TOWARD A NEW PARADIGM: SIMULTANEOUS USE OF MULTIPLE PROJECT DELIVERY METHODS

By John B. Miller,1 Associate Member, ASCE, Michael J. Garvin,2 P.E., Student Member, ASCE, C. William Ibbs,3 P. E., Member, ASCE, and Stephen E. Mahoney,4 Associate Member, ASCE

ABSTRACT: Since World War II, the American Strategy for infrastructure procurement has evolved to rely primarily upon a single delivery method, design/bid/build. While this strategy was used to implement massive federal investment in highways, transit systems, and wastewater treatment, it has restricted state and local flexibility in aligning the procurement process to achieve best value for locally funded projects. The engineering, procurement, and construction community in the United States has now recognized the limitations of a procurement process designed to support a single delivery method. Change is coming, and the transition to a new process will challenge public owners in novel, but meaningful ways. This paper focuses upon shifting from the current paradigm toward a new model that supports simultaneous use of multiple project delivery methods. The discussion and frameworks provided are the result of a variety of research efforts by the Infrastructure Systems Development Research team at the Massachusetts Institute of Technology. Studies of the history of American Infrastructure, analyses of case studies across the country, development of decision support models for capital programming, and real applications to municipal infrastructure planning provide the underpinnings for the results and conclusions presented.

INTRODUCTION

American infrastructure is in flux, particularly in the broad context of capital programming and procurement methods. Different combinations of finance, design, construction, operations and maintenance provided by the public and private sectors offer great promise to provide better value to public owners struggling to adequately serve growing infrastructure demand. Modifications to current legislation are essential to promote sustainable infrastructure development strategies, and governments must alter their approaches to the acquisition, operation, and renewal of infrastructure assets. Emerging project delivery methods offer owners a choice in their search for value in infrastructure quality, service, technology, and price.

Currently, public planning and procurement strategies are tailored to the design/bid/build (DBB) project delivery method. As the environment regarding project delivery continues to change, a structured planning approach considering all delivery methods will better facilitate effective infrastructure acquisition and sustainment. Portending changes in the public procurement process are already evident, but the current paradigm is ill equipped to endure such changes. Further, it continues to impede the introduction of new methods, designs, and technology for producing value. This paper suggests how the current public procurement paradigm can evolve to a new model that supports simultaneous use of multiple delivery methods, including DBB. Our suggestions are the result of a progression of research efforts by the Infrastructure Systems Development Research (ISDR) team at the Massachusetts Institute of Technology including case study development, historical research of American infrastructure, municipal infrastructure modeling and analysis, and the evolution and deployment of a decision support system for capital programming (Miller 1997).

BACKGROUND

Definitions

For clarity, a number of terms used throughout this document are defined below:

- Capital programming—a process whereby an organization’s capital needs are identified, evaluated, programmed, budgeted, delivered, and accounted.
• Public infrastructure—commonly accessible goods or services that are ultimately under the control of public owners.
• Procurement—the acquisition of goods or services through a transparent, competitive, public process.
• Procurement process—the statutory and regulatory requirements by which owners acquire goods or services from the private sector.
• Project delivery method—a system for organizing and financing design, construction, operations and maintenance activities that facilitates the delivery of a good or service.
• Source selection method (or method of selection)—one of the common procurement activities for selecting vendors including competitive sealed bids, competitive sealed proposals, and qualifications based selection.
• DBB—the “traditional” project delivery method where a designer prepares complete construction documents for an owner. The owner then receives bids based on the design documents from contractors and awards a construction contract to the lowest, responsive, responsible bidder. The contractor builds the project, and upon completion, the owner assumes the responsibility for the operation and maintenance of the project. The owner provides all financing.
• Design/build (DB)—a project delivery method that is a slight variation of the traditional method. The owner selects a single contractor to both design and build the project. Upon completion of construction, the owner assumes responsibility for its operation and maintenance. The owner provides all financing.
• Design/build/operate (DBO)—a project delivery method that integrates operation with the tasks of design and construction. The owner selects a single contractor to design, build, and operate the project for a specified period of time. Maintenance and repair responsibilities during the operations period are normally delineated in the contract. At completion of the contract, the owner assumes operation and maintenance responsibilities itself or recompetes this task through another procurement process. The owner provides all or partial financing. User fees may be collected under public owner auspices to provide all or part of the project financing.
• Design/build/finance/operate (DBFO)—a project delivery method similar to DBO, except that the responsibility for financing the project is assumed completely by the contractor, typically at the contractor’s risk. Usually, financing relies upon projections of future user fees. Control of the asset produced is returned to the owner at the end of the contract period.
• Transparency—those attributes of the procurement process that make it stable, reliable, and predictable to actual and potential participants, to procurement officials implementing the process, to legislators evaluating the process, and to the rate/tax paying public who see and use the results.

