US Navy Contracted Construction Delivery Methods

Recent Project Performance Analysis,
Review of Alternative Delivery Methods,
and Recommendations for the Future

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Abstract

Navy and Marine Corps shore infrastructure construction has been completed with either Design-Build (DB) or Design-Bid-Build (DBB) delivery methods since the late 1980s; meanwhile, alternative project delivery methods (e.g., Construction Manager at Risk and Integrated Project Delivery) have been developed to improve construction project performance. This research compared current Navy construction delivery methods, developed a schedule growth prediction formula for these methods, examined alternative delivery methods, and developed recommendations for updating Navy procurement methods. The research found that DB outperformed DBB in both cost control (29% reduction in cost growth) and project changes (76% reduction in changes per million dollars). There was no statistically significant schedule growth difference between DB and DBB. The schedule growth model predicts that the most complex projects will suffer the most schedule growth, followed by the lowest complexity projects, with the least schedule growth expected on projects of average complexity. The Integrated Project Delivery (IPD) method was recommended as a potentially superior alternative to DB. Because full implementation of IPD could require changes to federal procurement policy, a number of recommendations were made to incorporate elements of IPD to improve the Navy's current DB model.

Introduction

Naval Facilities Engineering Systems Command (NAVFAC) manages the planning, design, and construction of shore facilities for all Department of the Navy activities. As the construction agent for the Navy and Marine Corps, NAVFAC and the Engineering and Expeditionary Warfare Center (EXWC) seek to use the most effective and efficient project delivery methods available. NAVFAC has used traditional Design-Bid-Build project delivery since its inception, and began using Design-Build in the late 1980s (NAVFAC, 2017).

30 years later, Design-Build and Design-Bid-Build remain the only delivery methods regularly used for Navy and Marine Corps shore facility construction. Private sector construction firms and customers are reporting improved project performance with alternative delivery methods such as Construction Manager at Risk (CMR) and Integrated Project Delivery (IPD). Both of these delivery methods encourage closer collaboration between Owner, Designer, and Constructor (AGC of America, 2010). EXWC and NAVFAC are interested in whether alternative delivery methods should be used by NAVFAC to improve project performance and control cost and schedule growth in an effort to deliver projects on time, and increase the value of constructed facilities to the American Taxpayer.

Research Statement

The scope of this research is to develop recommendations on Navy use of one or more alternative delivery systems, and determine if modifications to regulations or exceptions to policy would be required in order to facilitate the new delivery systems. Performance on recent Navy contracted construction projects was examined first to compare the expected Cost Growth, Schedule Growth, and Changes per Million Dollars using the current delivery methods. An attempt was then made to develop models to predict actual cost and actual schedule from data available at the beginning of a project. A collection of non-Navy projects with various delivery methods (both traditional and alternative) were analyzed and compared to the Navy project data set, and used to examine alternative delivery methods. A literature review of emerging delivery method project performance and applicability in private and public projects was conducted. Federal, Department of Defense (DoD), and Navy acquisition regulations were then reviewed to determine any limitations to using an alternative delivery system, and final recommendations were developed.

Definition of Terms

Design-Bid-Build (DBB) is the traditional construction project delivery system in which an architect or engineer works with the customer to develop a complete design, and the customer then solicits bids from construction firms to construct the facility (Carpenter & Bausman, 2016). This "design, then construct" model creates a long timeline from identification of need to finished product, and if there are problems with the project along the way, the customer can be caught between a design agent and construction agent who each blame the other for the issues (Hayes, 2014).

In Design Build (DB), the customer solicits bids on a project before most of the design has been completed and awards one contract to a single firm who agrees to both design and construct the facility. The DB model creates opportunity for increased collaboration between the designer and constructor, and DB projects can often be fast-tracked since construction can begin before the design is complete (Hayes, 2014).

Construction Manager at Risk (CMR) is similar to a traditional DBB, but the Owner hires a Construction Manager (CM) who joins the project early in the design phase to coordinate with the Designer. Once the design is complete, the CM hires contractors to complete the construction. The CM is said to be "at-risk" because the CM awards the construction contracts, so their profit is at risk if their contractors suffer cost overruns (Choi, Yun, Leite, & Mulva, 2019).

Integrated Project Delivery (IPD) is a highly collaborative delivery method which seeks to integrate the project team from the beginning of the project to the end in an effort to harness insight and decision making from the whole group, and optimize efficiency throughout design and project delivery (Silberman, Kovars, & Steedman, 2014). In a pure IPD project, the Owner, Designer, Constructor, and potentially other entities sign onto one multiparty agreement, each promising to do what is best for the project over what is best for their company (Kim, Rezqallah, Lee, & Angeley, 2016). The parties are brought on early in the design phase so that the Designer can get feedback and ideas from the Constructor and Owner in real time, with a focus on value, and cost savings or cost overruns are split between the Owner and the Contractors (AGC of America, 2010).

Project Start is defined as the Notice to Proceed (NTP) date. Project End is defined as the Beneficial Occupancy Date (BOD), or the day the customer moves into the completed facility. BOD is a term commonly used in military construction projects, and is analogous to the Substantial Completion date (US Army Corps of Engineers, 2012). Cost Growth is defined as the percent increase from award price to final price at contract completion. Schedule Growth is the percent increase from planned schedule (planned NTP to planned BOD) to actual schedule (actual NTP to actual BOD). Construction Speed is defined as the total project cost divided by the schedule in thousands of dollars per day ($K/Day). Projected Construction Speed is the original award amount divided by the planned schedule. Actual Construction Speed is the final price at contract completion divided by the actual project schedule.

