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The Development of the Performance Based Procurement System (PBPS)

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The Performance-Based Studies Research Group (PBSRG) at the Del E. Webb School of Construction has developed a methodology to reduce facility system life-cycle cost. The methodology reshapes the current construction industry model from a "low-bid" industry, in which facility owners assume that all bidding contractors performs at the same level, into a value added performance-based industry in which facility owners make purchase decisions based on actual contractor/system performance data as well as bid price. The new information-regulated industry changes roles and partnerships between the construction industry and facility owners and facilitates an environment in which performing contractors are rewarded and contractors can continuously improve. The research group is concern with the identification of performance levels in the industrial sector, the design of a performance-based structure for manufacturers and contractors in the commercial sector, and the education of the construction industry. The PBSRG research efforts ($ 1,200K, 1994-present) includes the design and improvement of the Performance-Based Procurement System (PBPS); performance data collection on general, mechanical, and electrical contractors; landscaping and janitorial services; and design services in the public and private commercial sectors.

Key Words: Performance Based Procurement System (PBPS), Design-Build, Displaced Ideal Model, Low-Bid construction delivery system.

Introduction

The Performance-Based Studies Research Group (PBSRG) at the Del E. Webb School of Construction has developed a methodology to reduce facility system life-cycle cost. The methodology reshapes the current construction industry model from a "low-bid" industry, in which facility owners assume that all bidding contractors performs at the same level, into a value added performance-based industry in which facility owners make purchase decisions based on actual contractor/system performance data as well as bid price. The new information-regulated industry changes roles and partnerships between the construction industry and facility owners and facilitates an environment in which performing contractors are rewarded and contractors can continuously improve. The research group is concern with the identification of performance levels in the industrial sector, the design of a performance-based structure for manufacturers and contractors in the commercial sector, and the education of the construction industry. The PBSRG research efforts ($ 1,200K, 1994-present) includes the design and improvement of the Performance-Based Procurement System (PBPS); performance data collection on general, mechanical, and electrical contractors; landscaping and janitorial services; and design services in the public and private commercial sectors.

The Development of the Performance-Based Procurement System

Background

Performance information on roofing systems has been collected and analyzed since 1983 (Kashiwagi, 1991), leading to the following definitions:

1. *Performance* is "the value and level of service provided to meet the requirement of the end user as defined by the end user" (Kashiwagi, 1996a).
2. *Performance information* is "data that assists in differentiating and assigning value to contractors, facility systems or product performance in relation to the end user's requirements" (Kashiwagi, 1996b).
3. *Non-informational data* are numbers or explanations that do not assist in assigning the relative value of performance.

Non-informational data can be found where the following exist:

1. Alternatives (contractors, suppliers, materials) are perceived as "all the same." This is a major assumption of the predominate specification and competitive low-bid award delivery system. When a contract is awarded on price alone, the facility owner assumes that all the bidders will perform at the same level, and the only differentiating factor among the bidders is their price.
2. Environments with a multitude of factors or combination of factors that govern performance. This situation makes it very difficult to identify performance information using the stochastic or probabilistic analysis approach.
3. Environments in which the training of personnel is difficult to justify. It is a need but not a requirement; facility owners would like contractors to train their personnel but are not willing to pay the extra cost for doing so. Thus, skill levels degrade over time, risk is high, and profits are low (all manifestations of the construction industry) (Kashiwagi, 1995a, Spratt, 1996).
4. Proliferation of rules and regulations, specifications, and standards. These tools are an attempt to reduce risk because all the construction options "look the same."
5. Environments in which experts, lawyers, and sales people are found in great numbers. Litigation is a manifestation of confusion and a lack of communication.
6. Environments in which research is difficult to finance, conduct, and implement.

Construction Industry Structure

The construction industry is sectored by two major constraints, competition and performance (Figure 1.). The greater the competition, the lower the price (quadrant I in Figure 1); the greater the performance, the higher the price (quadrant III in Figure 1).

