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

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IMPLEMENATION OF INTEGRATED PROJECT DELIVERY ON DEPARTMENT

OF NAVY MILITARY CONSTRUCTION PROJECTS

by

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ABSTRACT

Implementation of Integrated Project Delivery on Department of Navy

Military Construction Projects

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The concept of the project delivery system refers to the overall processes by which a project is designed, constructed, and/or maintained. There are many different types of project delivery systems to fit particular situations involving the owner and his intended project. The project delivery system is what establishes the framework that enables a construction project to be developed and ultimately executed.

The construction industry has observed that projects (both private and public) frequently suffer from factors such as adversarial relationships, low productivity, high inefficiency and rework, frequent contractual disputes concerning who was at fault, and lack of innovation. Not only do these factors result in cost and schedule growth, they also contribute to work related injuries and fatalities and poor end project quality

Integrated Project Delivery (IPD) is a unique project delivery method that was generated to address these problems. In contrast to a traditional project team, the revolutionary concept of IPD is that the integrated team is contractually bound to each other and includes not only the owner, architect, and contractor, but can also extend to subcontractors, engineers, and major systems suppliers. Because of the inherent innovativeness of IPD, it is well suited to address the problems that traditional project delivery systems never could.

This research examines the extent to which Integrated Project Delivery can be implemented on Department of the Navy (DON).military construction projects. This research will first focus on understanding the culture and mindset of how facilities management and construction are currently executed within Marine Corps installations and Naval Facilities Engineering Command (NAVFAC).

Data were taken through a survey mechanism with questions covering major points to understand the culture. After this culture was understood and determined, recommendations were then made for partial and full implementation of IPD within NAVFAC. This thesis also uses a literature review and case studies to gain context and understand the techniques and benefits of IPD, Lean Construction and Building Information Modeling (BIM) and the obstacles to IPD implementation.

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CHAPTER 1

INTRODUCTION

1.1 Overview

Construction projects frequently suffer from adversarial relationships, low productivity, gross inefficiency and rework, frequent disputes, and poor innovation. This has resulted in too many projects experiencing cost and schedule over-runs and owners' dissatisfaction with the quality of the end product (Thomsen et al, 2010). All of these problems are simply symptoms of a much larger technical and cultural problem within the design and construction industry. The industry has not fundamentally changed for well over a century and while it is making significant progress in terms of usage of new tools, methodologies and roles, it is still only beginning to address the significant issues of waste/lack of productivity, technology utilization, and owner demand for value (Kenig et al, 2010).

Utilizing statistical data from the U.S. Bureau of Labor, Dr. Teicholz shows that productivity of the construction industry has decreased since 1964 while all other non-farm industries have increased by almost 200% (Teicholz, 2004; BOL, 2004).

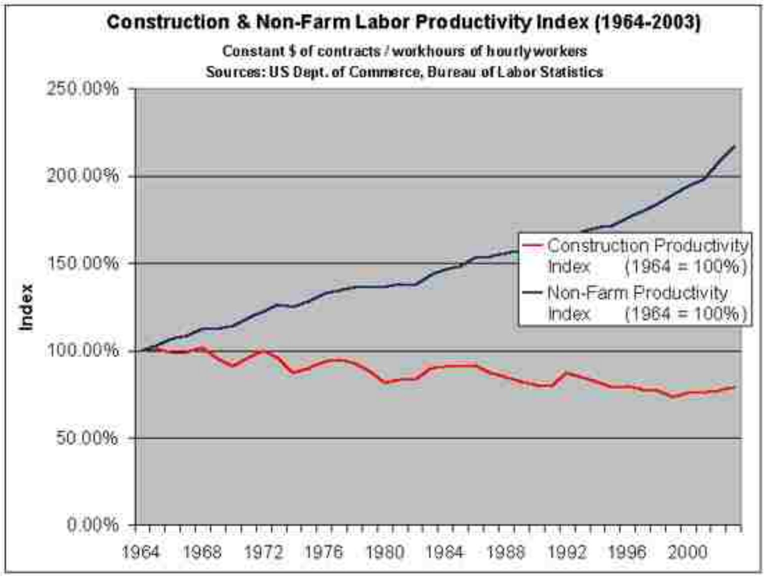

Figure 1.1: Construction & Non-farm Labor Productivity Index, 1964-2003 (Teicholz, 2004)

One of the significant factors that causes decreased productivity is software interoperability between the different project entities (e.g.: architect, client, contractor). For instance, the National Institute of Standards and Technology (NIST) showed that a lack of software interoperability costs the construction industry almost $16 billion annually (Gallaher, 2004). A 2004 Construction Industry Institute / Lean Construction Institute study suggested that as much as 57% of time, effort and material investment in construction projects does not add value to the final product, while the corresponding percentage in the manufacturing sector is only 26%. The construction industry should, therefore, be well positioned to find and eliminate waste (Kenig, 2010).

While information technology used by the design and construction industry has made great strides in terms of being able to manage an enormously wide range of complex data and becoming simpler to use, complete adoption by the industry still is relatively slow (Kenig, 2010; Rekola, 2010). Current applications, such as Building Information Modeling (BIM), enable different stakeholders at different phases of the life cycle of a facility to insert, extract, update or modify information in BIM to support and reflect the roles of that stakeholder. Thus, BIM is a shared digital representation founded on open standards for interoperability (AIA, McGraw-Hill, 2007). As the newer generation of design and engineering professionals enter the industry, the entire industry will eventually fully adopt these software tools, but because of the problem of gross inefficiency and waste that the industry is currently experiencing, great efforts are needed to implement these tools sooner rather than later. Accordingly, McGraw-Hill estimated that a tipping point was reached in spring of 2008 where more construction teams were using BIM than simply exploring it. This explosive growth has been supported by development of BIM standards by the National Institute of Building Sciences at the industry level and by the US Army Corps of Engineers (USACE) and the General Services Administration (GSA) at the federal government level (NIBS, 2012; USACE, 2006; GSA, 2007). Additionally, this growth has been supported by other related issues, such as electronic data licensing and file transfer. BIM has become an inevitable technology (Ashcraft, 2008; Kenig, 2010).

As budgets become tighter and as our government policies put a stronger chokehold on our country's economic situation every year, owners are becoming increasingly focused on demanding more value (Kenig, 2010). Whenever any requirement is not met (e.g. schedule, budget), this is waste (Howell, 1999). In 2004, the Construction Users Roundtable (CURT) urged significant change throughout the construction process. Many owners shared the frustrations associated with the traditional methods and continuously experience many of the same problems as other institutions and corporate construction projects. Owners also characterized the difficulties experienced on typical projects as evidence of a construction process plagued by lack of cooperation and poor integration of disparate information. The reasons for this dysfunctionality included multiplicity of participants with conflicting interests, incompatible cultures among team members and limited access to timely information (CURT, 2004).

In response to this, the American Institute of Architects (AIA) in 2007 developed a new project delivery system called Integrated Project Delivery (IPD). It is based on the concept of an integrated project team that not only includes the owner, architect, and contractor, but also extends beyond the major stakeholders to also include subcontractors, engineers, and major systems suppliers, among others. AIA also provided direction on how IPD could enable transitioning existing project delivery models to a collaborative, integrated team model. The resulting model leverages the early contribution of individual expertise and allows all team members to better realize their potential while expanding the value they provide throughout the project lifecycle (Cadalyst, 2007).

In addition to its innovative collaborative relationship approach amongst the project stakeholders, IPD also leverages BIM. Although integrated projects can be performed without BIM, the full potential of IPD can only be achieved when both are used together (AIA, 2007).

The ultimate intent behind the development of IPD is to mitigate those factors that have plagued construction projects using traditional project delivery systems in order to provide the owner with a high quality product.

The Department of the Navy (DON), which includes the US Navy (USN) and the US Marine Corps (USMC), has had times of explosive construction growth in response to various global conflicts throughout our national history. In fact, the US Marine Corps most recently experienced a $11 billion construction boom, $3.5 billion of which was at USMC installations in the Southwest region of the United States. The Officer in Charge of Construction for Marine Corps Installations West (OICC MCIWEST), which is a separate command under Naval Facilities Command Southwest (NAVFAC SW), is the organization in charge of managing this $3.5 billion project workload. In a strategic move designed to manage all of these construction projects simultaneously, Naval Facilities Engineering Command (NAVFAC) Headquarters decided to make the majority of these "Grow the Force" construction projects design-build (DB), as opposed to the traditional design-bid-build (DBB). With the limited number of personnel unable to handle the 100-fold increase in design work necessary for design-bid-build, design-build seemed like the most beneficial option. Design-bid-build is still retained for highly specialized projects such as fuel facilities and other unique situations.

1.2 Statement of the Problem

While the traditional project delivery systems of design-bid-build and design-build were sufficient to meet the immediate construction needs at the time, they ultimately locked NAVFAC into an inescapable paradigm of executing construction within rigid protocols, static boundaries and non-collaborative tools and methods. During execution of these construction projects, it soon become apparent that the issues that plagued non-Department of Defense (DOD) construction projects (adversarial relationships, low production rates, high inefficiency and rework etc…) were also very prevalent on these USMC construction projects. In some ways actually, those problems were even more heightened. In a $131M project that constructed a new Bachelor Enlisted

Quarters (BEQ) facility, the government ended up paying the contractor over $1M in delay costs because of poor project development and planning.

1.3 Purpose and Scope of the Study

With factors such as these, it is imperative that the DON do much better in terms of providing a more robust project delivery system that is more collaborative and flexible so that construction projects can actually support the operational requirements of the warfighter in terms of the highest quality, in the timeframe that the projects are actually needed and within the congressionally appropriated budget.

1.4 Objectives of the Study

This research project focuses on the feasibility of implementing integrated project delivery (IPD) as a standard project delivery method on Department of Navy military construction projects. In order to accomplish this, it is critical to first gain an understanding of how federal and military facilities professional view currently executed project delivery methods, risk sharing, technology utilization and BIM implementation. Therefore, the main objectives of this study are:

1. To develop a questionnaire for collecting data from facilities professionals for the purposes of determining the general culture of facilities management and construction within the government sector.
2. To determine what techniques can be implemented and integrated within existing NAVFAC culture, processes and protocol. In other words, what key process elements can be modified to accommodate IPD immediately?

3. To determine what will be necessary to fully implement IPD in NAVFAC as a viable construction project delivery method.

    a) Changes to various federal acquisition regulations?

    b) Changes to NAVFAC Business Management System (BMS, existing NAVFAC protocol)?

1.5 Significance of the Study

With ever decreasing military budgets, and constant gross inefficiencies and waste still present in current federal/military construction execution, this study strives to be relevant in attempting to understand how IPD can be a powerful and innovative tool that NAVFAC and the federal government can use.

1.6 Sequence of the Study

The study begins in Chapter 2 with a literature review of various journal articles and publications focusing on three main areas critical to IPD: IPD itself as a delivery method, lean construction, and BIM. Additionally, obstacles to IPD implementation and relevant government documentation will be discussed. Chapter 3 discusses the methodology used to gather and analyze the survey data in order to draw conclusions of the current state of construction within NAVFAC. Chapter 4 describes the data gathered. Chapter 5 analyzes the study's findings and draws conclusions in order to fulfill the second and third objectives of this study.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

While commercial construction projects (non-DOD) frequently suffer from adversarial relationships, low productivity, gross inefficiency and rework, frequent disputes, and poor innovation, these problems become more heightened and acute on military (DOD) construction projects due, in large part, to the excessive regulatory nature of the federal government.

Only since 2007 did NAVFAC start implementing design-build as a project delivery method. Before 2007, all NAVFAC projects utilized design-bid-build. At that time, the intent was to utilize design-build processes/practices to allow flexibility, creativity and innovativeness in design approach; take advantage of time-savings, and complete projects within cost (NAVFAC Capital Improvements Business Line, 2005). While the design-build project delivery method did accomplish these things to a certain extent, NAVFAC never escaped the paradigm of executing construction within rigid protocols, static boundaries and non-collaborative tools and methods, which become even more apparent during the explosive $3.5 billion worth in construction growth for southwestern USMC installations. IPD could be potentially of great value to NAVFAC and the federal government in order to address these significant issues. Although IPD is still relatively new within the construction industry, there is a fair amount of academic research publication concerning the subject. However, there are also many more research studies done regarding lean construction and BIM implementation. The majority of these publications has been qualitative in nature, and has relied upon surveys, empirical reports, and case studies.

The intent of the literature review is to address five areas of research critical in enabling and utilizing IPD to its fullest extent. In the first section, research studies related to discussing IPD and its major characteristics will be presented. This is especially crucial because there is a somewhat vigorous debate between the American Institute of Architects (AIA) and the Lean Construction Institute (LCI) on what exactly constitutes an IPD project. Through this first section, a formal definition will be produced that will serve as the basis for the entire thesis. The second section will cover the major aspects and techniques of lean construction that allow IPD to flourish. The third section will cover BIM implementation. The fourth section will cover various obstacles to IPD implementation. This will be especially useful in eventually making correlations to implementation obstacles within the federal government. Finally, the fifth section will report on existing government documentation.

2.2 Integrated Project Delivery Literature

With the advent of IPD AIA, along with various other agencies, has produced a plethora of publications to explain and promote IPD. One recent publication details the basics of IPD and its application for both public and private owners in the title called “Integrated Project Delivery For Public and Private Owners” (AIA et al, 2010). A significant consideration that AIA et al (2010) describe concerning IPD is that they view IPD both as a philosophy and as a delivery method. For the purposes of this research thesis, IPD will be considered both and not one or the other.

AIA et al (2010) give a good general comparison of the standard project delivery method and IPD in Table 2.1.

Traditional Project Delivery		Integrated Project Delivery
Fragmented, assembled on "just-as-needed" or "minimum-necessary" basis, strongly hierarchical, controlled	**Teams**	*An integrated team entity composed of key project stakeholders, assembled early in the process, open, collaborative*
Linear, distinct, segregated; knowledge gathered "just-as-needed;" information hoarded; silos of knowledge and expertise	**Process**	*Concurrent and multi-level; early contributions of knowledge and expertise; information openly shared; stakeholder trust and respect*
Individually managed, transferred to the greatest extent possible	**Risk**	*Collectively managed, appropriately shared*
Individually pursued; minimum effort for maximum return; (usually) first-cost based	**Compensation / Reward**	*Team success tied to project success; value-based*
Paper-based, 2 dimensional; analog	**Communications / Technology**	*Digitally based, virtual; Building Information Modeling (3, 4 and 5 dimensional)*
Encourage unilateral effort; allocate and transfer risk; no sharing	**Agreements**	*Encourage, foster, promote and support multi-lateral open sharing and collaboration; risk sharing*

Table 2.1 Comparison between traditional and integrated project Delivery. (AIA et al, 2010).

AIA et al (2010) recognize a tiered approach to IPD based on three levels of collaboration. The three levels represent a typical spectrum through which owners move. Collaboration Level 1 (typical) involves collaboration that is not contractually required. Collaboration Level 2 (enhanced) consists of some contractual collaboration requirements, while Collaboration Level 3 (required) calls for collaboration by multi-party contract. Within this framework, Level 1 and 2 view IPD as a philosophy and while Level 3 views IPD as a delivery method.

	Level One "Typical" Collaboration	Level Two "Enhanced" Collaboration	Level Three "Required" Collaboration
Level of Collaboration	lower ←	→	higher
Philosophy or delivery method?	IPD as a Philosophy	IPD as a Philosophy	IPD as a Delivery Method
Also known as...	N/A	IPD-ish; IPD Lite; Non Multi-party IPD; Technology Enhanced Collaboration; Hybrid IPD; Integrated Practice	Multi-Party Contracting; "Pure" IPD; Relational Contracting; Alliancing; Lean Project Delivery System™
Delivery Approaches	CM at-Risk or Design-Build	CM at-Risk or Design-Build	Integrated Project Delivery

Table 2.2 Comparison of Collaboration Levels. (AIA et al, 2010).

The collaboration levels clearly delineate when a project is IPD-lite versus pure IPD. It is these collaboration levels that describe the various levels of contractual and behavioral principles found within the IPD related project. A pure IPD project will encompass all of these principles:

Key Participants Bound Together as Equals: Whether it is a minimum of Owner, Architect and Contractor, or a broader group including all project participants essential to project success, a contractually defined relationship as equals supports collaboration and consensus-based decisions.

Shared Financial Risk and Reward Based on Project Outcome: Tying fiscal risk and reward to overall project outcomes rather than individual contribution encourages participants to engage in “best for project” behavior rather than best for stakeholder thinking.

Liability Waivers between Key Participants: When project participants agree not to sue one another, they are generally motivated to seek solutions to problems rather than assigning blame.

Fiscal Transparency between Key Participants: Requiring and maintaining an open book environment increases trust and keeps contingencies visible—and controllable.

Early Involvement of Key Participants: Projects have become increasingly complex. Requiring all participants essential to project success to be at the table early allows greater access to pools of expertise and better understanding of probable implications of design decisions.

Intensified Design: The cost of changes to projects increases in relation to time. Greater team investment in design efforts prior to construction allows greater opportunities for cost control as well as enhanced ability to achieve all desired project outcomes.

Jointly Developed: Project target criteria carefully defining project performance criteria with the input, support and buy-in of all key participants ensures maximum attention will be paid to the project in all dimensions deemed important.

Collaborative Decision-Making: Requiring key project participants to work together on important decisions leverages pools of expertise and encourages joint accountability. Behavioral principles that would enable these contractual principles include mutual respect, willingness to collaborate, and open communication.

AIA et al (2010) also describe how in order for IPD to be executed properly, there are several catalysts that must be included:

Multi-Party Agreement: A contract between all key project participants that includes all of the contractual principles outlined above as well as language about behavior can support IPD projects.

Building Information Modeling: The tool of BIM, especially employed in a collaborative setting, can greatly enhance collaboration, sharing of information, and streamline project design and construction.

Lean Design and Construction: Focused on maximizing value, minimizing non-value added support, and elimination of waste, lean design and construction techniques are a natural fit for IPD projects.

Co-location of Team: When key project participants can be co-located, opportunities for collaboration and innovation increase. Project commitments are more likely to be met when one becomes closer to one's teammates.

During their research, AIA et al (2010) delve into very important areas such as how IPD should be adopted, and particular lessons learned. These items are vital in understanding the successes and needs for improvement so that an owner (whether government or commercial) can be fully informed about the implications and effects of implementing IPD. One of the key issues that AIA et al addressed for government owners in particular was the issue concerning working through current procurement rules. Public owners are often unable to share in the risk or the reward outside of the very rudimentary ways in which this is currently being done under traditional collaborations. AIA et al (2010) have encountered some owners that were able to identify one project as an exception or a prototype and get special permission to try some level of IPD on that one project. This is what they recommend as a more expeditious way to try IPD than trying to change the applicable rules, regulations, or legislation that might apply to all projects. Especially for a such a risk averse organization like the government (any level), this is the most prudent action to be taken, especially since this would not require any make legislative changes, and would be simply regarded as a pilot trial project.

Through the research, AIA et al (2010) provide an excellent summary of what it takes to make an IPD project and conclude their research by offering some recommendations for all owners, government and commercial. They have observed that IPD and collaboration are being used almost synonymously. They also recognize though that not every owner organization, whether public or private, is going to evolve to IPD as a delivery method using contractual collaboration. However, they are optimistic about the future of IPD. AIA et al use the key differentiator of the multi-party contract to separate IPD into two types (1. a philosophy and 2. a delivery method) and then further examining

IPD based on the three levels of collaboration (1. typical collaboration; 2. enhanced collaboration; and 3. required collaboration). It is very commendable that they clearly understand that not all owner situations are the same, and that it will be impossible for some to implement IPD in its purest form. Within that framework, they contend that understanding IPD utilization as either a philosophy or a delivery method and through the various collaboration levels can enable owners to have a clearer vision of what options may be available and have the ability to make a more informed decision of which options to pursue. This is especially important for federal government purposes. Implementing pure IPD would necessarily require changes in congressional legislation. Since this is very time consuming, implementing parts of IPD in the interim as AIA et al (2010) recommend is an excellent way to bridge the gap between traditional delivery to integrated delivery.

When attempting to execute a smooth transition from traditional project delivery methods to IPD it is important to first understand the current construction industry experience. Kent and Becerik-Gerber (2010) understand this and have performed research in this exact area. While organizations such as AIA and LCI are supporting the advancement of IPD, and AIA even published a case study document that showcases twelve projects that either were full IPD or "IPD-ish" projects (AIA, 2012), the total number of projects using IPD in the US still remains relatively small.

Kent's and Becerik-Gerber's (2010) research is based on the results of a web-based survey that was designed to target a wide range of construction professionals. The intent was to understand the current status of IPD use and its future widespread adoption by the construction industry. Their research attempts to provide hard data concerning the knowledge and experience levels of professionals in the construction industry regarding IPD, as well as their opinions concerning its benefits and problems as a project delivery method to shed light on the future of IPD use and what it would take to achieve widespread adoption by the industry.

Kent and Becerik-Gerber (2010) have adopted the definition of IPD from AIA: “a project delivery approach that integrates people, systems, business structures, and practices into a process that collaboratively harnesses the talents and insights of all project participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction (AIA, 2007).” Even with this definition, Kent and Becerik-Gerber understand a common IPD definition is not accepted by all. In the context of their research, they used the following common principles to define IPD: multiparty agreement, early involvement of all parties, shared risk and reward.

A significant amount of the information for this research was gained from interviews, which were conducted with 15 construction industry professionals. All interviews were conducted over the phone, with three resulting in face-to-face interviews. Interviews were conducted for two main purposes: to attain general information about IPD and its current use within the construction industry and to develop the appropriate constructs for the survey instrument. Through these interviews, it became obvious that there are little empirical data regarding IPD application.

Kent and Becerik-Gerber (2010) also distributed an online survey. It was designed to target a wide range of professionals in the construction industry and to determine the level of awareness, experience, and interest of the respondents regarding IPD.

There were 417 people who took the survey. Overall, 44.7% of total respondents had experience with IPD. The rest of respondents 55.3% were inexperienced, saying they had not been involved with an IPD project. Approximately 55.1% of those inexperienced respondents were, however, informed about IPD (30.6% of all respondents). The results show that the majority of the respondents either do not have direct IPD experience or are not familiar with IPD concepts. This suggests that despite the best efforts of professional organizations, there is still a need for professional development and education on the topic since one-fourth of the respondents are uninformed about IPD.

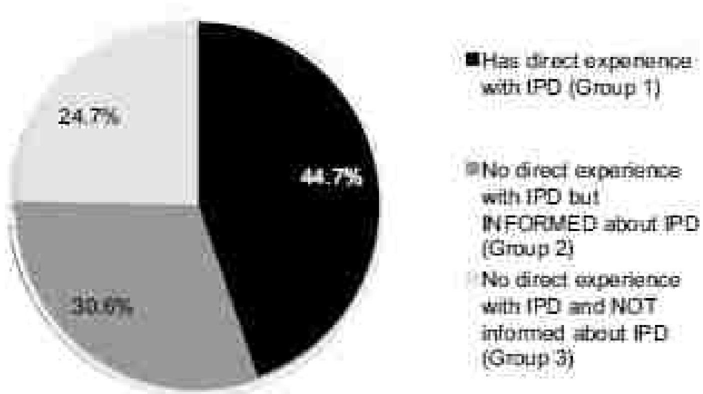

Figure 2.1 IPD experience and awareness level of respondents. (Kent and Becerik-Gerber, 2010)

Survey participants with IPD experience were asked to consider a specific IPD project while answering a series of detailed questions regarding IPD principles. The purpose of these questions was to verify whether or not these projects were actually being delivered in the same manner as described in prevalent literature on the topic. The topics discussed were multiparty agreements, early involvement of all parties, and shared risk and reward.

Background research revealed the following three contract models the most widely available IPD agreements for construction projects: IFOA, ConsensusDOCS 300, and AIA's transitional agreements or single purpose entity agreement. Based on the survey results, AIA contracts are the most widely used at 28.7%, next is the IFOA at 15.7 and 5.6% have used the ConsensusDOCS 300 agreement, and 21.3% said they have used another IPD contract. These were modified traditional contractual agreements created internally or created by a client. The remaining 28.7% said they have not used a multiparty or IPD agreement, which suggests that their experience was on projects that employed some principles of IPD while using traditional contracts. Only slightly more than half of the respondents (51%) have actually used one of the three IPD contracts. Although the other half of the respondents (49%) claimed that they have experience with IPD, they implemented IPD concepts and tools with traditional or modified traditional contractual agreements.

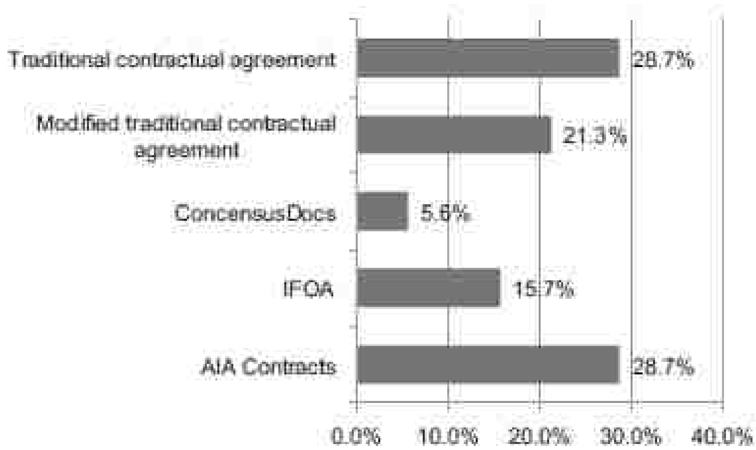

Figure 2.2 Utilization of IPD contracts within the respondents experienced with IPD. (Kent and Becerik-Gerber, 2010).

For early involvement, experienced respondents were asked to indicate which team members were involved during each phase of their specific IPD project in order to determine how early each party was getting involved. Table 2.3 shows the percentage of projects in which each party is involved at the corresponding project phase. Of particular interest in this analysis is the involvement of the general contractor, subcontractors, and manufacturers or suppliers during the design phases because these parties are typically not involved until the construction phase on traditional projects. However, the degrees of involvement of the owner, architect, engineers, and specialty consultants are useful for comparison with these other parties.