Integrated Framework
National confusion exists about project delivery systems, and the privatization moniker is often misplaced. Miller’s (1995) four quadrant operational framework shown in Fig. 1 effectively simplifies the nomenclature that applies to project delivery methods by focusing on two key characteristics, integration of delivery and source of finance. Integration of delivery measures the degree to which the different project elements such as planning, design, construction, and operation are segmented or combined during the production cycle. Consider an example of a new fixed crossing, such as a bridge. If the owner chooses to deliver the project as

![Operational Framework for Project Delivery Systems](Image)
DBB, the owner will likely engage an engineering consultant in the planning and design of the project, solicit bids from general contractors for construction, and then operate the bridge itself or hire an operations contractor. On the other hand, if the owner chooses to deliver the project by awarding a DBO franchise, the owner will select a single contractor to design, construct, and operate the facility.

Source of finance, the second characteristic, measures the degree of financial risk the owner assumes in executing the project. Returning to the new fixed crossing example, in both DBB and DBO deliveries, the owner assumes all financial obligations for the project. If the owner chooses, however, to award a DBFO franchise, the owner will have no financial responsibility for the capital costs of design, construction, operations or maintenance. Further, depending on the criteria in the request for proposals issued by the owner, private sector respondents may propose a tunnel rather than a bridge for the crossing. Obviously, the project now requires toll collections from citizens to facilitate private finance. In the framework, DBB is plotted in Quadrant IV, DBO in Quadrant I, DBFO in Quadrant II, and DB in Quadrant IV, close to Quadrant I. This framework cuts through popular jargon and delineates project delivery methods by considering only the responsibilities of production and finance. It allows strategists to fully understand the characteristics of the available delivery alternatives and assists in the evaluation of each option.

FUNDAMENTAL PRINCIPLES

Throughout the course of our research, we have identified a number of key principles of procurement and capital programming that transcend the methods of delivery and finance. These elements are particularly significant in the public environment since public owners are stewards of public trust and resources. They are obligated to conduct themselves in a conscientious, competent, and accountable manner.

Influencing Project Outcomes

Project planning for public infrastructure is an owner-driven process that must correlate with an owner’s overall economic conditions and social policies, not only in the present, but in the future as well. Proper alignment requires an owner, and its consulting engineers, to consider finance, management, design, construction, operation, and maintenance early in the project life cycle. Decisions made in the initial phases of a project’s life cycle have a much greater influence on a project’s outcome than decisions made in later phases. Fig. 2, developed by Paulson (1976a,b), illustrates that it is easier to favorably influence a project’s outcome during the project configuration phase when expenditures are minimal than it is during the construction or operations phase when expenditures are more significant and work-in-place increasingly limits flexibility.

Value

Public owners are consistently challenged to put public dollars to their maximum use. The interplay of cost, quality, and time are the primary determinants of value, and owners constantly struggle to find the right combinations of these variables in their asset management programs. An optimal frontier for the fusion of these variables exists, but defining it is quite difficult. Public owners must possess the ability to at least approach this frontier. Low initial cost can contribute significantly to overall value, but sole focus upon it eliminates other important components of the value equation. This is particularly true with infrastructure assets where long-term use converts initial cost into a small percentage of life-cycle cost.

