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THE COST OF INACTION
DOES MASSACHUSETTS NEED PUBLIC CONSTRUCTION REFORM?

Douglas D. Gransberg
University of Oklahoma

Pioneer Institute for Public Policy Research
Boston, Massachusetts

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PREFACE

"Those who do not remember the past are condemned to relive it."—George Santayana

In the spring of 1978, rocked by scandal that implicated its own members as well as awarding authorities and a wide segment of the private sector in the award of contracts for design and construction of public buildings, the Massachusetts Legislature created a Special Commission Concerning State and County Buildings.[1] Commonly known as the "Ward Commission" after Chairman John William Ward, the Special Commission was directed "to investigate and study as a basis for legislative action the existence and extent of corrupt practices and maladministration concerning contracts...related to the construction of state and county buildings." Armed with subpoena power and staffed by a group of talented, experienced, and committed professionals, the seven members of the Ward Commission had broad discretion concerning what to investigate and study, but there was one subject about which they were mandated to inquire. The resolve specified that the Commission "shall include" in its investigation and study "consideration of the awarding, implementation and the subsequent events concerning the contract between the firm of McKee-Berger-Mansueto, Inc., (MBM) and the Commonwealth relating to the management of construction of certain buildings on the Boston Campus of the University of Massachusetts." The referenced contract had been awarded almost a decade earlier for construction management services in connection with the construction of the University of Massachusetts-Boston campus. That project turned out to cost roughly $150 million, which was then "said to be the largest construction project undertaken by the Commonwealth to that time."[2]

In the spring of 1998, two decades after the Ward Commission was formed, the Executive Office for Administration and Finance issued the final report of the Construction Reform Task Force it had formed to revisit the substantive law last seriously revised on the recommendation of the Ward Commission. This time the call for reform was unaccompanied by headlines. No scandal prompted the work of the Task Force. Instead, what prompted it was money. The "Big Dig"—the construction project that dominates our capital city in the 90s and will as we begin the 21st century—has a price tag almost 100 times higher than the University of Massachusetts extension did in the 1970s. The Commonwealth's annual construction budget is now $3 billion, according to Professor Gransberg's thought-provoking study. With spending of that magnitude, can we afford the reforms of the past?

"The Cost of Inaction: Does Massachusetts Need Public Construction Reform?" is essential reading for today's policy makers. In it, Douglas Gransberg provides comparative data from other states of a depth and quality not seen in Massachusetts since the Ward Commission itself. It sifts through the

[1] Massachusetts Resolves, 1978 c. 5 and 9.

rhetoric of the potentially charged debate and provides an empirical basis on which law makers can make informed decisions about the future of public construction in Massachusetts. It provides quantitative analysis of the work product of the Task Force, which was compelling in its own right in its clarion call for change.

One proposal of the Task Force, which Professor Gransberg's work strongly supports, appears inconsistent with the recommendations of the Ward Commission. The Task Force report is highly critical of the current restrictive contracting process and champions alternative methods of delivery, including use of construction managers—the very subject the Ward Commission was required to study and predictably condemned 20 years ago. Professor Gransberg focuses on a different restriction also highlighted by the Commission—separating the study designer from the final designer of a project—and provides data demonstrating that this device, employed to avoid designing for self-interest, increases the cost of design to what may be unacceptable levels. His focus nicely frames the larger question confronting us: Are the lost economies that come with the Ward Commission reforms worth the cost 20 years later when their price has increased one hundred fold?

"Bad cases make bad law," like most trite aphorisms, is based on truth. The MBM scandal of the past presented a bad case for construction management in particular and alternative delivery methods of construction generally. The real lesson of history is not that one delivery system is corrupt and another pure. It is instead that every system has its weaknesses, which some will attempt to exploit. Rather than react to crisis and scandal, "the swing of the pendulum" as the Ward Commission's vice chairman, Attorney General Francis X. Bellotti, used to call it—Massachusetts policy makers should shape tomorrow's contractual process based on today's experiences and historical and analytical works like those you are about to read. If the contractual process remains frozen in the past, we will indeed relive its problems in the future.

Thomas R. Kiley
September 7, 1999

[2] *Ward v. Peabody*, 380 Mass. 805, 807 (1980).

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EXECUTIVE SUMMARY

As debate continues over reform of public construction in Massachusetts, Douglas Gransberg, associate professor of construction science at the University of Oklahoma, offers two significant contributions: First, he has employed a vast collection of data to measure the efficiency of the Design-Bid-Build process currently in use in the Commonwealth. And, in so doing, he has neatly separated the issue of efficiency from the fear of corruption that in the 1970s spawned the Ward Commission and continues to inspire opposition to reform. The truth of the matter is that the two issues—corruption and reform—can and should be debated separately. There is no evidence correlating the use of alternative procurement methods with an anomalous level of corruption. State and federal agencies that have chosen the path of innovation have also developed tools to minimize corruption. The question is, therefore, whether Massachusetts can gain in efficiency by lifting legislative restrictions to take advantage of all available procurement methods.

Before the Massachusetts legislature is a proposal for reform of public construction procurement based on a report published by the Construction Reform Task Force, a group convened by then Secretary of the Executive Office of Administration and Finance Charles D. Baker, Jr.'s Special Initiative to Reform Construction and Management by Commonwealth Agencies.[3] The Task Force concluded that improvements could be made to the Commonwealth's construction procurement system and called for a reengineering of the relevant laws with a vision toward "increasing flexibility to use alternative methods, saving time and achieving excellence, and promoting customer service."[4] The purpose of Professor Gransberg's study is to determine whether the Massachusetts Design-Bid-Build system ensures an efficient construction process or whether legislation is needed to eliminate its costly restrictions, as the Task Force report asserts.

The analysis compares the performance of the Commonwealth's construction procurement process to alternate methods used in three other states, with respect to project cost and timely completion. Data from 10 Commonwealth agencies that routinely procure design and construction services were gathered on 926 projects worth $1.1 billion in completed construction cost. These data were compared to similar information on 463 projects worth $2.5 billion from the states of Florida, Indiana, and Texas. It is likely the largest empirical sample ever put together for a comparative study of procurement systems.

The author charted the life cycle of a typical Massachusetts project, so as to isolate legislative constraints that increase delivery time and cost and found two "bottlenecks" that restrict project progress. The first is in the provisions of Chapter 7, which mandate that the feasibility study and final design for a

[3] Final Report, Construction Reform Task Force, Secretary's Special Initiative to Reform Construction Procurement and Management by Commonwealth Agencies, Executive Office for Administration and Finance, Boston, Massachusetts (1998): 8-24.

specific project be completed by different design firms. Chapter 7 delays the design process and increases its cost by reducing the scope of work for each designer and eliminating the ability to achieve economies of scale. The second is the Chapter 149 provision that requires public agencies to open filed subcontractor bids for each trade on vertical projects and furnish them to the general contractors for use in the preparation of their bids for the general contract, thus preventing the formation of strategic relationships among general contractors and subcontractors. The impact of Chapter 149 is twofold. First, it further increases the cost of design by forcing the designer to prepare additional construction documents so that each trade subcontractor has a stand-alone package on which to bid. Second, it creates an adversarial environment between the general contractor and the subcontractors, which leads to greater numbers of change orders and corresponding delays, which raise costs further.

Several metrics were used to determine the impact, in dollars and time, of these regulatory constraints on actual project performance. These metrics were applied to all the projects in four state sample populations and the results tabulated for comparative analysis. The study found that Massachusetts had the poorest project performance in virtually every category. Average cost growth (percentage increase from award cost to final project cost) was 30 percent higher on a Commonwealth project than in Florida, 3.5 times the rate in Texas, and 9 times the cost growth of the average Indiana project. Likewise, Massachusetts projects experienced average time growth (percentage change in length of the contract) of over 55 percent, compared to 17 percent in Florida, 12 percent in Texas, and 6 percent in Indiana. Finally, when unit costs for delivering public buildings were calculated and then normalized to account for local conditions such as union labor and severe winters, Massachusetts projects cost $202 per square foot to build, whereas similar projects in Indiana, Florida, and Texas cost $142, $128, and $127 per square foot, respectively.

If the construction procurement process could be refined to focus on quality, timeliness, and cost-effectiveness, and if the result merely reduced cost growth to the roughly 4 percent average of other states, savings from this factor alone would be nearly $220 million of the Commonwealth's $3-billion annual construction budget. Overall, for the same outlay of dollars corrected for labor and weather differences, the Commonwealth overextends its budgets, takes longer to build, and ultimately builds less. This leads to losses of revenue for businesses and thus tax revenues for the state, inconveniences for citizens, and fewer construction projects and jobs in the Commonwealth.

The study then looks at potential savings from implementing alternative delivery methods that employ a quality- and price-based selection process, and found that the three other states have indeed benefited from their experiments with A+B Bidding and Partnering.

[4] Ibid., p. 4.

The paper concludes that the cost of legislative inaction is high. The solution to high public construction costs in Massachusetts is not technical. All the alternative project delivery tools are available with the historical performance data needed to evaluate their specific application in Massachusetts. The challenge is to develop the political will to seize these tools and use them to deliver needed public projects.

The Cost of Inaction
Does Massachusetts Need Public Construction Reform?