Data Characteristics

Assessment of the Navy's current delivery methods began with a list of hundreds of Navy contracted construction projects completed between 2016 and 2021. Projects built outside the Continental United States (CONUS) were removed to control for variability in projects completed overseas. Building modifications, expansions, and rehabilitation were also removed, along with energy efficiency measures and utility projects.

The seventy-four remaining projects are relatively evenly distributed between the delivery methods, with 35 Design-Bid-Build and 39 Design-Build Projects. The majority of the projects are of average complexity (59%), 30% are low complexity, and 11% are high. Over half of the projects are either Training Facilities (19%), Operations Facilities (19%) or Command and Control Facilities (16%). Maintenance Facilities and Laboratory Spaces are 9% each, and the remaining 28% are split between nine additional facility types (e.g., Hangars, Barracks, Security Infrastructure, and Fuel Stations). The projects range in size (based on award price) from $1.3M to $240M, with a median of $11.5M and a mean of $24.8M. The projects were sorted by size roughly into thirds: 26 small projects (less than $4M), 24 medium projects, and 24 large projects (greater than $20M). The two delivery methods have similar median project sizes with $10M for DBB and $14M for DB.

Cost and Schedule Growth were computed for each project, and the prospective change and modification lists were examined to determine the number of changes (or contract modifications) made to each contract after award. Administrative changes and time extensions were not considered project changes for the purposes of this research. These changes were then divided by the contract size in millions of dollars to give Changes per Million Dollars.

Methodology and Research Scope

This research examines the difference in cost and schedule growth between DB and DBB construction delivery methods for Navy contracted construction projects. The number of changes (whether due to unforeseen conditions, design flaws, or customer requests) is also considered to determine if one delivery method leads to more changes, and whether the number of changes impacts project cost and schedule growth. Finally, project size was also examined to determine any impact on cost or schedule growth and ascertain if the preferred delivery method changes with project size.

Comparative Assessment of Delivery Methods

In comparing the medians and means of the two delivery methods in Table 1, DB scored better than DBB in each of the three categories with lower schedule growth, lower cost growth, and fewer changes per $M.

Table 1 - Project Performance by Delivery Method

		Schedule Growth	**Cost Growth**	**Changes / $M**
DB	**Mean**	60%	10%	0.94
	Median	46%	10%	0.53
DBB	**Mean**	84%	17%	2.44
	Median	55%	14%	2.22

DB outperforms DBB in all categories: lower schedule growth, lower cost growth, and fewer changes per million dollars. Further statistical analysis was performed to determine the validity of the differences between the two delivery methods. Figure 1 is a set of box plots comparing the delivery methods by their schedule growth, cost growth, and number of changes.

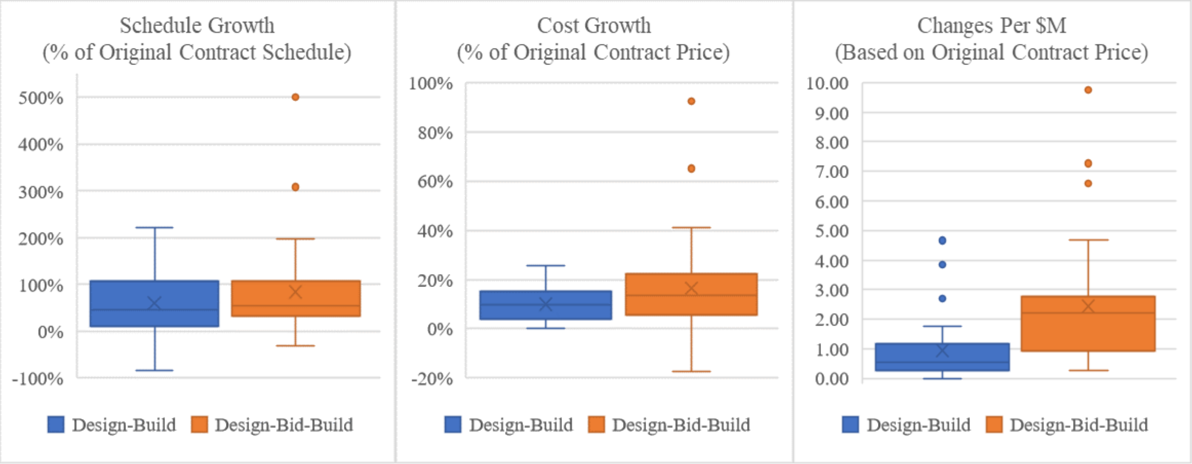

Figure 1 - Box Plots Comparing Delivery Methods

The data is not normally distributed, so a nonparametric method is preferred to validate the differences. The Kruskal-Wallis test was used to check the Null Hypothesis that the difference between the medians for the delivery methods is statistically significant. The resulting P-Values are shown in Table 2.

Table 2 - P Values for Kruskal-Wallis Test of Null Hypothesis

	Schedule Growth	Cost Growth	Changes/$M
P Value	0.2717496	0.063078	2.47e-05

Using a significance level of 0.1, the Null Hypothesis is not rejected for Schedule Growth, so DB cannot be said to statistically outperform DBB in schedule control, despite having a lower median. But the test confirms that DB outperforms DBB in cost control and limiting project changes.

Predicting Project Cost and Schedule Performance

The project data was next analyzed to determine if variables available at the beginning of a project could be used to predict the project's cost and schedule performance. Cost Growth and Schedule Growth were examined separately as the dependent variables. The explanatory variables in Table 3 were considered along with the interaction term between each pair of the variables.