Transparency

Transparency—the notion that potential competitors in the acquisition system can see and understand the acquisition process prior to making a commitment to participate, and can rely upon government to impartially implement this process to its conclusion—is arguably the government’s central interest in the acquisition process (Miller 1999). At stake is the response of potential private sector bidders. If they elect to add value to the procurement process by contributing their resources, technologies, and expertise, the government must treat
them in a stable, reliable, and predictable fashion. The perception of potential competitors is of greater importance than commonly recognized. This is because the quality of the services and goods the government acquires cannot be better than the pool of private sector firms willing to participate in the acquisition process. This is especially true in new technology procurements. Private sector technology leaders and innovators have little or no incentives to participate in the public procurement process if their private sector market alternatives are more predictable and reliable.

**Competition**

Competition affords public accountability. Without it, the government lacks objective criteria for the award of contracts for public goods and services. In fact, research indicates that objective criteria for selecting and awarding contracts directly influence the breadth of participation by private sector firms in public infrastructure competitions (ISDR 1997c). In addition, objective competition promotes best value. When participants are vying for a single project against clear and impartial criteria, competition forces them to render their best proposals to obtain the work.

**Scope of Work**

A fundamental element of procurement is the description of the good or service that the owner desires to purchase. How well or poorly the owner defines the scope of work will dictate the content and quality of the proposals submitted by respondents as well as the resulting product or service. Often, it will govern technologies considered, design techniques, construction methods, and operations processes. In addition, the scope of work becomes the core, enforceable component of the contractual relationship between government and vendor. More importantly, the scope of work determines whether the owner can reasonably assume that competition for the work among potential contractors will independently confirm the government’s assessment of the project’s technical feasibility, time for completion, and cost (ISDR 1997b, 1997d, 1997e).

**Risk**

The risks associated with each project differ dramatically, and risk allocation is a key part of any successful procurement and management strategy. Rubin and Wordes (1998) suggested that risk allocation is simply the distribution or apportionment of the risks associated with a project throughout its life cycle. They also argued that risk allocation depends on the project delivery method used. “Because the project delivery systems organize the building process differently, each system allocates risks differently . . . the cost associated with each risk can be minimized if it is allocated to the party with the greatest ability to understand and control it” (Rubin and Wordes 1998). Hartman and Snellgrove (1996) asserted that clear risk assignment means that contracting parties have the same understanding of risk apportionment and risk management accountability.

**Revenues**

Projects that generate substantial and reliable revenues offer the possibility of private sector participation in their finance. Revenues can come directly from the project, such as water consumption fees that result from a new water treatment plant and distribution system, or from tolls collected for crossing a new bridge. Revenues can also arise indirectly from the project, such as peripheral retail or commercial development around a new railway station. Without a stable, predictable source of revenue, private financing is usually not a feasible alternative.

**Owner Sophistication**

Owner sophistication is often defined as breadth of expertise or staffing. We define sophistication of a public owner as its ability to effectively configure, deliver, operate, and manage a collection of public goods and services for best value. While this definition is still difficult to measure, it has little to do with the size of a staff; rather, it suggests that a sophisticated owner can be one who recognizes its limitations, augments its capabilities as necessary, and provides public goods and services sensibly and efficiently. Essentially, public owners will attain their goals by different means. Sophisticated owners recognize this and understand that there are different approaches to the same end.

**CURRENT PARADIGM: USE OF SINGLE DELIVERY METHOD**

**Predetermined Contracting and Financing Strategies**

Federal, state, and local governments have relied almost exclusively on the DBB method of project delivery over the past few decades. After World War II, the EPA Construction Grants Program and the Interstate Highway System Program firmly entrenched the delivery of public infrastructure in the use of DBB strategy. In 1972, the Brooks Act required the segmentation of design from construction for public projects (40 U.S.C section 541–544). DBB was a successful common project delivery method for federally disbursed grant programs, with numerous checks and balances built into the process. The widespread voluntary adoption of DBB as the general state and local project delivery method has unintentionally created a variety of barriers to effective and nimble delivery of projects funded by state and local governments. One consequence of limiting the government’s project delivery options is that federal, state, and local governments have been forced to assume not only direct responsibility for planning, designing, constructing, maintaining, and operating infrastructure projects, but also for managing the interfaces among these functions.

