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United States General Accounting Office  
Washington, D.C. 20548

General Government Division

B-285663

July 11, 2000

The Honorable Jeff Sessions  
United States Senate

The Honorable Richard C. Shelby  
United States Senate

The Honorable Sonny Callahan  
House of Representatives

Subject: Federal Facilities Council's Report on the Role of Facility Design Reviews in Facilities Construction

This letter responds to your request for a review of federal agencies' practices for reviewing the plans and specifications used in the facility acquisition process. Your request resulted from reports you had received from constituents that plans provided to their construction firms for federal contracts were often inadequate and that the design and review process of the government has gotten progressively worse in recent years. You were concerned that either agency engineering departments or the architect-engineering (A/E) firms hired by the agencies, or both, were neglecting their duties to provide construction contractors with plans and specifications that were sufficiently clear and comprehensive to allow projects to be completed without extensive change orders and rework.

Early in the planning of our work, we learned that the Federal Facilities Council (FFC) had completed a study of public and private sector design review practices.<sup>1</sup> This study, which was published in January 2000, identified best practices and technologies that could be used by federal agencies and other owners to provide adequate management and oversight of design reviews throughout the facility acquisition process. We discussed the contents of the FFC study with Senator Sessions' office and jointly reached the conclusion that information in the study would satisfy the intent of the requested review. We then agreed to provide an abridgment of the findings and best practices discussed in the FFC study in lieu of going forward with the requested review, which is provided in enclosure I. We did not independently verify the information contained in the FFC study. However, on the basis of prior work and experience in this area, we were already aware of many of the problems in the

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<sup>1</sup>Ralph S. Spillinger, in conjunction with the Federal Facilities Council Standing Committee on Organizational Performance and Metrics, Adding Value to the Facility Acquisition Process: Best Practices for Reviewing Facility Designs, Federal Facilities Council Technical Report #139 (Washington, D.C.: National Academy Press, n.d.).

facility design review area discussed in the study, as well as the efforts that have been made by federal agencies to address the conditions covered in the study.

## Results in Brief

According to the FFC study, opportunities exist to significantly reduce total project cost (TPC) by conducting an effective design review process. The study found that effective design review practices result in less rework on the part of the construction contractor, fewer change orders to correct design errors and omissions, and lowering the cost of belatedly adding project upgrade features that should have been addressed in the original design. FFC reported that, historically, 30 to 50 percent of all construction change orders result from errors in the design documents directly related to improper interfaces between design disciplines (civil, structural, architectural, electrical, and mechanical).

The FFC study notes that attention should be focused on review of designs during the conceptual planning and design phases, where the ability to influence ultimate functionality and cost of the project is the greatest. The study states that the potential savings resulting from conducting effective design reviews range from a minimum of 3 percent to as much as 20 percent of TPC, and even higher when indirect savings are taken into account. The FFC study concludes that, in the end, effective review of designs maximizes the probability that a mission or operational requirement will be successfully supported by a facility that was conceived, designed, constructed, and placed into operation efficiently and effectively.

The study identifies 18 best practices that federal agencies and other facility owners can use to manage and/or oversee design reviews throughout the facility acquisition process. It organized the best practices into five categories related to (1) the role of the owner, (2) teamwork and collaboration, (3) advance planning, (4) process, and (5) benchmarking.

## Background

FFC (formerly the Federal Construction Council) is a continuing activity of the Board on Infrastructure and the Constructed Environment of the National Research Council (NRC). It is a cooperative association of 20 federal agencies with interests and responsibilities related to all aspects of facility design, acquisition, management, maintenance, and evaluation. FFC is convened under the aegis of NRC, the operating arm of the National Academies. Its mission is to identify and advance technologies, processes, and management practices that improve the performance of federal facilities over their entire life cycle, from planning to disposal. The federal agencies that sponsored the facility design review study, which was produced as an element of the FFC's 1999 Technical Activities Program, included the

- Department of the Air Force, Office of the Civil Engineer;
- Department of the Air Force, Air National Guard (ANG);
- Department of the Army, Assistant Chief of Staff for Installation Management;
- Department of Energy (DOE);
- Department of the Navy, Naval Facilities Engineering Command (NAVFAC);
- Department of State (DOS), Office of Foreign Buildings Operations;

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- Department of Veterans Affairs (VA), Office of Facilities Management;
- Food and Drug Administration;
- General Services Administration (GSA), Public Buildings Service;
- Indian Health Service (IHS);
- International Broadcasting Bureau;
- National Aeronautics and Space Administration (NASA), Facilities Engineering Division;
- National Institutes of Health (NIH);
- National Institute of Standards and Technology (NIST), Building and Fire Research Laboratory;
- National Science Foundation;
- Smithsonian Institution, Office of Facilities Services; and
- U.S. Postal Service (USPS).

FFC's study discusses the results of a questionnaire survey of nine federal agencies that acquire, maintain, and operate a significant inventory of buildings and other constructed facilities in supporting their mission.<sup>2</sup> Questionnaires were answered by agency headquarters senior facilities engineering program directors and field-activity-level project managers. In addition, FFC used the results from research done by The Business Roundtable (TBR), NRC, U. S. Army Corps of Engineers (USACE), Construction Industry Institute (CII),<sup>3</sup> and other FFC efforts, as well as others, to augment the study. A literature search was used to identify facility acquisition practices and industry trends, as well as best practices and technologies being used to provide adequate management and oversight of design reviews. Supplemental information was obtained through interviews with various public agencies, private sector facility owners, trade and professional organizations, and A/E firms in order to characterize the current state of the art from a broader perspective.

The federal government, the nation's largest building owner, acquires buildings and other structures to support specific functions and missions and the general conduct of its business. It spends more than \$20 billion a year for facility design, construction, and related services. Owners, the government included, traditionally have maintained some level of internal facility planning and design oversight capability to ensure that new facilities acceptably balance the factors of cost, schedule, quality, and performance.

Over the last decade, as a result of efforts to reduce the size of government, agencies have downsized their design and engineering staffs and relied more on outside consultants for technical expertise. Although agencies have generally retained their design oversight responsibilities, fewer staff resources are now devoted to reviewing facility designs. The changes in the facilities acquisition environment led FFC to conclude that a review of issues, practices, and methods related to the design phase of the acquisition process would be beneficial.

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<sup>2</sup>The report was authored by Ralph S. Spillinger in conjunction with the FFC Standing Committee on Organizational Performance and Metrics. Mr. Spillinger is a retired federal official with 30 years experience in planning, design, and construction of federal facilities with the Navy and NASA.

<sup>3</sup>CII's membership includes several federal agencies--GSA, USACE, NAVFAC, NASA, DOS, NIST, and the Tennessee Valley Authority.

## FFC Findings

The core issues of the FFC study concern the value added by design review processes and the appropriate role of facilities owners, particularly federal agencies, in such processes. In developing a detailed scope of work for its study, FFC found that no two of the sponsoring agencies defined the design review process and its elements in exactly the same way. Nor was a common start or end point identified for design review. In view of the lack of commonly accepted definitions of the elements, duration, and substance of the design review process, FFC decided to focus on practices for reviewing facility design over the entire facility acquisition process. The study viewed design review as a multiphased process not limited to the reviewing of designs during the design phase of the acquisition. The objective of the study was to identify a range of best practices and technologies that could be used by federal agencies and other owners to provide adequate management and oversight of design reviews throughout the facility acquisition process.

Briefly, the FFC study presents five key findings on design review processes.

- Effective design review processes add value by saving time and money over the entire facilities acquisition process.

Effective design review processes result in the preparation of more comprehensive and accurate design and construction documents that, in turn, result in lower project construction costs. Areas of savings include less rework on the part of the construction contractor, fewer change orders to the owner for correction of design errors or omissions, and a lowering of the cost of belatedly adding project upgrade features that should have been addressed in the original design. Indirect cost savings can be realized by avoiding costs associated with loss of productivity during construction-delayed facility start-up, and with litigation. In short, effective review of designs maximizes the probability that a business requirement will be successfully supported by a facility that was conceived, designed, constructed, and placed into operation efficiently and effectively.

