The Impact of Project Delivery Methods on Subcontracting:

USAF Construction Projects Case Study

Aaron M. Hall

A thesis

submitted in partial fulfillment of the

requirements for the degree of

Master of Science

University of Washington

2024

Committee:

Giovanni Migliaccio

Yong-Woo Kim

Program Authorized to Offer Degree:

College of Built Environments

University of Washington

Abstract

The Impact of Project Delivery Methods on Subcontracting:

A USAF Construction Projects Case Study

Aaron M. Hall

Chair of the Supervisory Committee:

Giovanni Migliaccio

Construction Management

This thesis investigates subcontracting practices in the construction industry, specifically focusing on U.S. Air Force (USAF) construction projects. It explores the nuances and challenges of different project delivery methods, namely Design-Bid-Build (DBB) and Design-Build (DB), and their impact on subcontracting. The study builds upon existing research, emphasizing the influence of prime contracts on subcontractor selection, project management, risk and scope sharing, contract specifications, and financial considerations.

The research uncovers key trends and preferences in subcontractor qualifications through comprehensive interviews with industry professionals, highlighting a priority on technical expertise and local knowledge over cost. It examines the complexities in project execution under DBB and DB methods, revealing the efficiency of Design-Build Subcontracting (DBS) in

reducing project delays and enhancing collaboration. The study also delves into the risk distribution in subcontracting, finding that DB fosters shared risk and trust among contractors, contrasting the more risk-averse nature of DBB.

Furthermore, the thesis addresses contract and specification challenges specific to Air Force projects, such as outdated designs and the necessity for proprietary products. It discusses the financial implications of subcontracting, including the potential for inflated costs due to project uncertainties and niche subcontractor markets.

Conclusively, the thesis identifies gaps in current knowledge and suggests directions for future research, advocating for a broader exploration of subcontracting practices in various military and federal contexts and a deeper understanding of subcontractor perspectives. This work contributes to the discourse on subcontracting in construction, offering valuable insights for practitioners and policymakers engaged in USAF and similar large-scale construction projects.

The views expressed in this thesis are those of the author and do not reflect the official policy or position of the United States Air Force, Department of Defense, or the U.S. Government.

Acknowledgments

I would like to extend my deepest gratitude to my thesis advisor, Professor Giovanni Migliaccio, for his invaluable guidance, unwavering support, and insightful critiques throughout this research. His expertise and mentorship have been pivotal in shaping the direction and quality of this work.

I am also immensely thankful to Professor Yong-Woo Kim, whose expertise and insightful feedback as a committee member greatly enriched my research experience. His perspectives and constructive suggestions have significantly contributed to the completion of this thesis.
I owe a debt of gratitude to the Air Force Institute of Technology's Civilian Institute Program. Their support and faith in my capabilities allowed me to embark on this academic journey, enabling me to grow professionally and personally.

On a personal note, I must express my profound appreciation to my wife, McKell. Her sacrifices, patience, and unwavering support have been the bedrock of my resilience and persistence throughout this challenging yet rewarding journey. Her understanding, love, and the time she spent managing our lives, especially with our daughter Rosie, have been immeasurable. The time away from Rosie has been one of the most complex parts of this endeavor, and McKell's strength during these times has been my constant source of encouragement. D

This thesis is a testament to the collective effort and encouragement of all who have participated in this journey. To each one of you, I extend my heartfelt thanks.

Table of Contents

List of Figures

List of Graphs

List of Tables

Chapter 1. Introduction

1.1 Overview

Subcontracting, an integral mechanism within the modern construction industry, involves delegating specific project responsibilities from the primary contractor to a secondary entity. While the foundational goal of subcontracting is to capitalize on specialized skills and resources, the methods, strategies, and relationships it encompasses are intricate and multifaceted.

Viewing these complexities through the lens of various project delivery methods further deepens them—each with its unique approach to design, execution, and contractual obligations. Traditional methods such as Design-Bid-Build (DBB) have historically dominated the industry, emphasizing a sequential process where design completion precedes contractor engagement. Conversely, modern methodologies like Design-Build (DB) promote collaborative environments, merging the roles of designer and builder to varying degrees.

The choice of project delivery method dictates the overarching project timeline and stakeholder involvement and profoundly influences subcontracting practices and dynamics. As subcontractors often represent the nexus where design meets execution, their role is pivotal in translating project visions into tangible structures.

1.2 Background

The construction industry is a significant player in the economic landscape, and its complexity is characterized by the intricate web of relationships between the main contractors, subcontractors, and the overarching client, often in the form of government or large private organizations. This

web of relationships has historically been a focal point for researchers due to its impact on project outcomes in terms of cost, time, and quality (Chau and Walker 1994; Hassan and Le 2021).

Military projects have seen a surge in complexity because distinctive requirements and security concerns underpin them and often demand a nuanced approach to subcontracting. While military construction's general dynamics mirror civilian projects, the security-centric environment creates unique challenges and practices (AFI 2015; Franz et al. 2012).

Subcontracting, a pivotal element in the construction industry, has evolved. Historically, subcontracting was seen as a means to offload specialized tasks in which main contractors lacked expertise. However, the scope and significance of subcontracting have expanded significantly in the modern construction landscape (Yik and Lai 2008). Today, subcontracting is no longer just about offloading tasks; it is about leveraging expertise, optimizing resources, enhancing productivity, and ensuring that each construction phase is executed by specialists who can guarantee the best results (Gil et al. 2001).

The modern perspective on subcontracting acknowledges its role in improving collaboration between main contractors and subcontractors, facilitating better project outcomes(Akintan and Morledge 2013). Tools and frameworks such as the Web-based subcontractor evaluation system (WEBSES) have been proposed to refine the selection process, suggesting the increasing importance of a strategic approach to subcontracting (Arslan et al. 2008).

However, despite the broader understanding of subcontracting in general construction projects, the specific nuances within the USAF remain underexplored. The USAF's environment, characterized by rigid security protocols, specialized infrastructure needs, and stringent timelines, demands a deep dive into understanding how subcontracting dynamics play out in such a setting (Brown 2009; Rosner 2008).

Given this backdrop, bridging the knowledge gap and understanding the unique challenges and practices associated with subcontracting in a military and security-centric environment like the USAF is imperative. Such an understanding will contribute to the academic discourse and offer actionable insights for practitioners and policymakers engaged in USAF construction projects.

1.3 Research Methodology

The study aimed to understand subcontracting within the context of Air Force construction projects through a multi-phased research methodology. The initial phase involved a literature review, examining published work, databases, and archival resources. This phase identified gaps in existing knowledge, shaping the research objectives.

The focus shifted to research design and planning after defining the research question. Given the intricate nature of the subject, qualitative research methods centered around interviews were selected. The rationale was that the experiences and insights of industry professionals would offer valuable data on subcontracting practices.

Establishing participant criteria ensured the relevance of the data. Participants were chosen based on their role as general contractors, involvement in substantial projects, and a consistent work history on Air Force construction projects. Geographic factors were also considered, with a focus on specific time zones. Potential candidates were identified through the Air Force's Business Intelligence Branch, consultations with Air Force Civil Engineer units, contract award data analysis, and internet searches.

The interview process was structured, starting with understanding the participant's professional background in the construction industry and their history with specific project delivery methods on Air Force projects. As the interviews progressed, participants were introduced to various subcontracting models, prompting discussions on their experiences and observations, especially when working on Air Force projects.

Data collected was analyzed using template analysis, an effective method for qualitative data. This method identified and reported themes within the data. Strategies such as independent coding, respondent feedback, and maintaining audit trails ensured a rigorous analysis.

The final phase of the methodology involved presenting the findings and conclusions. This phase detailed the data, providing an understanding of the implications and potential future recommendations. Through its methodological approach, the study sought insight into the impact of DB and DBB procurement methods on subcontracting practices within Air Force construction projects.

1.4 Summary

This thesis commences in Chapter 2 with a comprehensive literature review to elucidate the fundamentals of subcontracting within the construction industry, mainly focusing on its application in Air Force projects. The review meticulously explores the rationale behind subcontracting, delves into the various models employed, and scrutinizes each model's inherent advantages and challenges. It particularly emphasizes the pivotal role of collaboration dynamics, contractual formality, and the nuanced approaches to integrated specialty work in shaping the efficiency and effectiveness of subcontracting strategies in large-scale construction endeavors.

Following the literature review, Chapter 3 describes the research methodology, detailing the procedures for data collection and analysis of interviews conducted with industry professionals. In Chapter 4, the focus shifts to data analysis, where interview responses are compiled to provide insights into industry trends and preferences. This chapter mainly examines interview responses to uncover the reasoning behind adopting various subcontracting models. It highlights the influence of project scale, complexity, corporate culture, and stakeholder interpersonal relationships. Chapter 5 concludes the thesis by synthesizing findings and insights gained from the research. It summarizes the key conclusions drawn from the analysis and suggests directions for future research, emphasizing the need to expand our understanding of subcontracting practices in the construction industry.

The scope of this thesis is intentionally focused on Air Force construction projects, meaning that the findings are specifically applicable to this area. It is important to note that this concentration on Air Force projects implies that the results may not universally apply to construction practices

in other military branches, federal agencies, or the private sector. This scope was chosen to provide a deep understanding of a specific area rather than a broader but less detailed overview. In addition to the deliberate focus on Air Force projects, other potential limitations of this study include its geographic reach and the number of participants. The geographic limitation and the sample size of Air Force contractors could mean that the findings might vary if the study were expanded to include a larger and more diverse group of Air Force contractors or if the methodology were replicated across the entire Air Force population. These aspects represent areas where further research could yield different results, offering a more comprehensive understanding of construction practices across a wider range of scenarios.

2 Chapter 2 Literature Review

2.1 Introduction

The construction industry is vast and dynamic, spanning a spectrum of projects from simple residential structures to highly complex infrastructural endeavors. Within this broad expanse, subcontracting has emerged as an essential pivot, shaping the intricate processes and collaborations that culminate in successful project completion.

Subcontracting is more than just a logistical tool; it is a critical mechanism determining efficiency, cost-effectiveness, and the nature of collaborations within construction projects. This literature review offers a comprehensive understanding of the various subcontracting methodologies prevalent in the industry today. Each methodology, from Traditional Subcontracting to the more integrated approaches, comes with advantages, challenges, and use cases, illuminating the diverse strategies in the sector.

However, as expansive as the world of general construction might be, there are domains within it that carry unique weight due to their implications. Such is the case with USAF construction projects. Tied intrinsically to national security and governed by stringent regulations, these projects are a world unto themselves. This review delves into the particularities of USAF construction, elucidating the regulatory, security, and financial intricacies that set them apart.

In navigating this journey from the general to the specific, this chapter aims to bridge the understanding between overarching construction practices and the specialized realm of USAF projects. The objective is to equip the reader with a holistic perspective, encompassing the

universal tenets of subcontracting and the unique challenges and considerations that define Air Force construction endeavors.

2.2 Project Delivery Methods and Trends

The subsequent section aims to define project delivery methods (PDM) that will be of consequence in this paper by drawing upon existing literature and referencing the definitions provided by authoritative sources such as the American Institute of Architects (AIA) and the Associated General Contractors of America (AGC). Typical use scenario characteristics and advantages and disadvantages of these PDMs will be briefly described.

2.2.1 DBB

Design-bid-build is a project delivery method where the owner contracts separately with the designer/architect and the construction contractor. The progression of work in construction projects generally adheres to a linear sequence. It begins with the owner entering a contract with an architect to undertake the design phase. The architect produces the required design documents, which the owner subsequently employs to solicit competitive bids from contractors. After evaluating the bids and selecting a suitable one, the owner contracts with the chosen contractor to construct the building (Gransberg et al. 2022).

Design-bid-build is considered viable when project-specific factors for projects that possess a fully completed design, a clearly defined scope, minimal potential for change, and limited flexibility for modifications.

Design-bid-build offers advantages related to procurement and contract arrangements. As a method where the lowest bidder is typically chosen through open market competition, it provides the owner with the most favorable project deal and helps them meet budget constraints (Migliaccio and Holm 2018). Additionally, design-bid-build allows for a wide range of contractors to compete, unlike other project delivery methods that may have limitations based on procurement processes and past experiences of bidders.(Gransberg et al. 2022)

However, due to separate contracts, DBB can lead to limited collaboration between the designer and the construction team, resulting in communication gaps and potential conflicts(Gransberg et al. 2022). DBB projects often exhibit higher cost growth performance than other methods like DB and Construction Manager at Risk (CMAR), indicating less predictability in project schedules and budgets (Sullivan et al. 2017). Additionally, they may experience challenges in achieving high-quality outcomes. These issues can be attributed to the separation of the design and construction phases, limited collaboration between teams, and a higher risk allocation to the owner, making DBB less conducive to early contractor involvement and efficient problem-solving during project execution (Sullivan et al. 2017).

The study indicates that the DBB project delivery method tends to experience more change orders (Minchin et al. 2013). These change orders can result from design issues, modifications, or other factors, leading to increased project costs and potential delays.

2.2.2 DB

Design-Build (DB) is a project delivery method that merges the design and construction phases into a unified process, with a single entity responsible for both aspects of the project. This approach offers several advantages, making it a preferred choice for complex projects with uncertain scopes (Gransberg et al. 2022). These benefits include expedited project delivery, cost predictability, enhanced collaboration between the contractor and designer, a single point of responsibility, early involvement of contractors and designers, simplified administrative management for owners, and reduced claims and disputes.

In contrast, the traditional DBB method gives owners more control over the design phase until project completion. DBB, known for its competitive and cost-focused approach, is often favored for smaller and simpler projects funded by public entities (Gransberg et al. 2022). It ensures transparency in contractor selection and is particularly suitable when comprehensive design costs remain relatively low.

The Clinger-Cohen Act of 1996 marked a turning point in adopting DB as a procurement method and legalizing its use at the federal level (Gransberg et al. 2022). Subsequent studies have consistently demonstrated the superior performance of DB compared to other project delivery methods (Park and Kwak 2017). As project complexity increases, DB gains a strategic advantage, although the owner's willingness to delegate project execution authority also influences the choice of delivery method.