Table 3 - Explanatory Variables Considered for Cost and Schedule Prediction

Explanatory Variable	Variable Type (Unit)
Delivery System	Discrete (DB / DBB)
Project Size	Continuous ($M)
Complexity	Discrete (Low / Average / High)
Changes per Million Dollars	Continuous (Changes / $M)
Contract Type	Discrete (Stand-Alone Contract / Task Order)
Projected Construction Speed	Continuous ($K / Day)

Predicting Cost Performance

Attempts to construct a statistically significant Cost Prediction Model were unsuccessful. The best model has an overall P-Value of 0.291, and the best explanatory variable (the interaction between DBB and Medium Complexity) has a P-Value of 0.227. Both values are over twice the maximum significance threshold of 0.1. Cost performance cannot be reliably predicted from the available variables.

Predicting Schedule Performance

When modeling Schedule Performance with a 95% confidence, seven variables passed the initial significance test. Insignificant variables were removed, and a refined model was developed. A Cook's Distance analysis identified one influential point which was removed. The final model has an overall P-Value of 4.32×10^{-7}, well below the 0.1 significance threshold. The P-Values for individual variables can be found in Table 4.

Table 4 - Schedule Performance Prediction Model P-Values

Explanatory Variable	P-Value
Project Size	0.0926
Complexity	0.00209
Projected Construction Speed	0.0161
Interaction Term: Project Size / Projected Construction Speed	0.0718
Interaction Term: Complexity / Projected Construction Speed	0.00244

The resulting model can be used to predict Actual Project Schedule based on Original Project Schedule, Project Size, Complexity, and Projected Construction Speed using the following equation:

$$\text{Predicted Schedule} = \left(\sqrt[0.5454]{\mathrm{X\beta}}\right)(\text{Original Schedule})$$

Where Xβ is the weighted sum of the following coefficients:

$$2.497 \times \text{High Complexity}$$
$$1.356 \times \text{Average Complexity}$$
$$1.480 \times \text{Low Complexity}$$
$$7.584 \times 10^{-10} \times \text{Project Size (\$M)}$$
$$-0.1627 \times \text{Projected Construction Speed}$$
$$4.280 \times 10^{-11} \times \text{Projected Construction Speed} \times \text{Project Size}$$
$$0.1554 \times \text{Projected Construction Speed} \times \text{Average Complexity}$$
$$0.1498 \times \text{Projected Construction Speed} \times \text{Low Complexity}$$

Where Project Size is the award price in millions of dollars, Project Construction Speed is the award price divided by the original project schedule in $K/Day, and the Complexity figures are discriminator coefficients which equal one for a project of that complexity, and zero for other projects:

$$\text{Project Size } = \text{Project Award Price in millions of dollars}$$

$$\text{Projected Construction Speed} = \frac{\text{Original Constract Price (\$K)}}{\text{Original Project Schedule (Days)}}$$

$$\text{High Complexity (High} = 1, \text{Other} = 0)$$

$$\text{Average Complexity (Average} = 1, \text{Other} = 0)$$

$$\text{Low Complexity (Low=1, Other=0)}$$

Splitting up the coefficients by Project Complexity results in three simplified Xβ expressions, one for each level of project complexity:

<u>High Complexity Project</u>

$$\begin{aligned} X\beta = {} & 2.497 \\ & -0.1627 \times \mathit{Projected\ Construction\ Speed} \\ & +0.0007584 \times \text{Project Size} \\ & +0.00004280 \times \mathit{Projected\ Construction\ Speed} \times \mathit{Project\ Size} \end{aligned}$$

<u>Average Complexity Project</u>

$$\begin{aligned} X\beta = {} & 1.356 \\ & -0.0073 \times \mathit{Projected\ Construction\ Speed} \\ & +0.0007584 \times \text{Project Size} \\ & +0.00004280 \times \mathit{Projected\ Construction\ Speed} \times \mathit{Project\ Size} \end{aligned}$$

<u>Low Complexity Project</u>

$$\begin{aligned} X\beta = {} & 1.480 \\ & -0.0129 \times \mathit{Projected\ Construction\ Speed} \\ & +0.0007584 \times \text{Project Size} \\ & +0.00004280 \times \mathit{Projected\ Construction\ Speed} \times \mathit{Project\ Size} \end{aligned}$$

Schedule Prediction Analysis

A larger positive Xβ term in the Schedule Prediction Model equation will result in a longer expected schedule (though the relationship is not linear), so Xβ coefficient terms can be compared directly to determine which variables have the greatest impact on schedule. The main element of Xβ in all cases is Project Complexity with the most complex projects predicted (as may have been expected) to have the greatest schedule increase. Low and Medium Complexity projects both have significantly lower base Xβ values, but the simpler projects are predicted to have slightly higher Schedule Growth. Table 5 compares projects of varying complexity with other variables held constant.

Table 5 - Predicted Schedule Comparison for Projects of Varying Complexity

Project Size ($M)	Project Complexity	Projected Construction Speed ($K/Day)	Original Schedule (Days)	Predicted Schedule (Days)	Predicted Schedule Growth (%)
5.0	High	5.0	1,000	2,613	161%
5.0	Average	5.0	1,000	1,674	67%
5.0	Low	5.0	1,000	1,903	90%

The only negative coefficient in Xβ is Construction Speed, predicting that a project with a more aggressive schedule will suffer less Schedule Growth than a similar project with a less aggressive schedule. Table 6 examines the same three projects from Table 5 with three different schedules.

