‘JUST IN TIME’ INFORMATION FOR PERFORMANCE BASED SYSTEMS

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One of the major problems in implementing performance contracting is the identification of selection performance criteria and the enormity of the amount of performance information required to guarantee performance. Every construction project has unique requirements. To have an efficient information system, the amount of information required to minimize risk makes a performance contracting process seen uneconomical in terms of cost and time. This research proposes that a “Just-in-time” approach to information that has been very successful in the manufacturing supply chain area can be used in construction performance based contracting. In conjunction with the concepts of information measurement theory (IMT), where the information system minimizes the amount of data, where the data is refined instead of the processor, and where decisions are minimized and used to delegate responsibility, the “just in time” concept would minimize the need for complex modeling, excessive information gathering, and decision making and minimum standards. The research uses the results of over 300 tests of the Performance Information Procurement System (PIPS) to support the theoretical hypothesis of “Just-in-time” Information. The research proposes that the concepts of performance information may be more effective than complex modeling and extensive database systems in minimizing risk and producing performing construction.

Keywords: just in time information, best value procurement, construction performance information, information management.

INTRODUCTION

There is a movement from the design, bid, build to best value (price and performance) procurement. Low-bid procurement has not been successful in minimizing the risk of nonperformance (not on time, not on budget, and not meeting the quality expectations of the owners). The purpose of information is to predict the future outcome or to minimize the uncertainty of the event outcome, or to minimize risk. Performance information can include past performance data and the ability to quantify and minimize risk in a future event. There is very little documentation on the impact of the use of performance information in the procurement of construction on the minimization of risk in construction procurement. There are many possible reasons for the performance information not being able to minimize the construction risk. They include: inability to get sufficient information, the high risk of the project caused by unique requirements, the inability to process the information to compare value and minimization of risk, the inability of the procurement process due to time and financial constraints, and the adversarial position of the parties due to different perceptions of the risk, and ability to minimize risk.

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Information Measurement Theory
Information Measurement Theory (IMT) was developed in the early 1990s to minimize risk by the measurement of relative data to predict the future outcome (Kashiwagi 2002). Using the deductive logic that every condition (at a unique time and location) is impacted by the previous condition at the same location, IMT states the both conditions can be identified by characteristics with relative measurements. The difference between the two conditions or states, could then be measured by the difference in the values of the characteristics. The change of the value of the characteristics can be predicted by the use of laws, which define the cause and effect relationship of current and future states. IMT correlates the ability of an entity to perceive information to the ability to minimize risk. Different alternatives with different performance values at one state can be compared to identify which alternative will perform to certain requirements at a future state. IMT states that perceptive entities feel very comfortable and are very successful and competitive in environments with a high level of information. These concepts lead to the following components of an information environment:

- *Requirement of performance.* If performance (on-time, on-budget, meet quality expectations) is the requirement, information will minimize risk.
- *Environment of high information.* If performance is defined by the minimizing of risk or being on-time, on-budget, and meeting quality expectations, a high information environment will identify performing contractors.
- *Minimized subjective controls and decision-making.* The higher degree of information in an environment, the fewer subjective controls are needed.
- *Minimized management of information.* There is a requirement for a philosophy that will minimize the management of information. Information must not become an obstacle or burden to performance.
- *Minimize management's physical functions.* The lower the level of information, the higher the requirement of management to minimize the risk.

Deming (1982) states that performance in production will result from the following:

- End practice of awarding based on the low-bid and awarding to poorly qualified (not using performance information).
- Break down barriers and have continuous improvement.
- Eliminate standards and cease dependence on inspection to achieve quality (minimize inspection and management).
- Institute leadership (allow performing people to perform rather than controlling).

An information environment requires performance information. It requires information workers to process the information. Information like material inventory takes resources to manage. To implement an information environment in the construction industry, the cost of managing the performance information and managing the process must be minimized.

JUST IN TIME PRINCIPLES

The principles of Just in time (JIT) was developed by Taiichi Ohno and Eiji Toyoda at Toyota by the early 1960s (Womack 1990, Ohno 1988). The principles included:

- Unifying the entire production team, suppliers, and distributors of into one team.
- Delivering components to the line only as needed.