Fig. 3 describes the current DBB procurement process. Its sequential nature is evident (Mahoney 1998). When a need is identified, a project evolves in distinct stages, and the owner coordinates and manages the entire process. The focus of this process is upon downstream activities, design development, and construction. The pro-

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cess minimizes the owner’s obligation to define the project and to explore financing alternatives. Owners do not need to fully address the project’s objectives or definition before proceeding; this will occur during design development. Further, they need not evaluate financing or delivery options. Both are predetermined.

The current public procurement process based solely upon DBB dramatically simplifies the tasks of the engineering, construction, and procurement community. Indeed, this process promotes a series of “commodity” purchases without significant need for professional judgment regarding appropriate delivery methods or financing arrangements. “Value” is determined by the lowest, responsive, responsible bid for construction of the work described in the construction documents. Transparency and competition are guaranteed during the construction phase. Scope of work is defined by a 100% complete set of construction documents; risks are generally well defined and regularly allocated by standard contracts. Project revenues are basically irrelevant since external or private financing is not an option.

Limitations of Current Approach
For most projects, DBB is a viable method of delivery. In fact, of all the delivery methods, DBB may be the one method that can be universally applied. Its place as a fixture in the procurement process is secure. Each project delivery method, however, supports owner priorities and project goals differently. For example, DB is generally faster than DBB from the start of design to the completion of construction (Songer and Molenaar 1996; Konchar and Sanvido 1998). An owner with a tight schedule may be better served to use DB rather than DBB, but this schedule advantage may not be sufficient, particularly for projects where the owner wants to carefully settle upon a design before committing to funding construction. Similar trade-offs would exist if the only available delivery method were DBO or DBFO. For example, exclusive use of DBFO would not be likely to satisfy all public infrastructure needs. In such an environment, the private sector would only take projects that produce favorable discounted cash flows. Other needs would remain unmet, without public owner input and control over scope. We have concluded that sole reliance upon a single delivery method is a fundamental mistake. The limitations of this approach are illustrated in a number of ways.

Singular Engineering Solutions Offered
In DBB, the owner only sees the engineering solution of a single designer with one combination of cost, quality, and time attributes. In fact, there are numerous possible engineering solutions with different trade-offs in cost, quality, and time. Unfortunately, the current approach limits the analysis of alternatives because a single designer cannot consider all possible alternatives. The designer is never in a position to fully compare options for layout, technology, life-cycle cost, or initial cost among various design solutions. The designer’s limitations for considering alternatives automatically become the owner’s.

Inadequate Provision of Long-Term Needs
Owner objectives are often mismatched with the current process. Our experience with public agencies in a number of settings indicates that public owners tend to align their objectives with the current DBB process. Projects are configured to spend available funds rather than to meet long-term public needs. This trend is potentially disastrous. Modern infrastructure demand is expanding at a time when the existing stock is decaying and available public capital is inadequate. In 1998, Congress passed the largest public works bill in American history, the Transportation Equity Act for the 21st Century (TEA-21), appropriating over $217 billion for national transportation needs. TEA-21 funds, plus state and local funding sources, should provide an annual capital outlay of about $40 billion (1995 dollars) in highway finance from 1998 to 2003. Yet, the Federal Highway Administration estimates that $53.5 billion a year is needed to maintain existing highway and bridge conditions, whereas the cost to improve highway, bridge, and

transit conditions is estimated to average $79.6 billion a year, an annual shortfall of nearly $40 billion (Giglio and Williams 1998).

Identifying projects based on spending available funds has profound negative impacts on the overall performance of infrastructure networks. Regional infrastructure networks, particularly supply and transportation systems, have dramatic impacts upon regional economies, so America’s decaying infrastructure base will present innumerable challenges as modern requirements escalate. The complexity of the pending acquisition, renewal, and replacement cycle will dwarf the effort required to put the current national stock in place. Signals of massive system failures are already sounding. In 1981, the city of St. Louis had over 4,000 sewer collapses in its 125-year-old system (Weil 1990). ASCE (1998) reported that nearly one of every three bridges is either structurally deficient or functionally obsolete, and 46% of national public schools lack basic wiring to support computer systems. In addition, more than 16,000 community water systems (29%) did not comply with the Safe Drinking Water Act standards in 1993. Estimates of the total infrastructure investment needs through 2003 are $1.3 trillion. Procurement strategies based upon spending insufficient federal aid will not get the job done.

