 85% of the time. This made cost control important, but it did not come at the expense of the quality, schedule, or owner satisfaction. The owner and contractor goals were aligned, and it allowed the government to lower target cost for similar work when it reoccurred if there were previous cost savings. The PenRen project was completed in late 2011, three years earlier than planned. Overall it exhibited IPD characteristics of lean construction, painsharing and gainsharing, goals and incentives, and award fees and performance evaluations.

The Orlando Utilities Commission (OUC) awarded a $6 million, DB GMP contract to the mechanical contractor, Westbrook Air Conditioning and Plumbing for a chiller plant. Westbrook had recognized in past work that even when working with the best of their peers that each party's self-interest always outweighed teamwork initiatives and the construction process suffered. Westbrook developed a new construction delivery method for the chiller plant and created a team of contractors known as Integrated Project Delivery, Inc. Construction began May 4, 2004 and ended July 28, 2004. Completing an expensive, mechanically complex building in two months is practically unheard of and the building was delivered $600,000 below GMP (split between the owner and the IPD team), saved solely due to improvements in construction process. This was not a true IPD project because the owner was not a signatory of a relational contact agreement. The team members agreed to be bound together and responsible for all terms and conditions, agreed to open their accounting books to other team members/owner, and that actual costs would be reimbursed to all team members (shared according to agreed-upon formula, so the only cost that mattered was total project cost). Each team member also agreed to fully disclose any potential problems. Westbrook's construction delivery method added value and reduced costs. Overall it exhibited the IPD characteristics of integrated teams, high performing/cross-functioning teams, lean construction, collective risk sharing/relational contract, painsharing/gainsharing, and profit pooling. It also showed that IPD can be highly beneficial even if the owner will not or cannot be a signatory to the IPD contract.

The Cathedral Hill Hospital (CHH) was still in progress at the time of this study but was used as an example of a full IPD project. Sutter Health (SH) is the owner and manager of the project. SH hosted the Sutter Lean Summit with help of LCI in 2004 to develop a plan to deliver future facilities and developed a strategy with "The Five Big Ideas": collaborate, increase relatedness among project participants, projects are networks of commitments, optimize the project not the pieces, and tightly couple action with learning. This strategy led to a new form of contract with Lichtig's Integrated Form of Agreement (IFOA). The design of CHH began in 2005, was verified in 2007, and approved by the California Office of Statewide Health Planning and Development in 2009. The original project was designed at $93M over the target cost but using target value design (TVD) the revised design cost was $13M below target cost.

A summary of the IPD techniques implemented in the PenRen, OUC, and CHH projects are recorded in Table 3.3, along with whether the technique is recommended for implementation into NAVFAC MILCON construction projects and additional comments.

Table 3.3 IPD technique recommendations

Technique	Case Study	Recommended for implementation?	Comments
Integrated teams – relational contract, owner was not a party	OUC	Yes	NAVFAC could encourage contractor relationships similar to OUC project without a relational contract with bid evaluation factors
Integrated teams – Relational contract, owner was a signatory of the contract	CHH	No	Not allowed by FAR
Integrated Governance – All major project decisions made by consensus by the IPD Core Team	CHH	Yes	Strongly encourages designer and contractor to take "ownership" of their projects. Government would need to retain ultimate decision-making authority
High performing teams – Cross-functional teams	OUC	Yes	NAVFAC could encourage contractor relationships similar to OUC project without a relational contract by using bid technical evaluation factors
High performing teams – Cross-functional design clusters	OUC	Yes	Increases customer, designer, and contractor "ownership" of design
Lean Construction – Integrating process design with project design	OUC	Yes	Include as part of bid technical evaluation factors and award fee criteria
Lean Construction – Last Planner System	CHH	Yes	Due to learning curve of LPS, NAVFAC should start with small, simple projects
Lean Construction – Reverse phase/pull scheduling	CHH	Yes	"Schedule charrettes" which employ reverse-phase/pull scheduling would greatly improve accuracy/reliability of construction schedules

Lean Construction – Set-based design	CHH	Yes	Can be used to improve design and increase value. Leads to innovations that can be used on other projects
Lean Construction – Target value design – Project design is being driven by target cost and owner values	PenRen, CHH	Yes	Can be used to drive down cost on FPI contracts and reduce concerns of lack of competitive bidding in project prices. Target costing must be implemented as a part of TVD, as it can reduce value on its own
Lean Construction – Location-Based Scheduling	N/A	Yes	Recommend a pilot project with high repetition of tasks, requires a contractor with LBS/Vico software experience
Lean principles – Sutter Health's "Big Five"	CHH	Yes	Defining NAVFAC-wide principles in a manner similar to what Sutter Health has done would be greatly beneficial to ensure designers and contractors know what is expected of them
Collective risk sharing –relational contract	OUC, CHH	No	Would not benefit NAVFAC without a relational contract, and not allowed by FAR
Painsharing and Gainsharing – Sharing of Under/Overruns	PenRen, OUC	Yes	Must be used in conjunction with a way to ensure this does not result in excessive "value engineering" and reduced value
Profit pooling – each party put their entire profit "at risk"	OUC	No	FPI contract with award fees (i.e. PenRen contract) has the same effect
Goals and Incentives – Meeting owner's value led to large profits and share of under runs	PenRen	Yes	Fixed Price Incentive (FPI) contracts are ideal for initial IPD technique implementation
Award Fees/Performance Evaluations – Tied to owner's values and performed periodically	PenRen	Yes	Develop standards which are tied into guiding principles (see Lean Principles - Sutter Health's "Big Five" below). Increased administrative burden of evaluations could be negated by improved contractor performance

Singleton devised a simple numerical project selection tool for calculating whether NAVFAC should implement IPD techniques on a project by weighting project attributes. The attributes are listed in Table 3.4 and their weights in Table 3.5. Table 3.6 gives definitions on how to assign a score to an attribute. By adding the results, an overall project score is given that can use Table 3.7 to see if IPD techniques are recommended for the project. Table 3.8 shows the calculated scores for the case studies reviewed in Singleton's report.

Table 3.4 Construction project attributes and their relationships to IPD

Attribute	Definition of Attribute	Relationship to IPD
Cost	Total amount of money an owner spends on a project	One of the main components of value; IPD strives to reduce costs
Timeline	How quickly an owner wants the project completed	One of the main components of value; IPD strives to reduce timelines
Complexity	How complex the building systems (structural, mechanical, electrical, finishes, etc.) are	IPD uses collaboration and teamwork to create better solutions to complex problems
Size	Square footage of the project	IPD can be useful in finding design innovations, which tend to be more repeatable on larger projects
Uniqueness	If an identical or largely similar building has been constructed previously or not	IPD excels in the design and production of one-of-a-kind buildings. IPD is less necessary on "cookie-cutter" buildings

Customer involvement	How involved the customer wants to be in the design and construction process	An involved customer is paramount to IPD's success. A customer with a "hands-off" mentality makes IPD techniques less beneficial, but still possible
Importance	Who the building will support and how it will contribute to National security	IPD techniques can require extra management resources, which the importance of a project could be used to justify
Location	Where the project is being built	IPD needs skilled, resourceful, and flexible team members. Some locations may not have such team members readily available

Table 3.5 Explanation of project attribute weighting

Attribute	Low	Zero	High	Weighting Justification
Cost	-10	0	10	Cost is of the utmost importance of NAVFAC projects. Since the federal government does not operate like a typical for-profit business, special care must be taken to ensure taxpayers' funds are being spent wisely
Timeline	-8	0	8	Timeline is very important within the USN, and one of the main components of value, so it received a high weighting. For projects that need to be finished ASAP, IPD can be very helpful in accelerating a project's timeline
Complexity	-10	0	10	Complexity is the technical attribute which is most important when deciding to use IPD or not, hence complexity's high weighting. A complex project will benefit more from IPD techniques than a simple project
Size	-1	0	3	On most projects, size is interdependent with cost and complexity, but it still requires some weighting in the tool for those projects where it does not correlate with cost and complexity. The positive and negative weights differ because a small project could still be a good candidate for IPD, but a very large project will almost certainly benefit from IPD techniques.
Uniqueness	-1	0	4	Unique projects can require innovative designs which IPD techniques can help create. Uniqueness does not have a high weighting because even if a project is unique, the tasks that comprise a project are usually not. The positive and negative weights differ because a "cookie-cutter" project will benefit from IPD techniques, but many of them may provide less of a benefit than on a one-of-a-kind project
Customer Involvement	-6	0	6	Customer involvement is key on NAVFAC projects in order to successfully provide value. An average weighting was assigned since this is not a physical project characteristic but is still important to the success of IPD techniques. A customer that does not want to be involved can hurt the IPD process just as much as an involved customer can benefit it
Importance	-2	0	4	The perceived increased workload (and costs) that comes with IPD can be more easily justified on projects which are of utmost importance to national defense. A smaller penalty was assigned for those that are not snice this importance is not a physical characteristic of the project
Location	-20	0	5	An average weighting was assigned since location is not a physical project attribute but being in an area that has innovative contractors can contribute to IPD's success. The large weight put on the low score for location is due to the fact that IPD techniques will fail if contractors are incapable of managing them. If a project falls in the low category, the -20 score will ensure that the project cannot receive a strong recommendation for IPD techniques

Table 3.6 Project Scoring System

Attribute	Low score definition	Zero score definition	High score definition
Cost	Less than $5M	$5M - $25M	Greater than $25M
Timeline	Customer does not have a requirement-driven hard date for project completion	Customer has a requirement-driven hard date for project completion	Customer has an immediate and pressing requirement which requires the project to be completed ASAP
Complexity	No complex systems, minimal number of trades involved	Multiple trades involved, coordination between trades is beneficial	Large number of trades involved, including numerous specialty trades; highly complex mechanical and electrical systems required; coordination between trades crucial
Size	Less than 10,000 SF	10,000 – 100,000 SF	Greater than 100,000 SF

Uniqueness	Identical buildings exist on similar sites	Similar buildings exist on other sites, or identical buildings exist on non-similar sites	One-of-a-kind
Customer involvement	Customer doesn't want to participate at all, and doesn't have resources to devote to the project	Customer wants regular process updates and attends meetings fairly regularly, but does not make the project a top priority	Customer wants to be at every meeting and devotes extensive time and personnel to the project.
Importance	Indirect effect on USN tactical goals	Indirect effect on USN strategic/operational goals, or direct effect on USN tactical goals	Direct effect on USN strategic/operational goals
Location	Contractors in area are not capable of/willing to try IPD/lean techniques	Contractors in area have not done IPD/lean construction, but manage projects well in the traditional fashion	Contractors in area are already using IPD/lean construction techniques

Table 3.7 Recommendation for IPD Technique Implementation Based Upon Overall Score from Table 3.8

Score	Recommendation
Below 0	Project not recommended for IPD techniques
0 – 30	Potential IPD technique candidate project
31 – 50	Project strongly recommended for IPD techniques

Table 3.8 Scoring of the Case Study Projects in the IPD Project Selection Tool

Attribute	PenRen	OUC	CHH
Cost	10	0	10
Timeline	0	0	0
Complexity	10	10	10
Size	3	-1	3
Uniqueness	4	-1	0
Customer Involvement	6	0	6
Importance	0	0	4
Location	0	5	5
Total Points	**33**	**13**	**38**

Conclusion:

Singleton 2010 document, *Implementing Integrated Project Delivery on Department of the Navy Construction Projects*, presented case studies that demonstrate a wide array of IPD techniques, and how they can be successfully implemented. The projects demonstrated current industry-best practices in both the public and private sector, on small and large projects, and on complex projects. An overarching theme of teamwork and collaboration is present. One important conclusion was the IPD cannot succeed without a true desire between the parties to work together and put the needs of the project above all others.

The importance of the project operating system on construction projects cannot be overstressed, yet these systems see very few attempts at improvement. IPD can successfully improve the construction process and adds value. Singleton suggested the creation of a step-by-step process for executing IPD techniques, potentially based on a refinement and future calibration of his own IPD project selection tool. Singleton 2010 document, *Implementing Integrated Project Delivery on Department of the Navy Construction Projects*, study encouraged measuring workload changes for NAVFAC employees that resulted from IPD techniques, as well as case studies of NAVFAC ECI pilot projects to see if the techniques proved to be beneficial.

Implementation of Integrated Project Delivery on Department of Navy Military Construction Projects

Overview:

Lee 2013, *Implementation of Integrated Project Delivery on Department of Navy Military Construction Projects*, examines the extent to which IPD can be implemented on USN MILCON projects. Lee focuses on understanding the culture and mindset of how facilities management and construction are currently executed within USMC installations and NAVFAC. Data was taken through survey questions covering major points to understand the culture. After this culture was understood and determined, recommendations were made for partial and full implementation of IPD within NAVFAC. Lee includes a literature review and case studies to gain context and understand the techniques and benefits of IPD, LC, and BIM while also including the obstacles to IPD implementation. The USN and USMC need to provide a more robust construction delivery method that is more collaborative and flexible, so construction projects can support the operational requirements of the warfighter in terms of the highest quality, in the timeframe the project is needed and within the congressionally appropriated budget.

Results and Findings:

Lee 2013, *Implementation of Integrated Project Delivery on Department of Navy Military Construction Projects*, found that while commercial construction projects frequently suffer from adversarial relationships, low productivity, gross inefficiency, and rework, frequent disputes, and poor innovation, these problems become more heightened and acute in MILCON projects due to the excessive regulatory nature of the federal government. Only since 2007 did NAVFAC start to implement DB as a delivery method, prior to 2007 all projects were DBB.

In a publication by the AIA, IPD is considered as both a philosophy and a delivery method. Lee 2013 considered IPD as both for his research. A project can be IPD-lite and still incorporate IPD techniques, while other projects are pure IPD projects. A pure IPD project encompasses the following principles: key participants are bound together as equals, sharing financial risk and reward, liability waivers exist between the key participants, fiscal transparency between the key participants, early involvement of key participants, intensified design, the project is jointly developed, and collaborative decision-making. For an IPD project to be executed properly, several catalysts should be considered: a multi-party agreement, Building Information Management (BIM), lean design and construction, and co-location of the team.

AIA covered the main issues with how IPD should be adopted. One of the primary issues for government owners was the issue concerning working through current procurement rules. One solution was to identify a project as an exception or prototype and get special permission to try some level of IPD on the project. This is one of the most expeditious ways to implement IPD rather than try to change rules, regulations, or legislation that applies to all projects, because the government is a risk averse organization. IPD can be used on varying levels of collaboration based on owner situations: AIA recommended implementing parts of IPD in the interim time to make changes to bridge the gap between traditional construction delivery methods and IPD.

Lee 2013, *Implementation of Integrated Project Delivery on Department of Navy Military Construction Projects*, used a survey by Kent and Becerik-Gerber (2010) in which roughly 45% had experience with IPD. Of the remaining 55% respondents, 55% were informed about IPD (31% of the total). Most of the respondents did not have IPD experience or familiarity with IPD concepts. Kent and Becerik-Gerber concluded that IPD is still in its infancy, and this situation was exacerbated in the federal government because it lags the general industry. This is because business risk and fear of change are the biggest obstacles, along with the lack of IPD awareness, the lack of an appropriate legal structure, limitations of technology, and the lack of industry-wide standardization. They concluded that the US needs to take educational steps on how to execute IPD contracts.

Lee 2013 defines lean construction as a system of techniques, concepts, and principals, not a project delivery method. It has the key methods of collaborative pull-scheduling, MakeReady, collaborative pull-based production planning, production management, and measurement, learning, and continual improvement. These methods enable integrated design and delivery of projects. The AIA does not recognize lean construction as a form of IPD.

