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Implementing Integrated Project Delivery on Department of the Navy construction projects

Michael S. Singleton[2] and Farook R. Hamzeh[3]

Abstract

Research Questions: 1) Which IPD techniques can be integrated into the Navy's project delivery method, and how would Naval Facilities Engineering Command (NAVFAC) benefit from them? 2) How can NAVFAC determine which projects are potential candidates for using IPD techniques?

Purpose: To determine which techniques contained within IPD and their associated efficiency improvements and waste reductions may directly benefit NAVFAC projects and public sector construction projects in general.

Research Design/Method: This research employs case study analysis to asses IPD techniques that can be implemented on Navy projects. It reports research results from three construction projects employing various levels of IPD implementation.

Findings: This research has identified numerous IPD techniques that could be successfully implemented on NAVFAC projects with no changes to contract laws. The research also resulted in a tool which can be helpful in identifying which projects are preferred for implementing the IPD techniques identified.

Limitations: This research did not examine changing the Federal Acquisition Regulations. It focused strictly on identifying techniques that could be integrated into the current project delivery system.

Implications: This research will allow for a greater understanding of IPD within NAVFAC and could accelerate efforts to bring IPD to Navy and other public sector construction projects.

Value for practitioners: This paper provides an easy-to-understand list of IPD techniques that could be implemented on Navy projects as well as an easy-to-use IPD project selection tool. Both findings will allow those that have little experience with IPD to understand how IPD works, the implications of IPD, and how to identify projects that will benefit the most from IPD techniques.

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1 The views expressed in this paper are those of the authors, and do not reflect the official positions or policy of the United States Navy, Department of Defense, or the U.S. Government

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Introduction

Integrated Project Delivery

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 affect 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. 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 or the project, 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 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 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).

Naval Facilities Engineering Command

Naval Facilities Engineering Command (NAVFAC) is the organization 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. This research will examine ways that NAVFAC can improve its delivery of construction projects by implementing IPD techniques.

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).

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 (FAR). The FAR does not allow the government to participate in IPD-related financial motivation techniques such as risk sharing, profit pooling, or contingency pooling. The FAR also does not allow for multi-party agreements or relational contracting, and mandates competitive bidding for construction contracts with very limited exception. There also is 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).

Defining IPD techniques

In order to identify which techniques can be integrated into NAVFAC's project delivery system, the techniques which comprise IPD first had to be defined. IPD is a relational construction delivery method in which the owner, designer, and contractor(s) are contractually bound to one another to perform/deliver projects 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). A typical IPD contract includes requirements for the following 11 main attributes which differentiate them from traditional contracts (Thomsen, et al., 2010):

Integrated Teams: The general contractor and, shortly thereafter, key trades are contractually brought into the project during the early stages of design. The contractors, who 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), assist the designer in completing a design that maximizes value to the owner, and provide themselves the benefits of a design with high predictability and constructability (Colledge, 2004).

Integrated Governance: Since the IPD contract is designed to share the "pains and gains" of the project between all team members, all team members will want to share in major project decisions. For this reason, IPD projects operate on a "leadership by committee" basis, with the executive committee typically consisting of senior representatives of the owner, designer, general contractor, and others. All decisions are made on a consensus basis (Lichtig, 2005).

High Performing Teams: IPD starts with traditional forms of Partnering such as team-building exercises, tracking performance, and building trust, and then picks up where Partnering leaves off. One teamwork technique is to create cross functional teams consisting of individuals from different companies and to assign work based upon their strengths and project needs. In essence, the flexibility of IPD allows for maximizing each person's productivity by putting the right person in the right job (Thomsen, et al., 2010).

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). Detailed descriptions of these techniques are beyond the scope of this paper, but include: reverse-phase scheduling (Ballard & Howell, 2003), the Last Planner™ System (LPS) (Alarcon & Calderon, 2003; Ballard, 2000a; de la Garza & Leong, 2000; Hamzeh, 2009), set-based design (Ballard, 2000b), target-value design (Macomber & Barberio, 2007), and location-based scheduling (LBS) (Kenley & Seppanen, 2010).

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. 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 the success of IPD (Lichtig, 2005).

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 one or more parties being responsible for risks that they have little or no control over. Additionally, the parties who are not “at risk” have no incentive to help the parties who 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 it to all parties involved on a 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.

Painsharing and Gainsharing: The IPD team will set a target cost for the project at some stage in the design process and then any cost overruns or underruns of that target cost will be shared between the IPD team. This encourages all parties to develop innovative designs and methods that can reduce the cost of not only their work, but the work of other parties as well. 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).

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 affect the bottom line of the entire IPD team.

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, and it encourages teamwork and creative problem solving from all team members.

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 for meeting the goals.

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 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 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 (Hoag & Gunderson, 2005; Thomsen, et al., 2010).

Case Studies

Pentagon Renovation Program (PenRen)

Project Background

In 1991, the Pentagon was in serious need of repair. Recognizing this problem, congress established the Pentagon Reservation Maintenance Revolving Fund, with the expressed intent of renovating the building. In 1998, the contract to renovate the first wedge (1/5th of the building) was awarded (PenRen, 2010). 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 PenRen Office recognized that the remainder of the renovation could not be conducted in the same manner (Hoag & Gunderson, 2005).

To solve their problem, the PenRen 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 underruns 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 a FPIF contract focuses strictly on cost, a FPAF contract rewards a contractor based on the customer's rating of non-cost criteria (Hoag, 2008). The contractor is evaluated by the owner on a regular basis, and the contractor "earns" its rewards if 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 the only way contractors would make additional money on the FPIF side of the contract was to complete the project below the target cost. The FPAF portion of the contracts provided up to a 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 underruns if the contractor met the award fee performance goals more than 85% of the time.