Sullivan et al. (2017) synthesized extensive research encompassing over 4,500 projects and concluded that DB consistently outperforms DBB regarding cost control, schedule adherence, and delivery speed. Notably, DB exhibits lower rates and costs of changes, especially in the controllable category, owing to the contractor's design responsibility.

DB's superiority extends to military construction projects, where it has been shown to reduce change orders (Rosner 2008). Hale et al.'s analysis of military quarters construction projects revealed that DB projects outperform DBB counterparts in terms of time and cost (Hale et al. 2009). This trend is further supported by research on Air Force DB projects, indicating consistent planning accuracy and adaptability in implementing DB across various locations and facility types (Kramer 2017).

Despite extensive research on DB, there is a growing need to explore beyond the common topics and delve into aspects involving subcontractors and their evolving role in the project delivery process (Brown 2009). As DB continues to gain prominence, its impact on project performance metrics and the relationships between prime contractors and owners remains well-documented and understood. However, future research should address emerging areas of interest to ensure that the benefits of DB are maximized across the construction industry.

However, after the contract award, the owner loses design control under traditional DB. In DBB, the owner retains full control until completion. DBB allows full and open competition, ensuring the lowest price and transparent selection. DBB’s low-price approach minimizes impropriety allegations when public entities fund projects with taxpayer dollars (Gransberg et al. 2022).

2.2.3 CM at Risk

Construction Manager-at-Risk (CMAR) is a project delivery method that combines early contractor involvement with owner control. It consists of two phases: preconstruction and construction. During preconstruction, CMAR aids in design, cost estimation, scheduling, and constructability reviews, promoting collaboration among the owner, designer, and construction manager (Gransberg et al. 2022).The CMAR evolves from the role of a consultant to the owner during the predesign and design phases to the legal equivalent of a general contractor during the construction phase, especially when they commit to delivering the project within a fixed price or a Guaranteed Maximum Price (GMP) (Migliaccio and Holm 2018).

CMAR mitigates risks related to design errors and delays. One frequently highlighted benefit of CMAR is the capacity to impact design choices early in the process through contractors' preconstruction services (Gransberg and Gransberg 2020). The GMP negotiation ensures cost certainty and reduces the chances of budget overruns. CMAR's open-book approach enhances transparency, allowing owners to participate in subcontractor selection, leading to better project outcomes and shorter timelines(Gransberg et al. 2022).

Construction Manager-at-Risk (CMAR) project delivery has its disadvantages to consider. First, it can lead to increased project costs due to changes during the design phase and higher fees associated with CMAR selection. CMAR processes are also more complex, demanding additional administrative efforts and coordination. (Gransberg et al. 2010). Research indicates that very few comprehensive studies have been conducted to assess CMAR performance

quantitatively. This lack of conclusive data suggests that it may be challenging to make definitive claims about the effectiveness of CMAR compared to other methods (Sullivan et al. 2017).

2.2.4 IPD

Integrated Project Delivery (IPD) is a collaborative project delivery method that aims to foster a highly cooperative and integrated approach to construction projects. In IPD, all major project stakeholders, including the owner, architect, contractor, and often key subcontractors, work together as a unified team from the earliest stages to completion. This approach encourages open communication, shared risk and reward, and joint decision-making, leading to a more efficient and effective project delivery process(Gransberg et al. 2022).

IPD's advantages include improved project outcomes in terms of cost, schedule, and quality due to the early involvement of all key participants, enhanced collaboration, and shared incentives. It also promotes a no-blame culture, reducing disputes and change orders. IPD can lead to innovative solutions, cost savings, and a more streamlined project(Gransberg et al. 2022).

However, IPD has some challenges, such as the complexity of creating multiparty contracts and the need for a significant cultural shift within the construction industry. It may not be suitable for all projects or organizations and requires high participant trust and commitment. Additionally, the legal and insurance aspects of IPD contracts can be complex and may require specialized expertise (Gransberg et al. 2022).

2.2.5 PPP

Public-Private Partnership (PPP) is an integrated project delivery approach where a government or public entity collaborates with the private sector to develop, finance, and operate public infrastructure or provide services. PPP offers several key advantages, making it suitable for complex and resource-intensive projects (Gransberg et al. 2022).

PPP projects offer efficiency and speed, often ensuring timely completion and cost certainty. They foster collaboration between the public and private sectors, optimizing designs and operations. The single point of responsibility streamlines decision-making. Early private sector involvement enhances outcomes, contributing expertise from project planning and simplifying administrative management. However, managing complex PPP contracts and the potential for higher costs are concerns that require vigilant oversight (Gransberg et al. 2022).

While Public-Private Partnerships (PPPs) offer various advantages, they also have potential drawbacks. One notable concern is the complexity of negotiating and managing PPP contracts. These contracts can be intricate, requiring comprehensive legal and financial expertise to protect public interests. Furthermore, the long-term nature of many PPP agreements, often spanning decades, introduces the challenge of adapting to changing circumstances, such as technological shifts or public needs. Additionally, the private sector's profit motive may lead to higher costs for services compared to traditional public delivery models, potentially impacting affordability for the public(Jayasuriya et al. 2019). Therefore, carefully considering the specific project and diligent oversight are essential to mitigate these disadvantages and ensure the success of PPP initiatives.

2.2.6 IDIQ

Indefinite Delivery/Indefinite Quantity (IDIQ) contracting represents a versatile project delivery method that accommodates a broad spectrum of services, from planning and design to construction and maintenance. In the IDIQ contract model, an owner establishes an agreement with one or more contractors, often spanning an extended duration, to furnish services as the need arises. This approach proves highly advantageous, particularly when the scope of work exhibits repetitive patterns or may undergo changes over time, granting the owner the ability to issue individual work orders based on evolving project requirements (Gransberg et al. 2022).

IDIQ contracts offer numerous benefits, both in the public and private sectors. Federally, they are a pivotal tool, facilitating the efficient procurement of services across various agencies and departments. Federal agencies employ IDIQ contracts extensively to ensure rapid access to resources, whether it involves infrastructure projects, emergency responses, or other specialized needs. These contracts enable cost-effective project management, encourage competition among contractors, and often result in substantial cost savings for the federal government (Gransberg et al. 2022)

Nonetheless, IDIQ contracts come with their set of challenges. The competitive nature of selecting contractors for specific work orders can sometimes lead to the necessity of negotiating unit prices for distinct tasks or potential disagreements over project scopes. Additionally, the federal government must navigate legal considerations, including bid protests and ensuring fair evaluations of proposals, making the procurement process more complex (Stanford 2017).

2.3 Subcontracting

Subcontractors play a vital role in the construction industry. Subcontracting allows general contractors to focus on their core competencies and outsource specialized tasks to experts. Due to the increased complexity of construction requirements, subcontracting is becoming essential in most projects. The success of construction projects relies heavily on the effective management between main contractors and subcontractors (Tan et al. 2017). It is not uncommon for 80%-90% of work done on a project to be performed by subcontractors (Hinze and Tracey 1994). However, this can depend on the region of the country where work is being done and the nature of the work. Firms with a focus on design activities and technical management subcontract more of the implementation activities, allowing them to work as a general contractor in the activities they excel in while subcontracting the rest(González-Díaz et al. 2000). Understanding the prevalence of subcontracting in the construction industry leads us to examine the underlying reasons for its widespread adoption.

2.3.1 Reasons for subcontracting

Subcontractors embody a realm of specialized expertise that is crucial for executing complex projects economically and proficiently. Subcontracting can ensure that individuals lead each segment with the optimal skill set, which is particularly important given the rarity of multi-skilled workers across varying trades(Yik and Lai 2008). This strategy elevates work quality and drives economic efficiency, embodying a practical and smart approach to project management (Ling 2004). when a general contractor is good at managing and controlling subcontractors, they

tend to give out more work to subcontractors and use a wider variety of them in their projects (Tang et al. 2023).

Subcontracting is a significant aspect of managing capacity in construction, allowing for a dynamic approach to handle workloads. The prevalent utilization of subcontractors can be predominantly ascribed to the cost-benefit of identifying and bargaining for prices concerning the specific elements of a construction project. This expense typically proves to be significantly lower than the costs linked to the planning and direct supervision of workers' performance at a construction site (Chau and Walker 1994). By subcontracting, firms can swiftly adjust to project demands without significant investments in permanent resources or infrastructure(Lidelöw and Simu 2015). Subcontracting offers the benefit of delegating portions of the project to subcontractors, easing the organizational burden on the main contractor (Yik et al. 2006).

General contractors are very sensitive to liability exposure problems that could arise from various sources, such as construction defects, accidents on site, or delays in project timelines. Subcontracting emerges as a strategic approach in such scenarios, attempting to transfer a portion of this inherent risk to subcontractors who then assume responsibility for their designated tasks, thereby potentially mitigating the liability burden on the general contractors and providing a level of insulation against the unpredictable and often financially draining repercussions that might ensue (Costantino and Pietroforte 2002).

Maintaining relationships with contractors is also important. One study identified four contractor-subcontractor relationship types: adversarial (focused on self-interest), cooperative

(balancing cooperation and competition), collaborative (sharing knowledge and resources), and partnering (long-term, trust-based collaboration for mutual benefit) (Tan et al. 2017). General contractors known for their fairness and attentiveness to subcontractors' requirements often attract high-quality subcontractors and more competitive pricing from them (Proctor 1996). The success and benefits derived from subcontracting are significantly influenced by the nature and structure of the subcontracting contracts in place.

2.3.2 Subcontracting Contracts

Since the subcontract represents a legally binding agreement encompassing all pertinent project specifications, ensuring its precision and comprehensiveness guarantees the project's success (Proctor 1996). These agreements are tailored to encompass the scope of work, payment terms, quality standards, and other critical aspects that govern the subcontractor-prime contractor relationship. Additionally, they provide a mechanism for addressing disputes, ensuring quality, and meeting project timelines. The contractual agreements, while tailored to the specifics of each project, provide a structured framework that underpins the subcontracting process, ensuring that the deliverables are met as per the stipulated standards and timelines.

Construction firms rely on a manual process that carefully reviews contract documents to extract the subcontractor's scope. When crafting a back-to-back subcontract, the contracting team thoroughly examines the contract to identify the exact terms, clauses, and sections that should be included. These pinpointed clauses and sections are cross-referenced within the subcontract document (Elmugtaba Ali Bannaga and Khaled Masadeh 2015). Consequently, subcontractors often encounter challenges navigating the entire primary contract to comprehend a few specific

requirements relevant to their scope. This frequently necessitates subcontractors to delve into the detailed sections of the primary contract to attain a comprehensive understanding of the terms referenced in the subcontract document, as outlined in the provided references (Hassan and Le 2021).

The success and benefits derived from subcontracting are significantly influenced by the nature and structure of the subcontracting contracts in place.

2.3.3 Subcontractor Selection

How much a construction firm subcontracts depends on both its business strategy and how it manages its operations, and the choice to subcontract is also influenced by how much control a firm wants over the construction process (Üsdiken et al. 1988). The fluctuation in subcontracting rationale can be attributed to factors such as the concurrent execution of multiple projects, variations in a project's complexity, and their influence in local markets(Tarziján and Brahm 2014).

The choice to subcontract or not, along with the selection of subcontractors, should consider cost-related and non-cost factors such as time and quality. These non-cost criteria are essential for the project's overall success in terms of its duration, cost-effectiveness, and the quality of the work performed (Biruk et al. 2017). Despite its numerous advantages, subcontracting is not without its challenges, some of which stem from inherent complexities in the construction process.

2.3.4 Subcontracting Challenges

While a subcontractor is ultimately necessary and advantageous, in construction, institutional gaps exist between the contracting parties, namely the general contractor and subcontractor. These gaps may either naturally occur or develop over time with little attention. However, they can fragment the construction team into isolated groups, each with a self-centered decision-making approach. Failure to address these institutional gaps, rather than the subcontracting practice itself, significantly hampers site productivity (Hsieh 1998).

General contractors take on an increased risk by subletting out more of the contractual work to subcontractors. Subcontractors that minimize the risks associated with subcontracting should be selected based on their timely completion of projects, relationship with the main stakeholders, profitability, cash flow, and willingness to adopt new technologies and methodologies (Thomas Ng et al. 2009). The processes of selecting and planning subcontracting often suffer from a lack of objective decision-making and dependable standards. This deficiency renders it challenging to foresee the overall performance and levels of risk entailed in executing a project during the initial planning stages(Arslan et al. 2008).

Delegation requires a system to measure and oversee the performance of subcontractors, swapping the costs of in-house production with those of managing subcontractor performance, both of which fall under the umbrella of transaction costs. The effectiveness of subcontracting is contingent on keeping these transaction costs low(Yik et al. 2006). The subcontracting chain is only as strong as its weakest link. A single hiccup in one subcontract, leading to a dispute, can trigger a domino effect of delays and cost claims, impacting the primary parties involved and

potentially extending to other stakeholders in the construction project, including the client. This ripple effect can make cost and time overruns an unfortunate yet unavoidable reality(Uher 1991). General contractors may struggle to coordinate various subcontractors and suppliers involved in a construction project. This can include scheduling conflicts, communication breakdowns, and logistical challenges (Akintan and Morledge 2013).

A study has shown that main contractors mainly maximize their profits in traditional construction procurement. They choose subcontractors solely based on the lowest price, neglecting considerations of best-value and exerting significant pricing pressure, often leaving subcontractors in a precarious financial position (Dainty et al. 2001). Subcontractors often face issues related to delayed payments from main contractors. This can lead to cash flow problems, impacting subcontractors' ability to meet financial obligations and invest in their businesses (Akintan and Morledge 2013). In the traditional construction procurement process, main contractors and subcontractors cannot collaborate on planning and developing the project once the project is completed. This lack of coordination can lead to inaccuracies and guesswork in estimating the duration of critical activities due to the absence of comprehensive information (Johansen and Porter 2021).

Bid shopping has become a point of contention between prime and sub-contractors. Keeping subcontractor costs in check presents a formidable challenge. General contractors perpetually grapple with the specter of unforeseen expenses that threaten to obliterate profit margins(Proctor 1996). Many subcontractors refuse to submit prices to general contractors with reputations as bid shoppers (Hinze and Tracey 1994). Subcontractors increasingly use aggressive tactics to pressure

generals into awarding them subcontracts, even if they are not the lowest bidder (Stockenberg 2001).

