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Strategies to Manage Risks in Infrastructure Projects

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Abstract

The City of Atlanta has utilized several delivery methods in previous water and wastewater infrastructure projects executed so far. The most commonly used in the past ten (10) years has been the Design-Bid-Build method with a Lump Sum Contract Price for project delivery. Facts related to these projects have provided a common theme of cost overrun and delivery time extensions for each project. The objective of this study was to recommend a delivery method for projects to enhance delivery satisfaction through cost containment and curtailment of project delivery time. As a result of this study, four specific strategies emerged that empowers a public owner, to manage the cost and schedule risks in infrastructure projects. Project size, external design, oversight & management, risk sharing through the delivery method are the four specific strategies that could better manage cost and schedule risks for public owners. One major finding from the study was to utilize a Design-Build delivery method with a unit price contract in infrastructure projects. Suggested changes in the project delivery method would achieve higher productivity for each dollar spent on infrastructure projects.

Introduction:

The objective of this study was to propose delivery processes for future contracts to improve the cost containment and schedule control for infrastructure projects. The focus of the study was on projects related to city storm water and sewage system improvements. The projects considered in the study included twenty-seven (27) projects previously executed for the city, which belonged to the specified focus area. *The delivery process used for both conveyance projects in the study was Design-Bid-Build*. The delivery processes used for construction of facility projects were Design-Bid-Build, Build-Operate, and Design-Build. The contract type used for facilities projects was exclusively Lump Sum Fixed Price Contracts. Conveying system contracts included Lump Sum and Unit Price contracts. These contracts, in general, delivered projects that cost the city more than original estimate and incurred delays in terms of project schedule.

Literature Review:

A literature review of numerous journals and books on delivery processes for public and private projects was conducted. This review compared and examined the performance of the different delivery processes available for infrastructure projects in general as well as specifically concerning water and waste water projects. It was determined from the review that the owners in a new project prefer decrease in overall project duration and limit time extensions. The owner's second major preference was production of a cost establishment, which is not likely to change a lot. (See table 1)

Table 1

Owner Reasons for Change in Delivery Processes

Reason	Rank
Reduced Schedule	1
Early Cost Establishment	2
Single Entity for design and construction	3
Innovation	4
Qualification/past performance of both the designer and the builder	4
Builder involvement in the process	4
Best value	4
Cost savings	8
Enhanced quality	9

(Puerto, Et Al, 2008)

A look at the determination of which delivery systems used in public infrastructure projects yielded a movement toward Design Build as the delivery system of choice. *This is supported by the increases in productivity the delivery system provided over the Design Bid Build process.* The literature review shows that the Design-Build process provided a reduction in project delivery time in the range of 15% to 36% as compared to the Design-Bid-Build process. Further the Design-Build process reduced overall project cost from 6% to 15% depending on the study reviewed (Levy, 2006/McClure, 2002). While owners did indicate they are willing to pay more for higher quality in a project, limiting the cost creep due to Change Orders (CO) and Requests for Information (RFI's) were also very important considerations from their perspective (Gransburg, Et Al, 2007).

Analysis of Literature Review:

The most successful use of the Design-Build process is based on the use of a two-step selection process for the Design Build team. This involves first qualifying the biding teams with a Request for Qualifications (RFQ's) followed by Request for Proposals (RFP's) from a 'short list" of qualified bidders based on the RFQ review. The two-step process ensures that the best possible competition of bidders would take place, allowing price and innovation considerations while maximizing schedule reduction (Puerto, 2008). The RFQ process was further defined to include a weighted scoring system to allow the participating contractors to give their best possible information to the owner to select the "short list" of responsive bidders for the project. The RFP process requires more detailed information from the owner to enable the GC participate in the "short listing" of bidders. Before initiating the RFP process the owner's team must have a well-defined set of requirements, needs, and expectations for the project. The bidders then submit proposals that are again reviewed against weighted criteria and the Design-Build team is selected from the responsive bidders "short list". The RFP's are judged based on the criteria stated and provide the owner with a close approximation of cost, schedule, and innovation that the project will

require. The process empowers the public sector owner to manage the project with much less creep in cost and duration of the project. Additionally, the projects can be funded and completed during the allotted time constrains, which is a typical problem encountered by public projects due to their funding mechanism through annual budget appropriations. This process allows the funds to be obligated and the project possibly completed in the scheduled fiscal year (Gransburg, 2007).