- The team responsible for design oversight should include representatives of all project stakeholders: owner, user, A/E, construction contractor, operation and maintenance staff, and major equipment vendors.

The team should participate in and contribute to design-related activities associated with each phase of the facility acquisition process, from conceptual planning through start-up.

- The use of metrics by federal agencies to measure the value added by design review processes is not well established.

Although research has been done by the Construction Industry Institute and other organizations to identify metrics that may be used to measure both the efficiency and the effectiveness of each phase of the facility acquisition process, the extent to which individual federal agencies measure design review processes and analyze results is highly variable.

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- To provide effective oversight of design review processes, the owner's interests are best served when the in-house staff can fulfill the functions of a "smart buyer."

A smart buyer is one who retains an in-house staff who understands the organization's mission, its requirements, and its customer needs, and who can translate those needs and requirements into corporate direction. A smart buyer also retains the requisite capabilities and technical knowledge to lead and conduct teaming activities, accurately define the technical services needed, recognize value during the acquisition of such technical services, and evaluate the quality of services ultimately provided. As long as the owner retains the in-house capabilities to operate as a smart buyer of facilities, there does not appear to be any greater risk from contracting out a broad range of design review-related functions, so long as such functions are widely available from a competitive commercial marketplace. If the owner does not have the capacity to operate as a smart buyer, the owner risks project schedule and cost overruns and facilities that do not meet performance objectives.

- The ongoing revolution in information technology and communications offers opportunities to improve design review processes.

Examples include audio and video teleconferencing, immediate and widespread data distribution via the Internet, computer-aided design and drafting, and a wide range of project management software. Emerging technologies, such as the use of holographic projection techniques to create three- and four-dimensional models of project designs, guarantee a continuing stream of future enhancements.

The FFC study identifies 18 best practices for the review of designs, which it summarized as follows:

### Role of the Owner

- Be a smart buyer.
- Develop a scope of work that clearly and accurately defines the owner's expectations regarding cost, schedule, performance, and quality.
- Avoid the temptation to micromanage the design review process.

### Teamwork and Collaboration

- Use teambuilding and partnering techniques.
- Ensure that all interested parties participate in design review processes.
- Use the same A/E throughout the process.
- Use senior, experienced staff to evaluate the evolving design and guide the review process.
- Commit for the duration of the activity.
- Participate in a design awards program.

## Advance Planning

- Focus attention at the front end during the conceptual planning and design phases, where the ability to influence the ultimate cost of the project is the greatest.
- Do not start the final stage of design until the preliminary engineering is complete.

## Process

- Tailor the review approach to project specifics.
- Keep up the pace of the process to maintain momentum.
- Pay special attention to civil, structural, architectural, electrical, and mechanical interfaces.
- Exploit technology.
- Conduct a post-occupancy evaluation to develop a lessons-learned document.

## Benchmarking

- Measure results achieved by the design process.
- Document both unusually good and bad performance.

FFC's study identifies four areas where it was felt that additional cooperation, research, and discussion could lead to either fundamentally new approaches or significant improvements to current practices. These areas are

- establishment of a senior-level advisory group on federal facilities issues;
- identification of a set of metrics that could be used to measure performance across all phases of the facility acquisition process;
- evaluation of current practices of federal agencies with regard to the standards, guidelines, and policies supplied to A/Es in support of facility acquisition activities; and
- study of the potential benefits of establishing a peer review process for agency design review practices.

The study also identifies a number of federal agency initiatives related to the design review process. These initiatives are included in the enclosure to this letter, which provides a more detailed presentation of pertinent information extracted from the FFC study relating to the changing facilities acquisition environment confronting federal agencies today, facility acquisition practices and trends, and best practices.

## **Government/Industry Forum**

On May 24, 2000, FFC sponsored a government/industry forum on best practices for reviewing facility designs. Approximately 120 individuals from 30 federal agencies registered to attend the forum. The major participants were GSA, all branches of the Department of Defense, DOS, DOE, NASA, and the Smithsonian Institution.

The forum highlighted identified best practices and tools that can be used by federal agencies and other facility owners to manage and/or oversee design reviews throughout the facility

acquisition process. The findings and 18 best practices highlighted in the FFC-sponsored study were presented to the forum participants by FFC. Government and industry practitioners discussed best practices, tools, and processes they have used or seen used to review facility designs, and suggested how federal agencies could use such tools and processes to foster quality design.

In addition, presentations were made on three systems that have been developed to support different aspects of the design review process. These design review tools were the Army's DrChecks software program for documenting, collecting, distributing, and archiving design review comments; the Construction Industry Institute's (CII) Project Definition Rating Index for preproject planning; and the REDICHECK Interdisciplinary Coordination system for design reviews—the first system designed specifically to correct the interdisciplinary coordination discrepancies that account for about half of the construction change orders involving errors and omissions.

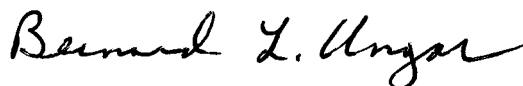
## FFC Comments

On May 24, 2000, we asked both the FFC Staff Director and the primary author of the FFC study to review and comment on a draft of this letter and enclosure I. Both concurred with our presentation of the information. In her letter dated June 7, 2000, the FFC Director said that the letter fairly and objectively presented the findings of the FFC study, and the primary author in his letter dated June 5, 2000, said that the abridgement of the study both accurately reflected the report and maintained its spirit and intent. Both provided minor technical changes and updated information, which we incorporated into the letter and enclosure I where appropriate. The FFC Director's letter is reproduced in enclosure II, and the letter of the primary author of the FFC study is reproduced in enclosure III.

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We are sending copies of this letter to Senator George V. Voinovich, Chairman, and Senator Max S. Baucus, Ranking Minority Member, Subcommittee on Transportation and Infrastructure, Senate Committee on Environment and Public Works; Representative Bob Franks, Chairman, and Representative Robert Wise, Jr., Ranking Democratic Member, Subcommittee on Economic Development, Public Buildings, Hazardous Materials and Pipeline Transportation, Committee on Transportation and Infrastructure; and to others upon request.

If you have any questions about this letter, please call me or Ron King at (202) 512-8387.



Bernard L. Ungar  
Director, Government Business  
Operations Issues

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# Abridgment of the Federal Facilities Council Study on Facility Design Reviews

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*We condensed the FFC study Adding Value to the Facility Acquisition Process: Best Practices for Reviewing Facility Designs, Federal Facilities Council Technical Report #139 (Washington, D.C.: National Academy Press, n.d.), authored by Ralph S. Spillinger in conjunction with the FFC Standing Committee on Organizational Performance and Metrics, to focus on issues that address the concerns of the requesters. We made minor revisions to the wording in some instances for clarity and contextual purposes. We also omitted parts of the study, including some footnotes and bibliographic references, to shorten the presentation. We have nevertheless retained the essential elements and relative completeness of the original FFC study.*

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## Background

The federal government, like private corporations and other organizations, acquires facilities to support specific functions and missions and the general conduct of its business. Confronted with a requirement to acquire a building or other constructed facility, owner organizations, both public and private, traditionally participate in a multiphased process involving conceptual planning, design, procurement, construction, and start-up. Throughout this process, owners usually maintain some level of design oversight to ensure that the acquired facility is an acceptable balance of cost, schedule, quality, and performance.

Until the 1990s, federal agencies often maintained an in-house facilities engineering organization, comprised in part of architects and engineers, responsible for both the technical aspects and the oversight of the planning and design phases of the acquisition process. As a result of executive and legislative initiatives to reduce the size of the government, federal agencies have downsized their design and engineering staff. Agencies are increasingly using outside consultants to provide technical expertise for the planning and design phases of both new projects and major renovations of existing facilities. Although oversight responsibility for the facility planning and design phases generally remains within the agencies, fewer staff resources are being devoted to the effort than in the past.