Table 6 - Predicted Schedule Comparison for Projects of Varying Projected Construction Speed

Project Size ($M)	Project Complexity	Projected Construction Speed ($K/Day)	Original Schedule (Days)	Predicted Schedule (Days)	Predicted Schedule Growth (%)
5.0	High	3.3	1,500	5,148	243%
5.0	High	5	1,000	2,613	161%
5.0	High	10	500	392	-22%
5.0	Average	3.3	1,500	2,552	70%
5.0	Average	5	1,000	1,674	67%
5.0	Average	10	500	796	59%
5.0	Low	3.3	1,500	2,933	96%
5.0	Low	5	1,000	1,903	90%
5.0	Low	10	500	875	75%

As expected from examination of the Xβ coefficients, a more aggressive schedule is predicted to result in reduced Schedule Growth, but the difference is greater for the High Complexity projects than for those that are of Low or Average Complexity.

Project Size is the final significant variable. Project size (in $M) impacts Xβ slightly, but is also present in a significant interaction term with Projected Construction Speed (a variable which is otherwise decreasing Xβ) to have a further positive pressure on Xβ. Table 7 compares Schedule Growth for otherwise similar projects with different Project Size.

Table 7 - Predicted Schedule Comparison for Projects of Varying Project Size

Project Size ($M)	Project Complexity	Projected Construction Speed ($K/Day)	Original Schedule (Days)	Predicted Schedule (Days)	Predicted Schedule Growth (%)
1.0	High	1	1,000	4,735	373%
5.0	High	5	1,000	2,613	161%
10.0	High	10	1,000	794	-21%
1.0	Average	1	1,000	1,733	73%
5.0	Average	5	1,000	1,674	67%
10.0	Average	10	1,000	1,606	61%
1.0	Low	1	1,000	2,021	102%
5.0	Low	5	1,000	1,903	90%
10.0	Low	10	1,000	1,764	76%

While larger Project Size should lead to larger Xβ values, Project Size is dominated by Project Construction Speed, so a larger project with the same schedule will result in a lower predicted Schedule Growth. The difference is most significant when comparing highly complex projects: a $1M project scheduled for 1,000 days can expect 373% Schedule Growth, while a $10M project with the same schedule is predicted to finish 21% early.

Application of Schedule Performance Prediction Model

The Schedule Performance Prediction Model was created using 74 recent (2015-2020) NAVFAC contracted new-build construction projects completed in CONUS using DB or DBB delivery methods. The resulting model can serve as a good predictor of similar projects executed using the same delivery methods. Applying this model to a new construction contract could be used to set and manage realistic customer expectations at the beginning of a project. Contractors cannot expect contract time extensions simply based on past experience, so sharing the model's results with a contractor is not advised.

Limitations of Schedule Performance Prediction Model

The model was developed using Navy contracted new-build construction projects from $1.3M to $240M completed in CONUS. The model may not be reliable for privately-funded projects, repair or remodeling projects, construction executed overseas, or for projects less than $1M or greater than $250M. Due to the limited number (8 of 74) and small size range ($1.3M to $13M) of projects with a High Complexity, the model may be less reliable for highly complex projects, especially those greater than $15M.

Comparing Navy Project Data to Other Entity Project Data

Project data from other University of Wisconsin research was gathered for comparison and to investigate alternative project delivery methods. Data was collected from 90 projects with a mix of Public (72%) and Private (28%) projects, Small (9%), Medium (44%), and Large (47%) project sizes with costs from $780K to $430M. The majority of the projects are DBB (52%) or DB (20%), but the set also includes CMR (16%) and IPD (12%). The projects reflect a relatively even split between Low (41%), Medium (37%), and High (22%) Complexity.

Figure 2 compares Schedule Growth of different delivery methods for the new project set.

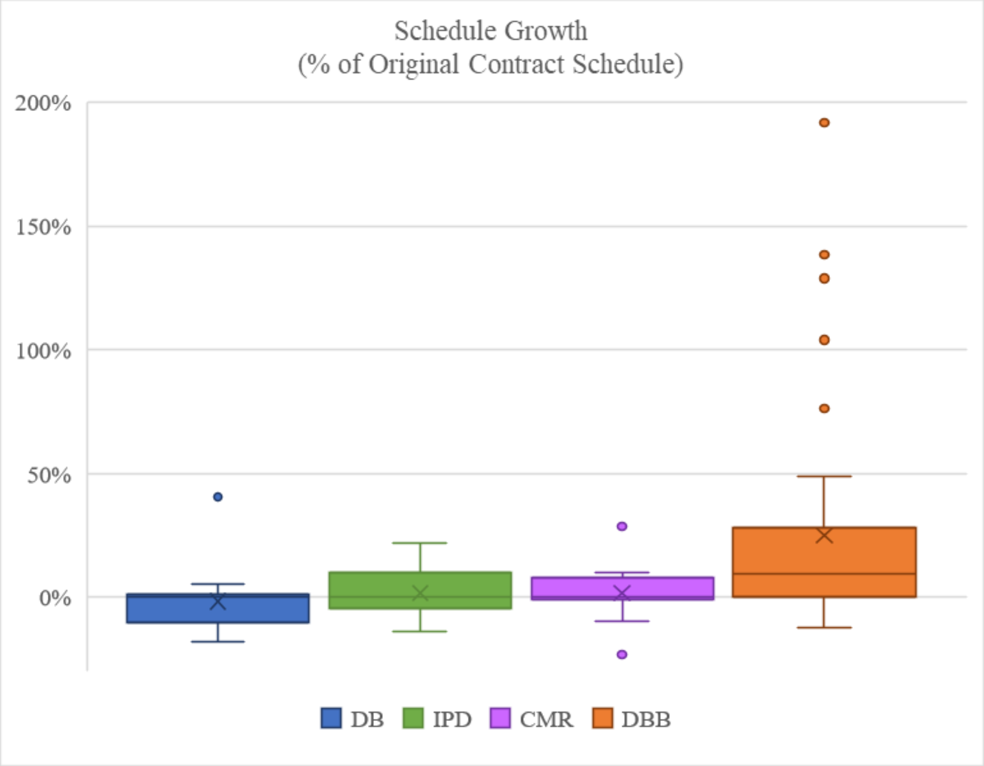

Figure 2 - Schedule Growth for non-Navy Project Data Set

In this data set, DBB is clearly inferior to the other delivery methods at controlling schedule. DB, IPD, and CMR are similar with medians around 0%. DBB has been removed in Figure 3 to allow a more detailed comparison of the remaining delivery systems.