Table 2

KEYS TO SUCCESSFUL RESPONSE TO RFP'S

Key Item	Rank
Qualifications	1
Price	2
Schedule	3
Technical/design approach	4
Management plans	5

(Puerto, 2008)

Analysis of Past City of Atlanta Projects:

The water and waste water projects conducted over the past 10 years provided some insight to the past performance of project delivery systems employed. The projects were examined in the context of cost, duration, delivery method, and contract type (Table 3).

The actual cost and schedule duration were compared with designer/engineer's estimated cost and schedule. The change orders, for each project, reflected increased delivery time for up to 400 plus days of extensions in some projects (Change Order Review). The cost and duration increases tend to adversely impact public perceptions about the performance of Construction Management unit, that manages projects, as well as satisfaction of the end users (tax payers – public and city governments). Therefore, it is imperative that the city adopts best practices used by others to deliver infrastructure projects more efficiently.

Table 3

Completed Project Analysis for City of Atlanta Waste and Storm Water Projects

Project Type	Contract Value	Status	Delivery Method/ Contract Type	Work Authorizations per Project	WA's per $1,000,000 Contract Value
Facility	$4,212,987	Complete	DBB/Lump Sum	46	11
Facitity	$32,049,000	Design only			
Facility	$33,396,331	Complete	DB/Lump Sum	27	0.8
Facility		Out for Bid			
Facility		Out for Bid			
Facility		Out for Bid			
Facility	$4,397,546	Complete	DBB/Lump Sum	56	12.7
Facility	$6,558,090	Under Construction	DBB/Lump Sum	10 currently	1.5
Facility	$38,439,245	Complete	DBB/Lump Sum	72	1.9
Facility	$33,083,378	Complete	DBB/Lump Sum	104	3.1
Conveyance	$19,697,350	No Data	DBB/Annual Contract		
Facility	$19,050,000	NTP	DBB/Unit Price		
Facility	$3,719,658	Complete	CO/Lump Sum	31	8.4
Facility	$7,517,498	Complete	CO/Lump Sum	93	12.4
Facility	$16,513,078	Contract Terminated	DBO/Lump Sum	35 at Termination	2.1
Facility	$19,949,424	Under Construction	DBB/Lump Sum	81 currently	4
Facility	$41,500,758	Complete	DB/Lump Sum	180	4.3
Facility	$1,385,715	Complete	DBB/Lump Sum	19	13.6
Conveyance	$9,102,971	Under Construction	DBB/Unit Price	1 currently	
Facility	$4,944,640	Complete	DBB/Lump Sum	43	8.8
Facility	$55,118,256	Complete	DBB/Lump Sum	272	4.9
Facility	$5,107,407	Under Construction	DBB/Lump Sum	10	2
Facility	$6,074,886	Complete	DBB/Lump Sum	120	20
		DBB WA's Average per $1,000,000 of Contract Value	7.6	DB Average WA's by Contract Over $10,000,000	103.5
		DBB Average WA's by Contract Over $10,000,000	105.8	CO Average WA's by Contract Under $10,000,000	62
		DBB Average WA's by Contract Under $10,000,000	42		

(City of Atlanta Completed Project Analysis Information Template, 2007)

Simultaneously, it equally important to learn lessons from previously executed projects, to foresee likely problems and avoid repetition of mistakes. The aim of this study is to have a tighter control of cost and schedule for future water and sewage projects through the application of best practices and lessons learned from the past.