- The minimized inventory forced every part of the team to understand their job (leading to efficient performance), and minimize the risk of shutting the entire system down.
- Allowing each component to do their function in relation to the performance of the production line. Every component knew how their performance was measured.
- Making sure the user was connected to the production process and that the user's requirements were met.

Just in time manufacturing minimizes inventory and waste, cycle times, and response time to changing environments in the manufacturing industry. Just in time means to use the minimum amount, with the minimum effort, at the right time. "Just in time (JIT) manufacturing is a system of enforced problem solving. Managers have a choice between putting a huge effort in finding and solving causes of production problems, or learning to live with an intolerable level of interruptions in production" (Henderson 2002).

This JIT or lean manufacturing process has the following philosophy:

- Customers get performance when they want it.
- The system always improves (continuous improvement).
- Customers are the reason for the process.
- All buffers of serving the customer are minimized.
- Improving performance of the process is a career.

The JIT system needs to:

- Identify performance in customer's language.
- All components of the process center around customer's need for performance.
- All suppliers should be aligned to what the customer wants.
- Minimize activities that do not increase the performance of the system.
- Establish performance measures in all parts of the process in terms of the customer.

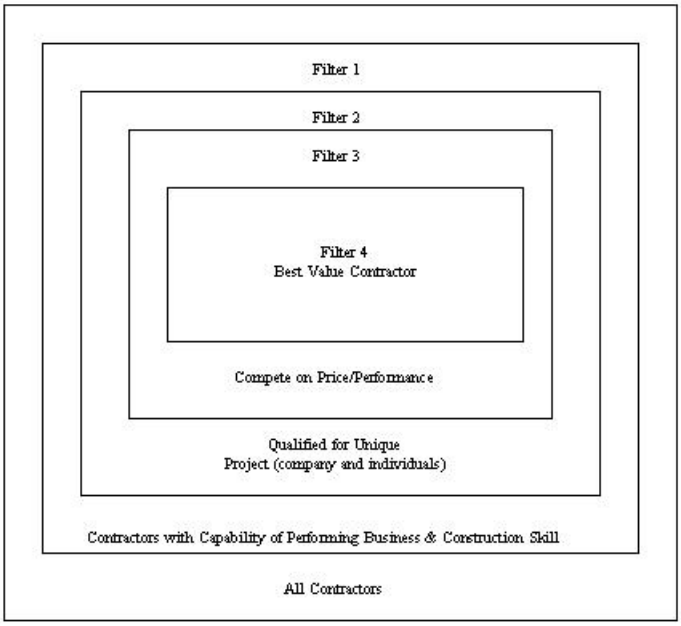
The construction delivery process has similarities to a manufacturing environment. Inventory and material can be compared to information. There is the potential of too much information, which cannot be managed, information that does not increase the performance to the user. The authors will first identify a process that optimizes the delivery of construction. Each step in the process will be defined in terms of the requirement and need of information.

CONSTRUCTION PROCUREMENT PROCESS

The objective of the process is to procure best value performing construction. The process must prevent the following from getting an award:

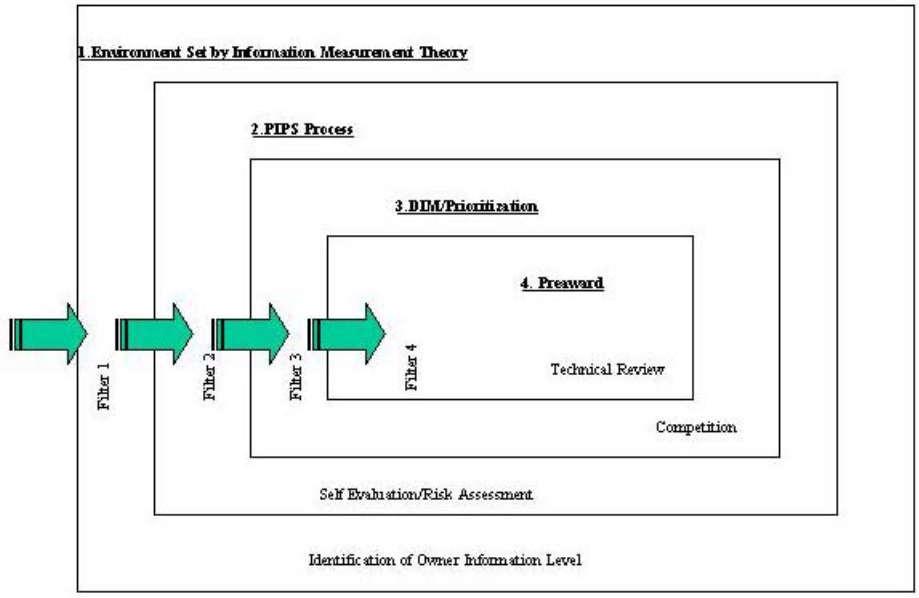
- Contractors with poor business practices that result in nonperformance. Poor business practices is a major reason for construction failure. (Schleifer 1994).
- Unqualified craftspeople that require more management being assigned to the project (Post 2001).
- Contractors who need to be managed and directed.

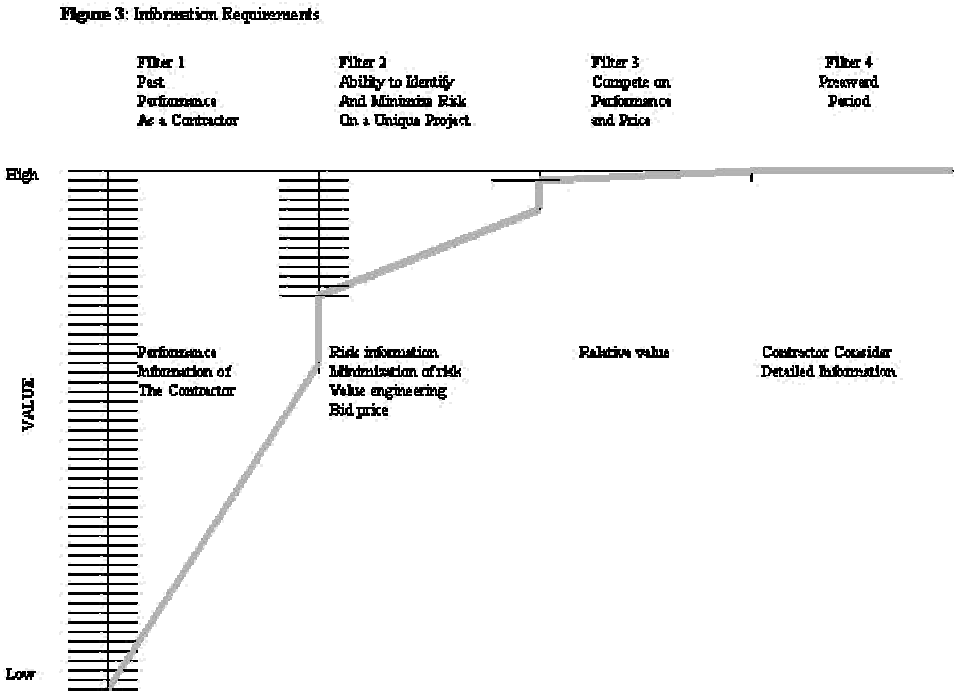
Figure 1: Population of Contractors



The authors use a Venn diagram to identify dependency of the factors. Figure 1 shows that all contractors form the population of alternatives. A subset of this is contractors who have the capability of performing on construction projects. A smaller subset is contractors who do have personnel and craftspeople who can possible compete based on value on a unique project. The smallest subset of contractors is the top prioritized or best value contractor. The minimization of the populations to the best value contractor is translated into a process with information filters which are made of JIT procedures (Figure 2) resulting in a reduction in the number of contractors and the required information at each step (Figure 3).