General contractors, however, are not the only ones to blame for poor relationships between general and subcontractors. One study found that "Most subcontractors deliberately submit their quotes 12 hours or less before general contractors make their bids to owners so that a proper evaluation is difficult or impossible (Shash 1998)." Main contractors often express concerns about subcontractors occasionally bringing insufficiently skilled workers to the construction site. This practice can disrupt project progress and contribute to conflicts (Johansen and Porter 2021). As general contractors strive to manage resource demands across multiple construction sites, subcontractors sometimes prioritize the contractor who makes the most noise, figuratively speaking, regarding resource allocation for the day (Akintan and Morledge 2013).

As the project complexity increases, the administrative construction management task becomes increasingly difficult as project complexity increases. Weakened communication links between the client and subcontractors can occur on projects with multiple tiers of subcontractors. The realm of subcontracting is rife with communication breakdowns and misunderstandings, often leading to protracted disputes, project bottlenecks, and escalating expenses (Proctor 1996). This can make it difficult for the client to communicate directly with the firms performing the work, as the client may not know the identity of the lower-tier subcontractors (Choudhry et al. 2012). The greater the reliance of the general contractor on the technical expertise of a particular subcontractor, the more challenging it becomes to manage costs and the more imperative it becomes to depend on specific producers(Arslan et al. 2008).

In traditional procurement, where self-interest takes precedence, the prevailing dynamics typically result in a transactional rather than a collaborative relationship between the parties involved. However, it is worth noting that the construction industry is at its best when characterized by collaboration (Akintan and Morledge 2013). Adopting a relational approach becomes instrumental in achieving exceptional outcomes in building projects. This shift in mindset cultivates an environment where collaboration is encouraged and becomes an integral part of the process, ultimately leading to improved project performance and success (Franz et al. 2012).

While there are many known difficulties with subcontracting, increased usage of more collaborative PDMs, like DB, may provide opportunities for new solutions. Emerging subcontracting methodologies are intended to address friction between contractors and subcontractors and minimize problems caused by increased project complexity.

2.4 Emerging Methodologies

Subcontractors involved early in a project's design phase can contribute creative solutions, space considerations for construction processes, knowledge of fabrication and construction capabilities, and understanding of supplier lead times and reliability (Gil et al. 2001b).

One such method of early integration, design-assist, encourages project architects and engineers to work more closely with construction managers and subcontractors. This integrated approach can benefit the project by improving efficiency, reducing costs, and increasing quality. However,

it can also create risks for the participants, such as increased liability and potential disputes (Kelly 2014).

Case studies within Clevenger and Khan (2014) research on the impact of BIM technologies on building delivery exhibited unique, nontraditional subcontracting strategies. There are instances where lower-tier subcontractors have contractual relationships with multiple upper-tier parties. Osmanbhoy et al. (2015) surveyed 92 respondents in Washington to determine the frequencies, rationales, advantages, and disadvantages of emergent contractual schemes.

Their research identified five distinct subcontracting models, namely: (1) traditional subcontracting (TS); (2) traditional subcontracting with design-assist (DAS); (3) design-build subcontracting (DBS); (4) integrated design-construction subcontracting (IDCS); and (5) integrated specialty work subcontracting (ISWS).

Fernandez Angulo et al. (2019)expanded the scope of the research nationwide to gain a comprehensive understanding of subcontracting models. Their research culminated inMigliaccio et al.'s (2022) research.The study found that these models were mainly familiar to participants in the West Coast and mountain regions of the United States, with subtle variations being employed to varying degrees.

As these models play a large part of the research in this paper, they are defined as below.

2.4.1 Traditional Subcontracting (TS)

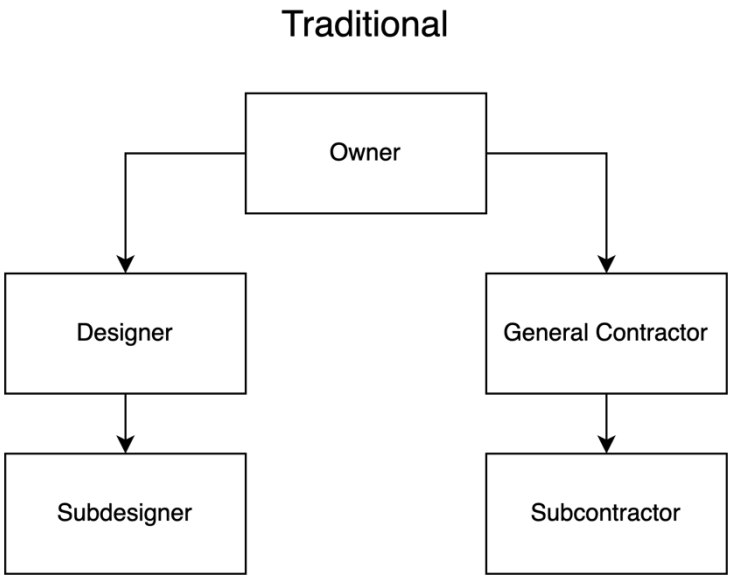


Figure 1 Traditional Subcontracting Method

The Traditional Subcontracting (TS) model operates fundamentally on the DBB strategy, a two-phase process separating general contractors' and design professionals' roles and collaborative efforts. Initially, architects or engineers are tasked with developing the project's drawings and specifications without the collaborative input of the contractor. The emphasis is on creating two linear phases, each with discrete objectives and segregated activities.

Following the completion of the design phase, the procurement process commences, wherein contractors aim to present the most competitive, often the lowest, bid to secure the project. This methodology inherently transfers notable risk to the prime contractor during the construction activities, notably due to pre-determined design specifications and resultant contractual obligations. Under this modality, subcontractors often operate within compartmentalized

conditions, wherein their primary point of contact and communication is the prime contractor, who subsequently liaises with the project owner or alternate parties in the construction phase.

Moreover, general contractors within the TS framework select specialty contractors via a competitive bidding process, which occurs once design specifications are established, fundamentally limiting opportunities for collaborative design input. Occasionally, owners might select specialty contractors in the early stages of a project; however, under the TS methodology, this early selection does not inherently translate to participative opportunities in the design stage(Gil et al. 2001). Consequently, general contractors manage the construction phase alongside these pre-selected “nominated contractors” without the opportunity to select them under a competitive bidding framework.

2.4.2 Traditional Subcontracting with Design-Assist (DAS)

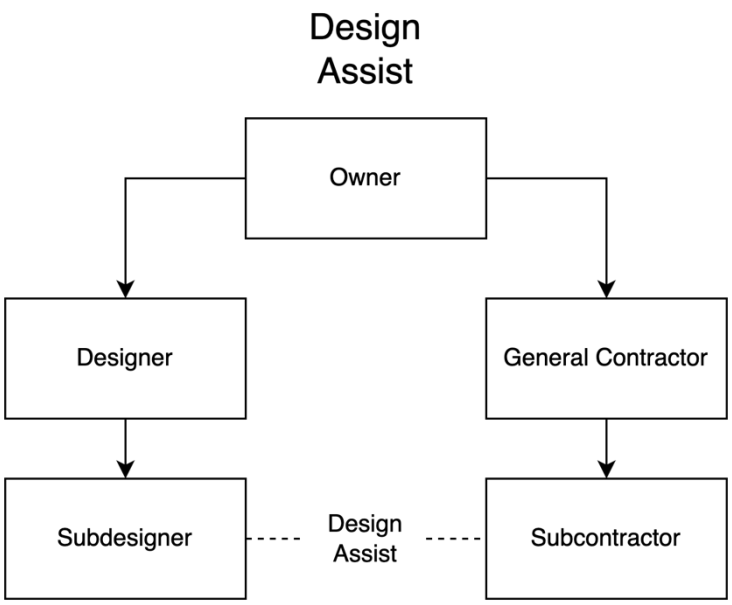


Figure 2 Design Assist Subcontracting Method

The DAS subcontracting model incorporates a nuanced collaboration strategy that distinguishes it from conventional Traditional Subcontracting (TS). Unlike TS, DAS facilitates a collaborative interface between designers and specialty contractors, creating a proactive environment that seeks to enhance design and constructability through early specialist involvement in design activities without directly transferring design liabilities to them. The key merit, highlighted by Kelly (2014), underscores improved specifications, drawings, and communication across projects, particularly where comprehensive, trade-specific specifications prove challenging for designers and general contractors.

However, it is essential to note the precarious balance of design liabilities within the DAS framework. This emerges from an absence of explicit contractual or legal stipulations detailing specialty contractors' responsibilities during design activities, potentially sparking future disputes

due to ambiguous demarcation of responsibilities and roles during DA development (Kelly 2014).

2.4.3 Design-Build Subcontracting (DBS)

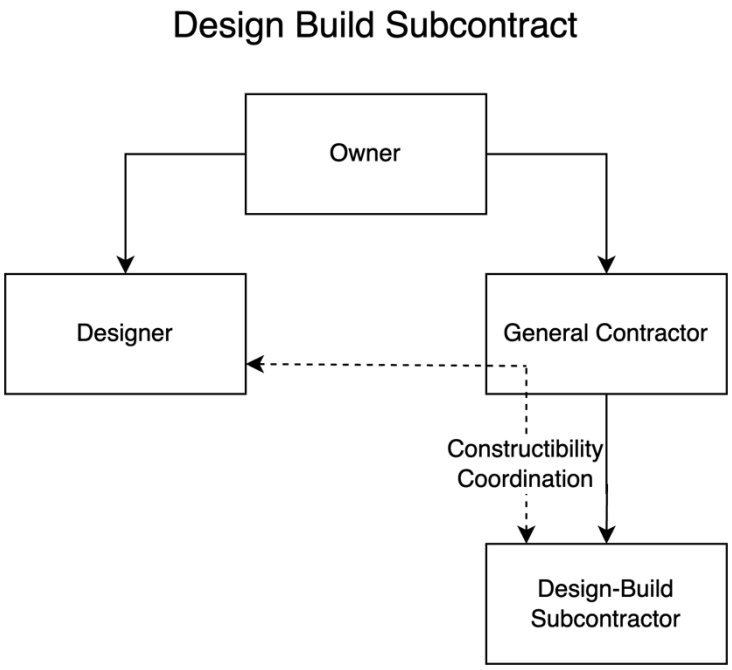


Figure 3 Design Build Subcontracting Method

This variant of the subcontracting model can manifest in multiple forms. For instance, the owner may appoint nominated contractors to the design-build entity, or various design-build frameworks may be established for each specialized trade. As underscored by Gil et al. (2001), an advantage of involving specialty contractors at an early stage is the effective minimization of the total project duration and a lowered probability of exceeding budgetary confines during the project. By leveraging the expertise of specialty contractors, the prefabrication process and the delivery of pivotal elements can be planned and executed efficiently, thus circumventing potential future delays and quality claims. Therefore, this methodology offers the construction

industry an option that is both multifaceted and ensures proficient project delivery (Fernandez Angulo et al. 2019).

2.4.4 Integrated Specialty Work Subcontracting (ISWS)

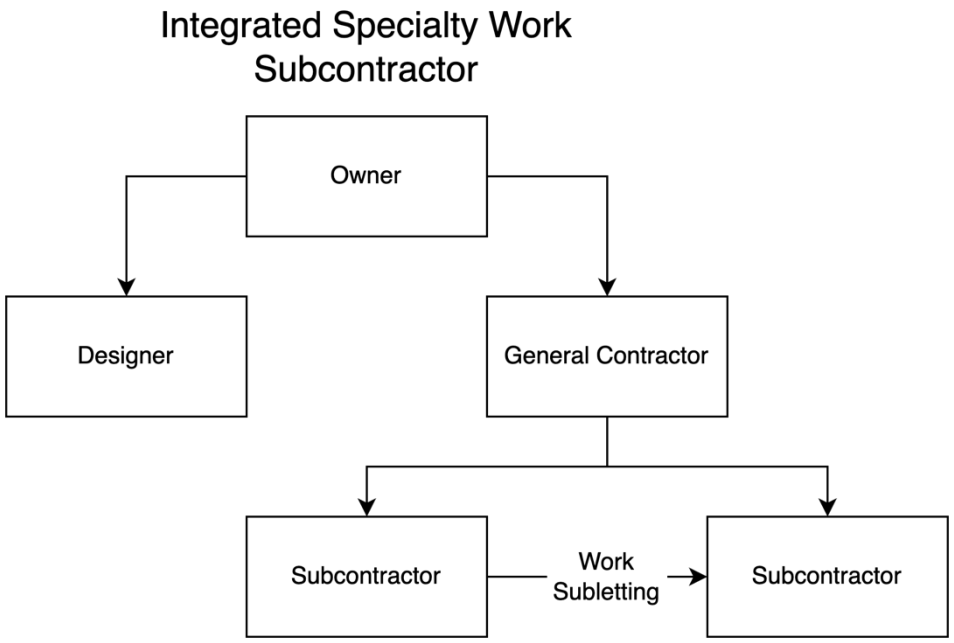


Figure 4 Integrated Specialty Work Subcontracting Method

ISWS involves specialty contractors who work autonomously but do not operate in isolation due to their interconnected activities on construction sites. A popular approach for this subcontracting model is the horizontal structure. This model relies on various collaborative practices and strategies. These models aim to ensure on-site tasks are scheduled effectively based on resource status and upcoming activities, while benefits derived from these models are distributed via either a uniform method or based on each subcontractor's contribution to the project (Fernandez Angulo et al. 2019)

2.4.5 Integrated Design Construction Subcontracting (IDCS)

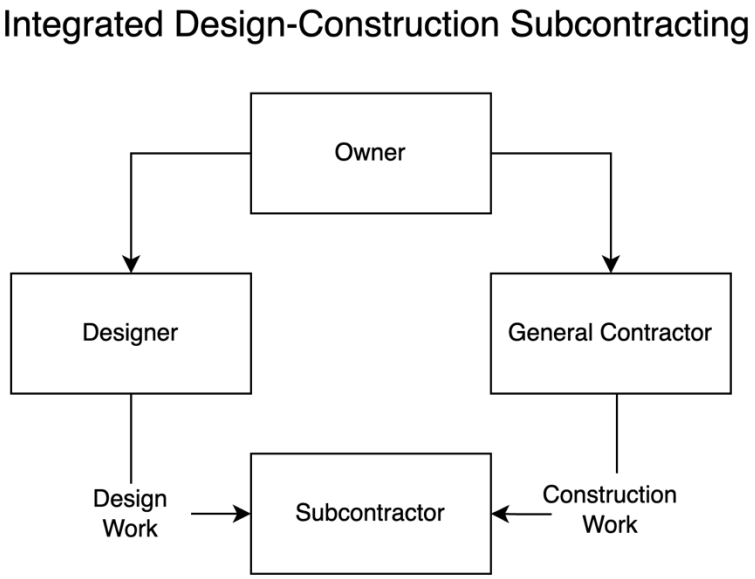


Figure 5 Integrated Design-Construction Subcontracting Method

Integrated Design Construction Subcontracting (IDCS) emerges as a methodology aiming to integrate specialty contractors in the early design phases of a construction project while granting them distinct rights and responsibilities. This is realized through a three-tier collaboration framework. The initial level does not incorporate collaboration within contractual clauses. Formal subcontractor participation in the design phase is implemented into team agreements. The third level introduces multi-party contracts, binding key stakeholders like designers, prime contractors, and specialty contractors, migrating from transactional engagements to more relationally driven ones.