Table 4

City of AtlantaProject Cost Creep Due to Change Orders

Project Type	Contract Value	Status	Delivery Method/ Contract Type	Porject Cost Increase Due to Change Orders	Percentage Increase in Contract Cost
Facility	$4,309,000	Complete	DBB/Lump Sum	$84,489.00	2.0%
Facitity	$32,049,000	Design only			
Facility	$31,000,000	Complete	DB/Lump Sum	$2,446,451.00	7.9%
Facility		Out for Bid			
Facility		Out for Bid			
Facility		Out for Bid			
Facility	$3,502,316	Complete	DBB/Lump Sum	$895,230.00	25.6%
Facility	$6,558,090	Under Construction	DBB/Lump Sum	$18,682.00	0.3%
Facility	$36,611,260	Complete	DBB/Lump Sum	$4,526,913.00	12.4%
Facility	$28,556,466	Complete	DBB/Lump Sum	$104.00	
Conveyance	$19,697,350	No Data	DBB/Annual Contract	No Data	
Facility	$19,050,000	NTP	DBB/Unit Price		
Facility	$3,191,032	Complete	CO/Lump Sum	$528,626.00	16.6%
Facility	$5,713,368	Complete	CO/Lump Sum	$1,804,130.00	31.6%
Facility	$15,011,785	Contract Terminated	DBO/Lump Sum	$1,501,293.00	10.0%
Facility	$15,482,000	Under Construction	DBB/Lump Sum	$4,467,424.00	28.9%
Facility	$34,396,715	Complete	DB/Lump Sum	$7,104,043.00	20.7%
Facility	$1,569,275	Complete	DBB/Lump Sum	$66,440.00	4.2%
Conveyance	$8,969,691	Under Construction	DBB/Unit Price	$133,280.00	1.5%
Facility	$4,328,045	Complete	DBB/Lump Sum	$616,595.00	14.2%
Facility	$47,293,314	Complete	DBB/Lump Sum	$7,824,942.00	16.5%
Facility	$4,840,000	Under Construction	DBB/Lump Sum	$267,407.00	5.5%
Facility	$5,454,748	Complete	DBB/Lump Sum	$920,138.00	16.9%

(City of Atlanta Completed Project Analysis Information Template, 2007)

Delivery Processes

Adoption of a project delivery process is also subject to legal and policy requirements of the city. The use of "different" delivery methods may require approval of city council or changes in laws and a "sweetening of the project fees" to motivate participation by qualified contractors *(Ibbs, 2003)*. It is for this reason that the current study will focus on the Design-Build format for delivering water and wastewater infrastructure projects. Design-Build delivery method is being proposed after considering prevailing best practices, and lessons learned from the past. The method appears to have the greatest potential for improving cost and schedule control of the infrastructure projects. Reduction in the duration of delivery time is obvious. In Design-Build process, construction of each component can be initiated when the component (part of the whole) is designed, and approved. Thus the project construction could

start earlier, and is likely to have fewer interruptions, which are otherwise motivated by Requests for Information (RFI's) due to actual or perceived design errors. The design process has the potential for cost curtailment through an on-going value engineering process due to designer-contractor-interface at the initial design stage and the application of "third party" value engineering reviews at major design milestones may bring further design and life cycle cost enhancements. In addition the contract could include incentives for the contractor for bringing down construction and operations costs for, at the outset, the city *(Molenaar, 2004)*.

The Design-Build delivery method reduces communication problems by providing a single point of contact for the owners. The method also allows the contractor to be involved in the design process right from the start of the design, thereby ensuring that constructability, and cost effectiveness are constantly kept in view along with design objectives and structural soundness. Hiring of an independent or third party (contractor) to perform the Value Engineering (VE) process could also ensure constructability, and cost effective design goals. Such a vetting process could also include consideration of long-term operations cost (life-cycle costing), in addition to VE of the capital cost. Limiting the need for design related change orders improves schedule control of the project as well. Thus Design-Build projects enable design changes to take place at a time when changes are actually possible without excessive increase in design cost or serious impact on construction costs or schedule. Design-Build permits the adoption of most cost effective design, and not designs created with little or no consideration of constructability and capital or life cycle cost considerations *(Levy, 2006)*.