Figure 2: Information Process By Components





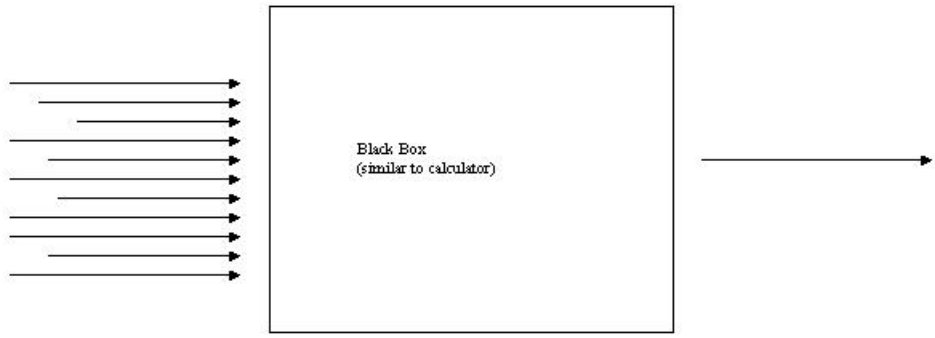
In keeping with the JIT philosophy of managing the minimum amount of information and being able to collect and use the information quickly at the right time, the process educates the contractors on the entire process at the beginning of the process. By definition of a high level information environment where subjective decisions are minimized, the participants who have the greatest control over the process becomes the contractors who can perform. The procedure of forcing the contractor to show past performance, prove the capability to identify and minimize risk on the subject project, and compete based on performance and price, to get the award, forces the contractors to make a decision early in the process of whether to participate or not. The information environment minimizes the likelihood of a non-performing contractor getting the project. Non-performing contractors have a far greater chance of getting projects when past performance and the capability to minimize risk are not considered. In the information environment, non-performing contractors can no longer depend on a personal relationship or someone's subjective opinion that the contractor can perform. The process becomes a black box similar to a calculator function (Figure 4). These non-informational actions are minimized by the following procedures:

- Management plans are restricted to concise identification and minimization of risk.
- Management plans are rated "blind" or without any names on a relative basis by multiple rating personnel.

The prioritization model, the modified Displaced Ideal Model (DIM), uses an information factor and distances away from the best line. The information factor is an exponential factor which prevents a contractor who is weak in a critical area from compensating in another area. This forces a contractor to compete based on all critical components.

The contractor is forced to accept the risk to perform on the project.

Figure 4: Selection Process Using Minimized Selection Subjectivity



Just in time principles identify that each component in the process must function without management. Each component must know its own performance. Information must be minimized; therefore, the process must identify and deliver the right information only when it is required. The process should therefore require only the minimum amount of information transfer and decision making.

DETAILED DESCRIPTION OF FILTERS

Filter One is composed of the contractor proving past performance, the knowledge that the entire process will select based on information and not subjective bias, the contractor's performance on the project if awarded, would count more heavily than any project they have done in the past, and that the process will be more expensive for non-performing contractors. These procedures force the contractor to make a decision in Filter One if they will be competitive in all criteria based on performance and price. This decision by contractors minimizes the owner's designer's need to create regulatory minimum standards and detailed means and methods specifications which are usually needed for low performing contractors. This minimizes the need for information transfer to the contractors. Filter One and Two may be combined by many designers. However, by the nature of the filters, there will be far fewer contractors at Filter Two than at Filter One. Therefore, Filter One should serve as a filter that minimizes the number of alternatives to performing contractors, and Filter Two further minimizes the alternatives to those who can minimize the risk on a unique construction project. At Filter Two, contractors must identify the risk to the owner (not on time, not on budget, not meeting quality expectations) and how they will minimize the risk, knowing they will have to compete at the next filter based on performance and price. By forcing the contractors to minimize the risk, the owner has now shifted the risk to the contractor. Contractors minimize risk by using their experience and skill learned on similar projects. Those who do not have the expertise must make the decision before Filter Two to withdraw. This minimizes the amount of information that the owner must analyze.

