Implementing Integrated Project Delivery on Department of the Navy Construction Projects

by

Michael Scott Singleton, BS

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Committee in charge:
Professor Farook R. Hamzeh (Construction Management), Chair
Professor Caroline M. Clevenger (Construction Management)
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This research will examine ways that NAVFAC can improve its delivery of construction projects by implementing IPD techniques. It will primarily focus on the ways IPD can affect a project's operating system, but will also include discussion of the project organization and commercial terms. This paper will use a literature review and case studies to demonstrate the techniques and benefits of IPD, provide recommendations on which techniques of IPD can and should be integrated into NAVFAC's existing project delivery system, and discuss specific benefits applicable to the Navy. It will also develop criteria for which NAVFAC projects should be potentially considered for the implementation of the recommended IPD techniques.

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LIST OF ACRONYMS

A/E	Architect/Engineer
AIA	American Institute of Architects
BIM	Building Information Modeling
CHH	Cathedral Hill Hospital
CI	Capital Improvements
DB	Design-Build
DBB	Design-Bid-Build
DoD	Department of Defense
ECI	Early Contractor Involvement
FAR	Federal Acquisition Regulation
FFP	Firm-Fixed-Price
FHWA	Federal Highway Administration
FPAF	Fixed Price Award Fee
FPIF	Fixed Price Incentive Firm
GC	General Contractor
GMP	Guaranteed Maximum Price
GSA	General Services Administration
IFOA	Integrated Form of Agreement
IPD	Integrated Project Delivery™
LBS	Location-Based Scheduling
LCI	Lean Construction Institute
LPDS	Lean Project Delivery System™
LPS	Last Planner™ System
MILCON	Military Construction
NAVFAC	Naval Facilities Engineering Command
OUC	Orlando Utilities Commission
PenRen	Pentagon Renovation
PPC	Percent Plan Complete
RFP	Request for Proposal
TVD	Target Value Design
USN	United States Navy

CHAPTER 1 - INTRODUCTION

1.1 Purpose

The purpose of this research is to determine which Integrated Project Delivery[TM,1] (IPD) techniques the United States Navy could implement in order to improve its construction project delivery systems. The Navy has a unique and broad-ranging inventory of facilities including: Waterfronts, Airfields, Industrial Areas, Administrative Spaces, Warehouses, Training Facilities, Ordnance Storage, Fuel Systems, Quality of Life facilities, Bachelor Quarters, and Family Housing (USN, 2002). Naval Facilities Engineering Command (NAVFAC) is the organization which is responsible for the execution of infrastructure management, operations, and construction services on Navy bases worldwide. NAVFAC employs approximately 20,000 people and manages an annual budget of approximately $17 billion (Washington, 2010). In the management of such a wide range of facilities projects and such a large budget, NAVFAC is not immune from the problems of today's construction industry. The techniques contained within IPD and their associated efficiency improvements and waste reductions may directly benefit NAVFAC, its employees, the contractors that build NAVFAC's projects, and the American taxpayer.

1.2 Scope

This research will examine ways that NAVFAC can improve its delivery of construction projects by implementing IPD techniques. It will primarily focus on the ways IPD can affect a project's operating system, but will also include discussion of the project organization and commercial terms. This paper will use a literature review and case studies to demonstrate the

[1] "Integrated Project Delivery", "Lean Project Delivery System", and "Last Planner" are registered business marks with the US PTO.

techniques and benefits of IPD, provide recommendations on which techniques of IPD can and should be integrated into NAVFAC's existing project delivery system, and discuss specific benefits applicable to the Navy. It will also develop criteria for which NAVFAC projects should be potentially considered for the implementation of the recommended IPD techniques.

Legal ramifications of IPD in relation to the Federal Acquisition Regulations (FAR) will be mentioned briefly during the literature review, but since this paper seeks only to define what NAVFAC can do now without modifications to the FAR, they are not a primary focus area of this research.

CHAPTER 2 - BACKGROUND

Construction's project delivery system consists of three domains: the project organization, or how the parties participating in the contract are organized; the project operating system, or how the project is managed on an overall and day-to-day basis; and the project commercial terms, or the contract (Thomsen et al., 2010). Over the past 20 years, innovations have brought major changes to the project organization and commercial terms domains, such as Design-Build and partnering. While these changes have been successful in ways such as the reduction of claims, reduction of change orders, and schedule adherence (Killian & Gibson, 2005; Schmader, 1994), they have had little effect on overall project duration and no effect on total project cost (FHWA, 2006). Additionally, they have done nothing to effect the way a project is actually being constructed in the field, to include the efficient use of labor, equipment, and materials. This is where the project operating system domain comes into play. One way to determine the efficiency of a project operating system is to measure labor productivity, or the

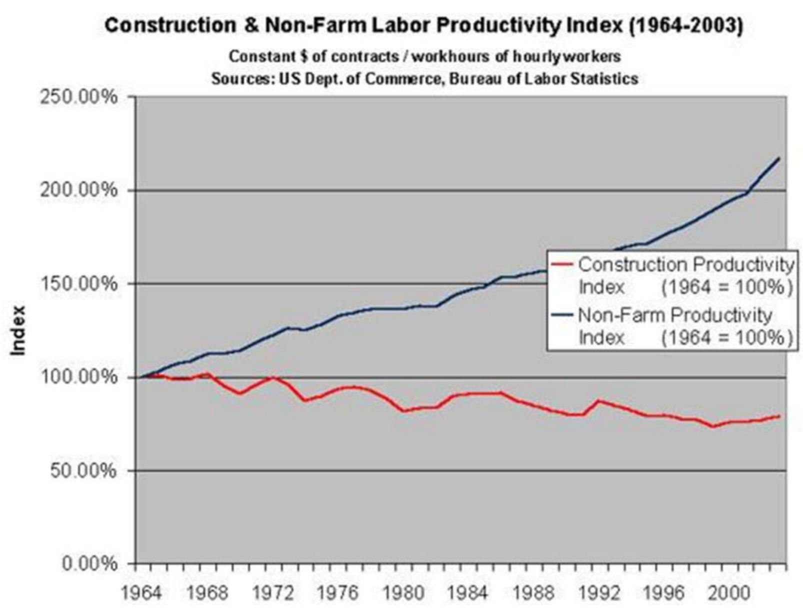

Figure 1.1 – Construction & Non-farm Labor Productivity Index, 1964-2003. (BOLS, 2004)

amount of work being completed per man-hour. Figure 1.1 shows that in the 40-year period from 1964-2003, productivity in the construction industry has decreased by approximately 20%, while all other non-farm industries have experienced over 100% labor productivity increases. Despite the advances in equipment, materials, management, and technology made over this 40 year period, owners are getting less for their construction dollar today than they were in the 1960's.

The project operating system has been largely neglected throughout the history of construction. Standard practice in the construction industry consists of a "siloed" approach. In this typical project structure, each entity involved in a project (owner, designer, contractor) worries about their own interests, which may or may not align with those of the other parties, and communication only occurs along contractual lines. These problems contribute significantly to inefficiency and waste, and lead to construction's extremely low productivity rates (Thomsen, et al., 2010).

In the past 10-15 years researchers have put a greater focus on developing ways in which a construction project's operating system can be improved. One such recently-developed method is known as Integrated Project Delivery. It was developed in conjunction with the Lean Construction Institute, and shares many of the same principles as lean construction, foremost of which are to maximize value (giving the owner what they need and want) and to minimize waste of time, money, and materials. (Ballard & Howell, 2003). Standard construction industry practices use project organizations and commercial terms which stand in the way of operating system improvements. IPD was developed as a method to allow the construction industry to overcome current operating system roadblocks with the additional benefits of improving project organizations and commercial terms (Thomsen, et al., 2010).

CHAPTER 3 - METHOD

3.1 Research goal and objectives

The goal of this research is to determine which IPD techniques can be implemented in order to improve the way that NAVFAC manages its construction projects. The definition of a technique used in this research is “a practical method applied to some particular task” (Miller, 2009), with the particular task in this case being construction project delivery. The way this research will achieve its goal is to recommend the implementation of techniques used on IPD projects which can be used to maximize value and reduce waste which, in the end, will benefit the building end-users and the taxpayers that fund the Navy’s projects. With that goal in mind, the following research objectives are presented:

- **Objective #1:** Create a list of IPD techniques that can benefit and be implemented on NAVFAC projects today by using best practices identified in the literature review, and use case studies to demonstrate how and why the techniques should be implemented.
- **Objective #2:** Develop a simple, easy-to-use criteria based upon easily identifiable project attributes that can be used to select IPD project candidates for NAVFAC.