No Consideration of Life-Cycle Value

Another consequence of the traditional delivery method is the minimization of life-cycle cost principles. Too often in the political arena, the measure of success is the receipt of goods and services at the lowest possible initial cost. DBB competes over an incomplete scope of work because it only includes the cost of construction; it fails to evaluate the costs of financing, designing, building, maintaining, and operating infrastructure facilities over an extended period of time (Miller 1995). Success metrics should extend beyond minimum initial costs to include life-cycle costs. National recognition of the importance of life-cycle value is growing. In 1991, Section 1024 of the Intermodal Surface Transportation Efficiency Act required that any organization depending on federal funds for infrastructure investment perform a life-cycle cost analysis to satisfy funding requirements.

Unfortunately, most public agencies have limited resources, and they are under political pressure to produce short-term results between elections. A majority of investments are therefore made on the basis of initial costs without consideration of life-cycle value (Arditi and Messiha 1996). The current procurement process generally ignores the implication that a majority of a project’s costs occur during operations. Initial design and construction ought to be expressly aimed at long-term operations, maintenance, and finance—particularly since initial design and initial choice of technology commit the owner of the facility (public or private) to the resultant cost of maintenance and operations for 3–5 decades (Miller 2000).

Lack of Innovation

Prevailing construction technologies generally restrict innovation by designers. Under the current paradigm, the designer cannot foresee who will build the project, and the designer is not fully aware of the technologies available to the contractor. Consequently, technology selection is performed by professionals who are not responsible for either technology placement or use, and the selection is generally based upon stable and familiar technologies that support implementation by any number of contractors. Designers are reluctant to innovate, fearing that contractors will either refrain from bidding or will submit high bid prices (Nam and Tatum 1992). Public owners are also hesitant to involve contractors in the planning and design processes. If a contractor were compensated for involvement during the design process, that contractor would most likely be excluded from bidding on the job due to the potential conflict of interest and perceived unfair advantage (Gibson et al. 1996). Further, prior to bid, contractors are reluctant to suggest ideas on improving the project or reducing cost because of the value of such information and the potential for loss of competitive advantage (Warkol 1997).

The current procurement process separates the designer from the builder indiscriminately, so the designer’s focus on reputation and the contractor’s focus on price competition and cost reduction typically leads to a lack of cooperation. Although new ideas in design can often be introduced with new material or methods of construction, continued coordination between these two occupations in the whole process is difficult. This helps make a potentially dynamic industry technologically rigid (Nam and Tatum 1992).

TOWARD NEW PARADIGM

A sustainable, national infrastructure procurement strategy recognizes that the method of delivery is a variable for analysis and management. More than one practical, viable project delivery option exists for most major public works projects. Simply put, it is the mix of project delivery methods applied to a collection of desirable infrastructure projects that is becoming increasingly important. One of the clear teachings of the history of construction management in the United States is that no single form of project delivery and finance is preferable across numerous projects and sectors over time (Miller 2000). The ideology behind allowing the public sector to use all available contract procurement strategies is based on the belief that the public and private sectors can collectively provide the best services to meet the growing needs of American infrastructure. Together, the public and private sectors must strive to improve the quality of national infrastructure assets through proper allocation of financial risk and the encouragement of innovation. If the government can realize life-cycle cost reductions or push financially viable capital projects into the private sector, more public funds can be better allocated to projects that cannot support themselves.

NEW PARADIGM: USE OF MULTIPLE DELIVERY METHODS

The transition to the new procurement paradigm will pressure public owners in novel, but meaningful, ways.
Sophisticated owners will readily adapt to the new environment; others will struggle to keep pace. It is our belief that the fundamental role of public owners is the identification and configuration of projects to achieve public objectives, along with managing their delivery and operation. Giglio and Ankner (1998) suggested that the key roles of the public sector are threefold: it is responsible for ensuring that service levels and standards are maintained, social goals are achieved, and the best financial package is used, whether that means public, private, or a combination of the two. This is somewhat of a departure from the public sector's current role, but it is an essential element of the new paradigm. Some public owners, such as the city of Indianapolis, have already forged a path for others to follow, one that permits optimal use of public resources.