In the IDCS model, subcontractors are not merely executors but also participants in various project facets such as costing, scheduling, designing reviews, and onsite activities coordination, with all stakeholders being recipients of the output of these activities.

2.5 Air Force Construction-Related Challenges

The previous sections of this chapter have delved extensively into various project delivery methods (PDMs). The following section introduces additional variables and considerations relevant to Air Force construction projects.

2.5.1 Project Development Process

Project programming and development within the context of USAF Civil Engineering involves a systematic approach to planning, classifying work, determining fund sources, selecting program avenues, and ultimately guiding the project through to completion. The following section encapsulates the procedures focusing on the framework that USAF civil engineers are to follow.

2.5.1.1 Planning

Project planning commences with the clear identification of mission requirements. Planners must evaluate needs versus constraints, aiming to fulfill the mission objectives with the minimum number of facilities while concurrently minimizing lifecycle costs. Strategic foresight is applied in this phase to forecast future requirements and incorporate them into present planning. The intent is to ensure that all projected needs align with resource efficiency and operational efficacy goals. (AFI 32-1020 2023)

2.5.1.2 Classifying Work

Classifying work involves a detailed analysis of the nature of the project. Projects are typically categorized by the type and scope of the work involved—whether it is new construction,

maintenance, repair, or an upgrade. Precise classification is critical as it dictates the regulatory pathway for approvals, the type of funding applicable, and the thresholds for various levels of authority required for progression (AFI 32-1020 2023).

2.5.1.3 Determining Fund Source

Fund sources are identified based on the classification of work. There are two primary types of funds: Appropriated Funds (APF) and Non-Appropriated Funds (NAF). APF are federal funds allocated by Congress, typically used for mission-centric projects, while NAF is generated by USAF service activities and used for community support and morale purposes. Determining the correct fund source is a financial imperative and is guided by regulatory compliance and the nature of the project (AFI 32-1020 2023).

2.5.1.4 Selecting the Program Avenue

Program avenues—Operation & Maintenance (O&M), Unspecified Minor Military Construction (UMMC), and Military Construction (MILCON)—are selected based on the scale and type of the project. O&M funds are generally used for routine maintenance and repairs, UMMC for minor construction projects within certain financial limits, and MILCON for major construction and complex projects. The selection of the program avenue is informed by funding ceilings, with specific caps dictating the appropriate path (AFIT 2019).

Specific thresholds are set to categorize the projects for routine Operation and maintenance (O&M) activities, which encompass the daily expenses required for the upkeep and function of USAF facilities. Sustainment Repair projects are allocated O&M funds if they are below $2

million. Restoration & Modernization (R&M) Repair projects tap into these funds if they are under $1 million, a threshold established in fiscal year 2020. Projects that exceed these cost limits must seek funding beyond O&M due to their complexity or scale (U.S. House of Representatives 2022).

Additionally, Unspecified Minor Military Construction (UMMC) projects, which involve smaller-scale construction efforts, have their fiscal limits. Historically, these limits have evolved: the ceiling was $750,000 before December 19, 2014; between December 19, 2014, and December 12, 2017, the limit increased to $1 million; and post-December 12, 2017, the ceiling has been set to $2 million adjusted by the Area Cost Factor (ACF). The ACF accounts for regional cost variations, thus ensuring that the UMMC funds are appropriately scaled to the economic conditions of the project's location. (AFI 32-1020 2023)

Military Construction (MILCON) funds are utilized for expansive and strategically significant construction endeavors. These projects surpass the financial boundaries of both O&M and UMMC and are characterized by their large scope and high costs, often extending over multiple fiscal years. The MILCON funding is heavily regulated and subject to Congressional approval, reflecting the significant investment and importance of such construction projects within the military's infrastructure. (AFI 32-1020 2023)

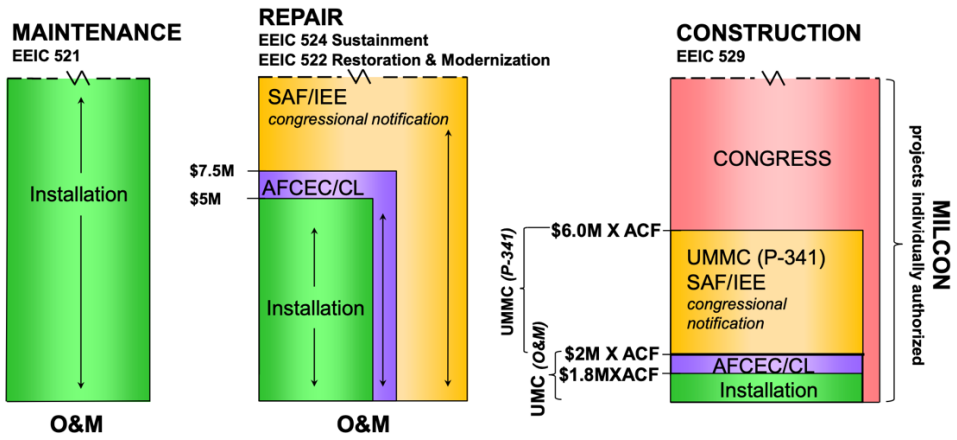


Figure 6 Program Avanue Thresholds (AFIT 2019)

2.5.1.5 Project Development

Project development is a multifaceted phase that includes designing the project, securing approvals, and acquiring resources. Proper documentation of approval authority is a pivotal part of this phase to ensure legal and regulatory compliance. The programmer acts as a guardian of the project through its execution, monitoring changes, and managing reapprovals if necessary. The statutory limit for Construction is a consideration that has evolved, impacting the scale of projects that can be undertaken without additional authorization.

2.5.2 Unique Risk Factors in USAF Construction Projects

Within the sphere of construction management, few landscapes are as intricate and demanding as that of the USAF construction projects. These projects, distinctly characterized by their critical role in national security, navigate a realm where every decision converges with broader strategic implications.

Predominantly, most USAF facilities are classified as critical infrastructure, implicating a paramount significance to national security and necessitating a construction approach cognizant of physical and cyber security considerations (Surajbally 2011). In addition, the Air Force is required to operate within tightly regulated and secure information technology networks. This inflicts constraints on utilizing software tools, such as Building Information Modeling (BIM), commonly employed in the construction industry to enhance collaborative design, planning, and management of buildings and infrastructure.

Regulatory considerations form another pivotal axis. The contracts governing construction projects are regulated by the Federal Acquisition Regulation (FAR), which establishes the principal regulations and procedures for government procurement, ensuring that the acquisition process is conducted effectively and with integrity. Particularly in USAF construction projects, a noteworthy aspect is that large-dollar contracts are often administered as fixed-price contracts. This is attributable to the stipulation that such contracts, especially those entailing significant financial outlays, necessitate congressional approval and oversight, introducing an added layer of complexity and scrutiny into the project. While providing cost certainty, the fixed-price nature of these contracts demands meticulous planning and risk mitigation strategies to address potential cost overruns or modifications, considering the substantial and critical investments involved (Surajbally 2011). This intertwining of financial, regulatory, and security considerations epitomizes the unique and multifaceted risk profile inherent to USAF construction projects.

The USAF predominantly relied on the DBB method for construction projects for decades. However, with increased scrutiny on military spending, the Air Force continually sought to

improve its processes. Implementing the Simplified Acquisition of Base Engineer Requirements (SABER) program in 1987 offered a streamlined alternative for base engineering projects.

SABER is the name for the Air Force's program that manages job order contracts. These contracts offer advantages such as quicker awarding, flexibility in acquiring various services, and the establishment of long-term contractor relationships. However, SABER contracts are most suitable for small and straightforward projects, as they involve a single contractor responsible for multiple services and limited sub-contracting. This may pose challenges in managing complex projects requiring specialized expertise (Sexton et al. 2020).

The federal government is restricted by regulations that prevent them from utilizing project delivery methods commonly employed in the private sector. According to Tabb (2020) " The opinions of the (Air Force construction) experts generally favored DB over CMAR, and CMAR over DBB." However, CMAR can only be used at the Air Force Civil Engineering Center and not at the local bases.

2.5.3 Air Force Subcontracting

Subcontracting within the Air Force operates under a complex regulatory framework primarily governed by the Federal Acquisition Regulation (FAR 2023) Part 44. This component of federal contracting regulations specifically addresses subcontracting requirements within the construction industry. This section outlines essential provisions and guidelines aimed at ensuring effective subcontracting practices.

When a contractor works on a project exceeding $1.5 million, FAR Part 44 mandates creating and submitting a subcontracting plan. This requirement is not just a routine procedure. It is an integral component ensuring that the ecosystem of small businesses, women-owned enterprises, veteran-led businesses, and others remain active contributors to the project's success. The formulation of each plan considers factors such as the project's scope, the available subcontractors within the sector, and the contractor's historical achievements in subcontracting.

Federal contracting officers play a pivotal role in evaluating the adequacy and compliance of subcontracting plans, considering factors such as the contractor's past performance, the complexity of the contract, and the extent of small business subcontracting opportunities. The responsibility for cascading subcontracting requirements to subcontractors rests with the prime contractor, necessitating the incorporation of FAR clauses into subcontracts and diligent monitoring of subcontractor compliance. Contracting officers can set subcontracting requirements, such as stipulating if a general contractor must choose the lowest bidder that is responsive and responsible.

Contractors must ensure their subcontracting plans are comprehensive and include specific goals and targets for subcontracting small businesses. FAR 52.219-9 further refines subcontracting practices by defining the parameters for a "similarly situated entity.”. It defines a "similarly situated entity" as a first-tier subcontractor or independent contractor with the same small business program status as the prime contractor. It is considered small under the assigned North American Industry Classification System (NAICS) code. It outlines financial limitations and specific scenarios for contract applications, such as small business contracts or HUBZone

considerations. The essence is to maintain a balanced approach, ensuring that smaller entities gain fair access to contract opportunities.

The Air Force's perspective on subcontracting is articulated through Air Force Instruction (AFI) 32-1023, which states that the contracting officer may authorize the contractor to subcontract for any portion of the work except as prohibited by law or regulation. The contracting officer shall ensure that all subcontractors are qualified and meet all applicable Air Force and federal requirements. These regulations would include those outlined in the FAR as described above.

During construction work, FAR Part 44 mandates thorough recordkeeping and reporting practices. Contractors must maintain meticulous records of subcontracting activities, including subcontract awards and performance. Furthermore, they must submit periodic reports to the government, providing comprehensive insights into their subcontracting achievements and efforts to fulfill the goals outlined in their subcontracting plans.

A pertinent question arises in earlier discussions on DB versus DBB contracts: How do these contractual forms shape subcontracting in the Air Force's construction undertakings? While current research offers insights into general subcontracting trends, the intricate relationship between DB, DBB, and Air Force subcontracting awaits further exploration.

2.6 Conclusion

Subcontracting methodologies in the construction sector are vast, varied, and well-documented, from Traditional Subcontracting (TS) to innovative practices like Integrated Design Construction

Subcontracting (IDCS). However, a noticeable void emerges in the literature when focusing on USAF construction projects.

While we understand the unique challenges and regulatory landscapes of Air Force construction, such as the Federal Acquisition Regulation (FAR) and the use of methods like DBB, detailed insights into subcontracting within this realm are sparse. The relationship between contract forms, like DB and DBB, and their influence on Air Force subcontracting remains underexplored.

Moreover, the distinct nature of USAF projects, which intertwine national security with construction, demands specialized subcontracting approaches. How these are navigated and implemented in a security-centric environment is largely uncharted.

In short, while general subcontracting in construction is beginning to be understood, its specific nuances, challenges, and practices within the USAF environment remain a significant knowledge gap, warranting further exploration.

3 Chapter 3 Research Methodology

3.1 Research Objective

This research builds upon previous research by Migliaccio et al. (2022)to explore subcontracting practices in Air Force construction projects. Recognizing that subcontracting can vary greatly depending on the region and context, this study aims to deepen our understanding of how main contracts influence these practices within the Air Force. Specifically, it examines five subcontracting models: Traditional Subcontracting (TS), Traditional Subcontracting with Design-Assist (DAS), Design-Build Subcontracting (DBS), Integrated Design Construction Subcontracting (IDCS), and Integrated Specialty Work Subcontracting (ISWS). The focus is on how these models are selected and implemented and how effective they are in the unique environment of Air Force construction projects. This approach aims to uncover potential changes in strategy or benefits associated with different subcontracting methods in this specific setting.

Utilizing the five established subcontracting models—TS, DAS, DBS, IDCS, and ISWS—as a guiding framework, the research analyzes how prime contracts impact the selection, implementation, and effectiveness of these methods in the specialized setting of Air Force constructions. Focusing on such a specific environment ensures a more granulated understanding, revealing nuances that might be overlooked in a broader context.