3.2 Research questions

Public sector IPD is an area that has had relatively little research performed to date. IPD contains numerous sub-areas (listed in section 4.1), all of which could easily be an independent area of research. While drilling down into one specific IPD sub-area would be beneficial, the strategy of providing an overview of all IPD techniques was better aligned with the goal of this research. Hence, narrowing the focus of this research was a difficult task. Several potential research ideas were discarded in favor of research that was specific, interesting, and could benefit NAVFAC today. This led to the following research questions:

- **Question #1:** Which IPD techniques can be integrated into NAVFAC's project delivery method, and how would NAVFAC benefit from them?
- **Question #2:** How can it be determined which NAVFAC projects are potential candidates for using the selected IPD techniques?

3.3 Research Design

This research began with a literature review of IPD information, techniques, and best practices. The IPD literature reviewed consisted of academic papers, professional journal articles, and trade publications. A specific focus was made on identifying public sector IPD project information, as very few public sector entities have had the opportunity to attempt a true IPD project. The literature review continued with a brief examination of current Federal contracting regulations in order to examine what the roadblocks to IPD in the Navy are today. The literature review concluded with an examination of NAVFAC's current operating procedures and how they relate to IPD.

Given that very little research exists on public sector IPD, and because few[2] public sector IPD projects have been performed, a case study research strategy was chosen. The case study approach being employed is a Collective Case Study. Collective case studies study several cases that provide insight into an issue (Creswell, 2008). Qualitative data will be collected from documents and reports from three IPD projects, and will be presented with my commentary, specifically pointing out IPD techniques that were successful on each project. The projects will

[2] Four examples of public sector IPD projects were found in the literature review.

be chosen carefully in order to provide a wide range of project attributes, including: public vs. private sector, cost, “pure” IPD vs. partial implementations, and project complexity.

After the case study data has been compiled and examined, I will determine the advantages and disadvantages of each technique, and then make a determination of which techniques can potentially be applied to NAVFAC projects. This determination will then be overlaid with NAVFAC’s current operational policy and my knowledge of NAVFAC procedures and Navy culture to provide a final list of IPD techniques that can be implemented on NAVFAC projects.

After the list of IPD techniques has been presented, the research will conclude with the creation of a decision-making tool which will be useful in determining if a project is a good candidate for IPD techniques, or not. This decision-making tool will be presented in the form of a simple numerical project scoring system which will weigh selected project attributes, resulting in an overall project score that will assist in choosing potential NAVFAC projects on which the IPD techniques can be used.

3.4 Research Limitations

I am basing the determination of which IPD techniques should or should not be included in those that NAVFAC can currently implement upon how IPD techniques demonstrated in the literature review and case studies will integrate with existing NAVFAC operations. Others may have a different interpretation of the literature, case studies, or NAVFAC operational policy that may result in slightly different conclusions.

CHAPTER 4 - LITERATURE REVIEW

4.1 Integrated Project Delivery™

Customers on construction projects are known to state some or all of the following on a regular basis: "Construction costs too much, takes too long, and doesn't meet my needs/quality standards"(Kerschbaum, 2009). Integrated Project Delivery™ is one method that attempts to solve these problems. IPD has been developed over the past few years by the Lean Construction Institute (LCI). Since its inception in 1997, LCI has focused on improving construction project operating systems in order to complete construction projects cheaper, faster, and with maximum value[3](LCI, 2010). Originally, LCI was not focused on the commercial terms (e.g. contracting) domain of construction, but later found it to be crucial to allowing project operating system-improving techniques developed by LCI to be implemented (Abdelhamid, 2010).

The LCI's definition of IPD is "a delivery system that seeks to align interests, objectives and practices, even in a single business, through a team-based approach" (LCI, 2010). IPD is a relational construction delivery method in which the owner, designer, and contractor(s) are contractually bound to one another to as one team comprised of members that have agreed to put the interests of the "project as a whole" before their own interests (Decker, 2009). This is in stark contrast to the traditional transactional construction contract, in which separate parties exchange money for goods and services with only their own interests in mind.

IPD contracts are typically cost-reimbursement type contracts. A typical IPD contract includes requirements for the following 11 main attributes which differentiate them from traditional contracts (Thomsen, et al., 2010):

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[3] Value, as defined by lean principles, means to provide the customer what they want and need and when they need it (Liker, 2004).

1. Integrated Teams. The general contractor and, shortly thereafter, key trades are contractually brought into the project during the early stages of design. The contractors, which at that project stage must be chosen based almost completely upon their qualifications, gain a far greater understanding of what the owner's needs are (i.e. value), greatly assists the designer in completing a design that maximizes value to the owner, and provides themselves the benefits of a design with high predictability and constructability (Colledge, 2004).
2. Integrated Governance. Since the IPD contract is designed to share the "pains and gains" of the project between all team members (discussed further in #7 on this list), naturally, all team members will want to share in major project decisions that affect everyone as well. For this reason, IPD projects operate on a "leadership by committee" basis, with the executive committee typically consisting of a senior representative of the owner, designer, and general contractor. All decisions are made on a consensus basis (Lichtig, 2005).
3. High Performing Teams. Crucial to all collaborative efforts throughout the history of mankind, teamwork plays no less of a role in IPD. IPD involves traditional forms of partnering such as team-building exercises, tracking performance, and building trust, and then picks up where Partnering leaves off. One IPD technique is to create cross functional teams consisting of individuals from different companies who are assigned to work based upon their strengths and project needs. In essence, IPD allows the flexibility to maximize each person's productivity by putting the right person in the right job (Thomsen, et al., 2010).

4. Lean Construction Techniques. Lean construction techniques play a crucial role in IPD. Lean construction seeks to maximize value and minimize waste on a project, and provides specific methods which allow owners, designers, and constructors to reliably do so (LCI, 2010). These specific techniques will be discussed in section 4.2 of this literature review.
5. Lean Principles. The principles of lean were originally developed as part of the Toyota Production System. These principles recognize that it takes more than just the implementation of tools and techniques to truly maximize value and minimize waste in a production process. Lean principles focus on changing the culture within an organization to allow it to produce as efficiently as possible. The principles are divided into four sections (Liker, 2004):
    a. Long Term Philosophy – management decisions should be made based on a long-term philosophy, not short term financial goals.
    b. The Right Process Will Produce the Right Results – creating flow, using pull systems, leveling out the workload, getting quality right the first time, standardize tasks, use visual controls, and use only proven technology that supports people.
    c. Add Value to the Organization by Developing Your People and Partners – grow leaders from within, develop exceptional people who buy in to your company's philosophy, and challenge partner companies to help them improve.
    d. Continuously Solving Root Problems Drives Organizational Learning – supervisors need to go see problems for themselves, make decisions by consensus and implement them rapidly once made, and become a learning organization by

always analyzing what you have done and looking at ways the process could be improved.

IPD has recognized that cultural change is required to move construction from its traditional adversarial relationships to those that thrive on teamwork. IPD relies on trust and collaboration. On some IPD contracts, the parties agree to abide by the principles of lean, and they have proven to be highly successful in generating the levels of trust and collaboration required for IPD to be successful (Lichtig, 2005).