Lee 2013 indicates that IPD can be implemented without BIM, but not to its fullest extent. A project was analyzed in a case study by Yoders (2008): The Landmark at San Francisco. Construction took 16 weeks and the success of using IPD and BIM was obvious. Yoders discovered during his study that the US General Services Administration (GSA) has been actively encouraging BIM. The USACE published a BIM Road Map in 2006 detailing steps for BIM implementation. The GSA provided BIM advice and assistance to building teams on more than 70 government projects. The USA CoE requires BIM deliverables for all MILCON transformation standard facility types. Both GSA and USACE implemented BIM carefully with crafted BIM strategy guides, minimal contract changes were necessary, and this support towards BIM was generated at the highest level of both agencies. NAVFAC did not use BIM as of this study.

Lee 2013, *Implementation of Integrated Project Delivery on Department of Navy Military Construction Projects*, uses Fish and Keen (2012) research and observations that three major obstacles need to be resolved before IPD can be embraced by the construction industry, which included IPD structure for facilitation, contracts, and insurance. Solutions were also provided that could be applied to facilitate IPD implementation. In the traditional construction delivery methods, the architect typically plays the role of the project "facilitator", meaning they are the middle man for all interaction between the design team, construction team, and the owner. IPD requires the entire team to take responsibilities with the IPD facilitator (or without one). Ways to address this issue include facilitating through the core group or hiring an IPD facilitator as a reference.

Lee 2013 indicates that the second obstacle is contract administration, because IPD is a relational contractual relationship and not a transactional contractual relationship like traditional projects. Compensation for all parties is a large area of concern, but there are different contract types developed for IPD execution that address this. To counteract this issue, using a contract document designed for IPD projects is necessary.

The last significant obstacle is insurance because IPD contracts are not consistent regarding this topic (Fish & Keen, 2012). Some contract formats encourage "no suit" clauses waiving all liability between parties to promote team collaboration. As of 2010, no policy covered multiparty agreements. Even if each party on the IPD core team had their own liability insurance, the team would not necessarily be covered. Coverage of all parties and the project needs to be possible under one policy. Ways to address this include reverting back to traditional risk allocation, but this detracts from true IPD. To fix this issue the construction industry must rely on the insurance industry to create a comprehensive policy

From Lee's survey, 94% of NAVFAC and 84% of USMC employees were familiar with BIM, but the percentage of people who oversaw BIM projects was low (33%, 5%). When asked if BIM should be implemented there were mixed results (76%, 47%), with all those opposed citing software integrations would be the primary issue. FFP was favored by both NAVFAC and USMC (52%, 58%). It was a split decision on whether FPIF was better than FFP (48%, 58%) and whether FPAF was better than FFP (52%, 47%).   A majority personally agreed that DB was more effective than DBB (88%, 58%). Not many employees were familiar with lean construction (48%, 53%) and very few had overseen projects using it (5%, 5%). Most employees were unfamiliar with IPD (61%, 63%). Only one NAVFAC employee had worked an IPD project, and that was as a general contractor not in the USN. Most employees thought the USN should implement IPD (61%, 68%) for its cost control, BIM usage, construction and design quality, and the discouragement to contractors to understate profits, with those opposed citing IPD was too unconventional as their main reason. Those who were neutral said that projects could do well with or without IPD, and that it would not enhance quality or productivity. Most employees (79%, 58%) thought that partnering should be a formal process and should be mandated, because if it is not mandated it will not be performed.

Conclusion:

Lee 2013, *Implementation of Integrated Project Delivery on Department of Navy Military Construction Projects*, concluded that IPD is a new delivery model and implementation within the private sector is slow, and industry professionals generally feel more comfortable going with common methods like DB and DBB. IPD has unique technical, procurement, and contractual factors inherent within IPD, factors such as facilitation between parties involved, the uniqueness of risk sharing within the IPD contract structure, and the issue of insurance. BIM and lean construction should be used in conjunction for IPD to be implemented fully, which makes parties more wary of it.

NAVFAC lacked a formal BIM policy at the time of the survey and as such personnel did not interact with it much, with many projects still being designed and executed through the paper submittal process. Any hurdles to BIM implementation would be well worth the effort to overcome. With FFP, FPIF, and FPAF, none showed distinctive favoritism over the other two, so it is concluded that there is some potential within the context of the federal government to be open to the idea of eventually implementing an integrated risk sharing. Currently the FAR only recognizes DB and DBB as methods for executing construction. DB could be considered to have rudimentary elements that are more fully present in IPD. With personnel heavily favoring DB over DBB, this would indicate that IPD has potential as well. The main reasons for implementing IPD included cost control and enhanced quality by BIM usage. For the partial implementation of IPD, this could be possible by modifying NAVFAC's business procedures called Business Management System (BMS) to accommodate IPD principles. For BIM, contracts could be written to reflect the need for BIM to be a tangible deliverable. Within NAVFAC's execution of DB and DBB projects, early contractor involvement should be emphasized.

For full implementation of IPD, changes to the United States Code (USC) and the FAR would be necessary to allow IPD as an authorized project delivery method. The FAR could be changed to accommodate requirements for BIM, although a strategic plan could be generated by NAVFAC. Risk sharing needs to be legislated into the USC for IPD to be fully implemented, and training would be needed for selected personnel. Strategic plans would be needed for lean construction as well.

Three major conclusions can be made from Lee 2013, *Implementation of Integrated Project Delivery on Department of Navy Military Construction Projects*. The first conclusion is that the general culture of NAVFAC and USMC contains potential for implementation of IPD, indicated by the majority of positive responses for wanting NAVFAC to implement IPD. The second conclusion is that short term immediate changes can be made to implement some IPD principles without having to resort to major structural changes. The third conclusion is that full implementation of IPD will be extremely difficult, but not entirely impossible within the federal government. However, full implementation will require major legislative changes at the congressional level along with structural changes within current NAVFAC policy.

Chapter 4 - Survey Process and Results

The literature review showed evidence for DB to be used over DBB in most cases because it proved superior in almost every regard and showed that IPD should be examined as a potential USAF construction delivery method candidate because data suggests it can be better than both DB and DBB. This survey was conducted on USAF contracting officers to see if their viewpoint on construction delivery methods agreed with the conclusions drawn from data in the literary review. This survey was conducted over a period of a month and a half and was disseminated to USAF contracting officers around the world by Colonel Gerald Ray Jr., USAF, who works at the Air Force Installation Contracting Agency (AFICA). This survey will analyze the different construction delivery methods for USAF projects to determine potential improvements to the USAF construction contracting process and ideally show that contracting officers' opinions coincide with the conclusions from the literary review, showing DB is better than DBB and that there is support for IPD as a potential method.

General Demographics

A total of 145 personnel responded to the survey. This included 23 commissioned officers (16%), 73 General Schedule (GS) (50%), 45 enlisted officers (31%), and four local nationals (3%) as shown in Table 4.1.

Table 4.1 USAF Rank/USAF Rank Equivalent of Survey Participant

Rank/Rank Equivalent	Amount of People	Percentage
Commissioned Officer	23	16%
General Schedule	73	50%
Enlisted Officer	45	31%
Local National	4	3%
Total	145	100%

In terms of experience, most personnel have seven to ten years of experience in their career field (41/145, 28.3%) and the majority have over three years of experience (117/145, 80.7%) as shown in Table 4.2.

Table 4.2 Contracting Career Field Experience of Survey Participants

Year Range	Amount of People	Percentage
0 – 3 years	28	19.3%
4 – 6 years	25	17.2%
7 – 10 years	41	28.3%
11 – 14 years	16	11%
15 – 18 years	12	8.3%
Over 18 years	23	15.9%

The Acquisition Professional Development Program (APDP) was created to maximize the professional development and mission capabilities of the DoD's acquisition work force, and the level of certification in APDP reflects the level of proficiency of the personnel. The acquisition certification system reviews personnel records to determine if an individual meets Level 1 or 2 acquisition certification standards and if so they are automatically granted certification without having to request it. Level 3 certification requires the individual to apply, get supervisor recommendation, and then have the APDP manager review and approve the application (Moore & Frey, 2013). The personnel surveyed indicated that 93% had certification (135/145): 15% (22/145) having Level 1 certification, 48% (70/145) having Level 2 certification, and 30% (43/145) having Level 3 certification as shown in Table 4.3. Those without certification consisted of six GS, two enlisted officers, one commissioned officer, and one foreign national.

Table 4.3 Level of Certification (APDP) of Survey Participants

Level of Certification	Amount of People	Percentage
No Certification	10	7%
Level 1	22	15%
Level 2	70	48%
Level 3	43	30%

An overwhelming majority (142/145, 98%) of the contracting officers surveyed had worked on construction contracts. Those who had not (3/145, 2%) were exited out of the survey for the construction contracts questions portion of the survey, because they did not have experience in the field and therefore could not answer the questions.

A majority of those surveyed were located in different regions throughout the US (109/137, 79.6%), with the second most participants stationed in Europe (21/137, 15.3%), followed by five stationed in Asia (1 Senior NCO, 1 CGO, 3 GS) (5/137, 3.7%), one stationed in the Middle East (Airman) (1/137, 0.7%), and one stationed in Central America (GS-12) (1/137, 0.7%). Figure 4.1 indicates the survey participant's duty location when the survey was taken.

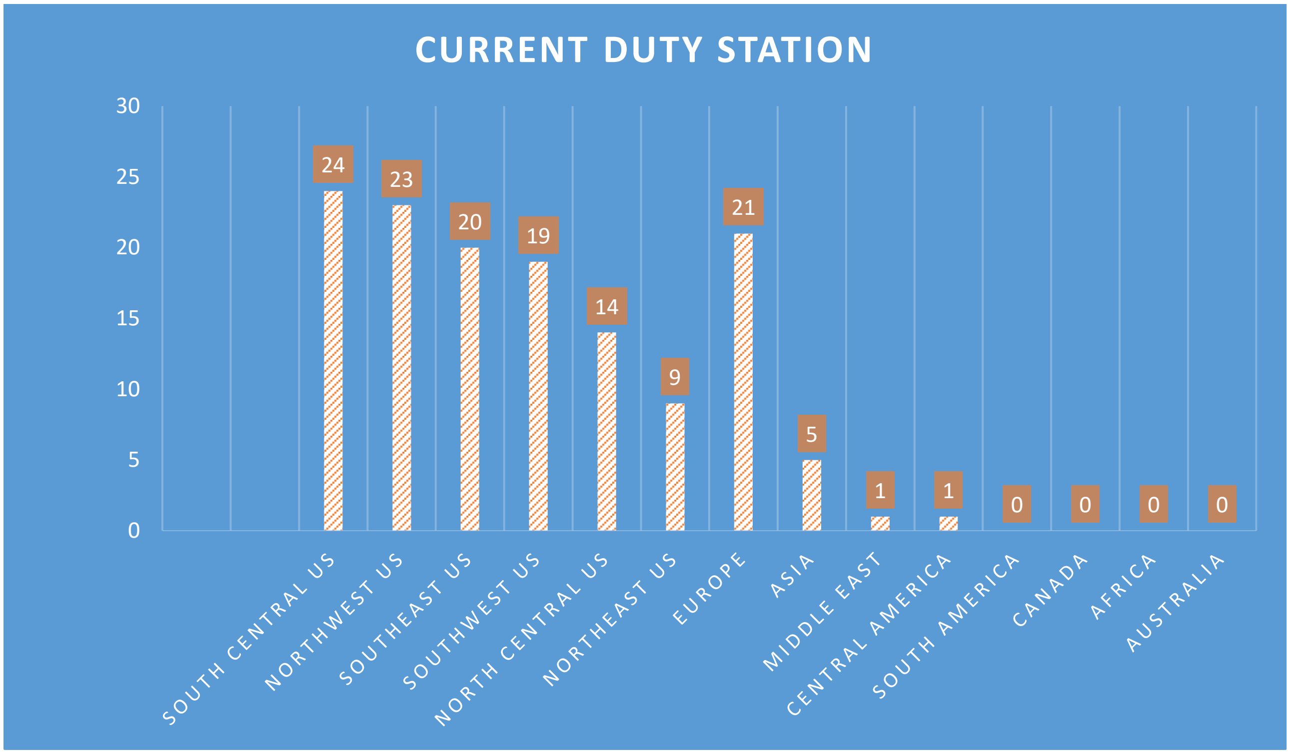

Figure 4.1 Survey Participants Current Duty Station

Of the contracting officers who had held a warrant (a warrant entitles the contracting officer a fixed maximum price with which to negotiate a contract for a project), when asked the highest warrant given to them to secure a construction contract, a small amount (9/112, 8%) specified the lowest range of under $25 K, but a majority (77/112, 69%) indicated above the under $25 K range and below the $10M - $25M range. Twenty-one percent (24/112) specified they worked with an unlimited warrant. Refer to Figure 4.2 for additional information.

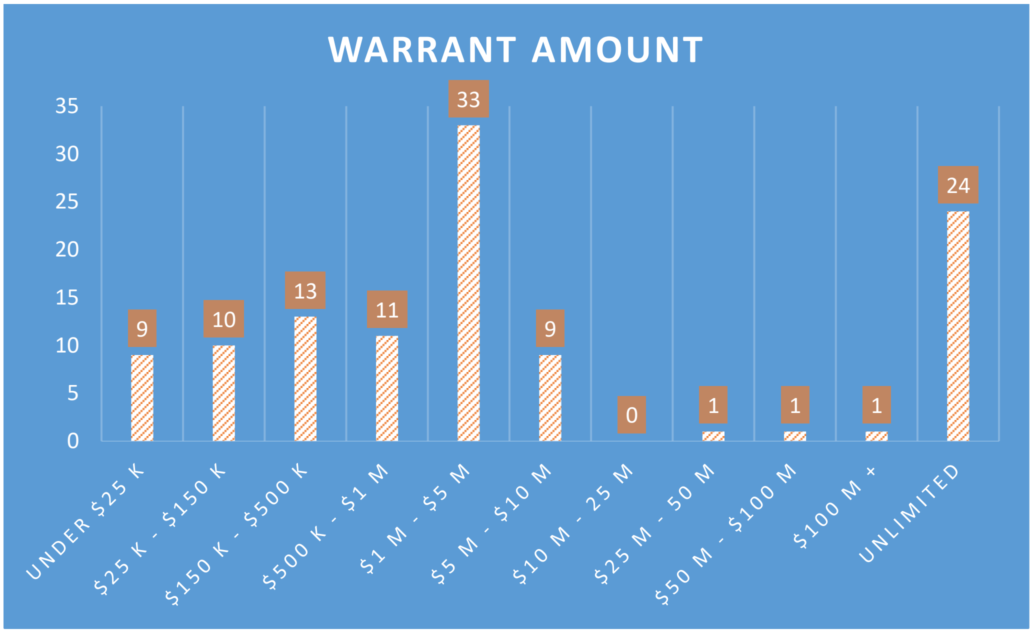

Figure 4.2 Highest Warrant Amount Held for Construction Contracts

As for their typical contract size, over twenty-eight percent (39/137) indicated that their contracts were in the under $500 K range but around sixty-six percent (91/137) were in the middle range of $500 K to $ 10 M as shown in Figure 4.3.