Douglas D. Gransberg
The University of Oklahoma

I. Introduction

In 1998, the Massachusetts Executive Office for Administration and Finance published the report of the Construction Reform Task Force, a group convened by the Secretary's Special Initiative to Reform Construction and Management by Commonwealth Agencies.[5] The Task Force concluded that improvements could be made to the Commonwealth's construction procurement system to increase flexibility, save time, and improve customer service. The Task Force report summed up the need for reform as follows:

> Massachusetts has the dubious distinction of having the most regulated public construction contracting process in the country. Massachusetts statutes override the normal rules of law governing private contracting in the area of public bidding and in many important aspects of the performance of public contract, as well as the fiscal aspects of contracts with state instrumentalities and municipalities.[6]

Is this an accurate description of public construction in Massachusetts? Will the empirical evidence confirm a need for reform? The goal of this report is to depict how Massachusetts matches up to other states, and to do so with verifiable statistical evidence. A procurement system in need of reform will produce a defective end-product or exhibit significant cost and time inefficiencies. Cost inefficiency is revealed in cost increases to the state that are attributable to unsatisfactory management, designs, or execution (or a mix of these). Time inefficiency is evident in delays, which also have direct costs to the state, as well as user costs, which are the costs to the public of disruption and congestion that accompany ongoing construction projects. In highly populated states like Massachusetts, the user costs of construction are considerable. When construction disrupts area businesses, the businesses lose revenue, but the state also forfeits tax revenues on that lost commerce. This is especially so when companies dependent on the mobility of goods and personnel are the mainstay of the economy, such as is the case in Massachusetts.

The paper is organized as follows: The next section offers a brief history of construction procurement in Massachusetts, section II gives a review of the use of alternative project delivery methods in other jurisdictions within and outside the United States, and section III presents a set of metrics for analyzing various aspects of construction projects. The study then employs these metrics to compare data

[5] Ibid., pp. 8-24.
[6] The quotation was drawn from James J. Meyers, Christopher L. Noble, and Penny P. Cobey, *Construction Law 1997*.

on construction project performance in Massachusetts to three other states to determine whether these data support the findings of the Construction Reform Task Force.

MASSACHUSETTS: AN OVERVIEW

Public construction in the Commonwealth is big business, exceeding $3 billion in fiscal year 1997 in contract costs alone.[7] How this money is spent in procuring construction projects is largely determined by federal statute. The Brooks Architect/Engineer Act (Public Law 92-582, enacted in 1972) forbids the competitive selection of design professionals on federal projects and requires that selection be based on professional qualifications alone (Qualifications-Based Selection or QBS). Thirty-four states and other public entities have adopted laws modeled after the federal statute requiring states and localities to utilize QBS procedures for procuring design services. Other states and localities have adopted regulations or executive orders that accomplish the same objectives.[8]

The law's intent is to protect the public from potentially unsafe designs developed by poorly qualified designers or designers who cannot thoroughly prepare their work because of competitive price pressure. Yet most public agencies are required to award *construction* contracts on a low bid basis to ensure that the taxpayers' money is wisely spent. Combining the two creates a dichotomy in public construction across the nation. Public agencies must contract with the very best qualified designers but award the actual construction to the contractor with the lowest bid, trusting in some sort of prequalification process and the bonding industry to weed out unqualified bidders. Bringing economics into the analysis reveals the magnitude of this dichotomy. A typical project will spend only about 8 percent of the total project cost on design.[9] Using this figure, the Commonwealth of Massachusetts' $3-billion annual construction program metes out about $240 million to highly qualified design professionals and the remaining $2.76 billion to anyone who can post a bid and performance bond.[10]

The state's statutory law is, however, the most important legislative determinant in the process. In 1939, the filed subcontractor bidding process was established in legislation prompted by a petition from the Massachusetts State Building and Construction Trades Council. Given the shortage of private construction work at the time, it was considered essential that subcontractors have an assured role in public construction projects. Four decades later, in response to massive corruption and defective work, the Ward Commission was created. On the basis of the Commission's findings, the legislature developed

[7] Final Report, Construction Reform Task Force (1998): v.
[8] National Society of Professional Engineers, "Qualifications Based Selection Issue Paper," http://www.nspe.org/govrel/gr2%2D4022.asp (1999).
[9] William D. Mahoney, *Public Works 1997 Costbook*, BNI Building News, Boston, Massachusetts (1997): 1-2.
[10] Author's calculation.

several legal restrictions that have effectively defined the public project delivery process since 1980.[11] In skeletal form, one can characterize the Commonwealth's current procurement system as follows. Horizontal construction is governed by Chapter 30, the fundamental premise of which is project delivery accord to the methods known as Design-Bid-Build (DBB). Vertical projects are covered by Chapter 149, which mandates that building projects be awarded to the "lowest responsible and eligible bidder." It also establishes DBB as the main delivery method and, contrary to the recommendation of the Ward Commission, leaves intact the requirement for filed subcontractor bids. Chapter 7 requires that two different firms complete the feasibility study and the project design.[12]

Design-Bid-Build

Design-Bid-Build takes its foundation from the fear that a construction contractor will not adequately safeguard public health and safety and therefore needs the close supervision of a design professional. Thus the owner retains an engineer or an architect on a separate contract to complete the design of the public facility. Once design is final, a set of plans, specifications, and contract boilerplate is advertised for bid by the construction industry. Construction contractors submit a price, and the project is awarded to the lowest responsive and responsible bidder. (See appendix A for more detail.)

The Massachusetts Design-Bid-Build system requires that the designer that does the feasibility study work be different than the firm that completes final design. The Task Force found that it often takes four to eight months to select a single design professional. The same amount of time is required to procure the second design consultant. In addition, the second design firm must become thoroughly familiar with the work of the first firm before it can begin final design in earnest, creating further project delay. The designer is charged with ensuring that construction conforms to the *minimum level of quality* specified in the plans; there is no incentive to the builder to exceed this level through good workmanship or innovative materials and processes. DBB thus creates an adversarial relationship between designers and contractors in a financial context that serves to minimize product quality.

II. Alternative Project Delivery Methods

There are four alternative contracting methods for which there are data comparable to those available for DBB: Construction Manager-at-Risk (CMR); Best Value Contracting (BVC); A+B Bidding; and Design-Build (DB). Each of these will be described briefly. Further discussions of each method can be found in appendix A.

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[11] D. F. Runde and Y. Sunayama, "Innovative Contractor Selections Methods: Alternatives to the Traditional Low Bid in Massachusetts Public Construction," Policy Analysis Report, John F. Kennedy School of Government, Harvard University, Boston, Massachusetts (1999): 46-48.
[12] Final Report, Construction Reform Task Force (1998): A-9.

Construction Manager-at-Risk

Construction Manager-at-Risk (CMR) projects are characterized by a contract between an owner and a construction manager (CM). In this agreement, the owner authorizes the CM to handle all the details of a project's life cycle. The idea of CMR is to furnish professional management of all phases of a project's life to an owner whose organization may not have those capabilities. Typically, CMR contracts contain a provision in which the CM stipulates to a guaranteed maximum price (GMP) above which the owner is not liable for payment. Often these contracts include incentive clauses in which the CM and owner split any cost savings realized below the GMP. CMR contracts can contain provisions for the CM to handle design, but most commonly, the owner retains the traditional responsibility by keeping a separate design contract and furnishing the CM with a full set of plans and specifications on which all construction contracts are based.

Best-Value Contracting

Best-Value Contracting (BVC) is a project delivery method in which the contract is awarded to the offeror that proposes the best combination of price, qualifications, and schedule. There is no requirement for the contractor to furnish design services. BVC operates on several simple principles: 1) The qualifications of the construction contractor are important to the successful completion of the project. 2) The industry is more experienced at setting realistic construction schedules than government. 3) A low bid is often achieved in error, leaving the "winning" contractor to make up losses by fomenting change orders and cutting corners on quality.[13]

A+B Bidding

A+B Bidding is an innovative form of construction contracting prevalent in transportation projects. In A+B Bidding the owner completes the design using traditional means. The plans and specifications are then advertised and contractors are asked to furnish not only a bid price, but also a contract period calculated in working days. The idea is to create a contract with an incentive to complete the work in the shortest period of time at the lowest relative cost. To do so, the owner gives each day a value based on user costs of construction. When the bids are opened, the bid price is Part A of the bid. The contractor-proposed contract period is then multiplied by the value of a day and becomes Part B of the bid. These values are added together to form the basis of award to the lowest combined bid. See table A1 in appendix A for an example of this process taken from Florida.[14]