To manage the two constraints, the construction industry has divided into four segments: the low-bid sector (quadrant I); the negotiated bid sector (quadrant III); the performance sector

(quadrant II); and an stable sector characterized by low competition and low performance (quadrant IV).

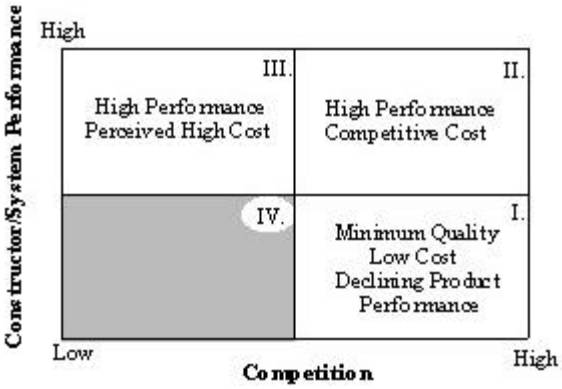

Figure 1. Construction industry structure (Kashiwagi, 1996)

The Low-bid Arena

The low-bid sector (quadrant I in Figure 1) has the following characteristics:

1. Specifications are issued by facility owners and their representatives.
2. Bidders, or "alternatives," are considered "all-the-same." Thus, facility owners cannot give credit to higher performing options.
3. The project is awarded to the lowest price alternative that is perceived to meet the minimum level of the specification.
4. Lack of incentive for contractors to continuously improve and provide higher performing facility systems.
5. The risk of constructed systems not meeting expectations is high due to the emphasis on meeting minimum requirements at the lowest possible cost.
6. A lack of entry/exit barriers, leading to a proliferation of "low cost" contractors, material, product, and services.
7. Marketing (promotion, sales, advertisements) becomes the differentiator. Marketing uses non-informational data that may confuse owners as to the difference between performance and marketing data.
8. The size of the contractor becomes more important than the profit of the contractor (the only differentiator becomes a lower price that is due to high volume). Success is measured in terms of size and not profitability.
9. Work is centered on non-informational data that is generated by the manufacturer's sales and marketing groups. A verification of this concept is the realization that there exists, except for the information collected by the Performance-Based Studies Research Group (PBSRG) at the Del E. Webb School of Construction, no performance information that differentiates the performance of a facility or facility systems by constructors of different skills levels.
10. The amount of regulations, specifications, standards, and data increases but does not differentiate performance.

Standards proliferate in the low-bid arena. Standards usually allow the majority of manufacturers and contractors to operate, resulting in an "all-the-same" environment that encourage minimal performance. When all the participants meet the standard, the standard has no value in differentiating the contractors/systems.

The Negotiated Bid Arena

Facility owners attempt to reduce risk by limiting competition in the negotiated bid sector. Facility owners award projects by "best value" and negotiation. However, the relative worth of the selected alternative is difficult to identify due to a lack of performance information and a lack of competition. The worldwide competitive marketplace's influence to reduce costs may lead to the perception by facility owners that they are paying "too much." Facility managers are pressured to lower costs by using more competition. More competition may bring lower quality. In this arena the following problems exist:

1. How does the facility owner maintain performance but yet get a more competitive price?
2. How does the owner identify a "fair" price for a performing service?
3. How does the facility owner motivate the constructor to continuously improve?

Performance-Based Sector

The performance or information based sector must have all five of the characteristics of a stable industry. The conflict between full and open competition and entry/exit barriers must be overcome. Performance information and the Performance-Based Procurement System (PBPS) fulfill all five requirements. Taking advantage of computer technology to store huge amounts of data and process the data into information by mimicking the human mind, the PBPS and the resulting performance information have increased the level of competition and performance of constructors in the commercial roofing sector of the construction industry. The performance-based sector is defined by the Information Theory (IT) developed at the PBSRG (Kashiwagi, 1996b). The theory includes:

1. A construction manufacturer or contractor is constrained by unique characteristics that limit his/her rate of improvement and information application. No two contractors can perform at the exact same level.
2. Participants must use performance information to maximize continuous improvement. A contractor cannot improve unless he/she first knows what his/her performance is relative to others in the industry.
3. Performance information has to be shared with competitors and end users.