The project risk for the contractor (constructor) increases due to lack of knowledge of general conditions, particularly the prevailing below-the-ground conditions, constructability risks (design-related), and changes (ground, traffic, market conditions) that might occur during the time lapse between design phase, and the construction phase. Mitigation of these risks, through a risk sharing method, such as unit price contract should definitely lower the overall risk for the contractor, thus the over all bidding price of the contractor would be lower. Risk sharing reduces the bid price cushioning for a project, since the risk of unforeseen conditions are substantially reduced or shared between the owner and the contractor. By utilizing a unit price contract and reducing contractor risks, during the bidding phase, the city is expected to achieve additional cost reductions on large projects. In conveying systems project, where repetitive construction activities are involved, the contractors have an opportunity for enhancing productivity of the workers and construction processes, resulting in better cost and schedule control of over all project. The unit price method allows the contractor to pass savings in cost and time to the city *(Levy, 2006)*.

Innovative changes in a construction project could also reduce overall cost of a project. Inclusion of a contract clause, providing incentive to the contractor for savings on over all contract price without compromising on scope and project performance objectives, is an important tool that must be considered in all city contracts. In this type of contract, if the contactor increases productivity through repetitive or improved processes, the payment for services is still made based on a unit price for work done but may reduce work hours or schedule, thereby reducing cost. The contractor still gets paid for every hour worked, but the City benefits from over all cost reduction and timely completion of the project. Additionally, if the contractor develops a more cost effective method or procedure for delivering the project they should be able to gain financially. The contract clause should clearly define a methodology for sharing the savings made in project budget as a bonus for innovation. This is a "win - win" concept since the city saves money overall and the contractor makes more money as well *(Ibbs, 2003)*.

Each of the above mentioned project delivery sub processes enhance the overall project cost savings and delivery time. The project should certainly be more cost effective as it is built. The overall strategy of a Design-Build process, with a unit price contract, is to bring about reduction in project cost and control schedule for timely completion of the project.

Oversight and Management

Infrastructure projects require extensive oversight and management. The "owner's representative" is an integral part of a successful delivery process. The owner's representative must be capable (capacity

and skills) of overseeing the design and construction process while approving pay requests. The owner's representative is also expected to possess problem solving skills (resolving difference of opinions), to preempt disputes that require arduous arbitration processes in contractual terms. Each project requires a "qualified representative" who is knowledgeable about the Design-Build process as well as general design and construction process for a particular type of project. The owner's representative could be a direct employee of the owner or may be a contracted third party representative who represents the owner on the Design-Build Project Team. In either case, experience and knowledge of the project processes and requirements cannot be over stated. If no one on the owner's team can successfully perform this duty the cost of a construction manager/construction management firm is certainly a reasonable and necessary cost, which needs to be budgeted in the Overall Delivery Cost Estimate of a project. A construction management firm (CMF), if employed for a fee, may bring additional capabilities to the owner during the project. CMF can also be contracted to perform constructability reviews, value engineering, and LEED (Leadership in Energy and Environmental Design) reviews, while performing normal owner's representative duties such as certifying payments according to the contract. A qualified owner's representative on an infrastructure project is more than likely to result in savings, both in capital (cost and schedule) and operational (life cycle) costs of the project *(McClure, 2002)*.