Design-Build

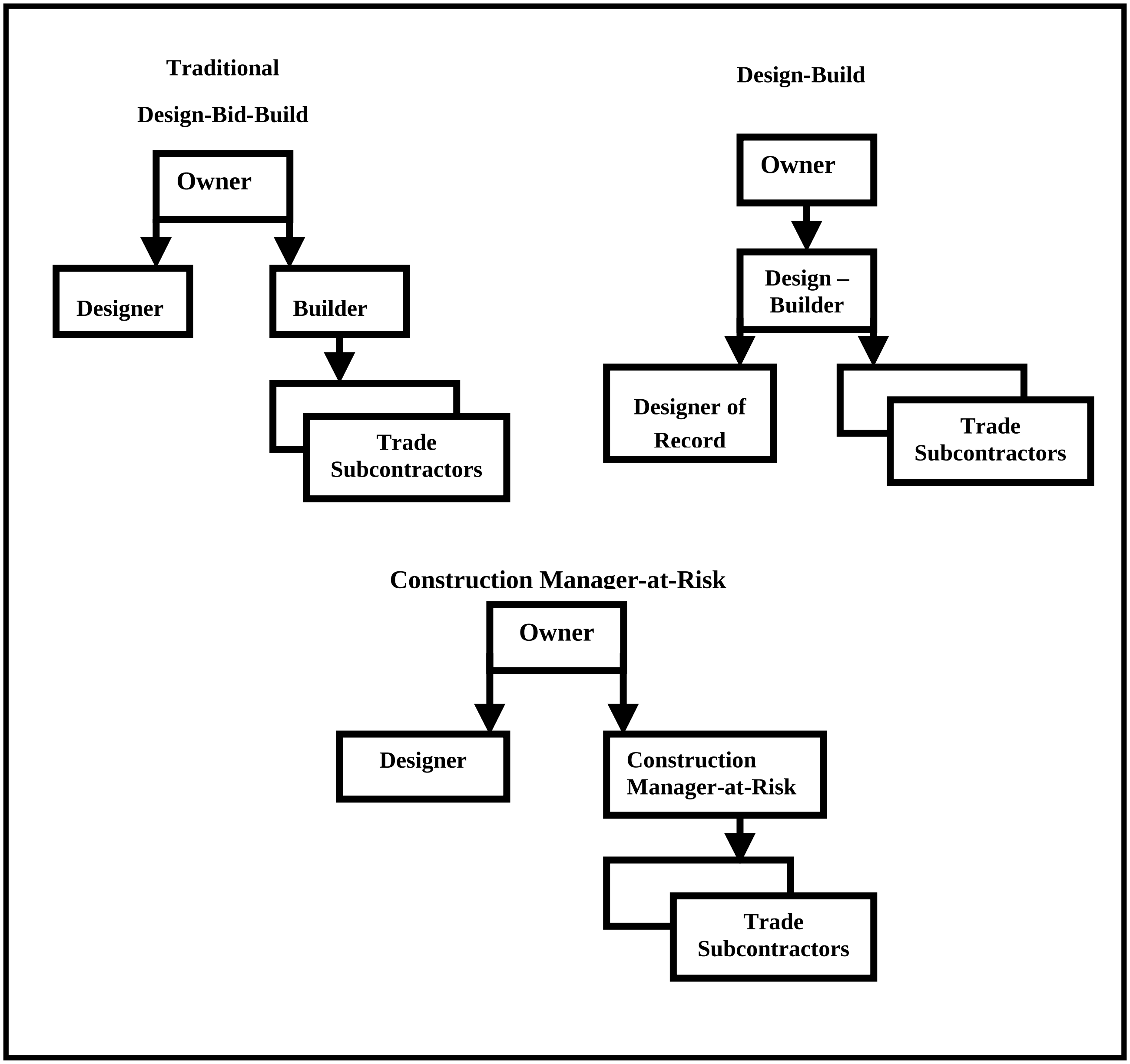
Design-Build (DB) is a project delivery method in which the owner procures both design and construction services in the same contract from a single, legal entity referred to as the design-builder. The

[13] M. A. Ellicott, "Best-value Contracting," Proceedings, Area Engineers Conference, TransAtlantic Division, U. S. Army Corps of Engineers (1994): 7.
[14] J. Bordelon, "Alternative Contracting Program-Preliminary Evaluation," Florida Department of Transportation (1998).

method uses Request for Qualifications (RFQ)/Request for Proposal (RFP) procedures rather than the DBB Invitation for Bids (IFB) procedures. There are a number of variations on the DB process, but all involve three major components. The owner develops an RFQ/RFP that describes essential project requirements in performance terms. Next is the evaluation of offerors' proposals, and finally, with evaluation complete, the owner must engage in competitive negotiations leading to contract award. Appendix A provides a complete description of the evaluation process. Appendix B contains details of three methods for advertising, evaluating, and awarding DB contracts. These seem to represent the best practice in this area, based on a study completed by the author for the State of Texas.

Figure 1 illustrates the difference between DB, DBB, and CMR.

Figure 1: Project Delivery Methods



Other states have successfully implemented innovative construction contracting practices and found that both time and money can be saved. In 1996, the Design-Build Institute of America (DBIA) surveyed the Offices of the Attorneys General of all 50 states and the District of Columbia. The purpose of the study was to "benchmark the acceptance and use of alternative and innovative contracting methods permitted by state governments."[15] There were 27 states that reported that Design-Build contracting (DB) was a permissible procurement mechanism. Only nine states had laws that expressly forbade DB. Of the states that did not permit DB, four reported that it was possible to use a DB subcontractor. Forty-five states reported that they are required to select architect/engineer services through a qualifications-based process, and 48 stated that they were required to award construction contracts that do not include design by competitive bids. Finally, 29 states reported that they employ contracting methods other than Design-Bid-Build (DBB) to procure projects.

A recent study by the Construction Industry Institute (CII) comparing the DB, DBB, and CMR project delivery methods showed that DB projects increased quality and minimized both cost and time growth. Details of the CII study show that DB projects cost 4.5 percent less than CMR projects and 6 percent less than DBB projects. DB projects were delivered 23 percent faster than CMR and 33 percent faster than DBB projects, and finally, using a quality scoring system devised to measure owner satisfaction, DB projects had the highest rating of the three delivery methods.[16]

When this information is taken along with information collected by the Federal Highway Administration (FHWA), an interesting picture emerges. Only 21 out of 50 state Departments of Transportation (DOTs) are currently using Design-Build to procure highway and highway-related projects, and the FHWA has approved DB projects in the following states: Alabama, Alaska, Arizona, California, Colorado, Florida, Georgia, Hawaii, Indiana, Maine, Maryland, Michigan, Minnesota, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, South Carolina, Utah and the District of Columbia.[17] The geographic dispersion of the states that have adopted DB covers virtually the entire country. No specific region seems to either espouse or reject DB.

The Florida DOT reported that it saw an award cost increase on DB projects of 4.59 percent, but this was more than balanced by a post-award cost growth of only 1.99 percent compared to the traditional DBB project cost growth of 8.78 percent.[18] Thus, the total growth on Florida DB projects was 6.58 percent, roughly 2 percent lower than on DBB projects. Florida also reported time savings of 21.1 percent

[15] "Survey of State Engineering and Architecture Boards on Design-Build (Combined Design and Construction Contracting)," Design-Build Institute of America (DBIA), Washington, D.C. (1997): 6-35.
[16] M. Konchar and V. Sanvido, "Comparison of U.S. Project Delivery Systems," *Journal of Construction Engineering and Management* (1998): 435-444.
[17] "Design-Build: FWHA's Role in the Design-Build Program Under Special Experimental Projects No. 14 (SEP-14)," Federal Highway Administration U.S. Department of Transportation, Washington, D.C. (1996); DBIA Dateline (January 1999): 7.
[18] State of Florida, Department of Transportation Executive Committee Agenda Request, Design Build Procurement and Administration, State of Florida: Procedure Number 625-020-010-a (1996).

on construction and a total project (design through construction) delivery time savings of nearly 54 percent.[19]

The experience of the federal government is also pertinent to this discussion. The Department of the Navy reported a 15 percent savings in DB project cost and a 12 percent reduction in facility delivery time over DBB projects. The Department of Defense Non-Appropriated Fund projects showed savings of 18 percent in costs and 14 percent in time.[20] A study of 209 Department of Defense projects showed that DB projects had 33 percent fewer change orders due to design deficiencies than projects procured in the traditional method.[21] These savings are significant in that they are for vertical projects, whereas the Florida DOT results were for horizontal projects. Vertical projects have a higher potential for savings through the use of innovative procurement practices than horizontal projects because there is much more room for technological innovation and creative design solutions. For example, most engineers will produce a similar solution when designing a highway rehab project, whereas every architect will have his or her own design approach for a new building.

CONTRACT DELIVERY METHOD BIAS

The definition of success for a public construction delivery method is its ability to form a contract with a bias toward quality, cost control, and timely completion. Legislation that forms the basis for public contracts must be cognizant of the bias established by legal restrictions. A bias toward quality is a contractual environment that rewards a contractor for furnishing more than the minimum level specified in the advertised contract. DBB uses the completed design to specify the minimum level of quality. Industry then bids on furnishing those minimums, and the only available method to increase profit margins is to furnish lower quality materials or cut corners on workmanship.

CMR generally follows the same pattern. Once the owner has selected the CM, that entity will then analyze the owner’s minimum requirements as defined by the designer’s plans and specifications and develop the required documentation for construction subcontractors, who then are in the same position as a straight DBB contract. On the other hand, both DB and BVC form the contract-defined level of quality with contractor involvement. DB contains the greatest bias toward quality by allowing the contractor to propose the design and measuring it against owner-defined performance criteria. BVC creates the quality bias through an award system that increases the probability that a well-qualified contractor will be selected. With BVC, the contractor has an incentive to furnish high-quality personnel and materials and

[19] R. D. Ellis, Z. Herbsman, and A. Kumar, “Evaluation of the FDOT Design/Build Program,” Final Report, No. 99700-7435-010, Submitted to the Florida Department of Transportation, Department of Civil Engineering, University of Florida, Gainesville, Florida (1991).
[20] “Survey of State Engineering and Architecture Boards on Design-Build (Combined Design and Construction Contracting),” Design-Build Institute of America, Washington, D.C. (1997): 6-35.
[21] J. Pocock, “Comparison of Traditional, Traditional with Partnering and Design-Build Project Performance,” Doctoral Dissertation, Department of Civil Engineering, University of Illinois, Champaign, Illinois (1997).

price the project at the point at which it offers the best value to the owner. Finally, A+B bidding furnishes a bias toward quality by releasing the contractor from low-bid, fixed-period projects and allowing contractor-proposed contract working days.

With regard to cost control, in DBB the contractor is tempted to under-price the basic contract in order to get the award and then try to make up profit margins by generating change orders and claims. This situation does not exist in the other four project delivery methods. The CMR is responsible for controlling total cost within the guaranteed maximum price. Both DB and BVC allow the contractor to control some if not all details of design and thereby promote cost control.[22] A+B Bidding links price and time in the bid, controlling costs better than under DBB. Finally, DB, BVC, and A+B Bidding use time as a factor for award, which promotes a bias toward timely completion.

III. Comparative Empirical Analysis

Once a method for project delivery is selected, its impact on project life cycle costs should be assessed. For this analysis, project life cycle is defined as the period spanning from project formulation to construction completion. Project life cycle costs are those costs incurred for completion of a feasibility study, final design, and construction.[23]

Figure 2 illustrates the project life cycle of a typical Massachusetts public project. Once the legal constraints are known, one can look for those points in the process that inhibit timely or cost-efficient project progress. These points are easily identifiable, as all project processes must flow through them; when project tasks backup, options for completing the project are markedly reduced.