Construction Industry Stability

Porter (1985) and Kashiwagi (1991) define a stable industry as an industry that can continually provide a performing product regardless of demand and is continuously improving the industry

performance. The following characteristics are necessary for the creation of a stable industry (Kashiwagi, 1991).

1. Differentiation by performance.
2. A fair profit to participants.
3. Full and open competition.
4. Buyer protection (reduction of risk).
5. Entry/Exit barriers (prequalification and specification).

Factors 3 and 5 are in conflict. The conflict is also seen in Figure 1, as facility managers who limit competition to increase performance are also pressured to increase competition to reduce cost.

1. Construction participants can utilize performance information to:
2. Design company structure and operations.
3. Design strategic plan.
4. Cause continuous improvement.
5. Identify markets of opportunity.
6. Select partners in the value chain to provide performance to the end-users.

Facility managers can use performance information to:

1. Procure the best option.
2. Outsource all facility services and systems while maintaining total control.
3. Reduce facility management requirements (design, inspection, renovation, and maintenance).

Construction Delivery System

The construction industry presently uses three delivery systems, the conventional, the design-build, and performance-based procurement, to deliver its product.

Conventional Delivery System

The most conventional delivery system for construction systems is shown in Figure 2.

Several factors create problems in the conventional delivery process.

1. Lack of communication between facility owner, designer, constructor, and inspector creates an inability for each to understand the other's problems that are due to different perceptions.
2. Lack of incentive to increase performance of the construction process. Current performance incentives have no correlation with relative performance that is usually oriented toward one contractor's performance under "unique conditions," finishing early (relative to some engineer's estimate) or within budget.

3. A secondary inspection (a duplication of the contractor's inspection) is performed by the facility owner's representative after the construction is completed. The representative has less expertise in construction, has no impact on the continuous improvement of the contractor's skill level, and is in an adversarial role. The initial inspection performed by the constructor may lose its effectiveness or not be conducted at all.

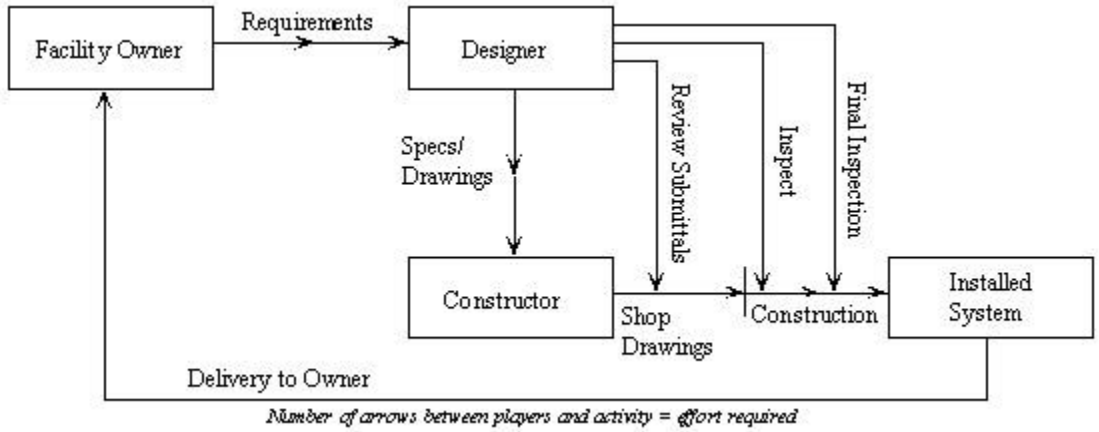

Figure 2. Conventional delivery process

Design-Build Delivery System

A delivery system that is gaining in popularity in the construction industry is the Design-Build process shown in Figure 3.