6. Collective Risk Sharing. A typical construction contract strives to transfer risk to whomever can best manage it. This may or may not happen, and usually leads to a party being responsible for risks that they have little to no control over. Additionally, the parties that are not "at risk" have no incentive to help the parties that are at risk, even if the not-at-risk party is responsible for the problem at hand. IPD projects strive to make risk shared by financially tying the risk into all parties involved with the project (IFOA, 2008). This leads to a collaborative culture in which all parties are financially motivated to help each other with any problems that arise. Typical methods of risk sharing on an IPD project include: sharing the cost-savings or cost overruns against an estimated cost of the work, pooling some portion of the team member's profit and placing it at risk, and/or pooling contingency funds and sharing any amount remaining after project completion (Thomsen, et al., 2010).
7. Painsharing and Gainsharing. When referring to the "pains and gains" on a construction project, the first thing that comes to most people's mind is money. This is no different on an IPD project. The IPD team will set a target cost for the project at some stage in the design process and then any cost overruns or under runs of that target cost will be shared

between the IPD team. This encourages all parties to come up with innovative designs and methods that can reduce the cost of not only their work, but the work of other parties as well. Despite these benefits, owners must use caution when employing this technique, as it can cause contractors to pad their estimates in order to ensure the project comes in under the target cost (Thomsen, et al., 2010). While the owner will receive a portion of the contractor's contingency back as part of the project's so-called "under run", the owner is still paying a contingency cost, which is one form of waste that IPD and lean construction try to minimize. Another defining feature of an IPD contract is the ability to move money across traditional contractual boundaries. For example, an electrical subcontractor finds that by increasing its scope of work by $100K, the mechanical subcontractor's work can be reduced by $150K. On a traditional project, the mechanical subcontractor would never allow this to happen, since reducing its scope would reduce its profit. On an IPD contract, the change would be encouraged, since the project would then have a $50K under run that would be placed into a profit pool to be distributed to all of the IPD team members. The mechanical subcontractor's portion of the $50K savings would likely far exceed the profit it was expected to make on the $150K that was removed from its scope of work (Matthews & Howell, 2004).

8. Profit Pooling. On an IPD project, each party puts a substantial portion of their profit at risk, and puts it into a project-wide profit pool. This money is "at-risk" because it will be used to pay for any cost overruns on the project. If the project has cost underruns, the extra money is added into the profit pool. At the end of the project, whatever is left in the pool is distributed to the team based upon pre-arranged percentages. The purpose of the profit pool is to give the parties a financial benefit for helping each other. In a profit-

pooling situation, if one party fails (i.e. has an overrun) it will hurt the bottom line of the entire IPD team.

9. Contingency Sharing. Contingency is defined as extra cost included in a contractor's bid to cover unforeseen costs that arise from labor or material cost increases, bid omissions, or a myriad of other causes. While IPD and lean construction practices can be helpful in reducing these unforeseen costs, completely eliminating contingency on a construction project is highly unlikely. On a typical cost-reimbursable IPD project, owners create contingency pools in order to manage project contingency funds. At the end of a typical IPD project, funds remaining in the contingency pool will be distributed among the entire IPD team (Lichtig, 2005). This technique provides three advantages: it prevents contractors from hiding contingency in their prices, it prevents contingency stacking (GC adding contingency for subcontractor contingency prices), and it encourages teamwork and creative problem solving from all team members. This is due to the fact that if one IPD team member has to use some of the contingency funds, it is taking money out of each IPD team member's potential profit .
10. Goals and Incentives. One of the main goals of IPD is to maximize value to the owner. One of the ways that IPD does this is to create measurable goals which align with the owner's interests, followed by metrics to track the progress made toward these goals and incentives (primarily financial) for meeting the goals.
11. Award Fees/Performance Evaluations. While the incentives listed above have a primary purpose of reducing the final project cost to the owner, reducing project cost is not the only goal of IPD. Award fees exist on an IPD project for this reason. Award fees can be used to reward high performance in any of the following areas: safety, quality,

sustainability, customer service, small/disadvantaged business hiring, or any other aspect of a construction project that is important to an owner. To determine if an award fee is justified, performance evaluations are used. The goal of award fees and performance evaluations is to increase the level of performance of the IPD team throughout the project, so timely and periodic evaluations should be used to drive the IPD team toward that goal (Hoag & Gunderson, 2005; Thomsen, et al., 2010).

An excellent example of an IPD contract which contains each of the aforementioned IPD techniques is William Lichtig's Integrated Form of Agreement (IFOA, 2008; Lichtig, 2006). Lichtig's contract was developed in close coordination with the Lean Construction Institute and is highly regarded by the construction industry and construction law professionals (ENR, 2008). Other standardized forms of IPD contracts that exist today are the *American Institute of Architects' (AIA) C195 and related documents* and the *ConsensusDOCS 300 Tri-party Collaborative Agreement* (Sive & Hays, 2009).

4.2 Lean Construction

Building construction is a process that is ripe for the picking with potential process improvements, but Lean principles must be adapted from manufacturing to construction for this to be successful (Salem et al., 2006). The difficulty in construction is that every project is different and has a different team of people working on it that get supplies from different sources. To overcome this difficulty requires a change in thinking. Glenn Ballard and Greg Howell of the Lean Construction Institute have produced extensive research into how lean manufacturing principles can be adapted to the construction industry in order to change the construction industry's collective mindset. They have recognized that while every construction project is different, they are comprised of construction operations which are similar between projects. Instead of viewing a project simply as piecing together some engineer's design, we must look at the project as a temporary production process, in which the focus is on making that production process the best it can be. If that same focus successfully eliminates waste and maximizes value, the project is then considered to be "lean" (Ballard & Howell, 2003).

Ballard and Howell have developed a detailed Lean Construction protocol, known as the Lean Project Delivery System™ (LPDS). LPDS seeks to redefine the traditional phases of construction, and focuses on applying lean principles to the design, supply chain, and assembly of a construction project. It recognizes that each phase of construction is highly dependent on those that came before it and will come after it, and places a strong emphasis on improving the overall project production system (Ballard & Howell, 2003). Their research has shown that the LPDS is also a superior management system. Even partial implementations have yielded substantial improvements in the value generated for clients, users and producers, and also a reduction in waste, including waiting time for resources, process cycle times, inventories, defects and errors, and accidents. The two major project management components of the LPDS are the Last Planner™ System (LPS) and Reverse Phase/Pull Scheduling.

LPS is a system that uses a weekly planning schedule which is focused on the work that can currently be completed, and strives to ensure that what the original project schedule says should be occurring during that week can occur during that week. (Alarcon & Calderon, 2003; Ballard, 2000a; de la Garza & Leong, 2000; Hamzeh, 2009). LPS breaks the schedule down into four levels:

1. Master schedule. The master schedule is broken down by project phases. These phases are typically project milestones that are set by the owner.

2. Phase schedule. Each phase has a schedule that is broken down into construction activities. Phase schedules are developed using pull scheduling techniques, which are described in more detail below. The phase (and master) schedules both represent what “should” be done on the project within the specified timeframes.
3. Lookahead schedule. The lookahead schedule is typically generated for each week between 2-6 weeks out from the current date. The purpose of the lookahead scheduling is to examine the activities that “should” be done to make sure that they “can” be done as scheduled. This process involves three steps:
    a. Breaking down activities into assignable tasks.
    b. Ensuring the operational design for the tasks to be performed is feasible.
    c. Removing constraints from the tasks.
4. Weekly work plan. The weekly work plan is generated for the current week and the next week. If a task is “made ready”, meaning it has passed the three checks included in lookahead planning, it is added to the weekly work plan and assigned to the people that will actually be doing the work. When a task is added to a weekly work plan, it is being moved from what “can” be done to what “will” be done.

Another key feature of the LPS is tracking what is known as Percent Plan Complete (PPC). PPC is a metric which is used to measure the success rate of LPS. PPC is calculated after a weekly work plan has been executed, and is simply the number of tasks that were completed divided by the number of tasks that were assigned. Alternatively, PPC can be defined as dividing what “did” get done by what was projected “will” get done. A high PPC means that

LPS is allowing for reliable work forecasting, and that tasks made ready are being completed as scheduled.

Reverse Phase or "Pull" scheduling is the technique used to develop the phase-level schedule that is used as a basis for implementing LPS. It a highly collaborative and cooperative project scheduling method which requires all parties involved in any given phase of construction project to work together in scheduling the project starting with a completion milestone date and working backwards (Ballard & Howell, 2003). Each phase's milestone date comes from the master project schedule, which usually contains very aggressive timeframes. The purpose of starting at the end and working backwards is to ensure that only tasks which release work to others (e.g. pull) are being worked on at any given time. Reverse phase scheduling is typically performed in a large room with a representative of every organization that does work within the phase. Each organization puts each of their construction activities on a sticky note, and includes what they need to be done before they can start their work on that activity. By starting at the end and working backward, the schedule will be sequenced in a pull manner. Typically, after the first iteration of scheduling, the time needed to do the work will exceed the time allotted to that phase by the master schedule. This is when collaboration is necessary to shorten activity durations, either by finding innovative ways to work with other organizations within the phase, or by removing time buffers from each individual activity, and placing them into one shared time buffer for the entire phase. Since each activity will not use 100% of their originally scheduled time buffer, the compiled time buffer will be smaller than the sum of the individual activity buffer. This results in an innovative, "fluff-free" schedule that will almost always meet the time allotted for the phase by the master project schedule.