	Preliminary design (%)	Early design (%)	Design development (%)	Construction (%)	Closeout (%)	Facility management (%)
Owner	94.3	85.8	84.9	82.1	72.6	71.7
Architect	92.3	89.4	92.3	82.7	67.3	15.4
Engineers	71.0	86.9	91.6	85.0	60.7	19.6
General contractor	46.7	69.2	82.2	89.7	76.6	23.4
Subcontractors	17.1	41.9	72.4	89.5	67.6	22.6
Manufacturers/suppliers	11.8	41.2	74.5	87.3	48.0	23.5
Specialty consultants	43.1	69.6	83.3	79.4	46.1	28.4

Table 2.3 Involvement of Project Team Members during Stages of a Project. (Kent and Becerik-Gerber, 2010).

Preliminary design: Traditionally, this phase is limited to the owner and architect. They are also the only two parties present at the beginning of this phase on IPD projects, but the specialty design consultants and general contractor are also to become involved during this phase. Approximately 43.1% of survey respondents indicated that specialty consultants were involved during this phase and 46.7% indicated that general contractors were involved. Involvement of subcontractors and manufacturers/suppliers was limited.

Early design: In addition to the owner and architect, design consultants are typically introduced during this phase on traditional projects. According to the AIA guidelines, all parties may be present at this phase of an IPD project. Respondents indicated that 69.6% of specialty consultants and 69.2% of general contractors and only 41.9% of subcontractors and 41.2% of manufacturers/suppliers were present.

Design development: According to AIA, all parties should now be present on IPD projects and continue their involvement at some capacity through the remainder of the project. Traditionally, the owner works with the architect and specialty consultants to design the project and no other parties are introduced until agency review and construction. The survey results do indicate a high level of involvement from all parties during this phase—82.2% of general contractors, 72.4% of subcontractors, and 74.5% of manufacturers and suppliers—as well as those traditionally present during this phase: 83.3% of specialty consultants; 84.9% of owners; 91.6% of engineers; and 92.3% of architects.

For sharing risks and rewards, experienced respondents were asked to indicate what compensation method was used to incentivize collaboration on their specific IPD project. The following options were provided: 45.8% selected "based on value," which incentivizes the project team by offering a bonus linked to adding value to the project; 25.2% selected "incentive pool," which reserves a portion of the project team's fees into a pool that can increase or decrease based on various agreed upon criteria before being divided up and distributed to the team; 17.8% selected "performance bonuses," which provides an award based on quality; 15.9% selected other; 13.1% selected "profit sharing," in which each party's profit is determined collectively rather than individually; and 7.5% selected "innovation and outstanding performance," in which the team is awarded for hard work and creativity.

Respondents were asked if they foresee IPD someday becoming a widely embraced project delivery method in the United States. Experienced respondents (66.7%) believe more strongly that IPD will be used widely in the future. However, informed respondents also agree (58.3%). Almost one-third of the respondents of both groups are still unsure (27% of experienced group and 31.5% of informed group). When owners are analyzed separately, two-thirds of the owners with IPD experience and half of the informed owners believe that IPD will become a widely embraced project delivery method in the future. Respondents were also asked to organize a list of potential obstacles in order of their hindrance to the widespread adoption of IPD. Both groups indicated that business risk and fear of change were the biggest obstacles. Lack of IPD awareness and lack of appropriate legal structure were next on the list for both groups. The obstacles most frequently listed last for both groups were limitations of technology and lack of industry-wide standardization.

While Kent's and Becerik-Gerber's (2010) research represent a first step towards understanding construction industry experience and attitudes regarding IPD, they suggested several other avenues as well. As the construction industry shifts toward adopting IPD, the education system should take a more collaborative approach in teaching and research. Degree programs in civil engineering and construction engineering and management (CEM) need to address new procedural and technological concepts in the undergraduate programs, in more sophisticated masters level courses, and as prime research objectives for doctoral students. While Kent and Becerik-Gerber do not address education within the federal government concerning IPD implementation, similar educational steps could be taken in order to inform government employees on how to execute IPD contracts.

One of the greatest difficulties that Kent and Becerik-Gerber (2010) acknowledge is defining the risks, responsibilities, expectations, project goals, and liabilities when negotiating IPD contracts. All of these items are also heightened when dealing with projects within the federal government.

From the survey data and analysis, Kent and Becerik-Gerber (2010) recognize that the use of IPD by the U.S. construction industry is still in its infancy. Although some professionals have worked on IPD or IPD-like projects, the majority either does not have direct IPD experience or is not familiar with its concepts, which suggests that a focus on education in IPD is necessary. This situation is exacerbated in the federal government as well since it consistently lags behind the general industry in terms of innovation. Considering the high level of interest in IPD and the industry-wide opinion that construction projects are delivered inefficiently, there would seem to be openness toward that further education. Respondents suggest trust, respect, and good working relationships. The majority of respondents prefer IPD to traditional delivery methods. However, contracts specifically developed for IPD are not widely used by the industry, and there are concerns around risk and reward sharing, liability insurance, and open-book accounting. Although several believe that there are benefits, the majority is still looking for more evidence to fully adopt IPD as a project delivery method.

2.3 Lean Construction Literature

Lean construction was born out of the lean production concept. The goal of lean production is to ultimately better meet customer needs while using less of everything (time, money materials etc…). What is unique about lean construction compared to conventional construction is that lean construction relies on these production management principles. Utilization of these principles results in a new project delivery approach that can be applied to any kind of construction but is particularly suited for complex, uncertain, and quick projects (Howell, 1999). Mossman et al (2010) conducted extensive research on lean project delivery and innovation in integrated design. Mossman's et al's (2010) contention is that the idea of integrated design and delivery is not new, and while there has been a gradual shift towards more integrated procurement of construction, it has been piecemeal, partial and is still far from the norm. Mossman et al (2010) also noted that this fragmented status is more prevalent in public sector design and construction.

Mossman's et al's (2010) research intent was to describe action research on a number of related and integrative collaborative processes that they believe enable teams using BIM and virtual construction to integrate design and delivery of projects. The principal processes are: lean project delivery, evidence-based design, set-based design, target value design. Lean project delivery (LPD) emerged in the 1990s and the other three areas are more recent. Target value design (TVD) and evidence-based design (EBD) both belong to lean project delivery, and, like set-based Design (SBD), is more a strategy than a method. Mossman et al (2010) contend that all four methods enable integrated design and delivery. In other words, all four of these techniques/concepts fit under the umbrella comprise of what is generally regarded as lean construction.

While lean construction and IPD share many common traits such as collaboration and innovation, it is important to understand that both are still in fact separate concepts. Additionally, because lean construction developed out of lean production, it can be more accurately thought of a system of techniques, concepts and principles as opposed to an actual project delivery method in the proper procurement sense. It is important to make this distinction clearly in order for one to understand what is meant when it is mentioned that the IPD method includes lean construction. As mentioned previously, although IPD can be executed without practicing lean construction, the effectiveness of the construction process is greatly diminished because many optimization techniques and methods from lean construction would not be used. Mossman et al (2010) do not mention this distinction within their research because they generally assume that IPD and lean construction are the same, and so it is also critical to understand that some (e.g. AIA) recognize this distinction while others (e.g. LCI) do not. For the purposes of this thesis, IPD will be distinct from lean construction. A comparative example of how Mossman et al (2010) view lean construction and IPD as the same thing is shown in figure 2.3.

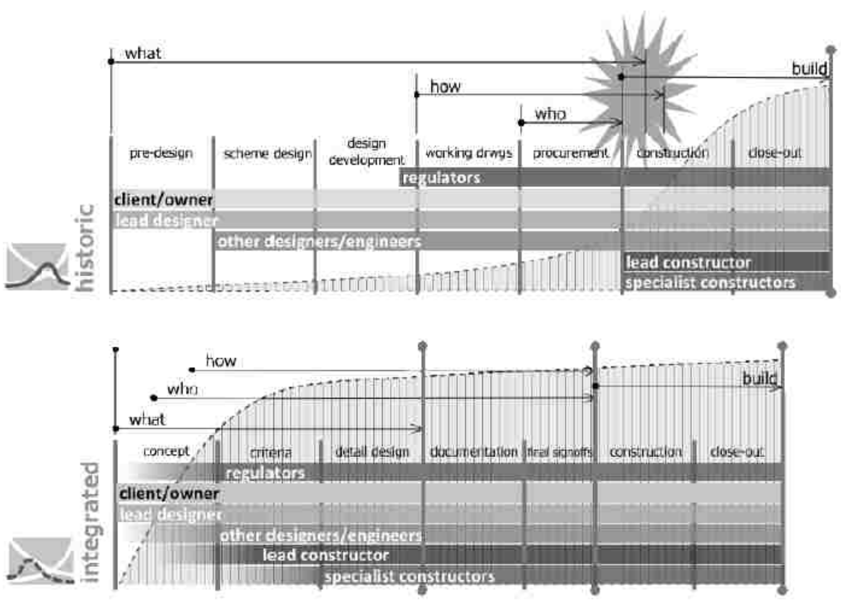

Figure 2.3 Comparison of historic and integrated project delivery timelines & their impact on the development of a shared understanding of the project by the whole team. The integrated model is intentionally shorter than the historic one as that tends to be what happens. The two small graphs to the left of each diagram are "MacLeamy Curves" (CURT, 2004)

Figure 2.3 provides a high level view of the design-bid-build process (top) and an integrated delivery process below. In the top process team members don't come aboard until the design is substantially complete. The vertically shaded background represents the extent to which the whole team understands what the client wants and how the project will deliver it. By contrast, in integrated design & delivery processes the team members join the team at or very soon after the start, they develop their understanding of client need and how it will be satisfied with the designers and are able to develop a cost-effective production process alongside the design.

Figure 2.4 describes the lean project delivery system. It captures both the linear and the iterative nature of the design and construction process and recognizes the importance of certain aspects of design and construction happening in parallel rather than sequentially.

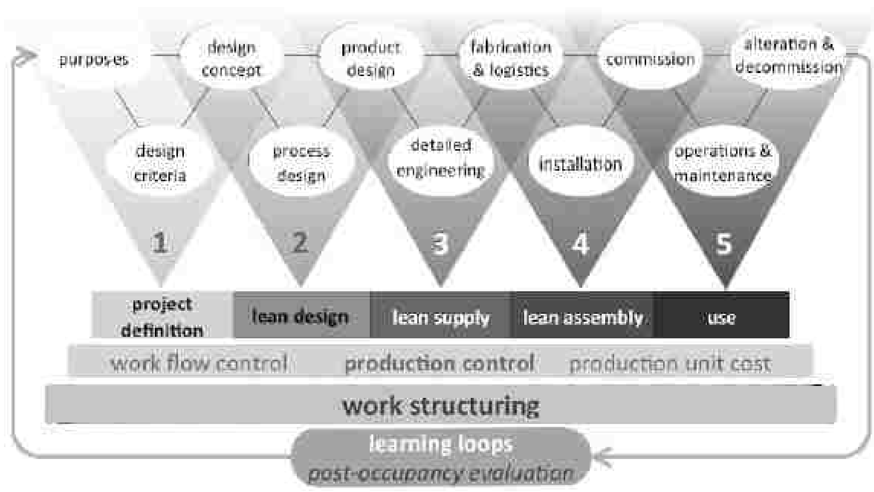

Figure 2.4 The Lean Project Delivery System (LPDS). (Mossman et al, 2010).

Set-based design enables a range of discipline specialists, including contractors, to develop a set of possible solutions to product design and production design problems and then to decide at the last responsible moment. Deciding at the last responsible moment allows the project team time to develop a number of design options in parallel and then choose between them with agreement among stakeholders. All of which reduces the need for later rework. Figure 2.5 illustrates the interaction between a designer and a contractor.

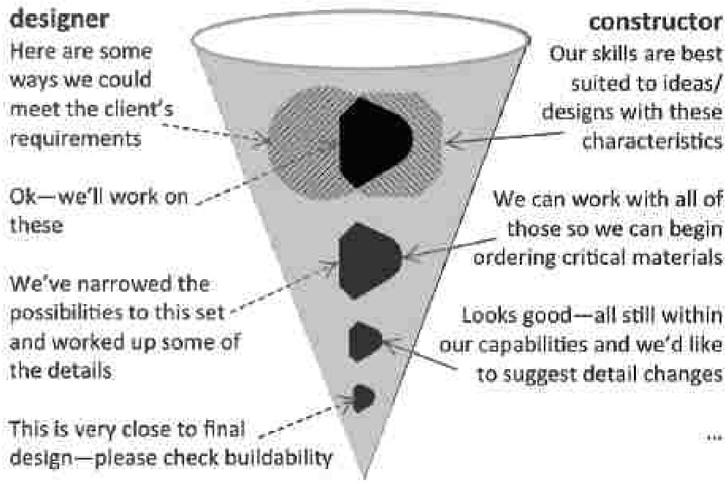

Figure 2.5 Set-based design dialogue. (Mossman et al, 2010).

Within the evidence-based design aspect of lean construction, it exists to help designers make a connection between design and the outcomes that owners want from their buildings. Additionally, it supports SBD. EBD research seeks to establish causal relationships between design decisions and desired corporate outcomes. Currently, EBD is most fully developed in healthcare where evidence from clinicians is available and meta-analyses are possible.

Choosing to use EBD is a commitment to basing design (generating, evaluating, selecting from alternatives) on the best available evidence, and to actively search for and create that evidence. Hence it can be said to be a commitment to research-based design. Mossman's et al's (2010) research reveals that target value design is a collaborative strategy and process for designing based on the articulated project values, which become design criteria rather than mere aspirations. Design is based on detailed estimates, rather than estimates waiting for a detailed design. This requires new skills, the ability and willingness to provide estimates based on a completely different paradigm consisting of incomplete & conceptual designs. Figure 2.6 shows the key stages of the TVD process. It is the primary methodology used to manage the definition and design phases.

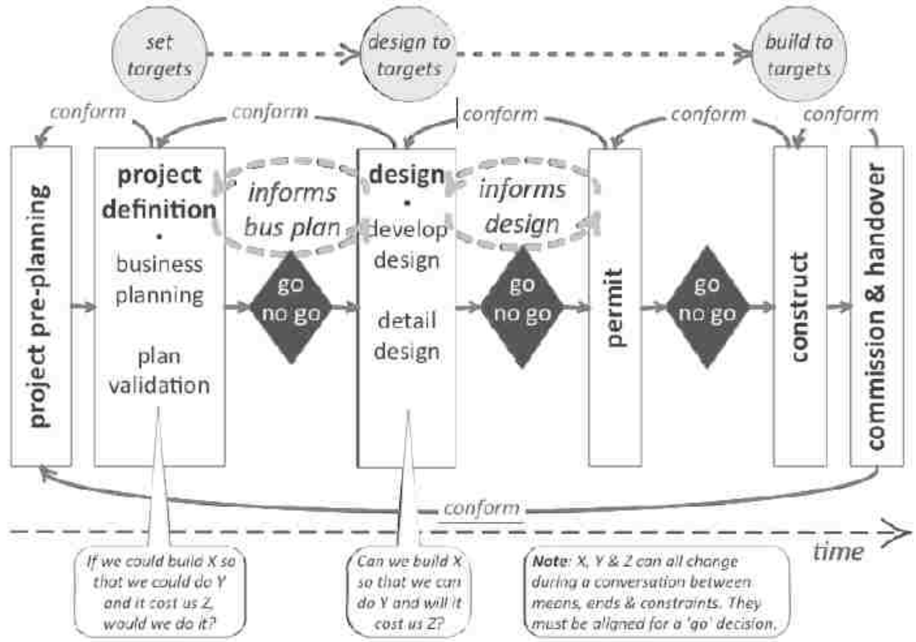

Figure 2.6 The target value design process. (Mossman et al, 2010).

After initial project pre-planning by the owner, the TVD process starts with a project definition phase. This phase seeks to establish a shared understanding of the business case for the proposed building or structure, an allowable cost and time, and to ensure that the project is executable within that cost and time. This process involves the client in building a picture of the activities they envisage in the new facility. The client lets the project team know when project definition is complete. Throughout this phase, all the key players are involved right from the start (early involvement), baseline expectations are explored for ends (what's to be delivered) and constraints (typically time and cost), and the team attempts to validate whether the ends can be provided within the constraints so that it can commit to the design and delivery.

During the lean design process, the team continues to engage with the client to establish the target value. Additionally, the team leads the design effort for learning and innovation, designs to a detailed estimate, collaboratively plans and re-plans, concurrently designs the product and the process in design sets, and tailors design to the user.

What underlies every lean construction project is the Last Planner System (LPS). The LPS is a commitment management system and its principal metric is percent plan complete (PPC), a measure of planning quality, which is the percentage of promises (to do work on or before a specified day) completed when promised. LPS was designed to improve the planning process in project-based production and create a more reliable production schedule. There are five key collaborative methods that together make up the Last Planner System. Each brings its own benefits. When all are working together, they reinforce each other and the overall benefits are greater. The key methods are:

Collaborative pull-scheduling: Creating and agreeing the production sequence

MakeReady: Making activities ready so that they can be done when we want to do them.

Collaborative pull-based production planning: Agreeing production activities for the next day or week and making promises about when they will be completed

Production Management: Monitoring production to help keep all activities on track.

Measurement, learning and continual improvement: Learning about and improving the project, planning and production processes by studying reasons for late delivery and activities that went better than expected.

Mossman et al (2010) conclude that all of the methods and techniques in lean project delivery are what enable integrated design and delivery of projects in the built environment in the US. They also state that these are robust processes that could be used in other contexts and with certain other building types. These inter-related and collaborative processes are integral to Lean Project Delivery.

Finally, Mossman et al (2010) do not recognize a distinction between IPD and lean construction in their particular research because they plainly state that they consider LPD to be IPD. In contrast, AIA does recognize a distinction. Mossman et al (2010) quote AIA's most recent definition of IPD as "a project delivery method distinguished by a contractual agreement between a minimum of the owner, design professional, and builder where risk and reward are shared and stakeholder success is dependent on project success."

In terms of a consistent definition of IPD, it becomes somewhat confusing that Mossman et al (2010) (along with Lean Construction Institute) define IPD and lean construction as the same thing while AIA does not. Therefore, it is helpful to further distinguish between IPD and lean construction by thinking of IPD as providing the structural framework and contractual procurement authority for collaboration and innovation while lean construction provides the specific tools, methods and techniques to enhance the IPD method. From Mossman's et al's (2010) research and from the attempt at delineating between lean construction and IPD, it can be seen that while both can and should be considered separate entities, both are vital to each other and both will function more effectively when utilized together.

2.4 Building Information Modeling Literature

The third key aspect to the implementation of IPD is the use of BIM. While IPD can be executed without BIM, IPD cannot be used to its fullest extent without BIM. Yoders (2008) provides extensive case study research concerning BIM and IPD concerning two projects: the Landmark at San Francisco and the MetLife stadium in Meadowlands. For the purposes of this literature review, only the Landmark will be discussed. From his research, Yoders (2008) has heard from many industry professionals who say that BIM is a lifesaver for complicated projects due to its ability to correct errors in the design stage and accurately schedule construction. Yoders (2008) rightly mentions that BIM and other 3D tools convey the idea and intent of the designer to the entire building team and lay the groundwork for integrated project delivery.

The software developer Autodesk expanded and reconfigured one of the 45,000-sf floors that it leases in the historic One Market Street building in San Francisco. Autodesk VP Phil Bernstein, FAIA, felt that the project represented an opportunity to show how BIM and IPD can make design and construction more efficient.

To achieve integrated design, Autodesk gathered a team that included the San Francisco office of HOK, virtual construction pioneers DPR, and the San Francisco office of Anderson Anderson Architecture. One of the significant steps was that the three firms and Autodesk agreed to form a four-way partnership that stipulated they work together as a team and share all risks and rewards equally: an IPD contract. Every non-owner team member was guaranteed to have its costs covered. Beyond that amount all profit generated by meeting contract benchmarks was put into a profit pool which was divided three ways upon completion. Autodesk also stipulated that the building team make One Market Street (the location of the Autodesk San Francisco office) a showcase for its Revit BIM platform.

Because of the IPD contract structure, gone were the traditional roles of design architect and architect of record. Both architects created a set of models and stamped drawings created from their Revit models. Anderson Anderson designed the briefing center for Autodesk's customers and HOK designed the actual office space. Peter Anderson, principal of Anderson Anderson said, “In the beginning, everyone was somewhat concerned about two architects and how that would work, but this close collaboration has benefited us and, I hope, HOK. We're talking a lot more because of the contract. We're specifying a lot of the same products on both halves of the floor, and even though there's a line dividing us, we've talked a lot about what each firm is planning."

For DPR, which has delivered four integrated project delivery jobs on time and on schedule at the time of this publication, the collaboration was ongoing with both architects. DPR used Autodesk NavisWorks to merge the individual Revit models created by Anderson Anderson and HOK. The general contractor also used a point-cloud laser scan of the existing floor into a final design. The laser scan even took into account the structural integrity of the building's existing slabs and brick columns.

Construction began March 10 2008, and the project was completed in June. The 16-week construction schedule was highly coordinated with all subcontractors.

"Since the design is constantly evolving, even as we go into construction, we have ongoing constructability analysis with everyone at the table figuring out how and what to build within the constraints of the project. For example, by coordinating everything down to the straight-line support wires for the lighting fixtures in the virtual environment, we are eliminating the need for rework in the field," said DPR's Rippingham. "Also, to make sure we hit our turnover date, we ordered the skyfold doors, which have an 8-10 week lead time, even without design finalized." With this highly planned and coordinated project schedule in place, the project team was able to meet the contract's benchmarks.

From Yoder's (2008) research, the success of IPD and BIM together is very obvious. What is not well discussed in the article but is implicit within the project is that every member of the facilities team was committed to making this project work with the unique IPD contract structure and with the utilization of BIM. In other words, while the contract and BIM are important, if the team members were not willing to use these tools, the IPD contract would have failed.

In the previous example, Yoders showed how members in private industry were readily able and willing to utilize the revolutionary techniques of BIM and IPD. By comparison, it is generally well recognized that the public sector lags far behind in terms of innovation and technical ability when executing projects. In a different research effort, Yoders (2008) clearly understood that the federal government does not have the greatest reputation for nurturing positive change in the private-sector industries with which it works. However, during this study, Yoders discovered that one federal agency, the U.S. General Services Administration (GSA), went against the grain and has been actively encouraging the use of building information modeling. The benefits and advantages of BIM were so powerful that the GSA's Public Buildings Service produced the GSA BIM Guide Series. This series serves as specific instructions and mandates for GSA to follow for using BIM in construction projects. In fact, since 2003 that GSA has been aggressively pushing 3D, 4D, and BIM in an effort to encourage architecture and construction firms to rethink the processes and deliverables that it had produced for the last 50 years. This effort by GSA has not gone unnoticed by the architect-engineer (A/E) industry at large. Not only GSA, but USACE also published a BIM Road Map in October 2006 detailing the steps needed for BIM implementation.

At the time of Yoders' (2008) research, it revealed that GSA had provided BIM advice and assistance to the building teams on more than 70 government building projects. The tasks ranged from assisting designers on using BIM software to assuring spatial requirements are met, to adding scope-of-work language to contracts, and to simply informing building teams as to what BIM is and how it can be used. Since GSA began requiring a BIM spatial model for all its projects in late 2006, the agency had put 12 fully BIM-mandated projects on the boards by 2008.

GSA's interest in BIM was born of economic necessity. During the 1970s, GSA had a staff of 42,000, which shrunk to 12,000 (5600 of them in the Public Building Service, PBS) by 2008. PBS owns 1,500 buildings and builds or modernizes about 20 a year. Three decades ago, there was more PBS staff available to check drawings and ensure conformance to standards. A major cause of cost overruns was that space designed for GSA buildings exceeded the program. The U.S. Courts Design Guide defines occupant-based rules for U.S. Courthouse circulation design. In the past, GSA validated circulation design using visual inspection. The process was both time-consuming and error-prone. However, by using BIM, GSA staff could check spatial models required for each of its projects in Washington, D.C., without visual inspections. Two hundred sixteen circulation rules were extracted from the U.S. Courts Design Guide and implemented in the spatial validation program that today requires a BIM model.

Through the U.S. Courthouse effort, GSA realized the usefulness and the power of BIM. It launched the initiative to foster the use of BIM technologies. That program was a rousing success from both a cost-cutting and design excellence perspective. Subsequently, another notable success that GSA experienced with BIM was the new

587,000 sf Social Security Administration Payment Processing Center in Birmingham, Alabama. The center was built using a BIM (Revit) spatial model and achieved LEED Silver certification, thanks in part to the modeling done by lead designer and architect HOK. The project was completed in late 2007.

Yoders'(2008) research also revealed that the USACE was also tackling the switch to BIM head on. USACE has been facing a number of organizational, programmatic, and project level issues-from the Base Realignment and Closure (BRAC) Act of 2005, the ongoing global war on terror, and the transformation of USACE itself that all required a major change to the way it has operated in the past.

Between 2008 and 2014, USACE has been charged with constructing $40 billion worth of facilities under rigorous conditions: For each project, it was mandated to begin construction within the year of the appropriation, complete construction within 18 months of contract award, use design-build, and achieve an average of 20% cost reduction in the facility cost over traditional USACE design, construction, and procurement methods. Additionally, it is the Army's expectation that these facilities will have to be recapitalized for reuse or repurpose at some time in the project's 25-year life due to the constant change in mission requirements.

USACE determined that conventional methods would never be able to meet these demands. BIM was the key to delivering on these demands. In 2006 USACE signed a preferred vendor agreement with Bentley Systems that entitles all USACE sites to unlimited software licenses and software support, unlimited open enrollment training at Bentley facilities, and unlimited attendance at the annual Bentley Conference. USACE is now requiring BIM deliverables for all of its Military Construction (MILCON)

Transformation standard facility types. There are over 40 standard facility types, including barracks, dining facilities, and headquarters buildings.

What is significant to notice is that both GSA and USACE proceeded with using BIM in a very deliberate manner by implementing carefully crafted BIM strategy guides. Minimal contract changes were necessary, and this support towards BIM was something that was generated from the highest levels of both agencies.