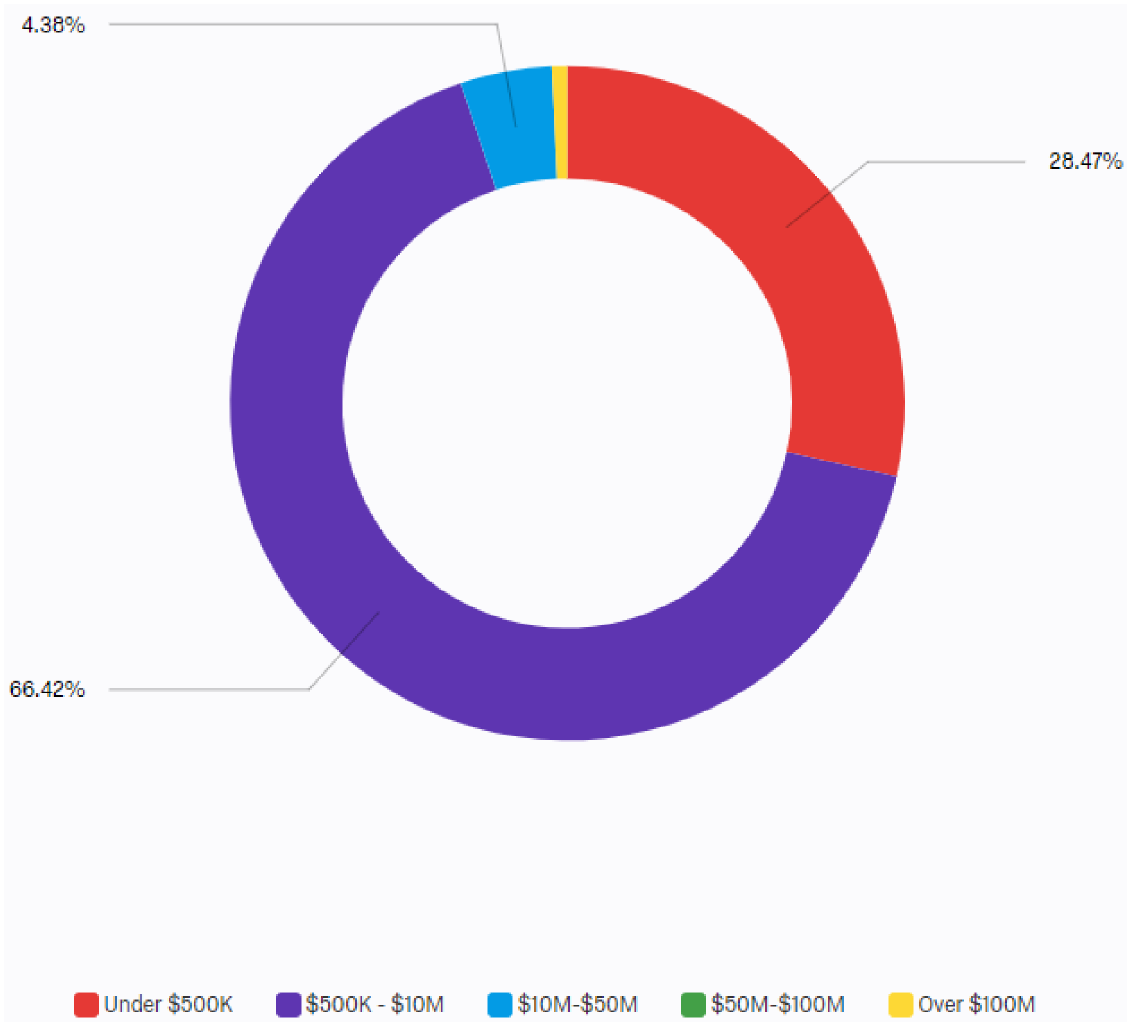

Figure 4.3 Typical Construction Contract Size

Of those surveyed, seventy-five percent (103/137) had awarded over 25 contracts in their career as a contracting officer. Based on this result, it is assumed that the respondents were knowledgeable on the different construction delivery methods and their impacts on securing a contract and completing a project.

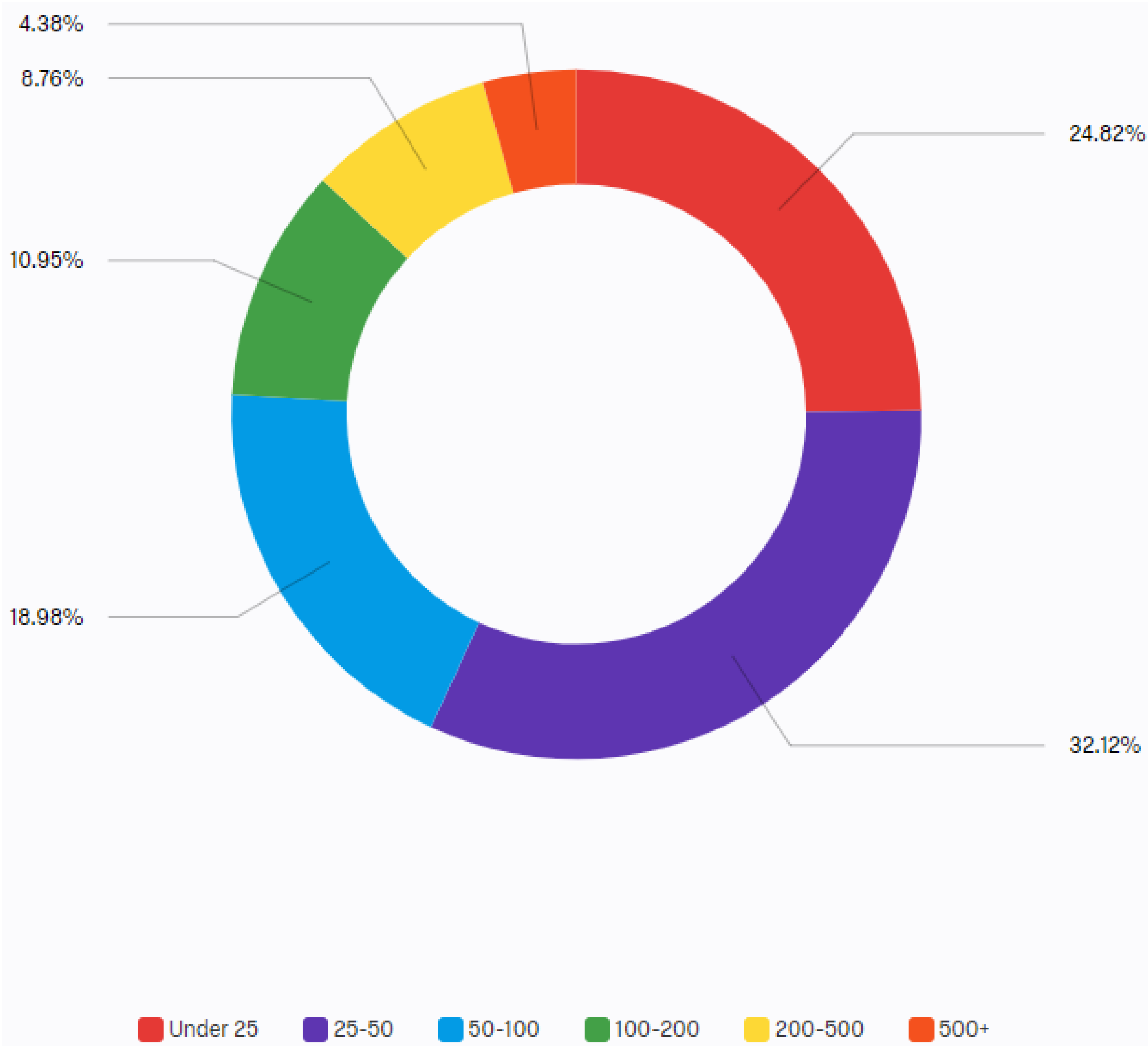

Figure 4.4 Number of Construction Contracts Awarded

Of those contracts awarded, the personnel surveyed were asked in what order they saw the construction delivery methods utilized in contracts to secure a project. The most common project delivery methods indicated were DB (55/115, 47.83%) and DBB (42/115, 36.52%). It appears those who did not select DB as the most common construction delivery method selected DBB, and vice versa, as the second most common construction delivery methods were DBB (48/104, 46.15%) and DB (44/104, 42.31%). These results make sense as DB and DBB are the two officially recognized construction delivery methods by the FAR. The third most common construction delivery methods were IPD (52/95, 54.74%) and CMAR (12/95,12.63%), and were also the fourth most common construction delivery method (IPD, 25/101, 24.75%) (CMAR, 66/101, 65.35%). It is important to realize some personnel selected IPD over other methods, even though IPD is not allowed in the FAR except for trial projects. This was attributed to a misinterpretation of the method definitions by the respondents with the methods used by the USAF. Data from personnel selecting IPD first was omitted from analysis due to this, and therefore should not invalidate any of the other responses. The option ‘other methods’ came in as the least common construction delivery method. This was anticipated, as the option was provided primarily to analyze if a construction delivery method not listed (not DB, DBB, CMAR, or IPD) was utilized commonly in the USAF acquisitions process. However, no other notable construction delivery methods were largely specified. Figure 4.5 indicates the surveyed personnel’s ranked delivery methods (1-5) selection of construction delivery methods; with 1 being most often used and 5 least often used.

Figure 4.5 Rank Order of Construction Delivery Methods in Contracts

As a follow up question to the above rank ordering of the construction delivery methods, the surveyed personnel were questioned whether they believed the method they listed as the most common was the most efficient overall method. A majority (89/122, 73%) agreed their choice was the most efficient method. However, a considerable amount (33/122, 27%) did not consider their choice as such. Of these 33 responses, DBB was mentioned 16 times out of the 42 personnel who selected DBB as the most common method (16/42, 38%). DB was mentioned 10 times out of the 46 personnel who selected DB as the most common method (10/46, 22%). CMAR was mentioned four times out of the five personnel who selected CMAR as the most common method (4/5, 80%). IPD was mentioned one time out of the eight personnel who selected IPD as the most common method (1/8, 13%). Other (IDIQ/SABER) was mentioned two times out of the four personnel who selected Other as the most common method (2/4, 50%). IDIQ and SABER are USAF specific construction delivery methods that could be considered CMAR, or depending on the relationship with the contractor could potentially bleed into an IPD-type scenario. IPD represents a very small portion of the findings and should not be considered because as stated before DB and DBB are the only officially recognized methods by the FAR. These numbers show a large dissatisfaction by the contracting officers with the DBB construction delivery method although it is a widely used method, with large dissatisfaction also for CMAR and other methods used, although the sample size for CMAR and other methods was much smaller.

The surveyed personnel who said the construction delivery method they listed as number one was also the most efficient method were asked why they believed that method was the most efficient. Relevant given reasons are summarized for DBB efficiency in Table 4.4 and DB efficiency in Table 4.5.

For those surveyed who believe DBB is the most efficient method, one repeating factor is its flexibility. In addition, the competitiveness of the process makes the project have better options and offers lower prices. They mention how the design phase is more complete with more details given on the desired project and the need for several design submittals. One important factor mentioned is the manpower (and for more complex projects, the necessary skill) is not present in USAF engineering to perform the design and construction of a project in-house, thus arises a need to outsource jobs to the public sector when possible to not overwork USAF personnel.

Table 4.4 Reasons DBB is most efficient

The government and the service providers (A/E and contractor) have lower/less risk with DBB. DBB also gives the contractor a larger stake in the overall outcome of the project.
DBB has fast procurement because the need for additional A/E design and procurement time is not required, allowing construction to begin sooner, saving time. However, depending on the timeliness of the completion of the design phase (prior to project solicitation), streamlining in the Bid/Build process is limited.
DBB is best because it places design and execution under the service providers' (A/E and contractor) control. The contractors who are bidding for the project have a full and complete design with which to create their proposals. DBB relies on the contractor's expertise to execute the specified construction requirements (which is important because quality specifications are a must).
DBB removes the A/E from having a guaranteed contract before award, as is the case with DB (where the combined A/E and contractor designs and constructs). It allows for the contractor to correct any potential flaws the A/E might have missed in their design through change orders..
DBB provides the government with the most oversight and control during the design process, keeping everything together after the project is awarded and making it easy to manage. The government knows what it wants and communicates its objective/goal in words clear enough for the contractor to do work without requiring additional clarification.
Proposal evaluations are rather straightforward with DBB because it promotes fair and open competition since everyone is proposing the same design.
DBB permits competitive bids after the design phase which in turn promotes competitive pricing. DBB is an industry best practice, resulting in the least overall cost for the stated construction. This cost control notably provides pricing that is fair for the taxpayer.
With a limited number of organic construction project managers in the USAF, it is most effective to have service providers entirely design and build the desired product. By completing the DBB method, it also allows the government to choose the most advantageous way to build the project.

DBB is best because it provides the most flexibility. It also allows for flexibility with funding for the major renovations in millions and for implementation of design projects for on-the-shelf, ready-to-execute construction projects when funds are made available.

For those who believe DB is the most efficient method, having one contract and the absence of bidding after design allows for a quicker timeline are the two most mentioned factors. The ability to have the same contractor design and build the project also helped lessen confusion between the two phases. Overall, the timeliness of DB was the most cited reason for why it was the most efficient. Several of the personnel stated that DBB was better if the project was more complex and specialized.

Table 4.5 Reasons DB is most efficient

DB is best because you do not have to award a separate A/E design contract so there are fewer issues with design. With DBB, working with two different service providers (A/E and contractor) adds delay. With DB the design and construction are both accomplished by the prime contractor. When problems with the design occur, the prime contractor corrects it because they are working off their own designs; therefore, it is most effective for them to understand. Having a single contractor eliminates the need for the government to be the integrator (because the contractor is responsible for ensuring design is compatible with the construction and execution).
DB is best because it saves time because there is no bidding after design and reduces lead times overall.
In addition, DB has proven to be the most cost-effective method, working primarily with Firm Fixed Price.
The only time DBB would be more efficient than DB is if the project is so complex that it needs an A/E contractor to study and design the project prior to construction.
DB is best because Holloman AFB doesn't hold an A/E contract in-house. Its only capabilities come from design elements and contractors submitting proposals in which we take the lowest price technically acceptable.
Single responsibility of design and construction makes it is faster, cheaper, and has higher quality. DB is more efficient, and the contractor usually completes the project.
It is all I have ever seen used, I do not have experience with the other types of contract methods.
With DB there is less confusion and better understanding of the project requirements. DB allows the government to ensure their requirements are met.
The DBB method is of value when the customer cares about the end design or it's a specialized design type such as militarized building, special hospital, etc. For common construction types, DB is the way to go.

The bidding/negotiating is all done up front allowing the government to evaluate best value. After award, the contractor then designs, and work is all done with one vs many for evaluation purposes.
DB requires a single contract and all responsibility goes to the contractor with reduces risk to the owner.
DB is always the preferred and most efficient method, especially when using a Multiple Award Construction Contract or a similar type of IDIQ. DB usually requires a review process at the 35%, 65%, and 95% designs which allows customers to make any necessary changes to the overall design.
DB is the closest to performance-based construction we can get with current regulations. It allows the DBE to design and build within IAW code and be responsible for faults should they arise. The general contractor works with the owner on the design. They understand the intent in the design and can make recommendations to adjust the design if needed. I think it's better than IPD, which seems essentially the same, because it provides a POC for all matters. If you have too many communication channels, then you can end up with miscommunication and two entities moving in two different directions.
DB allows the most amount of flexibility during the construction process to alter/course correct designs. For smaller construction type of contracts, DB allows for more contractor uniqueness if we get the finished product we want.
DB allows us to award DB requirements utilizing our Multiple Award Construction Contracts obtaining competition while reducing the amount of time it takes from building the solicitation RFP package, issue the RPF, hold the site visit, and have proposals submitted, evaluated, and awarded. Typically, we can award a DB requirement within 60 calendar days versus the 180 calendar days it would take under conventional contact award process.

All participants were then asked why the project delivery method they listed as number one was used the most, regardless of whether they believed it to be the most efficient method. An overwhelming factor for why DB is used the most, regardless of whether it is believed to be the most efficient method, is due to the lack of manpower and in-house capabilities to perform the design themselves. In addition, ease of contract and competition of bids. Tables 4.6 and 4.7 indicates the reasons which were given for DB and DBB respectively:

Table 4.6 Why DB is Used the Most

Everyone thinks DB is the easiest.
DB is used the most because Civil Engineering does not have the manpower or capabilities to provide adequate design for projects in-house. There is a lack of engineers within the DoD. DB works because the USAF pays prime contractors a premium to sub-contract the design work.

The other methods are not as efficient and make it difficult to create competition because there are too many unknowns to bid on.
The customer (the USAF) delivers a requirements package in this format.

The next survey question was ‘Why is DBB used most often?’. One factor that appeared consistently was that civil engineering squadrons preferred DBB over other methods. It was also cited that this is the traditional method and therefore was used and is still used over newer methods. It is a method that does not use as much USAF personnel as other methods like DB.