In addition to the LPDS, numerous other lean construction-related techniques have been developed by the LCI and others:

1. Set-based design. Set-based design was originally adapted (Ballard, 2000b) from the Toyota Production System's practice known as set-based concurrent engineering (Sobek et al., 1999; Ward et al., 1995). The traditionally used alternative to set-based design is point-based design, in which a set of alternatives is developed and evaluated, and the best alternative is chosen as quickly as possible. In set-based design, multiple alternatives are continued to be developed as far along into the design process as is possible, until what is known as the "last responsible moment"(Liker, 2004). It is intuitive to think that continuing to develop these "unused" design alternatives is a waste of resources, but set-based design allows for the reduction of negative design iterations[4] and allows for more time for designed alternatives to be reviewed, resulting in better design decisions (Ballard, 2000b).
2. Target value design (TVD). TVD is a completely different way of designing a construction project. TVD uses the following practices which will allow a project to meet a client's target value (Macomber & Barberio, 2007): design based on an estimate instead of estimating based on a design, design what is constructible instead of evaluating the constructability of a design, work in groups and use the groups to make design decisions before designs are completed, use set-based design, and engage deeply with the client to establish their target value.
3. Integrating the process design with the product design. Typically, a construction project is designed with little to no consideration of how it will be built. A/E's complete their

[4] A negative design iteration is when a portion of a design is completed and later found to be in error, causing the entire project's design to revert to the point where that portion began.

design, and throw it over the wall to the contractors, who are responsible to "just figure it out". Lean construction recognizes that how a project will be built is just as important as what needs to be built (Magent et al., 2005). To ensure the construction process is taken into account during design, the contractors that will be building the project need to be involved in the design as early as possible (Pulaski & Horman, 2005). This ensures two things: constant constructability reviews throughout the design process, and improved teamwork between the designer and builders during construction, since the builders now have "buy-in" to the design. Additionally, Building Information Modeling (BIM) software has proven to be highly successful in helping integrate the process design into the project design (Suermann, 2009).

4. Location-based scheduling. Location-based scheduling (LBS) was developed independently from the LCI, but it shares many of the same basic principles of lean and certainly should be presented here as an alternative project operating system methodology. LBS traces its roots back to the construction of the Empire State Building and industrial production improvement methods developed by the US Navy in the 1940's (Kenley & Seppanen, 2010). LBS revolves around the flowline method of project scheduling. A flowline schedule uses time on the x-axis, and location on the y-axis. Each construction activity plotted together on the same graph and is represented by a positively sloped line that shows when each activity will be occurring in each location. A typical flowline schedule is shown in figure 4.1.

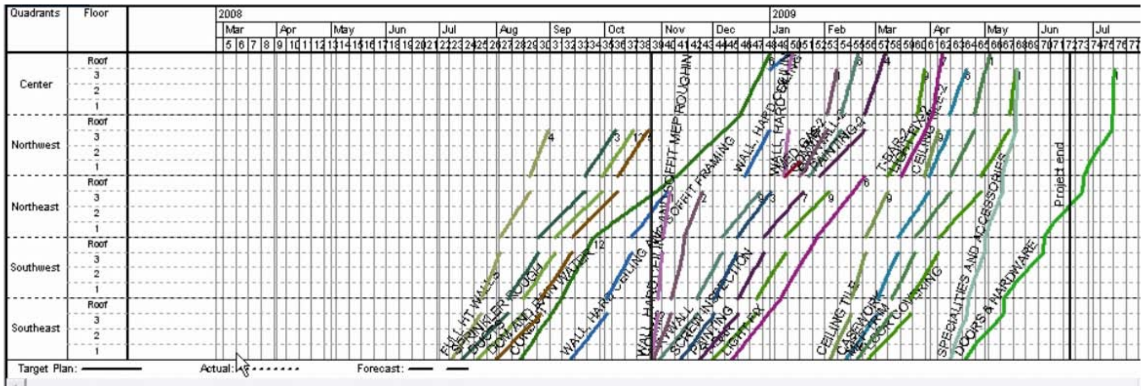

Figure 4.1 – Construction project flowline schedule from Vico Control software. (Screenshot taken from audiovisual demo located at http://www.vicosoftware.com/products/Vico-Control/tabid/84573/Default.aspx)

Flowline schedules graphically display production rates for each construction activity, and make it extremely easy to identify potential work stoppages or conflicts. Greater detail on the LBS and flowline scheduling can be found in the Vico Control software tutorials and documentation located at www.vicosoftware.com, as well as Russell Kenley and Olli Seppanen's book, *Location-Based Management for Construction*.

4.3 Roadblocks to IPD

The federal government has been at the forefront of recent trends in the construction industry, such as sustainability[5] and BIM[6]. Unfortunately, when it comes to implementing IPD, federal agencies typically do not have the authority to issue contracts which allow for IPD (Sive & Hays, 2009).

The primary document that governs federal contracting procedures is the Federal Acquisition Regulation (FAR). While the FAR has been updated over time to allow for more modern contracting vehicles than design-bid-build, it lags behind current industry best practices. Specific examples of IPD techniques that cannot be fully implemented are below:

[5] The Department of Defense now requires all new construction to meet a Leadership in Energy and Environmental Design (LEED) Silver rating (Gott, 2009).
[6] The General Services Administration (GSA) now requires the use of BIM on all capital improvement projects (Suermann, 2009).

- In general, the FAR does not allow for the government to participate in financial motivation techniques such as risk-sharing, profit pooling or contingency pooling. As will be demonstrated in section 5.1, there are exceptions to this rule, but they are very seldom used on construction contracts.
- The FAR does not allow for multi-party agreements or relational contracts. Separate contracts are required for professional services (e.g. design) and construction.
- The FAR contains competitive bidding requirements for construction which make hiring a construction contractor early on in the design process a difficult and time-consuming process. Working around these competitive bidding requirements is possible, but potentially exposes the government to contract award protests and claims if not done in exactly the right way. NAVFAC and the US Army Corps of Engineers are currently piloting Early Contractor Involvement (ECI) contracts which do bring a contractor into the design process. NAVFAC's ECI process will be discussed in greater detail in section 4.4.
- Contract language only goes so far as to mandating the way a contractor must conduct their business. While this is good in that it encourages contractors to "think outside the box", many are not interested in being innovative, and will carry out business as usual unless contract specifications mandate an alternative method.

4.4 Current NAVFAC Design and Construction practices

The Capital Improvements (CI) branch of NAVFAC is the most pertinent branch to this paper, as it is responsible for the process by which the Navy procures construction services. The mission of the CI branch of NAVFAC consists of the following taskings (Washington, 2010):

- Provide Design (A&E & In-house) and Construction Services

- Provide Specialized Technical Engineering and Services
- Improve Delivery of Products & Services
    - Sustainable Development
    - Quality Assurance – Construction
    - Energy Efficiency
- Improve acquisition Strategies
- Maintain/Develop Skilled Engineering Workforce
    - Design Competency
    - Career Paths to Maintain/Develop Workforce
    - Boots on Ground – Project Management Competency
- Benchmark with Professional Associations/Industry and Academia

NAVFAC currently operates under a mandate that was set in Fiscal Year 2007, requiring that at least 75% of Military Construction (MILCON) projects be delivered via design-build contract. In FY09, 80% of MILCON projects were executed under a design-build contract (Gott, 2009). Design-build construction combines both the design and construction of a new building into one contract, placing sole responsibility for successful project delivery on one company. The previously preferred method, known as Design-Bid-Build, used one contract with an Architect/Engineer firm to complete the project design, and then that design was then put out for bid on a separate contract for construction. Design-build has proven to be an excellent contracting method, which has resulted in fewer claims against the Government, increased on-time delivery of projects, and fewer cost increases due to change orders (Cantrell, 2006). One weakness of the design-build approach is that the A/E firm that the government hires to develop the Request for Proposal is not allowed to be part of a design-builder that actually bids on the contract. Throughout the RFP generation process, this A/E firm gains extensive knowledge on what the customer wants and needs from their new facility. Little of this knowledge is ever transferred to the design-builder that is awarded the contract (Beck & Whitnell, 2009).