Concurrent with downsizing, procurement regulations have been modified to allow agencies greater flexibility and choice in selecting contracting methods for acquiring facilities. As recently as 5 years ago, the design-bid-build method of facility acquisition was used almost exclusively. Today, agencies increasingly rely on design-build, construction management, and program management contracting methods. Further, advances in computer-aided design and other technologies are occurring



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simultaneously with process changes in federal agencies, increasing the importance of technology support in the design process.

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## Defining Design Review

Prior to developing a detailed scope of work for the study, the sponsor agencies shared information on their own design review processes and the design review processes of some private sector organizations with which they were familiar. Analysis of this information revealed that no two of these organizations defined the design review process and its various elements in exactly the same manner. Nor was a common start or end point identified for design review as an element of the facility acquisition process.

For some organizations, design review was limited to reviewing a consultant-prepared schematic design to ensure that it met the owner organization's functional requirements for floor area, functional adjacencies and connections, and budget. For other organizations, design review primarily involved reviewing a more detailed facility design prepared by an in-house design team or a private A/E firm under contract.

The level of the review and the elements reviewed—for example, architectural reviews, mechanical and electrical interface reviews, or constructability<sup>1</sup> reviews—also varied. Some processes were formal, incorporating design reviews at specific design milestones (such as at 15, 30, and 60 percent of design completion). Others were less formal, relying on periodic meetings between the owner and the design team to review the progress being made toward preparation of final construction contract plans and specifications.

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## Study Purpose and Objective

The core issues of the FFC study concerned the value-added of design review processes and the appropriate level of oversight for owners of facilities, particularly federal agencies, in such processes. FFC's objective was to identify a range of best practices and technologies that can be used by federal agencies and other owners to provide adequate management and oversight of design reviews throughout the facility acquisition process. Specifically, it sought to provide answers to the following questions:

- What is the value-added of design review processes?
- How do (and how can) federal agencies measure the value-added?

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<sup>1</sup>In constructability reviews, experienced construction managers look for such items as inappropriate materials, physical barriers, and complex interfaces that will unnecessarily complicate the construction phase.

- What is the role of in-house staff, and what value do they add to design review processes?
- What functions are being (and should be) contracted to outside consultants?
- What skills and resources do federal agencies need to provide effective oversight of design review processes?
- What risks and liabilities do federal agencies face in outsourcing most or all of their design review functions?
- How can new and emerging technologies be integrated into design review processes?

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## Facility Acquisition Practices and Industry Trends

The process of acquiring a facility usually includes five phases that can be generalized as conceptual planning, design, procurement, construction, and start-up. The contracting method used will determine whether the five phases occur in sequence or if some phases occur concurrently. The contracting method can also affect who is involved at each phase (A/E, construction contractor, etc.). For example, using the design-bid-build contract method, the five phases generally occur in sequence with the A/E involved in the design phase and a construction contractor in the construction phase. A design-build acquisition, in contrast, will use the same contractor for the design and construction phases, thus allowing some phases and activities to occur concurrently. Regardless of the contracting method used, the acquisition of a facility will necessarily involve activities and decisions related to all five phases.

During the conceptual planning phase various feasibility studies are done to define the scope or statement of work based on the owner's expectations for facility performance, quality, cost, and schedule. Several alternative design solutions can be considered during this phase, leading up to the selection of a single preferred approach. The preferred approach may be a schematic that includes functional requirements, such as square footage estimates for various functions and adjacencies or connections to functions that are desirable or required.

The design phase usually starts once the statement of work and preferred design approach have been developed. From the schematic, the design matures into final construction documents comprising the plans and specifications from which equipment procurement and construction bids can be solicited. Estimated facility cost and schedule issues receive increasingly intense review during the design phase so that the owner has a high level of confidence prior to bid that the performance, quality, cost, and schedule objectives defined during the conceptual planning phase can be met.

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Complex facility projects usually include a procurement phase in order to expedite the purchase, manufacture, and delivery of long-lead-time equipment, such as unique process machinery, large electrical and mechanical equipment, and sophisticated architectural components. Such equipment procurement may proceed in parallel with construction phase activities, so that the owner ultimately is able to furnish long-lead-time equipment to the construction contractor in a timely manner, thus avoiding construction delays attributable to late equipment delivery.

Early in the construction phase a formal construction management plan is developed describing the intended sequence and method of construction activity as well as the relationships, responsibilities, and authorities of all involved parties (owner, user, A/E, construction contractor, specialty contractors, and relevant consultants). The biggest challenge during the construction phase is managing changes resulting from such sources as scope of work changes by the owner, errors and omissions in the construction documents, and unknown or changed site conditions. The construction phase is considered complete when the owner accepts occupancy of the facility, although final completion of construction may continue for months (or even years) until all discrepancies have been identified, resolved, and mutually agreed upon.

The start-up phase, sometimes called commissioning, begins with occupancy of the facility by its user. Building components are tested individually and then together with other components in order to measure and compare their performance against the original design criteria. Facility operation and maintenance plans are implemented, tested, and refined as appropriate.

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## Downsizing of Facility Engineering Organizations

During the last 20 years, change has been particularly pronounced with regard to how corporate and government owners manage the acquisition of facilities and other projects. As noted by TBR in a 1997 white paper,

“Virtually all major firms have reduced the size and scope of work performed by engineering organizations. Many firms are drifting because they are uncertain about the appropriate size and role of their in-house capital projects organization. Nearly every owner’s engineering and project management organization in the U.S. has been reorganized, sometimes repeatedly, without achieving a satisfactory result in many cases.”<sup>2</sup>

Since 1970, owner engineering downsizing has resulted in increased use of contractors to perform design and construction functions. Graphs published by TBR, based on data compiled by Independent Project

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<sup>2</sup>The Business Stake in Effective Project Systems (Washington, D.C.: TBR, 1997).

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Analysis (IPA) of Reston, VA, for more than 2,000 projects from a variety of industries, show a decline in the percentage of major projects designed by owners' in-house staff from about 30 percent during 1970-1975 to about 25 percent during 1981-1985, to less than 10 percent after 1991.

Many owners originally identified the project definition activity as a core competency.<sup>3</sup> However, IPA's data indicate that project definition, too, is increasingly being outsourced. Data compiled through 1997 by CII, closely correlates with TBR data.<sup>4</sup>

Fortunately, an increasingly competitive, productive, sophisticated, and capable facility design and construction industry is capable and willing to take on this increased workload. Unfortunately, this trend has not reduced owners' overall engineering costs as a percentage of TPC.<sup>5</sup> The engineering share of TPC has increased over the past 20 years from 13 to 20 percent. The interpretation of this increase is controversial: It is not clear if the increase reflects an increased cost of outsourced engineering or simply the cost of increased intensity of engineering required by today's technology-driven projects and more sophisticated design and construction practices.

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## Contracting Methods

Since 1993, federal regulations have been modified to allow agencies greater flexibility and choice in the contract methods used for acquiring facilities. Downsizing and the increased outsourcing of design and construction services have provided the impetus for selecting methods other than the traditional design-bid-build contract method.

Although there are many variations, current practice recognizes four basic categories of contract types that apply to several facility acquisition systems:

- general contract,
- construction management,
- design-build, and
- program management.

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<sup>3</sup>Core competency is defined as an essential skill that should be retained within the organization in order to perform effectively.

<sup>4</sup>Benchmarking and Metrics Summary for 1997, Benchmarking and Metrics Committee (Austin, Texas: The University of Texas at Austin, 1998).

<sup>5</sup>TPC is defined as the sum total of all costs associated with a project's planning, development, design, construction, outfitting, and start-up, not including land costs.

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General Contract Approach

The general contract approach assumes that the owner contracts individually for all engineering and construction services required to acquire a facility. This is the traditional approach that most large-scale owners (both public and private) used to design and construct their facilities until the relatively recent growth of interest in outsourcing of design and construction services. It is illustrative of the design-bid-build contract method used by federal agencies.