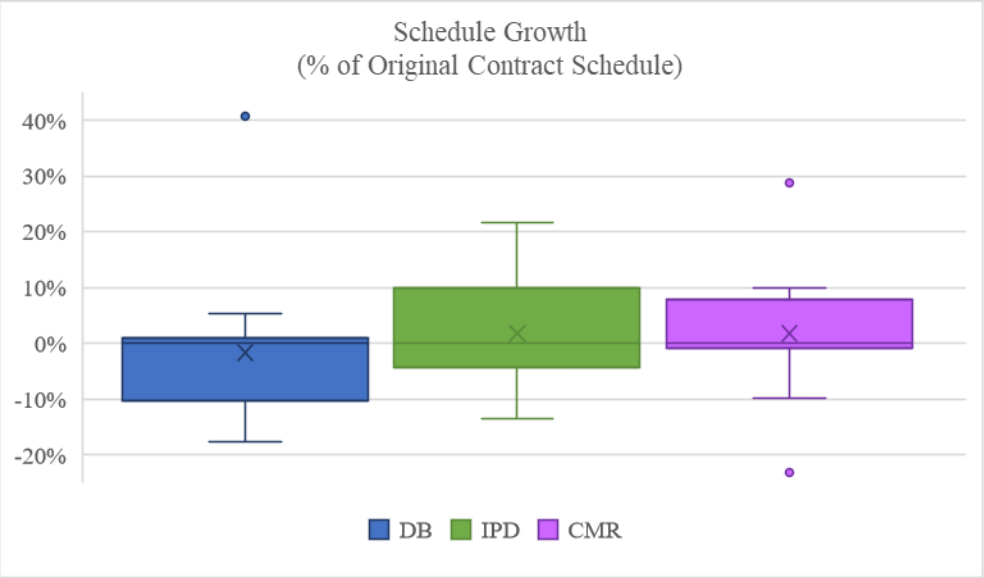

Figure 3 - Schedule Growth Comparison for DB, IPD, and CMR

As can be seen in Figure 3, the remaining delivery systems perform similarly at controlling schedule.

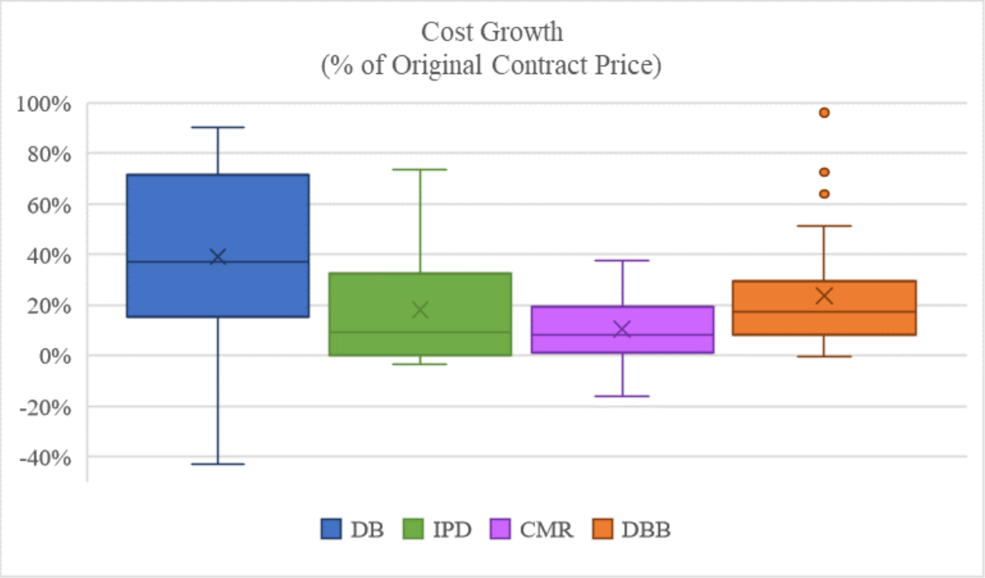

Figure 4 - Cost Growth for non-Navy Project Dataset

Figure 4 shows that IPD and CMR outperformed both DB and DBB in cost control for this dataset.

IPD and CMR have similar schedule performance scores to DB, and both are preferable to DB in cost performance. IPD and CMR were considered as potential alternatives to the Navy's traditional delivery methods.

Delivery Methods Analyzed and Excluded

Project data was available for 91 projects delivered using a Multiple-Prime delivery system, and 13 projects that used Construction Manager as Agent (CMA). These delivery methods were both excluded from consideration for this research.