Another key technique that NAVFAC currently uses to improve project delivery is Partnering. Partnering in the construction industry is defined as "a long term commitment between two or more organizations for the purpose of achieving specific business objectives, by maximizing the effectiveness of each participant's resources". Partnering has been successful at NAVFAC in reducing claims and keeping projects on schedule, but has had little effect on change orders and overall project cost (Schmader, 1994). Additionally, partnering has been found to have little effect on the communication and relationship between parties on a construction project (Nystrom, 2008).

NAVFAC has not implemented any overarching policy or guidance to date regarding IPD, likely due to the previously discussed highly collaborative project delivery/contracting methods that IPD requires which are currently not allowed by Federal Acquisition Regulations. There also appears to be a concern within NAVFAC that IPD will increase the administrative workload in administering a contract. A review of the most recent NAVFAC CI Acquisition Strategies briefing shows that the majority of new acquisition programs are focusing on adding post-construction maintenance to the building (Thurber, 2010).

One IPD technique that NAVFAC has begun testing is that of integrated teams. To do so, NAVFAC is using a contracting method known as Early Contractor Involvement (ECI). On an ECI project, a GC is brought into the project during the design phase as a consultant and actively participates in the project design (Affeldt, 2009). Following the design phase of the project, NAVFAC has the option to award the construction of the project to the same GC, provided that the post-design project target price does not exceed the ceiling price that the contractor provided the government in their initial bid to become the "CM at risk". ECI is being piloted by NAVFAC on the construction of a new fitness facility located at Marine Corps Air Station New River, Jacksonville, NC. This pilot project was awarded on a Firm-Fixed-Price (FFP[7]) contract instead of a Fixed Price Incentive (FPI[8]) contract, so it did not include the target costing aspect, but many of the attributes of ECI were still included in the contract. The pilot project is currently in the final stages of design, and has been successful in encouraging collaboration between the customer, A/E, and contractor and has resulted in a satisfied customer that is highly engaged and having its values met (NAVFAC, 2010).

[7] A FFP contract is one which the contract price is the price bid, with no incentives or fees added. Cost responsibility is placed wholly on the contractor.
[8] A FPI contract is one which is a fixed-price type contract with provisions for adjustment of profit. The final contract price is based on a comparison between the final negotiated total costs and the total target costs.

CHAPTER 5 - CASE STUDIES

5.1 Pentagon Renovation Program (PenRen)

5.1.1 Project Background

The Pentagon is located in Arlington, Virginia, and is the headquarters building for the United States Department of Defense. The building's floor area is 6.6 million square feet, and construction was completed in January, 1943 (PenRen, 2010).

In 1991, the Pentagon was in serious need of repair, and had become inadequate for supporting the mission of DoD. Recognizing this problem, congress transferred control of the building from GSA to DoD, and established the Pentagon Reservation Maintenance Revolving Fund, with the expressed intent of renovating the entire building. The renovation began in 1996, starting with small projects that were external to the main building. In 1998, the contract to renovate the first wedge (1/5th of the building) was awarded (PenRen, 2010). The traditional view of construction in the federal government is that it is a commercial item, and should be procured with a traditional Firm-Fixed-Price (FFP) contract. Hence, Wedge 1 was awarded on a traditional FFP, design-bid-build contract. Wedge 1 was completed in March 2001, behind schedule and over-budget. With over 4 million square feet/$4 Billion of renovations remaining, the Pentagon Renovation Program Office recognized that the remainder of the renovation could not be conducted in the same manner (Hoag & Gunderson, 2005).

The PenRen Program Office studied the relationship between acquisition strategy and project delivery, and found that FFP contracts strictly emphasize cost control, but do nothing to positively affect a contractor's performance. They found that on the Wedge 1 renovation, the contractors were focused almost solely on constructing the building within their bid cost, and that quality, resource management, project controls, and customer relations all suffered dramatically since cost was the only thing on the contractors' minds. Poor quality led to rework, poor resource management led to wasted materials, equipment, and labor, poor project controls led to poor productivity, and poor customer relations led to an unsatisfied customer that was not receiving what they wanted. Each of the above problems increased cost, and despite the contractors' strong focus on cost, the project came in over budget, with the government ending up footing the additional bill in the form of claims and change orders.

To solve this problem, the PenRen program office used a "new" contracting vehicle, which was a combination of two existing contract vehicles: Fixed Price Incentive Firm (FPIF), and Fixed Price Award Fee (FPAF). Fixed-price incentive (FPIF) contracts include a target cost, a target profit, and a sharing arrangement for under runs and overruns, all determined at the outset when the contract is negotiated and issued. FPIF also includes a ceiling price, for which the contractor is responsible for 100% of costs that exceed it. While an FPIF contract focuses strictly on cost, a FPAF contract rewards a contractor based on the customer's rating of non-cost criteria, such as safety, quality, timeliness, project controls, sustainability, resource management, etc. (Hoag, 2008). The contractor is evaluated by the owner on a regular basis, and the contractor "earns" its rewards if its performance meets the criteria set at the outset of the project.

The PenRen project was highly innovative in the way it combined the two acquisition vehicles (Hoag & Gunderson, 2005). First, the target profit on the FPIF side of the contracts was set at $0. This meant that the only way the contractors would make additional money on the FPIF side of the contract was to complete the project below the target cost. The FPAF side of the contracts provided up to a highly lucrative 10% profit, if the contractor met the required performance goals 100% of the time. Additionally, the contractor was only allowed to receive a share of the FPIF under runs or have the government pay for its share of an overrun if the contractor met the award fee performance goals at least 85% of the time.

5.1.2 Results of the Project Strategy

The combination of these strategies led to the following results which relate to IPD techniques:

- Cost control was important as a result of the FPIF side of the contract, but it did not come at the expense of quality, schedule, or owner satisfaction due to the award fee profits.
- The owner and contractor's goals were aligned. The contractor wanted the owner to be satisfied, since the owner determined the amount of the contractor's award fee. The owner's goals of safety, quality, timeliness, etc. were all met, since they also became the contractor's goals. Additionally, since cost under runs were shared between the government and the contractor, it was in both parties' interest to work together to come up with innovative ways to do the work for less.
- Contractors could maximize profit by meeting the owner's performance goals and creating a cost under run. Meeting the performance goals and a cost under run were exactly what the owner wanted as well.
- Cost saving approaches which led to under runs would lead to a windfall profit for a contractor the first time they occurred, but they were also very beneficial to the government. On a project of this magnitude, these cost saving approaches were certain to be duplicated later on in the project. This allowed the government to lower the target cost for similar work when it reoccurred.
- The PenRen project is currently scheduled to be completed in late 2011, three years earlier than originally planned.

5.1.3 IPD Techniques Demonstrated

Table 5.1 lists the IPD techniques that the PenRen project demonstrated, along with the advantages experienced and possible disadvantages of each technique.

Technique	Advantages	Possible Disadvantages
Integrated Teams	N/A	N/A
Integrated Governance	N/A	N/A
High Performing Teams	N/A	N/A
Lean Construction - Target costing: FPIF contract required definition of target cost	Contractor and government worked together to negotiate target cost upfront. Both sides had buy-in to the target cost.	When used alone and not as a part of Target Value Design, target costing can lead to reduced value for the customer
Lean Principles	N/A	N/A
Collective Risk Sharing	N/A	N/A
Painsharing and Gainsharing – Sharing of Under/Overruns	Motivates contractor to find design/process efficiencies	Could have reduced customer value if not used in conjunction with Award Fee strategy
Profit Pooling	N/A	N/A
Contingency Sharing	N/A	N/A
Goals and Incentives – Meeting owner’s value led to large profits and share of under runs	Prevented value engineering proposals from being strictly cost-savings driven. Government shared in cost under runs, and could implement innovations on remaining work	It is unlikely, but the government may have paid more profit than was necessary to have the building delivered successfully
Award Fees/Performance Evaluations – Tied to owner’s values and performed periodically	Motivated contractors to excel in areas that were important to the government and rovided regular feedback to contractors so they could adjust to meet the government’s values, if necessary	It is unlikely, but the government may have paid more profit than was necessary to have the building delivered successfully. Also has an increased administrative burden to the government

Table 5.1, IPD techniques demonstrated by the Pentagon Renovation Project

5.2 Orlando Utilities Commission, North Chiller Plant

5.2.1 Project Background

In December 2003, the Orlando, Florida Utilities Commission (OUC) awarded a contract for the construction of a 3,000 ton capacity chilled water plant to a mechanical design-build contractor, Westbrook Air Conditioning and Plumbing. Prior to this award, Westbrook, having worked as a prime contractor and subcontractor on numerous projects, recognized that even when working with the best of their peers, each party's self interest always outweighed teamwork initiatives and the construction process as a whole suffered as a result of this. This realization led Westbrook to try to develop a better way to deliver a project. This new project delivery method became the basis for relational contracting in construction (Matthews & Howell, 2004).