Project Size

It is important to "size" projects to an optimum size for construction from a contractor's perspective. As infrastructure projects come to the planning phase, it is often desirable for the government to create large infrastructure projects with a scope and cost that allows a single entity (designer and contractor) to be responsible for the entire project. From a government oversight perspective this may seem like the best way to manage a large project. With only one company responsible, the government agency can easily look at the management and processes with a small staff for project oversight. While this may seem more efficient and cost effective from a government perspective, it causes numerous problems from a contractor's perspective. Fewer contractors are able to participate in bidding for large contracts, thus limiting competition and innovation. Since most public infrastructure projects require a performance bond, which is in addition to normal insurance requirements, the over all cost of the project becomes a restrictive factor for many contracting firms. The bonding companies control the size (maximum committed price) of over all undertakings possible at any time for a contracting firm *(Gavin 2005)*. As an example, a company with $1,000,000 (One Million Dollars) in assets typically has a bonding capacity, assuming a good track record of completing projects on time and within budget, of not exceeding $ 10,000,000 (Ten Million Dollars) and only Fifty Percent (50%) of Ten Million Dollars can be tied up in a single contract. For this reason, large size infrastructure projects appear to attract fewer contractors, who possess the required bonding capacity and who are able and willing to bid for the infrastructure project. As a result number of participants in the "bidder pool" decreases, therefore, the competition and benefits of competition (competitive cost) brought about by competition decreases. Such a situation leads to more expensive contracts since the projects approach the point of "sole source" contracts when their project size drives the bid price beyond the capability of most local contractors. Under the circumstances, only large national or international contracting firms are able to bid for large infrastructure projects. Thus limiting the positive economic impact of local government dollars spent on infrastructure projects. Net result is in the form of substantially higher "bids" since the big contracting firms have numerous possible projects to bid on and can be very selective depending on availability of "special sweetening provisions" in contracts. Such provisions could include tax incentives or such other special provisions that could cost the local government a whole lot more in the longer-term perspective.

External Design versus Internal Design

The use of a Design-Build contract allows for the use of RFP's to seek possible preliminary designs that are based on specified project criteria. This can greatly reduce the public (local governments) cost of design and attract more innovation and creativity to the design process from those firms willing to participate. Internal designs tend to look like the previous design used for similar projects with little

innovation or flexibility. By allowing competing design proposals, innovation and new technologies find their way into the design process. Design firms can be given "initial design development contracts" to further develop promising/innovative designs to a more schematic level before final design selection is made. Such a process results in adopting of relatively more cost effective and constructible design and utilization the best available technology to meet the specified criteria of an infrastructure project *(McClure, 2004)*. If the design firm is tied to a prescribed design, they may not have the necessary motivation to enhance the design since it is "what the customer wants" that tends to be the primary driver for the design process.

Conclusions:

The City of Atlanta has completed a number of facility and conveyance infrastructure projects over the past 10 years and a lot more are yet to come. Most of these past projects have used the traditional delivery approach of Lump Sum Fixed Price / Design-Bid-Build Contract type process for project delivery. The general outcome of these contracts has been a consistent increase in cost due to design errors and unforeseen conditions requiring the use of "Work Authorizations" to satisfy change orders to correct the deficiencies in design that occurred during the planning stages of the project. Almost all of these change orders have resulted in the increase in the final price and the duration of the project. Many of these could have been foreseen during the design stage, if the contractor had been an integral part of the design work review, as a member of the Project Team. The ability of the contractor and designer interface to correct problems before they occur on the job site can greatly reduce the project cost or cost overruns and control schedule through timely completion of the project.

Utilization of Unit Price contracts can substantially reduce the risk of the contractor, which can bring about a reduction in the overall cost of the project. It further entices the contractor to seek cost reduction processes to enhance savings during the construction of the project.

Project Sizing for bidding can increase the competition between contractors since more qualified firms can bid on smaller contracts (under $10,000,000 each) due to bonding capacity limitations for contractors. This makes the overall contract for infrastructure projects more cost effective and enables more local contractors to compete in infrastructure work. Keeping infrastructure dollars spent on public projects local also provides cash infusion into the local economy. Another benefit is the capacity building of local contractors to carry out future infrastructure projects.

Project Management (PM) oversight (owner's representative) greatly enhances the chances of success of an infrastructure project. This can be achieved by the use of a third party project management firm, who is employed for oversight and project management. The PM firm or owner's representative ensures contract compliance, timely pay request approvals, and may conduct periodic reviews of the design that may include constructability, value engineering, and LEED compliance where required.

The use of above specified strategies can increase efficiencies in terms of schedule and cost containment for future infrastructure projects. The application of such project delivery techniques, as a package may well provide the best overall success and satisfaction from a tax payer's perspective.

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