Multiple-Prime (or Multi-Prime) Contracting is a delivery model in which the Owner directly contracts with more than one general contractor and/or hires specialty contractors. The Owner holds all the contracts, so the various contractors generally do not have contractual relationships with one another, and the Owner must take the lead on coordinating all work. Multi-Prime delivery places the responsibility for all coordination on the Owner, and without detailed pre-planning, can lead to significant cost and schedule overruns (Kuprenas & Rosson, 2000). Additionally, research by Labib and others has shown significantly lower project success rates with Multiple-Prime than with other delivery methods (Labib, Lotfallah, Hanna, & Boulos, 2021). For these reasons, Multiple-Prime was excluded from consideration.

In a Construction Manager as Agent (CMA) delivery model, the Owner hires a Construction Management firm to oversee a project in addition to the Designer and Builder (Hayes, 2014). The Construction Management firm is hired as a construction expert to act as the Owner's representative, but does not have a contractual relationship with the Designer or Builder (unlike in CMR where the CM contracts directly with those doing the work), so assumes no risk for actual construction costs (Hayes, 2014). While this model makes sense for an Owner who does not have the staff or expertise to oversee a project, NAVFAC has a robust staff of construction managers and contract specialists, so CMA was excluded from consideration.

Literature Review

Just as DB encourages more early collaboration between a project's Designer and Constructor, the goal of both IPD and CMR is to foster early project collaboration. In the case of CMR, that emphasis on collaboration is focused on bringing the constructor into the project early in the design phase (Gransberg & Gransberg, 2010). In this way, CMR encourages early coordination between Designer and Constructor to identify and address issues early in the design process, a benefit over traditional DBB, but not very different from the DB delivery method.

Indeed, the Literature Review found that DB outperformed CMR in most cases. Recent University of Wisconsin research concluded that DB outperformed CMR on 189 state-funded projects (Labib, Lotfallah, Hanna, & Boulos, 2021). A study of 212 projects distributed cross 35 of the 48 contiguous states concluded that "DB projects were delivered faster and with nominally lower cost and schedule growth than their CMR and DBB counterparts," confirming the results of a similar study from 1998 (Franz, Molenaar, & Roberts, 2020). And a research review of 30 studies, examining performance on 4,623 projects found that, while DB and CMR had similar cost growth number (+10.7 % and +10.2%, respectively), DB outperformed CMR in cost control, with an average of +2.8% Cost Growth to CMR's +5.8% (Sullivan, El Asmar, Chalhoub, & Obeid, 2017). CMR was also found to be inferior to IPD when a study comparing CMR and IPD projects directly found better team integration, increased BIM implementation, and higher rates of customer satisfaction in IPD projects than in those using CMR (Choi, Yun, Leite, & Mulva, 2019). CMR is not recommended as a potential alternative to DB project delivery.

The IPD model was developed in an attempt to improve project performance by encouraging collaboration beyond that which is common in DB or CMR. The key features of IPD models include early involvement of key participants, collaborative decision-making, and shared risks and rewards (Ling, Teo, Li, Zhang, & Ma, 2020).

IPD is a newer delivery system (Elmore, Ralls, & Catoe, 2013), but there is evidence the IPD outperforms DB in many cases. A 2013 study of 12 IPD projects and 23 comparable projects completed with traditional delivery systems found that, while IPD had similar cost and schedule performance to DB and DBB, IPD outperformed the traditional delivery methods in Construction Speed and Project Quality metrics (Asmar, Hanna, & Loh, 2013). A later study of 109 projects again found that IPD and DB had similar cost and schedule performance, but also found that IPD outperformed DB in overall project quality (Ibrahim, Hanna, & Kievet, 2020). IPD appears to have some advantages over DB, and may be a favorable delivery method.

Features of the Integrated Project Delivery Model

The IPD model has six key features (Asmar, Hanna, & Loh, 2013), and while some of the features cannot currently be used by public owners due to their procurement or competition regulations (Silberman, Kovars, & Steedman, 2014), elements of the IPD model can be selected and incorporated into traditional delivery systems to encourage increasing levels of collaboration (AGC of America, 2010). The six elements of IPD are discussed below with recommendations about how the Navy (and other public entities) may be able to incorporate them.

1. Multiparty Contract

A pure IPD project includes a multiparty agreement, joining the Owner, Designer, Constructor, and any other key participants in one contract, sometimes even creating a single purpose entity (The American Institute of Architects, 2007). The multiparty construct creates a legal relationship between all parties, and removes many of the communication and collaboration barriers that exist in a traditional contract structure (Ling, Teo, Li, Zhang, & Ma, 2020). One contract creates a “one team” mentality where all entities are trying to do what is best for the project rather than what is best for their own organization.

Multiparty Contracting is not common in federal acquisition, and may only be allowed when using Other Transaction Authority (OT). OT agreements do not generally have to comply with federal acquisition regulations, so can be used to create nontraditional contract relationships like multiparty agreements (Peters, 2019). Most OTs are granted to conduct research, develop prototypes, or for the production thereof (Peters, 2019). Even if an OT could be granted to conduct research into construction delivery methods, the ability to use true multiparty IPD would require an exception to federal procurement policy.

However, implementing IPD concepts and deep collaboration into future DB projects may lead to improved project performance without requiring exceptions to policy or changes to regulations.

2. Early Involvement of Key Participants

The IPD model encourages broad collaboration as early as possible with the goal of improving the design and construction process, and increasing the value to the owner and overall performance on the project (AGC of America, 2010). In addition to the owner, designer, and constructors, those who will use, operate, and maintain the building should be included, and key subcontractors must be brought in early to review, estimate, and make recommendations on the design (Spackman, 2021). This collaborative approach allows the use of Target Value Design (TVD), and Lean Construction principle where the design and estimating happen simultaneously, allowing the team to make decisions on tradeoffs in order to maintain the function of the building while staying on budget, and ultimately delivering better value to the owner (Macomber & Barberio, 2007).