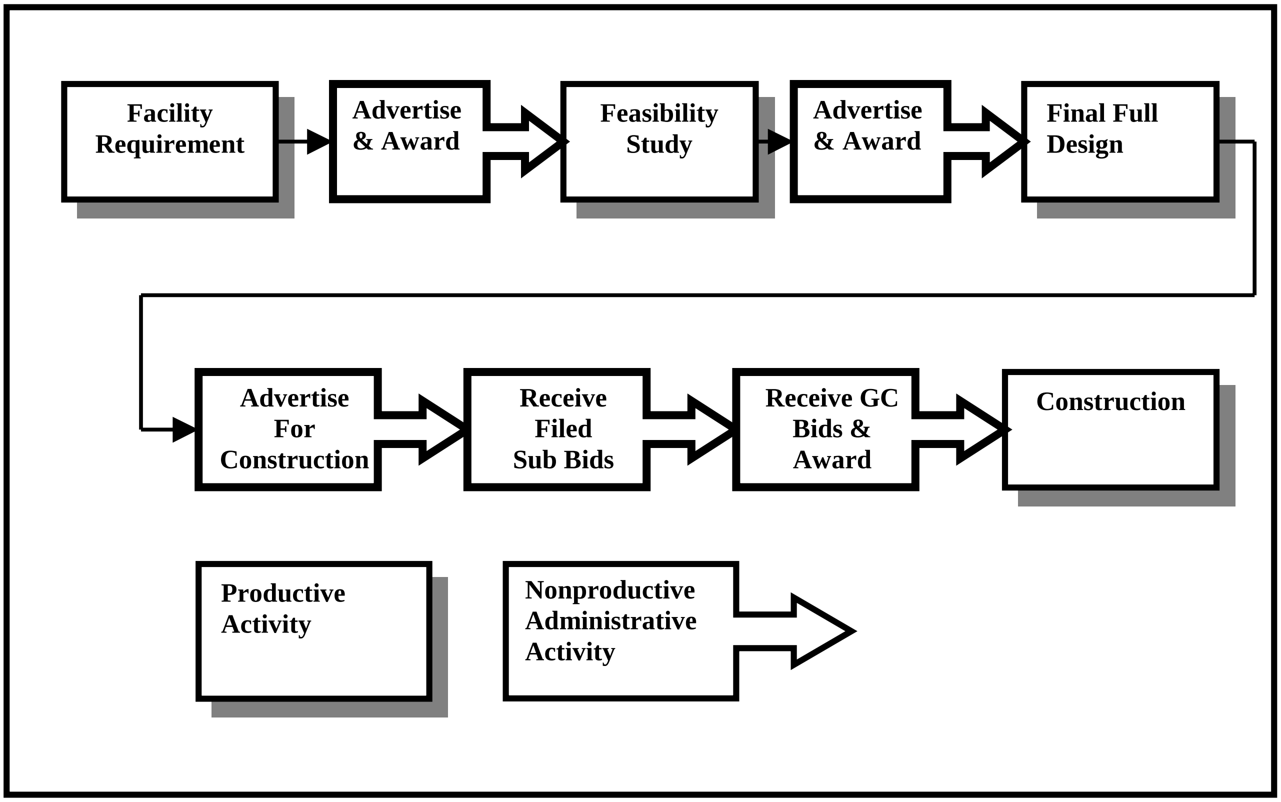
Figure 2 shows two bottlenecks in the Massachusetts procurement process. The selection of a design consultant is constrained with respect to the consultant that completed the feasibility study. By requiring a new consultant to complete the design, additional time is added to the process while the new consultant gets up to speed on the project's requirements and peculiarities. Contracting for two pieces of the same project separately also eliminates the possibility of achieving a lower overall price by giving a single consultant a larger contract. BNI's *Public Works Costbook* shows that as the amount of the design contract goes up, the consultant's fee goes down on a percentage basis.[24]

A second bottleneck is created by the requirement for filed subcontractor bids, which can add either cost or time to the project delivery process. First, a stand-alone design package must be prepared for each trade subcontractor's bid. This not only adds cost and time to the design process, but may also increase the probability of design errors that must be corrected by change orders. It also puts the owner in

[22] M. Konchar and V. Sanvido, "Comparison of U.S. Project Delivery Systems," pp. 435-444.
[23] It should be noted that the period after construction completion, called the design life of the facility, is normally included in the project's life cycle. Decisions made during concept, design, and construction can greatly affect the cost to operate and maintain a given facility. These factors are beyond the scope and range of this study.
[24] William D. Mahoney, *Public Works 1997 Costbook,* pp. 1-2.

a position of having to coordinate the details of design between subcontractors. This increases the risk of design performance and the potential for change orders.

Figure 2: Massachusetts Vertical Public Project Life Cycle



THE MODEL

The impact of these systemic constraints should be measurable by a straightforward project cost and time performance model based on Cost Index Number Theory (CINT). CINT is a variant of basic Utility Theory that seeks to measure the difference between two alternatives by reducing salient performance parameters to an index based on a common dimensional unit.[25] Typically, the cost index is a function of value and capacity, while the time index is often a function of time and capacity. However, CINT is flexible enough to allow the analyst to select a common dimensional unit that best portrays the critical relationships under analysis. The basic idea is to focus on the differences between various alternatives' indices rather than on discreet measurements of value or time. Any trends that exist become more evident, and conclusions can be drawn as required.

Several indices are required for an authoritative comparative analysis. The construction industry already recognizes several of these as standard metrics to measure project performance.

1) Cost Growth (CG) measures the percentage increase of a construction contract amount from its award price to the total final price. The total final price is normally the original contract amount plus or minus the value of any change orders that occur during the period of the contract.[26]

2) Time Growth (TG) measures the increase or decrease in a contract's life.[27] Construction contracts will normally have a finite period of execution that sets the schedule for project delivery. Contract time must change as project scope changes. Typically, TG and CG are directly proportional.

3) The Engineer's Estimate (EE) is developed before the project is advertised and tells the analyst how much the owner thought the project would cost. In public works, the funding cycle is often based on such estimates.

4) Award Growth (AG) is the difference between the value of the EE and the AC (i.e., the award cost or industry's estimate of project cost tempered by competitive market forces). Award Cost is used to measure the change in project financial expectations.[28]

The next set of indices is based on the concepts of earned value and dollar placement. Earned value is the yardstick used by nearly all public owners to make periodic partial payments to contractors for work satisfactorily completed. It measures the speed with which a contractor can earn the full contract amount.[29] Dollar placement is the average earned value over a specific portion of a project's life cycle. While earned value is normally not applied to design contracts in industry, the concept can be extended in this study as a means of measuring design contract performance in terms of a cost/time index.

Three metrics relating to dollar placement are used:

1) Design placement (DP) is the average daily cost of a design contract.[30]

2) Construction placement (CP) is the average rate at which the construction contractor earns value over the entire period of the construction contract.[31]

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[25] J. L. Riggs and T. M. West, *Engineering Economics*, Third Edition (New York: McGraw-Hill, Inc., 1986): 781-789.

[26] Cost growth is expressed by the following equation: CG = (FC – AC)/AC, where CG = Cost Growth (percent), AC = Award Cost ($), FC = Final Cost ($). If CG is high, several inferences can be made. In a DBB project, the quality of the design could be poor, requiring numerous change orders to correct design errors and deficiencies. This can be particularly critical in a low-bid award project in which a contractor has made a bidding mistake and must make up the monetary loss by inflating change orders or promulgating claims for perceived scope changes. A high CG could also indicate a major unforeseen site condition that gravely affects the contractor's production. Generally, these types of problems arise from inadequate site investigation by the designer during the design phase. A negative CG (i.e., the final amount is less than the original amount) indicates that the owner failed to scope the magnitude of the project properly and tied up working capital unnecessarily. While it is always desirable to complete a project below its estimated budget, committing unneeded funding to a project reduces the total benefit to the taxpayer when taken in the context of an agency's entire capital improvement program.

[27] TG is expressed as follows: TG = (FT – OT)/OT, where TG = Time Growth (percent), OT = Original Contract Time (days), FT = Final Contract Time (days).

[28] AG = (AC – EE)/AC, where AG = Award Growth (percent), EE = Engineer's Estimate ($), AC = Award Cost ($).This metric furnishes an interesting view of the government's ability to forecast the cost of capital improvements. As a project proceeds from concept to completion, the owner's commitment to actual delivery gets greater and greater. If the owner underestimates the project's cost in early stages, that owner is liable to be more willing to pay an inflated price for the project as it draw closer to fruition. It is very important that the owner be able to develop a good cost forecast immediately after design is complete so that a project that is marginally feasible is not awarded for construction. A high AG indicates the potential that a public agency will build projects that are economically unjustified merely because a public commitment to project delivery has been made.

[29] F.E. Gould, *Managing the Construction Process* (New Jersey: Prentice Hall, 1997): 289-295.

[30] DP = DC/DT, where DP = Design Placement ($/day), DC = Design contract cost ($), DT = Design contract time (days).

3) Design-construct placement (DCP) is the sum of the design contract and the construction contract divided by the total time period between the start of the design contract and the completion of the construction contract.[32]

DCP measures not only the aggregate of design and construction but also the impact of the period between the two phases during which the project is advertised and awarded. This is a particularly interesting metric in that it allows the analyst to draw inferences about the efficiency of the regulatory requirements surrounding the project's award.