For the $6 Million, design-build, guaranteed maximum price (GMP) North Chiller Plant project, Westbrook created a team of contractors known as Integrated Project Delivery, Inc. Construction began on May 4, 2004 and was completed on July 28, 2004. Completing a mechanically complex $6M building in just over two months is practically unheard of in today's construction industry. Additionally, the building was delivered for $600,000 below the GMP, which was shared between the owner and the IPD team. These savings were not a result of value engineering during design. The $600,000 was saved solely due to improvements in the construction process (Matthews & Howell, 2004).

The North Chiller Plant project differed from what is considered to be "pure IPD" today, in that the owner was not a signatory of the relational contract agreement. The owner issued a typical design-build, cost-reimbursable GMP contract to Westbrook. Westbrook and the members of the IPD team then signed a relational contract with each other. The details of the IPD team's relational contract are as follows (Matthews & Howell, 2004):

- All team members agreed to be bound together and fully responsible for all terms and conditions in Westbrook's prime contract with the OUC. This meant that all the team members had the same scope of work, which was the scope of the entire project.
- Each team member agreed to open their accounting books to the other team members and the owner.

- Actual costs would be reimbursed to all team members. Profit would not be distributed until the end of the project, and would be shared according to an agreed-upon formula. This meant that the only cost that mattered was the total project cost.
- Each team member agreed to fully disclose and potential problems that may prevent them from completing their work as planned.

5.2.2 Results of the Project Strategy

The project delivery strategy led to the following results:

- The project design phase involved all of the IPD team members throughout the entire design. Since the minimum profit for the team members was pre-established, the team members' participation in the design took place with a true effort from each party to add value to the design and to reduce costs to the client. For example: since this project had a large amount of mechanical equipment, the mechanical contractor was brought into the structural steel design. By doing so, the steel was designed to accommodate the equipment, instead of the typical approach where the equipment would have to be shoehorned into the building around the steel.
- Since the total project cost is the only cost that affects the team members' bottom line, field problems were quickly resolved on the site by the superintendent, without having to get information or buy-in from each team members' home office. The superintendent was trusted to make decisions based upon which solution would have the lowest cost and least impact to the project as a whole.
- The project management team was comprised of individuals from the different IPD team companies based upon who was best qualified for each specific job. Once assigned to the project management team, they took on roles typically filled by GC

personnel, but instead of looking out for the GC's bottom line, they were looking out for the project instead.

- Manpower was shared between trades/team members. If one IPD team member needed help with a specific task the other team members would provide labor in order to ensure the project did not get delayed.
- Money could be moved across traditional boundaries. The electrical contractor received a favorable quote for a piece of equipment that was supposed to be purchased by the mechanical contractor. On a typical project, the mechanical contractor would never let the procurement of a large piece of equipment be removed from its scope of work, since that would decrease its profit. On this project, the change was made instantly. The electrical contractor procured the equipment, and the savings became part of the profit pool, with some of the savings returned to the owner.
- The contractors went out of their way to help each other in order to benefit the project. The building's electrical conduits were originally planned to be run overhead, which requires conduit hangers and more materials since the conduit would have to be run parallel to column lines. The electrical contractor proposed the idea of running the conduit under the slab by laying out the conduit and then backfilling over it. Typically, this idea would be discarded instantly, since backfilling over and around the conduit would increase the amount of work required by the earthwork contractor. On the North Chiller Plant, the earthwork contractor recognized the immense savings that the project would realize by running the conduit under the slab, and came up with an alternative backfilling method that involved spreading backfill

sand in and around the conduits with a fire hose. This change shortened the project schedule by three weeks and saved thousands in material and overhead costs.

- The success of this project illustrates that IPD can be highly beneficial even if the owner will not or cannot be a signatory to the IPD contract.

5.2.3 IPD Techniques Demonstrated

Table 5.2 lists the IPD techniques that the OUC North Chiller Plant project demonstrated, along with the advantages experienced and possible disadvantages of each technique.

Technique	Advantages	Possible Disadvantages
Integrated teams – Relational contract, owner was not a party	All parties were involved in design. Innovative design solutions were developed with ease, since there was no concern over who would pay for them	None
Integrated Governance	N/A	N/A
High performing teams – cross functional teams	By pulling individuals from each company, a project management team was formed that truly functioned in the best interest of the project	Project management team members could not understand IPD and still work in the best interest of their company
Lean Construction - Integrating process design with product design	Constant constructability reviews by the people that were actually going to build the building allowed for innovative construction methods and minimized design conflicts/errors	Choosing the proper time to lock in the target cost of the project can be difficult
Lean Principles	N/A	N/A
Collective risk sharing – relational contract	Team members willingly helped each other out, since if one member failed, they all failed	Some contractors have a difficult time getting over the fact that other team members could cause them to lose money
Painsharing and gainsharing – making the total project cost more important than each team member's cost	Encouraged money to be moved across boundaries. The only bottom line that mattered to the team members was the total project cost	None
Profit pooling – each party put their entire profit "at risk"	Encouraged innovation and collaboration in order to maximize the size of the profit pool	If one party has an overrun, the entire IPD team will pay for it
Contingency Sharing	N/A	N/A
Goals and Incentives	N/A	N/A
Award Fees/Performance Evaluations	N/A	N/A

Table 5.2, IPD techniques demonstrated by the OUC North Chiller Plant project

5.3 Cathedral Hill Hospital

5.3.1 Project Background

When completed, the Cathedral Hill Hospital (CHH) will be a new 555 bed, 920,000 square foot, 15 story, $1.7 Billion hospital located in San Francisco, California. The hospital will be owned and managed by California Pacific Medical Center, which is a division of Sutter Health, a not-for-profit health care organization located in Northern California. Sutter Health is currently in the middle of a $5.5 Billion capital improvement program in the Northern CA region.

The design, design approval, and construction of a hospital of this size is a very long process. Prior to the start of their current capital improvement program, Sutter Health (SH) was determined to find a better way to build their new facilities. SH had built many new facilities over the course of their existence, and, as is the norm in construction, had experienced disputes and claims on a large number of these projects. In 2004, SH hosted the Sutter Lean Summit, and with the help of the Lean Construction Institute, they developed a plan for the delivery of their future facilities (Cohen, 2010). The strategy that was developed revolves around what they call "The Five Big Ideas", which are (Lichtig, 2005):

1. Collaborate; really collaborate, throughout design, planning, and execution.
2. Increase relatedness among all project participants.
3. Projects are networks of commitments.
4. Optimize the project not the pieces.
5. Tightly couple action with learning.

SH then decided that to ensure these principles were implemented, a new form of contract was required. This led to Lichtig's Integrated Form of Agreement (IFOA), which was previously mentioned in section 4.1. With the Big Five and the IFOA in place, the IPD team was formed and the CHH project began. The IFOA project delivery method is considered to be a form of "pure IPD", and includes requirements for the majority of IPD and lean construction techniques that were discussed in sections 4.1 and 4.2 of this paper. Design on CHH began in 2005, was completed and verified in 2007, and was approved by the California Office of Statewide Health Planning and Development in 2009. The demolition of the existing building on the site is scheduled to begin this year, and the hospital is scheduled to begin operations in early 2015 (Hamzeh, 2009).

5.3.2 Results of the Project Strategy

The design of the CHH project was highly successful in the implementation of IPD. The results were as follows:

- The IFOA contract started as a three-party agreement, where the owner, A/E and GC signed on as partners. This formed what was known as the IPD Core Group. During the design process, key subcontractors, such as the concrete company and the company responsible for the hospital's permitting were added to the core group. The remainders of the IPD team (e.g. specialty contractors) were chosen by the core group based on their qualifications and how well the contractors could work in the collaborative environment required by IPD (IFOA, 2008). Once chosen, the specialty contractors are required to sign a joining agreement which states that they understand the IFOA and that they will participate in the project at the required levels of responsibility and collaboration. Due to these contractual requirements, the CHH project has set a new standard for collaboration and teamwork on a project of this size and complexity.