While NAVFAC has had projects in which the contractors have utilized BIM, such as the new construction of the $400M Naval Hospital at Camp Pendleton, this is more of an exception as opposed to common practice. NAVFAC currently has no BIM strategy and there are currently no specific efforts in place to generate one. As seen with GSA and USACE, BIM has immensely helped their construction processes. This is something that is critically lacking within NAVFAC's business processes and as budgets come tighter, it will become even more increasingly difficult for NAVFAC to execute construction without the cost savings and increased productivity that BIM provides.

Even with the ever increasingly common understanding about BIM, it is easy to not realize that there are actually various BIM modules for particular phases in the construction process. It isn't simply one application or module that produces a BIM output to handle everything. Vico Software (2013) is an organization that understands this very well. It offers construction management solutions, and also is on the forefront of providing virtual construction software that leverages the power of the 3D BIM model for 4D model-based scheduling and 5D model-based estimating.

Specifically, Vico Software (2013) offers various modules under the overall umbrella construct of BIM, which make up the Vico Office Suite. In the Office Suite, there is a 3D BIM for general visualization. The Vico Constructability Manager module offers the 3D BIM for clash detection. This is useful in providing an integrated solution for clash detection and coordination resolution so that constructability issues can be identified in the planning stage before they occur in the field. There is also a 4D BIM for Scheduling and Production control that is governed by the Vico Location Manager, Schedule Planner, Production Controller, and the 4D Manager. For 5D BIM estimating, Vico Cost Planner and Cost Explorer modules are responsible.

Understanding that BIM isn't simply one program but a myriad of applications that produce different BIM outputs is critical in putting together a robust strategic BIM implantation plan. Combining the work already done from USACE and GSA along with a proper understanding of how BIM is utilized within various modules and different applications will help enable NAVFAC to be able to proceed with BIM implementation in an efficient and effective manner.

2.5 Obstacles to Implementation Literature

Although IPD is innovative and has been proven in many instances to lower costs, and increase quality and collaboration especially in conjunction with lean construction and BIM, there still exist major hurdles for implementation throughout the entire construction industry. Fish and Keen (2012) conducted research to understand the obstacles that limit the use of Integrated Project Delivery (IPD) as a project delivery method in the design and construction industry. They observed three major obstacles to IPD that must be resolved before this delivery method will be embraced by the industry. The three obstacles of implementation include: IPD structure for facilitation, contracts, and insurance. In addition to identifying and examining these obstacles, Fish and Keen

(2012) provided solutions that could be applied to facilitate and encourage IPD implementation within the industry.

In the traditional project delivery methods executed in industry, the architect has typically played the role of project "facilitator." This essentially means that he is the "middle man" for all interaction between the design team, construction team, and the owner and has been responsible for setting meetings, tracking paperwork, etc. In contrast to this, the structure of pure IPD project administration requires the entire team to take on these responsibilities. In cases where the core group has not worked together previously there may be a need for a facilitator, or "director" of the core group during the early implementation stages. The idea of an IPD facilitator is one that makes a lot of sense in the implementation of a new project delivery method. An IPD facilitator is a person that would know all the ins-and-outs of IPD and help to guide the owner, designer, and builder through the IPD process. The IPD facilitator would take the role of a senior executive on the board of an IPD project. This would allow any of the three entities to be in the position of the facilitator role. The idea of the facilitator is that there would be someone to direct the group and a more knowledgeable entity on the workings of IPD.

While having a facilitator is a great benefit, it can be argued that IPD could work well without one. It seems to be more common to have an independent facilitator on projects where the members of the core group have had little to no IPD experience.

The second obstacle focuses on contract administration. There are issues that arise when utilizing traditional construction contracts while implementing IPD as the delivery method. Additionally, Fish and Keen (2012) introduce some of the different contract options currently being used successfully. What owners are sometimes not aware of is that construction contracts applied to traditional construction methods are not suitable for use with IPD projects. The contractual relationships that occur between the different parties involved in construction are much different in IPD from other traditional delivery methods since IPD is relational, while the other methods are transactional. Instead of parties coming entering into the project at various times and only being concerned about their assigned tasks, IPD contracts are designed so that all parties are involved from the beginning of the project and all of the planning, design, and construction is a group effort. This relational contractual relationship is difficult because traditional contracts are not setup for teamwork. This reinforces that traditionally each party manages themselves to minimize their own risks, increasing the separation of the parties, creating adversarial relationships between architects, engineers, and contractors, and minimizing integration and collaborative design.

One issue that Fish and Keen (2012) identified that comes out of contract administration is compensation. Since IPD contracts are relational, this would necessarily involve understanding how exactly compensation is affected for all parties involved. Compensation in IPD projects is a large area of concern especially for those new to IPD as a construction delivery method. There are several different contract types (AIA Document C19-2009, ConsensusDOCS 300, IFOA/IPDA) that were developed for IPD execution that address this. The C191-2009 addresses compensation in a flexible manner leaving the IPD core group to determine the method and the amount of compensation that each party will receive, but is contingent on the success of the project. Each party agrees to deliver their services at cost while profit is earned by goal achievement compensation and incentive compensation. Goal achievement compensation is compensation that is received by the parties for "successful achievement of certain project goals." The IPD team works together to determine the project goals early on in the process and the amount of compensation that will be associated with the project goals. This form of compensation is an all-or-nothing form of profit. If the set goal is met, all non-owner IPD core group members receive the chosen profit compensation, but if the goal is not met, no one receives profit compensation.

Incentive compensation is paid to the parties as a portion of the difference between the actual cost and the target cost. The target cost is another item that is determined by the IPD team. ConsensusDOCS 300 and IFOA/IPDA also handle profit similarly to C19-2009 in that ConsensusDOCS 300 and IFOA/IPDA also approach it from an incentive fee standpoint.

Insurance is a third significant obstacle that Fish and Keen (2012) identified in moving toward integrated project delivery. IPD contracts are not consistent in regards to this topic. Some contract formats encourage "no suit" clauses that waive all liability between parties to promote team collaboration. As of 2010, no insurance policies or products cover multiparty agreements. Even if every party in the IPD core group carries its own liability insurance, the team/contract as a whole would not necessarily be covered. Because of the collaborative and relational nature of IPD, its goal is to have coverage for all the parties and the project under one policy. IPD success is hinged upon the insurance companies providing ways to underwrite the insurance policies.

One way to address this issue is to revert back to traditional risk allocation where each party of the team is completely liable for any negligence, breach of contract, and warranties on its part. This choice is similar to traditional contracting and project delivery methods. However, traditional risk allocation strays from IPD goals in that it takes the trust needed for an IPD project out of the equation since now all team members would only be liable for their own mistakes.

Even with the advantages that IPD offers, the three obstacles described above are items that need to be addressed. The first obstacle, the structure of facilitation is the largest area of disagreement among the proponents of IPD. There are two ways of structuring the facilitation: the core group and the IPD facilitator. The core group is what IPD is based on but because of lack of knowledge about IPD throughout the industry, the IPD facilitator is a good alternative when new to the implementation of IPD. When the option is retained to either have a facilitator or not, this creates more flexibility for those parties that become more adept at IPD, and therefore eventually don't need a facilitator. This concept of a facilitator is in fact not new, and traditional projects use a facilitator albeit he is used during partnering sessions, and not for the managing of the contract. However, when an IPD facilitator is initially used, this can be viewed as an extension of the present traditional facilitator concept as opposed to something that is completely new.

In terms of contract administration, it is critical to understand that a project cannot fully and properly implement IPD if traditional contracts are being used. Since traditional contracts cannot handle the issues of early participant involvement, compensation, and insurance, it would be beneficial to use one of the three contract documents that can be used to circumvent the traditional contracting methods AIA C191-2009, ConsensusDOCS 300, and IFOA/IPDA). Each of these documents is unique and slightly different from the other two, but all can be used just as effectively as the other for IPD. The issue of insurance is still an area of concern because the design and construction industry is relying on the insurance industry to create a comprehensive policy that could protect all parties involved in the IPD process. Although these are large obstacles, with knowledge and research they can be resolved in order to enable increased IPD implementation into the industry.

These three obstacles are also items that the federal government would have as well for barriers to IPD implementation. Because of the excessive regulatory nature of federal procurement and contracting, the role of the IPD facilitator would have to fall upon someone from either the base public works department or NAVFAC. Finally, the issues of insurance coverage would be very similar to industry concerns.

Rekola et al (2010) also performed similar research in terms of barriers to implementation, but were more specifically focused on BIM and the design process within a construction project. Although Rekola et al (2010) do not specifically mention IPD, many of the challenges, if not all, would be applicable to IPD when it is coupled with BIM. New technology and new design tools, such as BIM, have become available but their adoption by the industry has been somewhat slow. It has been shown that design and construction firms are adopting building information modeling more slowly, compared with the adoption of two-dimensional computer-aided design in the past.

In their research, Rekola et al (2010) discovered different reasons for slow adoption of BIM. To capture the full benefit of BIM tools, firms in project networks must coordinate and develop interoperable business practices. Additionally, there is a need to redefine the work processes and roles that each player must have in the future, in addition to national BIM standardization. All of this point to what the AIA reports as the number one obstacle for utilizing interoperability: "There is a lack of understanding on the part of industry participants of how to achieve integrated workflows through integrated technology."

Rekola's et al's (2010) objective was to understand and reveal the barriers and challenges of integrated design and delivery system (IDDS) processes. What are the reasons for the slow adoption of BIM and what are the problems to solve so as to help the change of the construction processes and transformation of the industry towards an integrated design and delivery solutions (IDDS)? Through this research, Rekola et al (2010) identified the process points that needed development so that the implementation of BIM would be possible in the best and most productive way. They also identified the shortcomings in the software tools so that the tools could be developed to be more usable and to better suit the working processes of designers, consultants and other participants.

From their research, Rekola et al (2010) have determined that IDDS refers to using collaborative work processes and enhanced skills, with integrated data, information, and knowledge management to minimize structural and process inefficiencies and to enhance the value delivered during design, build, and operation, and across projects.

This is very similar to IPD. The only difference is that IDDS focuses on design management before construction while IPD seeks to manage the entire project from design to final completion.

The research was a qualitative explanatory case study. Rekola et al (2010) used a research method that was developed and frequently used by Helsinki University of Technology (HUT) Enterprise Simulation Laboratory (SimLab). The method combines a background study of literature and case data, interviews and group discussion workshops, called process simulations.

Rekola et al (2010 based their research on a single case study of a project in which BIM and IDDS (very similar to using IPD in the design phase) were applied in a very advanced way, considering the year of 2006. BIM was used in inter-organizational operation and communication, and in various analyses. The studied case project was a public university building developed by public building owner. The study consisted of reviewing primary project documentation, single-person and small-group interviews, and a whole day process simulation. The project documentation included project schedules, a project development plan, minutes from meetings of the design team and minutes from building site meetings.

A central tool of the research approach was a design process map. It is an evolving presentation of the process of the project and it is modified based on the inputs from the interviewees. The workflow was studied and the process was documented in as much detail as possible, considering the broad scope. The finalized process map was used as the discussion object in the process simulation where all the interviewed people were present to share their knowledge, opinions and feelings concerning the project.

With the map, the discussion was focused on questions that researchers had identified as the most important and interesting, from the point of view of the process change and further development. Numbered points in the process identified the problems or benefits. Figure 2.7 shows the process map that was used in the study and a zoomed snapshot of a certain portion of it. In addition the process map, process simulation was used. This involved a day long facilitated group discussion workshop, which was attended by 23project individuals. In the workshop, the benefits and challenges related to BIM and IDDS were discussed and the process development issues were further validated.

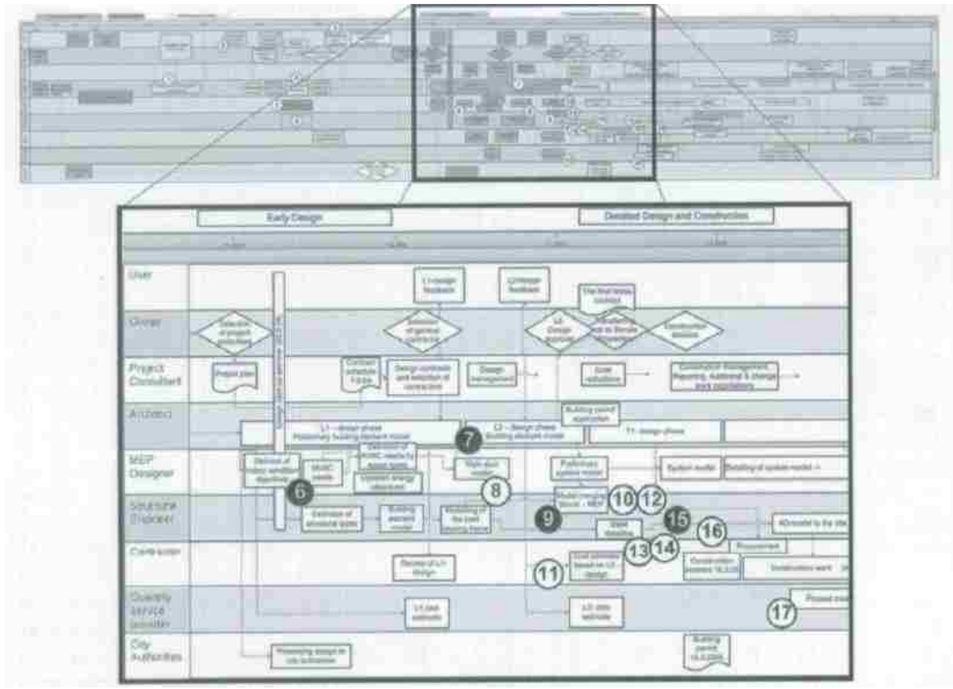

Figure 2.7 A process map describing the events, decisions and data flow. The project stakeholders are listed along the rows and time runs to the right. The challenges and benefits of the technology numbered and pinpointed to the process context. (Rekola et al, 2010).

After the simulation day, the process map was updated as a result of validation at the workshop. Based on the framework, the perceived problems and benefits were classified into three general categories: process, technology and people. A concise table of the problems and the categories are presented in Table 2.4. A problem was considered a “people” problem if it involved a competence or knowledge problems, or was related to collaboration or attitudes. Problems related to workflows, timing, procurement and contracts, or roles were categorized as process problems. Technology problems were mainly software originated. Even with these neat and clean categories, given the complex nature of the problems, most of them fell into at least two categories, sometimes even in all three.

An example of a problem that had multiple aspects was that steel parts, not belonging to the building frame, were not modeled (number 16 in Table 2.4). This was because the structural frame was designed by a structural engineer, modeled and later fabricated, but other steel structures were designed by another fabricator and not modeled or otherwise coordinated with the structural frame design before structural frame fabrication. As a result, connecting parts had to be welded to structural frame parts on site, instead of as part of prefabrication. This was considered a process problem, because it had to do with the procurement and timing and coordination of design and fabrication. It was also considered a competence (people) problem, because there was no prior experience among project participants of model-based design and fabrication at the scale piloted in this case.

	PINPOINTED BENEFITS AND PROBLEMS WITH THEIR ASPECTS	PROCESS	TECHNOLOGY	PEOPLE	BENEFIT
Conceptual design phase					
1	Visualization of spatial group model for end-user and client				X
2	Delays in modifications of spatial programme and additions	X			
3	Energy simulations as basis for alternative solutions				X
4	Unusually early modelling of facades and window openings before actual design of facades	X	X	X	
5	Structural alternatives were not consulted in design of alternatives	X			
Early design phase					
6	Space-specific MEP requirements on basis of space-specific ambient condition goals				X
7	Architect's model for technical space reservation (for collision checking with MEP model)				X
8	Main MEP routes were modelled too late from structural designer's point of view	X	X	X	
9	Visual collision checking				X
10	Too many insignificant collisions reported in automatic collision checking		X	X	
11	Quantity take-off problems	X	X		
Detailed design and construction phase					
12	Penetrations were not possible to be communicated based on models		X		
13	During steel detailing, structural designer had to make assumptions due to unavailability of some architectural details at the time	X			
14	MEP system model was available too late for structural design and detailing	X	X		
15	Integration of steel detailing and fabrication				X
16	Non-bearing steel structures were not modelled	X		X	
17	Phased model for quantity and cost calculations was isolated from design models	X	X		
18	4D structural frame model on site				X
19	4D structural frame model arrived too late for full utilization on site	X			
20	Quantities from MEP model were not utilized in procurement of mechanical equipment	X	X	X	
General problems					
21	Team building, selection of designers and contractors	X			
22	Sharing and utilization of incomplete models/model views		X	X	
23	(Unsynchronized) Information in parallel sources	X	X		
24	IFC usability problems		X	X	
25	IFC translation problems		X		
26	Problems in model-based costs calculations	X	X		

Table 2.4 Table of problems and their classification. (Rekola et al, 2010).

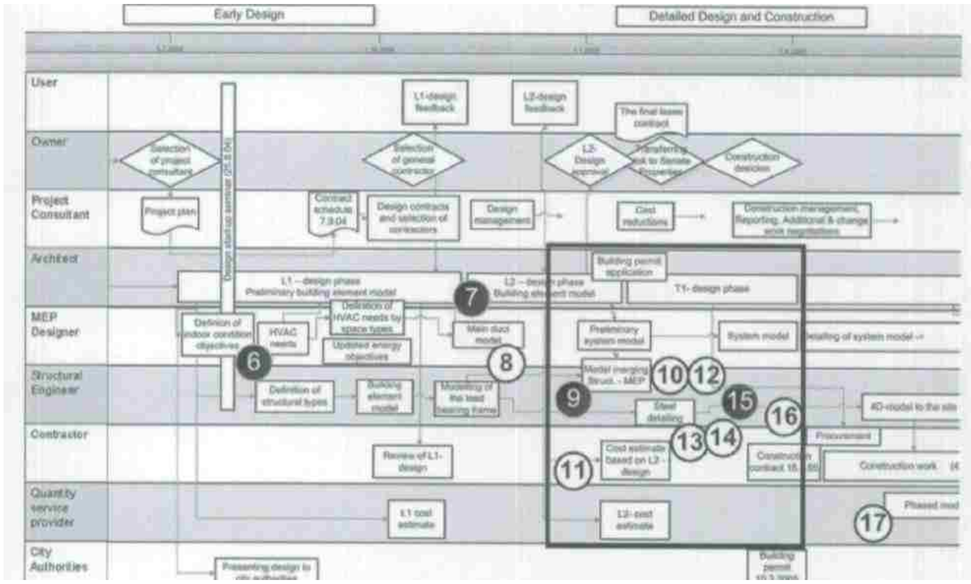

Figure 2.8 A process map snapshot from the detailed design. (Rekola et al, 2010).

Rekola et al (2010) examined possible solutions to the problem which included changes of design contents or changes and enhancements to the design coordination. These would further mean changes in roles, contracts, procurement models and changes in project management. This can be thought of as a complex mixture of developments, requiring changes in multiple organizations and process phases. Rekola et al (2010) have cited that some have referred to this as systemic innovation.

What is noticeable about this example is that this is exactly a problem that IPD was designed to address. This example is evidence of how no effort for collaboration or integration within the overall design team caused significant problems in the field. Additionally, because of the lack of experience with BIM within the design team, this further compounded the design problem.

Rekola et al (2010) also discovered that the process simulation was effective in creating a mutual understanding of the entire process and the reasons and needs for change in one's own work. Because of the fragmented practice in building projects, the understanding of the whole process has become a rare skill. This concern was stated repeatedly in the interviews.

Open dialogue and common understanding of the process were seen as one solution to tackle unsatisfying interfaces, poor commitment, lack of team synergies and general fragmentation. This meant that understanding the processes holistically played an important role in implementing BIM-supported new integrated processes. While Rekola et al (2010) were primarily focused on the design aspects of a project, IPD goes beyond this and addresses these integration and collaboration concerns through the entire project life-cycle. With IPD's emphasis on collaboration and contractual risk sharing, these problems due to interface, poor commitment etc… become greatly mitigated.

Based on this research, Rekola et al (2010) concluded the slow adoption of BIM and minor development and changes in the construction process are caused by the difficulty of combining development efforts in technology, process and people. This difficulty is really a symptom of the fragmented and archaic methods that the construction industry has utilized for more than 100 years. Additionally, because of this fragmentation, it has been hard to see that technological issues, work and business process issues, knowledge and human factors are interconnected. Rekola et al (2010) used the process simulation workshops of this research to expose this interconnectedness in order to increase the mutual understanding of the process and its problems, and ultimately to raise the collective will to change current practices.

Utilizing BIM efficiently requires tight integration of the project network to the project right from the beginning. Rekola et al (2010) contend that it is especially beneficial to have the whole design team and the cost estimator participating early on, but also that expertise from the contractor perspective is probably needed. Hence, the owner needs to decide on how to allocate these resources to the project. Apparently, this would mean inventing new bidding and contracting practices to get the participants involved early enough. In addition, the use of BIM needs to be acknowledged in contracts so that the responsibilities of different stakeholders are defined at the beginning of a project.

The conclusion that Rekola et al (2010) came to regarding early involvement and inventing new contracting practices indicates that the concept of IDDS are not enough. While IDDS does attempt to bring all participants in early, it has no contractual basis behind it, and therefore it will not be as effective. Therefore, while some participants on projects will be more willing than others to follow IDDS principles, there will still be some hindrances for BIM utilization even when a project is executed well. Only through the contractual strength of IPD in which the requirement for collaboration and integration is legally mandated will a project see the fullest power of BIM.

2.6 Government Documentation

Every four years, NAVFAC generates a command wide strategic plan that provides an outlook between 4-8 years beyond the time of publication and outlines a deliberate course of action for its future. In the 2013-2016 NAVFAC strategic plan, there are three focus areas: enabling the warfighter, acting judiciously, and maintaining readiness (NAVFAC, 2013). NAVFAC enables the warfighter by delivering quality, timely and cost effective products and services to ensure that he has the proper logistical resources to execute his tasks. NAVFAC also focuses on acting judiciously by making decisions and executing work based on sound analysis that reinforces fiscal responsibility. Finally, readiness is maintained by advancing the talent and initiative of its highly capable workforce.

This strategic plan affects the entire organization of NAVFAC worldwide, and the intent is for all field offices to align their daily activities to this strategic plan by localization of those three focus areas.

The vision of enabling continuous mission success for the warfighter is accomplished within the framework of the three focus areas by the fulfillment of seven strategic goals: (1) providing capabilities for forces to maintain forward presence, (2) maintaining agility to support changing operational needs, (3) providing safe and efficient utilities systems, (4) fulfilling all energy goals, (5) increasing productivity by optimizing cost, (5) schedule and performance across the life cycle, (6) ensuring financial and moral accountability, and (7) promoting a safe efficient, and supportive culture that fosters agility, accountability and productivity.

One of NAVFAC's goals is to maintain readiness. This particular goal has not changed from the 2010-2017 NAVFAC strategic plan to the current plan. However, the previous strategic plan was more specific in describing readiness by identifying the need for high performing teams that are integrated, collaborative and results-oriented. Similarly, the previous strategic plan provided more specific and detailed guidance on how to maintain and increase performance than the current strategic plan does, particularly the goals of adapting and innovating by creating and leading innovative teams and pushing towards progressive solutions regarding information management and technology. While the current strategic plan does not go into more detail as the previous strategic plan does, the current plan still maintains all of the intents of the previous plan, albeit simply in a more generalized fashion. Therefore, it would be safe to assume that both strategic plans accurately reflect NAVFAC's overall current culture and where it wants to eventually be.

With this in mind, some connections can easily be seen as to whether or not it would be feasible to implement IPD within NAVFAC. NAVFAC desires to promote integrative and collaborative high performing teams, and adaption and innovation. IPD is inherently collaborative and integrative, and especially with the usage of lean construction techniques and BIM this is a strong indication that IPD can be a robust solution and an excellent complement to NAVFAC's current usage of the DB and DBB project delivery methods. However, even though NAVFAC's culture appears conducive to IPD implementation, there are still some cultural barriers and significant legislative obstacles to overcome. These will be discussed in Chapter 5.

In addition to supporting the US Navy and all of its installation worldwide, NAVFAC's other significant end user/client is the US Marine Corps. The USMC recently stood up its own facilities command organization called Marine Corps Installations Command (MCICOM). MCICOM exercises command and control of Marine Corps Installations via regional commanders in order to provide oversight, direction, and coordination of installation and facilities services (MCICOM, 2012). Although MCICOM is tasked with overseeing all facilities and installation related issues, it still relies on NAVFAC to perform the engineering, design and construction of facilities and associated infrastructure on USMC installations. Because both NAVFAC and MCICOM are reflections of their respective parent organizations, and because they are in fact functionally different organizations, there has been a great deal of conflict, misunderstanding, and coordination misalignment that has significantly hindered facilities management and construction for the USMC. In response to this, the commanders of NAVFAC and MCICOM issued a joint memorandum of agreement on November 29, 2012 that established the NAVFAC-USMC Facilities Organizational Alignment Operational Planning Team (OPT). The OPT is responsible to develop recommendations and draft guidance to implement approved courses of action for improved organizational alignment and a strengthened supporting-supported relationship between NAVFAC and USMC and its installations.

There are five deliverables that the OPT is expected to develop: (1) a revised NAVFAC organizational structure, (2) a standardized USMC installations facilities organizational template, (3) improved alignment between NAVFAC and USMC, (4) a NAVFAC OICC MCIEAST and MCIWEST transition plan, and (5) an improved Navy Civil Engineer Corps (CEC) assignment and community management across the Marine Corps. The last deliverable will not be discussed since this involves issues related more to personnel and community management as opposed to facilities engineering or construction engineering and management.

All four deliverables interact with and are dependent on each other to a certain extent. Deliverable #1 recommends revising the existing NAVFAC organizational structure by making changes at every structural level ("Echelon" II, III, IV, V). The intent behind proposing structural changes is to best deliver products, services and support to the USMC. At the same time, MCICOM understands that it needs to follow suit as well by fulfilling Deliverable #2 by proposing a consistent organizational structure for facilities and public works departments at all USMC installations. This consistency would greatly enhance working relations and alignment with various NAVFAC entities and promote business and engineering process standardization.