By emphasizing the role of prime contracts, the study endeavors to unravel potential shifts in strategy, limitations, or advantages inherent to different subcontracting methods when applied to Air Force construction projects. Moreover, informed by the findings of earlier studies, this research will further identify and spotlight specific areas within Air Force projects that might

exhibit innovative or progressive trends in subcontracting, serving as potential benchmarks or areas of interest for future investigations.

In essence, this study seeks not merely to bridge the existing gaps in knowledge but to significantly expand the understanding of how prime contracts intricately mold and steer subcontracting strategies, particularly in the nuanced environment of Air Force construction projects.

3.2 Research Process

The research process for this study is organized into seven phases, beginning with building on prior research to identify new data and assess the influence of main contracts on subcontracting. A comprehensive literature review follows, focusing on the nuances of Air Force construction projects. The study then identifies knowledge gaps that shape the research framework.

Next, an appropriate methodology is established, involving interviews with selected Air Force contractors to gather relevant insights. Data is collected through structured interviews, then qualitatively analyzed to identify key themes and trends. The final phase of the research synthesizes the findings, articulates the study's conclusions, and suggests avenues for future research, encapsulating the study's overall contributions to construction subcontracting practices.

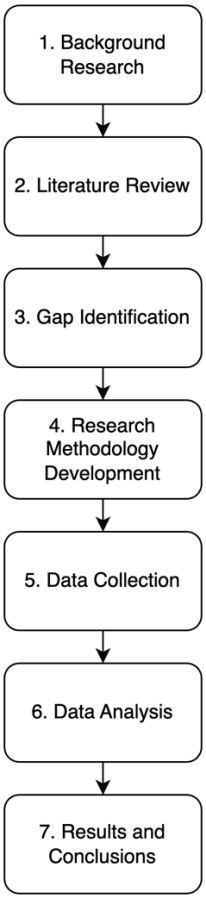


Figure 7 Research Process

3.2.1 Background Research

The research began with a thorough understanding of the various subcontracting models outlined byMigliaccio et al. (2022). The focus of this study was intentionally narrowed to explore the relationship between prime contracting and subcontracting within Air Force construction projects. This approach was selected to investigate how the main contracting methods might shape or affect the use of different subcontracting models in this setting.

3.2.2 Literature Review

A thorough literature review highlighted the extensive understanding of prime contracts, their relationship with the owner and general contractor, and the importance of comprehending subcontracting practices. Studies focused on Air Force construction projects were examined to illuminate the challenges of working within its specific framework. The review also detailed relevant Air Force construction regulations and contracting practices.

3.2.3 Gap Identification

The third research phase prioritized identifying gaps between the subcontracting practices examined by Fernandez Angulo, Osmanbhoy and Miggliaccio as well as those outlined in the literature review. Pinpointing these discrepancies informed the development of pertinent questions and hypotheses, shaping a research framework. This structure solidifies connections among current subcontracting practices, binding theories, and practical applications into a comprehensive exploration that would validate and potentially expand the existing body of knowledge in the field. Thus, systematically identifying and examining these gaps sought to weave a richer, more thorough understanding of subcontracting.

3.2.4 Research Methodology Development

In the fourth stage, the research methodology was crafted, beginning with discussions with known Air Force contractors to identify research constraints.

Criteria were set for participant selection to ensure quality data. Participants needed to be primarily general contractors with substantial subcontracting experience and recent Air Force

construction work. Contact information was requested from Air Force construction representatives from around the U.S. to find eligible participants, ensuring a diverse geographical representation.

Interviews were meticulously planned to collect in-depth information, emphasizing selecting participants who could offer valuable insights. While most interviews were one-on-one, some included multiple representatives from a single company to capture a broader perspective.

The discussions aimed to extract detailed knowledge about the participants' experience with subcontracting models and the effect of prime contracts on their decision-making within the Air Force context. The subcontracting models explored were traditional subcontracting, traditional subcontracting with design assistance, design-build subcontracting, integrated design construction subcontracting, and integrated specialty work subcontracting.

3.2.5 Data Collection

During the fifth phase, the research focused on conducting interviews. The study design did not link responses to individuals to ensure participant anonymity. Instead, they were categorized and analyzed based on their geographic locations and roles in contracting.

Interviews were conducted with an initial focus on understanding participants' professional backgrounds, using a structured yet flexible interview guide. The initial questions sought to understand each participant's experience and role in the construction industry, exploring their history with both design-build and design-bid-build project delivery methods, particularly on Air

Force construction projects. This foundational information outlined the context from which their subsequent insights into subcontracting practices would emerge.

As the interviews progressed, participants were asked about different subcontracting methods, how often they use them, and their advantages and drawbacks. They also shared any specific ways they have to adapt these methods for Air Force projects. Each question was designed to uncover detailed information and guide an in-depth discussion about subcontracting in the industry.

During the interviews, the guide was used flexibly, allowing participants to discuss topics and offer insights beyond the planned questions naturally. The guide was revised throughout the process to reflect the participants' feedback and the study's evolving focus. Interviews, typically lasting 45 minutes to an hour, were recorded with consent to ensure the information was captured accurately and to promote a detailed and engaging discussion.

3.2.6 Data Analysis

The sixth phase was data analysis. Template analysis was utilized during the data analysis phase to qualitatively understand themes and trends based on the interviewees' responses and experiences.

Template Analysis is a method used for thematically analyzing qualitative data, often in the form of interview transcripts, but can also include other textual forms like diary entries or questionnaires. The process involves creating a coding template, which organizes and

summarizes themes that the researcher finds significant in the data. This method features hierarchical coding, starting with broad themes and narrowing down to more specific ones.

The process used for this paper was modeled off of Nigel King's (2012) "Doing Template Analysis," and the general steps for this process were done as follows.

1. **Define A Priori Themes**: Priori themes like "frequency of use" and "impact on subcontracting" were utilized for a general start of analysis.
2. **Transcribe and Familiarize with Data**: All interviews were transcribed in preparation for coding.
3. **Initial Coding**: Transcripts were then read, and the priori codes were highlighted. Other codes that became apparent from the transcripts were also identified and marked on the initial subset of transcripts.
4. **Develop Initial Template**: Higher-order codes representing broader themes were identified after coding a subset of the transcripts.
5. **Refine Template with Full Data Set**: The initial template was applied to the entire data set. The template was modified when some text did not fit existing themes.
6. **Finalize and Interpret Using Template**: The final template was developed with the major themes identified and their corresponding codes. The final template was used for presenting the data in the data analysis section of this paper.
7. **Quality and Reflexivity Checks**: Throughout the coding process, quality and reflexivity checks were done to ensure the analysis was not biased by any preconceptions.

3.2.7 Results and Conclusions

The seventh and final phase encompassed the presentation of findings and conclusions. In this critical phase, the results gleaned from the research were meticulously detailed, elucidated, and expanded upon. This stage culminated all previous phases, synthesizing the collected data into coherent and comprehensive insights. The conclusions drawn provided a clear understanding of the research's implications, the significance of the findings, and potential recommendations or future directions. This concluding phase summarized the research and offered an evaluative perspective on the entire study's outcomes and implications.

4 Chapter 4 Data Analysis

This dataset results from the research methodology outlined in the previous chapter. A total of 20 participants were surveyed, each representing a distinct company. The ensuing sections delve into interview highlights and provide an overview of the general demographics of the interviewees.

4.1 Interviewee information

4.1.1 Overview

The dataset provides an overview of the participants' backgrounds for the study. To add context to their responses, they were questioned about their experience in the construction industry, including how long they have worked in this field, their current job title and the duration they've held this role, and the size of the largest contract they've been involved with in the past three years. To gain insight into the companies they represent, participants were also asked about their firm's average annual revenue. Furthermore, to understand their experience with the Air Force, they were inquired about their use of the DB and DBB methods, as well as the Air Force bases where they have worked.

Regarding the interviewees, overall, they have a significant amount of experience in the construction sector, typically between 25 to 30 years. This points to a group of seasoned professionals. Their job titles range from high-level positions like 'President/Vice President' to more direct roles such as 'Project Manager.' This diversity shows they come from various levels of authority and involvement in projects.

When it comes to projects, the participants have worked on contracts of varying sizes. Although many of the projects are of a modest financial scale, some participants have also tackled larger and more intricate projects. This variety reflects their broad range of skills in handling construction contracts. The participants' companies also differ in size, from smaller businesses with lower yearly earnings to larger firms with substantial revenues.

Regarding their methods, the participants generally favor the 'Design Build' approach over the 'Design Bid Build' strategy. According to figure 8, they have worked in numerous locations across the country, indicating that the study captures a wide array of experiences and perspectives from different geographical areas.

The following table is a summation of the interviewee's background information overview.

Aspect	Information
Experience	The majority have 25-30 years in the industry. Fewer have 10-15 years and 35-45 years.
Job Titles	Most are 'President/Vice President' and 'Project Management,' with fewer specialized roles.
Time in Current Position	Common tenures at 1-5 years and 10-15 years, fewer over 20 years.
Size of Recent Contracts	Most contracts are modest in value, with some significantly larger.
Company Revenue	Most companies have lower to mid-range annual revenues, with some achieving higher figures.
Prime Contracting Methods	Preference for 'Design Build' over 'Design Bid Build.'
Location Data	Firms have completed projects at various Air Force base locations.

Table 1 Background Data Overview

4.1.2 Experience

Graph 1 Years Worked in the Construction Industry

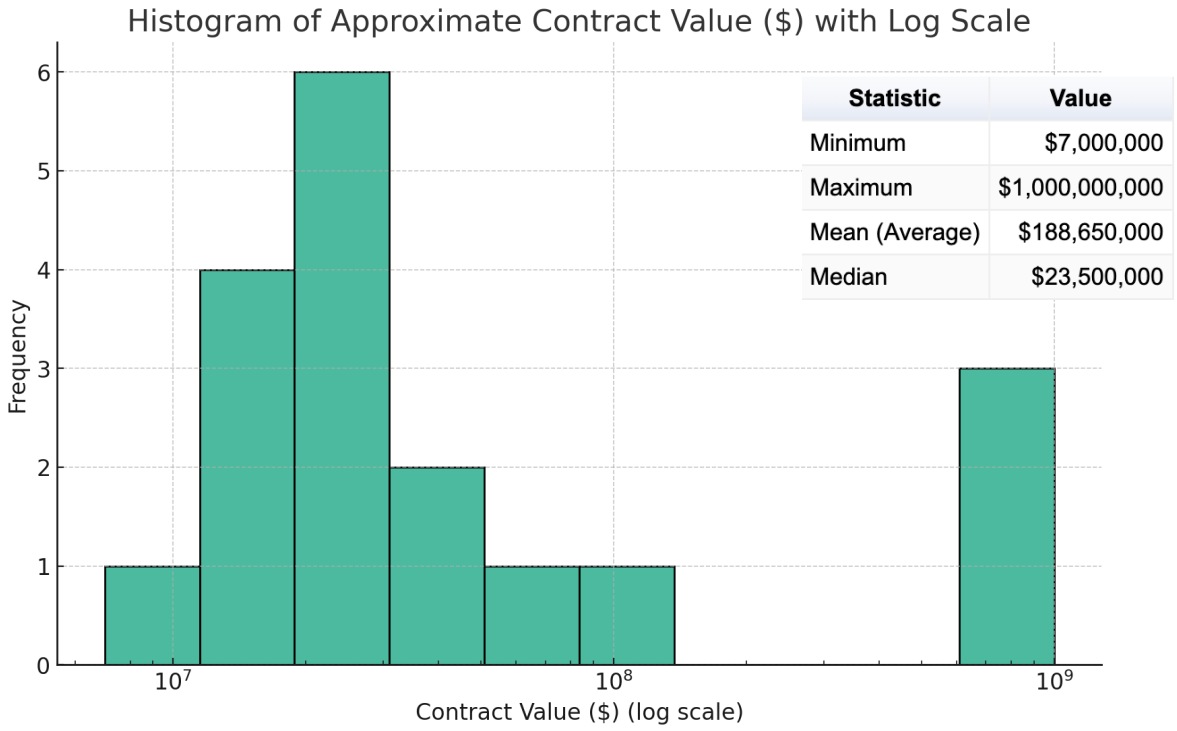
Construction industry experience gives the most credibility to the answers of the interviewees. The most common tenure among the individuals surveyed falls between 25 and 30 years, indicating a workforce with substantial experience. There is a notable decrease in the number of individuals with fewer years (10 to 15 years) and those with more years (35 to 45 years) in the industry. The data's unimodal nature, with a single prominent peak in the 25- to 30-year range, suggests that most of the workforce has spent a significant portion of their career in construction, with relatively fewer individuals in the early or late stages of their professional journey.

4.1.3 Time in current position

Graph 2 Time in current Position

Time in current position gives insight into the perspective the interviewee responded to questions from. Modest peaks around 0-5 years and 10-15 years indicate common tenure lengths. The distribution also shows a smaller number of individuals with very long tenures (over 20 years), which may reflect a natural career progression or changes in position over time. The majority of interviewees still had room to progress in their career path.