Table 4.7 Why DBB is Used the Most

DBB reduces the risk on the government and adds risk to the A/E firm.
DBB is used the most because we don't have the engineers we used to have to design the projects to the level they need to be before we solicit for them, so things get missed or not specified out.
DBB is what the Civil Engineering Squadron is structured for and knows how to do. Government engineers refuse to support DB as the government because they view it as decreasing the government’s need for Federal Employed Engineers.
Civil Engineering in Europe prefers DBB.
We have a 5-year A/E contract, then we request proposals to promote/receive maximum competition.
DBB is the traditional practice and used the most because of familiarity and belief that it reduces cost.
DBB is used the most because the base has the CE personnel to design the project, then compete the projects for a fair price.
The USAF programming/funding process drives DBB.
In my experience, DBB has been adopted in the squadron for many years. The contracting office and other stakeholders such as the CE squadron are familiar with the process. However, the project's success heavily relies on the quality of the 35% design produced either internally or contracted out. The firm who created the 35% and the general contractor who builds it are not necessarily the same so there might be some misinterpretation on the details. These misinterpretations are costly and can delay projects significantly.

Next, the personnel who said that the method listed as number one was not the most efficient were asked what method they believed should be used in its stead. As shown in Figure 4.6, the respondents recommended IPD 41.4% (12/29), DB 31% (9/29), DBB 24.1 % (7/29), and CMAR 3.5%, respectively, as the most efficient. Upon further analysis, a large portion of the IPD (5/12, 42%) recommendations come from personnel who listed DB as the most used method. All the recommendations for DB (9/9, 100%) came from personnel who listed DBB as the most used method, with the same personnel who listed DBB as the most used method having the second most recommendations for IPD (4/12, 33%). Most of the recommendations to switch to DBB came from personnel who had listed DB as the most used method (4/7, 57%).

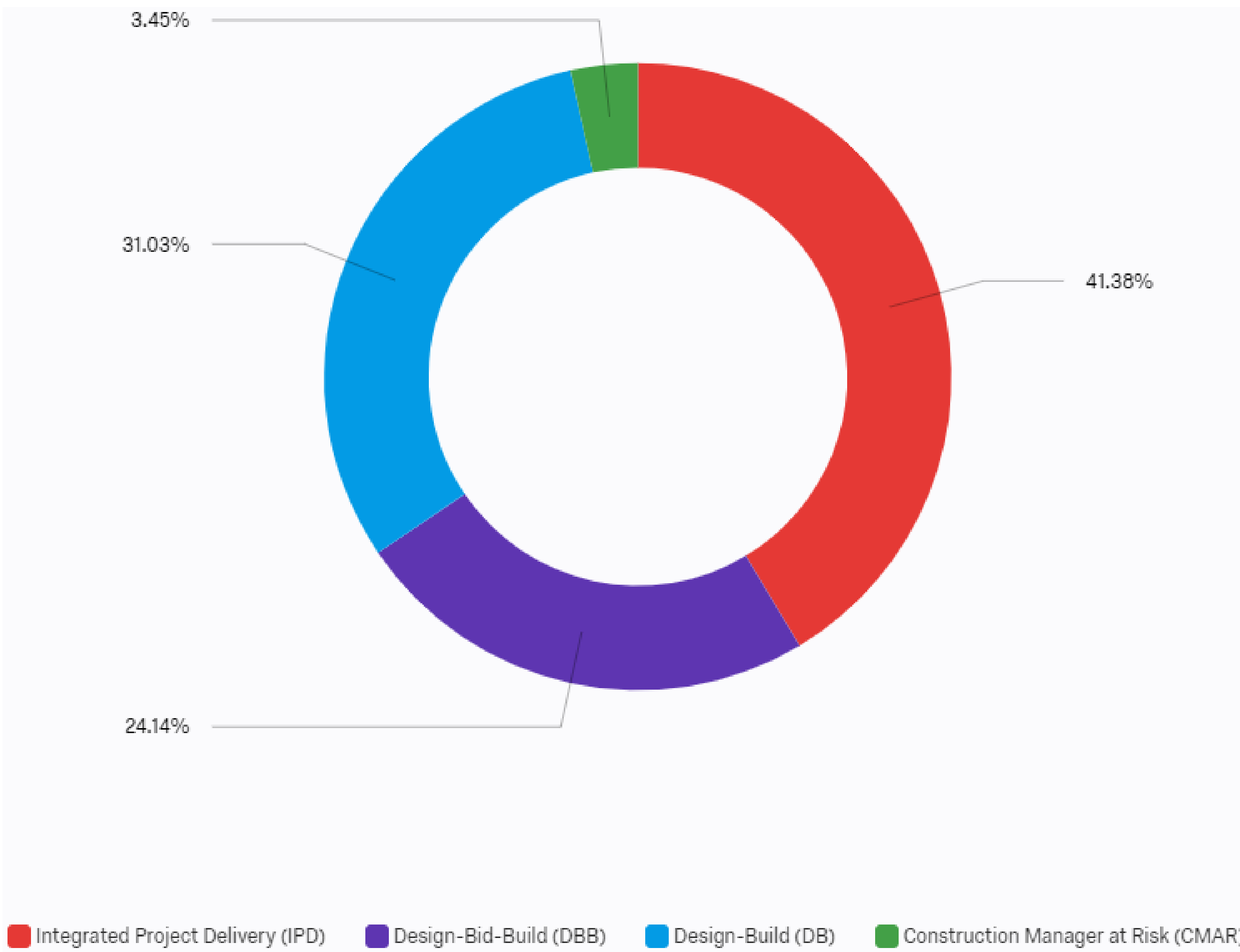

Figure 4.6 What Method Should be Used in the Stead of the Method You Listed as #1?

The participants were asked what percentage of the time they saw each construction delivery method used. The means for each method are recorded in Table 4.8. This table agrees with the analysis asking what method was the most used (Figure 4.5). DB edges out DBB, with IPD, CMAR and Other taking up very small percentages.

Table 4.8 Construction Delivery Methods Means

Method	Mean
DB	41.4
DBB	39.83
IPD	6.79
Other	4.87
CMAR	2.72

Personnel were asked if any trend towards using a specific construction delivery method in the past six years had occurred. This time range was selected because it was a multiple of the choices given for years served; therefore, making the data easier to analyze if a trend was to be spotted. A potential trend toward a new method is indicated by the responses, with more people saying yes (36/106, 34%) than no (29/106, 27%). However, most people answered, ‘Do Not Know’ (41/106, 39%).

Of those that specified a trend towards a specific method is occurring, most believed that DB was seeing more focus (21/36, 58.3%) than DBB (12/36, 33.3%). Very few believed the USAF industry was trending towards IPD (3/36, 8.3%). This data is shown in Figure 4.7. A majority (15/21, 71.4%) of those who listed DB as the most popular method also said the industry was trending towards it. The second most votes for DB came from those listing DBB as the most popular method (5/21, 23.8%), although most of the votes for DBB (7/12, 58.3%) came from those listing DBB as most popular. For those who initially listed DBB as the most popular method, the difference between those believing there’s a trend towards DBB and those believing there’s a trend towards DB is essentially nonexistent (5 for DB vs. 7 for DBB). Conversely, the same metric for those listing DB as the most popular method is much more significant (15 for DB vs. 2 for DBB).

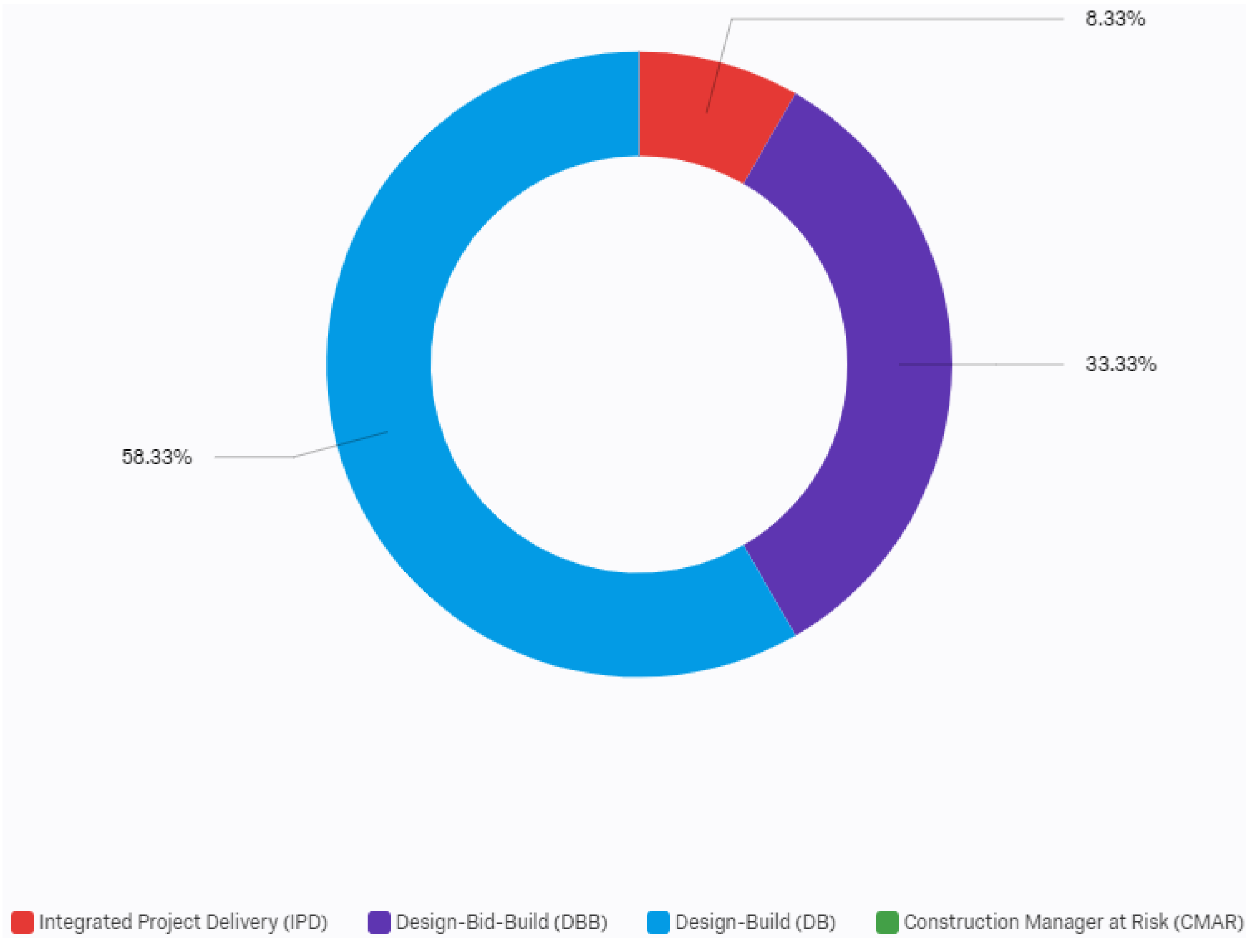

Figure 4.7 Survey Question Answers: What method have the trends been towards?

A slight majority (16 vs. 13) of the personnel asked believed that the USAF should be investigating and evaluating the use of a specific construction delivery method, with the largest amount of those saying yes (6/14, 42.9%) favoring IPD by a large margin for investigation and evaluation over the other construction delivery methods (DBB, 3/14, 21.4%; DB, 3/14, 21.4%, CMAR, 2/14, 14.3%). Some gave reasons as to why they believe the methods should be pursued, with most presenting reasons for why IPD should be used. These responses for IPD are recorded in Table 4.9.

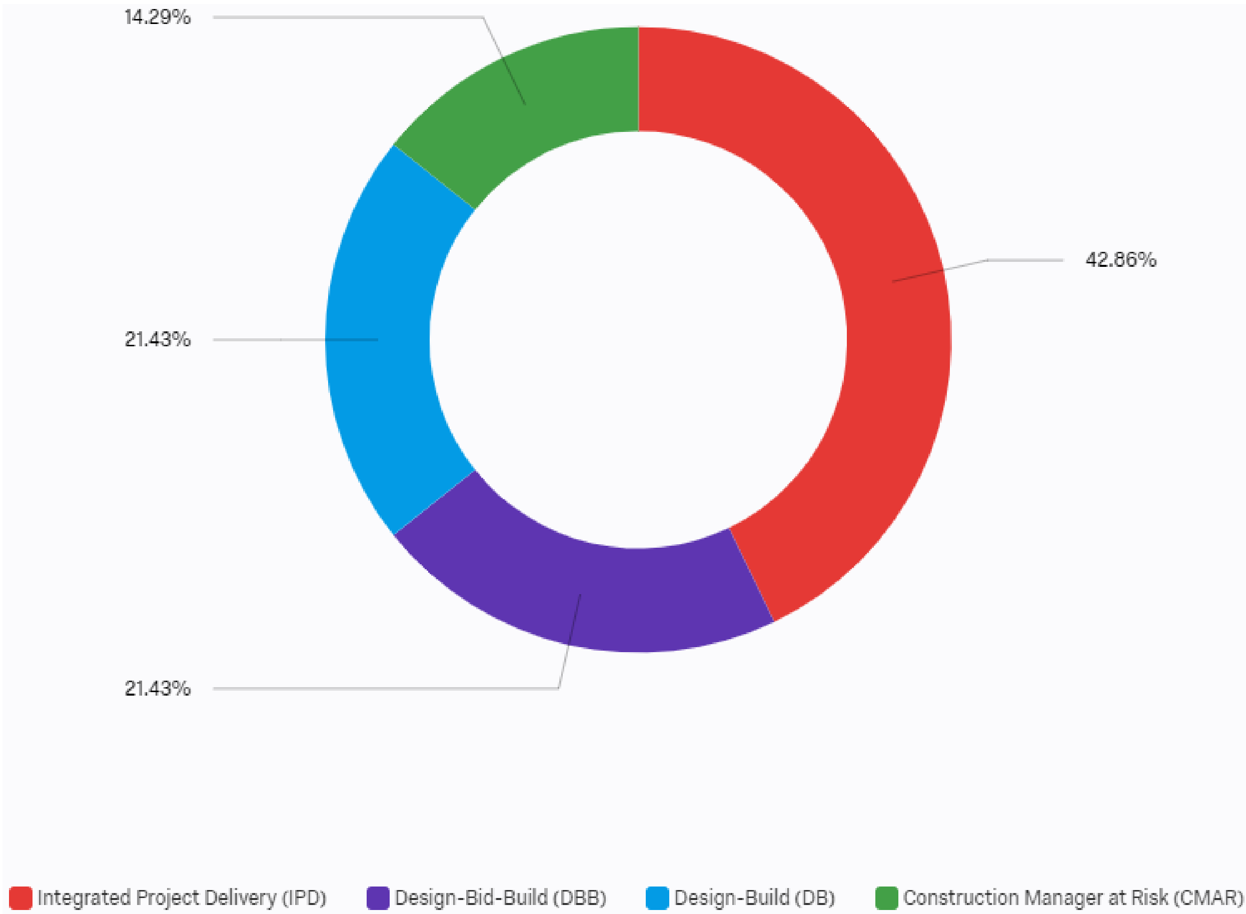

Figure 4.8 Survey Question Answers: What method should be investigated/evaluated?

Table 4.9 Why the USAF should investigate/evaluate IPD

I believe this would get everyone involved from day 1. This could make the construction/contracting process much smoother and need less modifications for the future.
IPD appears to have a built-in system for streamlining the requirements portion of the acquisition. Using a collaborative approach to create and manage a construction requirement from cradle to grave, the USAF can leverage the experience, knowledge, and creative thinking of the group members to identify and possibly create efficiencies at a process level.
The multifunctional nature of the IPD sounds like it would yield significant benefits.
IPD is flexible, adaptive, and allows for current trends and efficiencies.
IPD should be pursued because working as a team can provide a better requirement and a better understanding by all parties.
IPD gives complete buy-in and support from all essential agencies for successful completion of a construction project, thus equally spreading the risk factor.