Deliverable #3 seeks to improve alignment between the USMC and NAVFAC by recommending standardized, defined and formalized supporting-supported relationships in order to provide improved consistency, communication, and partnership. It also involves defining appropriate alignment between the two organizations, and addressing alignment of financial information tracking and reporting and project level tracking and reporting.

Deliverable #4 seeks a transition plan to disestablish the construction arms for both west coast and east coast USMC installations (OICC MCIEAST and OICC MCIWEST), and establish a plan for follow-on organizations to provide the requisite level of support required.

What can be concluded from these deliverables is that they all identify that there are serious organizational deficiencies from both organizations and that there is a great need to have better integration and better alignment at all levels for both NAVFAC and MCICOM. Additionally, it is clearly recognized that these organizational deficiencies lead to substandard performance, efficiency and integration. Not only does this alignment effort keep in line with the intent of the NAVFAC strategic plan to support the warfighter and produce integrated teams, it has the potential to change and develop both organizations to be able to support IPD.

Within IPD, the basic construct consists of the owner, architect, and the general contractor. Typically in industry, the owner is one entity. In the case of NAVFAC and the USMC, the "owner" is not only the local end user at that particular base, but it also involves the base public works office which acts as the end user/client representative, the local NAVFAC construction office (Resident Officer in Charge of Construction, ROICC), the respective regional organizations that oversee the local NAVFAC construction office (regional facilities engineering command) and the base public works office (Marine Corps Installations West, East or Pacific), and the respective corporate and higher headquarters organizations, some in various locations and others located in Washington D.C. (NAVFAC Atlantic, NAVFAC Pacific, NAVFAC Headquarters, and MCICOM).

In order for IPD to be executed properly within the federal government, it is critical that all of the members that consist of the government "owner" be properly aligned internally in order to provide a consistent and clear voice to the architect and general contractor. With the efforts currently underway as directed by the memorandum of agreement, NAVFAC and MCICOM are well on their way to make the environment conducive from a cultural standpoint for the implementation of IPD.

While making efforts to induce structural change and better internal alignment is necessary for the implementation of IPD within NAVFAC, none of these efforts address the legislative regulations by which NAVFAC operates. NAVFAC, along with the rest of the federal government, is governed by the Federal Acquisition Regulation (FAR). The FAR is the primary regulation in use by all federal executive agencies in their acquisition of supplies and services with appropriated funds. It is comprised of 53 parts (chapters), in which Part 36 deals specifically with construction and architect-engineer contracts. There is also a DOD specific FAR supplement called the Department of Defense Federal Acquisition Regulation Supplement (DFARS). The US Navy produced its own regulations as well called the Navy-Marine Corps Acquisition Regulations Supplement (NMCARS). Funneling down even further, even NAVFAC itself has its own acquisition regulation called the NAVFAC Acquisition Supplement (NFAS). As the regulations proceed from large (FAR) to small (NFAS), the regulations become more restrictive.

Within FAR Part 36, various items within contract procurement are discussed that would be familiar to those in construction industry such as liquidated damages, site inspection, notice of award, and architect-engineer services. Related to this discussion concerning project delivery methods, the only two methods acknowledged are design-build and design-bid-build. Additionally, in other parts of the FAR, the procurement methods of fixed price incentive firm (FPIF) and fixed price award fee (FPAF) are discussed. FPIF involves rewarding contractor achievements in exceeding quantifiable standards (profits increase) and negatively rewarding (decreased profit) contractor's failures to reach said standards. FPAF contracts establish a fixed price, including normal profit, paid for satisfactory contract performance. An award fee is paid in addition to the fixed price based on an award-fee plan, if the contracting officer deems so. Award fees are used to motivate a contractor, since other incentives cannot be used when contractor performance cannot be objectively measured.

A cursory glance at the FAR and also the other acquisition regulations would indicate that the nature of the federal government's procurement and contracting is transactional instead of relational. It can be clearly concluded that IPD is not a current project delivery method that the federal government uses. Although the federal regulations are not currently set up for relational contracting, hence IPD, it does utilize FPIF and FPAF which can, in certain contexts, be perceived as rudimentary procurement precursors to relational contracting. Though there is still no sharing of risk within FPIF and FPAF, there are elements of positive consequences for good performance and negative consequences for poor performance or performance that does not meet standards. Because of this and the previous discussion concerning NAVFAC and its strategic plan, good justification can be made for the federal government to execute a transition from transactional to relational contracting through the FAR. Of course this is much more difficult to execute in reality since this would involve changing congressional legislation, but given the body of evidence just discussed, implementation of IPD within the federal government would be a worthwhile endeavor.

CHAPTER 3

RESEARCH METHODOLOGY

This research analyzes the responses from the survey questions from US Navy Civil Engineer Corps officers, and Department of Navy facilities and construction professionals. The responses were obtained between March 2013 and May 2013.

Through analysis of the responses, the general culture of facilities management and construction within the government sector was determined. Additionally, this understanding of the general culture allows us to answer the previously mentioned research objectives:

1. To determine what techniques can be implemented and integrated within existing NAVFAC culture, processes and protocol. In other words, what key process elements can be modified to accommodate IPD immediately?

2. To determine what will be necessary to fully implement IPD in NAVFAC as a viable construction project delivery method.

   a) What changes would be required to the congressional appropriations process?

   b) Changes to various federal acquisition regulations?

   c) Changes to NAVFAC Business Management System (BMS, existing NAVFAC protocol)?

3.1 Outline of Research Methodology

The methodology consists of six steps described below. The six steps are as follows:

- Definition of scope and objectives

- Review literature
- Develop survey questions
- Identify target population (convenience sample)
- Collect and analyze data
- Propose conclusions and recommendations

3.1.1 Definition of Scope and Objectives

The major objective of this research is to determine how IPD can be implemented within the Department of the Navy. The results of the survey and the analysis of current NAVFAC engineering and business processes will enable a realistic picture of that implementation. The detailed research objectives, background, study objectives were described in Chapter 1.

3.1.2 Review Literature

A thorough review of pertinent literature is critical to gaining a strong grasp of the research problem and the context in which it resides. Various publications, such as academic journal articles, research white papers, and trade and organizational publications were studied in order to finalize the research methodology and to refine the scope of the research. Literature review was presented in Chapter 2 and the publications used during this research are listed in the reference section.

3.1.3 Develop Survey Questions

There were 33 questions that comprised the survey (Appendix A). The survey consisted of questions that are generally grouped around six areas:

- Area 1: General Demographics – This section consisted of questions related to job description of the survey participant, duration at current job, rank (if military), and number of years in facilities work.

- Area 2: Building Information Modeling – This section collected information on participants' understanding of BIM, experience in BIM, and their assessment on the feasibility for NAVFAC to implement BIM.
- Area 3: Pricing/Procurement Method – This section consisted of questions that asked participants' understanding and assessment of current federal government pricing/procurement methods.
- Area 4: Project Delivery Method – This section consisted of questions that related to participants' assessment and experience concerning traditional project delivery methods.
- Area 5: Lean Construction and IPD – This sectioned inquired about participants' current level of knowledge concerning lean construction and IPD. This section also asked questions on whether IPD should be implemented within the federal government.
- Area 6: Partnering and Collaboration – This section collected information on the current state of partnering between the federal government and contractors and also the assessment of internal collaboration between various government agencies (i.e.: USMC and NAVFAC).

3.1.4 Identify Target Population (convenience sample)

A convenience sample of 52 participants was used to conduct the survey. The participants were selected from this researcher's previous interactions with them during his time at Camp Pendleton and NAVFAC Southwest (NAVFAC SW). The pool of participants works throughout the Southwest region at Camp Pendleton, Marine Corps

Air Station (MCAS) Camp Pendleton, MCAS Yuma, MCAS Miramar, Marine Corps Mountain Warfare Training Center Bridgeport, and NAVFAC SW located in San Diego. From these locations, participants came from both the USMC facilities organizations and NAVFAC organizations. The participants were selected due to their extensive involvement of facilities work currently going on within their respective organizations.

3.1.5 Collect and Analyze Data

Phone calls and email messages were sent to 55 people and 52 responses were returned. During the phone interview, the questions were asked and the answers were recorded onto an Excel spreadsheet. Each interview lasted anywhere between 10-30 minutes. Within the convenience sample, great efforts were expended to ensure that all levels of hierarchy were interviewed. The highest ranking individuals were US Navy captains, while the lowest ranking participant was simply an engineering technician.

After the collected data were recorded, they were categorized in terms of research areas and common themes. Excel data analysis using various pie charts and bar charts were used to identify trends and patterns. The intent of the survey was to attain information from individuals who worked at NAVFAC and the USMC installations in order to get an approximate understanding of the state of construction within these two organizations. Detailed procedures regarding the data analysis are described in Chapter 4.

3.1.6 Propose Conclusions and Recommendations

The conclusions of this research, its limitations, and the scope for further research are discussed in Chapter 5.

CHAPTER 4

DATA AND RESULTS

4.1 Area 1: General Demographics

Within the 52 personnel sampled, 63% (33/52) were members of NAVFAC while 37% (n=19/52) were members of the USMC installations.

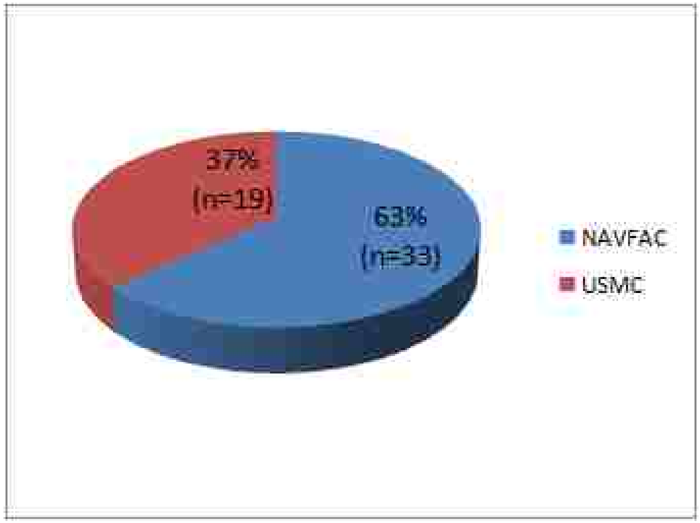

Figure 4.1 Overall demographic of sample

Within NAVFAC, 42% (14/33) were classified at “individual contributors” level, 45% (15/33) at the “management” level, and 12% (4/33) at the “senior executive” level.

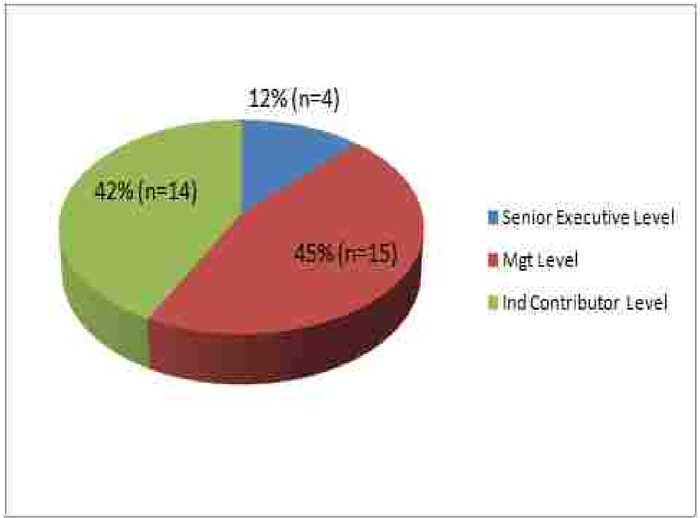

Figure 4.2 Composition of NAVFAC sample

Within the USMC installation organizations, 32% (6/19) were classified at "individual contributors" level, 47% (9/19) at the "management" level, and 21% (4/19) at the "senior executive" level.

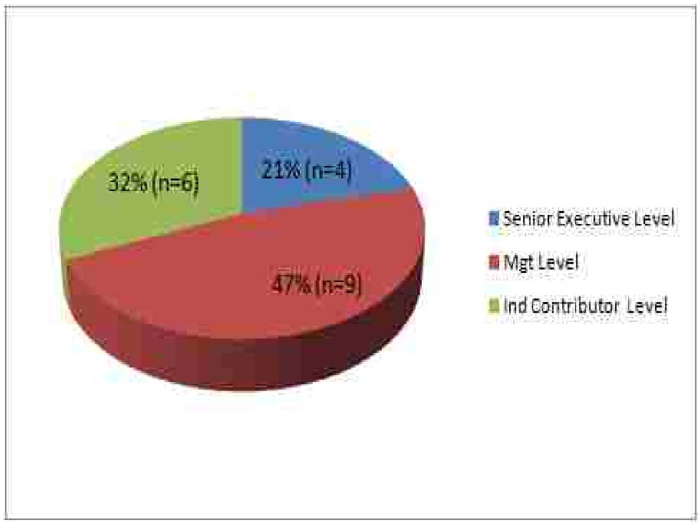

Figure 4.3 Composition of USMC Sample

Within both NAVFAC and USMC, the majority of the survey respondents had between one and five years in their current job, 67% (2/33) and 53% (10/19) respectively.

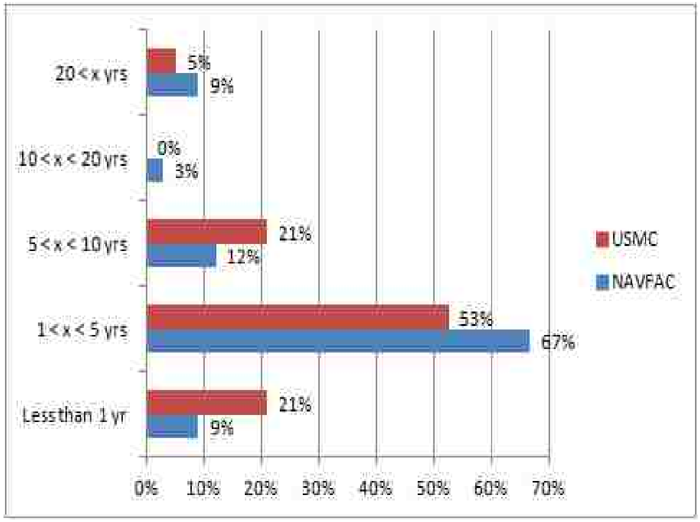

Figure 4.4 Length of Time in Current Job

Regarding the number of years within the overall construction process (from initial planning/programming of funds to construction to project close-out), the largest percentage for both organizations came from those workers that had more than 15 years experience.

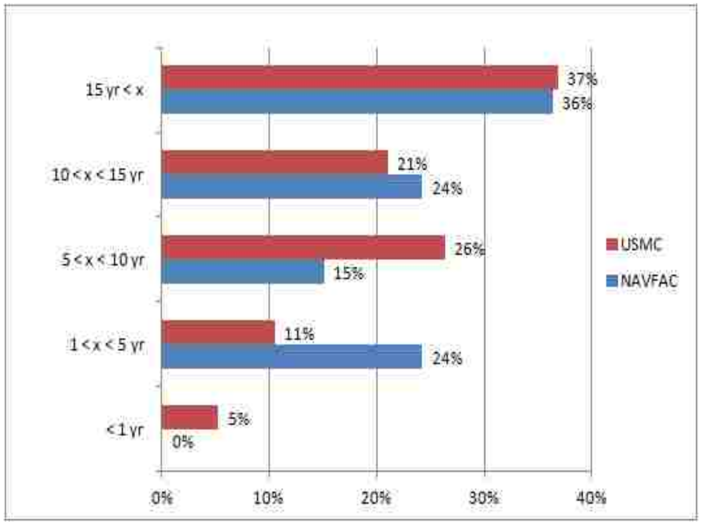

Figure 4.5 Overall Experience Within the Construction Process

In terms of the amount of experience within the actual construction execution itself, the results were varied, and it isn't immediately easy to determine which organizations had the most number of years experience.

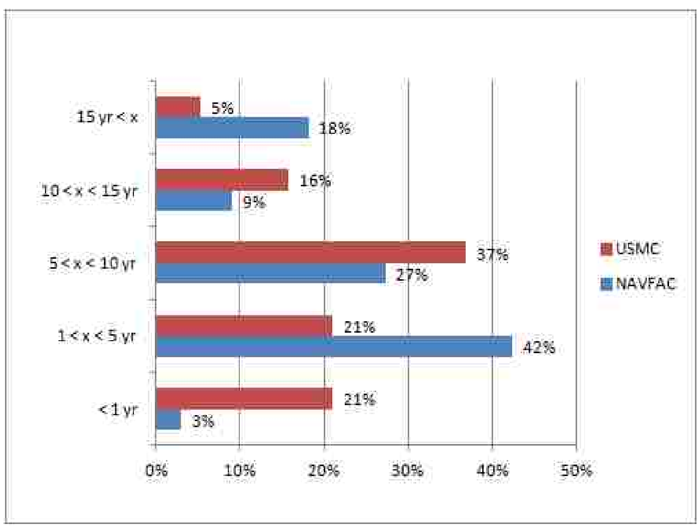

Figure 4.6 Specific Experience Within Construction Execution

4.2 Area 2: Building Information Modeling

In terms of familiarity with BIM, an overwhelming majority of both NAVFAC (94%, 31/33) and USMC (84%,16/19) employees responded that they were familiar with BIM. Even with this overwhelming majority of personnel who are familiar with BIM, the percentage of people who oversaw BIM projects drops dramatically (NAVFAC: 33%, 11/33; USMC: 5%, 1/33).

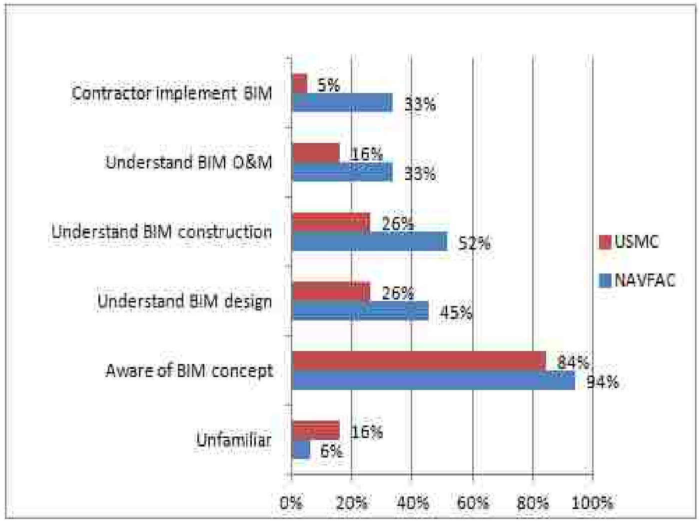

Figure 4.7 Familiarity with BIM.

When asked as to whether NAVFAC should implement BIM on construction projects, the majority of NAVFAC personnel were in favor of it (76%, 25/33), yet this figure is not as high as those who said that they were familiar with BIM. For the USMC, the percentage of those who wanted NAVFAC to implement BIM was not quite the majority (47%, 9/19).

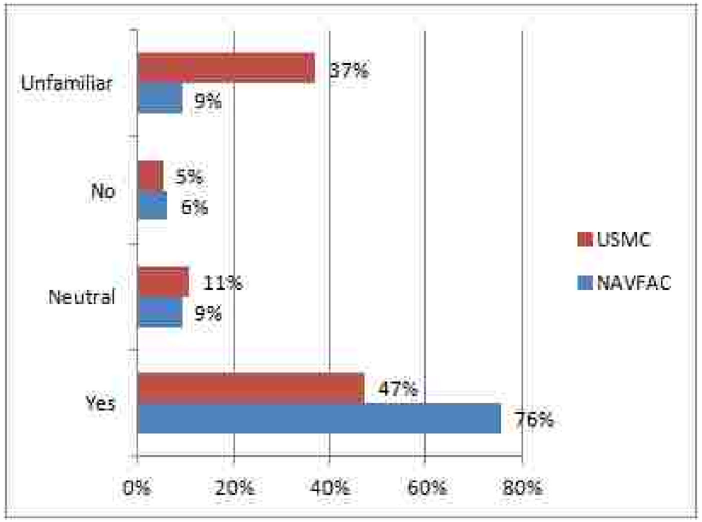

Figure 4.8 Implementing BIM by NAVFAC

For those personnel who said that they wanted NAVFAC to implement BIM, there seemed to be a consensus (between 67%-100% for each answer) that all of the properties listed in the answers were valid reasons. This generally shows that this group of personnel recognizes the various advantages that BIM has to offer.

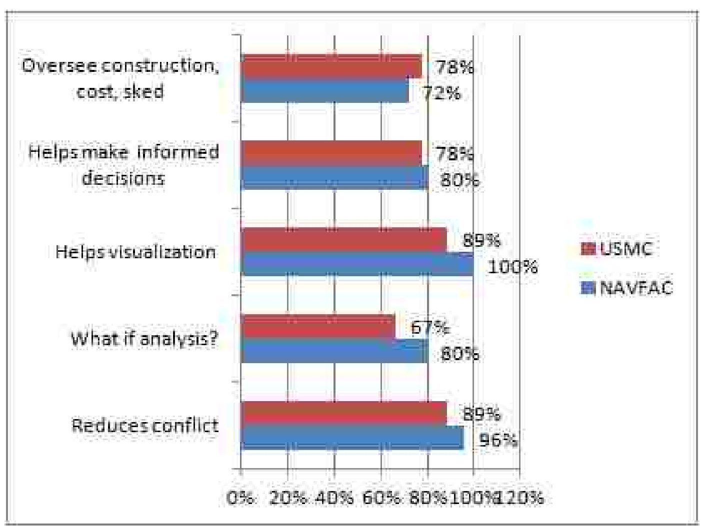

Figure 4.9 Reasons to Implement BIM

For those personnel who said that they wanted NAVFAC to implement BIM, between 67%-100% of the participants thought that all of the properties listed in the answers were valid reasons. For those personnel that did not think that NAVFAC should implement BIM, 100% of those respondents mentioned software integration issues as a reason. All the other reasons garnered 50% selection. However, it should be noticed that only three people were in this respondent pool.

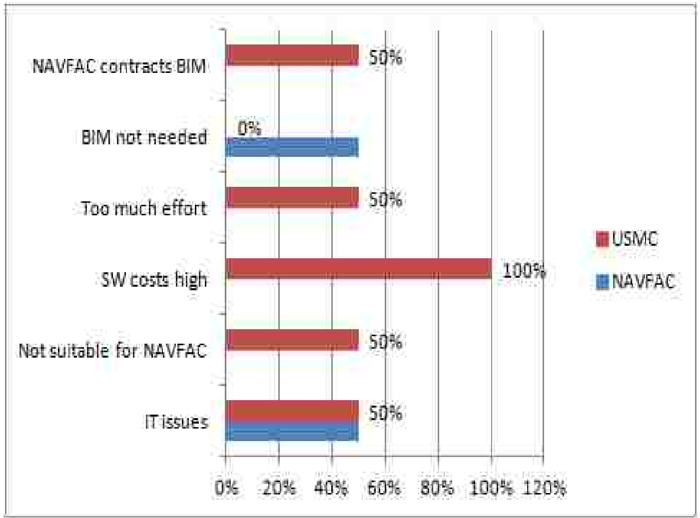

Figure 4.10 Reasons Not to Implement BIM

4.3 Area 3: Pricing and Procurement Methods

When asked about FFP, a slight majority for both NAVFAC (52%, 17/33) and USMC (58%, 11/19) personnel answered that it was useful in optimizing costs, thus enabling good performance from the contractor.

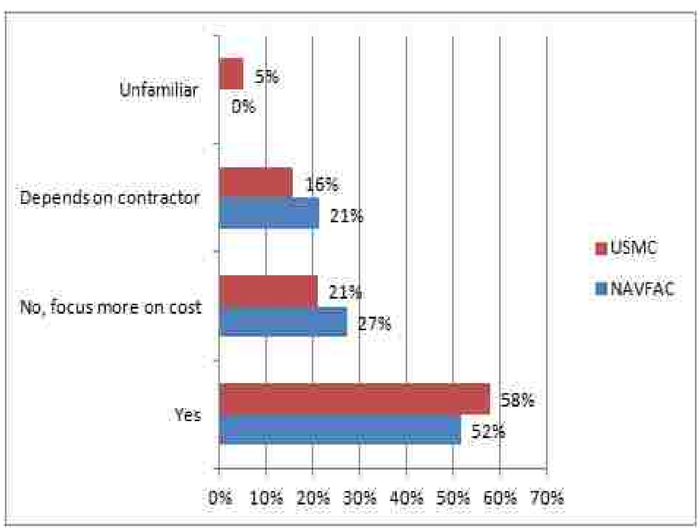

Figure 4.11 Effect of Firm Fixed Price (FFP) on Performance

A little less than the majority of NAVFAC personnel (48%,16/33), and the majority of USMC personnel (58%, 11/19) responded by saying that FPIF was a better method compared to FFP.

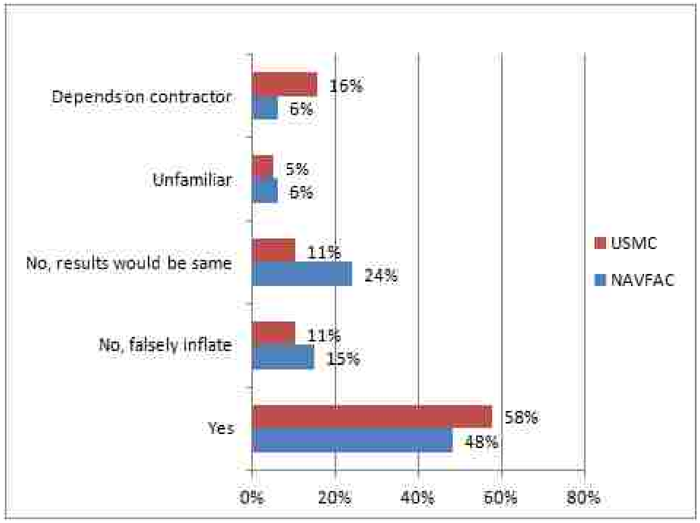

Figure 4.12 FPIF effect compared to FFP.

The situation for FPAF is slightly reversed compared to FPIF. Specifically, the majority of NAVFAC personnel (52%, 17/33) and a little less than the majority for USMC personnel (47%, 9/19) felt that FPAF would be better than using FFP.