Under this approach, the owner manages individual contracts with all design, engineering, and construction service providers, implying that the owner must also manage all interfaces between service providers. Interface management becomes critical because assessment of accountability for problems incurred during the project's evolution is difficult due to the variety and separation of individual contracts. To succeed, such a process requires a relatively large and experienced facility design, engineering, and management staff within the owner's organization in order to protect the owner's interests.

Construction Management Approach

Under the construction management approach, the owner contracts with an outside firm to manage the construction of a project. The construction manager (CM) may function either as an "agency" CM, or as an "at-risk" CM.

- Agency CM: The owner holds all individual construction contracts, and the CM functions as the construction contract administrator, acting on behalf of the owner and rendering an account of activities. The CM is typically not responsible for construction means and methods, nor does the CM guarantee construction cost, time, or quality.
- At-risk CM: The actual construction work is performed by trade contractors under contract to the CM, who then becomes responsible to the owner for construction means and methods and delivery of the completed facility within the owner's scope of work for cost, time, and quality.

Under this approach, the owner typically retains responsibility for managing all preconstruction A/E services, and therefore must address all interface issues between service providers.

Design-Build Contract Approach

The design-build contract approach represents a much larger step toward outsourcing of traditional owner functions than occurs with the above-described CM contract. Under this approach, an owner prepares a project scope definition and then engages a single entity that will provide all services necessary to complete the design and construct the facility.

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Generally, the scope definition package represents a design that is between 15 and 35 percent complete, although variations may begin much earlier, often with a performance specification, or much later with perhaps a 65 percent design package.

Project success under this approach is primarily dependent on the owner's ability to produce a comprehensive, well-defined, and unambiguous scope of work upon which all subsequent design-build activity will be based. Once the design-build contract has been awarded, changes to owner requirements will generally incur heavy penalties to the project cost and schedule. The owner is therefore well advised to ensure that preparation of the project scope definition package accurately and clearly expresses expectations for project performance, quality, cost, and schedule.

Use of the design-build approach for project delivery is growing dramatically in both public and private organizations; NAVFAC, GSA, and USPS have become particularly strong proponents of this approach, but not without controversy.

**Program Management Contract Approach**

The program management contract method represents the ultimate step in outsourcing of the owner's project management functions. The program manager (PM) is engaged by the owner to exercise oversight of the entire facility delivery process for a multitude of projects. Similar to the construction management approach, the PM can serve in either an "agency PM" or "at-risk" capacity.

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**Owner as a "Smart Buyer"**

American business has regained its competitive edge by reengineering its business practices to improve their effectiveness and, in the process, downsize their in-house staff. However, competitive pressures caused many organizations to approach staff downsizing without adequate planning. Mistakes were made: reductions were insufficient, or too extensive, or made in the wrong area.

The loss of technical competence through downsizing was sufficiently pervasive that FFC, in conjunction with TBR and the NAVFAC, conducted the "Government/Industry Forum on Capital Facilities and Core Competencies" in March 1998. A fundamental finding of this forum was that owner facilities engineering organizations need to identify and retain core competencies—the essential technical and managerial skills that cannot be outsourced without serious risk to an organization's ability to conceive and acquire necessary facilities. The forum participants recognized the advisability of the owner performing as a "smart buyer" of

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outsourced services. A smart buyer is one who retains an in-house staff capable of

- understanding the organization's business or mission, its requirements, its customer needs, and who can translate those needs and requirements into corporate direction or mission;
- accurately defining the technical services to be contracted;
- evaluating the quality, performance effectiveness, and value of technical work performed by contractors; and
- managing the interface between technical service contractors and the owner's line-of-business managers who will ultimately benefit from services provided.

These functions are intrinsic to the entire facility acquisition process and underscore the need for the owner's in-house staff to be intimately involved in these aspects of the process, particularly the leadership role.

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## Cost Implications of Facility Acquisition Practices

It should be intuitive that poor planning and design practices result in increased TPC. These cost growth drivers include

- construction change orders required to correct errors and omissions in the design documents;
- owner-driven construction change orders required to incorporate desirable features overlooked during design;
- inefficient construction resulting from a failure to incorporate construction-enhancing features during design;
- rework resulting from unclear construction documents;
- standby costs incurred while construction is either stopped or slowed to incorporate changes;
- litigation;
- delayed completion of the facility (i.e., lost business revenue, staff standby, nonproductive capital investment costs); and
- a poorly performing facility.

Numerous research reports have been published characterizing cost growth resulting from poor planning and design practices. The following are a few of the key statistics contained in documents abstracted by FFC:<sup>6, 7, 8, 9, 10</sup>

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<sup>6</sup>Benchmarking and Metrics Summary for 1997, CII, Benchmarking and Metrics Committee (Austin, Texas: The University of Texas at Austin, 1998).

<sup>7</sup>The Business Stake in Effective Project Systems, (Washington, D.C.: TBR, 1997).

- Project design costs average 13 percent of TPC.
- Total project engineering costs average 20 percent of TPC (in addition to design costs discussed above, includes planning, development, and project management costs).
- Project rework costs average 12.4 percent of TPC. Eighty percent of this rework results from errors and omissions in the design documents. The remaining 20 percent results from poor construction practices.
- Fifty percent of construction change orders result from errors in the design documents directly related to improper interfaces between design disciplines (civil, structural, architectural, electrical, and mechanical). These change order costs contribute anywhere from 0.8 to 3.4 percent of TPC.
- Comprehensive review of project document development during the design phase of acquisition should cost from 0.2 to 0.5 percent of TPC. Properly done (i.e., using best practices discussed later in this study), such activity should drive down the cost of construction change orders by an average of 3 percent of TPC.
- To evaluate the value of thorough concept definition a CII-led review of 62 projects compared final TPC against the estimated TPC at time of project approval for construction. The 21 projects with the highest degree of definition averaged 4 percent cost underrun. The middle 21 projects averaged 2 percent cost underrun. The 21 projects with the lowest definition averaged 16 percent cost overrun.
- Indirect costs, the business impact costs discussed above, are highly variable and very difficult to estimate, but are potentially huge. An order-of-magnitude estimate would be 8-15 percent of TPC.
- Research conducted by Redicheck Associates, an A/E firm specializing in outsourced design review, indicates that the single biggest source of construction change orders (approximately 50 percent) is errors in the design documents directly related to improper interfaces between design disciplines (civil, structural, architectural, electrical, and mechanical). Redicheck's cost for conducting the discipline interface design review is approximately 0.1 percent of TPC, with a resultant reduction of rework cost ranging from 0.8 to 3.4 percent of TPC. The estimated payback ratio here ranges from \$8 to \$34 saved for every dollar invested in a discipline

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<sup>8</sup>Costs of Quality Deviations in Design & Construction, CII, Publication 10-1 (Austin, Texas: The University of Texas at Austin, 1989).

<sup>9</sup>William T. Nigro, and Martha W. Nigro, Redicheck Interdisciplinary Coordination, 3<sup>rd</sup> edition (Peachtree City, GA: The REDICHECK firm, 1992).

<sup>10</sup>Measuring the Cost of Quality in Design & Construction, CII, Publication 10-2 (Austin, Texas: The University of Texas at Austin, 1989).



interface design review activity.

The implication of these statistics is that opportunity exists to significantly reduce TPC by conducting an effective design review process. The potential savings range from a minimum of 3 percent to as much as 20 percent, and even higher when indirect savings are taken into account.

Intuitively, good design review practices result in the preparation of more comprehensive and accurate construction documents, which in turn result in lower project construction costs. Areas of savings include less rework on the part of the construction contractor, fewer change orders for correction of design errors or omissions, and the cost of belatedly adding project upgrade features that should have been addressed in the original design. By reducing changes that are required during the construction phase, good design review practices also generate significant indirect cost savings by avoiding costs associated with loss of productivity during construction-delayed facility start-up, and litigation.