New Project Life Cycle: Open System

By applying process management and analysis methodologies developed by Ibbs et al. (1994) and Ibbs and Kwak (1997, 1998) to the multiple project delivery environment, Mahoney (1998) developed a new project life cycle that supports multiple project delivery methods and multiple possibilities for a project's development. Fig. 4 presents this framework. After the government has sufficiently defined, organized, and analyzed the project, the private sector can then supply its expertise to the process. The direction of project development then depends on the project delivery method selected. This open system can create new markets that encourage private sector investment and innovation (Miller 1998). Variations of integrated finance, design, construction, and operations allow the public sector to obtain better service quality for lower costs by introducing competition across project life-cycle time periods. The approach emphasizes the identification and definition of public needs while providing maximum flexibility. Further, it is a cyclical process since the renovation or decommissioning decision forces the owner to reconsider the asset and determine viable approaches for repair, renewal, or abandonment.

The new approach capitalizes upon the differences between the public and private sectors by recognizing that each can contribute in ways that are amenable to their inherent strengths. The public sector can best

- Identify public needs and projects
- Align economic and infrastructure strategies
- Establish government commitment to viable projects and delivery processes
- Provide a fair competitive environment for private sector participation
- Establish reliable commitments for infrastructure financing
- Impose and manage market externalities such as permitting and environmental protection

The private sector can best

- Contribute efficient competencies that are managed and honed in competitive markets
- Develop and introduce innovations in technology, design, construction, and operation processes

![New Delivery Life Cycle Diagram]

**Procurement**

FIG. 4. New Paradigm: Project Life Cycle Supporting Multiple Delivery Methods
• Provide independent competitive checks of the technical and economic viability of projects
• Provide an alternative source of financing when projects are potentially self-sufficient

Implications of New Approach
The new approach marks a shift away from downstream procurement process activities toward upstream ones, balancing the public owner’s responsibilities between preconstruction and construction functions. This shift adds new dimensions to procurement and capital programming.

Project Configuration Process

Fig. 5 (Mahoney 1998) describes the project configuration process as a new element of public responsibility. The goal of the new project configuration process is to improve planning procedures and to establish standards that mutually benefit owners and the design and construction community. Mahoney’s development of this framework also evolved from the application of process management methodologies described by Ibbs and co-workers. The term configuration, used in this context, is probably new to most readers. If an owner has the flexibility to select the most attractive organizational structure, design alternative, and delivery, financing, and management strategies, the configuration process describes the evolution of these decisions and the tasks for completion before issuing a request for proposals to the private sector. The purpose of the process is not only to normalize public project development and project expectations, but also to allow designers and contractors maximum reasonable latitude in meeting those expectations.

Activities during the project configuration phase must accommodate the various options available for project delivery in order to successfully address life-cycle issues of cost and quality. Public owners will be compelled to (1) identify needs based upon public policy and goals; (2) package those needs into sensible and executable projects; (3) align projects with viable project delivery methods; (4) evaluate and select project proposals based upon clear and objective criteria; and (5) manage project contracts to maintain cost and quality control. Some might argue that this is no different than the owner’s current role, but the use of multiple delivery methods challenges owners in new ways, particularly regarding project packaging, financing, delivery, and proposal selection. Further, as the integration of project activities increases across the range of delivery methods, the

![Project Configuration Process Diagram](image-url)
owner loses some capacity to manage aspects of the process and its outcome. This produces a significant trade-off decision. An owner must decide whether the loss of control over the details is offset by benefits such as reduced initial cost, reduced life-cycle cost, quicker delivery, or better technology. To evaluate such trade-offs, the owner must develop a functional description of each project that is adequate to perform the necessary analyses. Additionally, an owner can retain substantial control of the details by properly packaging performance standards and contract conditions in the competitive process before a vendor is selected.