The top reason given was the personnel believed that the integrated nature of IPD would allow for more efficiency and benefits than currently used methods.

Personnel were asked if a method used by the USAF contracting system was favored or encouraged. A noticeable majority (64/104, 62%) believed a specific method is encouraged; 49% selected DBB (30/61) and 36% selected DB (22/61). Figure 4.9 indicates the perceived encouraged contracting method.

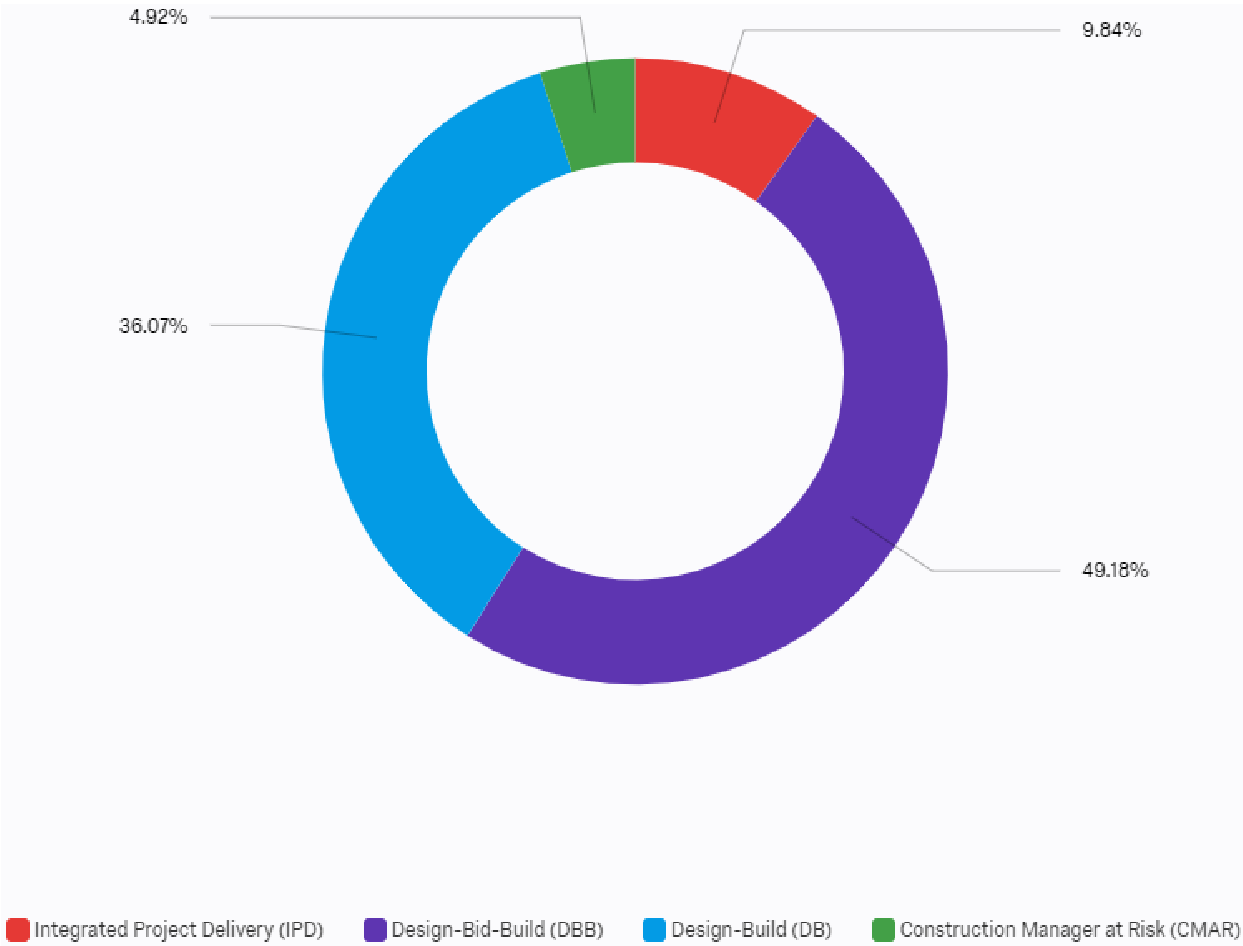

Figure 4.9 Answers: Which method is favored/encouraged by USAF contracting?

As for why they believed the USAF chose a specific method, several reasons were given. Tables 4.10 and 4.11 summarize responses for why the USAF prefers DB or DBB respectively. The main reasons given in Table 4.10 for why DB is the favored method is because it does not utilize USAF personnel as much, and is cited for being more efficient, simple, and more cost effective.

Table 4.10 Why the USAF favors DB

DB is the favored method because the contractor becomes familiar with the project.
The USAF favors DB because it typically requires less from USAF personnel although we may pay a price premium.
The USAF has reduced their engineering force and does not have the in-house design capability. DB allows the CES/CONS to expedite execution of awards which is needed in today's DoD funding environment.
DB is the favored method because you only deal with a single contractor.
DB is the favored method because task orders are much more efficient to award than standalone contracts.
DB is the favored method because of customer preference.
DB is the favored method because of efficiency.
DB is the favored method because of funding. The way the USAF programs and funds projects favors DB contracting. Additionally, DBB designs may sit on the shelf and expire (require refresh) before being used for actual construction contracts.
DB is the simplest method.
DB is the favored method because there is little time to prepare and few internal resources due to funds, so we pay contractors to do the work.
It really depends upon the project. For certain projects and customers, we must go with DBB. However, according to a GS-14 Engineering Chief, about 60% of his construction projects are DB. He is one of my main customers and they develop the requirements package.
DB is the favored method due to budgetary reasons
DB is the favored method because it mitigates owner risk.

In Table 4.11 the primary reasons for why DBB is the favored method are that it promotes healthy competition that provides competitive prices, it is the method people are familiar with, and because it outsources work.

Table 4.11 Why the USAF favors DBB

DBB is the favored method because it is fair and balanced and does not give one contractor all the information up-front.
DBB is the favored method because it promotes fair opportunity.
I am not sure. DBB is just what people are most comfortable with.
DBB is the favored method because it is FAR recommended.
DBB is the favored method because it takes less time and effort to get to construction. You do not have to write multiple requirements to get to a single end product.
DBB is the easiest to solicit and administer. Contractors can usually ascertain appropriate risk. If a project is highly complex or if marketplace has fluctuations - risk can also be managed by pricing the contract (i.e. FFP, FFP EPA, FPIF, CPIF, CPFF).
It depends on the installation, but some installations prefer DBB because it can also be simplified for fast acquisition.

COMPETITION
Civil Engineering Structure/Preference/Budget Constraints
DBB ensures fairness to potential bidders and improves decision making by the owner by providing a range of potential options.
DBB is the form most people are familiar with.
DBB is the favored method because we don't have the design capabilities we used to have on staff.
I assume DBB keeps the USAF engineers actively engaged in their craft. Unfortunately, they are hard to fill, and manpower numbers suggest a decrease in position fills.
DBB is the favored method because costs tend to be better known upfront.

As for whether a construction delivery method was favored based off the region the surveyed personnel were currently stationed in, a majority (71/101, 70%) of participants responded that they did not believe there was a favored method.

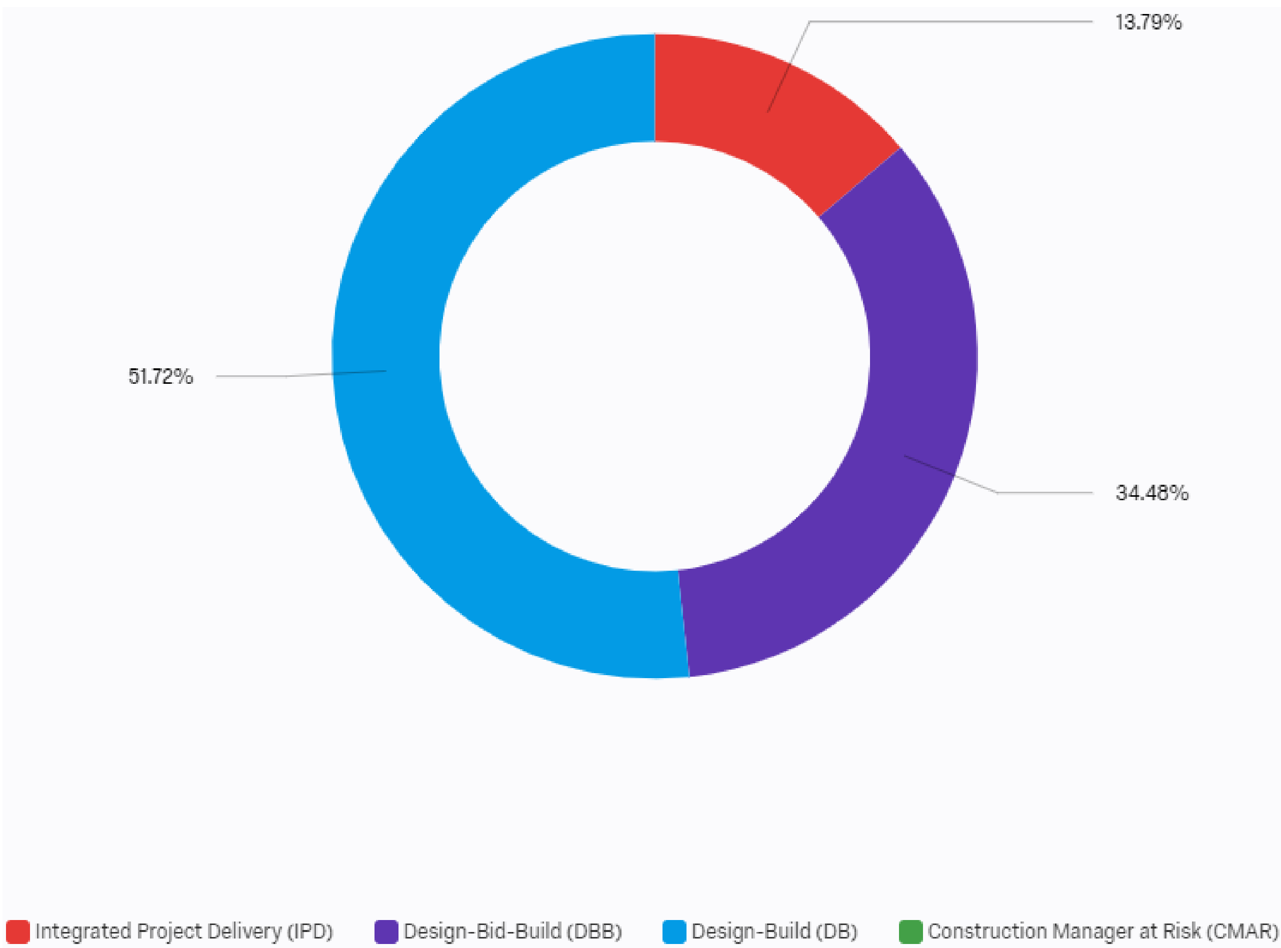

Figure 4.10 Survey Question Answers: Which method is preferred by your region?

Although most of the surveyed personnel responded that there was not a favored method based on the region, those that did say DB was favored by their region cited either they did not know why that method was favored, that it was because it is what the region is used to, or because of lack of USAF personnel and the need to contract the work out. A summary of the surveyed personnel's responses can be found in Table 4.12.

Table 4.12 Why a region favors DB

Unknown
DB is just all I have seen used at a few different bases. I am not sure why.
DB is favored because of lack of time.
The funding provided by the Base Civil Engineering allows for immediate design then flows right into construction.
DB is favored because of budgetary reasons and pattern methodology from previous contracts.
I think they favor DB because it allows them to start faster, they do not have to hire a separate A/E, and they believe it is inherently more flexible since all the design is not complete when the construction starts. This allows them to make some changes on the fly if they start seeing problems.
DB is favored because CE is contracted out and we have no other engineering support.
I think it comes down to availability of resources. I am saying this based on construction in New Mexico, even though I am currently in Florida. They don't have enough expertise in the area to support another method which could lead to issues with getting good competition.
DB streamlines the construction process while obtaining design and construction funds at the same time.
DB is the favored method because of convenience.
There is very limited contractor base for design services, and we have little to no in-house capabilities for them. It is more practicable to use DB in our projects.
The region has done it for so long they don't want to change.

Although most of the surveyed personnel responded that there was not a favored method based on the region, those that did say DBB was favored by their region cited the need to keep the work on base with the civil engineering squadrons to avoid complications, or because it promoted competition and allows for more control. A summary of the surveyed personnel's responses can be found in Table 4.13.

Table 4.13 Why a region favors DBB

DBB is the favored method because the base in Portugal is not a US base and the US government are visitors. Any changes to the base need Portuguese AF approval and keeping construction in-house is easier.
I don't really know to be quite honest. It appears that we have done DBB for so long that we don't know or aren't comfortable using alternative methods.
DBB is most often utilized as we also manage the contract for the design. One major region not included in map (PACAF- Alaska, Ascension Island, Wake Island, Shemya Island etc.) favors DB because of logistical issues and speed. The Middle East (FMS) also favors DB as the program is always late to delivery due to length of time for host nation agreements
My region uses an actual contract that contains 3 contractors for 5 years. We design a project almost entirely, have the contractors quote (including the rest of the project), and award. This cuts down time significantly.
COMPETITION
ISSUE: remote construction industrial base, RESOLUTION: DBB-helps maintain and grow businesses (small) for competition.
Local government engineers (CE Squadrons) do not support DB as it could remove their jobs.

Surveyed personnel were asked whether a method they had used exceeded the budgeted amount more than other methods. DBB was mentioned (42/99, 42%) far more than most other methods, with DB (32/99, 32%) being close behind. The other methods were not listed as much because they are not as common as DBB and DB, or because they are not legally usable per the FAR.

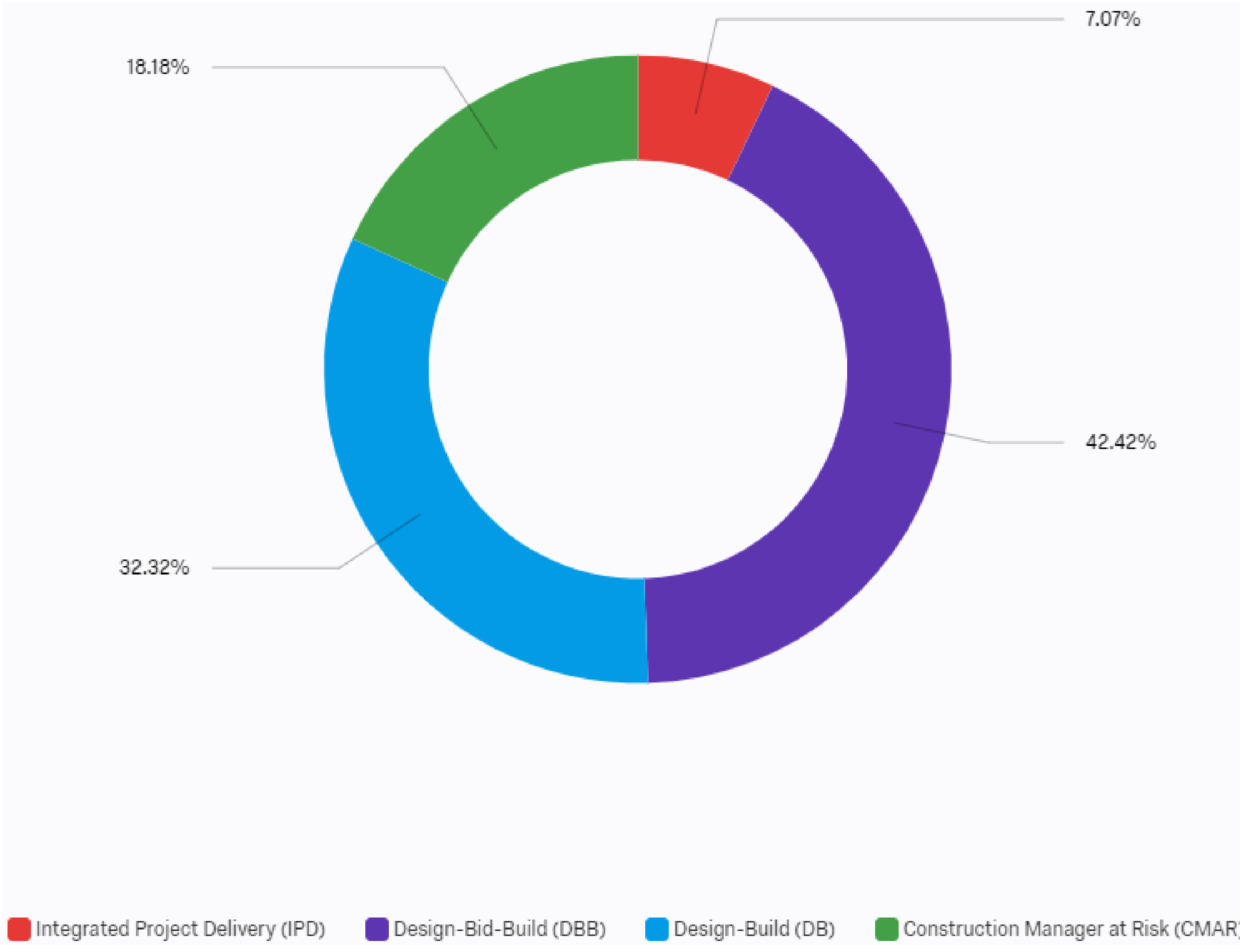

Figure 4.11 Does a construction delivery method exceed budget more often than others?