Placement tends to work in an opposite fashion to CG or TG. A high rate of construction placement indicates an efficient and effective construction management system. If two contractors were doing identical lump sum projects in identical environments, the one that finished first would have incurred the least cost, and this would be indicated by a higher rate of CP. The same concept can be applied to designers. The owner's ability to manage both design and construction can be measured by DCP using the same theory. The U.S. Army Corps of Engineers uses CP as one of its fundamental project performance parameters and has more than 30 years of experience with its use.[33]

The final set of metrics is based on the cost to furnish a single unit of capacity in a given class of facilities. For vertical projects, the most appropriate measurement is cost per square foot of finished facility. Only public building projects were selected for use in this analysis. The cost per linear mile of highway was selected for horizontal projects. Only highway construction, rehabilitation, and surface treatment projects were selected for this part of the analysis. For vertical projects, this is a very valuable metric because data of this nature are collected on a national basis by several well-respected organizations. Typically, this type of data is used to complete conceptual estimates. A number of large public agencies (the Naval Facility Engineering Command and the U.S. Air Force, for example) use the database maintained by R. S. Means Company of Kingston, Massachusetts, routinely to develop programming level estimates for large vertical construction projects.[34] Thus, the analyst is able to use these databases to compare costs in one state directly to the same types of costs in another state. This is done by adjusting actual projects in each state by an updated locality factor contained in the estimating manuals.[35] These data contain separate information on design fees and are collected specifically for public buildings, making the comparison even stronger.

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[31] CP = FC/CT, where CP = Construction Placement ($/day), FC = Final construction contract cost ($), CT = Construction Time (days).
[32] DCP = (DC+FC)/DCT, where DCP = Design-construct placement ($/day), DC = Design Contract cost ($), FC = Final construction contract cost ($), DCT = Design-construct time (days).
[33] U.S. Army Corps of Engineers, Engineer Regulation 1180-1-173, "Design-build Instructions (DBI) for Military Construction," Washington, D.C. (1994).
[34] P. L. Jackson, "Means Square Foot Costs," R. S. Means Company, Inc., Kingston, Massachusetts (1997).
[35] Ibid., p. 415-421. These locality factors allow each state's costs to be normalized to account for local differences in the construction industry, such as union labor and short construction seasons. The actual costs of a union labor state like Massachusetts with a severe winter can be directly compared to a right-to-work state with a 12-month construction season like

THE DATA

In light of the above discussion, the states of Florida, Indiana, and Texas were selected based primarily on the availability of data. However, these states make good benchmarks against which to measure Massachusetts' public construction programs because, with the exception of Florida which has the study/design restriction, none of them have the two previously mentioned "bottlenecks" in their procurement legislation. Florida has actively experimented with alternative project delivery systems, such as Design-Build and A+B Bidding.[36] Thus, its project performance demonstrates the potential available to Massachusetts. Indiana provides a basis of comparison with a state that has both union labor and a severe winter. It also has adopted A+B Bidding.[37] Texas has very restrictive procurement laws that prohibit the use of many innovative project delivery systems.[38] Using the locality factors to normalize project performance data, a comparison can be made directly with Massachusetts on a large number of projects delivered using traditional DBB. Texas implemented Partnering on its DBB projects on a wide scale in 1992.[39] Thus, its results can be used to indicate the potential benefit of trying this business practice.

The primary aim of the data collection phase of this study was to maximize the number of projects on which project performance data were collected. The ideal situation would have been to collect exactly the same set of data for every project in every state. This proved impossible. However, it is possible to use the largest complete data set for each parameter to make comparisons between states by assuming that the confidence with which each inference is made varies directly with the population size in a given set of data. A conclusion reached by looking at 200 projects can be made with greater confidence than a similar conclusion made by looking at 20 projects. The population size used to make specific inferences is noted in each table.

Based on the report of the Construction Reform Task Force, the desired set of data points for each project was as follows:

1. Date project was formally formulated.
2. Date project was advertised for design.
3. Date project was advertised for construction.
4. Original contract completion date.
5. Actual contract completion date.
6. Original estimated design cost.
7. Actual design cost.
8. Original estimated construction cost.
9. Original construction contract amount.

Texas. This filters out fundamental differences and permits inferences regarding the impact of local public procurement constraints to be made with confidence.

36 R. D. Ellis, Z. Herbsman, and A. Kumar, "Evaluation of the FDOT Design/Build Program," (1991).

37 D.F. Runde and Y. Sunayama, "Innovative Contractor Selections Methods," (1999): 16.

38 J. Wright, "Texas Department of Transportation Design/Build Contracting," Legal Brief, Office of General Counsel, Texas Department of Transportation, Austin, Texas (1997).

39 D. D. Gransberg and H.L. Reynolds, "Quantitative Analysis of the Partnering Plus Program," Texas Department of Transportation, Research Report TX-97/0-1729-2R (1998). See appendix A for a definition of partnering.

10. Actual final construction contract amount.
11. Number days liquidated damages.
12. Cost of liquidated damages.

These data points illustrated the salient milestones and values inherent to the typical public project's life cycle. They also captured the two legislative constraints of interest to the study. As the effort moved on, it was found that there was no uniform project formulation date. It was decided to substitute the date that a feasibility study was awarded to start the clock on project life. It was also found that the issue of liquidated damages differs greatly between vertical and horizontal projects. Some agencies seem to have an unwritten policy to assess liquidated damages as a last resort. Therefore, the decision was made to drop the last two data points and end the project's life cycle on the final completion date.

Construction data from the Departments of Transportation in Florida (FDOT) and Indiana (IDOT) were immediately available in a thesis recently completed by Dan Runde and Yutaka Sunayama at Harvard's Kennedy School of Government.[40] The author also had a large amount of Texas Department of Transportation (TxDOT) construction data from a study completed in 1997.[41] Coordination was made with officials in each of those states to collect the remaining life cycle data. Both vertical and horizontal data were collected in 10 Commonwealth of Massachusetts construction agencies.[42]

Construction data were collected on 926 Massachusetts projects worth a combined total of $1.1 billion. Design data were available on 103 projects, and a complete set of life cycle data was found on 79 projects worth over $810 million. Data for 29 Florida projects worth $242 million and 29 Indiana projects worth $315 million were also used. The Texas database contained 404 projects worth over $2.1 billion. A review of the literature indicates that this may be the largest database ever used to complete this type of study. The two largest previous studies contained 351[43] and 218[44] projects respectively.

THE ANALYSIS

The results of the Cost Growth analysis are shown in figure 3. The results have been broken down by state and by vertical and horizontal projects. One can see that CG on Massachusetts projects is greater than that experienced by other states. Because CG is a relative value, it filters out local industry variations. It is particularly interesting to note that Indiana, which has both union labor and a severe winter, had the lowest contract cost growth. This is attributable to the use of an innovative project delivery method, in this case, A+B Bidding.

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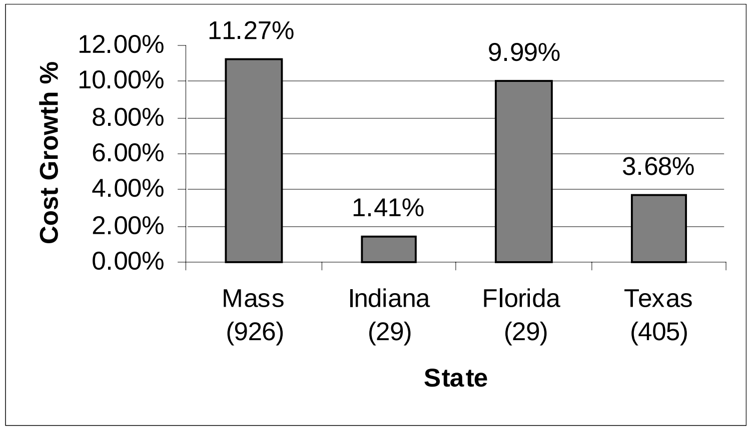
[40] D. F. Runde and Y. Sunayama, "Innovative Contractor Selections Methods," (1999): 16.
[41] D. D. Gransberg and H. L. Reynolds, "Quantitative Analysis of the Partnering Plus Program," (1998).
[42] Massachusetts Highway Department, Massachusetts Port Authority, Massachusetts Bay Transit Authority, Department of Capital Assets Management and Maintenance, Massachusetts State College Building Authority, Department of Education (School Construction), Massachusetts Turnpike Authority, Central Artery/Tunnel Project, and Massachusetts Water Resources Authority.
[43] M. Konchar and V. Sanvido, "Comparison of U.S. Project Delivery Systems."
[44] J. Pocock, "Comparison of Traditional, Traditional with Partnering and Design-Build Project Performance."

Figure 3: Average Cost Growth Analysis



Breaking the A+B projects out from the basic population yields a cost growth on Indiana Low Bid projects of 7.3 percent, which is more in line with expectations. The cost growth on A+B projects was –14.1 percent, which means they were completed under budget. For the Texas projects, those that were completed using Partnering had about 1 percent less cost growth, and for the projects whose value exceeded $5 million, the partnered projects outperformed the nonpartnered projects, with more than 2 percent less cost growth. These are good examples of the potential benefits of enacting legislation that permits innovative project delivery methods to be utilized.

Figure 4: Average Time Growth Analysis

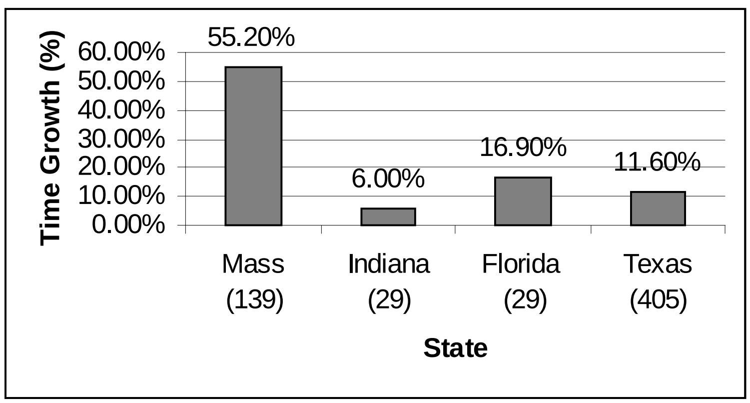


Figure 4 shows the results of the Time Growth analysis. It can be seen that the Commonwealth is experiencing a much greater degree of contract time growth than the other states. In this case, it is particularly dramatic with time growth nearly five times that of Texas, the state with the largest population of projects in the sample. Time growth is generally coupled with cost growth, and this rule holds true in the comparison with Texas. Massachusetts has more than three times the cost growth coupled with nearly five times the time growth. Again, we can make the more direct comparison with Indiana by removing the A+B projects; the Indiana Low Bid projects had an average time growth of 16.5 percent. Doing the same for Florida yields a Low Bid time growth of 33.5 percent. Finally, pulling out the Texas Partnered projects gives it a Low Bid time growth of 16.4 percent. A weighted average time growth for the three states yields an average Low Bid time growth of 17.9 percent.