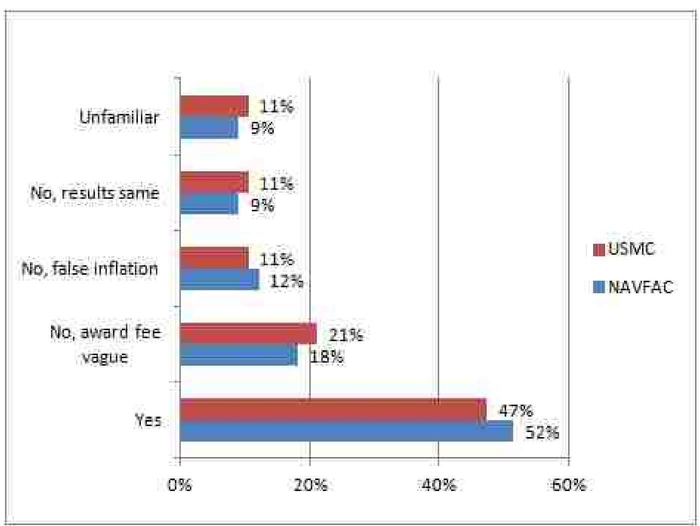

Figure 4.13 FPAF Compared to FFP.

4.4 Area 4: Project Delivery Methods

An overwhelming majority of NAVFAC personnel (88%, 29/33), and a slight majority of USMC personnel (58%, 11/19) assessed that design-build was more effective than design-bid-build for project execution.

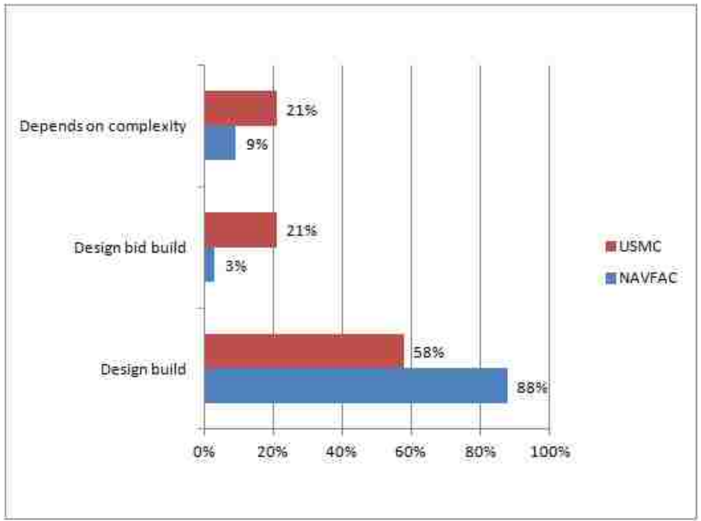

Figure 4.14 Preferred Project Delivery Method

When asked about what were the aspects about design-build that prompted a preference for that project delivery method, 72% to 84% of NAVFAC personnel selected: less risk to the government, saves time due to early contractor involvement, fast tracking of design, cost savings due to collaboration of architect/engineering and contractor, and better project innovation. A slight majority (59%, 19/33) of NAVFAC personnel also selected "Improved quality," although it wasn't as high of a majority as the other options. While "less risk to government" was the option most selected by NAVFAC personnel (84%), "saves on cost" was the option most selected by USMC personnel (80%).

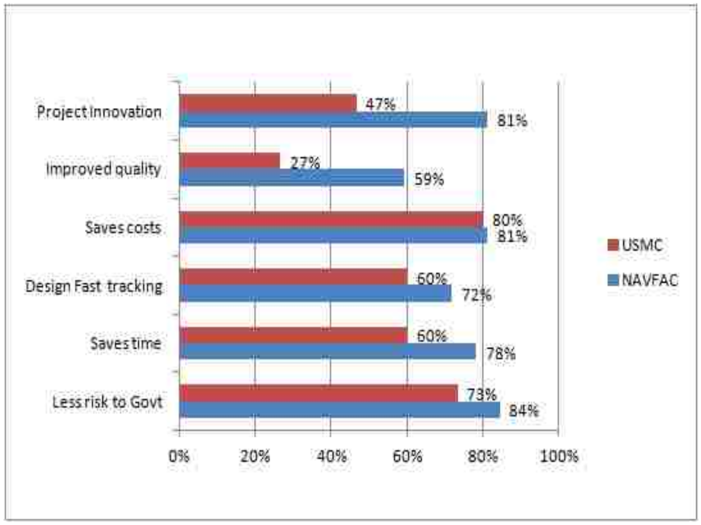

Figure 4.15 Aspects of Design-Build.

For responses concerning a preference for design-bid-build instead of design-build, respondents from both NAVFAC (100%, 4/4) and USMC (100%, 9/9) selected "exact product known" as a reason. Additionally, 100% of NAVFAC personnel liked how costs were better established using design-bid-build, while 44% (4/9) of USMC personnel also selected better established costs.

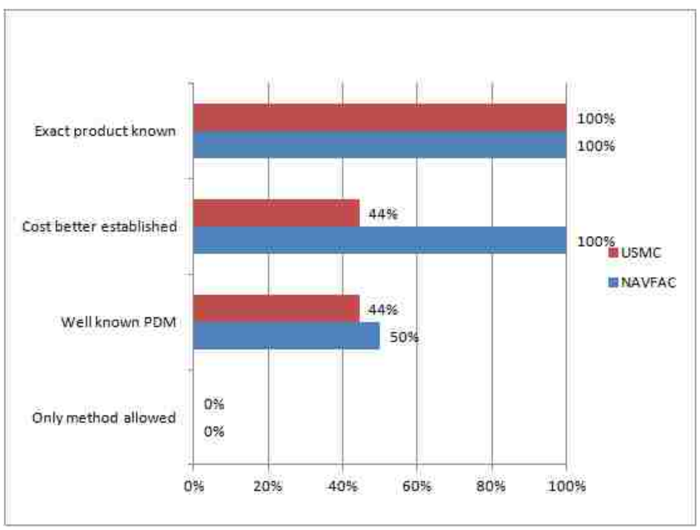

Figure 4.16 Aspects of design-bid-build.

4.5 Area 5: Lean Construction and IPD

A little less than half of NAVFAC personnel (48%, 16/33) and a little over half of USMC personnel (53%, 10/19) answered that they were familiar with lean construction. Not surprisingly, the percentage of personnel who have overseen projects that have implemented lean construction drops to a low level (NAVFAC: 5%, 5/33; USMC: 5%, 1/19).

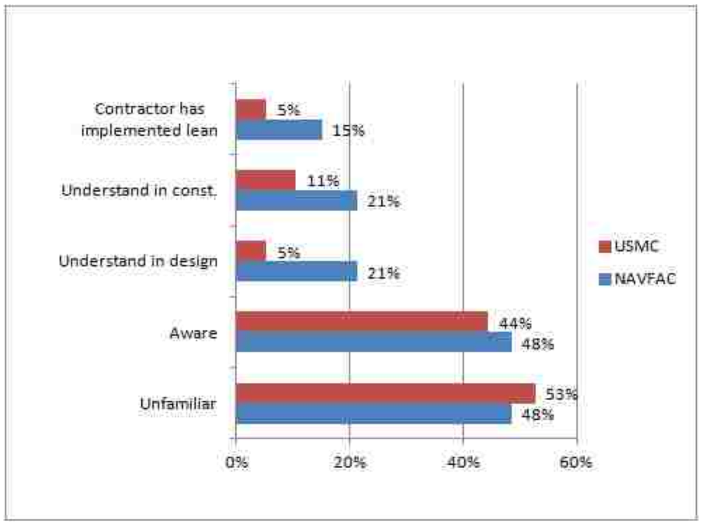

Figure 4.17 Familiarity with lean construction.

For those personnel who dealt with lean construction in the past, all of them understood that lean construction maximizes productivity while minimizing waste, and also emphasizes total project performance and not simply reducing costs.

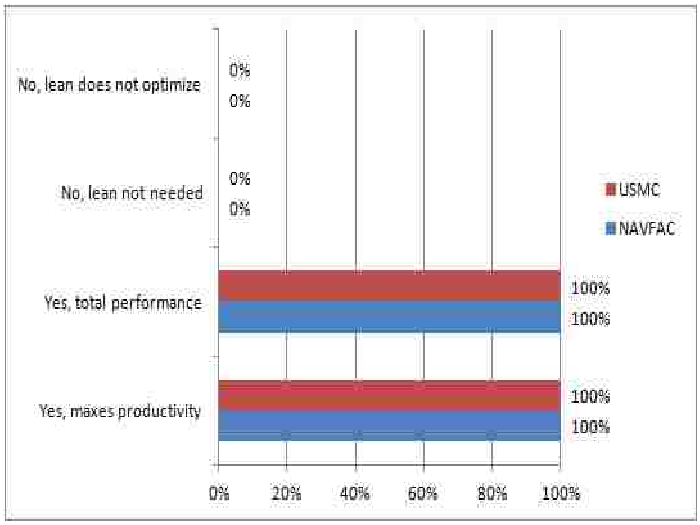

Figure 4.18 Lean construction compared to conventional.

A majority of both NAVFAC (61%, 20/33) and USMC personnel (63%, 12/19) were unfamiliar with IPD. For those personnel who mentioned that they were familiar with IPD (NAVFAC: 39%, 13/33; USMC: 37%, 7/19), only 1 employee from NAVFAC has actually worked on an IPD project, and this was only because of previous work that he performed when working for a general contractor. The rest are aware of IPD through their own personal studies through engineering journals and publications.

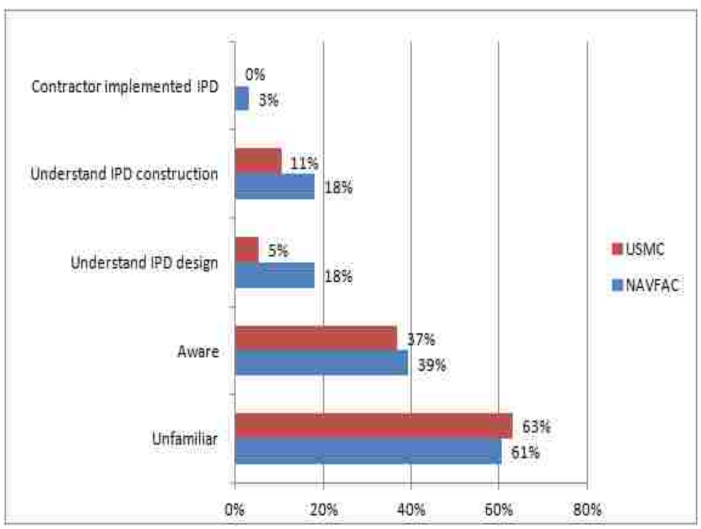

Figure 4.19 Familiarity with IPD

Based off the short description of IPD, it is encouraging to note that the majority of both NAVFAC (61%, 20/33) and USMC (68%, 13/19) responded that they think that NAVFAC should implement IPD.

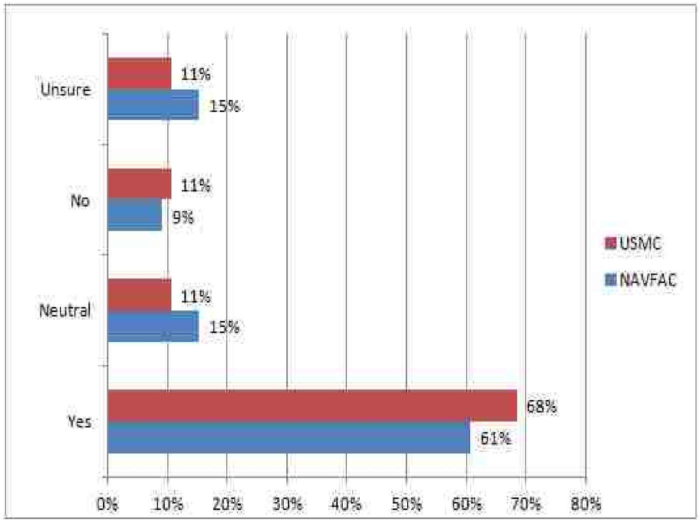

Figure 4.20 Should NAVFAC implement IPD?

For those NAVFAC respondents who felt that NAVFAC should implement IPD, cost control (90%,18/20) was overwhelming preferred, with BIM usage (65%, 13/20), construction/design quality (55%, 11/20), and discouraging contractors from understating profits (35%, 7/20) chosen in that order.

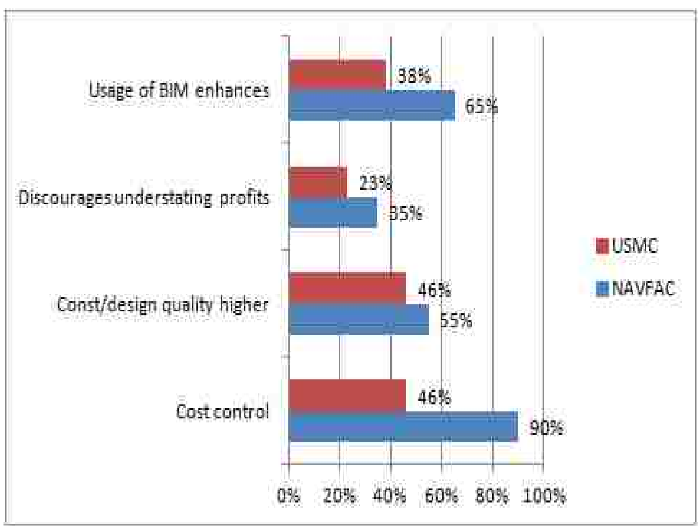

Figure 4.21 Reasons for BIM Implementation

Questions were also asked to those who stated that IPD should not be implemented by NAVFAC. The top reason given for NAVFAC (67%, 2/3) and USMC (50%, 1/2) was that IPD too unconventional.

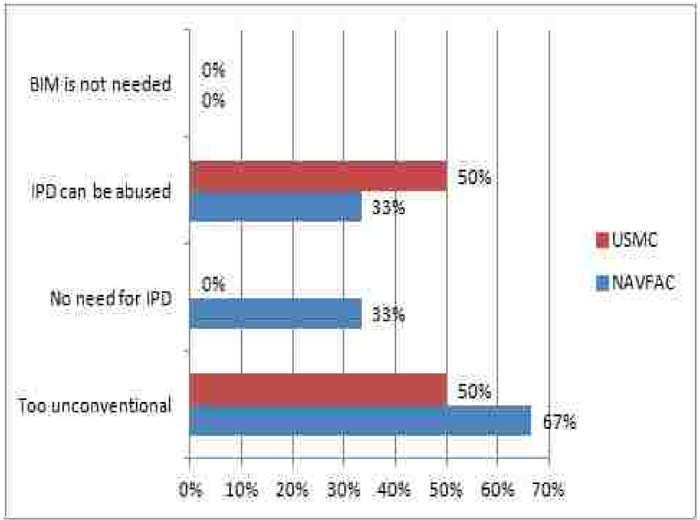

Figure 4.22 Reasons for not implementing IPD.

For those who felt neutral to NAVFAC implanting IPD, NAVFAC personnel (60%, 3/5) cited that IPD can be good but that a project can do well with or without it and (40%, 2/5) that IPD would not enhance quality or productivity enough to make it a standard. USMC personnel (100%, 2/2) also cited that IPD is good but that a project can do well with or without, but did not cite the second option.

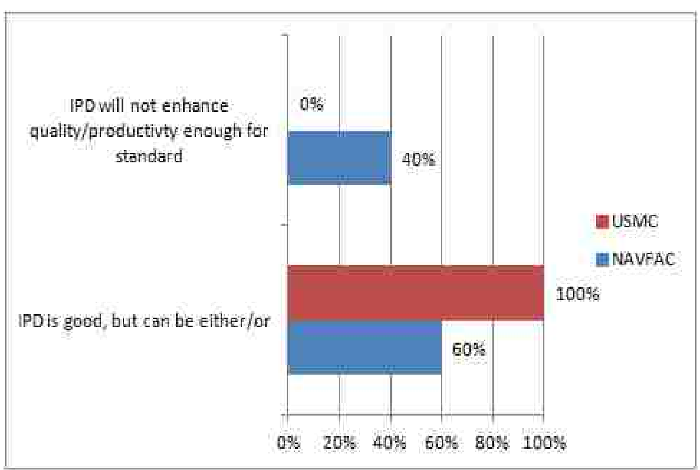

Figure 4.23 Reasons for Being Neutral with IPD

4.6 Area 6: Partnering and Collaboration

The last area of data focused on partnering and collaboration. An overwhelming majority of NAVFAC (79%, 26/33) and a majority USMC personnel (58%, 11/19) felt that partnering needs to be a formal process and needs to be mandated.

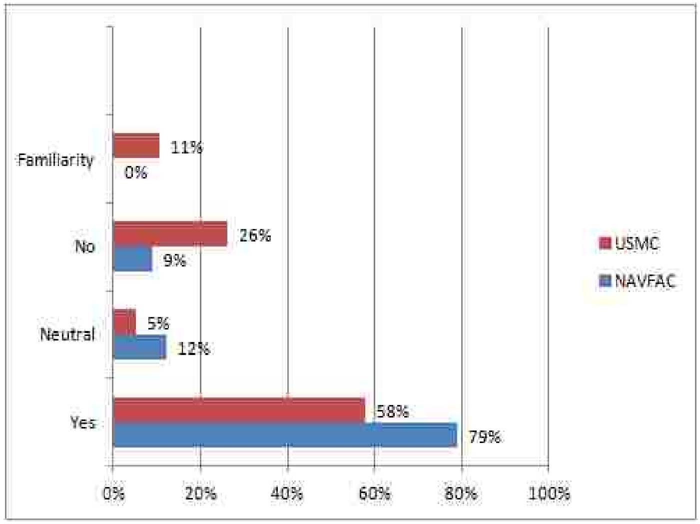

Figure 4.24 NAVFAC making partnering a formal process.

All NAVFAC (100%, 26/26) and USMC respondents (100%, 11/11) who said that NAVFAC needs to make partnering a formal process reasoned this way because if partnering is not mandatory, it will not be performed. A majority of NAVFAC (65%, 17/26) and USMC personnel (82%, 9/11) also assessed that the NAVFAC partnering system can only inherently provide sufficient collaboration and not full.

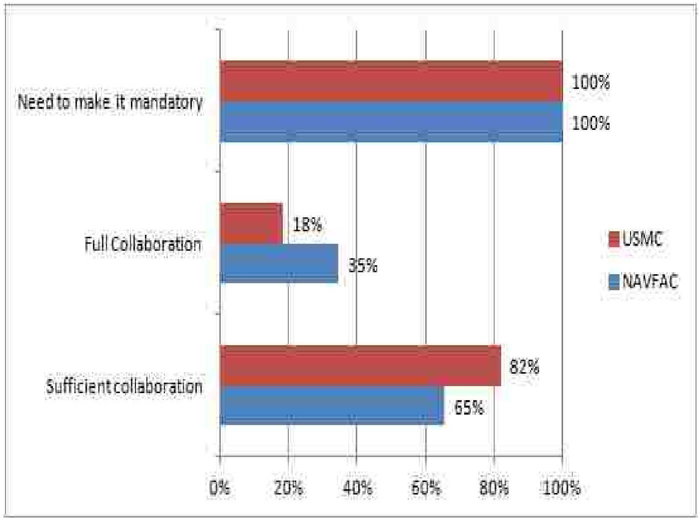

Figure 4.25 Reasons why partnering must be formal.

For those who assessed that partnering did not need to be informal, NAVFAC personnel (100%, 2/2) felt that partnering could be done without having it be mandated, and could be done "informally." Similarly, USMC personnel (100%, 5/5) unanimously agreed that partnering could be done informally, and 40% (2/5) assessed that partnering brought on minimal value.

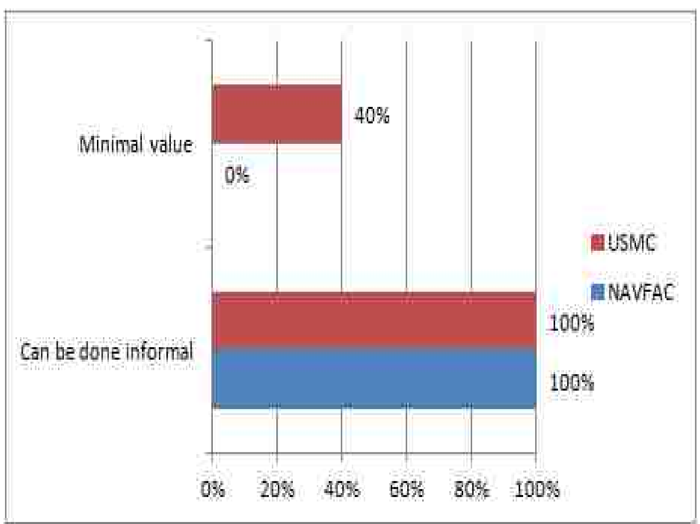

Figure 4.26 Why partnering does not need to be formal.

A certain number of NAVFAC personnel (50%, 2/4) and USMC personnel (100%, 1/1) felt neutral about partnering, and 50% of NAVFAC personnel (2/4) felt that partnering was not significant enough to enhance design quality or contractor productivity.

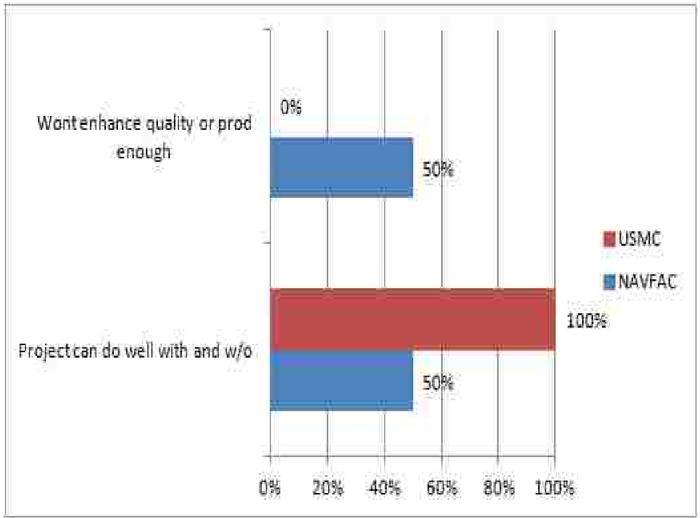

Figure 4.27 Why neutrality towards partnering.

Regarding specific interactions between NAVFAC organizations, and USMC organizations, less than a majority of NAVFAC personnel (45%, 15/33), and a majority of USMC personnel (63%, 12/19) determined that the interactions were working well. However, a slight majority of NAVFAC personnel (52%, 17/33) and a smaller percentage of USMC personnel (26%, 5/19) felt that interactions were not working well.

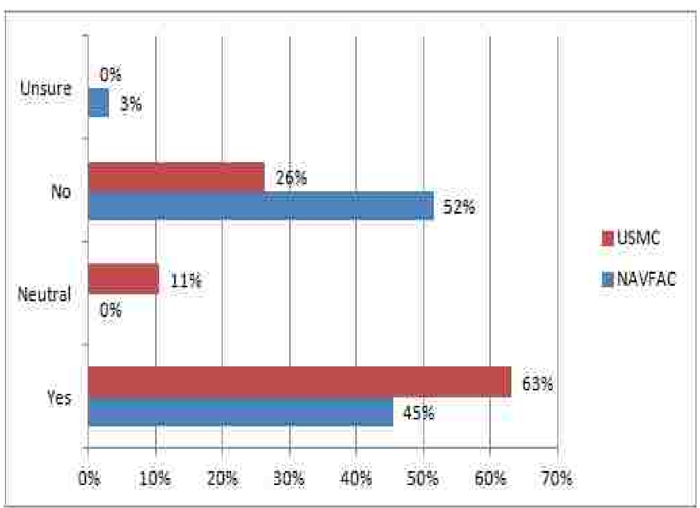

Figure 4.28 Are NAVFAC-USMC Interactions working well?

For those respondents who felt that the interactions work well, the top choice for both organizations was that they felt that there was a good rapport between the organizations.

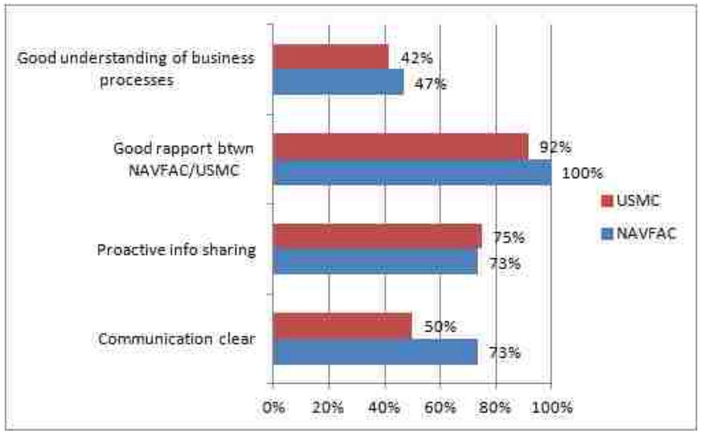

Figure 4.29 Reasons why interactions work well.

For those who assessed that interactions were not working well, the top reason cited was a lack of understanding of each organizations business processes. (NAVFAC: 76%, 13/17; USMC: 60%, 3/5).

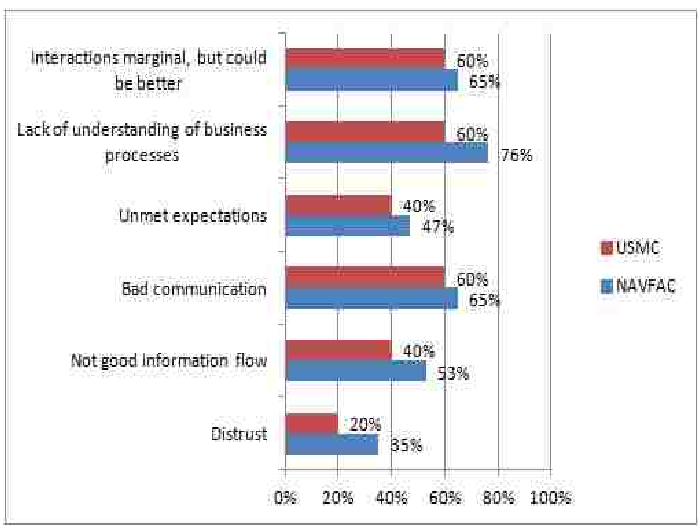

Figure 4.30 Reasons why interactions don’t work well.