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## Effective Design Review Processes: FFC Conclusions

During the 1980s and 1990s, a number of business practice studies were conducted by construction trade associations, professional societies, and academic groups to better understand which practices produced better results in terms of facility performance, quality, cost, and schedule. These studies concluded that quality design yields buildings that perform well throughout their service lives.<sup>11</sup> Quality design resulted when all interested parties (owner, user, A/E, construction contractor, and specialty consultants) in the facility acquisition process worked together in an intense, collaborative, complex, and multiphased process beginning with conceptual planning and concluding after the start-up phase.

These business practice studies also found that decisions made during the conceptual planning phase will establish initial constraints limiting future design flexibility. These early decisions thus have a disproportionately greater influence on a facility's ultimate performance, quality, cost, and schedule than decisions made later in the process. The conceptual planning phase should therefore be the phase when the review of designs is most intense, with the primary focus upon ensuring the appropriateness, accuracy, and thoroughness of the owner's expectations regarding facility performance, quality, cost, and schedule. This will be especially true when using the design-build and program management contract methods when

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<sup>11</sup>Improving the Design Quality of Federal Buildings, NRC, Committee on Improving the Design Quality of Federal Buildings, Building Research Board (Washington, D.C.: National Academy Press, 1989).

the owner's involvement in design reviews declines after the conceptual planning phase.

If design review activity during the conceptual planning phase has resulted in a clear scope of work regarding the owner's expectations, design reviews during the design phase are greatly simplified. Those parties involved should focus upon ensuring that the evolving facility design incorporates high standards of professional engineering practice, with regard to architectural, civil, structural, electrical, and mechanical systems and their interfaces. Formal reviews may be scheduled periodically during the design phase, at approximately the 35, 60, 90, and/or 100 percent design completion milestones (although these milestones may vary significantly depending on the individual project's size and complexity). Such structured formality helps ensure the widest possible participation of interested parties during the review, including specialists and consultants who bring expertise in such areas as value engineering, constructability, biddability,<sup>12</sup> operability, maintainability, and environmental compliance.

During the procurement phase, the review of designs can continue to contribute to overall project success by monitoring progress made in ordering the various items of long-lead-time equipment. It is not unusual for suppliers to detect errors in the ordering specifications, or to make substitution recommendations for either greater economy or performance enhancement. The review team should evaluate the impact of these changes on facility performance, quality, cost, and schedule.

It is almost inevitable during the construction phase that scope of work changes by the owner, errors and omissions in the plans, unknown or changed site conditions, and creative initiatives on the part of construction staff will result in recommended changes to the facility design. Design reviews in this phase should focus on assessing the impact and advisability of changes on facility performance, quality, cost, and schedule.

Design reviews should continue into the start-up phase. At this juncture, it is important to document the results achieved by conducting what is commonly referred to as a postoccupancy evaluation, whose purpose is to record lessons learned for future reference. Facility performance, quality, cost, and schedule actually achieved should be objectively measured and compared with the owner's original expectations. Lessons learned during

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<sup>12</sup>In biddability reviews, procurement specialists look for conflicts, errors, omissions, and lack of clarity in the construction documents that could create confusion on the part of prospective equipment suppliers or construction contractors.

the five facility acquisition phases concerning design strengths and weaknesses should be recorded for use in improving future similar project activities. And perhaps most important, the facility users' subjective satisfaction with both the acquisition process as well as the completed facility should be noted.

Based on industry research by CII, NRC, FFC, and similar organizations, interviews conducted for this study, and the author's experience, it can be concluded that an effective design review process will be structured to address all of the topics included in table I.1.

**Table I.1: Topics Addressed in an Effective Design Review Process**

| <b>Topic</b>                | <b>Key question to be addressed</b>  |
|-----------------------------|--|
| Owner satisfaction          | Does the constructed facility meet the owner's expectations as originally defined by the project scope definition or statement of work (i.e., performance characteristics, architectural statement, level of quality, cost, schedule, and any relevant owner-published standards and/or policies)? |
| Sound professional practice | Is the approach taken in each of the specialty areas (architectural, civil, mechanical, and electrical) commensurate with professional standards?  |
| Code compliance             | Does the design comply with all applicable codes, such as fire protection, life safety, and access?  |
| Architectural statement     | Is the overall presentation representative of established architectural standards?   |
| Value engineering           | Are there any less expensive methods or materials that could be used in the design without impacting project quality or performance (or life-cycle costs)?   |
| Biddability                 | Are the construction documents sufficiently clear and comprehensive so construction contractors will have no difficulty developing an accurate bid with minimal allowance for contingency?   |
| Constructability            | Does the design impose any unnecessarily difficult or impossible demands on the construction contractor?   |
| Operability                 | Does design of the facility operating systems ensure ease and efficiency of operation during the facility's useful lifetime?   |
| Maintainability             | Does the facility design allow for easy and cost-effective maintenance and repair over the useful life of the facility?  |
| Life-cycle engineering      | Does the design represent the most effective balance of cost to construct, cost to start up, cost to operate and maintain, and (perhaps most important) the user's cost to perform the intended function for which the facility is being acquired over the useful life of the facility?            |
| Postoccupancy evaluation    | Based on a review of the construction, start-up, and ongoing functioning of the facility, could any unexpected difficulty have been avoided by a different design approach?  |

Source: Federal Facilities Council Technical Report #139.

## **Design Review Practices in Federal Agencies**

Federal facilities comprise a portfolio of significant, durable assets that have been acquired to support specific functions and missions and the general conduct of the government's business. It is estimated that the government spends about \$20 billion per year for new facilities and major renovations of existing facilities. Even a relatively small agency such as IHS is a major player, with over \$265 million of construction activity in planning, design, or construction as of 1999. At the other end of the

spectrum are the truly capital-intensive agencies, such as the Department of the Navy with a \$2.5 billion annual construction budget.

As missions, priorities, and situations change, agencies may experience wide fluctuations in the scope and budget for their facility acquisition programs. For example, a recent program to upgrade federal courthouses around the country has added billions of dollars to GSA's construction activity. DOS is facing a similar situation. Following the 1998 bombings of embassies in Africa, legislation requiring rapid and extensive upgrade of embassy security features worldwide was enacted which could require several billion dollars to execute. Given the size of the government's expenditures on facilities, it is important that federal agencies have effective design review processes that result in buildings that perform well throughout their service lives.

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### Downsizing of Federal Facilities Engineering Organizations

Like private sector corporations, federal agencies' facilities engineering staffs have been considerably downsized in the past 10-15 years. A 1987 report of FFC noted that "due to budget cuts, agencies have had to reduce the number of project managers, design reviewers, inspectors, and field supervisors they employ." Procurement specialists trained primarily in contract negotiation and review rather than design and construction have been playing increasingly greater roles in facilities development.<sup>13</sup>

The federal downsizing trend accelerated after 1991 as a result of a changed global environment, a shift in focus toward smaller and more cost-effective government, and a number of legislative initiatives. In the nine federal agencies that responded to the questionnaire associated with this FFC report, facilities engineering staffs have been reduced on the order of 20 to 65 percent, with the average at about 50 percent. As a consequence of the loss of technical staff, particularly architects and engineers, federal agencies are increasingly outsourcing design and construction-related functions.

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### Design-Review-Related Trends in Nine Federal Agencies

The FFC's Standing Committee on Organizational Performance and Metrics developed a two-part questionnaire focused on design review processes and distributed it to FFC sponsor agencies. Part one was sent to senior facilities engineering program directors at the headquarters level and focused on agencywide policy issues. Part two was sent to randomly selected project managers at the field activity level and focused on

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<sup>13</sup> On the Responsibilities of Architects and Engineers and Their Clients in Federal Facilities Development, NRC, Committee on Architect-Engineer Responsibilities, Building Research Board (Washington, D.C.: National Academy Press, 1994).

individual project review issues. The nine federal agencies that answered the questionnaires were ANG, DOE, DOS, GSA, IHS, NASA, NIH, NAVFAC, and VA.