The other mechanism at Filter Two that minimizes the amount of alternatives and data is the requirement to deliver a very concise, brief assessment of risk and value engineering based on differentials. This forces a contractor to simplify the complex issues in business terms of risk minimization. Management theory identifies that those that can simplify a complex problem very quickly are expert at what they do. Those that need more text to explain the issues do not have an understanding of the project. The JIT principle of allowing only a brief business management plan becomes an excellent mechanism for reducing the amount of information that needs to

be analyzed and actually becomes a secondary filter. This process will work only if the user's representatives understand that less is better and simple is better.

Filter Three reinforces Filter Two. In a high level information environment which forces contractors to compete on a level playing field, the nonperformers will be more expensive than the performer when considering value (price and performance). Filter Three should use a multicriteria decision making tool to link the price with the performance. This tool should identify which differentials are most critical, forcing the contractors to continually improve in order to stay competitive. This identification of differential drives continuous improvement. The Displaced Ideal Model (Zeleny 1985), which is used in the Performance Information Procurement System (PIPS) (Kashiwagi 2002), not only identifies the differential, but uses an information factor which emphasizes the differential. This is one of the critical purposes of a decision making tool. Another advantage of the information factor is that it prevents a contractor from using a critical component in their bid which is non-performing, because the information factor prevents them from compensating in another critical area.

Filter Four makes the best available option review the project in detail. Only one contractor must do this. The contractor must seek clarifications, coordinate the drawings between subcontractors to ensure that the design is constructible, review their construction schedule to ensure that it can be done, and coordinate with the user to ensure that how they propose to manage the construction does not conflict with the constraints of the owner. This process also forces the designer to answer any questions quickly, before construction starts, minimizing costs. The contractor then agrees to construct the intent of the designer as the contractor envisions the project. The owner agrees to buy the construction as the contractor has outlined it. The risk is clearly placed on the contractor to perform.

The last filter is the pertinent information is at the end of the construction project. The contractor is rated on their work, and the rating will make up 25% of their future rating. This process directly links the performance of the contractor to their future capability of getting more work. This motivates the contractor to do better on this project than they have done before. This can only happen if the contractor sends their best personnel, they minimize the risk of nonperformance, and they make a fair profit based on the value they bring to the project. This is an economic decision made by the contractor. They send their best qualified people where they can make a fair profit. This procedure minimizes the amount of information that needs to be passed from the contractor to the designer and owner's representative during construction. It minimizes the need for the owner's representatives to have a detailed critical path chart, change order documentation on no cost change orders, and other paperwork currently needed to control the contractor.

APPLICATION OF PRINCIPLES IN PIPS

The JIT principles have been implemented in over 300 PIPS tests since 1994 on over $167M of construction. The performance result has been 99% on time, on budget, and meeting quality expectations. In the State of Hawaii tests that have been going on for the past three years, the following performance results have been identified:

1. Contractors improved their performance by an average of 5%.
2. 97% of the projects have been on time, on budget, and met quality expectations.

3. Average rating of performance on a scale from (1-10) has been 9.7 on 100 projects.
4. Contractors have performed much better on best value jobs than on low-bid projects.
5. The amount of management on the best value projects has been far less than on low-bid projects.

Analyzing the impact of the models have brought the following results:

1. Number of bidders is reduced due to not having the right personnel or subcontractors. This happened on the largest projects in both Utah and Georgia projects.
2. Filters Two and Three made most projects easy to identify the best value contractor. In the majority number of projects, the users selected the same alternative as the process.
3. Filter Four made the contractors minimize the risk of the owner, coming up with solutions instead of just problems. There were no identified cost change orders on any of the projects. Contractors went out of the way to minimize risk and perform.
4. On the University of Hawaii projects, the project manager stated that the final rating was the most important factor to the contractors.

Other results include:

1. Satisfied customers (99%).
2. Continuous improvement of contractor performance.
3. On projects where the process was followed, every component of the process has taken ownership of the performance.
4. The users of the process were looking for individuals who would improve the process and not get bogged down in either design, inspection, or procurement paperwork.