As the main difference between the four state project delivery systems appears to be the legislative constraints, an inference can be made that the regulatory environment creates a contract administration system that is favorable to both cost and time growth. Using the same weighted average for cost growth, one gets a three-state average of 3.9 percent cost growth or about 7.4 percent less than Massachusetts. Extrapolating this to the Commonwealth's $3-billion annual construction budget would indicate that changing the regulatory environment could potentially save approximately $220 million per year.

Figure 5: Award Growth Analysis

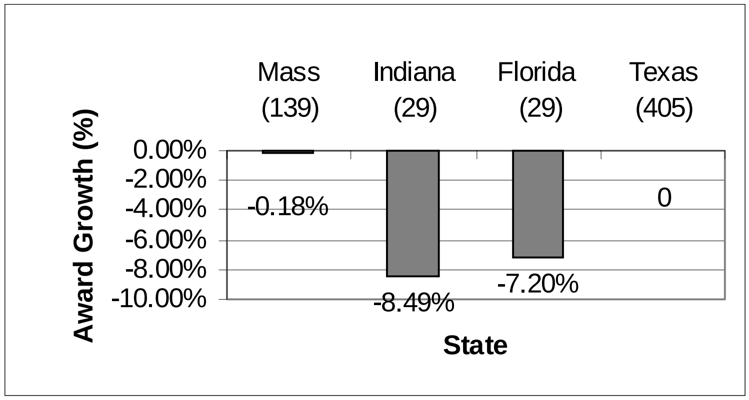


Figure 5 shows the outcomes for the Award Growth analysis. Award Growth is important because it measures the way in which available public funding is committed. If an agency consistently overestimates its construction costs, it will be tying up funding and preventing it from being used on other projects. This is particularly critical in areas where fiscal year constraints foster a "Use it or Lose it" cost accounting system. This is not a problem in the Commonwealth, as agency estimates are very close to construction award amounts. This may become a problem, however, if the agency estimate is intended to include a contingency for changes during construction. This is the case in Indiana and Florida. (No estimate data were available in Texas.) If one balances Indiana's negative award growth with its positive cost growth, it can be seen that Indiana is tying up about 7 percent too much money in its contingency. Florida, on the other hand, is about 2.8 percent short. Unexpected cost growth creates turmoil inside the system as managers scramble to find funding for ongoing projects, which often creates delays on other projects. The impact of these types of delays can be found by measuring both design and construction placement.

Table 1 shows how the Placement analysis came out for each state. The three types of placement—design, construction, and design-construct—are shown and illustrate the impact of regulatory procurement constraints. An efficient, well-managed project will have a high placement rate. In other words, a project with an error-free design and strong, positive relationship between and among the general contractor and subcontractors will be able to earn value at the maximum rate allowable by the physical constraints of the project. A project plagued by change orders and whose business relationships are defined legalistically will have three project performance indicators: high cost growth, high time growth, and low construction placement.

Looking at table 1 and comparing Massachusetts to Texas to maximize the sample size, one sees that construction placement in Massachusetts is roughly half of what it is in Texas. This is a very telling comparison because of the climate difference in the two states. Texas' effective construction season is almost twice as long as Massachusetts. Thus, it would be expected that Massachusetts construction placement would be higher than in Texas because the time available (i.e., the number in the denominator) is smaller. However, this is not the case. The difference is even more drastic when one considers the normalized construction placement.

Table 1: Placement Analysis Results

	Massachusetts	Indiana	Florida	Texas
Total Average Design Placement	$1,752/day [$1,637/day][a]	$752/day [$817/day]	$474/day [$564/day]	$159/day [$199/day]
(N)	(86)	(22)	(13)	(362)
Total Average Construction Placement	$10,595/day [$9,902/day]	$58,831/day [$63,946/day]	$16,974/day [$20,207/day]	$19,374/day [$24,218/day]
(N)	(138)	(29)	(13)	(405)
Total Average Design-Construct Placement	$4,235/day [$3,958/day]	$16,785/day [$18,245/day]	$7,913/day [$9,420/day]	$6,517/day [$8,146/day]
(N)	(86)	(22)	(13)	(362)

[a] Bracketed figures are normalized using an average of location factors developed by R.S. Means Co. in P. L. Jackson, “Means Square Foot Costs,” R.S. Means Company, Inc., Kingston, Massachusetts (1997):428-432. Massachusetts = 1.07; Indiana = 0.92; Florida = 0.84; Texas = 0.80.

The analysis of design placement differs from construction placement. It generally takes the same amount of design effort to produce the design regardless of location. The difference between localities is in the form and format of the documents necessary to proceed to construction. In this case, those projects governed by Chapter 149 and requiring filed subcontractor bids may have a higher design cost. The requirement that the architect/engineer produce the final documents in a manner that permits multiple, stand-alone design packages for each subcontracted trade adds cost.

Combining the design cost and the final construction cost and dividing by the time between design start and construction finish allow the analyst to measure the impact of the advertise and award period along with both placement parameters in a single metric. This gives the benefit of the doubt to a project delivery system that deliberately spends more time on design as a means of controlling construction cost growth. This metric is analyzed in the same manner as construction placement with a higher value indicating a more efficient system. As before, the Commonwealth’s values show it to be less efficient than the other three states.

Table 2 shows the results of the Unit Cost analysis for vertical projects. The values shown for Florida, Indiana, and Texas come from the literature.[45] The bracketed value is the normalized value for Massachusetts and should be used to compare with the figures shown for the other states. It can be seen that both design and construction unit costs are higher in Massachusetts than in the other states. This

[45] William D. Mahoney, *Public Works 1997 Costbook,* pp. 1-2.

confirms the suspicion that the two previously identified "bottlenecks" are having an impact on public project delivery costs in Massachusetts.

Table 2: Unit Cost Analysis Results for Vertical Projects
(in dollars per square foot)

	Massachusetts	Indiana[a]	Florida[a]	Texas[a]
Design Unit Cost	14.65 [13.69][b]	9.98	8.99	8.88
Construction Unit Cost	216.17 [202.03]	142.51	128.41	126.85
Design-Construct Unit Cost	230.82 [$215.72]	152.48	137.40	135.73

[a] Unit costs from William D. Mahoney, *Public Works 1997 Costbook*, BNI Building News, Boston, Massachusetts (1997): 437-438.

[b] Bracketed figures normalized using locality factor to match other states' costs.

Table 3 depicts the change in unit costs over the project life cycle in Massachusetts. The estimated unit cost comes from the design and can be used for programming funding for construction. The award unit cost is based on the successful bid, and the completed unit cost comes from the final contract amount. It can be seen that industry is awarded a vertical project at 4 percent more than the estimated amount, and the projects are being completed at 28 percent more than originally estimated. This indicates that not only are public agencies underestimating the actual cost of public vertical projects, but they are also unaware of the problems hidden inside the contract design and construction documents that lead to change orders and cost growth.

Table 3: Massachusetts Change in Unit Costs During Life Cycle for Vertical Projects
(in dollars per square foot)

	Estimated Unit Cost	Awarded Unit Cost	Completed Unit Cost
Massachusetts	168.88	175.69	216.17

Unfortunately, we were unable to gather comparable data from the other three states for this specific piece of the analysis, so no authoritative assertion can be made. However, the trend is clear in the Massachusetts data. These can be compared with estimating manual data for Boston, Massachusetts.[46] Assuming a public school building to conform to the composition of the sample data, a range between $112.90/SF and $151.50/SF is found for a size range of 71,470 SF and 168,000 SF respectively. Adjusting these values by the Boston locality factor of 1.07, gives a range of $120.80/SF and $162.11/SF. School data were collected from two agencies. One of those agencies had been released from the routine procurement constraints for four of its projects. Those four projects were designed and built for an average unit cost of $135 to $150/SF,[47] furnishing an average of 168,000 SF per project. The remaining 17 school projects in the database cost an average of $323.80/SF and furnished an average of 71,470 SF

[46] P. L. Jackson, "Means Square Foot Costs," pp. 428-434.

per project. The fact that the four projects not subject to the procurement system bottlenecks were completed at an average unit cost less than the estimated unit cost demonstrates the potential benefit that can be accrued by the Commonwealth of Massachusetts through construction procurement reform.

IV. Conclusions and Recommendations

A number of conclusions can be made with regard to the cost of an unreformed construction procurement process in the Commonwealth of Massachusetts. First, the data support the assertion that the net effect of restrictive procurement legislation is to increase both the cost and the time it takes to deliver a public facility. Massachusetts project performance was consistently the worst of the four states studied. Projects in the Commonwealth showed all the indicators of a less efficient project management environment: high cost growth, extremely high time growth, and low construction placement. The results echo the findings of the Construction Reform Task Force and support the call to reduce restrictions on procurement practices.