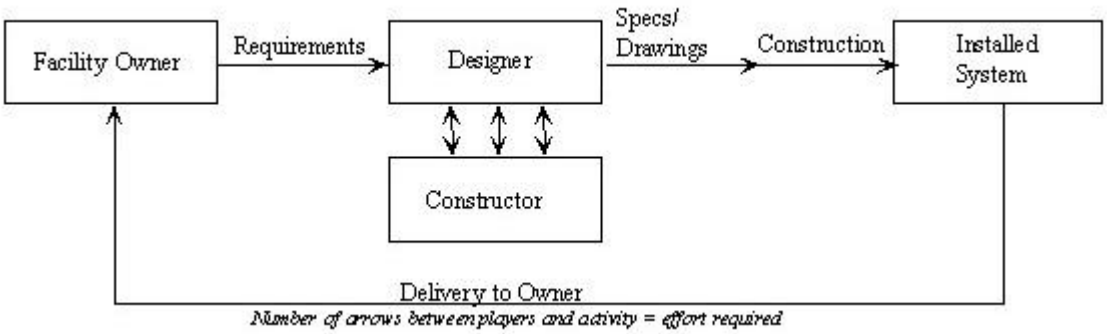

Figure 3. Design-Build model.

Communication problems are reduced in the design-build process because the number of communication links is reduced. Liability, responsibility, and problem solving lie one entity, the design-build constructor. The following questions exist with the design-build delivery system:

1. What is the value of the design-build effort, or exactly what is the quality of the constructed facility system? (This consideration limits trust and communication with the owner.)
2. How does the design-build team determinate the right level of performance and continuous improvement to maximize the facility owner's perception?

Performance-Based Delivery System

The Performance Information structure delivery system identifies the facility owner's perception of performance and matches that perception with the best available contractor and designers (using performance information). The facility owners uses the following types of contractor/designer/ performance information to make his selection:

1. Expertise and experience.
2. Price.
3. Contractor margins, financial stability, and payment of subcontractors.
4. Previous size of jobs.
5. Previous types of jobs.
6. Completion rates on time and below budget.
7. Performance of previously constructed facilities or facility systems.
8. Personnel proposed for construction management.

The facility owner determines the requirement in terms of the relative worth of performance criteria and then uses the performance information to select the constructor and designers that who match the owner's perception of performance. The facility owner becomes a player on the teams of the constructor's, the constructor, and designer. Each party adds information (instead of data) based on their experience. The system is shown in Figure 4.

Performance information brings trust between parties. The more information, the less distrust. It allows all parties to understand who and what all other parties bring to the partnership including positive and negative characteristics. The information system brings about partnerships of facility owners, constructors, and designers with common understandings of the objectives and limitations of the projects. The partnership uses the performance information to select systems, improve construction performance, and determine the price and worth of the construction and design efforts. The number of communications is reduced and tasks are streamlined due to a full understanding and availability of information between partners. The information system helps the design and construction components to continuously improve.