No one from NAVFAC answered that the interactions were neutral. The two USMC personnel who answered neutral for interactions were evenly split on the reasons.

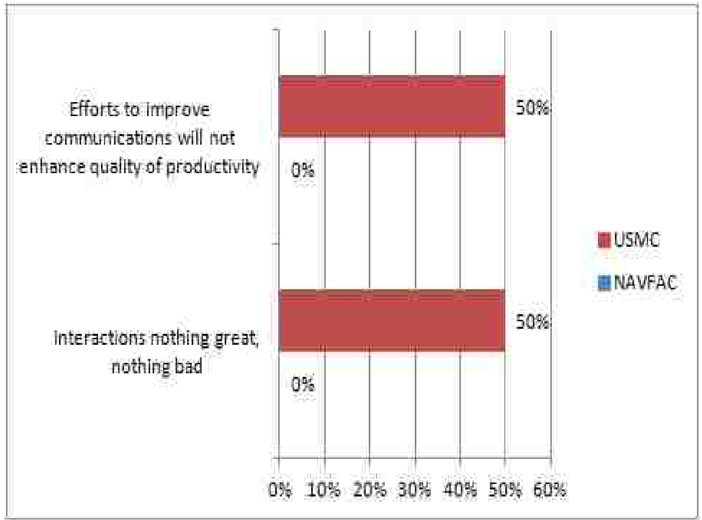

Figure 4.31 Reasons for interactions being neutral.

CHAPTER 5

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

Integrated Project Delivery is a revolutionary project delivery method that seeks to improve project outcomes through a collaborative approach of aligning the incentives and goals of the project team through shared risk and reward, early involvement of all parties, and a multiparty agreement (Kent and Becerik-Gerber, 2010).

Since IPD is a relatively new delivery model, it is not surprising that implementation within the private sector is slow and that these industry professionals feel more comfortable with more common methods such as DB (AIA Case Studies, 2012). The relative slowness of IPD implementation speaks to the unique technical and procurement, and contractual factors inherent within IPD, factors such as facilitation between the parties involved, the uniqueness of risk sharing within the IPD contract structure, and the issue of insurance (Fisk and Keen, 2012). In order for IPD to be implemented fully, it is critical that lean construction (Ballard, 2000) and BIM (Yoders, 2009) be used in conjunction. However, the inclusion of lean construction and BIM into IPD could cause some parties to be even more wary of implementing IPD if they are not accustomed to lean construction and BIM in the first place.

This purpose of this study was to understand the feasibility of implementing IPD as a standard project delivery method on Department of Navy military construction projects. This study used a survey mechanism to gain an understanding of how federal and military facilities professional view currently executed project delivery methods, risk sharing, technology utilization and BIM implementation. Through this understanding of the current culture, there is now a basis for understanding what techniques can be implemented and integrated within existing NAVFAC culture, processes and protocol, and what will be necessary to fully implement IPD in NAVFAC as a viable construction project delivery method.

5.1 Discussion of Results

5.1.1 General Demographics

Within the area of "General Demographics," the personnel chosen were a convenience sample. Every attempt was made to have equal number of NAVFAC and USMC employees but personnel availability and other priorities prevented this from happening. Within both NAVFAC and USMC, the majority of the respondents were either at the management level or the individual contributor. This distribution of personnel seemed to provide good input below the executive level.

In terms of the number of years within the current job, the majority of both NAVFAC (67%) and USMC (53%) had between 1 to 5 years. This number is somewhat misleading in certain circumstances because many of the personnel interviewed have a significant amount of construction experience overall within their careers, but simply happened to move into their most recent job at the time of this interview. Additionally, when asked about the number of years in the overall construction process, responses widely varied, and there was no clear majority. Interestingly, when asked about the number of years in actual construction execution, 42% of NAVFAC personnel answered between 1 and 5 years while the largest percentage for USMC personnel was 37% between 5 to 10 years. This can be explained by the fact that for those personnel who answered this question with 5 to 10 years, half of them were Civil Engineer Corps officers assigned to USMC commands. Similar to the question concerning overall construction process experience, the responses varied quite greatly regarding number of years experience within actual construction execution.

This demographic data have shown that there was a good variety of personnel at all levels that were participated in the survey, and one group was not unduly focused on at the expense of another.

5.1.2 Building Information Modeling

It is significant to note that an overwhelming majority of NAVFAC and USMC personnel are familiar with BIM. However, what is also noticeable is the dramatic drop in personnel who are familiar with BIM's application within design, construction and operations and maintenance. This would seem to make sense due to NAVFAC's lack of a formal BIM policy at the time of this writing. There have been a few projects in which the contractor has used BIM, but this was something that the contractor did on its own initiative as opposed to being mandated. Awareness of these BIM projects would spread, but more in an anecdotal fashion instead of an official case study as to capabilities and power of BIM. This would seem to explain the great disparity between the number of people who are aware of BIM versus the number of people who understand BIM's various applications.

A noteworthy factor is that the number of personnel who felt that NAVFAC should implement BIM was lower (76%, 47%) than those who were familiar with it. This would seem to indicate that a full understanding of BIM is not recognized among all of those who are familiar with BIM. This is understandable because the current culture within NAVFAC military construction is not one in which BIM is mandated or even encouraged. Because of this, many projects are still designed and executed through the paper submittal process. The general tendency for federal workers especially is to simply rely on what is familiar (paper submittals) even though a different technique could be vastly superior.

What is interesting is the responses that were given as to why BIM should be implemented within NAVFAC. This question measured the responses from those personnel who affirmed that NAVFAC should implement BIM. While all response choices were selected by the majority of both NAVFAC and USMC personnel, it is surprising that not all of the personnel for this particular question chose each option. All of the response choices involve standard characteristics of BIM. The fact that not all participants for this question selected all options would seem to indicate there is still some unfamiliarity with BIM and its capabilities even amongst those who want NAVFAC to implement BIM. This underscores the need for NAVFAC to implement BIM education before BIM implementation can be feasible.

For the personnel who felt that BIM should not be implemented, 100% of the USMC respondents mentioned software integration issues being too difficult and implementation costs being too high too to overcome. Based on the universally known characteristics of BIM, and the requirements necessary to implement BIM on a project, all of these concerns are valid. However, for both NAVFAC and USMC personnel, these responses seem to reflect more about the low understanding and view of BIM. Even 50% of NAVFAC respondents mentioned that BIM was not needed. Because BIM is so powerful and useful, any hurdles towards BIM implementation would be well worth the effort to overcome.

5.1.3 Pricing and Procurement Methods

Firm Fixed Price (FFP) is one of the most commonly used procurement methods within military construction projects. The main reason that it is so commonly used is that it provides an almost ironclad certainty regarding pricing for a project. Since the majority of both NAVFAC and USMC felt that FFP was effective in enabling good contractor performance, this would seem to indicate that those who oversee military construction projects would tend to desire more stability and surety in terms of invoicing. This is reflective of the culture of the federal government in which the dominant mentality is cost and price savings as much as possible.

Fixed Price Incentive Firm (FPIF) is a procurement method in which the contractor is positively rewarded (incentive) for exceeding set and measured standards (profits increased) and negatively rewarded (profits decreased) for failure to reach standards. FPIF is not commonly used on construction projects, and so it is noteworthy to see that a little less than the majority of NAVFAC personnel (48%, 16/33), and the majority of USMC personnel (58%,11/19) responded by saying that FPIF was a better method compared to FFP.

Fixed Price Award Fee (FPAF) is similar to FPIF. What is a little different is that instead of an incentive, there is an award fee that is paid on an award-fee plan. Award fees are used to motivate a contractor since other incentives cannot be used when contractor performance cannot be objectively measured. As mentioned previously, the situation for FPAF is slightly reversed compared to FPIF. Specifically, the majority of NAVFAC personnel (52%, 17/33) and a little less than the majority for USMC personnel (47%, 9/19) felt that FPAF would be better than using FFP.

The purpose of discussing these common procurement methods of FFP, FPIF, and FPAF is that the opinions given on them reveal the likelihood of being able to introduce the very foundation of IPD, which is risk sharing. FPIF and FPAF were also chosen to be surveyed because these procurement methods can be thought of as precursors to the risk sharing paradigm of IPD. Risk sharing involves all major parties within the integrated team sharing in both the gain and the pain during the construction project.

Although FPIF and FPAF are somewhat similar to risk sharing in that if the contractor does well, it is rewarded, there is actually no risk involved for the owner or any other parties working on the construction project. This is why FPIF and FPAF can be regarded as sorts of precursors to true integrated risk sharing. The fact that both FPIF and FPAF displayed a slightly less than a majority to a slight majority in preference over FFP would suggest that there is some potential within the context of the federal government to be open to the idea of eventually implementing an integrated risk sharing.

5.1.4 Project Delivery Methods

Within NAVFAC, the only two delivery methods currently being employed are design-build and design-bid-build. In fact, the Federal Acquisition Regulations (FAR) recognize only DB and DBB as the methods appropriate for executing construction. When comparing traditional project delivery methods with IPD, it can be seen that design-build has some rudimentary elements that are more fully developed with IPD. The fact that an overwhelming majority of NAVFAC personnel (88%) and USMC personnel (58%) chose design build as the preferred project delivery method would seem to indicate there is potential for IPD to eventually be implemented within NAVFAC.

Additionally, the fact that "less risk to government" was the option most selected by NAVFAC personnel (84%) and "saves on cost" was the option most selected by USMC personnel (80%) would seem to suggest a somewhat difference in emphasis and priority when both organizations approach construction. NAVFAC's very nature is to administer and execute contracts. It is therefore natural to see that its employees' emphasis on trying to reduce as much risk as possible to themselves. USMC personnel (73%) were also very conscious of risk, while cost savings was the overall top choice (80%). While both are federal agencies, it can be more accurate to say that the USMC can be considered the "owner" since all USMC projects are executed with funding coming from MCICOM, and it is MCICOM that promulgates tenant requirements. In the owner role, it seems appropriate that USMC employees would be a little bit more focused on costs versus contractual execution.

When asked about what are the qualities of design build that make it the preferred project delivery system, the answer choices were distributed between 72% to 84% of NAVFAC personnel, while it was between 27%-73% of USMC personnel. One of the outcomes of design build is to place more risk on the contractor since it is the party responsible for the design along with the architect-engineer that it hires. Because of the involvement of both the contractor and the architect-engineer in the very beginning of design, this would normally lead to increased quality. "Improved quality" received the lowest percentage for USMC personnel at 27%. This could possibly be more a result of projects that have gone very poorly or perhaps the technical abilities of the contractor were very lacking as opposed to the fact of design-build being used.

There also seemed to be a rather significant disparity between NAVFAC (81%, 26/33) and USMC (47%, 7/19) regarding design-build's effectiveness in bringing about project innovation. This also would seem to reflect the differences in approach that each organization takes concerning facilities. Since NAVFAC's sole existence is of a technical nature (being an engineering organization), it seems appropriate for it to recognize project innovation more so than the USMC.

5.1.5 Lean Construction and IPD

Lean construction and IPD should be considered to go hand in hand. This is exactly the reason why lean construction questions were asked through the survey mechanism. While the federal government most likely has had projects in which lean construction was implemented, this is actually difficult to determine to a certain extent because implementing lean construction techniques involves extensive process optimization regarding the contractor's internal business operations. This sort of information is not something that contractors commonly reveal to the government owners.

The results for both NAVFAC and USMC were roughly evenly split in terms of those who were aware (NAVFAC: 48%, USMC: 44%) of lean construction versus those who (NAVFAC: 48%, USMC: 53%) were not aware of it. These percentages dramatically drop when looking into whether lean construction was understood in construction (NAVFAC: 21%, USMC: 5%) and design (NAVFAC: 21%, USMC 11%).

There are two things worth mentioning with this result. First, the fact that the percentage dramatically drops between those who are aware of lean construction and those who understand its application in design and construction shows that over half of the people who said that they were aware of lean construction only have a very surface level understanding of it. Second, it seems very strange that there is a difference in number in USMC personnel who understand lean construction in actual construction and design. Theoretically, the two figures should be identical. This could be suggesting the severe lack of familiarity of lean principles within the federal construction.

For those NAVFAC and USMC personnel who have dealt with lean projects in the past, 100% of them correctly recognize that lean construction does encourage total contractor performance and maximization of productivity.

A majority of both NAVFAC (61%, 20/33) and USMC personnel (63%, 12/19) were unfamiliar with IPD. For those personnel who mentioned that they were familiar with IPD (NAVFAC: 39%,13/33; USMC: 37%, 7/19), only 1 employee from NAVFAC had actually worked on an IPD project. Even though a majority were unfamiliar with IPD, based off the short description at the beginning of the survey mechanism, both NAVFAC (61%, 20/33) and USMC (68%, 13/19) responded that they think that NAVFAC should implement IPD. This would seem to indicate a good potential for IPD to be able to fit within the NAVFAC and USMC facilities and construction culture.

Cost control was the overwhelming reason for NAVFAC personnel's desire to implement IPD, followed by enhanced quality by BIM usage. USMC personnel also gave cost control as the top choice, but not nearly as many personnel chose this option.
The fact that NAVFAC is solely an engineering and contract executing organization would seem to help explain such an undue focus on cost control, almost at the expense of the other factors, it seems. Similarly to the BIM questions previously, it seems strange that the 100% of the respondents did not select all of the characteristics of IPD as reasons to implement. This could potentially be explained by simply a lack of experience with

IPD since there have been no military construction projects that have been executed by IPD as of yet. So that would seem to explain the inconsistent distribution of answers.

For those personnel who objected to NAVFAC's implementing of IPD, the top reason given for NAVFAC (67%,2/3) and USMC (50%, 1/2) was that IPD too unconventional. It bears repeating that the number of people who answered this is very low, but it is still nonetheless noteworthy. Special attention should be paid to this reason because this could potentially reflect a significant number of people's opinion if IPD were ever actually to go into effect. As with anything new, there is always a difficult transition period in which personnel are still trying to get accustomed.

For those who answered that they felt neutral towards IPD implementation, NAVFAC personnel (60%, 3/5) cited that IPD can be good but that a project can do well with or without it and (40%, 2/5) that IPD would not enhance quality or productivity enough to make it a standard. USMC personnel (100%, 2/2) also cited that IPD is good but that a project can do well with or without. These responses would seem to indicate that both NAVFAC and USMC personnel are not familiar enough with the benefits and how exactly IPD functions. The complexity of NAVFAC construction projects is similar to those in the commercial industry, so there would be no reason why IPD would not be beneficial for a military project.

5.1.6 Partnering and Collaboration

One of the unique characteristics concerning IPD is its collaborative nature. It is contractually structured in such a way that full collaboration is inherent while executing an IPD project. This is most easily seen through its concept of risk sharing.

The conventional counterpart to integrated collaboration is partnering (internally between government agencies and externally with the contractors). It is encouraging to note that such an overwhelming majority of NAVFAC personnel (79%, 26/33) and a majority of USMC personnel (58%, 11/19) felt that partnering does need to be formal and mandated. What does seem strange is that not all NAVFAC and USMC personnel felt that partnering was required. This would seem to reflect a lack of broad experience and understanding of the complex interpersonal interactions that take place within construction projects.

For those personnel that felt that partnering needs to be done formally, all respondents stated that if partnering isn't done formally or mandated, partnering will never be accomplished. The respondents were also asked about their perception on whether conventional partnering provided full or sufficient collaboration.

Full collaboration is defined as collaboration in which maximum effort is placed in having all parties share information in order to complete a project successfully. Sufficient collaboration is defined as collaboration in which minimal effort is placed in having all parties share information for successful project completion.

An overwhelming majority of both NAVFAC (65%,17/26) and USMC personnel (82%, 9/11) felt that the NAVFAC partnering system produced only sufficient collaboration while a significantly decreased number felt that the NAVFAC partnering system enabled full collaboration (NAVFAC: 35%, 9/26; USMC: 18%, 2/11). This seems to suggest that the NAVFAC partnering system inherently cannot produce anything beyond sufficient collaboration. Even in full collaboration, this will never reach the level of interaction in integrated collaboration. This would provide a substantial case for IPD implementation since NAVFAC partnering can never achieve full integrated collaboration.

Since NAVFAC is a separate organization and the USMC facilities departments on each installation are also under MCICOM and not NAVFAC, there is a great deal of interagency coordination that is required for projects to be successfully overseen. Although slightly less than a majority of NAVFAC personnel (45%, 15/33) and a majority of USMC (63%, 12/19) personnel assessed that interagency interactions were working well, from a global perspective, the interactions in reality are, at best, extremely varied. Some installations do have very good working relationships between NAVFAC and USMC agencies, whereas at other installations, the interactions are ruinous. At the very top levels of NAVFAC and USMC, there is a general recognition that the interagency interactions overall have much room for improvement. The MOA described in the literature review directs the staff of each organization to find ways in which collaboration and coordination can be improved, not only at the headquarters level but also at the field level.

This is an important effort because while the USMC can be thought of as the owner, NAVFAC is in the unique position to execute and manage the projects for the USMC. This would then require both agencies to coordinate seamlessly in order for the USMC to be an effective owner.

There is a wide range of response frequency (42%-100%) for the reasons given as to why interactions work well. The answers depended upon such things as the location of the USMC installation, or the particular position of a person on a team. Even when interactions are perceived as going well, the wide range of response frequency seems to indicate is a lack of consistency between the NAVFAC and USMC teams. This issue of consistency is also apparent for those who said that interactions between the two agencies do not work well (20%-76%).

This lack of consistency for both positive and negative perceptions of interagency interactions does not enable the government as a whole to properly manage a project, and it will always suffer from fragmented relationships between NAVFAC and USMC. A proper execution of the forthcoming recommendations from the MOA would hopefully be able to address this positive and negative fragmentation. This would then greatly aid in providing an environment that would make IPD implementation more effective.

5.2 Summary of Culture

From the survey responses and the data analysis given, various aspects of the NAVFAC and USMC culture were discussed. An overall summary is provided as follows. The survey took a convenience sample from the ~700 employees of the NAVFAC and USMC organizations. The convenience sample was taken from the researcher's personal familiarity with the participants. No effort was made to intentionally target particular job positions over others. Within the sample, the majority of the respondents were either at the management level or the individual contributor. Overall, the organizational structure for both NAVFAC and USMC organizations are hierarchical.

BIM is a concept that an overwhelming majority of NAVFAC and USMC personnel are familiar with BIM, yet actually have very little practical experience. Among other things, this could be a symptom of NAVFAC's lack of a formal BIM policy. In terms of implementing BIM in NAVFAC, the response rate was lower than those who were familiar with it. This would seem to indicate that a full understanding of BIM is not recognized among all of those who are familiar with BIM. This lack of familiarity is also evident when not all answer options were chosen for why BIM should be implemented. It is generally understood within the construction industry that BIM is a very powerful tool, and any associated difficulties with BIM implementation are eclipsed by its benefits. Because some NAVFAC and USMC personnel felt that BIM implementation was not worth the associated difficulties, this would seem to indicate a low understanding of just how useful BIM is.

In military construction, Firm Fixed Price (FFP) is one of the most commonly used procurement methods while FPIF and FPAF are less commonly used. FFP is favored amongst contracting professionals because stability with regard to pricing. This is reflective of the culture of the federal government in which the dominant mentality is cost and price savings as much as possible. FPIF and FPAF are similar to each other in that both procurement methods offer an incentive and award fee, respectively, to motivate a contractor to exceed particular standards. The government's understanding of FFP, FPIF, and FPAF reveals a glimpse of how effective IPD can be. FPIF and FPAF can be considered precursors to the risk sharing paradigm of IPD. Risk sharing involves all major parties within the integrated team sharing in both the gain and the pain during the construction project. Although FPIF and FPAF positively and negatively reward the contractor, there is still no actual risk involved for the owner or any other parties. This is why FPIF and FPAF can be regarded as sorts of precursors to true integrated risk sharing. Since FPIF and FPAF was between a slightly less than a majority to a slight majority in preference over FFP, this would suggest that there is some potential for implementing an integrated risk sharing.

Within NAVFAC, the only two delivery methods currently being employed are design-build and design-bid-build. Design build can be considered to have has some rudimentary elements that are more fully developed with IPD. Since an overwhelming majority of NAVFAC and USMC personnel favored design build as the preferred project delivery method, this would seem to indicate there is potential for IPD to eventually be implemented within NAVFAC. It is interesting to observe the differences in emphasis that NAVFAC and USMC both have when assessing design build. For instance, there was about a 40% difference between NAVFAC and USMC regarding design build's effectiveness in bringing about project innovation. This seems to reflect their respective cultural differences. Since NAVFAC exists solely as an engineering organization, it seems appropriate for it to recognize project innovation more so than the USMC.

From the government perspective, it is difficult to determine to what extent lean construction has been implemented because this involves the contractor's internal business operations. This sort of information is not something that contractors commonly reveal to the government owners. NAVFAC and USMC were roughly evenly split in terms of those who were aware of lean construction versus those who were not aware of it. Additionally, since NAVFAC and USMC do not focus on lean construction in any of their policies, this would seem to indicate a great lack of familiarity with lean construction. Similar to lean construction, a majority of both NAVFAC and USMC personnel were unfamiliar with IPD. However, it is encouraging that the majority of both NAVFAC and USMC personnel felt that NAVFAC should implement IPD. Although there were still personnel from both organizations that were opposed or simply neutral to IPD implementation, the culture would still seem to indicate a good potential for IPD to be able to fit within the NAVFAC and USMC facilities and construction culture.

One of the unique characteristics concerning IPD is its collaborative nature. It is contractually structured in such a way that full collaboration is inherent while executing an IPD project. This is most easily seen through its concept of risk sharing.

The conventional counterpart to integrated collaboration is partnering (internally between government agencies and externally with the contractors). It is encouraging to note that such an overwhelming majority of NAVFAC personnel (79%, 26/33) and a majority of USMC personnel (58%, 11/19) felt that partnering does need to be formal and mandated. What does seem strange is that not all NAVFAC and USMC personnel felt that partnering was required. This would seem to reflect a lack of broad experience and understanding of the complex interpersonal interactions that take place within construction projects.

For those personnel that felt that partnering needs to be done formally, all respondents stated that if partnering isn't done formally or mandated, partnering will never be accomplished. The respondents were also asked about their perception on whether conventional partnering provided full or sufficient collaboration.

Full collaboration is defined as collaboration in which maximum effort is placed in having all parties share information in order to complete a project successfully. Sufficient collaboration is defined as collaboration in which minimal effort is placed in having all parties share information for successful project completion.

An overwhelming majority of both NAVFAC (65%, 17/26) and USMC personnel (82%, 9/11) felt that the NAVFAC partnering system produced only sufficient collaboration while a significantly decreased number felt that the NAVFAC partnering system enabled full collaboration (NAVFAC: 35%, 9/26; USMC: 18%, 2/11). This seems to suggest that the NAVFAC partnering system inherently cannot produce anything beyond sufficient collaboration. Even in full collaboration, this will never reach the level of interaction that integrated collaboration. This would provide a substantial case for IPD implementation since NAVFAC partnering can never achieve full integrated collaboration.

There is a great deal of inconsistency regarding interagency interactions between NAVFAC and USMC. In response to this, the senior executives at NAVFAC and USMC are currently engaged in various planning activities to make coordination and interaction standardized and more efficient at all levels. This is an important since the USMC can be thought of as the owner while NAVFAC executes and manage the projects for the USMC. If this lack of consistency is not addressed, poor and fragmented interagency interactions will prevent the government from properly managing a project, and there will always be fragmented relationships. Correcting these internal fragmented relationships would greatly enable in providing an environment that would make IPD implementation more effective.

5.3 Partial Implementation

Now that the culture has been assessed, this will help in determining what techniques can be implemented and integrated within existing NAVFAC culture, processes and protocol. In other words, what key process elements can be modified to accommodate IPD immediately?

In terms of immediate changes, this would involve modifying NAVFAC's business procedures called Business Management System (BMS). NAVFAC has a BMS that details how design build and design bid build projects are to be executed. This would be the framework that would be modified to accommodate as many IPD principles as possible.

5.3.1 Building Information Modeling

Since NAVFAC's current culture does not include any robust use of BIM, the BMS and subsequent contracts could be re-written to reflect the need for BIM to be a tangible deliverable. At this point, it would simply be used as a visualization tool.

5.3.2 Design-Build / Design-Bid-Build

Within NAVFAC's current execution of design-build and design-bid-build, early contractor involvement should be strived for. This is already happening to a certain extent on design-build projects in which the contractor hires to the architect/engineer for construction design. In design-bid-build, contracts should be looked at to see if contractor involvement is feasible from a legal standpoint during design. This would require a procurement board to meet before the design is even started to select a contractor. This contractor would then work with the government during the design phase.

5.3.3 Lean Construction

Since NAVFAC construction managers currently are not actively involved any lean construction processes, this would be a good opportunity to be more involved in the construction execution of the contractor. Currently, typical practice consists of looking at the construction schedule, and ensuring that the invoice matches with the progress on the schedule. No meaningful effort is really made to work alongside with the contractor to optimize the execution and the schedule. Techniques such as pull planning sessions, and investing in some metrics systems that are actively being used in lean construction would greatly increase the level of lean construction competence among NAVFAC construction managers.

5.4 Full Implementation

Changes to NAVFAC construction to fully implement IPD would require a rather extensive culture shift at the NAVFAC level, but just as importantly, it would also require changes at the congressional level.

At the congressional level, changes to the United States Code (USC) and the FAR would be necessary to account for IPD as another project delivery method alongside design-build and design-bid-build.

5.4.1 Building Information Modeling

The FAR could be changed to accommodate for requirements for BIM. At this level, the requirements would be general and would involve items that are standard across all projects that involve BIM. At the NAVFAC level, similar to the strategic implementation plans adopted by USACE and GSA, NAVFAC should generate its own strategic plan as well.