The Ward Commission was on the mark in its recommendation to rid the system of the filed sub-contractor bidding process. The system of filed sub-bids destroys the construction industry's ability to form long-term strategic partnerships between general contractors and their subs. These types of relationships reduce performance risk to the general contractors and translate directly to reduced construction costs to public owners. The unit cost data for vertical projects illustrate the result of the filed sub-bid system. When the unit cost for public schools delivered without filed sub-bids ($150/SF) is half the cost of one delivered with the system ($324/SF), the value of this restriction must be seriously questioned. The same system seems to be driving up the cost of design as shown by the design placement analysis and increasing the cost of change orders as shown by the cost growth analysis. Finally, it needlessly stretches out the length of the procurement cycle as shown by the 55 percent time growth result.

On the other hand, maintaining the Ward Commission's insistence on separating the study designer from the final designer will continue to have a negative effect on project performance in the Commonwealth. Not only does it add an administrative step, it increases the cost of the design work by eliminating any economies of scale that could be achieved by procuring the study and the final design in the same contract. This fact is borne out by the design unit cost analysis—Massachusetts' unit cost was roughly 50 percent higher than those estimated for the other three states.

The empirical evidence clearly falls into line with the literature on this subject, further demonstrating that the alternative project delivery methods in use around the nation are working to reduce

[47] Linda Snyder, review note, July 1999.

project delivery times and costs significantly.[48] The study found samples of both A+B Bidding and Partnering in each of the three states used for comparison. In the paper by Runde and Sunayama, A+B Bidding was found to reduce cost growth by 21.4 percent in Indiana and a less spectacular 5.8 percent in Florida. It also reduced time growth, by 37.9 percent in Indiana and 19.1 percent in Florida. Finally, it cut the average number of change orders in each state. In the TxDOT Partnering study, partnered projects with a value of $5 million or more out-performed non-partnered projects in every category. Partnered projects had marginally less cost growth, project time growth was negative (i.e., they were completed ahead of schedule), and non-partnered project time growth was positive. Finally, partnering projects virtually eliminated construction claims.

The comparative empirical analysis supports the conclusion that legislation is required to free public agencies from burdensome restriction on construction procurement. The following recommendations echo those made by the Task Force:[49]

1) Make legislative changes that would allow agencies to employ a construction delivery method appropriate to the project. If specific expertise is required, contractor selection should be based on demonstrated performance and price. If saving time is a priority, the process should balance price and the promise of timely delivery. Construction-manager-at-risk and partnering should be available options for certain projects as well.

2) Provide for the creation of incentives for individual contractors to minimize change orders, pursue cost savings, or deliver ahead of schedule.

3) Draw on standard industry practices to improve the quality of initial design and of the completed project. For vertical construction projects, lift the restriction and allow the same designer to perform both the feasibility study and final design. For horizontal construction projects, expedite project delivery and lower costs through the use of statewide or regional design contracts.

The Task Force report cites five projects that were successfully completed using alternative project delivery systems. Adding the Shurtleff and Chelsea School success to that group provides a vision for the future of public construction project delivery in Massachusetts. Other states and public agencies are successfully implementing the alternative project delivery methods discussed in this study. Public construction contract administrators must have the flexibility to customize the delivery methods to the unique needs of each individual project. The Commonwealth should develop a project delivery toolbox with sufficient tools to meet its needs for public construction. All the proper tools are available for immediate implementation. The Commonwealth only needs the political will to change the status quo and

[48] D. D. Gransberg and M. A. Ellicott, “Best Value Contracting Criteria,” *Cost Engineering, Journal of the American Association of Cost Engineers International,* 39 (6) (1997): 31-34; M. A. Ellicott, “Best-value Contracting” (1994): 7; J. Pocock, “Comparison of Traditional, Traditional with Partnering and Design-Build Project Performance” (1997); M. Konchar and V. Sanvido, “Comparison of U.S. Project Delivery Systems,” (1998): 435-444.
[49] See Final Report, Construction Reform Task Force (1998), pp. 9-18.

step out and create a procurement process with a bias toward quality, timely delivery, and cost-effectiveness.

APPENDIX A: PROJECT DELIVERY METHODS

Design-Bid-Build

In DBB, "responsive" means that the bidder has properly completed the required bid forms and posted the requisite bid security. "Responsible" normally means that the low bidder can post the required performance bond within the established award timeframe. In this method, the owner is relying on the surety industry to filter out unqualified contractors. As the owner has separate contracts with the designer and the builder, the owner essentially assumes the risk for the quality of the design during construction. Thus, if a design error is found and must be corrected, the owner must first pay the contractor for the change and then attempt to collect the added cost from the designer. While in theory this should be possible, in practice it is very difficult, particularly if the change is due to a difference of professional opinion between the owner and the designer.

Construction Manager-at-Risk

CMR permits the owner to reduce the total costs of profit and overhead accumulated within a single contract. This is its greatest virtue over DB. In a DB contract, the design-builder will mark up all subcontracts with its own overhead and profit margins. The owner ends up paying several levels of marked-up burden. In CMR, most players subcontract directly with the CM. Thus, the owner only sees a single layer of marked-up margins.

Despite some advantages, CMR has several disadvantages for the public owner. First, the CMR can be a very small organization created solely for the purpose of completing a specific project. This is not always the case. However, if this is the case and problems arise after project completion, the probability that the CMR will exist and be able to provide relief to the owner is less than in Design-Build, where the design-builder is most likely to be an established reputable company with a record of successful project completion. Therefore, the public owner must not assume that the CMR will exist indefinitely for purposes of problem rectification. Secondly, the use of a CMR does not totally eliminate the need for some level of agency technical oversight throughout the project life cycle. The fact that a well-qualified CMR has been retained tends to lull the owner into a potentially false sense of security. Therefore agencies that choose this project delivery method must also insure that provisions have been made to furnish the requisite level of oversight on the CMR.

Best-Value Contracting

BVC is an attempt to reconcile the best attributes of the qualifications-based selection with the requirement to maintain free and open competition in construction services. To award a Best-Value Contract, an owner asks for both a price/schedule proposal and a statement of contractor qualifications. Often the owner allows the price to be linked to the schedule and uses it as a means to establish a best-value decision. The contractor's statement of qualifications (SOQ) can include more than the typical designer's SOQ. One advantage of BVC is that it permits the owner the opportunity to evaluate the project safety plan, quality control/quality assurance plan, environmental protection plans, and other critical features of project success before award.[50] Certain technical items, such as specific models of major equipment and details of interior and exterior finishes, can also be requested, giving the owner additional categories to evaluate. Thus, before contract award is made, the owner substantially protects itself against future disputes by nailing down many contract details. It allows industry the flexibility to set its own schedules and base its prices on specifically approved items. Finally, the owner conducts a cost-technical trade-off analysis to identify the best value and make an award. An example of this process is detailed in table B3 in appendix B. The federal experience shows that these types of contracts minimize both cost and time growth because the owner has selected the contractor with the highest potential of successfully completing the project within the budget and time constraints spelled out in the solicitation.[51]

The US Army Corps of Engineers (USACE) pioneered the use of BVC in its Europe District in the early 1990s. An internal study of project performance had concluded that *low bid does not equal lowest final cost*.[52] The Europe District experimented with BVC on a wide range of projects in locations from Western Europe to the newly independent republics of the former Soviet Union. The results were so encouraging that USACE authorized the use of BVC without restriction by all its districts both in the United States and overseas.

Several European governments award contracts to the second lowest bid in an attempt to reduce the possibility of contractor bid errors negatively affecting ultimate construction quality.[53] The theory is that it is in the best interests of the public to select a well-qualified contractor that has been allowed some flexibility in the technical content of its proposal and the opportunity to price the contract with a bias toward quality rather than toward minimizing initial cost.

A+B Bidding

The FHWA recognized A+B Bidding in its Special Program-14 as one desirable means to break from traditional DBB award of highway projects.[54] These contracts often include an incentive clause that rewards the contractor for completing the project ahead of schedule and exacts a penalty beyond liquidated damages for completing the project late. The incentive clause enforces the spirit of the A+B method by creating a real penalty for deliberately under bidding the time component. It rewards the contractor that can most efficiently manage a project by allowing it to win the contract with a bid that is higher but accurately reflects the cost of faster completion.

[50] D. D. Gransberg and M. A. Ellicott, "Best Value Contracting Criteria," pp. 31-34.
[51] M. A. Ellicott, "Best-value Contracting," p. 9.
[52] Ibid., p. 7.
[53] D.F. Runde and Y. Sunayama, "Innovative Contractor Selections Methods," p. 18.

Table A1: A+B Bidding Example

	Construction Days	Cost per Day	Part A	Part B	A+B
Agency Estimate	Maximum-650	$6,000	$9,200,000	$3,900,000	$13,100,000
Contractor					
1 Winner	300	6,000	9,420,000	**1,800,000**	**11,220,000**
2	355	6,000	9,416,000	2,130,000	11,546,000
3	480	6,000	9,279,000	2,880,000	12,159,000
4	490	6,000	9,338,000	2,940,000	12,278,000
5	550	6,000	**9,229,000**	3,300,000	12,529,000
6	600	6,000	9,447,000	3,600,000	13,047,000
			Low Part A Bidder (Price)	Low Part B Bidder (Time)	Low A+B Bidder (Price+Time)

Source: "Alternative Contracting Program-Preliminary Evaluation," FDOT.

Design-Build

RFP development is driven by specific project requirements, and award procedures are constrained by both legal and policy restrictions. Thus, the most important piece of the DB contract is the evaluation process. The definition of success is the creation of a fair, consistent evaluation system that has a bias to select the design-builder with the highest probability of successfully completing the project to a higher level of quality than is required by the RFP.

The evaluation process for DB has three parts. First, the qualifications of the DB contractor team must be checked to ensure that the proposed designer-of-record possesses both the requisite registrations and the necessary past experience to develop a design that will meet the project's technical requirements. The DB process permits something that is not common in the construction industry—a qualifications check on the construction contractor. The second part of the evaluation is a technical review of the DB contractor's proposed design solution. This mainly consists of ensuring that it is fully responsive to the requirements outlined in the RFP and satisfies the project's functional requirements. This portion of the evaluation permits competing technical solutions, such as concrete versus asphalt pavement, to be compared. In addition, the design-builder is allowed to propose a technical solution it is particularly well qualified to implement and for which it has excellent past history to aid in the accurate estimation of project price. Evaluating the proposed project price for realism and reasonableness is the final portion of the process.