Surveyed personnel were asked to state how important four major aspects of project application were to the selection of the construction delivery method, and then asked to rank the aspects together. Obviously, all the aspects were ranked highly. For budget, most put extremely important (42/94, 45%) or very important (32/94, 34%). For schedule, most put extremely important (35/94, 37%), or very important (42/94, 45%). For the experience of the contracted agency, most put extremely important (24/94, 26%) or very important (46/94, 49%). For the scope of the project, most put extremely important (26/94, 28%) or very important (41/94, 44%). For the quality of the product, most put extremely important (29/94, 31%) or very important (42/94, 45%). When comparing these numbers, this would suggest that budget is considered most important, followed in order by schedule, scope, quality, and then experience. When ranking them together, the experience of the contracted agency was omitted, and the order of aspects was budget was first, followed by schedule, quality, and then scope. This would indicate that budget is of primary importance, followed by schedule, whereas quality and scope are interchangeable.

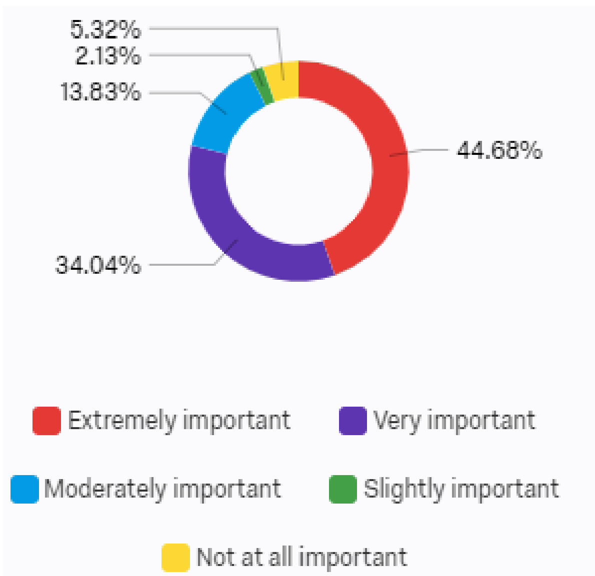

Figure 4.12 Importance of budget

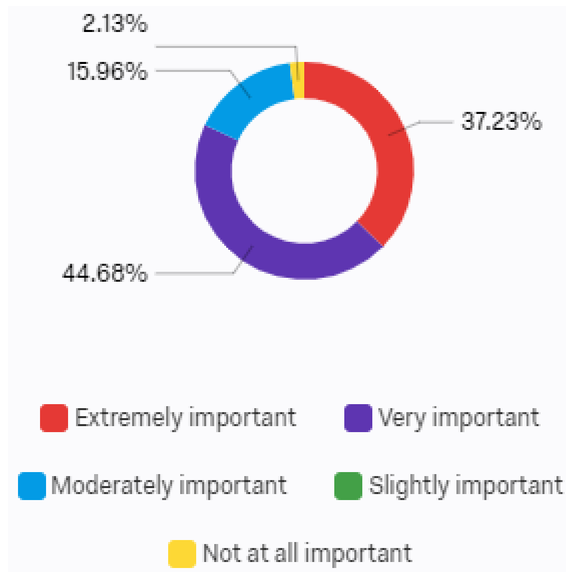

Figure 4.13 Importance of schedule

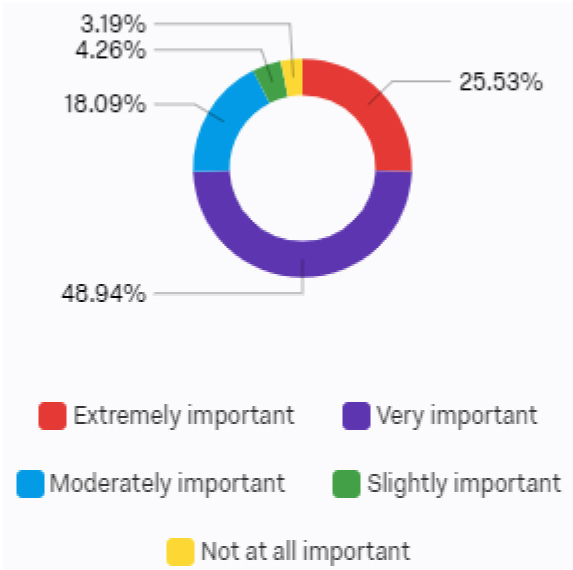

Figure 4.14 Importance of experience of contracted agency

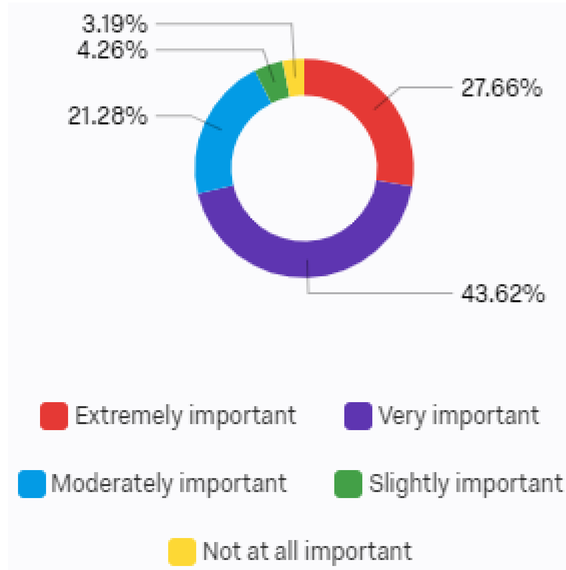

Figure 4.15 Importance of scope

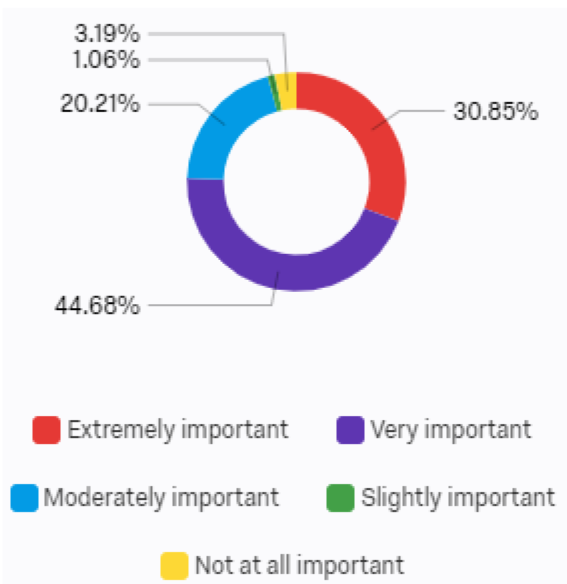

Figure 4.16 Importance of quality

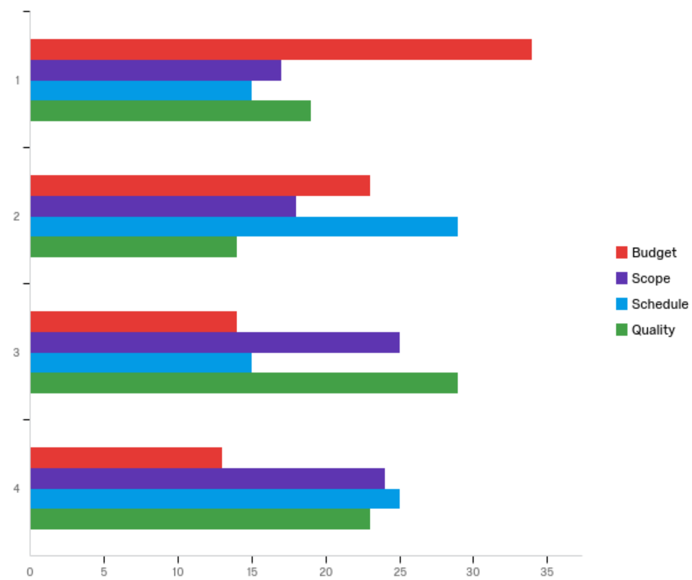

Figure 4.17 Ranking in decision making process

The surveyed personnel were then asked what method they believed was best suited to accomplish the goals they listed in rank order in the previously question. Most chose DB (39/92, 42%) or DBB (34/92, 37%), which can be attributed to familiarity and their legality in the FAR. IPD was well represented (17/92, 18%), which is notable especially considering it is not legally applicable currently because of the FAR and bias towards DB and DBB as legal methods.

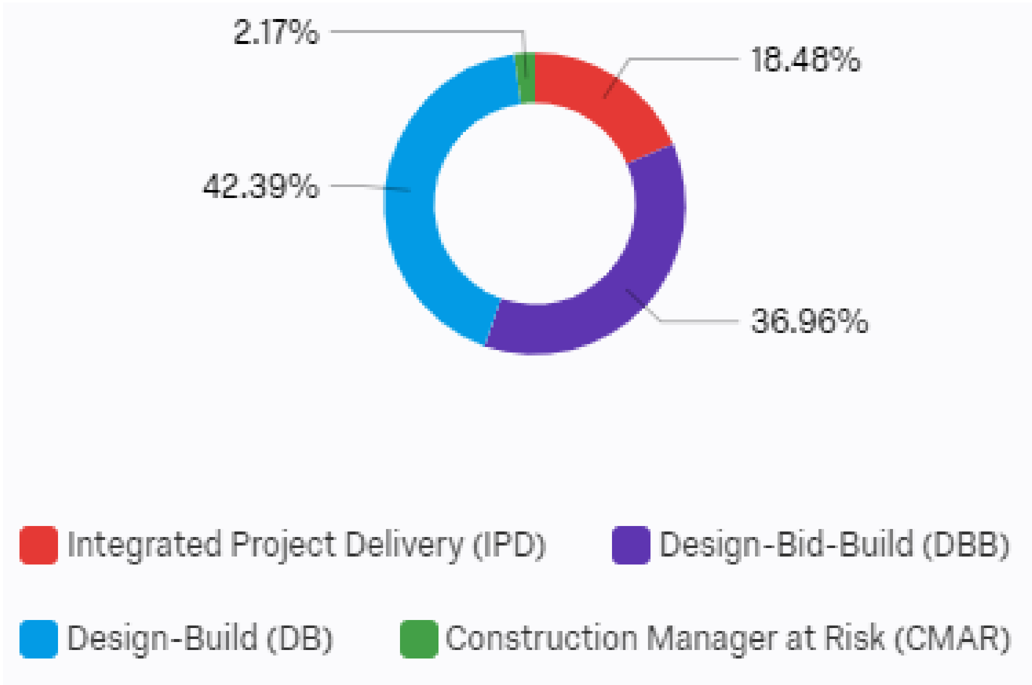

Figure 4.18 Method best suited to accomplish goals

Most surveyed personnel (57/91, 63%) stated there was not a favored method based off contract size. Those that did believed DB was heavily favored (22/32, 69%) for small contacts, whereas DBB is favored for projects between $500,000 and $10,000,000 (18/32, 56%) and projects over $10,000,000 (16/32, 50%).

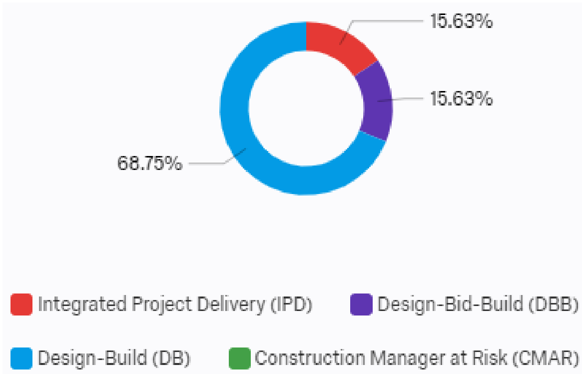

Figure 4.19 Small projects (under $500k)

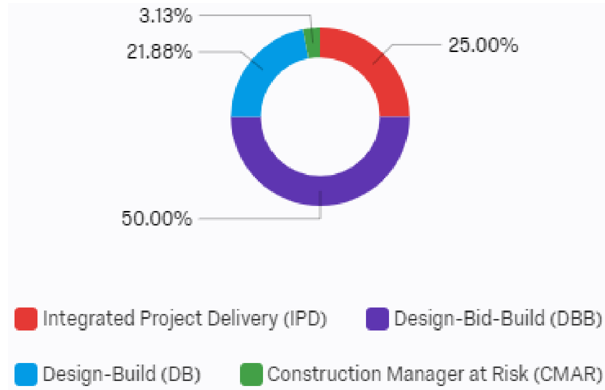

Figure 4.21 Large projects ($1M+)

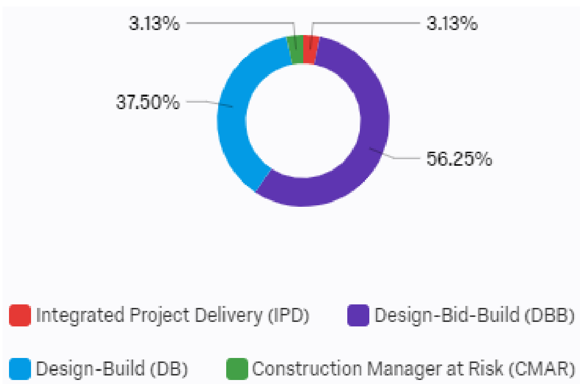

Figure 4.20 Medium projects ($500-1M)

Most of the surveyed personnel (55/88, 63%) stated the type of contract was dependent on the complexity of the project. DB was favored for low complexity projects (24/48, 50%), while DBB was favored for medium complexity projects (25/49, 51%) and IPD and DBB tied for high complexity projects (19/49, 39%). Although IPD is not a legal method in the USAF per the FAR, it is a highly recommended method in the construction industry for high complexity projects and the survey question does not ask only about projects in the USAF.