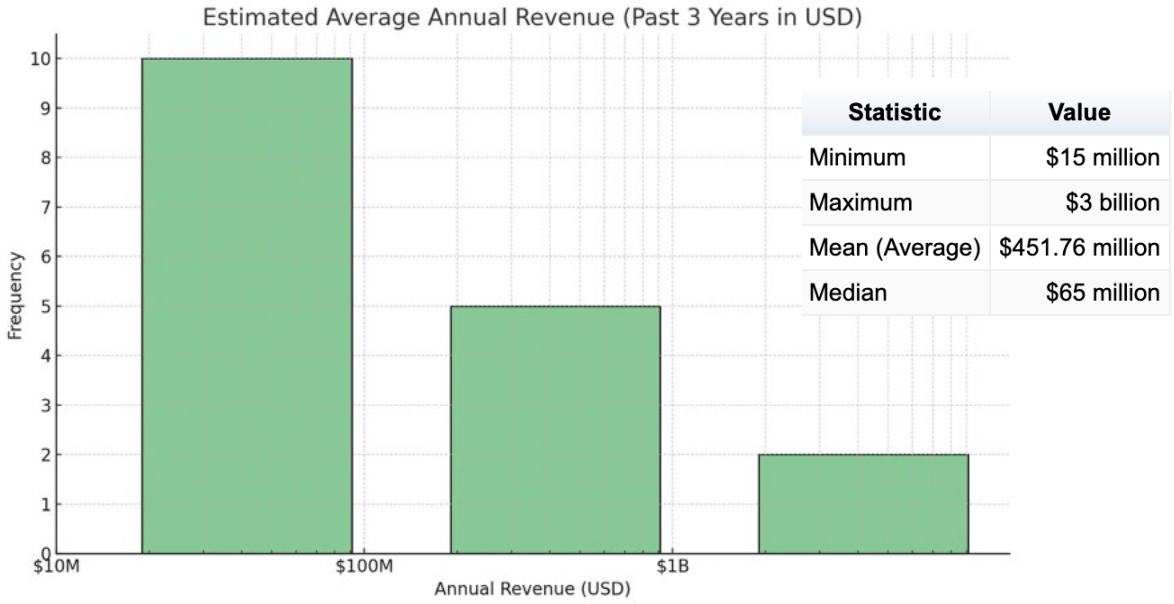
4.1.4 Size of Recent Contracts



Graph 3 Size of Recent Contracts

The value of the recent contracts worked shows the experience the interviewee has with larger, more complex projects. The concentration of data at the lower end indicates that most interviewees have their largest projects in the modest financial range. However, the presence of data points across the entire spectrum, including the higher end, reveals that a subset of interviewees has been involved in significantly larger projects. This distribution implies a mix of experience and capability among the interviewees, ranging from handling smaller, possibly more frequent projects to managing larger, potentially more complex, and lucrative contracts. The broad range of project values reflects varied expertise and scope of work within the construction industry represented by the interviewees.

4.1.5 Company size



Statistic	Value
Minimum	$15 million
Maximum	$3 billion
Mean (Average)	$451.76 million
Median	$65 million

Graph 4 Estimated Average Annual Revenue

According to the interviewee's responses, most companies have their annual revenues between $10-$100 million range. However, there are also companies with significantly higher revenues, as shown by the presence of data points extending even above $1 billion. This spread suggests a majority of smaller companies that rely on subcontractors instead of their own companies work force.

The distribution underscores the varied economic scales within which these companies operate, reflecting a range of company sizes and market capacities. The presence of companies with high annual revenues indicates the involvement of some large-scale players in the industry. In contrast, the prevalence of lower revenue figures suggests a significant number of small to medium-sized enterprises.

4.1.6 Prime contracting preference

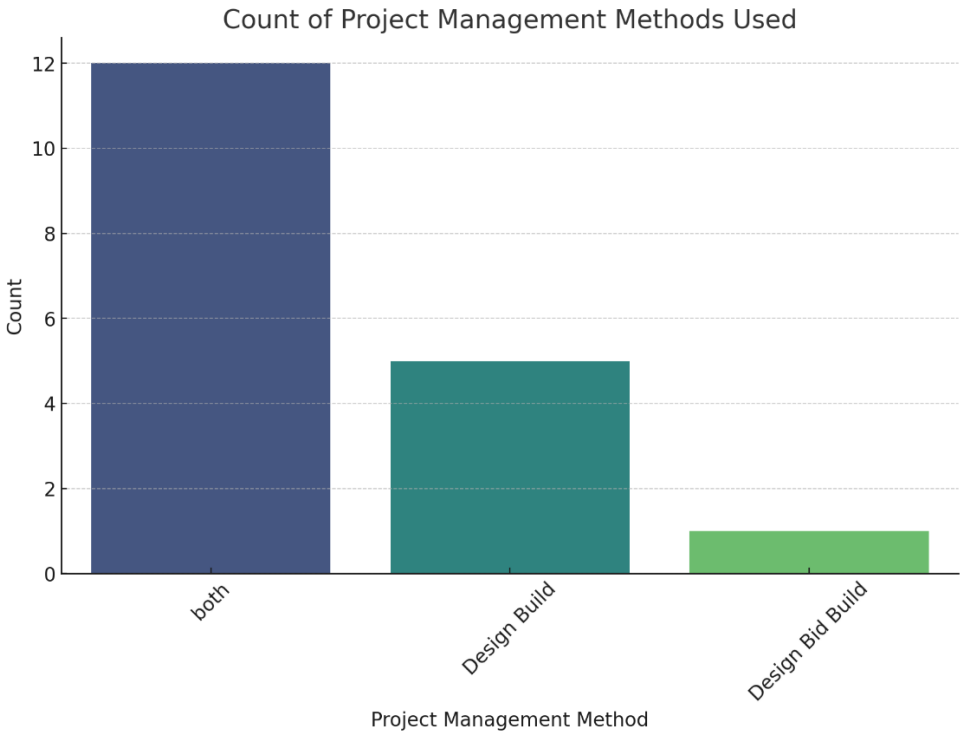


Figure 8 Project Management Method Used

The provided data shows the distribution of project management methods among construction companies through percentages. Over have of those interviewed operate both within DBB and DB. Some only use DB and only one interviewee had exclusively worked with DBB. Interviewees having experience in both methods of construction allowed for direct comparison between their effects on subcontracting.

4.1.7 Job Title

Title	Count
President/Vice President	9

Construction Technology Manager	1
Project Management	7
Pre-Construction Manager	1
Owner	1
Strategic Business Director	1

The dataset reveals a diverse range of job titles representing different levels and functions within the construction industry. Notably, there is a significant presence of senior leadership roles such as "Vice President," "President," and "Owner," indicating the involvement of decision-makers from the participating firms. On the project execution side, roles like "Project Manager" are prominent, emphasizing day-to-day project management. Additionally, strategic roles like "Strategic Business Director" and specialized positions like "Construction Technology Manager" and "Pre-Construction Manager" are also present. This distribution suggests a broad spectrum of expertise and responsibilities among the participants, offering a holistic view of the industry's structure and operation.

4.1.8 Location Data

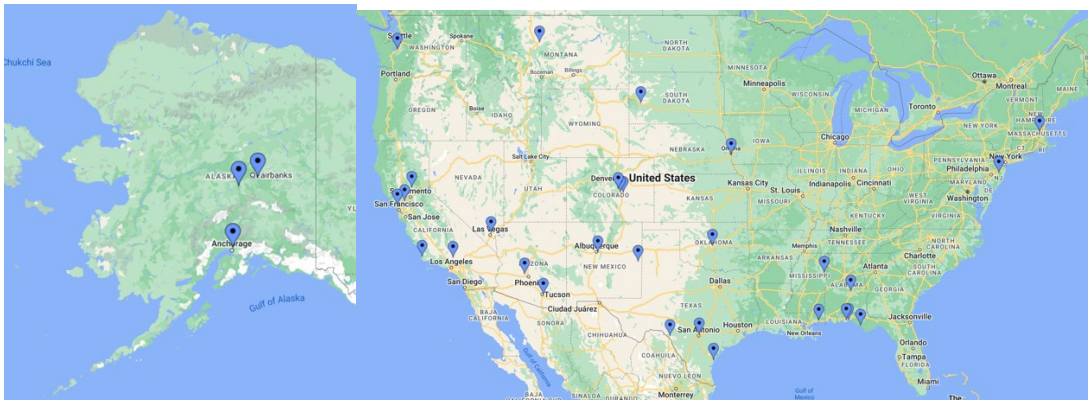


Figure 9 Air Force Base Construction Experience

The image represents the various Air Force Bases where each interviewee has gained experience. Notably, every interviewee has a history of working across multiple AFB sites. The accompanying image offers a visual representation of these widespread locations, underscoring the diverse project involvement and the construction firms' comprehensive portfolio of completed assignments within the Air Force. The variety of experience allowed for data to be representative as trends within Air Force construction and not tied to geographical locations.

4.2 Thematic Analysis of Interviews

The following are the trends found while analyzing the interviews for themes related to the impact of DBB and DB on subcontracting methods. As a clarification, the following discussions regarding the selection of subcontractors focused on those with specialized expertise in critical fields. This includes but is not limited to, areas such as mechanical, electrical, and structural work.

4.2.1 Subcontractor Qualifications and Selection

General contractors overwhelmingly expressed a desire to prioritize the qualitative attributes of subcontractors, focusing on their specific expertise, familiarity with the location, and experience with DB. Cost, however, can influence subcontractor selection. DBB is one main driver that can affect GCs in selecting subcontractors based on cost, but that isn't always the case.

Interviews revealed an overwhelming preference for the particular skills a subcontractor brings to a project. An Interviewee encapsulated this sentiment by saying, "Most of our sub-contracting is going to be based on whether they possess a technical expertise that our company lacks." For general contractors, the main objective is to harness specialized knowledge that their firm doesn't have.

In DB projects, there's a focus on the qualitative contributions from subcontractors. Their insights are highly valued, leading to a widespread preference for Design-Assist subcontracting. An interviewee encapsulates this approach, stating, "Yeah, that's probably the most popular model we use right there… We feel like it's huge. Rather than have the designer come up with his

way. We'd like to have our subcontractors' input to ensure that costs and schedules stay controlled. One subcontractor knows what available parts are, and they know the most economical way to complete a task. At the end of the day we do like to have our subcontractors involved from day one."

Another constant factor, irrespective of the procurement approach, is the inclination to engage subcontractors who deeply understands the project's location. Large firms frequently operate across various Air Force bases in different states, while even smaller entities engage with numerous installations within a particular region. Familiarity is key, as one quote highlights: "At all the different bases, you end up with a group of subcontractors that know that base. So, it ends up being very base-specific, which subcontractors we can be successful with."

Such local insight is particularly evident when general contractors operate under an IDCS framework. An interviewee with experience in IDCS arrangements observed, "The advantage is that these subcontractors are generally well-versed in federal projects, especially on their assigned site. They understand the system, the contracting office, and the structure itself. They know precisely how things are supposed to function."

A third predominant selection qualification is the subcontractors' experience with DB projects. Having subcontractors with DB experience on a DB project seems like a natural expectation. The strong consensus among all respondents is that this experience is crucial. Subcontractors with a background in DB typically possess a more comprehensive skill set. One respondent emphasized, "Generally if we're going to bring subs into a design-build, we want subs who have

been on a design-build and involved in that design process because then they are much better when they can bring more to the table."

On the other hand, subcontractors without DB experience can be a drag on project progress. Another observed, "Having a subcontractor team that's done design builds before is crucial because otherwise you're having to hold their hand a lot, and they're going to have even more questions than normal." It's generally acknowledged that the capabilities of DB-experienced subcontractors justify a higher cost, given their ability to enhance the project's value through practical engineering solutions.

The presence of DB-experienced subcontractors in a region can significantly affect their selection by a GC. Most DB contractors prefer to work with familiar subcontractors with whom they've had past successes. This familiarity helps overcome typical communication barriers, leading to a symbiotic relationship where subcontractors become a reliable part of the construction process. One GC explained this preference: "I have good subs, I know I'm going to hire them to do the build, and I have longtime designers who my subs know. I just call them up, and I'm like, hey, we will have a design meeting on this. Why don't we save all of ourselves a load of headaches. Why don't you just come into our first design charrette, and let's pick your brain."

In the context of DB projects, the question arises whether a subcontractor's technical expertise or experience with DB is more crucial. The feedback from interviewees suggests that possessing technical expertise is fundamental to being considered an experienced DB subcontractor. One contractor emphasized the need for a subcontractor who can intuitively understand and work

beyond explicit instructions, stating, "DB projects need a subcontractor to read between the lines. The subcontractor has to be of high quality." Another pointed out the preference for subcontractors who are experienced in DB projects and added significant value to the project: "Going into a design-build, we generally like to bring our 'A' game for our team. Generally, if we're going to bring subs into a design-build, we want subs who have been on a design-build and involved in that design process because then they can bring more to the table." Since general contractors typically seek subcontractors who can fill the gaps in their expertise, the prevailing view indicates that DB subcontractors deemed suitable for hiring inherently possess expertise that the general contractor is missing.

In DBB projects, the focus is on the qualitative attributes of a subcontractor towards cost considerations. Most GCs acknowledge that while price is not the sole deciding factor in subcontractor selection for DBB projects, it does gain increased emphasis. As one interviewee put it, “In a Design Bid Build environment, you're almost incentivized to pick a low cost. Not that that's going to be your sole selection criteria. But if you're all basing your numbers off of a known set of documents, a known set of scope, you're sort of incentivized by default to choose that way.” Even Contractors with a strong preference for the DB framework expressed that when working on DBB projects, “We usually go for a low bid. We like to use the same trades. Mechanical, electrical, plumbing, but other than those, we look at their price.”

One factor that influences general contractors tend to focus on the price of subcontractors over other factors is the general lack of Design-Assist Subcontracting when working within the DBB framework for the Air Force. In the DBB model, the general contractor’s involvement starts only

when project documents are fully complete, leaving no opportunity for the GC and their subs to participate in constructability reviews. Nineteen out of twenty interviewees had no experience with Design-Assist Subcontracting when they were working with DBB and the ones who had experienced it early in their careers.

4.2.2 Project Management and Execution:

In managing construction projects, the way a project is carried out greatly affects its success. The majority of interviewees have criticized the DBB method for producing poor-quality designs. These poor designs led to complex project management decisions that led to project management and execution problems further into the future of the project.

Design Assist Subcontracting (DAS) was indicated as having the highest impact on minimizing the impact of design quality on the project. As indicated in section 4.2.1, Design Assist subcontracting is only available when working on DB projects. Many interviewees expressed interest in the Air Force allowing for more design assistance subcontracting within DBB. Design Build Subcontracting (DBS), however, offers an approach that mitigates these design problems. ISWS is a method that all GCs recognize as a method to control project timelines.