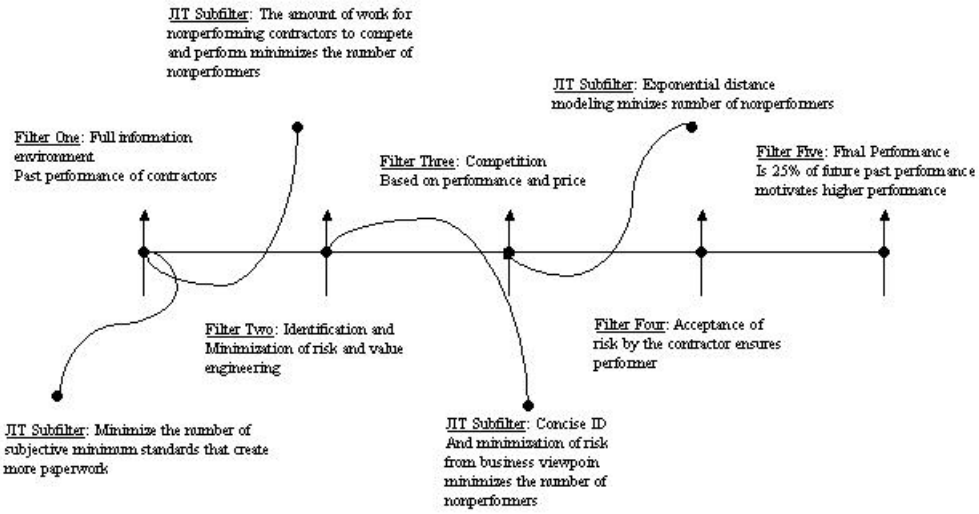
There has been no other documented performance of construction with similar results. Surveys conducted in Europe and the United States have far lower performance numbers (Vickers 2001, Post, 1998). The difficulty in implementing the JIT principles include the following challenges (Kashiwagi 2002):

1. The change to less information and effort makes managers who were used to a high level of risk and management, uncomfortable.
2. The understanding of the concept of moving the risk from the owner to the contractor for construction services is difficult to accept due to industry practices, which minimize the risk of designers and contractors.
3. Owners not understanding the JIT principle of compiling the minimal information to maintain the information environment.
4. Owners not understanding the impact of the performance on projects and maintaining the information environment.
5. Accepting the JIT principle that minimal procedures and rules are needed due to the competition between high performers.
6. Accepting the principle that one of the main causes of construction nonperformance is the users inability to compile, use and pass information (bureaucracy).

The authors propose that these difficulties must be overcome as the construction industry moves into the information age. The movement into the information age

does not only entail using information systems (computer technology) but also information theory such as IMT and JIT principles to minimize buffers or obstacles or non-value added functions. The research work done on the 300 test cases of PIPS identifies the inability to understand IMT and JIT principles far greater than the technological problems. This agrees with Bill Gates (Gates 2001) perception that the social adaptation to using information will be the obstacle to implementing technology. The authors also propose that the research investment into information theory will result in greater contribution to performing construction than information database and modeling technology. This study has identified the key component or limiting factor as the personnel who can implement the theory to the process which increase construction performance.

Figure 5: JIT Filters Minimize Need For the Management Of the Delivery of Construction



CONCLUSION

The use of information has a cost. This cost should be minimized. If an information environment is used where subjectivity is minimized, and control and decision making is given to the bidding contractors, and information is used to minimize risk, the amount of information required can be minimized. JIT principles used in an environment structured by IMT will result in the process shown in Figure Five. By the same methodology that JIT minimizes inventory in the manufacturing sector, it can minimize the amount of data and information that the user's representative has to manage. Results show that the same principle of the reduction of inventory taking away the safety net in case of shutdowns forcing everyone in the manufacturing process to perform to a higher level, the same forces everyone in the construction delivery process to pass information and minimize the subjective decision making and control over the contractor. This paper concludes that the biggest opportunity to improve construction performance is to use the JIT and IMT concepts to change how business is done.

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