The FFC report included a summary and analysis of questionnaires returned by each of these agencies that described the agency's design review practices at the time of the study. The following discussion compares and contrasts the responses contained in the 44 questionnaires that were returned by the 9 federal agencies listed above.

How Are Agency Facility Engineering Functions Organized to Carry Out Their Missions?

There is no single organizational model for federal agency facilities engineering organizations. DOE's facilities are government-owned but contractor-operated. Some agencies, like the VA, have moved to field-based design review and a mix of field-based and headquarters-based project management. Others, like NASA, have a centralized program policy and oversight office, with all program and project management functions conducted at the field activity level. The majority of the responding agencies maintain multiple regional project execution offices.

What Has Been the Extent of Downsizing on Agency Facility Engineering Organizations?

Seven of the nine responding agencies' facility engineering organizations experienced significant downsizing between 1994 and 1999, on the order of 20 to 50 percent reduction of in-house staff positions (the VA's reduction has been estimated at 65 percent). As of August 1999, only DOS and ANG have been able to maintain a relatively stable situation with regard to staff size.

How Are Agency Facilities Engineering Organizations Responding to Mitigate the Impacts of Downsizing?

During the early stages of downsizing, the responding agencies simply tried to do more with less. However, this adaptation became untenable at a certain point. Agencies then began to reengineer their facility engineering processes and practices. Intensity of this reengineering varies among the responding agencies, reflecting the fact that the speed and extent of downsizing has varied greatly from one agency to another. Impact-reducing strategies reported by various agencies include the following:

- Augmenting in-house staffing voids through personal service contracts. Personal service contracts allow agencies to add contractor staff to in-house staff on a temporary basis to fill voids in specific disciplines, or to address unusual peaks in workload. Procurement policies vary among agencies with regard to allowing use of personal services contracts.
- Outsourcing functions previously accomplished in-house. Nearly all facility acquisition functions except agency policy development and oversight have been considered for outsourcing by one agency or another.

- Reducing the intensity of oversight activities such as design review and construction inspection by either contracting such functions to third parties, or by including the functions within the scope of the design and/or construction primary contracts.
- Eliminating some activities entirely. One NAVFAC field office reported that it has eliminated formal design reviews on many smaller projects, holding A/Es responsible for instituting a self-review process. Similarly, a GSA region reported that it generally only requires a single formal progress review during design.
- Using project delivery contracting schemes that shift more responsibility for design and construction oversight to the contractor, such as design-build, construction management, and program management. Indeed, NAVFAC reports that design-build is now the favored contracting strategy and the traditional design-bid-build strategy has become the least favored.

### Why and How Do Federal Agencies Approach the Practice of Design Review?

Risk management, compliance with user expectations, and reductions of change orders were cited as the primary reasons for conducting design reviews. The least cited reason was to maintain in-house core competencies. All nine responding agencies report participation in a design review process. Significant differences were noted, however, as follows:

- All responding agencies reported that they participated in design reviews, although not at every field office (a few field offices of decentralized agency engineering organizations reported no or minimal design reviews—they rely on A/Es to self-review their work). Also, the degree to which agencies and their field activities varied the intensity of the design review process between simple and complex projects varied greatly from one agency to another.
- Design review functions identified as having the greatest value-added were scope and budget compliance, constructability, and compliance with client design guides. Functions identified as adding the least value were the discipline reviews—architectural, electrical, mechanical, and structural (although the responses did not support the idea that these functions could be dropped from the review process without risk.)
- Nearly all responding agencies reported conducting formal design reviews at the 30 and 90 percent project design milestones. Only two (NASA and GSA) reported conducting formal reviews routinely earlier than the 30 percent milestone.
- The primary criteria used to determine the intensity of design review are project value, complexity, and the project delivery method. Conversely, these criteria had little impact on the decision to review with in-house or

outsourced resources. That decision rested primarily on in-house staff availability.

- When elements of design review are outsourced, all responding agencies still use in-house staff to review project scope and budget compliance. The most consistently outsourced elements included constructability, value engineering, and compliance with building codes.
- Nearly all responding agencies exploit technology tools to support their design review activities, including computer-aided or assisted design software, Internet and Intranet communication links, and computer software word processing and project management programs.
- Fewer than half of the agencies measure performance of their design review processes.

### How Have Federal Agencies Changed Their Approach to Design Review?

Eight of the nine responding agencies reported that they have changed their approach to design reviews since 1994. The primary reasons cited for change are staff downsizing, changes in contract methods, and business process reengineering. The most frequently reported changes included

- consolidation of agency design guides and standards for simplification,
- increased outsourcing of either parts or all of the design review activity,
- exploitation of technology to assist the process, and
- reduced frequency of formal design reviews.

Several questions related to outsourcing of design review functions. Opinions and experience on this issue were varied, and no conclusions could be reached from the data provided. The following were typical comments:

- “Outsourcing results in a loss of core design capability. This in turn results in a lack of ability to be a Smart Buyer. At some point, we wouldn’t even have enough expertise to hire a contractor to conduct design reviews.”
- “Outsourcing poses no risk, as long as the contractors are liable for performance.”
- “Outsourcing poses a very significant risk, particularly on renovation type work. And it is very difficult to have technically competent contractors in specialty areas.”
- “Outsourcing is our present way of doing business, and we have experienced little risk.”

Looking to the future, about one-third of the responding agencies reported that they are considering further outsourcing of design review functions.

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| Interesting Initiatives                                       | During the course of interviews and an extensive literature search, a number of innovative practices were noted that may have broader implications. These practices are discussed below.  |
| Partnering and Team-building Training                         | Although this practice is achieving widespread recognition, some programs have proven more effective than others. USACE and CII have both been recognized for their particular programs, and both offer formal training.  |
| In-house Training Programs                                    | Agencies have developed in-house training programs specializing in program and project management practices for federal agencies. Among the oldest are schools run by USACE and NAVFAC. More recently, NASA has developed two 1-week short courses of facility engineering management practices.  |
| Review Comment Documentation                                  | USACE's latest software program used for documenting, collecting, distributing, and achieving design review comments is called DR CHEKS. It runs on a desktop computer and uses the Internet for communication among design review participants. Perhaps most important, it has features to aid follow-up of actions taken in response to review comments, which is a particularly troublesome area.  |
| Project Management Center of Expertise                        | <p>GSA recently established the GSA Project Management Center of Expertise. The center has been staffed by GSA's most senior and competent project managers to serve two functions:</p> <ul style="list-style-type: none"><li>• Actively manage all of GSA's uniquely large, complex, or high-visibility projects, regardless of location.</li><li>• Provide mentoring, counseling, and training services in the area of project management in support of all of GSA's regional offices.</li></ul>  |
| International Standards Organization (ISO) 9000 Certification | Some large A/E firms have secured ISO 9000 certification as a quality control activity. Among federal agencies, several USACE's district offices have received ISO 9000 certification for their design and construction programs. Other agencies, including NASA and NIH are working toward ISO 9000 certification for their facility engineering activities. <sup>14</sup> It should be noted that ISO 9000 does not guarantee a quality product. Rather, it guarantees that the process that produces the product (good or bad) has been carefully structured, documented, and measured. Organizations have |

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<sup>14</sup>Subsequent to the issuance of the FFC report, NASA received ISO 9000 certification for its headquarters office and each of its centers. Also, NIH received certification for the design and construction branch of its Division of Engineering Services.



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found that the process of securing ISO 9000 registration has been a valuable experience in understanding just what they do and how they go about it.

**Conceptual or Advance Planning** Most projects that fail to meet their planned objectives do so because of faulty or inadequate predesign development. CII has recently developed a comprehensive preproject planning approach that allows organizations to measure whether they have adequately addressed all predesign requirements. CII also has developed a training module intended to assist organizations in adopting this recommended approach to preproject planning.