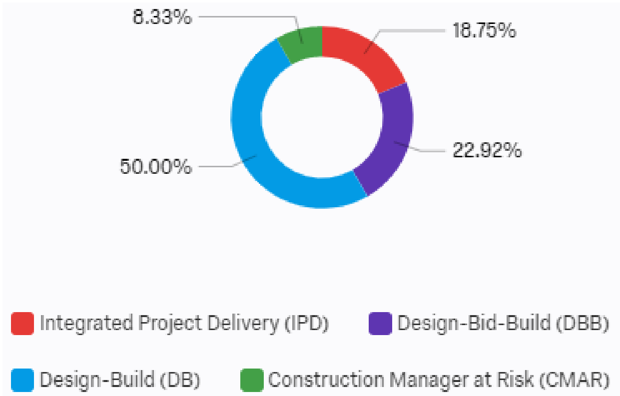

Figure 4.22 Low complexity

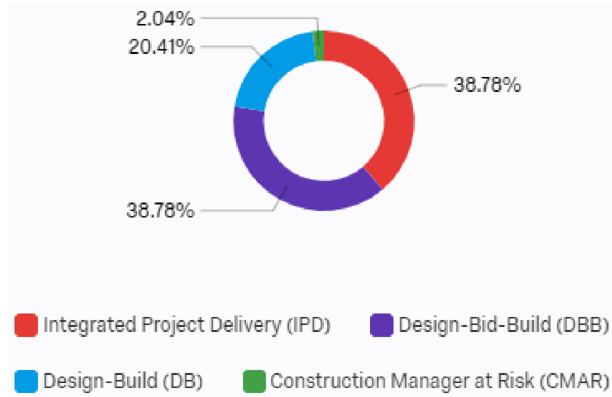

Figure 4.24 High complexity

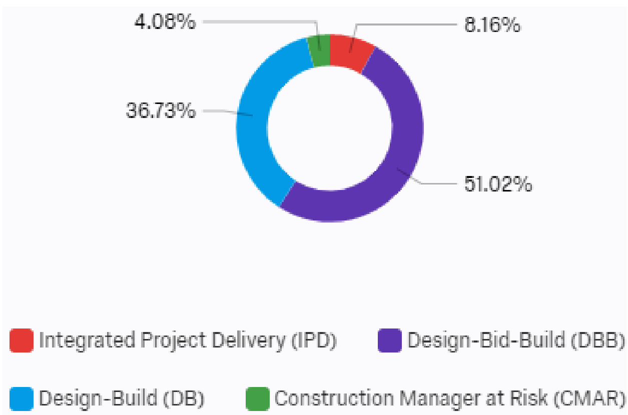

Figure 4.23 Mid complexity

Surveyed personnel did not believe the size of the contracted agency effected the construction delivery method specified in the contract (52/82, 63%). Those that did believed DBB (24/48, 50%) and DB (10/48, 21%) were favored for contracts with small businesses. For medium businesses DBB (14/28, 50%) and DB (13/28, 46%) were again favored. Lastly, for large businesses, DBB (11/28, 39%) and IPD (9/28, 32%) were favored.

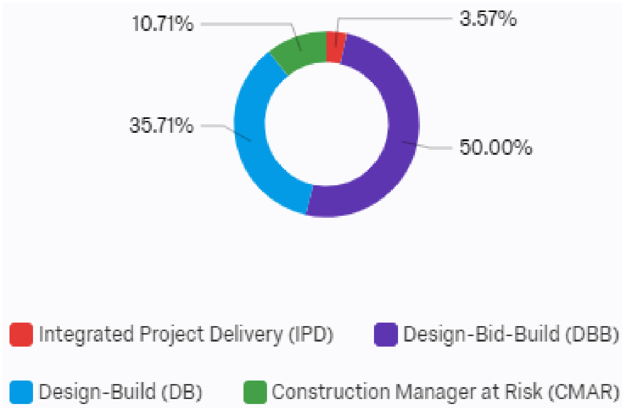

Figure 4.25 Small businesses (under 100 employees)

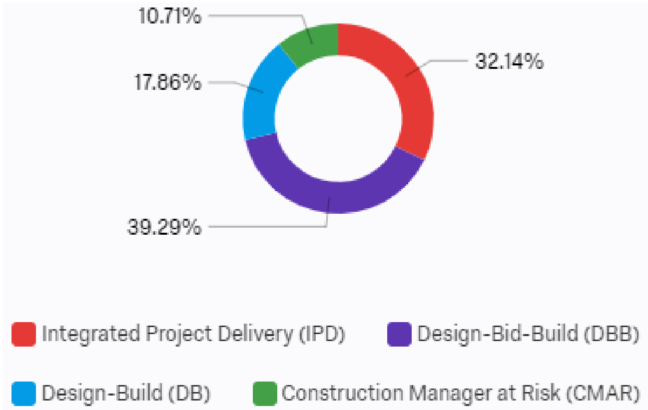

Figure 4.27 Large businesses (1000+ employees)

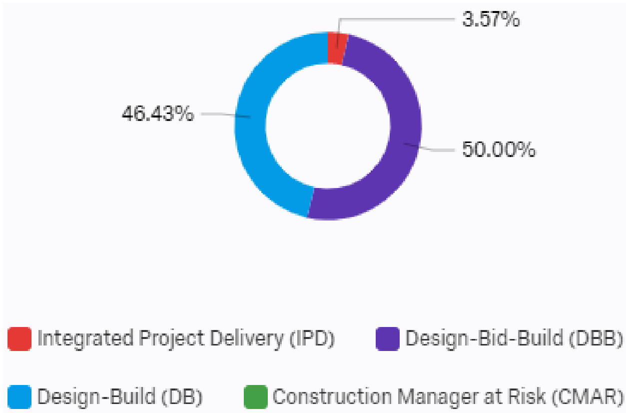

Figure 4.26 Medium businesses (100-999 employees)

Surveyed personnel were asked how involved the USAF prefers to be in a project and given the options of ‘extremely involved’, ‘very involved’, ‘moderately involved’, ‘slightly involved’ or ‘not involved’. Most of the surveyed personnel stated that the USAF prefers to be extremely involved (45/80, 56%) or very involved (30/80, 38%) in the design and construction of the project through ways such as monitoring the progress and quality of the project through site inspections, with the remaining personnel (5/80, 6%) stating the USAF prefers to be moderately involved.

Chapter 5 - Comparison of Literary Review and Survey

The main similarities between the literary reviews and the results of the conducted survey are: they both indicate that DB is favored and performs better than DBB, and an interest in implementing IPD as a potential construction delivery method exists among contracting personnel surveyed.

Design-Build versus Design-Bid-Build

Rosner 2008 document, *An Analysis of the Design-Build Delivery Approach in Air Force Military Construction*, concluded that studies and reports lent support to DB as the best construction delivery method to utilize, surpassing the traditional method of DBB that USAF MILCON used prior to DB being introduced. Rosner (2008) data showed DB performing better than DBB in six of eight metrics (unit cost, cost growth, schedule growth, construction speed, modifications per million dollars, current working estimate/programmed amount (CWE/PA) ratio) while DBB outperformed DB in two (construction timeline and total project time). However, DB showed improvement over the analyzed time in four metrics (cost growth, modifications per million dollars, construction timeline, total project time) while DBB showed improvement in only two areas (cost growth, modifications per million dollars). Rosner (2008) facility-type analysis showed DB was best suited for seven of the nine facility types.

Hale et al. (2009) concurred with Rosner (2008), concluding DB projects proved superior in performance to the DBB construction delivery method, with DB taking less time to complete and demonstrating less time and cost growth with statistical significance. While it was not statistically significant, data indicated DB may be less expensive to build with than DBB.

Research in Allen 2001 document, *Comparison of Design-Build to Design-Bid-Build as a Project Delivery Method* agreed with Hale et al. (2009) and Rosner (2008). When looking at homogenous DB and DBB projects the award growth was -2% for DB and 7% for DBB, with cost growth also higher for all DBB projects. DB resulted in lower time growth of schedule than DBB. DB resulted in higher DCP except for horizontal projects in which DBB performed better. The survey questionnaire showed DB outperformed DBB in two out of three areas for turnover process quality. DBB outperformed DB in three of four categories regarding system performance quality, but despite higher scores, actual remarks testified to poor quality materials and warranty problems. The research provided conclusive evidence that DB is superior based on DB's outperformance of DBB in areas of cost growth, construction cost growth, award growth, and design-construct placement and should be used if the project is a viable candidate.

The conducted survey for this report showed that DB was slightly preferred over other methods, edging out DBB in most cases. DB was listed as the most predominate method and was also cited as the method that the USAF is trending towards, although DBB was cited as the currently favored method. Survey participants stated that this was largely because DBB is the traditional method and seems to be what USAF civil engineering favors.

IPD as a Potential Construction Delivery Method in the USAF

Singleton 2010, *Implementing Integrated Project Delivery on Department of the Navy Construction Projects* concluded IPD can successfully improve the construction process and adds value. Singleton (2010) suggested the creation of a step-by-step process for executing IPD techniques, potentially based on a refinement and future calibration of his own IPD project selection tool. He encouraged measuring workload changes for NAVFAC employees that resulted from IPD techniques, as well as case studies of NAVFAC ECI pilot projects to see if the techniques proved to be beneficial.

The suggestions in Lee 2013, *Implementation of Integrated Project Delivery on Department of Navy Military Construction Projects* mirrored Singleton's. Lee (2013) found that between FFP, FPIF, and FPAF, no one showed distinctive favoritism over the other two and concluded that there is some potential within the context of the federal government to be open to the idea of eventually implementing an integrated risk sharing. The main reasons for implementing IPD included cost control and enhanced quality by BIM usage. Lee (2013) stated the general culture of NAVFAC and USMC contained potential for implementation of IPD, indicated by most positive responses for wanting NAVFAC to implement IPD. Lee (2013) also said it was possible to make short term immediate changes to implement some IPD principles without having to resort to major structural changes, a route that should be considered since full implementation of IPD would be extremely difficult, but not entirely impossible within the federal government.

The survey conducted for this report showed interest for IPD, with the personnel saying the construction delivery method they listed as most common was not most efficient and should be replaced with IPD, and with most of the personnel saying the USAF should be investigating how IPD can be implemented. This especially holds weight considering DB and DBB are currently the only acceptable methods and therefore should have some inherent bias due to being more traditional methods.

Chapter 6 - Conclusions

Two major conclusions can be drawn from the literary review and survey conducted for this report: DB should be used over DBB in most cases, and IPD should be examined as a viable USAF construction delivery method candidate.

DB has proven to be superior to DBB in almost every regard, and contracting personnel also tend to favor it over other construction delivery methods. DB should be selected as the "go to" construction delivery method if the project is a viable candidate with no extenuating factors that suggest another method should be used. For higher complexity or large projects, DBB can offer more control but sacrifices timeliness.

IPD has provided data that suggests it can be a construction delivery method that is better than both DB and DBB. The system that Singleton (2010) suggests for NAVFAC could very easily be adapted and suggested for the USAF and MILCON in general. USAF should consider exploring what parts of IPD can be implemented for now (as a form of IPD-lite), while waiting for the larger legislative changes to the FAR that would be necessary for use of full IPD to be made at the congressional level.

It may be beneficial for future studies to be conducted on civil engineering officers in the US military to observe their viewpoint on construction delivery methods and compare the results to those identified in this report regarding USAF contracting officers. While contracting officers seem to place more importance on the ease of contract negotiation and the timeliness of the project, civil engineers may place more emphasis on the level of completion of the design before construction begins and the quality of the end-product delivered.

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Appendix A - Survey

Consent Question Section:

You are being invited to participate in a research study titled USAF Construction Delivery Methods, conducted by Isaak Giefer from Kansas State University.

The purpose of this study is to determine which construction delivery methods the US Air Force uses for construction projects and what factors dictate why those construction delivery methods are selected. Your responses may help us learn more about which construction delivery methods are more predominantly used by the contracting career field and why, serving as a reference for present/future contracting officers. It should take approximately 15-25 minutes to complete. Your participation in this study is completely voluntary and you can withdraw at any time.

Your survey answers will be stored in Qualtrics in a password protected electronic format. Qualtrics does not collect identifying information such as your name, email address, or IP address. Therefore, your responses will remain anonymous. No one will be able to identify you or your answers, and no one will know whether or not you participated in the study. At the end of the survey you will be asked if you are interested in participating in an additional interview [by phone or email]. If you choose to provide contact information such as your phone number or email address, your survey responses may no longer be anonymous to the researcher. However, no names or identifying information would be included in any publications or presentations based on these data, and your responses to this survey will remain confidential. By clicking "I agree" below you are indicating that you have read and understood this consent form and agree to participate in this research study.

- Agree
- Disagree

Demographic Questions:

What is your rank in the Air Force?

- Company Grade Officer (2d Lt through Capt)
- Field Grade Officer (Maj through Col)

- Airman (E-1 through E-4)
- NCO (E-5 through E-6)
- Senior NCO (E-7 through E-9)
- GS-7
- GS-8
- GS-9
- GS-10
- GS-11
- GS-12
- GS-13
- GS-14
- GS-15
- Other (Please Specify): Free Response

What is your age?

- Free Response

What gender do you identify with?

- Male
- Female
- Prefer Not to Respond

How many years have you worked in the contracting career field?

- 0-3 years
- 4-6 years
- 7-10 years
- 11-14 years
- 15-18 years
- 18+ years

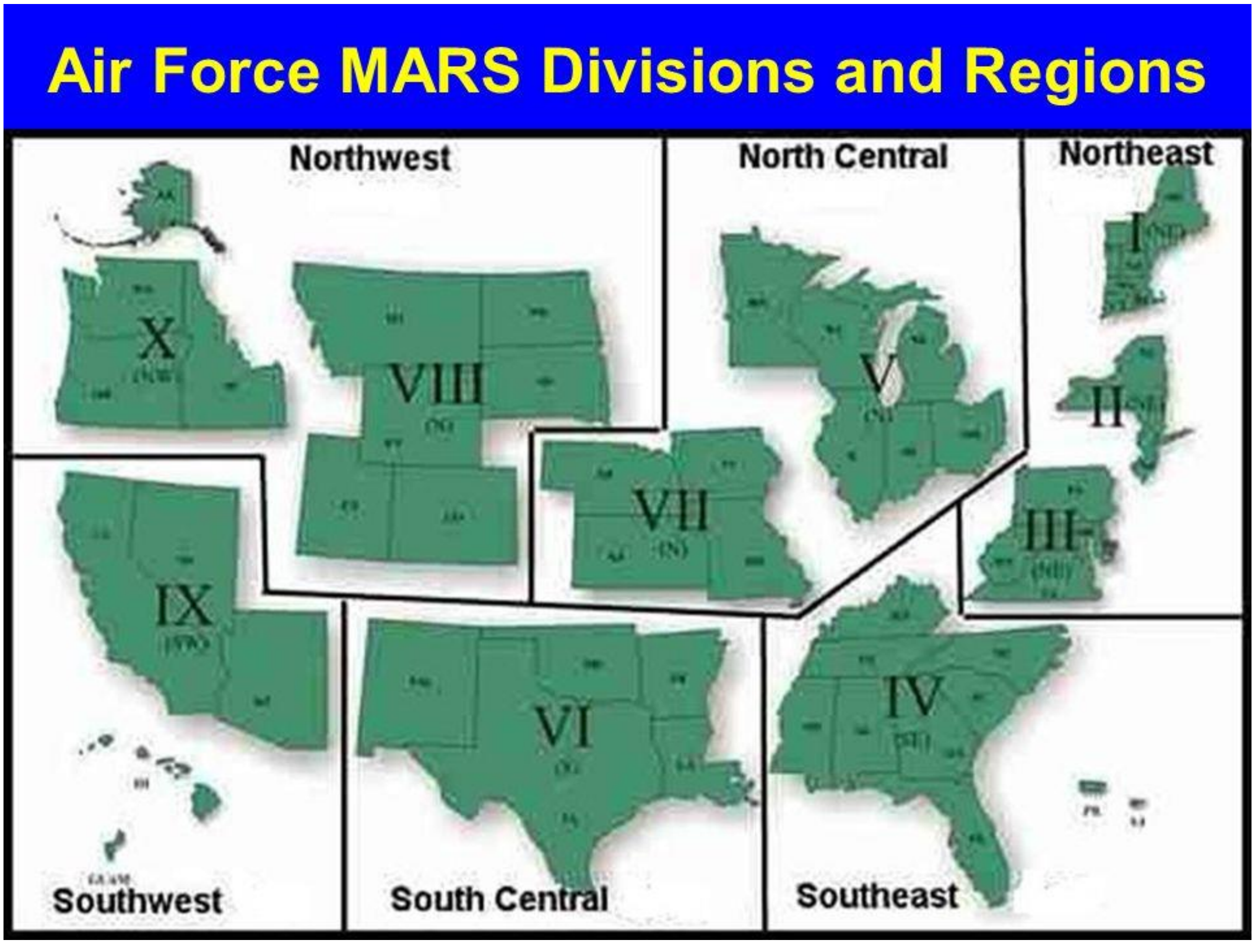
What is your level of certification? (Acquisition Professional Development Program (APDP))

- Level I
- Level II
- Level III
- No Certification

In your contracting career, have you ever worked construction contracts?