5.4.2 Pricing and Procurement Methods

This would by far be the most significant change to the way in which the federal government manages its funding. In order for the federal government to fully implement IPD, the concept of risk sharing would need to be legislated into the USC, and then filtered down into the FAR. After this change is made, training would be required for all legal counsel employees, contracting professionals, and facilities engineering professionals to include construction managers.

5.4.3 Lean Construction and IPD

Formal strategic plans would need to be drafted and implemented at the NAVFAC level to set the particular vision for how lean construction and IPD will be handled at the headquarters level and eventually all the way down the field and project level. The formal strategic plans would then be codified for day to day operational usage through changes and additions to the NAVFAC BMS.

5.4.4 Partnering and Collaboration

When IPD is implemented, the NAVFAC partnering system may not have to change substantially to accommodate the new mode of collaboration within IPD. The continuous collaboration from IPD would be able to address day to day situations. At the same time, there is always a need to pause and evaluate the status and progress of collaboration. Regularly scheduled partnering meetings would be able to fulfill this need, taking into account the daily interactions up to that point. This integrated collaboration would only enhance the current partnering system. If anything, items that are being fulfilled through the continuous collaboration would then not have to be emphasized as prominently through the NAVFAC partnering system.

5.5 Limitations

Although this study was able to provide a sense of the culture within the facilities community for NAVFAC and USMC, and some recommendations for short term and long term actions for IPD implementation, there were several limitations to the study. The first limitation was related to the sample and sample size. The sample size was small and could have been bigger. The sample size was 52 people. The overall number of personnel working in the southwest region of NAVFAC and USMC installations is well beyond 700 personnel. A second limitation was the types of questions that were asked in the survey. If a Likert scale was used for some of the questions, some correlations based on certain demographics could have been made.

5.6 Recommendations for Future Research

Based on the results of the study, there is some opportunity for further research. One possibility would be to study the case studies that the AIA has produced and gather cost and schedule data from this. Then, cost and schedule data could be taken from similar projects in scope, and normalized comparisons could be made to determine the differences between IPD projects and conventional projects. The comparisons would serve as substantial justification of the benefits of IPD.

A second possibility would be to study the project execution and the associated metrics of the construction of the new USMC Naval Hospital that is currently being construction at Camp Pendleton. While not an IPD project, both the government and the contractor are heavily invested in lean construction techniques and utilization of BIM. The level of "integration" of the government and the contractor could be studied to see how close this project is to an IPD project and recommendations could be made as to what additional items would be needed for this hospital project to become fully IPD. This information could then be used for reference to implement lean construction and BIM on other military projects in order to eventually make the transition to a full IPD execution.

A third alternative is for the federal government to actually execute a project using IPD as the delivery method, even if this would require some sort of legal exemption. The results of this project could be compared to another project of similar size and scope. Qualitative and quantitative data from the project would be used as substantial justification to implement the short term and long term recommendations made above.

5.7 Conclusion

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

Through the survey, there were general positive indications that a majority of participants were willing to see IPD being implemented by NAVFAC. The central concept of IPD, risk sharing, is not something that is currently being done in the federal government, but rewarding the contractor is, albeit at a very rudimentary level with FPIF and FPAF. Additionally, a majority of participants responded by saying that NAVFAC should implement BIM, a critical tool in bringing about IPD's full collaborative power.

While immediate and full implementation of IPD is not currently feasible, small transitional steps are possible, feasible and legal within the current legislative framework of the FAR and the current business practices of NAVFAC. Perhaps with the exception of early contractor involvement in design bid build, all other recommendations for partial implementation could be made with only minor changes in contract language and minor changes within NAVFAC BMS.

Full implementation will be the most difficult and arduous task since it would involve changes to federal law, and a subsequent change in overall strategic plan for NAVFAC and its subordinate strategic implementation plans. As academic research regarding IPD continues, there will be eventually be enough data and analysis to be able to provide robust justification for IPD implantation within the federal government. The changes in strategic plans and the implementation plans would then naturally follow from changes within the USC and the FAR.

Integrated Project Delivery is truly a unique and innovative project delivery method. It has proven to be competitive and it was designed specifically to orient the priorities of the participants back to the project and not to themselves. As the construction industry continues to use IPD, it will eventually become the new standard for how projects will be constructed. With all of the hurdles that the federal government would have to overcome to implement IPD, the benefits would by far outweigh those hurdles. Not only would the service implementing IPD benefit from a properly priced and efficiently executed project, but ultimately the American taxpayer would benefit as well knowing that his tax dollars were well spent.

APPENDIX A

Survey mechanism:

Questions for Survey

1) What is your position?
    a. Construction Manager
    b. Assistant Resident Officer in Charge of Construction (AROICC)
    c. Contracting Specialist / Officer
    d. Supervisory General Engineer
    e. Supervisor Civil Engineer
    f. Supervisory Structural Engineer
    g. Public Works Engineer
    h. Public Works Planner
    i. Public Works Program Manager
    j. Public Works Officer
    k. Deputy Public Works Officer
    l. Resident Officer in Charge of Construction – Officer in Charge
    m. Integrated Product Team (IPT) member (please state?)
    n. Officer in Charge of Construction member (please state?)
    o. Marine Corps Installations West (MCIWEST) member (please state?)
    p. Other (please state)

2) How long have you been in your present position?
    a. < 1 year
    b. 1 < x <5 years
    c. 5 < x < 10 years
    d. 10< x < 20 years
    e. More than 20 years

3) If you are a Civil Engineer Corps (CEC) officer, what is your present rank?
    a. Ensign
    b. Lieutenant Junior Grade
    c. Lieutenant
    d. Lieutenant Commander
    e. Commander
    f. Captain
    g. Rear Admiral

4) How many years of experience do you have in the overall construction process? **("Overall construction process" means anything from initial planning/programming of funds to construction to project close-out, not just execution).**

  a. < 1 year
  b. 1 < x <5 years
  c. 5 < x <10 years
  d. 10 < x <15 years
  e. More than 15 years

5) How many years of experience do you have specifically in the construction execution phase of a project? **("construction execution phase" means the actual construction of the facility by a general contractor).**

  a. < 1 year
  b. 1 < x <5 years
  c. 5 < x <10 years
  d. 10 < x <15 years
  e. More than 15 years

6) What is your level of familiarity with Building Information Modeling (BIM)? (check all that apply)

  a. Unfamiliar
  b. Aware of BIM concept
  c. Understand the application of BIM in design
  d. Understand the application of BIM in construction
  e. Understand the application of BIM in operation and maintenance of facilities
  f. Contractor implemented BIM on my project(s).

7) If you answered question #6 with answer G, what was your level of effort in implementation of BIM on your project? (check all that apply)

  a. Architect/Engineer designed with BIM. I gave constructability and/or other inputs
  b. Contractor used BIM during execution. I oversaw construction progress through the BIM outputs (including cost and schedule growth).
  c. I used BIM simply as a qualitative tool for general visual representation.

8) Should NAVFAC implement BIM on construction projects?

  a. Yes
  b. Neutral
  c. No
  d. Unfamiliar

9) If yes in question #8, what is the reason? (check all that apply)
    a. BIM reduces possible conflicts arising during execution (e.g. clash detection, rework reduced, productivity increases)
    b. BIM allows for more "what if" analysis, such as construction sequencing options, fine-tuning cost factors, etc
    c. BIM helps government/owners and end-users understand and visualize the end product
    d. BIM helps government/owners and end-users in making informed decisions about the proposed project
    e. BIM helps oversee construction execution for cost and schedule growth in real time

10) If neutral in question #8, what is the reason? (check all that apply)
    a. BIM is a good tool, but a project will do well with or without it
    b. BIM will not necessarily enhance design quality or contractor productivity enough to require it to be a standard to be used

11) If no in question #8, what is the reason? (check all that apply)
    a. Too many interface IT issues between government, architect/engineer, contractor, and sub-contractor(s)
    b. NAVFAC staff education and background not suitable for BIM training and use
    c. Costs in software, and licensing would be too high to implement
    d. Too much costs/effort to train government personnel to know how to use this
    e. BIM not needed. Construction projects are being executed well enough.
    f. NAVFAC contracts are not ready to take BIM into account properly

12) The purpose of Firm Fixed Price (FFP) contracts is to emphasize cost/price control. FFP is currently used on all construction projects.
    With this kind of emphasis on cost control, would this have a positive or negative effect on contractor performance? (Check all that apply)
    a. Yes. Contractor is forced to optimize costs, which is key to good performance
    b. No. Contractor would focus more on costs and not job performance/quality
    c. Any additional comments?
    d. Unfamiliar

13) Fixed Price Incentive Firm (FPIF) contracts attain cost or technical incentives by **rewarding contractor achievements in exceeding standards (profits increase) and negatively rewarding (decreased profit) contractor's failures to reach standards**.
If/when FPIF is used on a construction project, would this be better than using FFP? (check all that apply)
   a. Yes. Contractor will exceed standards while simultaneously controlling costs.
   b. No. Contractor will falsely inflate performance information to get more profit.
   c. No. Results would be the same whether FPIF or FFP is used.
   d. Unfamiliar

14) Fixed Price Award Fee (FPAF) contracts establish a fixed price, including normal profit, paid for satisfactory contract performance. An **award fee is paid in addition to the fixed price based on an award-fee plan**, if the contracting officer deems so.
Award fees are used to motivate a contractor, since other incentives cannot be used when contractor performance cannot be objectively measured.
If/when FPAF is used on a construction project, would this be better than using FFP? (check all that apply).
   a. Yes. Contractor will optimize in all areas (cost, quality, schedule) to obtain award fee.
   b. No. Award fee criteria is too vague to be effective on construction projects
   c. No. Contractor will falsely inflate performance information to get more award fee.
   d. No. Results would be the same whether FPAF or FFP is used.
   e. Unfamiliar

15) Please choose which project delivery method that you feel is generally more effective for project execution?
   a. Design-Build
   b. Design-Bid-Build
   c. Depends on complexity

16) If you chose design-build, why? (please check all that apply)
   a. Generally less risk to Government and more to contractor
   b. Saves time because there is early contractor involvement starting with design
   c. Allows fast tracking of design
   d. Saves costs, due to collaboration of architect/engineer, and construction contractor
   e. Improved quality
   f. Better project innovation

17) If you chose design-bid-build, why? (please check all that apply)
   a. Only project delivery method allowed
   b. Most well known project delivery method. So, everyone is comfortable with it
   c. Costs/price better established at bid time
   d. When construction starts, exact product is fully designed and known

18) What is your level of familiarity with "lean construction"? (please check all that apply)
   a. Unfamiliar
   b. Aware of lean construction concept
   c. Understand the application of lean construction in design
   d. Understand the application of lean construction in construction execution
   e. Contractor has implemented lean construction on projects that I have worked on

19) If you answered Question 18 with E, is there any value in executing lean construction compared to conventional construction?
   a. Yes. Lean construction emphasizes maximizing productivity and minimizing waste
   b. Yes. Lean construction emphasizes total project performance not simply reducing costs
   c. No. Lean construction is not necessary. Conventional construction/design is sufficient
   d. No. Lean construction does not optimize project performance.
   e. Neutral

20) If you answered Question 19 with E, what is the reason?
   a. Lean construction is a good principle, but a project will do well with or without it
   b. Lean construction will not necessarily enhance design quality or contractor productivity enough to require it to be the standard

21) Are you familiar with the project delivery method Integrated Project Delivery (IPD)? (please check all that apply)
   a. Unfamiliar
   b. Aware of IPD project delivery method
   c. Understand the application of IPD in design
   d. Understand the application of IPD in construction
   e. Contractor implemented IPD on my project(s).

22) Based on the short description of IPD, should NAVFAC implement IPD?
   a. Yes
   b. Neutral
   c. No
   d. Unsure

23) If you answered Yes to Question 22, what is the reason? (check all that apply)
   a. Provides a good financial incentive (good cost control) for team members to be integrated, sharing both pain and gain (risk sharing)
   b. Construction/design quality would be higher than what you get from D-B or D-B-B due to integrated collaborative environment
   c. Discourages contractors from understating to make profits from change orders
   d. Usage of BIM will enable greater collaboration , more robust design and more efficient construction execution

24) If you answered No to Question 22, what is the reason? (check all that apply)
   a. Too unconventional (sharing risks)
   b. No need for IPD. Current D-B and D-B-B approaches work well
   c. IPD can be abused by a member due to integrated risk sharing paradigm
   d. BIM is not needed

25) If neutral in question 22, what is the reason? (check all that apply)
   a. IPD is a good project delivery method, but project will do well with or without it
   b. IPD will not necessarily enhance design quality or contractor productivity enough to require it to be a standard

26) Does NAVFAC really need to make partnering such a formal process (between government and contractor)?
   a. Yes
   b. Neutral
   c. No
   d. Unfamiliar

27) If you answered yes in Question 26, what is the reason? (check all that apply)
   a. It provides the environment for **sufficient** collaboration and decision making
   b. It provides the environment for **full** collaboration and decision making
   c. It needs to be formal/mandated because people will not do it otherwise

28) If you answered no in Question 26, what is the reason? (check all that apply)
   a. Partnering on a formal basis not necessary. It can be done informally.
   b. Formal partnering has minimal value. Contractor needs to do the work specified by the contract.

29) If neutral in question 26, what is the reason? (check all that apply)
   a. Formal partnering is a good component of the project, but a project will do well with or without it being formal
   b. Formal partnering will not necessarily enhance design quality or contractor productivity enough to require it to be a standard

30) Do you feel that the interactions between the NAVFAC (e.g. ROICC, OICC, or IPT) teams and the USMC public works teams generally work well?
   a. Yes
   b. Neutral
   c. No
   d. Unfamiliar

31) If you answered yes in Question 30, what is the reason? (check all that apply)
   a. Communication and expectations are clearly understood
   b. Proactive sharing of information is present
   c. Good general rapport between NAVFAC and USMC
   d. Good understanding of each other's business processes

32) If you answered no in Question 30, what is the reason? (check all that apply)
   a. General attitude of distrust
   b. Not very good flow of information back and forth
   c. Communication is not performed very well
   d. Expectations of the other party are not met
   e. General lack of understanding of each other's business processes
   f. Interactions are marginally adequate but could be better

33) If you answered neutral in Question 30, what is the reason? (check all that apply)
   a. Interactions between NAVFAC and USMC are what they are. Nothing great, but nothing bad enough to change anything.
   b. Efforts to improve communications and interactions will not necessarily enhance design quality or contractor productivity enough for the level of effort required.

34) Any comments that you would like to make about anything that you were asked in this survey? (not required)

APPENDIX B

Survey Data:

NAVFAC	Question 1	SPSS Question 1 (USMC/USN)	SPSS Question 2 (Level)	Question 2	SPSS Question 3 (Years)	Question 3	SPSS Question 4 (Rank)
1	J	1	2	C	3	D	4
2	N (XO)	1	2	A	1	D	4
3	L	1	2	B	2	C	3
4	A	1	3	E	5	-	
5	C	1	3	C	3	-	
6	C	1	2	B	2	-	
7	N	1	1	A	1	F	6
8	M	1	2	B	2	E	5
9	P	1	1	A	1	F	6
10	A	1	3	C	3	-	
11	D	1	2	B	2	-	
12	C	1	2	B	2	-	
13	C	1	3	B	2	-	
14	C	1	3	E	5	-	
15	C	1	3	B	2	-	
16	D	1	2	B	2	C	3
17	J, L	1	2	B	2	C	3
18	A	1	3	B	2	-	
19	D	1	2	B	2	-	
20	C	1	3	B	2	-	
21	C	1	3	B	2	-	
22	A	1	2	B	2	C	3
23	A	1	3	B	2	A	1
24	A	1	3	B	2	-	
25	L	1	2	B	2	D	4

	Question 1	SPSS Question 1 (USMC/USN)	SPSS Question 2 (Level)	Question 2	SPSS Question 3 (Years)	Question 3	SPSS Question 4 (Rank)
26	A	1	1	B	2	A	1
27	D	1	2	C	3	-	
28	L	1	2	B	2	E	5
29	N	1	1	B	2	-	
30	A	1	3	B	2	-	
31	C	1	2	B	2	-	
32	C	1	3	E	5	-	
33	C	1	3	D	4	-	
USMC							
34	G	2	3	B	2	-	
35	J	2	2	A	1	D	4
36	K	2	2	B	2	-	
37	H	2	3	B	2	-	
38	G	2	3	A	1	-	
39	G	2	3	C	3	-	
40	H	2	3	B	2	-	
41	D, O	2	1	E	5	-	
42	O	2	2	B	2	-	
43	J	2	2	A	1	E	5
44	I	2	2	B	2	C	3
45	L	2	2	A	1	D	4
46	K	2	2	C	3	-	
47	P	2	1	C	3	-	
48	O	2	1	B	2	F	6
49	P	2	1	B	2	F	6
50	G	2	3	B	2	-	
51	J, L	2	2	B	2	D	4
52	D	2	2	C	3	-	

	Question	SPSS Question	Question	SPSS Question		Question
	4	5 (Years Overall)	5	6 (Const)		6
NAVFAC						
1	D	4	C	3		B
2	D	4	C	3		B, C, D, E
3	B	2	B	2		B
4	E	5	E	5		B, C ,D
5	C	3	A	1		B
6	E	5	E	5		B, C, D
7	E	5	C	3		B,C, D, E, F
8	E	5	B	2		B
9	E	5	C	3		B,C, D, E, F
10	D	4	D	4		B, D
11	C	3	C	3		B,C, D, E, F
12	D	4	C	3		B, D, F
13	B	2	B	2		A
14	E	5	E	5		B
15	B	2	B	2		A
16	C	3	B	2		B,C, D, E, F
17	C	3	B	2		B
18	E	5	D	4		B, C, D, F
19	E	5	E	5		B
20	B	2	B	2		B
21	B	2	B	2		B, F
22	B	2	B	2		B, C
23	C	3	B	2		B, C, D, E
24	E	5	E	5		B, C, D, E
25	D	4	C	3		B,C, D, E, F

	Question 4	SPSS Question 5 (Years Overall)	Question 5	SPSS Question 6 (Const)		Question 6
26	B	2	B	2		B
27	B	2	B	2		B, C, D, E
28	E	5	C	3		B,C, D, E, F
29	E	5	E	5		B,C, D, E, F
30	D	4	B	2		B, D, F
31	E	5	B	2		B
32	D	4	D	4		B
33	D	4	C	3		B
USMC						
34	D	4	C	3		B
35	D	4	C	3		B, C, D, E, F
36	C	3	D	4		B
37	C	3	C	3		A
38	A	1	A	1		A
39	C	3	C	3		B
40	C	3	C	3		B
41	E	5	D	4		B, D
42	B	2	D	4		B
43	D	4	A	1		B, C
44	C	3	A	1		A
45	E	5	C	3		B
46	E	5	B	2		B, C, D, E
47	E	5	B	2		B
48	D	4	B	2		B
49	E	5	B	2		B
50	E	5	A	1		B, C, D
51	B	2	C	3		B
52	E	5	E	5		B, C, D, E

NAVFAC	SPSS Question 7 (BIM Familiar)	SPSS Question 8 (BIM design, C)	SPSS Question 9 (BIM const, D)	SPSS Question 10 (BIM O&M, E)
1	1	2	2	2
2	1	1	1	1
3	1	2	2	2
4	1	1	1	2
5	1	2	2	2
6	1	1	1	2
7	1	1	1	1
8	1	2	2	2
9	1	1	1	1
10	1	2	1	2
11	1	1	1	1
12	1	2	1	2
13	2	2	2	2
14	1	2	2	2
15	2	2	2	2
16	1	1	1	1
17	1	2	2	2
18	1	1	1	2
19	1	2	2	2
20	1	2	2	2
21	1	2	2	2
22	1	1	2	2
23	1	1	1	1
24	1	1	1	1
25	1	1	1	1

	SPSS Question 7 (BIM Familiar)	SPSS Question 8 (BIM design, C)	SPSS Question 9 (BIM const, D)	SPSS Question 10 (BIM O&M, E)
26	1	2	2	2
27	1	1	1	1
28	1	1	1	1
29	1	1	1	1
30	1	2	1	2
31	1	2	2	2
32	1	2	2	2
33	1	2	2	2
USMC				
34	1	2	2	2
35	1	1	1	1
36	1	2	2	2
37	2	2	2	2
38	2	2	2	2
39	1	2	2	2
40	1	2	2	2
41	1	2	1	2
42	1	2	2	2
43	1	1	2	2
44	2	2	2	2
45	1	2	2	2
46	1	1	1	1
47	1	2	2	2
48	1	2	2	2
49	1	2	2	2
50	1	1	1	2
51	1	2	2	2
52	1	1	1	1

NAVFAC	SPSS Question 10 (BIM implement, F)	Question 7	SPSS Question 11 (BIM implemented, A)	SPSS Question 12 (BIM implemented, b)	SPSS Question 13 (BIM implemented, C)
1	2	-			
2	2	-			
3	2	-			
4	2	-			
5	2	-			
6	2	-			
7	1	A, B, C	1	1	1
8	2	-			
9	1	A, B	1	1	2
10	2	-			
11	1	B	2	1	2
12	1	C	2	2	1
13	2	-			
14	2	-			
15	2	-			
16	1	C	2	2	1
17	2	-			
18	1	B	2	1	2
19	2	-			
20	2	-			
21	1	-			
22	2	-			
23	2	-			
24	2	-			
25	1	A, B	1	1	2

	SPSS Question 10 (BIM implement, F)	Question 7	SPSS Question 11 (BIM implemented, A)	SPSS Question 12 (BIM implemented, b)	SPSS Question 13 (BIM implemented, C)
26	2	-			
27	2	-			
28	1	A, B, C	1	1	1
29	1	A, B	1	1	2
30	1	B, C	2	1	1
31	2	-			
32	2	-			
33	2	-			
USMC					
34	2	-			
35	1	B	2	1	2
36	2	-			
37	2	-			
38	2	-			
39	2	-			
40	2	-			
41	2	-			
42	2	-			
43	2	-			
44	2	-			
45	2	-			
46	2	-			
47	2	-			
48	2	-			
49	2	-			
50	2	-			
51	2	-			
52	2	-			

	Question 8	SPSS Question 14 (NAVFAC BIM?)	Question 9	SPSS Question 15 (Why BIM?) A	SPSS Question 16 (Why BIM?) B	SPSS Question 17 (Why BIM?) C
NAVFAC						
1	C	3	-			
2	C	3	-			
3	A	1	A, B, C	1	1	1
4	A	1	A, B, C, D, E	1	1	1
5	D	4	-			
6	A	1	A, B, C, D, E	1	1	1
7	A	1	A, B, C, D, E	1	1	1
8	A	1	A, B, C, D, E	1	1	1
9	A	1	A, C, D, E	1	2	1
10	B	2	-			
11	A	1	A, B, C, D	1	1	1
12	A	1	A, C	1	2	1
13	D	4	-			
14	B	2	-			
15	D	4	-			
16	A	1	A, C, D	1	2	1
17	A	1	A, B, C, D, E	1	1	1
18	A	1	A, B, C, D, E	1	1	1
19	A	1	A, B, C, D, E	1	1	1
20	A	1	A, B, C, D, E	1	1	1
21	A	1	A, B, C, D, E	1	1	1
22	A	1	A, B, C, D, E	1	1	1
23	A	1	A, B, C, D, E	1	1	1
24	A	1	A, B, C, D, E	1	1	1
25	A	1	A, B, C, D, E	1	1	1

	Question 8	SPSS Question 14 (NAVFAC BIM?)	Question 9	SPSS Question 15 (Why BIM?) A	SPSS Question 16 (Why BIM?) B	SPSS Question 17 (Why BIM?) C
26	B	2	-			
27	A	1	A, B, C, D, E	1	1	1
28	A	1	A, B, C, D, E	1	1	1
29	A	1	A, B, C, D, E	1	1	1
30	A	1	A, C, D	1	2	1
31	A	1	A, C	1	2	1
32	A	1	A, B, C, D, E	1	1	1
33	A	1	B, C	2	1	1
USMC						
34	A	1	C,D	1	2	1
35	A	1	A, B, C, D, E	2	1	1
36	D	4	-			
37	D	4	-			
38	D	4	-			
39	B	2	-			
40	D	4	-			
41	C	3	-			
42	A	1	A, B, C, D, E	1	1	1
43	D	4	-			
44	D	4	-			
45	A	1	A, B, C, D, E	1	1	1
46	A	1	A	1	2	2
47	A	1	A, B, C, E	1	1	1
48	A	1	A, B, C, D, E	1	1	1
49	D	4	-			
50	A	1	A, C, D, E	1	2	1
51	A	1	A, B, C, D, E	1	1	1
52	B	2	-			

	SPSS Question 18 (Why BIM?) D	SPSS Question 19 (Why BIM?) E	Question 10	SPSS Question 20 (BIM neutral?) A	SPSS Question 21 (BIM neutral?) b	Question 11
NAVFAC						
1			-			A
2			-			E
3	2	2	-			-
4	1	1	-			-
5			-			-
6	1	1	-			-
7	1	1	-			-
8	1	1	-			-
9	1	1	-			-
10			B	2	1	-
11	1	2	-			-
12	2	2	-			-
13			-			-
14			A	1	2	-
15			-			-
16	2	2	-			-
17	1	1	-			-
18	1	1	-			-
19	1	1	-			-
20	1	1	-			-
21	1	1	-			-
22	1	1	-			-
23	1	1	-			-
24	1	1	-			-
25	1	1	-			-

	SPSS Question 18 (Why BIM?) D	SPSS Question 19 (Why BIM?) E	Question 10	SPSS Question 20 (BIM neutral?) A	SPSS Question 21 (BIM neutral?) b	Question 11
26			B	2	1	-
27	1	1	-			-
28	1	1	-			-
29	1	1	-			-
30	1	2	-			-
31	2	2	-			-
32	1	1	-			-
33	2	2	-			-
USMC						
34	1	2	-			-
35	1	1	-			-
36			-			-
37			-			-
38			-			-
39			A	1	2	-
40			-			-
41			-			C, D
42	1	1	-			-
43			-			-
44			-			-
45	1	1	-			-
46	2	2	-			-
47	2	1	-			-
48	1	1	-			-
49			-			-
50	1	1	-			-
51	1	1	-			-
52			-			A, B, C, F