Partnering

Partnering is not a project delivery method like those discussed above. It is a formal method that seeks to modify business relationships in a manner that reduces the probability of claims and disputes. Most public agencies can implement partnering without the need to enact enabling legislation. This is the

[54] "Design-Build: FWHA's Role in the Design-Build Program Under Special Experimental Projects No. 14 (SEP-14)," Federal Highway Administration (1996).

case in the Commonwealth, where some limited experimentation has taken place. Essentially, partnering seeks to increase the level of trust between the various parties in a construction contract before work begins. The idea is to promote enhanced honest communications by the development of a non-binding partnering charter in which all parties agree to work for the common good. Partnering cannot "save" a poorly developed contract rife with design deficiencies or historically sour relationships. However, it can furnish common ground on which all parties to the agreement can communicate their concerns about potential project problems and seek mutually beneficial resolutions before work commences. Once this type of communication is established, it tends to continue throughout the life of the project. A study of over $1 billion worth of partnered projects in Texas showed that for contracts greater than $5 million, claims and disputes were completely eliminated.[55]

Partnering is included in this study to demonstrate the potential benefits of discontinuing the tradition of drafting construction contracts in a manner that promotes the growth of adversarial relationships. This climate of distrust and discord manifests itself in construction cost and time growth fueled by disputes, claims, and litigation. While successful partnering requires a strong commitment by both parties, the benefit to the taxpayer is evident when one looks at the Texas study as well as other anecdotal information at both the federal and state level by various authors. The true benefit to partnering is not in the gimmicks used during the workshops to promote team-building and cooperation. It is when both government and industry recognize that changing basic business relationships is profitable to both parties and institutionalize those practices as everyday routine policies and procedures.

[55] Gransberg et al., *ASCE*, June 1999.

APPENDIX B: SELECTING A DB CONTRACTOR

Three different processes are used to select the contractor to perform DB services on DOT projects.[56] All three seek to strike a balance between the quality of the offerors' qualifications and technical approach and the proposed price. The salient idea is to optimize cost, quality, and time considerations, leading to the selection of a contractor who is not only well qualified and competitive, but whose price is justified by the quality of the design solution.

The methods are Low-bid DB, Adjusted-Score DB, and Best-Value DB. As a general rule, the low-bid approach was preferred on projects where the scope is very tight and clearly defined and innovation or alternatives are not being sought. This might include highway projects with a specified type of pavement, geometric design, and minimal ancillary works.

The adjusted-score approach seems to work well when overall outcomes can be clearly defined and a number of alternatives may exist that could provide the outcomes desired. This could include highway projects for which alternative geometric designs and material types are acceptable.

The best-value method should be selected when innovation and new technology are to be encouraged or specific types of experience are required to obtain the desired outcome.[57] This approach should also be used when a fast track schedule is required or when external factors, such as minimizing traffic disruption or innovative environmental protection, are inherent to the successful execution of the project.

All methods separate the evaluation and the award process. The process is designed and controlled by an engineer in the DOT or public agency (referred to as the Agency) who is responsible for the project. Because this person's position can logically be found in a number of places within a typical DOT's organization, this person will hereafter be referred to as the Project Administrator (PA). The evaluation is typically done by a Technical Review Committee (TRC) made up of engineers possessing the necessary technical backgrounds to evaluate properly the qualifications of the DB contractors and the proposed design. For example, if a highway project includes a bridge, a structural engineer would be included on the TRC along with traffic and pavement specialists. The prime objective of the TRC is to provide a fair and equitable evaluation of each proposal as well as to ensure that the design solution proposed by the winning DB contractor will conform to Agency requirements.

The following sections detail the three methods for advertising, evaluating, and awarding DB highway contracts. The author of this paper has made an attempt to generalize the processes. Therefore, readers familiar with specific DB practices in other state DOTs may find slight variations to the process.

[56] Arizona 1997, Colorado 1997, Florida 1996, Pennsylvania 1995, USACE 1994.
[57] FAR 1996.

Low Bid Design-Build (LBDB)

Under the Low Bid Design-Build process,[58] the Agency publicly opens the price proposals on the day, time, and location noted in the announcement and sends the TRC the technical proposals. Proposed price is evaluated first, and then the TRC reviews the design concepts and preliminary designs proposed by the lowest bidder, assessing the responsiveness of the proposal to the RFP. A proposal is considered non-responsive if it does not contain all the information and level of detail requested in the RFP. In the event the lowest bidder's technical proposal is found to be non-responsive, the TRC will review the next lowest bidder's technical proposal to determine its responsiveness. The process continues until the lowest bidder having a responsive proposal is found. The TRC then notifies the Agency. Unless all proposals are rejected, the Agency awards the project to the contractor with the lowest responsive bid. The Agency normally reserves the right to reject all proposals if none can be found that meet both technical and price criteria.

Rather than immediately opening the bids, the TRC may evaluate the qualifications and design approach detailed in each proposal. The idea is to create a short list of DB contractors using a "Brooks Bill-like" qualifications-based selection process. Once the short list is assembled, the Agency opens the price proposal and awards to the lowest priced, qualified DB contractor. Thus, an attempt is made to satisfy the demands of competitive selection of construction contractors and qualifications-based selection of designers.

Adjusted Score Design-Build (ASDB)

Under the Adjusted Score Design-build process,[59] the Agency sends the technical proposals to the TRC and holds the sealed price proposals until after the technical proposal scores are provided by the TRC. Each contractor's technical proposal is evaluated on specific rating criteria provided in the RFP. Each TRC member scores the contractors' proposals. The TRC submits a final technical proposal score for each contractor to the Agency. The Agency then publicly opens the sealed price proposals and divides each contractor's price by the score given by the TRC to obtain an adjusted score. The contractor selected will be that contractor whose adjusted score is lowest. An example of how the selection formula would work is shown in table B1. Unless all proposals are rejected, the Agency awards to the contractor with the lowest adjusted score.

Table B1: Adjusted Score Design-Build Example

Firm	Technical Score	Price	Adjusted Score
A	90	$6.7m	74,444
B	80	$6.5m	81,250
C	70	$6.3m	90,000

[58] Florida 1996.
[59] Florida 1996.

Best Value Design-Build (BVDB)

BVDB differs from ASDB in that the technical proposal and the price proposal are scored together, with the project price being one category in the evaluation. Each evaluation category is assigned a weight consistent with the objectives of the project, and the score for each evaluation category is multiplied by its weight. The sum of the weighted scores in each category is the final score for each proposal. Upon completion of the final score determination, the scores are arranged from lowest price to highest price, and the TRC must conduct a "cost-technical trade-off" analysis. The TRC must justify the selection of a proposal whose price is higher than the lowest proposed price by determining that the added increment of cost is offset by an added increment in value as measured by the evaluation plan. For example, if the difference between the low and second low proposals is 3 percent, the difference in the weighted scores should be greater than 3 percent to justify expending the additional increment of cost. The example below is a simplified illustration of BVDB and not intended to describe the whole process. Each project is different, and the PA should strive to develop a set of evaluation criteria that best describe the evaluation requirements for each project.

In the example, the PA has determined that five evaluation categories are appropriate: Professional Qualifications, Price, Schedule, Traffic Control Plan, and Previous Experience. Each category can achieve a score in the range of 0 to 5 depending on its quality. Proposing the minimum acceptable quality would receive a score of 3. The weights, TRC scores, and weighted scores are shown in table B2. The cost/technical trade-off analysis is shown in table B3 using the prices in table B1. From this analysis the TRC would recommend the award of the contract to Firm B because the additional 3 percent of added costs is offset by 11 percent in added value as measured by the evaluation plan developed by the PA.

Table B2: Best Value Design-Build Example

Category	Weight	Firm A		Firm B		Firm C	
		Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Professional Qualifications	20	3	60	4	80	3	60
Price	25	3	75	3	75	4	100
Schedule	10	5	50	2	20	4	40
Traffic Control	25	3	75	3	75	3	75
Experience	20	3	60	5	100	2	40
Total	100		320		350		315

Table B3: Cost Technical Trade-Off Analysis for BVDB Example

Ranking	Price	Weighted Score	Price Increment	Score Increment
C	$6.3 Million	315	--	--
B	$6.5 Million	350	3 percent	11 percent
A	$6.7 Million	320	3 percent	- 9 percent

About the Author

Douglas D. Gransberg recently accepted a position as Associate Professor of Construction Science at the University of Oklahoma. Prior to arriving in Norman, Oklahoma, he was an Associate Professor of Construction Engineering Technology and Civil Engineering at Texas Tech University for five years. He retired from the U.S. Army Corps of Engineers in 1994 after 20 years of service both in the United States and overseas. He had various assignments in both public works and military construction. In his last assignment, he was the Europe District's Area Engineer in Turkey, where he was responsible for nearly $200 million worth of publicly funded design and construction projects. In that assignment, he helped pioneer the Corps' use of innovative project delivery methods such as Best Value Contracting and Design Build Contracting on projects under his supervision. Additionally, he gained firsthand experience on over $100 million worth of partnered construction and design-build projects. Currently, he delivers a seminar for the American Society of Civil Engineers on Design Build Contracting at various locations throughout the nation. He also owns an active consulting practice providing a variety of project management services to clients such as the Naval Facility Engineering Command, the Washington Area Metro Transit Authority, and the Texas Department of Transportation.

His recent work has focused on quantifying the impact of project delivery strategies on both owners and construction contractors using rigorous cost engineering methodologies. He is also involved in developing methods to expand the use of both constructability and partnering.

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