- The project mandated set-based design, which led to the selection of an innovative seismic damping system that has never been used in the US before. This system increased the design time required by the structural engineers, but since they were being paid on a cost-reimbursable basis, they gladly accepted the change. The decision to go with the innovative damping system was made collaboratively by all parties in the best interest of the project, and ultimately saved the project $9M (Hazelton et al., 2008; Parrish et al., 2008).
- Target value design was used with great success. Using the budget to influence design decisions has been crucial to getting the project below the owner's target cost. The original project design cost was $93M over the target cost, but through the use of TVD the current design cost is approximately $13M below target cost. TVD is also being used to drive down project operating system costs. The IPD team is examining the processes by which the building will be constructed and employing the lean technique of value stream mapping in order to reduce waste in these processes (Hazelton, et al., 2008).
- The LPDS was employed (Hamzeh, 2009). The Last Planner™ System was implemented throughout the project design, and greatly improved production planning and design collaboration when compared to industry standard practices. Reverse phase/pull scheduling was also used, allowing the IPD team to successfully meet aggressive design completion milestones.

5.3.3 IPD Techniques Demonstrated

Figure 5.3 lists the IPD techniques that the Cathedral Hill Hospital project demonstrated, along with the advantages experienced and possible disadvantages of each technique.

Technique	Advantages	Possible Disadvantages
Integrated Teams – Relational contract, owner was a signatory of the contract	All parties have a common understanding of the project. Co-location of parties has contributed significantly to collaboration and teamwork	Insurance policies for relational contracts are still being developed
Integrated Governance – All major project decisions made by consensus by the IPD Core Team	Consensus decisions lead to collaboration	Perceived loss of control by project owners
High performing teams – Cross-functional design clusters	High levels of trust between the team members	None
Lean construction – Last Planner™ System	Increased reliability in work scheduling led to increased productivity, increased communication among design clusters	Steep learning curve to implement the Last Planner™ System correctly
Lean construction – Reverse phase/pull scheduling	No design delays, successfully met all phased approval submission deadlines	None
Lean construction - Set-based design: Design alternatives carried until last responsible moment	Significant construction cost savings, design solutions that better meet owner's values	Perception of wasted effort being put into non-selected design alternatives
Lean construction - Target value design: Project design is being driven by target cost and owner values	Owner is getting what they want at the price they want	None
Lean principles – Sutter Health's "Big Five"	Clear definition of what is important to the customer in the delivery of their new facilities	Learning curve of lean principles required training of project personnel
Collective risk sharing – Part of the IFOA contract	Increased collaboration, parties are willing to help each other out	Some contractors have a difficult time getting over the fact that other team members could cause them to lose some of their profits
Painsharing and Gainsharing	TBD [9]	TBD
Profit Pooling	TBD	TBD
Contingency Sharing	TBD	TBD
Goals and Incentives	TBD	TBD
Award Fees/Performance Evaluations	TBD	TBD

Table 5.3, IPD techniques demonstrated by the Cathedral Hill Hospital project

[9] These techniques are part of the CHH project, but their advantages and potential disadvantages should be determined during and after the construction phase of the project.

5.4 Summary and Conclusions

The case studies presented demonstrate a wide array of IPD techniques, and the ways in which they can be successfully implemented. The projects demonstrated current industry-best practices in both the public and private sector, on small and large, complex projects. The advantages that each technique delivered along with potential disadvantages that could be associated with each technique were presented. Amongst the three projects, an overarching theme of teamwork and collaboration is present. IPD cannot exist without a true desire between the parties to work together and to put the needs of the project above all others. In all three case study projects, the contract requirements were developed in such a way as to encourage the parties to do so. In chapter 6, the techniques that were listed for each project will be analyzed for their applicability to NAVFAC construction projects, and a recommendation will be made as to if each technique can and should be implemented.

CHAPTER 6 – RESULTS

6.1 IPD Techniques that can be implemented by NAVFAC

Table 6.1is a summary of the IPD techniques demonstrated by the case studies, and includes recommendations for which techniques can and should be implemented on NAVFAC projects. Recommendations are based upon the feasibility of implementing each technique within NAVFAC's current policies and procedures.

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

Lean construction - Target value design – Project design is being driven by target cost and owner values	PenRen, CHH	Yes	Can be used to drive down cost on FPI contracts and reduce concerns of lack of competitive bidding in project prices. Target costing must be implemented as a part of TVD, as it can reduce value on its own
Lean construction - Location-Based Scheduling	N/A[10]	Yes	Recommend a pilot project with high repetition of tasks, requires a contractor with LBS/Vico software experience
Lean principles – Sutter Health's "Big Five"	CHH	Yes	Defining NAVFAC-wide principles in a manner similar to what Sutter Health has done would be greatly beneficial to ensure designers and contractors know what is expected of them
Collective risk sharing – relational contract	OUC, CHH	No	Would not benefit NAVFAC without a relational contract, and not allowed by FAR
Painsharing and Gainsharing – Sharing of Under/Overruns	PenRen, OUC	Yes	Must be used in conjunction with a way to ensure this does not result in excessive "value engineering" and reduced value
Profit pooling – each party put their entire profit "at risk"	OUC	No	FPI contract with award fees (i.e PenRen contract) has the same effect
Goals and Incentives – Meeting owner's value led to large profits and share of under runs	PenRen	Yes	Fixed Price Incentive (FPI) contracts are ideal for initial IPD technique implementation
Award Fees/Performance Evaluations – Tied to owner's values and performed periodically	PenRen	Yes	Develop standards which are tied into guiding principles (see Lean Principles - Sutter Health's "Big Five" below). Increased administrative burden of evaluations could be negated by improved contractor performance

Table 6.1, IPD technique recommendations

[10] See case studies in chapters 15-17 of Russell Kenley and Olli Seppanen's book, *Location-Based Management for Construction.*

6.2 Identification of IPD Candidate Projects

6.2.1 Selection of project attributes to be evaluated

There are several key attributes of a construction project. These attributes, which are typically used to define a project, should also play a role in the selection of a project delivery method. Not every project will benefit from IPD techniques. As shown by the potential disadvantages in tables 5.1, 5.2, and 5.3, some IPD techniques may even produce a negative effect. Defining construction project attributes and how they relate to IPD is the first step in identifying the projects which may or may not benefit from IPD. Table 6.2 is a summary of construction project attributes, and how each relates to IPD. The attributes were selected from a study conducted by Rubin Favie and Ger Maas which defined the most important project characteristics (Favie and Maas, n.d.).

Attribute	Definition of Attribute	Relationship to IPD
Cost	Total amount of money an owner spends on a project	One of the main components of value; IPD strives to reduce costs
Timeline	How quickly an owner wants the project completed	One of the main components of value; IPD strives to reduce timelines
Complexity	How complex the building systems (structural, mechanical, electrical, finishes, etc.) are	IPD uses collaboration and teamwork to create better solutions to complex problems
Size	Square footage of the project	IPD can be useful in finding design innovations, which tend to be more repeatable on larger projects
Uniqueness	If a identical or largely similar building has been constructed previously or not	IPD excels in the design and production of one-of-a-kind buildings. IPD is less necessary on “cookie-cutter” buildings
Customer involvement	How involved the customer wants to be in the design and construction process	An involved customer is paramount to IPD’s success. A customer with a “hands-off” mentality makes IPD techniques less beneficial, but still possible
Importance	Who the building will support and how it will contribute to National security	IPD techniques can require extra management resources, which the importance of a project could be used to justify
Location	Where the project is being built	IPD needs skilled, resourceful, and flexible team members. Some locations may not have such team members readily available

Table 6.2, Construction project attributes and their relationships to IPD

6.2.2 IPD project selection tool

Selecting the right projects for implementing IPD techniques will be crucial to these methodologies gaining traction within NAVFAC. Below is a simple numerical project scoring system which weighs the project attributes listed in Table 6.2, resulting in an overall project score that will assist in choosing potential NAVFAC projects on which the IPD techniques that were recommended in Table 6.1 can be used.