Results of the Project Strategy

- 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 underruns 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 underrun.
- Cost saving approaches which led to underruns 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.

Orlando Utilities Commission, North Chiller Plant

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 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 develop a better way to deliver a project (Matthews & Howell, 2004).

For the $6 Million, design-build, cost-reimbursable, 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. 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, but were 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. Westbrook and the members of the IPD team signed a relational contract with each other, and bid as a typical design-build entity.

Results of the Project Strategy

- The project design phase involved all of the IPD team members. 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.
- 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 that would result in 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 in order to ensure the project was not 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 their scope of work, since that would decrease their 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. 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. This change shortened the schedule by three weeks and saved thousands in material and overhead costs.
- This project demonstrated that IPD can be highly beneficial even if the owner will not or cannot be a signatory to the IPD contract.

Cathedral Hill Hospital

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 (SH), a not-for-profit health care organization located in Northern California. SH is currently in the middle of a $5.5 Billion capital improvement program in the Northern CA region.

Prior to the start of their current capital improvement program, 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 "The Five Big Ideas", which are (Lichtig, 2005):

- Collaborate; really collaborate, throughout design, planning, and execution.
- Increase relatedness among all project participants.
- Projects are networks of commitments.
- Optimize the project not the pieces.
- 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). With the Big Five and the IFOA in place, the IPD team was formed and the CHH project began. 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 in the second half of 2010, and the hospital is scheduled to begin operations in early 2015 (Hamzeh, 2009).

Results of the Project Strategy

- 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 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. 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 (TVD) was used with great success. 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 LPS was employed (Hamzeh, 2009). The LPS 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.

Summary

The case studies presented demonstrate a wide array of IPD techniques, and the ways in which they can be successfully implemented. In the next section, the techniques that were listed for each project are analyzed for their applicability to NAVFAC construction projects, and recommendations are made whether or not each technique can and should be implemented.

IPD Techniques that can be implemented by NAVFAC

The advantages and potential disadvantages of each IPD technique demonstrated by the case studies were determined (Singleton, 2010). Following this determination, a recommendation for each technique's applicability to NAVFAC projects was made. These recommendations are summarized in Table 1.

IPD project selection tool

Selecting the right projects for implementing IPD techniques will be crucial to these methodologies gaining traction within NAVFAC. A simple numerical project scoring system was developed which weighs typical construction project attributes, and results in an overall project score that will assist in choosing potential NAVFAC projects for IPD.

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 user understand that certain project characteristics 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. Weighting was assigned based on both the importance of each attribute to construction in general and the importance of each attribute on NAVFAC projects. Additionally, weights of the positive and negative scores within each attribute can differ. Table 2 provides an explanation of the project attribute weighting that was used.

Table 1 – IPD technique recommendations (Rec? = recommended for implementation?)

Technique	Case	Rec?	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	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 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 related to 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 (see case studies in Kenley & Seppanen 2010, chaps 15-17)	N/A	Yes	Recommend pilot project with high task repetition. 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 Sutter Health would be greatly beneficial to ensure designers & 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 poor “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 a similar effect
Goals and Incentives – Meeting owner’s value led to large profits and share of underruns	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 tied into guiding principles. Improved contractor performance will over-compensate and cover for increased administrative burden of evaluations

Table 2 - Explanation of project attribute weighting

Attribute	Low	Zero	High	Weighting Justification
Cost	-10	0	10	Cost is of utmost importance 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

Attribute	Low	Zero	High	Weighting Justification
Complexity	-10	0	10	Complexity is the most important technical attribute when deciding to use IPD or not, hence complexity's high weighting. A complex project will benefit more from IPD techniques than a simple project
Size	-1	0	3	On most projects, size is interdependent with cost and complexity, but it still requires some weighting in the tool for those projects where it does not correlate with cost and complexity. The positive and negative weights differ because a small project could still be a good candidate for IPD, but a very large project will almost certainly benefit from IPD techniques
Uniqueness	-1	0	4	Unique projects can require innovative designs which IPD techniques can help create. Uniqueness does not have a high weighting because even if a project is unique, the tasks that comprise a project are usually not. The positive and negative weights differ because a "cookie-cutter" project will benefit from IPD techniques, but many of them may provide less of a benefit than on a one-of-a-kind project
Customer Involvement	-6	0	6	Customer involvement is key on NAVFAC projects in order to successfully provide value. An average weighting was assigned since this is not a physical project characteristic, but is still important to the success of IPD techniques. A customer that does not want to be involved can hurt the IPD process just as much as an involved customer can benefit it
Importance	-2	0	4	The perceived increased in workload (and cost) that comes with IPD can be more easily justified on projects which are of utmost importance to National defence. A smaller penalty was assigned for lesser importance since it 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 because IPD techniques will fail if contractors are incapable of managing them. If a project falls in the low category, the -20 score will ensure that the project cannot receive a strong recommendation for IPD techniques

Table 3 is the project scoring system. Determining many of the attributes in table 3 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 given. When this occurs, two scoring methods can be used:

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

Both methods will produce acceptable results, since the scoring system was designed to be a general guide, not an exact instrument.

Table 3: Project scoring system

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 4 provides a recommendation on a project's suitability for IPD techniques based upon the overall project score.

Table 4: Recommendation for IPD technique implementation based upon overall score

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

Project selection tool testing

In order to verify the calibration of the IPD project selection tool, the three case studies 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. The testing produced the following results:

Table 5: Scoring of the case study projects in the IPD project selection tool

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

The results in table 5 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. 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. 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.

Conclusions

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. 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.

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 or other public sector agency personnel could use to manage IPD 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 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 employees, and if so, a cost/benefit analysis should be performed on the additional workload.

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