When executing projects within the DBB framework, the quality of the design work is a pivotal factor influencing project management. The prevailing view among some in the industry is that government-hired designers may not always produce optimal designs. As one contractor pointed out, “The Government says, hey, this is what we're looking for. Build it. And it should be pretty straightforward. But then, as soon as you start digging into it, you're talking to your subcontractors, and you're realizing we need to actually get some design involved.” This

perception of inadequate design often leads to Requests for Information (RFIs) and change orders, escalating project costs.

Design-Assist Subcontracting was seen to have the most significant impact on project execution. The proactive nature of DAS is acknowledged for reducing design issues, “We generally get better design, better timelines during design, better decisions during design about things that have to be settled on very early.” DAS projects avoid delays, as indicated by the quote, “[DAS] means we don't have to spend time and money later on sending RFIs and changing drawings and fixing things that could affect the 65% design.” However, as indicated in section 4.2.1, Design Assist subcontracting is only available when working on DB projects. Many interviewees expressed interest in the Air Force allowing for more design assistance subcontracting within DBB.

Contractors' keen interest in DAS reflects their desire to contribute constructability insights to the design. Since DAS is not always an option, General Contractors often turn to Design-Build Strategies (DBS) as the most effective alternative for influencing project design. DBS is a strategy all interviewees indicated that alleviated some of the issues prevalent in DBB projects. Contractors describe this strategy as "Delegated Design" or “Deferred Submittals.” The consensus among those interviewed is favorable toward DBS. One interviewee summarized the benefit: “This way, it eliminates the designer from potential errors and omissions.” Assigning more complex design tasks to the GC is seen as enabling more efficient project execution. Contractors frequently observed that having a delegated design reduces the number of RFIs and change orders, thus expediting the overall project timeline. Since contractors may not always

have the opportunity to influence the initial design, DBS provides them with the latitude to control complex and challenging aspects of a project's design. This shift in responsibility enables contractors to mitigate potential project management issues that could arise from leaving the design entirely in the hands of the designers. While there was no specific relation as to when the best time to bring on a DBS subcontractor in a project, the majority of interviewees phrases like, “right away”, “as soon as possible”, or “immediately” when talking about when they integrate their subcontractors into design processes.

Regardless of design quality, an aspect of construction that all interviewees dealt with was maintaining the project timeline. In both DB and DBB methods, ISWS is crucial for maintaining and potentially recovering the project timeline. Having subcontractors working amongst each other led to simple solutions that minimized delays. As one contractor explained, “The electrician will say, ‘instead of me hiring another excavator, you're out here. You have your equipment out here. Can you go ahead and trench this for the electrical at the same time that you're out here doing the civil?’ Schedule-wise, it makes sense, logistically, it keeps less equipment on site, which is always good. And it's better for the schedule.” While contractors prefer to plan this type of coordination in advance, they recognize that “problems happen every once in a while, and things suddenly get jammed up. I wouldn't say that's a standard way to look at a job, but subs working together can make up for lost time.” This highlights the adaptability of subcontractors collaborating to address unexpected delays and keep the project on schedule. Allowing for ISWS on a project with subcontractors who have a teamwork-oriented mindset to project completions generally leads to better project timelines.

4.2.3 Risk

General contractors aim to reduce risk when they choose subcontractors. In the DBB model, one main risk comes from the quality of the design they're given to work with. Another issue with DBB is that it can lead to adversarial relationships between the general contractor and subcontractors, which can make risks harder to manage. While DBS is often preferred for lessening these risks, it can bring its own challenges. However, a Design-Build (DB) approach tends to allow better sharing of risk among subcontractors. This sharing of risk highlights why general contractors often prefer to work with subcontractors who have experience with DB projects.

The DBB model presents risks to general contractors when government designs are perceived to be error-prone, as indicated in section 4.2.2. This leads to a potential underestimation of the project's requirements. One general contractor expressed concern: “This is a massive risk for us. When you're bidding on something that isn't necessarily fully designed, and you think you know what it's going to take, but it may take considerably more effort or a longer timeframe. As the GC, I would be worried about the risk.” The ambiguity inherent in DBB contracts also complicates the hiring of appropriate subcontractors. General contractors may have confidence in their subcontractors' capabilities, yet they might find it challenging to depend on their bids if the designs do not accurately detail the necessary work. Oversights in the design can result in overlooking certain areas of expertise during the subcontractor selection process. More design errors lead to increased risk for both the GC and those he subcontracts with.

In the DBB environment, the relationship between contractors and subcontractors can become adversarial, as each party aims to mitigate its own risk. The dynamic is described as follows: “You give that subcontractor a scope, and he follows that scope. It's black or white; you either meet the intent by following the specification and the intent of drawing, or you don't. If they follow it, great. If they don't, then you have a warranty claim, and you, as a GC, have zero risk other than making sure that no workmanship error that may potentially occur is resolved.” This interviewee's perception highlights the “us-vs-them” mentality that can arise between the GC and subcontractor. The dynamics of relationships with subcontractors can sometimes devolve into a cycle of fault-finding and finger-pointing.

While DBS is generally desirable amongst interviewees, it does come with its own set of risks. Concerns arise about the uncertainty of liability ownership. Interviewees felt that blurred lines of responsibility can arise when they are responsible for portions of the design. One GC pointed out: “I think it can be a little risky for the general. Because it's just, it's got a gray area: who owns the liability for what?” There's apprehension that by supplementing their designs, contractors might lose the ability to attribute blame for project complexities to the designer.

In contrast, DB arrangements promote a culture of shared risk among contractors. One contractor highlighted the collaborative approach: “We get buy-in across the entire team. Since we get buy-in, we make sure that the designer is not putting any gold plating on anything in a manner of speaking, and we also make sure that the quality that the subcontractor is installing is to the base’s standards, which the designer has more insight and control over.” This shared responsibility fosters trust within the DB team and motivates all members to work toward

the best outcome for the project. DAS is the exemplifier of this mentality: “what you have is everyone supporting each other. All of the stakeholders are equally responsible for the outcome. So it's one of those things where, hey, you're scratching my back. I'm scratching your back. I'm looking out for you. You're looking out for me.” The fostered sense of teamwork minimizes the risks of the project.

Understanding risk gave greater insight into a general contractor's preference to hire subcontractors with DB experience, as indicated in 4.2.1. DB contractors deliberately take on projects with less clearly defined scopes, inherently carrying more risk. Contractors value teamwork and collaborative relationships, as these traits in subcontractors help mitigate the risks involved. General contractors naturally desire to partner with subcontractors who actively work to reduce the overall project risks rather than prioritizing their own interests. Those with a solid track record in DB projects demonstrate a commitment to the project's success, which aligns with the general contractor's goals.

4.2.4 Air Force Specific Impacts

Air Force decision-makers typically rotate every two to three years. This frequent change in leadership can result in shifting project priorities. As one General Contractor expressed, “[The Air Force] also doesn’t have good continuity of leadership. So, the design changes because different planners want to advance different preferred outcomes.” The consequence is that the timing of when a project is constructed can be affected. New leaders may reprioritize construction projects, causing previously designed projects to be postponed. Another GC

observed, “I've seen where plans might sit on the shelf for five to ten years, and you know, technology and building codes are always changing.”

To mitigate designs with outdated code processes, General Contractors adopt a DBS approach to ensure that engineering designs comply with current codes. One GC elaborated on the necessity of updating codes: “If something wasn't a code, to begin with, or it's so old, it's out of code. We got to bring in a third-party designer to get it to code, meet the life safety, meet the standard requirements for electrical and stuff like that.” In this situation, the Air Force acts as the approval authority for updates provided through the GC.

The use of proprietary products in construction is another factor that dictates how GCs manage subcontracting under DBB. IDSC is infrequently used among interviewees; however, the need for proprietary products often necessitates its use. For example, an interviewee recalled the Air Force Academy's requirement for specific control contractors for installation, noting: “We've done that at the Air Force Academy pretty frequently, but that generally happens a lot where you have a controls contractor that has the base wide integrated control system. So, like Siemens controls or Honeywell or something like that, where the rest of the base operates on their systems. So, the designer has to work with them to make sure whatever they're designing lines up with all of their systems, and then we hire that contractor to install essentially what the designer designed. I've had a couple of those, but um, it's not super common outside of that.”

4.2.5 Financial Considerations:

Budget constraints play a big part in how the Air Force develops their construction projects. These limits lead to poorly budgeted projects that both the GC and the subcontractor may try to take advantage of when working on a DBB project. Budget assurance is higher within low-complexity DBB contracts with few subcontractors involved. DBS is an option to help with project cost prediction. Conversely, DB procurement allows for cost savings on the general contractors' part due to vertical integration of services by the subcontractor. In both DBB and DB methods, ISWS gives subcontractors an outsized influence on the cost of the project.

Funding limitations are a significant concern in subcontracting for Air Force construction projects. An interviewee with experience on the Air Force side observed, “[The Air Force] doesn’t have enough people, resources, time, and effort put into developing what they want to, so the design will falter.” This sentiment aligns with general contractors' views that design quality often falls short. Such financial constraints affect how general contractors manage their relationships with subcontractors, leading to a mutual lack of confidence in the accuracy of construction budgets.

General contractors entering bids on DBB projects recognize that the final costs are expected to exceed the initial estimates. They believe that the Air Force anticipates this as well. A contractor stated, “We all know it's never going to be in that budget. We know it's not going to be that, but the Air Force is telling me I can get the project if I can get to this number, and so I'll get to this number. And how I get there may be in full, open transparency, or people might actually know that you're going to make mistakes somewhere along the way. You're going to come back to me,

and I'm going to upcharge those mistakes to cover my bases." This situation is seen as an opportunity by some subcontractors to inflate their profits due to the inherent uncertainties. A general contractor remarked, "Subcontractors will, you know, try to hide stuff. They want the job, but they want to exclude something that would make the general contractor eat the cost later on."

For DBB projects, cost savings were mainly associated with less complex, straightforward projects that do not demand highly specialized subcontractors. In such cases, as a contractor pointed out, "The pros are you're getting a bid on a contract, you know what the design is, and you know what the price is." This clarity and simplicity enable subcontractors to submit competitive bids with a good understanding of the project's requirements, ensuring that their bids are accurate. However, this confidence in price is only apparent when the contractors felt they were working on straight, forward, low-complexity jobs where design errors would likely be at a minimum.

Contractors utilizing DBS practices often find they can more accurately forecast project costs. This is because DBS allows for the distribution of more complex project factors away from the Air Force's budgetary constraints, enabling contractors to focus more closely on design development. As one contractor mentioned, "It takes a lot of guesswork away from the general as they develop the design."

In terms of DB procurement, the conversation frequently turned to the benefits of cost savings, particularly through the vertical integration of services among subcontractors. Contractors prefer

to work with subcontractors who can provide multiple services under one roof, which streamlines the process and reduces costs. One contractor praised their preferred mechanical subcontractors, saying, “All they do is mechanical work. They’re the type of subcontractor that we can take from base to base to base. And we're successful because one, they have the buying power for the equipment, they have the design ability, and they can be cost- and time-effective.” Such integration allows the general contractor to avoid additional mark-ups that would arise from hiring multiple subcontractors or from their subcontractors’ hiring others. An interviewee highlighted the financial impact on larger contracts, stating, “When you get up on the multi $10 million plus contracts, all those markups start adding up.”

The financial challenges of working within the ISWS subcontracting model were frequently noted by contractors. Many acknowledged that these subcontractors can command higher prices due to their niche position or perceived assurance of winning contracts. One contractor lamented, “Downside is generally those subcontractors because they know they're kind of a niche market or because they've kind of got it in the bag. The downside we see is that their prices are pretty high, and there's nothing we can do about it. And there's nothing the government can do about it because they've painted themselves into a corner.” This situation often leads to the inability to negotiate lower prices on ISWS contracts.

5 Chapter 5 Conclusions

5.1 Conclusions

The analysis of the impact of DBB and DB on subcontracting in Air Force construction projects reveals a trend towards valuing DB experience and technical know-how over cost. General contractors (GCs) focus on specialized knowledge and local expertise, particularly in DB projects where qualitative contributions of subcontractors, such as Design-Assist (DAS), are critical. Despite a preference for these qualitative traits, DBB tends to push selection towards cost-effectiveness to stay competitive.

Project management success is closely tied to execution quality, with DBB often criticized for lower-quality designs that hinder management and execution, leading to a call for more DAS integration within DBB. Implementing more integrated strategies like ISWS is recognized for promoting efficient progress and mitigating delays through subcontractor collaboration in contracts that would otherwise limit collaboration.

GCs aim to minimize risks through subcontractor selection, navigating the design quality risks of DBB and the unclear liability in DBS. DB's approach to shared risk and teamwork is becoming preferred, aligning with GCs' tendency to choose subcontractors with DB experience for their collaborative skills.

Air Force exerts a unique influence on projects through frequent leadership changes that can lead to delays and outdated designs. To keep designs current, GCs often resort to DBS, which allows

for the Air Force to approve necessary updates. Specialized needs occasionally give subcontractors leverage in decisions, especially when proprietary products are involved.

Budget considerations heavily impact project approaches. While DBB can offer cost certainty for simpler projects, it also opens opportunities for budget exploitation. Conversely, DBS facilitates better cost forecasting and design focus, with DB promoting cost savings through the integration of subcontractor services. However, ISWS can increase costs due to specialized subcontractor pricing, often leading to fixed contract terms.

In sum, the choice of DBB or DB significantly shapes subcontracting practices in Air Force construction projects, with various factors contributing to the complexity of these decisions.

5.2 Implications for the Air Force

Choosing the right procurement method is crucial for the Air Force's construction projects, with significant implications across various aspects of project delivery. The choice between DBB and DB shapes the overall approach to project design and quality, impacts cost and budget management strategies, alters risk profiles, influences the efficiency and timeliness of project completion, and affects the selection of projects with proprietary technology. Each of these factors must be carefully considered to ensure that project outcomes meet the high standards of efficiency, risk mitigation, and fiscal responsibility expected in Air Force projects.

1. **Project Design and Quality:** The Air Force needs to acknowledge that DBB can lead to design quality issues affecting project management and execution. Thus, there is a

compelling case for the Air Force to advocate for more DAS in DBB projects, which could improve design quality and project outcomes by tapping into the qualitative contributions of subcontractors early in the project lifecycle.