NAVFAC commonly uses DB project delivery, which is well-suited to early involvement of key participants since the designer and builder are selected early in the project and have a stake in one another’s success (Spackman, 2021). The Navy also uses Collaboration Addenda on many construction projects. NAVFAC could develop an updated Collaboration Addendum to expand the group of key participants who are brought together early in the project, and TVD concepts could be incorporated into DB Requests for Proposals (RFPs) and project specifications.

3. Collaborative Decision-Making and Control

An important part of fostering a collaborative environment is treating all parties as equals in a collaborative decision-making environment (AGC of America, 2010). This collaborative approach to problem solving and project controls also corelates well with TVD, where planning and decision-making happen in a “Big Room” where all the interested parties can be co-located (Macomber & Barberio, 2007). Working together to identify and solve problems and to make decisions as a team helps foster a sense of ownership and commitment to the success of the project.

Incorporating Collaborative Decision-Making could also be addressed in an updated Collaboration Addendum, but will also require a change in philosophy, both for contractors and for NAVFAC employees. NAVFAC Design and Construction Managers must coordinate closely with future building occupants, operators, and maintainers to ensure they are a regular part of design and construction progress meetings and reviews. All parties must commit to the success of the project and the eventual facility, and be open and honest about problems, challenges, or when help is needed (The American Institute of Architects, 2007).

4. Shared Risks and Rewards

In order to prevent project parties from focusing on maximizing their own reward at the expense of the project, IPD contracts tie compensation to overall project success (Ling, Teo, Li, Zhang, & Ma, 2020). IPD projects may use a Guaranteed Maximum Price (GMP) with contractors' profits at risk, or cost-plus incentive fees with incentives tied to project success (AGC of America, 2010). When a project is completed under budget, the reward is shared between all the parties in the form of additional contractor profit and funds returned to the owner; but profits can be reduced or eliminated completely if a project goes over budget, developing a strong incentive for all parties on the project to control costs and identify and solve problems (Ling, Teo, Li, Zhang, & Ma, 2020). In the profits-at-risk model, each contractor shares their full cost data with the group and submits to an overhead audit, the review and oversight of which can increase the administrative burden on the owner's representative (Huggett, 2021).

Fixed-price incentive (firm target) contracts operate very much like GMP, with a target cost, target profit, price ceiling, and profit adjustment formula (FAR 16.403-1(a), 2019) Federal Acquisition Regulation (FAR) 36.207 states that, "Generally, firm-fixed-price contracts shall be used to acquire construction." However, FAR 16.403-1(b) clarifies that, "A fixed-price incentive (firm target) contract is appropriate when the parties can negotiate at the outset a firm target cost, target profit, and profit adjustment formula that will provide a fair and reasonable incentive and ceiling that provides for the contractor to assume an appropriate share of the risk." With sufficient pre-solicitation planning and value discussion, good target costs and profits may be established, and used with TVD to provide better assurance that the target costs could be met, and allow collaborative decision-making for any required trade-offs.

5. Liability Waivers among Key Components

IPD depends on direct, continuous communication between all interested parties, a type of communication often discouraged on traditional project due to concerns it could induce liability (Ling, Teo, Li, Zhang, & Ma, 2020). Multiparty IPD projects often include liability waivers between the interested parties to reduce concern about liability arising from the open communication channels (Ling, Teo, Li, Zhang, & Ma, 2020).

If contractors are hesitant to have open communications and share their detailed cost data with NAVFAC personnel or other partners, liability waiver information may be included in base contract language.

6. Jointly Developed Project Goals

In addition to collaborative design and decision-making, IPD also encourages commitment to the project by having all parties participate in setting project goals. The team develops specific, achievable objectives as a group, soliciting input from all participants, and encouraging ownership of the goals (Ling, Teo, Li, Zhang, & Ma, 2020).

Joint goal development at the start of a project could be incorporated through a revised Collaboration Addendum, or by simply adding it to the Post-Award Kickoff (PAK) Meeting agenda. This is a simple change that would require little administrative burden, but could improve project collaboration and communication between the various key participants.

IPD in Publicly-Funded Projects

Procurement and competition generally preclude public organizations in the US from using multiparty contracting (Silberman, Kovars, & Steedman, 2014). Some organizations are also hesitant to incorporate IPD due to concerns over sharing profits and overruns with contractors, or due to internal resistance to change (Kim, Rezqallah, Lee, & Angeley, 2016). For public organizations who are unable or unwilling to implement full multiparty agreement IPD, it is common to incorporate some IPD elements into a more traditional contracting structure, a method known as “IPD-ish” or “IPD-lite” (Franz & Leicht, 2012). In addition to collaboration addenda, public entities can create an “IPD-ish” construct by including intent to use IPD in the RFP, and by adding IPD collaboration components to the project specifications (Kim, Rezqallah, Lee, & Angeley, 2016).

Penn State’s Office of Physical Plant (OPP) oversees design and construction of all Penn State campus facilities (Penn State University, 2021). Publicly-funded projects are subject to state procurement regulations which preclude multiparty agreements, but some projects overseen by OPP are privately-funded, and are not bound by the same regulations (Spackman, 2021). OPP collaborated with researchers in 2011 to examine the benefits of implementing IPD elements through collaboration addenda (Franz & Leicht, 2012), and went on to complete a full, multiparty IPD project with the privately-funded Agricultural Engineering Building Renewal in 2015 (Davis, Brown, & Spackman, 2016). Key elements of the project were: early engagement of constructor, specialty subs, and building operators; TVD with continuous cost estimating; and the Big Room concept, where all parties worked together in one large room to foster collaboration (Spackman, 2021). The project was considered extremely successful by the project team and the facility users and operators, leading the OPP to expand their use of IPD elements in publicly-funded projects (Spackman, 2021).