- Yes
- No

Where are your currently stationed? (Graphic attached for reference to US regions)



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- Northeast US (I, II, III)
- North Central US (V, VII)

- Northwest US (VIII, X)
- Southeast US (IV)
- South Central US (VI)
- Southwest US (IX)
- Canada
- Central America
- South America
- Europe
- Asia
- Middle East
- Africa
- Australia

Within which region have you completed a majority of your construction contracts? (Graphic attached for reference to US regions.) Enter whole numbers adding up to 100.

- Northeast US (I, II, III) (Enter Number)
- North Central US (V, VII) (Enter Number)
- Northwest US (VIII, X) (Enter Number)
- Southeast US (IV) (Enter Number)
- South Central US (VI) (Enter Number)
- Southwest US (IX) (Enter Number)
- Canada (Enter Number)
- Central America (Enter Number)
- South America (Enter Number)
- Europe (Enter Number)
- Asia (Enter Number)
- Middle East (Enter Number)
- Africa (Enter Number)
- Australia (Enter Number)

If you have held a warrant, what is the highest amount you have ever held for a construction contract (authorized sum of money with which to negotiate contracts)?

- Under $25K
- $25K - $150K
- $150K - $500K
- $500K - $1M
- $1M - $5M
- $5M - $10M
- $10M - $25M
- $25M - $50M
- $50M - $100M
- $100M+
- Unlimited

Approximately how many construction contracts have you awarded/worked on?

- Under 25
- 25-50
- 50-100
- 100-200
- 200-500
- 500+

What is your typical contract size?

- Under $500K
- $500K - $10M
- $10M - $50M
- $50M - $100M
- Over $100M

General Construction Delivery Method Questions

The following questions will cover 4 construction delivery methods. For your convenience, the construction delivery methods have been summarized below with diagrams outlining their basic structure.

Integrated Project Delivery (IPD) is a team-based approach method that involves the owner, architect, engineers, contractor and subcontractors working together throughout the design and construction phases. It is supposed to increase transparency/communication, save time, and create a shared accountability.

Design-Bid-Build (DBB) is also known as the traditional method. It involves three phases (design, bidding, and construction). In design phase the owner retains an architect/engineers to design/produce documents/drawings/specifications that will meet the project's needs. The finished documents are bid upon by general contractors during the bidding phase. The construction phase is where the project is constructed, typically through subcontractors hired by the winning general contractor.

Design-Build (DB) is a contract with a single entity known as the design-build contractor. The design-build contractor is a combination of the architect/engineers/general contractor and is contracted to design and build the project. This combination and the skipping of the bidding phase of DBB lets the design and build phases overlap.

Construction Manager at Risk (CMAR) is where the construction manager delivers the owner their documents/drawings/specifications for the project with a guaranteed maximum price (GMP) prior to bidding. The CMAR acts as a consultant and provides professional services to the owner, as well as providing construction (if not subcontracted), and managing and controlling project costs to not exceed the GMP. Excesses of the GMP that is not a result from change orders are the CMAR's responsibility.

In which order do you see construction delivery methods most often utilized in construction contracts? Select the appropriate number (1 being most often, 5 being least often)

- Integrated Project Delivery (IPD) Rate 1-5
- Design-Bid-Build (DBB) Rate 1-5
- Design-Build (DB) Rate 1-5
- Construction Manager at Risk (CMAR) Rate 1-5
- Other (Please Specify): Free Response Rate 1-5

Do you believe the construction delivery method you listed as #1 in the previous question is the most efficient overall method?

- Yes
- No

Why is this construction delivery method used the most?

- Free Response

Which method do you believe should be used in its stead?

- Integrated Project Delivery (IPD)
- Design-Bid-Build (DBB)
- Design-Build (DB)
- Construction Manager at Risk (CMAR)

What percentage of the time do you see each construction delivery method in construction contracts?

- Integrated Project Delivery (IPD) Enter 0-100
- Design-Bid-Build (DBB) Enter 0-100
- Design-Build (DB) Enter 0-100
- Construction Manager at Risk (CMAR) Enter 0-100
- Other (Please Specify): Free Response Enter 0-100

Have there been any trends towards using a specific construction delivery method more in the last 6 years?

- Yes
- No
- Do Not Know

Which method?

- Integrated Project Delivery (IPD)
- Design-Bid-Build (DBB)
- Design-Build (DB)
- Construction Manager at Risk (CMAR)

Do you believe the Air Force should be evaluating a specific construction delivery method?

- Yes
- No

Which one?

- Integrated Project Delivery (IPD)
- Design-Bid-Build (DBB)
- Design-Build (DB)
- Construction Manager at Risk (CMAR)

Why that particular construction delivery method?

- Free Response

Is there a favored/encouraged construction delivery method used by the Air Force contracting system?

- Yes
- No

Which method?

- Integrated Project Delivery (IPD)
- Design-Bid-Build (DBB)
- Design-Build (DB)
- Construction Manager at Risk (CMAR)

Why does the Air Force favor/encourage this construction delivery method over other methods?

- Free Response

Is there a favored/encouraged construction delivery method governed by the region in which you work?

- Yes
- No

Which method?

- Integrated Project Delivery (IPD)
- Design-Bid-Build (DBB)
- Design-Build (DB)
- Construction Manager at Risk (CMAR)

Why does the region favor/encourage this construction delivery method over other methods?
- Free Response

Are there any Air Force regulations that expressly prohibit/restrict the use of any of the construction delivery methods (IPD, DBB, DB, CMAR)?
- Yes
- No

Which methods? (Option to choose multiple)
- Integrated Project Delivery (IPD)
- Design-Bid-Build (DBB)
- Design-Build (DB)
- Construction Manager at Risk (CMAR)

Which Air Force regulations prohibit/restrict the use of this(these) delivery method(s)?
- Free Response

In your past experience, is there a construction delivery method that exceeds the budget more often than the other methods?
- Integrated Project Delivery (IPD)
- Design-Bid-Build (DBB)
- Design-Build (DB)
- Construction Manager at Risk (CMAR)

Is there a reason this happens?
- Free Response

How important is the budget in the selection of the construction delivery method?
- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

How important is the schedule in the selection of the construction delivery method?
- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

How important is the experience of the contracted agency/company in the selection of the construction delivery method?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

How important is the scope of the project for the selection of the construction delivery method?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

How important is the quality of the project for the selection of the construction delivery method?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

In which order would you rank the following project goals/objectives in the decision-making process when choosing a construction delivery method? Select the appropriate number (1 being most important, 4 being least important).

- Budget Rank 1-4
- Scope Rank 1-4
- Schedule Rank 1-4
- Quality Rank 1-4

Which construction delivery method do you believe is best suited to satisfying this order of decision-making factors?

- Integrated Project Delivery (IPD)
- Design-Bid-Build (DBB)
- Design-Build (DB)
- Construction Manager at Risk (CMAR)

Based on the construction contract size (dollar amount), is there a favored construction delivery method?

- Yes
- No

What construction delivery method is favored for small projects (under $500K)?

- Integrated Project Delivery (IPD)

- Design-Bid-Build (DBB)
- Design-Build (DB)
- Construction Manager at Risk (CMAR)

What construction delivery method is favored for medium projects ($500K - $10M)?

- Integrated Project Delivery (IPD)
- Design-Bid-Build (DBB)
- Design-Build (DB)
- Construction Manager at Risk (CMAR)

What construction delivery method is favored for large projects (over $10M)?

- Integrated Project Delivery (IPD)
- Design-Bid-Build (DBB)
- Design-Build (DB)
- Construction Manager at Risk (CMAR)

Does the construction delivery method differ based off the complexity of the project? Factors to be considered include:
1. Number of disciplines involved
2. Magnitude of social/legal/environmental implications
3. Overall expected financial impact
4. Strategic importance of project
5. Stability of overall project context

- Yes
- No

Rating each factor on a scale of 1 to 4, with 1 being simple and 4 being complex, what construction delivery method is favored for low complexity projects (total of 5-9 points)?
1. Number of disciplines involved (1, 2, 3, 4)
2. Magnitude of social/legal/environmental implications (1, 2, 3, 4)
3. Overall expected financial impact (1, 2, 3, 4)
4. Strategic importance of project (1, 2, 3, 4)
5. Stability of overall project context (1, 2, 3, 4)

- Integrated Project Delivery (IPD)
- Design-Bid-Build (DBB)
- Design-Build (DB)
- Construction Manager at Risk (CMAR)

Rating each factor on a scale of 1 to 4, with 1 being simple and 4 being complex, what construction delivery method is favored for medium complexity projects (total of 10-14 points)?
1. Number of disciplines involved (1, 2, 3, 4)
2. Magnitude of social/legal/environmental implications (1, 2, 3, 4)
3. Overall expected financial impact (1, 2, 3, 4)
4. Strategic importance of project (1, 2, 3, 4)
5. Stability of overall project context (1, 2, 3, 4)

- Integrated Project Delivery (IPD)
- Design-Bid-Build (DBB)
- Design-Build (DB)
- Construction Manager at Risk (CMAR)

Rating each factor on a scale of 1 to 4, with 1 being simple and 4 being complex, what construction delivery method is favored for high complexity projects (total of 15-20 points)?
1. Number of disciplines involved (1, 2, 3, 4)
2. Magnitude of social/legal/environmental implications (1, 2, 3, 4)
3. Overall expected financial impact (1, 2, 3, 4)
4. Strategic importance of project (1, 2, 3, 4)
5. Stability of overall project context (1, 2, 3, 4)
   - Integrated Project Delivery (IPD)
   - Design-Bid-Build (DBB)
   - Design-Build (DB)
   - Construction Manager at Risk (CMAR)

Does the construction delivery method vary based off the size of the business contracted to complete the project?
- Yes
- No

What construction delivery method is favored when dealing with small businesses (less than 100 employees)?
- Integrated Project Delivery (IPD)
- Design-Bid-Build (DBB)
- Design-Build (DB)
- Construction Manager at Risk (CMAR)

What construction delivery method is favored when dealing with medium businesses (100-999 employees)?
- Integrated Project Delivery (IPD)
- Design-Bid-Build (DBB)
- Design-Build (DB)
- Construction Manager at Risk (CMAR)

What construction delivery method is favored when dealing with large businesses (1000+ employees)?
- Integrated Project Delivery (IPD)
- Design-Bid-Build (DBB)
- Design-Build (DB)
- Construction Manager at Risk (CMAR)

How involved does the Air Force need to be in the design/construction of the project? (i.e. monitoring of progress/quality of project through site inspections)

- Extremely involved
- Very involved
- Moderately involved
- Slightly involved
- Not involved

Integrated Project Delivery

What percentage of construction contracts using the Integrated Project Delivery (IPD) construction delivery method are renovations v. new construction?

• Renovations	Enter 0-100
• New Construction	Enter 0-100
• Not Applicable	Enter 0-100

What percentage of Integrated Project Delivery (IPD) new construction contracts are solely site work, solely construction, or both site work and construction?

• Site Work	Enter 0-100
• Construction	Enter 0-100
• Site Work and Construction	Enter 0-100
• Not Applicable	Enter 0-100

Design-Bid-Build

What percentage of construction contracts using the Design-Bid-Build (DBB) construction delivery method are renovations v. new construction?

• Renovations	Enter 0-100
• New Construction	Enter 0-100
• Not Applicable	Enter 0-100

What percentage of Design-Bid-Build (DBB) construction contracts are solely site work, solely construction, or both site work and construction?

• Site Work	Enter 0-100
• Construction	Enter 0-100
• Site Work and Construction	Enter 0-100
• Not Applicable	Enter 0-100

Design-Build

What percentage of construction contracts using the Design-Build (DB) construction delivery method are renovations v. new construction?

• Renovations	Enter 0-100
• New Construction	Enter 0-100
• Not Applicable	Enter 0-100

What percentage of Design-Build (DB) construction contracts are solely site work, solely construction, or both site work and construction?

- Site Work — Enter 0-100
- Construction — Enter 0-100
- Site Work and Construction — Enter 0-100
- Not Applicable — Enter 0-100

Construction Manager at Risk

What percentage of construction contracts using the Construction Manager at Risk (CMAR) construction delivery method are renovations v. new construction?

- Renovations — Enter 0-100
- New Construction — Enter 0-100
- Not Applicable — Enter 0-100

What percentage of Construction Manager at Risk (CMAR) construction contracts are solely site work, solely construction, or both site work and construction?

- Site Work — Enter 0-100
- Construction — Enter 0-100
- Site Work and Construction — Enter 0-100
- Not Applicable — Enter 0-100

Conclusion Questions

Would you be interested in being contacted for a follow-up interview?

- Yes
- No

What is your email/phone number?

- Free Response

Thank you for participating in this survey over construction delivery methods in the USAF. The results of the survey will be analyzed and used in a Master's Report by Isaak Giefer (Kansas State University, Architectural Engineering graduate student) and will be available for the public in the spring of 2019.

Appendix B - Acronyms and Abbreviations

AC	Award Cost
ACES-PM	Automated Civil Engineer System – Project Management Module
AEC	Architecture, Engineering, and Construction
AFFARS	Air Force Federal Acquisition Regulation Supplement
AFICA	Air Force Installation Contracting Agency
AFIT	Air Force Institute of Technology
AFROTC	Air Force Reserve Officer Training Corps
AIA	American Institute of Architects
ASCE	American Society of Civil Engineers
A/E	Architect/Engineer
BEQs	Bachelor Enlisted Quarters
BIM	Building Information Modeling
BMS	Business Management System
CG	Cost Growth
CHH	Cathedral Hill Hospital
CMAA	Construction Management Association of America
CMAR	Construction Manager at Risk
CoE	Corps of Engineers
CP	Construction Placement
CSU	Colorado State University
CWE/PA	Current Working Estimate/Programmed Amount
DB	Design Build
DBB	Design Bid Build
DBIA	Design Build Institute of America
DCP	Design-construct Placement
DFARS	Defense Federal Acquisition Regulation Supplement
DoD	Department of Defense
DP	Design Placement
ECI	Early Contractor Involvement

EE	Engineer’s Estimate
EQ	Equipment Quality
FAR	Federal Acquisition Regulation
FDOT	Florida Department of Transportation
FFP	Fixed Firm Price
FPAF	Fixed Price Award Fee
FPI	Fixed Price Incentive
FPIF	Fixed Price Incentive Firm
FY	Fiscal Year
GMP	Guaranteed Maximum Price
GSA	General Services Administration
IFOA	Integrated Form of Agreement
IPD	Integrated Project Delivery
KSU	Kansas State University
LCI	Lean Construction Institute
LPDS	Lean Project Delivery System
LPS	Last Planner System
MFH	Military Family Housing
MILCON	Military Construction
NAVFAC	Naval Facilities Engineering Command
NIST	National Institute of Standards
OUC	Orlando Utilities Commission
PenRen	Pentagon Renovation
PPC	Percent Plan Complete
RFP	Request for Proposal
SH	Sutter Health
SQ	System Quality
TG	Time Growth
TLF	Temporary Living Facility
TQ	Turnover Quality
TVD	Target Value Design

UCB	University of Colorado Boulder
UDOT	Utah Department of Transportation
US	United States
USA	United States Army
USACE	United States Army Corps of Engineers
USAF	United States Air Force
USMC	United States Marine Corps
USN	United States Navy