2. **Cost and Budget Management:** The financial implications suggest the Air Force must ensure that their budgeting and cost estimation practices are robust enough to handle the nuances of both DBB and DB methods. For DB projects, the Air Force can achieve more accurate forecasting and potentially greater cost savings through promoting the use of DB on complex projects. The vertical integration of services provided by subcontractors and the general overall quality of subcontractors with DB experience can help control budgetary issues.

3. **Risk Management:** The Air Force, as project owners, need to be aware of the different risk profiles between DBB and DB. In DBB, there is a heightened risk of adversarial relationships for GCs and their subcontractors, as well as design flaws, whereas DB promotes a culture of shared risk and collaboration. Encouraging the selection of experienced DB subcontractors may also reduce cost and timeline risks associated with project delivery.

4. **Efficiency and Timeliness:** The Air Force should encourage the use of ISWS for maintaining and potentially recovering project timelines, as it encourages subcontractors to collaborate and find efficient solutions to project delays.

5. **Proprietary Products:** The Air Force must manage the influence of proprietary product requirements on subcontracting decisions. This includes understanding when specialized subcontractors are needed and how this affects overall project costs and subcontractor selection.

By carefully considering these implications, the Air Force can optimize its project delivery methods to improve efficiency, reduce risk, and help projects be completed within budget and on time.

5.3 Further Research

This study is a useful starting point for further investigation. Although it concentrates on Air Force construction projects, there's potential for a wider examination into construction and subcontracting practices. Including other military branches and federal agencies could offer a more complete understanding and highlight the effects of the FAR on subcontracting across various areas. Broadening research to include these perspectives could reveal insights that go beyond Air Force projects alone.

The study provides important information on how general contractors make decisions, but the crucial role of subcontractors also warrants attention. Future research should consider the experiences of subcontractors to deepen our knowledge and present a fuller view of decision-making in the construction industry. Acknowledging subcontractors' unique challenges could improve subcontracting practices and policies.

For wider relevance, this research could also explore the construction practices of international firms. With the Air Force operating globally, there's an opportunity to compare U.S. practices with those abroad. This comparative study could uncover new subcontracting practices and help multinational companies and policymakers understand differences and similarities in global construction processes. Such research could enhance our understanding of the construction industry worldwide.

Bibliography

AFI. 2015. *Designing and Constructing Military Construction Projects*. https://www.e-publishing.af.mil/Product-Index/#/?view=search&keyword=construction&isObsolete=false&modID=449&tabID=131.

AFI 32-1020. 2023. "Air Force Instruction 32-1020, Planning and Programming Built Infrastructure Projects." Department of the Air Force.

AFIT. 2019. "Management 101: Project Management." Air Force Institute of Technology.

Akintan, O. A., and R. Morledge. 2013. "Improving the Collaboration between Main Contractors and Subcontractors within Traditional Construction Procurement." *Journal of Construction Engineering*, 2013: 1–11. Hindawi Limited. https://doi.org/10.1155/2013/281236.

Arslan, G., S. Kivrak, M. T. Birgonul, and I. Dikmen. 2008. "Improving sub-contractor selection process in construction projects: Web-based sub-contractor evaluation system (WEBSES)." *Autom Constr*, 17 (4): 480–488. https://doi.org/10.1016/j.autcon.2007.08.004.

Biruk, S., P. Jaśkowski, and A. Czarnigowska. 2017. "Minimizing Project Cost by Integrating Subcontractor Selection Decisions with Scheduling." *IOP Conf Ser Mater Sci Eng*. Institute of Physics Publishing.

Brown, R. S. 2009. *An Analysis of Construction Contractor Performance Evaluation An Analysis of Construction Contractor Performance Evaluation System System*.

Chau, K. W., and A. Walker. 1994. *Subcontracting in the Construction Industry: A Transaction Cost Minimization Perspective*.

Choudhry, R. M., J. W. Hinze, ; Muhammad Arshad, and H. F. Gabriel. 2012. "Subcontracting Practices in the Construction Industry of Pakistan." https://doi.org/10.1061/(ASCE)CO.1943-7862.

Clevenger, C. M., and R. Khan. 2014. "Impact of BIM-Enabled Design-to-Fabrication on Building Delivery." *Practice Periodical on Structural Design and Construction*, 19 (1): 122–128. American Society of Civil Engineers (ASCE). https://doi.org/10.1061/(asce)sc.1943-5576.0000176.

Costantino, N., and R. Pietroforte. 2002. "Subcontracting Practices in USA Homebuilding: An Empirical Verification of Eccles's Findings 20 Years Later." *European Journal of Purchasing & Supply Management*, 8: 15–23.

Dainty, A. R. J., G. H. Briscoe, and S. J. Millett. 2001. "Subcontractor perspectives on supply chain alliances." *Construction Management and Economics*, 19 (8): 841–848. https://doi.org/10.1080/01446190110089727.

Elmugtaba Ali Bannaga, B., and A. Khaled Masadeh. 2015. *Understanding the Mutual Influence of Contract and Subcontract Terms on Construction Relationships*.

FAR. 2023. *Subcontracting Policies and Procedures*. https://www.acquisition.gov/far/part-44.

Fernandez Angulo, L. R., G. C. Migliaccio, R. J. Gebken, and K.-Y. Lin. 2019. *Emergent Subcontracting Models and Owner Involvement in Selecting Subcontracting Strategies and Participants in the U.S. Construction Industry*.

Franz, B., R. M. Leicht, and A. M. Asce. 2012. *Initiating IPD Concepts on Campus Facilities with a "Collaboration Addendum."*

Gil, N., I. D. Tommelein, R. L. Kirkendall, and G. Ballard. 2001a. "Leveraging specialty-contractor knowledge in design-build organizations." *Engineering Construction and Architectural*

Management, 8 (5–6): 355–367. Emerald. https://doi.org/10.1046/j.1365-232x.2001.00218.x.

Gil, N., I. D. Tommelein, R. L. Kirkendall, and G. Ballard. 2001b. "Leveraging specialty-contractor knowledge in design-build organizations." *Engineering Construction and Architectural Management*, 8 (5–6): 355–367. Emerald. https://doi.org/10.1046/j.1365-232x.2001.00218.x.

González-Díaz, M., B. Arruñada, and A. Fernández. 2000. *Causes of subcontracting: evidence from panel data on construction firms*. *J Econ Behav Organ*.

Gransberg, D. D., J. Sue. Shane, National Research Council (U.S.). Transportation Research Board., National Cooperative Highway Research Program., American Association of State Highway and Transportation Officials., and United States. Federal Highway Administration. 2010. *Construction manager-at-risk project delivery for highway programs*. Transportation Research Board.

Gransberg, D., M. Loulakis, and G. Gad. 2022. *The Engineer's Project Delivery Method Primer: Uniform Definitions and Case Studies*. American Society of Civil Engineers.

Gransberg, N. J., and D. D. Gransberg. 2020. "Public Project Construction Manager-at-Risk Contracts: Lessons Learned from a Comparison of Commercial and Infrastructure Projects." *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, 12 (1). American Society of Civil Engineers (ASCE). https://doi.org/10.1061/(asce)la.1943-4170.0000339.

Hale, D. R., P. P. Shrestha, ; G Edward Gibson, and G. C. Migliaccio. 2009. "Empirical Comparison of Design/Build and Design/Bid/Build Project Delivery Methods." *J Constr Eng Manag*, (7): 579–587. https://doi.org/10.1061/ASCECO.1943-7862.0000017.

Hassan, F. ul, and T. Le. 2021. "Computer-assisted separation of design-build contract requirements to support subcontract drafting." *Autom Constr*, 122. Elsevier B.V. https://doi.org/10.1016/j.autcon.2020.103479.

Hinze, J., and A. Tracey. 1994. "The Contractor-Subcontractor Relationship: The Subcontractor's View." *J Constr Eng Manag*, 120: 274–287.

Hsieh, T.-Y. 1998. *Impact of Subcontracting on Site Productivity: Lessons Learned in Taiwan*.

Jayasuriya, S., G. Zhang, and R. Jing Yang. 2019. "Challenges in public private partnerships in construction industry: A review and further research directions." *Built Environment Project and Asset Management*. Emerald Group Holdings Ltd.

Johansen, E., and G. Porter. 2021. *An Experience of Introducing Last Planner into a UK Construction Project*.

Kelly, D. 2014. "Examination of Design-Assist Subcontracting." https://doi.org/10.1061/(ASCE)LA.

King, N. 2012. *Doing Template Analysis*. (G. Symon and C. Cassell, eds.). SAGE.

Kramer, E. C. 2017. *An Empirical Analysis of Air Force Military Construction Project Delivery Method Performance in the United States Recommended Citation*.

Lidelöw, H., and K. Simu. 2015. "Understanding Construction Contractors and their Operations Strategies." *Procedia Economics and Finance*, 21: 48–56. Elsevier BV. https://doi.org/10.1016/s2212-5671(15)00149-5.

Ling, F. Y. Y. 2004. “How project managers can better control the performance of design-build projects.” *International Journal of Project Management*, 22 (6): 477–488. https://doi.org/10.1016/j.ijproman.2003.09.003.

Migliaccio, G. C., R. J. Gebken, L. R. Fernandez, and N. Osmanbhoy. 2022. “Emergent Subcontracting Models in the US Construction Industry.” *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*. American Society of Civil Engineers (ASCE).

Migliaccio, G. C., and L. Holm. 2018. *Introduction to construction project engineering*. *Introduction to Construction Project Engineering*. CRC Press.

Minchin, R. E., X. Li, R. R. Issa, and G. G. Vargas. 2013. “Comparison of Cost and Time Performance of Design-Build and Design-Bid-Build Delivery Systems in Florida.” *J Constr Eng Manag*, 139 (10). American Society of Civil Engineers (ASCE). https://doi.org/10.1061/(asce)co.1943-7862.0000746.

Osmanbhoy, N. M. A., G. Migliaccio, and L. Holm. 2015. *i Closing The Contractual Circle: Investigating Emergent Subcontracting Approaches*.

Park, J., and Y. H. Kwak. 2017. “Design-Bid-Build (DBB) vs. Design-Build (DB) in the U.S. public transportation projects: The choice and consequences.” *International Journal of Project Management*, 35 (3): 280–295. Elsevier Ltd. https://doi.org/10.1016/j.ijproman.2016.10.013.

Proctor, J. 1996. *Golden Rule of Contractor-Subcontractor Relations*.

Rosner, J. W. 2008. *An Analysis of the Design-Build Delivery Method in Air Force Military Construction*.

Sexton, D., I. H. El-adaway, M. Abdul Nabi, and A. H. El Hakea. 2020. “Using the Simplified Acquisition of Base Engineer Requirements in Construction Projects: Contract Administration Guidelines.” *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, 12 (3). American Society of Civil Engineers (ASCE). https://doi.org/10.1061/(asce)la.1943-4170.0000394.

Shash, A. A. 1998. “Bidding Practices of Subcontractors in Colorado.” *J Constr Eng Manag*, 124 (3): 173–244.

Stanford, M. S. 2017. *Competition and Price Analysis of Indefinite Delivery Indefinite Quantity Contracts for Construction*.

Stockenberg, R. A. 2001. “The perils of bid shopping.” *Reed Business Information, Inc*, 42 (3).

Sullivan, J., M. El Asmar, J. Chalhoub, and H. Obeid. 2017. “Two Decades of Performance Comparisons for Design-Build, Construction Manager at Risk, and Design-Bid-Build: Quantitative Analysis of the State of Knowledge on Project Cost, Schedule, and Quality.” *J Constr Eng Manag*, 143 (6). American Society of Civil Engineers (ASCE). https://doi.org/10.1061/(asce)co.1943-7862.0001282.

Surajbally, K. R. 2011. *Risks Associated with Federal Construction Projects Recommended Citation*.

Tabb, D. K. 2020. *Analysis of Construction Management at Risk Projects for Unites Analysis of Construction Management at Risk Projects for Unites States Air Force Applicability States Air Force Applicability Recommended Citation Recommended Citation*.

Tan, Y., B. Xue, and Y. T. Cheung. 2017. “Relationships between Main Contractors and Subcontractors and Their Impacts on Main Contractor Competitiveness: An Empirical Study

in Hong Kong." *J Constr Eng Manag*, 143 (7). American Society of Civil Engineers (ASCE). https://doi.org/10.1061/(asce)co.1943-7862.0001311.

Tang, Y., Y. Chen, D. Arditi, and F. Meng. 2023. "Effects of the General Contractor's Governance Capabilities and Project Goals on the Organizational Arrangement of Subcontracting." *IEEE Trans Eng Manag*, 70 (5): 1724–1737. Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/TEM.2021.3064020.

Tarziján, J., and F. Brahm. 2014. "Subcontracting in project-based firms: Do you follow the same pattern across your different projects?" *International Journal of Project Management*, 32 (6): 995–1006. Elsevier Ltd. https://doi.org/10.1016/j.ijproman.2013.12.001.

Thomas Ng, S., Z. Tang, and E. Palaneeswaran. 2009. "Factors contributing to the success of equipment-intensive subcontractors in construction." *International Journal of Project Management*, 27 (7): 736–744. https://doi.org/10.1016/j.ijproman.2008.09.006.

Uher, T. 1991. "Risks in subcontracting: Subcontract conditions." *Construction Management and Economics*, 9: 495–508.

U.S. House of Representatives. 2022. *Title 10 U.S.C. 2811 - Repair of facilities*.

Üsdiken, B., Z. Sözen, and H. Enbiyaoğlu. 1988. "Strategies and Boundaries: Subcontracting in Construction." *Management Journal*, 9 (6): 633–637.

Yik, F. W. H., and J. H. K. Lai. 2008. "Multilayer subcontracting of specialist works in buildings in Hong Kong." *International Journal of Project Management*, 26 (4): 399–407. Pergamon. https://doi.org/10.1016/J.IJPROMAN.2007.05.009.

Yik, F. W. H., J. H. K. Lai, K. T. Chan, and E. C. Y. Yiu. 2006. "Problems with specialist subcontracting in the construction industry." *Building Services Engineering Research and Technology*.