**Design Review Lessons Learned** Problems identified in the design review process can become a powerful tool to improve performance. VA uses a method of documenting and publicizing such lessons learned in an innovative program called ProCATS. Its purpose is to identify recurring problems that result in change orders, claims, and delays and then to take positive steps to avoid such problems in the future. The system is the first of its kind in the federal government and was a 1996 winner of the Vice President's Hammer Award.

**A/E Historical Performance Database** USACE has, for many years, maintained a database containing historical evaluations of A/E performance on past projects. This database, the ACASS, can be queried by any federal agency interested in a particular A/E's past performance.

**NIH Contractor Performance System** NIH has developed a multiple agency, shared file system that allows all authorized users to have access to the completed contractor performance evaluations of all subscribing agencies via the Internet. A separate module for each subscribing agency is developed with a unique URL, allowing each agency control of agency data and access authority. Planned future enhancements include automated construction and A/E forms, electronic storage of contractors' rebuttal and comments, electronic and encrypted transmittal of evaluations to contractor, and ad hoc reporting.

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## Findings About the Value-added of Design Review Processes

During the course of the study, a literature search was conducted, industry experts and practitioners were consulted, and federal agencies were surveyed. The findings of this report as they relate to the original questions posed about the value-added of design review processes and the role of facilities owners are addressed in this segment.

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## What is the Value-added of Design Review Processes?

Design reviews are an essential component of the facility acquisition process. An effective design review process helps to unify and align all interested parties to a common objective and integrate their knowledge,

experience, and skills throughout all phases of the facility acquisition process (conceptual planning, design, procurement, construction, and start-up). In the end, effective review of designs maximizes the probability that a business requirement will be successfully supported by a facility that was conceived, designed, constructed, and placed into operation efficiently and effectively.

Effective design review practices result in the preparation of more comprehensive and accurate design and construction documents, which in turn result in lower project construction costs. Areas of savings include less rework on the part of the construction contractor, fewer change orders to the owner for correction of design errors or omissions, and the cost of belatedly adding project upgrade features that should have been addressed in the original design. By reducing changes required during the construction phase, effective design review practices also generate significant indirect cost savings by avoiding costs associated with loss of productivity during construction-delayed facility start-up, and litigation.

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### **How Do (and How Can) Federal Agencies Measure the Value-added?**

The nine federal agencies that responded to FFC's questionnaire indicated that they currently measure the value-added of design review processes primarily from a broad context: Their insight is both subjective (is the user reasonably happy with the completed facility?) as well as objective (how close did the completed facility come to the original cost and schedule objectives?). Sufficient industry research has been conducted in recent years to identify metrics that can be used to measure both the efficiency and the effectiveness of each phase of the facility acquisition process and compare the results to established benchmarks. The extent to which individual federal agencies currently take such measurements and analyze results varies widely.

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### **What Is the Role of In-house Staff, and What Value Do They Add to Design Review Processes?**

Within most federal agencies, acquiring facilities is a means to support the agency's mission rather than the mission itself. The agency's in-house facility engineering staff exist to support the agency's mission. First and foremost, the in-house staff should be able to identify facility requirements in the context of their impact on the agency's mission success and, in so doing, to act as a smart buyer. The staff should be capable of leading a strategic planning process involving representatives of the agency's facility user community where give and take decisions are made balancing the facility's ultimate performance, cost, and schedule.

During the tactical facility acquisition phase, in-house facility engineering staff should be capable of providing the overall process leadership, ensuring that all activities proceed in the best interest of the owner.

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Toward this end, the owner's interests are best served if the in-house staff can also perform in the role of a "smart buyer" of the necessary technical services. A smart buyer is one who retains the requisite technical knowledge to accurately define the technical services needed, recognizes value during the acquisition of such technical services, and can evaluate the quality of services ultimately provided.

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**What Functions Are Being (and Should Be) Contracted to Outside Consultants?**

Individual and often uncontrollable circumstances have resulted in nearly all facility engineering functions, from conceptual planning to project start-up, being contracted to outside consultants at one time or another. Today's general practice among federal agencies is to outsource design development and, to a lesser extent, certain specialized technical review functions, such as shop drawing reviews, value engineering, and constructability.

As long as sufficient skills are retained in-house to meet the smart buyer approach discussed above, there does not appear to be any greater risk from contracting out a broader range of design review functions, including such services as construction document discipline reviews and code compliance checks, so long as such functions are widely available from a competitive commercial marketplace. The exception occurs when complex projects include unique and specialized features of high mission relevance and limited skill availability in the commercial marketplace (examples would include NASA wind tunnels, VA medical research facilities, and high-security military facilities). Agencies are well advised to retain such unique specialized skills in-house as core competencies, with design review a primary in-house responsibility.

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**What Skills and Resources Do Federal Agencies Need to Provide Effective Oversight of Design Review Processes?**

Industry-related research and the author's interviews with public and private sector practitioners suggest that agencies should retain the capabilities in-house to

- define facility requirements in relation to the agency's mission, assess facility-related mission impacts, and conduct facility-related strategic planning activities;
- lead and conduct teaming activities involving participants from various interested parties (owner, user, A/E, construction contractor, specialty consultants, etc.);
- develop, implement, and maintain overall policy and direction of the agency's facility engineering function; and
- perform as a smart buyer of outsourced technical services.

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### What Risks and Liabilities Do Federal Agencies Face in Outsourcing Most or All of Their Design Review Functions?

The risks and liabilities will vary depending on whether an agency maintains the in-house capabilities to perform the design review-related functions listed above. If an agency does not retain such in-house resources and capabilities, agencies risk the following consequences:

- Consultant access to agency decision makers may be limited, resulting in difficulty understanding the owner's project performance expectations.
- Project schedule may be compromised at key decision points due to lack of owner insight.
- A design review process with little or no owner participation may become ineffective without the owner being aware of the developing process deterioration. An owner with little or no participation in design reviews is less likely to become aware of any breakdowns in the process; the owner may find out too late to remedy the problem or to save the project schedule, and this may result in cost overruns.
- Consultants may find it difficult to communicate with owner staff regarding technical issues and problem solving.

In the case of unique or unusual facilities, consultants may have limited access to unique skills, potentially resulting in naïve and inappropriate technical solutions.

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### How Can New and Emerging Technologies Be Integrated Into Design Review Processes?

The ongoing revolution in information technology and communications offers unlimited opportunities to improve design review processes. Examples range from relatively simple practices, such as effective use of audio and video teleconferencing to improve meeting flexibility, to emerging technologies using holographic projection techniques to create three- and four-dimensional models of project designs in order to visualize the impact of proposed changes. The Internet and computer-aided design and drafting can be used for fast, comprehensive, paperless communication between reviewers, managers, and A/Es.

Benchmarking offers one tool to identify which technologies offer the most return for the investment made. Agencies can identify similar organizations that have successfully incorporated desirable technologies and adopt those practices that offer significant improvements in process, cost savings, time, or resources.

Agencies can also consider joining any of the many trade and professional organizations that assist their membership in identifying and implementing appropriate technology-based practices. It is important to recognize that some of the technology practices will cause major changes to established

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routines, require new equipment and software, and require mastering new sets of skills.

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## Best Practices

Effective design review processes require work, some of it obvious and some of it quite subtle. The following list of 18 best practices relies heavily on research conducted by CII, TBR, NRC, FFC, and similar organizations. The best practices are organized into five categories related to the role of the owner, teamwork and collaboration, advance planning, process, and benchmarking.