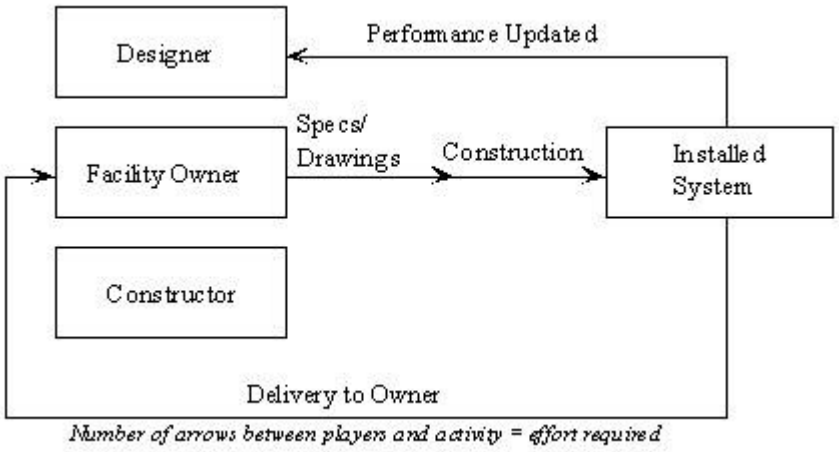

Figure 4. Performance-Based delivery model

Performance Based Procurement System

The Performance Based Procurement System (PBPS) is the centerpiece of the new construction environment. It collects information, it gives relative "worth" of different systems under different conditions, and selects the best performing contractor. The process of the PBPS is shown in Figure 5.

The decision making model is a "modified" relative distancing model of the "Displaced Ideal Model," (Zeleny, 1982) which uses the natural log function to measure information. The model's math was modified by Kashiwagi in 1995 to give more accurate information. The use of the model in the PBPS makes the following assumptions (Kashiwagi, 1996b).

1. All factors are related. There are no factors that do not have an impact on every other factor. Therefore, the problem of dependency is eliminated, and no effort is wasted on determining the impact of dependency or ensuring that the criteria are independent.
2. Everything is relative and every decision maker has a different perception of performance.
3. Performance is defined by available options as well as end user requirements. These two are dependent. All models that separate the two do not meet the requirements of a performance-based decision making tool in the procurement of construction systems (such as Analytic Hierarchy Process, also known as AHP).
4. The decision maker defines the performance requirement in his/her own terms. The model must be able to easily match the facility owner's prioritization with relative choices.

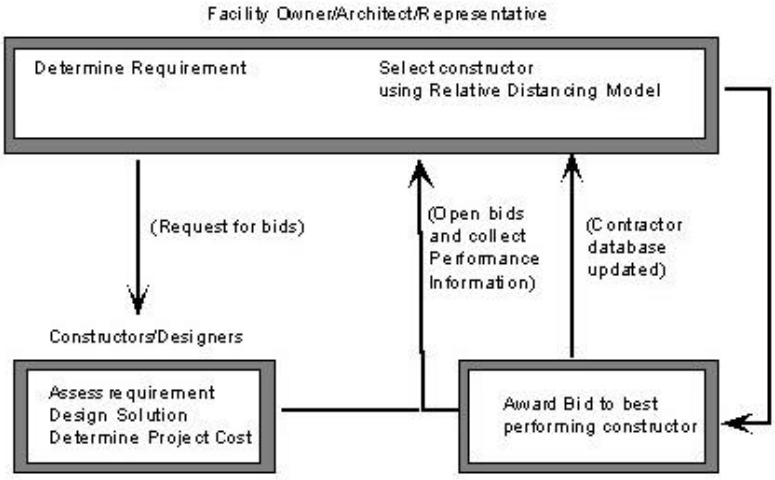

Figure 5. Performance-Based procurement process.

All information exists (Kashiwagi, 1996a). The problem in acquiring the information is the ability to perceive the information. The PBPS provides a tool for individuals to collect and analyze performance information to make intelligent decisions. Facility owners, including Motorola, Honeywell, IBM, McDonnell Douglas, Phelps Dodge, the State of Wyoming, the USA Army Medical Command, and the Fresno Unified School District, have participated in refining the PBPS. The Federal Aviation Administration Western Region will be the first United States

Federal Agency to implement the PBPS in the regular contracting format. They will be the first entity (public or private) to use the system to select a general contractor on complex construction projects.

Requirements of the Performance-Based Information Environment

The following are requirements of the information requirement:

1. The technology to process data into information. The technology must have the capability to handle a changing database without requiring redesign of the technology. This eliminates systems that have a set order of options and decision processes.
2. Performance information databases that are shared between facility owners, constructors, and designers.
3. Education of the construction industry participants.