	SPSS Question 22 (BIM no?) A	SPSS Question 22 (BIM no?) B	SPSS Question 23 (BIM no?) C	SPSS Question 24 (BIM no?) D	SPSS Question 25 (BIM no?) E	SPSS Question 26 (BIM no?) F
NAVFAC						
1	1	2	2	2	2	2
2	2	2	2	2	1	2
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
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14						
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16						
17						
18						
19						
20						
21						
22						
23						
24						
25						

	SPSS Question 22 (BIM no?) A	SPSS Question 22 (BIM no?) B	SPSS Question 23 (BIM no?) C	SPSS Question 24 (BIM no?) D	SPSS Question 25 (BIM no?) E	SPSS Question 26 (BIM no?) F
26						
27						
28						
29						
30						
31						
32						
33						
USMC						
34						
35						
36						
37						
38						
39						
40						
41	2	2	1	1	2	2
42						
43						
44						
45						
46						
47						
48						
49						
50						
51						
52	1	1	1	2	2	1

	Question	SPSS Question	Question	SPSS Question	Question	SPSS Question
	12	27 (FFP?)	13	28 (FPIF?)	14	29 (FPAF?)
NAVFAC						
1	C	3	A	1	E	5
2	C	3	C	3	B	2
3	B	2	C	3	B	2
4	A	1	B	2	A	1
5	A, B	3	A	1	A	1
6	B	2	A	1	A	1
7	C	3	A	1	B	2
8	A	1	A	1	A	1
9	B	2	A	1	A	1
10	A	1	C	3	D	4
11	A	1	C	3	E	5
12	A	1	C	3	D	4
13	A	1	B	2	C	3
14	B	2	A, B	5	A	1
15	B	2	A	1	B	2
16	A	1	B	2	C	3
17	A, B	3	A	1	A	1
18	B	2	A	1	A	1
19	B	2	A	1	A	1
20	A	1	B	2	C	3
21	A, B	3	B, C	3	D	4
22	A	1	A	1	A	1
23	A	1	D	4	E	5
24	B	2	A, B	5	A	1
25	A	1	A	1	A	1

	Question 12	SPSS Question 27 (FFP?)	Question 13	SPSS Question 28 (FPIF?)	Question 14	SPSS Question 29 (FPAF?)
26	A	1	A	1	A	1
27	B	2	C	3	A	1
28	A	1	B	2	C	3
29	A, B	3	A	1	A	1
30	A	1	C	3	B	2
31	A	1	D	4	B	2
32	A	1	A	1	A	1
33	A	1	A	1	A	1
USMC						
34	A	1	A	1	B	2
35	C	3	A	1	C	3
36	C	3	D	4	A	1
37	D	4	E	5	E	5
38	A, B	3	A	1	A	1
39	A	1	A	1	A	1
40	A	1	A	1	A	1
41	A	1	B	2	B	2
42	B	2	A	1	B	2
43	A	1	C	3	D	4
44	B	2	E	5	E	5
45	B	2	A	1	A	1
46	A	1	A	1	A	1
47	A	1	C	3	B	2
48	A	1	A	1	A	1
49	A	1	A, B	5	D	4
50	A	1	A	1	A	1
51	A	1	A	1	A	1
52	B	2	B	2	C	3

NAVFAC	Question 15	SPSS Question 29 (DB?DBB?)	Question 16	SPSS Question 30 (Why DB?) A	SPSS Question 31 (Why DB?) B	SPSS Question 32 (Why DB?) C
1	C	3	A, B, C, F	1	1	1
2	C	3	B, C, D, F	2	1	1
3	A	1	A, B, C, D, E, F	1	1	1
4	A	1	A, E, F	1	2	2
5	A	1	A, B, C, D, E, F	1	1	1
6	A	1	A, C, D, E, F	1	2	1
7	A	1	A,B,C,D,F	1	1	1
8	A	1	A, B, C, D, E, F	1	1	1
9	A	1	B, C, D	2	1	1
10	B	2	-			
11	A	1	A, B, C, D, E, F	1	1	1
12	A	1	A, B, C, D, E, F	1	1	1
13	A	1	B, D	2	1	2
14	A	1	D, E, F	2	2	2
15	A	1	A, B, C, D, E	1	1	1
16	A	1	A, B, C, D, E, F	1	1	1
17	A	1	A, B, C, D, E, F	1	1	1
18	A	1	A, B, D	1	1	2
19	A	1	A, B, C, D, F	1	1	1
20	A	1	A, B, C, D, E, F	1	1	1
21	A	1	A, B, C, D, E, F	1	1	1
22	A	1	A, B, C, D, F	1	1	1
23	A	1	A, B, C, D, E, F	1	1	1
24	A	1	A, B, C, D, E, F	1	1	1
25	C	3	A, B, C, D, E, F	1	1	1

	Question 15	SPSS Question 29 (DB?DBB?)	Question 16	SPSS Question 30 (Why DB?) A	SPSS Question 31 (Why DB?) B	SPSS Question 32 (Why DB?) C
26	A	1	A, B, C, D, E, F	1	1	1
27	A	1	A, B, C	1	1	1
28	A	1	A,B,C,D,F	1	1	1
29	A	1	D, E, F	2	2	2
30	A	1	A, B, D, F	1	1	2
31	A	1	A	1	2	2
32	A	1	A, F	1	2	2
33	A	1	A, E, F	1	2	2
USMC						
34	A	1	B, D	2	1	2
35	A	1	A, B, C, D,F	1	1	1
36	C	3	B, D	2	1	2
37	A	1	A, C	1	2	1
38	A	1	A, E, F	1	2	2
39	B	2	-			
40	B	2	-			
41	A	1	D	2	2	2
42	B	2	-			
43	A	1	B, C, D, E, F	2	1	1
44	A	1	A, B, C, D, E, F	1	1	1
45	A	1	A, B, C, D	1	1	1
46	C	3	A, B, C, D, F	1	1	1
47	C	3	A, B, C, D, E, F	1	1	1
48	A	1	A	1	2	2
49	A	1	A, D, F	1	2	2
50	B	2	-			
51	A	1	A, C	1	2	1
52	C	3	A, B, C, D	1	1	1

	SPSS Question 33 (Why DB?) D	SPSS Question 34 (Why DB?) E	SPSS Question 34 (Why DB?) F	Question 17	SPSS Question 35 (Why DBB?) B	SPSS Question 36 (Why DBB?) C
NAVFAC						
1	2	2	1	B, C, D	1	1
2	1	2	1	C, D	2	1
3	1	1	1	-		
4	2	1	1	-		
5	1	1	1	-		
6	1	1	1	-		
7	1	2	1	-		
8	1	1	1	-		
9	1	2	2	-		
10				C, D	2	1
11	1	1	1	-		
12	1	1	1	-		
13	1	2	2	-		
14	1	1	1	-		
15	1	1	2	-		
16	1	1	1	-		
17	1	1	1	-		
18	1	2	2	-		
19	1	2	1	-		
20	1	1	1	-		
21	1	1	1	-		
22	1	2	1	-		
23	1	1	1	-		
24	1	1	1	-		
25	1	1	1	B, C, D	1	1

	SPSS Question 33 (Why DB?) D	SPSS Question 34 (Why DB?) E	SPSS Question 34 (Why DB?) F	Question 17	SPSS Question 35 (Why DBB?) B	SPSS Question 36 (Why DBB?) C
26	1	1	1	-		
27	2	2	2	-		
28	1	2	1	-		
29	1	1	1	-		
30	1	2	1	-		
31	2	2	2	-		
32	2	2	1	-		
33	2	1	1	-		
USMC						
34	1	2	2	-		
35	1	2	1	-		
36	1	2	2	C, D	2	1
37	2	2	2	-		
38	1	1	1	-		
39				B, D	1	2
40				D	2	2
41	1	2	2	-		
42				D	2	2
43	1	1	1	-		
44	1	1	1	-		
45	1	2	2	-		
46	1	2	1	C, D	2	1
47	1	1	1	B, C, D	1	1
48	2	2	2	D	2	2
49	1	2	1	-		
50				B, C, D	1	1
51	2	2	2	-		
52	1	2	2	B, D	1	2

	SPSS Question 37 (Why DBB?) D		Question 18	SPSS Question 38 (Lean?) A	SPSS Question 39 (Lean?) B	SPSS Question 40 (Lean?) C
NAVFAC						
1	1		A	1	2	2
2	1		B	2	1	2
3			B	2	1	2
4			A	1	2	2
5			B	2	1	2
6			B, C	2	1	1
7			B	2	1	2
8			A	1	2	2
9			B, C, D, E	2	1	1
10	1		A	1	2	2
11			B, C, D, E	2	1	1
12			A	1	2	2
13			A	1	2	2
14			C, D	2	2	1
15			A	1	2	2
16			A	1	2	2
17			B	2	1	2
18			A	1	2	2
19			A	1	2	2
20			A	1	2	2
21			A	1	2	2
22			B	2	1	2
23			B, C, D	2	1	1
24			B, C, D,E	2	1	1
25	1		A	1	2	2

	SPSS Question 37 (Why DBB?) D		Question 18	SPSS Question 38 (Lean?) A	SPSS Question 39 (Lean?) B	SPSS Question 40 (Lean?) C
26			B	2	1	2
27			B	2	1	2
28			B, C, D,E	2	1	1
29			B	2	1	2
30			A	1	2	2
31			A	1	2	2
32			A	1	2	2
33			B, D, E	2	1	2
USMC						
34			B	2	1	2
35			D, E	2	2	2
36	1		B	2	1	2
37			A	1	2	2
38			A	1	2	2
39	1		A	1	2	2
40	1		A	1	2	2
41			B	2	1	2
42	1		A	1	2	2
43			A	1	2	2
44			A	1	2	2
45			A	1	2	2
46	1		B, C, D	2	1	1
47	1		B	2	1	2
48	1		A	1	2	2
49			B	2	1	2
50	1		A	1	2	2
51			B	2	1	2
52	1		B	2	1	2

	SPSS Question	SPSS Question	Question	SPSS Question	Question	Question	SPSS Question
	41 (Lean?) D	42 (Lean?) E	19	43 (Lean y?)	20	21	44 (IPD fam?) A
NAVFAC							
1	2	2	-		-	B	2
2	2	2	-		-	A	1
3	2	2	-		-	A	1
4	2	2	-		-	B, C, D	2
5	2	2	-		-	B	2
6	2	2	-		-	B, C, D	2
7	2	2	-		-	A	1
8	2	2	-		-	A	1
9	1	1	A, B	1	-	B	2
10	2	2	-		-	A	1
11	1	1	A, B	1	-	A	1
12	2	2	-		-	A	1
13	2	2	-		-	A	1
14	1	2	-		-	A	1
15	2	2	-		-	A	1
16	2	2	-		-	A	1
17	2	2	-		-	A	1
18	2	2	-		-	B	2
19	2	2	-		-	A	1
20	2	2	-		-	A	1
21	2	2	-		-	A	1
22	2	2	-		-	A	1
23	1	2	-		-	B	2
24	1	1	A, B	1	-	B, C, D, E	2
25	2	2	-		-	A	1

	SPSS Question 41 (Lean?) D	SPSS Question 42 (Lean?) E	Question 19	SPSS Question 43 (Lean y?)	Question 20	Question 21	SPSS Question 44 (IPD fam?) A
26	2	2	-		-	B	2
27	2	2	-		-	B, C, D	2
28	1	1	A, B	1	-	B, C, D	2
29	2	2	-		-	B, C, D	2
30	2	2	-		-	A	1
31	2	2	-		-	A	1
32	2	2	-		-	B	2
33	1	1	A, B	1	-	A	1
USMC							
34	2	2	-		-	A	1
35	1	1	A, B	1	-	B, D	2
36	2	2	-		-	B	2
37	2	2	-		-	A	1
38	2	2	-		-	A	1
39	2	2	-		-	A	1
40	2	2	-		-	A	1
41	2	2	-		-	B	2
42	2	2	-		-	A	1
43	2	2	-		-	A	1
44	2	2	-		-	A	1
45	2	2	-		-	A	1
46	1	2	-		-	A	1
47	2	2	-		-	B	2
48	2	2	-		-	A	1
49	2	2	-		-	A	1
50	2	2	-		-	B	2
51	2	2	-		-	B	2
52	2	2	-		-	B, C, D	2

	SPSS Question 44 (IPD fam?) B	SPSS Question 45 (IPD fam?) C	SPSS Question 46 (IPD fam?) D	Question 22	SPSS Question 47 (IPD use?)	Question 23
NAVFAC						
1	1	2	2	A	1	A, B, C
2	2	2	2	A	1	A
3	2	2	2	A	1	A, B, D
4	1	1	1	A	1	D
5	1	2	2	A	1	A,D
6	1	1	1	A	1	A,B ,C, D
7	2	2	2	A	1	A
8	2	2	2	A	1	A, B
9	1	2	2	D	4	-
10	2	2	2	D	4	-
11	2	2	2	C	3	-
12	2	2	2	B	2	-
13	2	2	2	A	1	A, B, C
14	2	2	2	D	4	-
15	2	2	2	D	4	-
16	2	2	2	A	1	A,B C, D
17	2	2	2	A	1	A,B ,D
18	1	2	2	A	1	A, D
19	2	2	2	A	1	A
20	2	2	2	C	3	-
21	2	2	2	C	3	-
22	2	2	2	A	1	A
23	1	2	2	A	1	A,B C, D
24	1	1	1	A	1	B, D
25	2	2	2	B	2	-

	SPSS Question 44 (IPD fam?) B	SPSS Question 45 (IPD fam?) C	SPSS Question 46 (IPD fam?) D	Question 22	SPSS Question 47 (IPD use?)	Question 23
26	1	2	2	B	2	-
27	1	1	1	A	1	A, B, D
28	1	1	1	A	1	A, C, D
29	1	1	1	A	1	A, B, D
30	2	2	2	A	1	A, C, D
31	2	2	2	B	2	-
32	1	2	2	B	2	-
33	2	2	2	D	4	-
USMC						
34	2	2	2	A	1	A
35	1	2	1	A	1	A,B,C, D
36	1	2	2	A	1	A
37	2	2	2	A	1	B
38	2	2	2	A	1	B, D
39	2	2	2	A	1	B
40	2	2	2	A	1	A, C
41	1	2	2	C	3	-
42	2	2	2	A	1	D
43	2	2	2	A	1	C
44	2	2	2	D	4	-
45	2	2	2	A	1	A, D
46	2	2	2	A	1	A
47	1	2	2	B	2	-
48	2	2	2	D	4	-
49	2	2	2	A	1	B
50	1	2	2	A	1	B, D
51	1	2	2	C	3	-
52	1	1	1	B	2	-

NAVFAC	SPSS Question 48 (IPD yes?) A	SPSS Question 49 (IPD yes?) B	SPSS Question 50 (IPD yes?) C	SPSS Question 51 (IPD yes?) D	Question 24	SPSS Question 52 (IPD No?) A
1	1	1	1	2	-	
2	1	2	2	2	-	
3	1	1	2	1	-	
4	2	2	2	1	-	
5	1	2	2	1	-	
6	1	1	1	1	-	
7	1	2	2	2	-	
8	1	1	2	2	-	
9					-	
10					-	
11					B, C	2
12					-	
13	1	1	1	2	-	
14					-	
15					-	
16	1	1	1	1	-	
17	1	1	2	1	-	
18	1	2	2	1	-	
19	1	2	2	2	-	
20					A	1
21					-	
22	1	2	2	2	-	
23	1	1	1	1	-	
24	2	1	2	1	-	
25					-	

	SPSS Question 48 (IPD yes?) A	SPSS Question 49 (IPD yes?) B	SPSS Question 50 (IPD yes?) C	SPSS Question 51 (IPD yes?) D	Question 24	SPSS Question 52 (IPD No?) A
26					-	
27	1	1	2	1	-	
28	1	2	1	1	-	
29	1	1	2	1	-	
30	1	2	1	1	-	
31					-	
32					-	
33					-	
USMC						
34	1	2	2	2	-	
35	1	1	1	1	-	
36	1	2	2	2	-	
37	2	1	2	2	-	
38	2	1	2	1	-	
39	2	1	2	2	-	
40	1	2	1	2	-	
41					C	2
42	2	2	2	1	-	
43	2	2	1	2	-	
44					-	
45	1	2	2	1	-	
46	1	2	2	2	-	
47					-	
48					-	
49	2	1	2	2	-	
50	2	1	2	1	-	
51					A	1
52					-	

	SPSS Question	SPSS Question	Question	SPSS Question	SPSS Question	Question
	53 (IPD No?) B	54 (IPD No?) C	25	55 (IPD No?) A	56 (IPD No?) B	26
NAVFAC						
1			-			B
2			-			A
3			-			A
4			-			A
5			-			A
6			-			A
7			-			B
8			-			A
9			-			A
10			-			B
11	1	1	-			A
12			A	1	2	C
13			-			A
14			-			A
15			-			A
16			-			A
17			-			A
18			-			A
19			-			A
20	2	2	-			A
21			-			A
22			-			C
23			-			A
24			-			C
25			A	1	2	A

	SPSS Question 53 (IPD No?) B	SPSS Question 54 (IPD No?) C	Question 25	SPSS Question 55 (IPD No?) A	SPSS Question 56 (IPD No?) B	Question 26
26			B	2	1	A
27			-			B
28			-			A
29			-			A
30			-			A
31			A	1	2	A
32			B	2	1	A
33			-			A
USMC						
34			-			D
35			-			A
36			-			A
37			-			D
38			-			C
39			-			A
40			-			C
41	2	1	-			C
42			-			A
43			-			A
44			-			A
45			-			A
46			-			C
47			A	1	2	B
48			-			A
49			-			A
50			-			A
51	2	2	-			C
52			A	1	2	A

	SPSS Question 57 (Partner?)	Question 27	SPSS Question 58 (Partner Suff?)	SPSS Question 59 (Partner Full?)	Question 28	SPSS Question 60 (Partner No?) A
NAVFAC						
1	2	-			-	
2	1	A, C	1	2	-	
3	1	A, C	1	2	-	
4	1	A, C	1	2	-	
5	1	B, C	2	1	-	
6	1	A, C	1	2	-	
7	2	-			-	
8	1	A, C	1	2	-	
9	1	B, C	2	1	-	
10	2	-			-	
11	1	B, C	2	1	-	
12	3	-			A	1
13	1	B, C	2	1	-	
14	1	A, C	1	2	-	
15	1	A, C	1	2	-	
16	1	A, C	1	2	-	
17	1	A, C	1	2	-	
18	1	A, C	1	2	-	
19	1	B, C	2	1	-	
20	1	B, C	2	1	-	
21	1	-			-	
22	3	-			A	1
23	1	A	1	2	-	
24	3	A, C	1	2	-	
25	1	B, C	2	1	-	

	SPSS Question 57 (Partner?)	Question 27	SPSS Question 58 (Partner Suff?)	SPSS Question 59 (Partner Full?)	Question 28	SPSS Question 60 (Partner No?) A
26	1	A, C	1	2	-	
27	2	-			-	
28	1	A, C	1	2	-	
29	1	B, C	2	1	-	
30	1	A, C	1	2	-	
31	1	A, C	1	2	-	
32	1	B, C	2	1	-	
33	1	A, C	1	2	-	
USMC						
34	4	-			-	
35	1	A, C	1	2	-	
36	1	A, C	1	2	-	
37	4	-			-	
38	3	-			A	1
39	1	B, C	2	1	-	
40	3	-			A	1
41	3	-			A, B	1
42	1	A, C	1	2	-	
43	1	A, C	1	2	-	
44	1	A, C	1	2	-	
45	1	A, C	1	2	-	
46	3	-			A	1
47	2	-			-	
48	1	B, C	2	1	-	
49	1	A, C	1	2	-	
50	1	A, C	1	2	-	
51	3	-			A, B	1
52	1	A, C	1	2	-	

	SPSS Question 61 (Partner No?) B	Question 29	SPSS Question 61 (Partner Neutral?) A	SPSS Question 62 (Partner Neutral?) B	Question 30	SPSS Question 62 (NAVFAC USMC)	Question 31
NAVFAC							
1		B	2	1	A	1	C, D
2		-			B	2	-
3		-			A	1	A, B, C, D
4		-			C	3	-
5		-			C	3	-
6		-			A	1	A, B, C, D
7		A	1	2	C	3	-
8		-			A	1	C
9		-			A	1	A, B, C, D
10		A	1	2	C	3	-
11		-			C	3	-
12	2	-			C	3	-
13		-			D	4	-
14		-			A	1	A, B, C
15		-			A	1	A, B, C
16		-			C	3	-
17		-			A	1	A,B, C, D
18		-			A	1	A,B, C, D
19		-			C	3	-
20		-			A	1	C
21		-			C	3	-
22	2	-			A	1	A,B, C, D
23		-			A	1	A, B, C
24		-			C	3	-
25		-			C	3	-

	SPSS Question 61 (Partner No?) B	Question 29	SPSS Question 61 (Partner Neutral?) A	SPSS Question 62 (Partner Neutral?) B	Question 30	SPSS Question 62 (NAVFAC USMC)	Question 31
26		-			A	1	A, B, C
27		B	2	1	A	1	A, C
28		-			C	3	-
29		-			C	3	-
30		-			C	3	-
31		-			C	3	-
32		-			A	1	B, C
33		-			C	3	-
USMC							
34		-			A	1	A, C
35		-			A	1	C, D
36		-			B	2	-
37		-			A	1	A, B, C, D
38	2	-			A	1	A, B, C, D
39		-			A	1	A, B, C, D
40	2	-			A	1	B, C
41	1	-			C	3	-
42		-			A	1	C
43		-			A	1	B, C
44		-			A	1	A, B, D
45		-			C	3	-
46	2	-			A	1	B, C
47		A	1	2	A	1	B, C
48		-			C	3	-
49		-			C	3	-
50		-			C	2	-
51	1	-			B	2	-
52		-			A	1	A, B, C

NAVFAC	SPSS Question 62 (NAVFAC USMC, yes) A	SPSS Question 63 (NAVFAC USMC, yes) B	SPSS Question 64 (NAVFAC USMC, yes) C	SPSS Question 65 (NAVFAC USMC, yes) D	Question 32	SPSS Question 66 (NAVFAC USMC, No) A
1	2	2	1	1	-	
2					-	
3	1	1	1	1	-	
4					A, B, C, D, E, F	1
5					B, D, E	2
6	1	1	1	1	-	
7					F	2
8	2	2	1	2	-	
9	1	1	1	1	-	
10					A, E, F	1
11					B, C, D, E, F	2
12					A, B, C, D, E, F	1
13					-	
14	1	1	1	2	-	
15	1	1	1	2	-	
16					F	2
17	1	1	1	1	-	
18	1	1	1	1	-	
19					F	2
20	2	2	1	2	-	
21					A, C, D	1
22	1	1	1	1	-	
23	1	1	1	2	-	
24					C, D, F	2
25					C, E	2

	SPSS Question 62 (NAVFAC USMC, yes) A	SPSS Question 63 (NAVFAC USMC, yes) B	SPSS Question 64 (NAVFAC USMC, yes) C	SPSS Question 65 (NAVFAC USMC, yes) D	Question 32	SPSS Question 66 (NAVFAC USMC, No) A
26	1	1	1	2	-	
27	1	2	1	2	-	
28					A, B, C, D, E, F	1
29					A, B, C, D, E, F	1
30					E, F	2
31					B, C, F	2
32	2	1	1	2	-	
33					B, C, E	2
USMC						
34	1	2	1	2	-	
35	2	2	1	1	-	
36					-	
37	1	1	1	1	-	
38	1	1	1	1	-	
39	1	1	1	1	-	
40	2	1	1	2	-	
41					A, B, C, D, E	1
42	2	2	1	2	-	
43	2	1	1	2	-	
44	1	1	2	1	-	
45					F	2
46	2	1	1	2	-	
47	2	1	1	2	-	
48					F	2
49					B, C, D, E, F	2
50					C, E	2
51					-	
52	1	1	1	2	-	

	SPSS Question 67 (NAVFAC USMC, No) B	SPSS Question 68 (NAVFAC USMC, No) C	SPSS Question 69 (NAVFAC USMC, No) D	SPSS Question 70 (NAVFAC USMC, No) E	SPSS Question 71 (NAVFAC USMC, No) F	Question 33
NAVFAC						
1						-
2						-
3						-
4	1	1	1	1	1	-
5	1	2	1	1	2	-
6						-
7	2	2	2	2	1	-
8						-
9						-
10	2	2	2	1	1	-
11	1	1	1	1	1	-
12	1	1	1	1	1	-
13						-
14						-
15						-
16	2	2	2	2	1	-
17						-
18						-
19	2	2	2	2	1	-
20						-
21	2	1	2	1	2	-
22						-
23						-
24	2	1	1	2	1	-
25	2	1	2	1	2	-

	SPSS Question 67 (NAVFAC USMC, No) B	SPSS Question 68 (NAVFAC USMC, No) C	SPSS Question 69 (NAVFAC USMC, No) D	SPSS Question 70 (NAVFAC USMC, No) E	SPSS Question 71 (NAVFAC USMC, No) F	Question 33
26						-
27						-
28	1	1	1	1	1	-
29	1	1	1	1	1	-
30	2	2	2	1	1	-
31	1	1	2	1	2	-
32						-
33	1	1	2	1	2	-
USMC						
34						-
35						-
36						A
37						-
38						-
39						-
40						-
41	1	1	1	1	2	-
42						-
43						-
44						-
45	2	2	2	2	1	-
46						-
47						-
48	2	2	2	2	1	-
49	1	1	1	1	1	-
50	2	1	2	1	2	-
51						B
52						-

	SPSS Question 72 (NAVFAC USMC, No) A	SPSS Question 73 (NAVFAC USMC, No) B
NAVFAC		
1		
2		
3		
4		
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6		
7		
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22		
23		
24		
25		

	SPSS Question 72 (NAVFAC USMC, No) A	SPSS Question 73 (NAVFAC USMC, No) B
26		
27		
28		
29		
30		
31		
32		
33		
USMC		
34		
35		
36	1	2
37		
38		
39		
40		
41		
42		
43		
44		
45		
46		
47		
48		
49		
50		
51	2	1
52		

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