Construction Management with IPD

Due to the collaborative nature of IPD, the requirements for an owner’s construction manager are different from those required in DB and DBB. In addition to understanding the plans and specs, the owner’s construction manager must be willing to find solutions beneficial to both contractors and the owner, and must serve as a liaison between future building users and operators, project sponsors, and the construction team (Huggett, 2021). Construction managers, contractors, and owners unfamiliar with IPD will need training in IPD methods to be effective (Spackman, 2021), and completing ongoing IPD training throughout the project ensures the collaborative culture is understood and supported, and that processes are executed (Huggett, 2021).

Recommendations

Full implementation of IPD on NAVFAC projects would require a policy change or exception to allow multiparty agreements in construction contracting. New multiparty contract solicitation, award, and administration documents would need to be developed, and processes would need to be established for monitoring contractors’ cost data in order to set and determine profit.

However, four of the six key features of an IPD project can be implemented into NAVFAC’s current DB delivery model. Select a group of experienced key NAVFAC personnel, train them on IPD principles and methods, work with the group to update contract documents and project procedures to incorporate IPD elements, and then try them on a small number of new projects. It would be preferable to work with a contractor who has IPD experience, so IPD project history should be included as an element of the RFP.

DB construction contracts are compatible with many IPD principles. Early Involvement of Key Participants already happens between the designer and contractor. Expand the list of Key Participants to meet IPD collaboration goals through adjustments to the Collaboration Addenda or other contract documents. Include key subcontractors, and building users, operators, and/or maintainers who should be brought in early in the process to provide input early in the design phase.

Jointly Developed Project Goals may be incorporated directly into NAVFAC's current delivery model. While this goal-setting could be completed as part of the PAK meeting, Establish a separate session with all the key participants. This meeting could happen two weeks after the PAK, giving the key participants time to become familiar with the basics of the project. In a Lump Sum DB contract, it may not be practical to discuss cost goals, but a detailed review of delivery dates should be conducted, and intermediate schedule milestones should be identified, discussed, and agreed on. Quality and suitability of purpose goals should be established, and interference with other projects, work spaces, roads, etc. should be identified, discussed, and confirmed by all key participants. Once established, these goals should be revisited and updated regularly throughout the project.

Encouraging collaboration through early involvement and project goals are simple, but may not encourage the kind of collaboration necessary for a successful IPD or "IPD-lite" project. Collaborative Decision-making and Shared Risks and Rewards provide significant incentives for real collaboration, but require more adjustments to NAVFAC's current model. High levels of collaboration could be encouraged by awarding construction contracts on a fixed-price incentive (firm target) [FPI(F)] basis with a contractual requirement to use TVD. Similar to the GMP model used on many private projects, FPI(F) contracts establish a target cost, target profit, a price ceiling (like GMP), and a profit adjustment formula. The FPI(F) structure provide financial collaboration and performance incentive to the contractor in the form of increased profits for cost savings, and decreased profits for cost growth. Used with early involvement of key participants, collaborative decision-making can happen throughout the design and construction process to identify and discuss issues and solutions, make collaborative trade-off decisions, and control project cost beginning in the design phase. Target cost, profit, and price ceiling are generally established during the design phase, so procurement competition may have to be purely on non-cost items. Conduct a proof-of-concept procurement on one or more low-risk construction project(s) using FPI(F) and TVD. DB contractor selection criteria must include experience with both TVD and project awarded with GMP.

Conclusion

Analysis of recent NAVFAC construction projects shows that DB outperforms DBB in cost control and limiting project changes. DBB had a 40% higher median cost growth and over four times as many median changes per million dollars. There is not a significant difference between DB and DBB in controlling schedule. Schedule growth is highly dependent on project complexity with the most complex projects projected to suffer nearly twice as much schedule growth as other projects, but low complexity projects are predicted to have slightly higher schedule growth than simple projects. NAVFAC construction managers can use the projected schedule model to predict actual project timeline from information available at the beginning of a project. This information may be used to set and manage realistic customer expectations.

Full implementation of IPD on NAVFAC projects would require a policy change or exception to allow multiparty agreements in construction contracting. However, many of the benefits of IPD can be incorporated into the current DB model. IPD elements that could be incorporated in the near term include setting collaborative goals and expansion of the key participants brought into the process early. Awarding an FPI(F) construction contract with a TVD requirement would establish shared risk and rewards, and ensure collaborative decision-making, but would require changes to established procedures to compete a project on non-cost factors, and accurately and fairly set target cost, profit, and ceiling price. If these elements can be implemented into the current NAVFAC DB project delivery, then multiparty agreements may not be necessary to see real improvement in collaboration and project performance.

Future Research

Lean Construction (LC) and IPD are closely related with lean delivery methods driving the push for collaboration in IPD projects (Ahmed & El-Sayegh, 2021). The multiparty agreements that play a key role in a pure IPD project, are heavily influenced by LC principles (Becker, Shane, & Jalselskis, 2012), and the TVD used in IPD projects is an LC concept (Macomber & Barberio, 2007). Spackman (2021) believes that learning LC principles and incorporating them into Penn State's IPD Agricultural Engineering Building Renewal was critical to the project's success. Since Lean Construction is not a delivery method, in-depth analysis was beyond the scope of this research. Future research could consider incorporating Lean Construction principles and techniques directly into NAVFAC construction project delivery methods.

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