The PBSRG at Arizona State University has adopted the above objectives. Started in 1994, the PBSRG has performed and planned research (over $1200K) to meet the above objectives. The long-term objective is to construct a performance-based construction sector regulated entirely by performance information (and not minimum standards). This environment would have the following advantages:

1. Eliminate all non-value added construction/design activities and functions.
2. Identify performing facilities systems that leads to a reduction of risk.
3. Allow total competition (prequalification in the same step using performance information) and allow performing constructors to receive a fair profit.
4. Motivate constructors to continuously improve.

The PBSRG has tested the PBPS twenty-five times in the public and private sector to purchase roofing systems, janitorial and landscaping services, and copy machine service. Performance information databases are currently being compiled for general, electrical, mechanical, roofing, and JOC contractors and systems. It has also been used to quantify the performance of roofing designers and will be used to quantify the performance of architects and engineers. The PBPS has also been tested by procuring five years of copy machine service for the State of Wyoming through one vendor (or joint venture group). In 1996 the State of Wyoming copy machine service had the following problems, which are shared by the construction industry and which led the State to seek the help of PBPS.

1. Many different vendors with different machines, different prices, different services.
2. An unclear objective of the highest possible level of performance at the best price.
3. The potential joint venturing of contractors who did not known each other before the bid opening.
4. The option for contractors to bid a part of the job, instead of the entire job.
5. The procurement of a “level of service” rather than the “installed system.”

Organizations that have used the PBPS system report satisfaction with the value received.

Future Research and Recommendations

The PBSRG is undertaking a project to design a performance-based structure for a major manufacturer of a facility system that includes the following areas:

1. Re-education of personnel.
2. Restructuring the company's marketing, organizations, and information system based on performance theory.
3. Designing the interface between contractors, facility owners, and manufacturers based on performance theory.
4. Identifying performing facility owners.

The PBSRG is also working with design consultants to transform their services from being centered around manufacturer generated "data" to performance information. Performance information and theory are also being used to redefine construction industry segment structure.

The PBSRG's five major objectives of 1997 include:

1. Complete the performance-based structure for a major manufacturing company of construction materials that will give the manufacturer the competitive advantage based on performance.
2. Implement and document the PBPS for the US Federal government.
3. Implement the performance environment on an industrial plan application.
4. Form a complex database for a complex construction craft, which can be used by the craft to design a strategic plan, drive training requirements, and educate end users on the cost of performance.
5. Implement the PBPS on general construction.

The following are the author's recommendations for the industry:

1. Move from an industry regulated by standards to one regulated by performance information. Reduce the number of standards.
2. Increase performance information databases.
3. Move from data based, problematic research to information based research.
4. Reduce the number of non-value added activities and participants in construction.
5. Reduce marketing efforts of construction manufacturers and contractors and use the funding to improve construction performance.
6. Move from rule based expert systems, which cannot be easily applied to different cases, to "AI rule generation" tools that are flexible and transform data into information.

References

Deming, E.W. (1985). *Out of the Crisis*. Cambridge, Massachusetts: Massachusetts Institute of Technology.

Kashiwagi, D. T., Anderson, J., & Sharmani, Z. A. (1997). *Job Order Contracting Performance.* Tempe, Arizona: Arizona State University.

Kashiwagi, D. T. (1996). *Advanced Procurement Systems.* Unpublished graduate class notes, Arizona State University, Tempe, Arizona.

Kashiwagi, D. T., & Ryan, S. (1995). *Arizona Construction Industry Performance.* Tempe, Arizona: Arizona State University.

Kashiwagi, D. T. (1991). *Development of a Performance Based Design/Procurement System for Nonstructural Facility Systems.* Tempe, Arizona: Arizona State University.

Porter, M. (1985). *Competitive Advantage*. New York: Macmillan.

Zeleny, M. (1982). *Multiple Criteria Decision Making.* New York: McGraw Hill.