The configuration process presented in Fig. 5 redefines public owner responsibilities. Owners will need to sufficiently define project objectives and drivers while understanding the characteristics of each delivery method and the conditions of the market to realize the benefits offered by the open system (Gordon 1991, 1994). New emphasis will also be placed upon managing a collection of projects at the portfolio level, because the freedom provided by the new paradigm presents opportunities to utilize public and private resources in an optimal fashion (Miller and Evje 1999). Greater understanding of owner operating budgets and trends is necessary to provide the appropriate context for capital decision making. Owners also will need to at least complete a functional design (minimum of 3–5%) to develop budgets and cash flow analyses sufficient to thoroughly evaluate available delivery and finance options. As in the past, an owner must continue to manage the evolution of a project while obtaining public consensus and regulatory permits.

The new process also suggests the use of specific deliverables that will produce better performance. Some tasks are already performed by owners, but others, such as functional design and financing/cash flow analyses, may require owners to add new internal capacity or to acquire such skills from the private sector. The project configuration process presented here suggests that owners will likely complete these activities through the use of both internal and external expertise.

**Transparency, Scope of Work, and Competition**

The configuration process described in Fig. 5 is consistent with the principle of transparency and depends upon the description of the scope of work and the competitive mechanisms chosen for awarding contracts. Strengths of the current paradigm include a well-defined scope of work (i.e., complete construction documents at the time of bid) and intense price competition during selection. A fundamental principle of the new paradigm is that source selection methods for all procurement contracts retain competitive processes. Recent “experiments” with alternative project delivery methods have demonstrated the inefficiency of noncompetitive procurements (ISDR 1997a, 1997c, 1997d) as well as the efficacy of competitive ones (ISDR 1998). The development of functional design requirements for the project and the establishment of clear evaluation criteria for selection are prerequisites to the fair comparison of proposals and the owner’s determination of best value. Without these, the process breaks down. The legislative framework for the new paradigm now exists, although with competitive source selection methods to implement it (American Bar Association 1999). The chosen source selection strategy is not nearly as important as its communication to potential bidders and its comprehension by respondents. At stake is the credibility and accountability of the public procurement process as well as the best offers from the private sector.

**CONCLUSIONS**

**Redefining Government’s Role**

The current paradigm supporting a single delivery method prevents public owners from making optimal procurement decisions by forcing them to align infrastructure needs with the present process. Mismatched project characteristics and procurement strategies reduce life-cycle value and innovation and allocate risks unfavorably. An open system designed to support multiple project delivery methods can allow greater public benefits by

- Attracting private sector investment in infrastructure
- Increasing the introduction of new technology and innovation
- Increasing infrastructure quality and service while controlling costs
- Conserving government resources to support public projects and services that only the government will perform

The transition to an open system brings new challenges to public owners. Paul F. Levy, former executive director of the Massachusetts Water Resources Authority, believes that many owners do not yet possess the required “institutional infrastructure” to deliver projects using multiple methods simultaneously (Levy 1999). Indeed, the new paradigm redefines the role of government in procurement and capital programming. It compels government to fulfill its obligations by focusing on its strengths as a policymaker, standard bearer, and regulatory agent, while inviting the private sector to contribute its capacity for innovation, specialized knowledge, and efficiency. Properly implemented, the new paradigm will allow public owners to fashion strategies of infrastructure procurement that fulfill long-term public needs and objectives under public sector leadership.

**New Frontiers for Civil Engineers**

Civil engineers are uniquely positioned to exploit the opportunities offered by the new paradigm. An open system amplifies the importance of creative design solutions, options analysis, engineering economy, systems evaluation, and technology development. In the course of infrastructure development, few professions are better suited to apply knowledge and discover new opportunities. Public owners will now require different and original services throughout the life cycle of infrastructure.
assets. New markets for the preparation of functional designs, studies of engineering economics, application of decision analysis techniques, and evaluation of proposals and technologies will emerge to complement the existing design and management functions of the profession. New design methods and solutions will evolve as engineers add systems' integration to the range of services offered in this open system where owners have a choice among project delivery and finance alternatives. As in the past, new tools will be developed to support the emerging markets. Some will view the new model as a threat, but in reality, the new paradigm supports a dynamic environment where new frontiers will open for civil engineering.

**APPENDIX. REFERENCES**