In this scoring system, each attribute will be assigned its own range of scores. Once each attribute has been assigned a score, the individual scores are summed to determine an overall project score. Each attribute was given a negative to positive range to help the tool user understand that certain project attributes contribute to IPD suitability, while others detract from it. It is recognized that some of the attributes selected are interdependent. An effort was made to minimize this interdependence in the low/zero/high score definitions, but it cannot be eliminated.

In order to assign proper weighting factors to the attributes, the scoring ranges for each attribute will differ. For example, project cost has a range of minus 10 to plus 10, while customer involvement has a range of minus 6 to plus 6. This means that project cost will have a greater effect on the overall project score. Weighting was assigned based upon both the importance of each attribute to construction in general and the importance of each attribute on NAVFAC projects. Additionally, the weights of the positive and negative scores within each attribute can differ. This was done in order to allow the tool to more accurately measure the effects of each attribute. Table 6.3 provides an explanation of the project attribute weighting that was used.

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

Table 6.3, Explanation of project attribute weighting

Table 6.4 is the project scoring system, and table 6.5 provides a recommendation on a project's suitability for IPD techniques based upon the overall project score which results from the project scoring system. Determining many of the attributes in table 6.4 requires a qualitative evaluation, and it is highly likely that when these qualitative attributes are determined, they will not exactly fit one of the three definitions (low, zero, high) given. When this happens, there are two acceptable scoring methods that can be used:

1. Choose the score (low, zero, high) which best represents where a project falls within that attribute.
2. Interpolate between scores in the table to where it is believed the project falls within the scoring range.

The interpolation method requires care and consistency in order to preserve the built-in weighting system, but both methods will produce acceptable results, since the scoring system was designed to be a general guide, not an exact instrument.

Attribute	Low	Zero	High	Low score definition	Zero score definition	High score definition
Cost	-10	0	10	Less than $5M	$5M-$25M	Greater than $25M
Timeline	-8	0	8	Customer does not have a requirement-driven hard date for project completion	Customer has a requirement-driven hard date for project completion	Customer has an immediate and pressing requirement which requires the project to be completed as soon as possible
Complexity	-10	0	10	No complex systems; minimal number of trades involved (examples: parking lot, pre-engineered building erection)	Multiple trades involved; coordination between trades is beneficial (examples: typical office building, barracks)	Large number of trades involved, including numerous specialty trades; highly complex mechanical and electrical systems required; coordination between trades crucial (examples: hospital, command & control facility)
Size	-1	0	3	Less than 10,000 SF	10,000-100,000 SF	Greater than 100,000 SF
Uniqueness	-1	0	4	Identical buildings exist on similar sites	Similar buildings exist on other sites, or identical buildings exist on non-similar sites	One-of-a-kind
Customer Involvement	-6	0	6	Customer doesn't want to participate at all, and doesn't have resources to devote to the project	Customer wants regular progress updates and attends meetings fairly regularly, but does not make the project a top priority	Customer wants to be at every meeting and devotes extensive time and personnel to the project
Importance	-2	0	4	Indirect effect on Navy's tactical goals	Indirect effect on Navy's strategic/operational goals, or direct effect on Navy's tactical goals	Direct effect on Navy's strategic/operational goals
Location	-20	0	5	Contractors in area are not capable of/willing to try IPD/lean techniques	Contractors in area have not done IPD/lean construction, but manage projects well in the traditional fashion	Contractors in area are already using IPD/lean construction techniques

Table 6.4, Project scoring system

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

Table 6.5, Recommendation for IPD technique implementation based upon overall score from Table 6.4.

6.2.3 Project selection tool testing

In order to verify the calibration of the IPD project selection tool, the three case studies presented in Chapter 5 were tested. The actual attributes from each project were used, but the OUC and CHH projects were assumed to be Navy projects in order to improve the accuracy of the testing. The OUC project was assumed to be a chiller plant on a Naval Station in Florida, and the CHH project was assumed to be a large military medical facility in California. Scoring method #1 from section 6.2.2 was used. The testing produced the following results:

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

Table 6.6, Scoring of the case study projects in the IPD project selection tool

The results in table 6.6 increase confidence that the IPD project selection tool is working as intended. The PenRen and CHH projects both fell into the "strongly recommended for IPD techniques" category, while the OUC project fell into the "potential IPD technique project" category. It should be noted that the OUC project received a 0 score in the cost attribute because of the Navy project criteria in the scoring system. If the scoring system was adapted to a different owner's needs, the project would have likely received a higher score. On the PenRen and CHH projects, the owners recognized the need for improving their project delivery system, while on the OUC project, the owner solicited for a standard design-build project delivery and the IPD techniques used were contractor-driven. If the scoring system was adapted to the OUC's needs, the project would likely have received 10 points in cost, This demonstrates that in the preliminary use of the project selection tool, it is in alignment with owners' interests. Projects that have a recognized need for improved project delivery systems are receiving higher scores and hence, a stronger recommendation for implementation of IPD techniques.

CHAPTER 7 - CONCLUSIONS

7.1 Conclusions and Recommendations

The importance of a project operating system on a construction project cannot be overstressed, yet historically, these systems have seen very few attempts at improvement. IPD is one such attempt, and as this research has described, it can successfully improve the construction process and add value to a construction project.

7.1.1 Research Findings

This research has studied how IPD techniques could be implemented by NAVFAC and developed a scoring system to help choose the most suitable projects for applying these techniques. At the beginning of this paper, two research questions were posed. The completion of this research demands that I verify they have been answered:

- **Question #1:** Which IPD techniques can be integrated into NAVFAC's project delivery method, and how would NAVFAC benefit from them?

  The literature review provided a comprehensive overview of current IPD best practices. Next, three case studies were presented. The IPD techniques that each case study demonstrated were presented (Tables 5.1, 5.2, and 5.3), along with the benefits and potential drawbacks of each technique. Finally, the techniques from each case study were consolidated (Table 6.1) and a positive or negative recommendation for integrating each best practice into the NAVFAC project delivery process was made.

- **Question #2:** How can it be determined which NAVFAC projects are potential candidates for using the selected IPD techniques?

First, a list of construction project attributes (Table 6.2) was presented, along with how each attribute relates to IPD techniques. Each attribute was then assigned a scoring range, which gave them relative weighting to each other based upon their importance to implementing IPD. Each scoring range was assigned criteria which will assist in determining where each attribute falls within its scoring range. Once each attribute has been scored, a project's overall suitability for IPD techniques can be determined by summing each attribute's score and applying the total score to Table 6.5.

7.1.2 Research Contributions

This research has made the following contributions to knowledge:

- The list of IPD techniques that are recommended for implementation on Navy projects. This list, which breaks IPD down into specific techniques, provides ways in which construction project delivery can be improved by the Navy and other public sector agencies that currently cannot implement "pure" IPD.
- The IPD project selection tool provides a simple, easy-to-understand method of deciding if a Navy construction project is a good candidate for implementing IPD techniques. This tool is the first of its kind, and can assist in standardizing the selection of projects which should use the recommended IPD techniques. It could also be used to select projects for the ECI project delivery method currently being piloted by NAVFAC. The tool can easily be adapted for use by other public sector agencies or the private sector.

7.1.3 Further Research

The research area of Public Sector IPD and specifically, IPD in NAVFAC is very new, and numerous possibilities for further research exist in this area:

- Refinement and further calibration of the IPD project selection tool. The project selection tool contained in this research is a general guide, and should be refined using feedback from its implementation on actual project selections. This tool could also be modified or expanded in order to make it an applicable decision-making tool for any construction project owner.
- Creation of a step-by-step process for executing IPD techniques. Defining a process checklist which NAVFAC personnel could use to manage IPD technique implementation would standardize the process and ensure the IPD techniques are receiving the level of attention they need to be successful.
- Measuring the workload change for NAVFAC employees that results from IPD techniques. One of the possible reasons for resistance to IPD techniques is that they are accompanied with an increased workload for project managers and contracting officers whom are already managing very heavy workloads. Research should be conducted to verify if IPD techniques affect the workload of NAVFAC employees, and if so, a cost/benefit analysis should be performed on the additional workload.
- Case studies of NAVFAC ECI pilot projects. Detailed studies of the effects of ECI on NAVFAC's project delivery process should be conducted during and after the pilot project deliveries. Action research is recommended in order to "embed" the researcher into the ECI process. The results of the ECI case study research could then be integrated with this research in order to expand the number of IPD techniques that are included in the ECI delivery method.

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