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## Role of the Owner

1. Be a smart buyer. Facility acquisition processes (including review of designs) work best when the owner has sufficient in-house expertise to qualify as a smart buyer. A smart buyer is one who retains an in-house staff that understands the organization's mission, its requirements, and its customer needs and who can translate those needs and requirements into a corporate or strategic direction. A smart buyer also retains an in-house staff that includes technical experts who can articulate the nature of technical services being bought, recognize good value during the negotiation of such services, and evaluate the quality of the services as they are provided.
2. Develop a scope of work that clearly and accurately defines the owner's expectations regarding facility cost, schedule, performance, and quality. The owner's standards, more than those of any other entity involved in the acquisition process, will set the tone for all aspects of design review activity. The owner's scope of work should be used as the yardstick against which to measure performance.
3. Avoid the temptation to micromanage design reviews. A/E's are selected based on their experience and expertise; they should be given wide latitude to bring that expertise to fruition.

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## Teamwork and Collaboration

4. Use team-building and partnering techniques to build good working and communicative relationships among the participants, as well as to align all participants toward common objectives and expectations.
5. Ensure that all interested parties participate in design reviews from the planning and design phases, so that all perspectives are represented as the design evolves. Broad participation creates early project endorsement or "buy-in," reducing the potential of later disagreement or need for changes. At a minimum, involve representatives of the owner, the user, the A/E, construction management staff, maintenance and operations staff, and special staff such as procurement, safety, and

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fire protection. Where possible and appropriate, include the construction contractor, permitting agency staff, and independent specialists for value engineering and independent review. Err on the side of excess participation—it is cost-effective protection against subsequent unexpected and expensive fixes and oversights.

6. Use the same A/E throughout the facility acquisition process to maximize continuity and allow participants to build and apply their experience baseline. Using the same A/E for conceptual planning, detailed design, construction support engineering services, and start-up takes advantage of the A/E's intimate understanding of both the owner and his project needs, and supports continuity of personnel involved.
7. Use senior, experienced personnel who understand the relationship of a facility to meeting the agency's overall mission and who can effectively evaluate the evolving design and guide the review process.
8. Participants should commit for the duration of the activity to ensure continuity. Changing participants from any of the organizations involved in reviewing the design can disrupt the work flow and threaten the stability of good teaming relationships.
9. Participate in a design awards program in order to recognize and motivate excellence. Nothing succeeds like success! Recognition of a job well done gives visibility to a successful process and motivates all of the participants to continually improve.

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## Advance Planning

10. Focus attention on the review of designs during the conceptual planning and design phases, where the ability to influence the ultimate functionality and cost of the project is the greatest. Effective design review processes start out being very intensive and proactive, with an intensity that declines through the procurement, construction, and start-up phases of the acquisition process.
11. Do not start the final stage of design—preparation of the construction plans and specifications—until the preliminary engineering has been completed. To do otherwise could significantly slow the overall design activity due to frequent interruption and rework caused by incomplete project scope definition.

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## Process

12. Tailor the design review approach to project specifics. Project complexity, cost, mission criticality, visibility, method of contracting,

and schedule are just a few of the variables that can drive aspects of the design review approach such as frequency, intensity, and reliance on outsourced experts and consultants.

13. Keep up the pace to maintain momentum and keep the facility acquisition process on schedule. The review of designs at each phase of the process should not impede progress toward a completed facility. A stop-start or prolonged process impacts the acquisition in many ways, perhaps the most critical being the increased potential that organizations will reassign participants.
14. Pay special attention to the civil, structural, electrical, and mechanical interfaces. Historically, 30-50 percent of all construction change orders result from interference fit problems between trades. Is the power supply appropriate to the specified mechanical equipment? Does the HVAC (Heating, Ventilating, and Air Conditioning) ducting interfere with structural members?
15. Exploit technology. The technological revolution has provided many tools to enhance design review processes, including computer-aided design, three-dimensional modeling, data collection and distribution software programs, and rapid communications systems, including the Internet.
16. Conduct a postoccupancy evaluation to develop a lessons-learned document for future reference. After facility start-up, the design review team should document objective results (how did final cost and schedule compare to planned?) as well as subjective results (is the user pleased with facility performance?). The postoccupancy evaluation should also relate approaches taken during the various phases of the facility acquisition process with the final results.

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## Benchmarking

17. Measure results achieved by design review processes in order to assess their level of performance. A process cannot be managed if it is not measured. Successful benchmarking requires an organization to identify relevant performance characteristics, measure them, and compare results against either established industrial norms or against similar measured characteristics of other organizations recognized for their excellence.
18. Document both unusually good and bad performance for future reference. Even better, find a way to share such information with other organizations and federal agencies.

# Comments from the Director, Federal Facilities Council

## THE NATIONAL ACADEMIES

*Advisers to the Nation on Science, Engineering, and Medicine*

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June 7, 2000

Mr. Ronald L. King  
U.S. General Accounting Office  
General Government Division  
441 G Street, NW, Room 2A10  
Washington, DC 20548

Dear Mr. King:

On behalf of the Federal Facilities Council (FFC), I want to thank for the opportunity to review the draft report of the U.S. General Accounting Office, *Oversight of Federal Facilities' Planning and Design Processes*. The draft report fairly and objectively presents the findings of the FFC-sponsored study *Adding Value to the Facility Acquisition Process: Best Practices for Reviewing Facility Designs*, published in January, 2000. As you know, the Federal Facilities Council is a cooperative association of 20 federal agencies with interests and responsibilities related to all aspects of facility design, acquisition, management, maintenance, and evaluation. The FFC is convened under the aegis of the National Research Council, the operating arm of the National Academies. The FFC's mission is to identify and advance technologies, processes, and management practices that improve the performance of federal facilities over their entire life-cycle, from planning to disposal. The study referenced in your draft report was produced as an element of the FFC's 1999 Technical Activities Program.

As a point of information, under the section International Standards Organization (ISO), the draft report notes that "NASA and NIH are working toward ISO 9000 certification for their facility engineering activities." NASA has now received ISO 9000 certification for its headquarters office and each of its centers. In addition, the National Institutes of Health (NIH) has received certification for the design and construction branch of the Division of Engineering Services

Thank you again for the opportunity to comment on the draft report.

Sincerely,



Lynda Stanley  
Director, FFC

Cc: Ralph Spillinger, Facilities Engineering Consultant  
Jack E. Buffington, Chair, FFC  
William Brubaker, Vice Chair, FFC

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See footnote 14 on p. 24.



# Comments from Mr. Ralph Spillinger, Primary Author of the FFC Study

Ralph S. Spillinger  
7464 Madrona Drive NE  
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206-780-8338

June 5, 2000

Mr. Ronald L. King  
Assistant Director, Government Business Operations Issues  
US General Accounting Office  
441 G Street NW; 2A10  
Washington DC 20548

Dear Mr. King:

Per your request, I've reviewed your draft response to the Alabama Congressional delegation concerning oversight of federal facilities planning and design processes.

In general, I think you did an excellent job of abstracting our Federal Facilities Council report while maintaining the spirit and intent of the original. The following comments are primarily related to either grammatical or clarification issues:

- Page 5; third line from bottom: grammatical; remove the word "is"
- Page 17: the final paragraph (beginning "Research conducted by Redicheck...") should be bulleted and added to the bulleted comments at the top of the page (i.e., in front of the paragraph that begins "The implication of these statistics...").
- Page 32: second line from bottom: change "their" to "this" as in "this recommended approach."
- Page 33: fourth line: change "call" to "called" as in "... program called ProCATS"
- Page 36: Change fifth line to read: "Within most federal agencies, acquiring facilities is a means to support..."
- Page 39: Change 13<sup>th</sup> line to read "In the case of unique or unusual facilities..." I recommend deleting the reference to "high-tech". High tech itself is not a problem for consultants – only when its government-unique or unusual.
- Page 41: Rewrite practice number 4 to read: "Use team building and partnering techniques to build good working and communicative relationships among the participants as well as to align all participants toward common objectives and expectations.
- Page 41: bottom line: add "subsequent" so that it reads "subsequent unexpected and expensive fixes and oversights."
- Page 43: Practice number 14: change "pass through" to "interfere with" so that it reads "ducting interfere with structural members?"

I appreciate the opportunity to review your draft. I'm really pleased to see my research used for such constructive purposes.

Sincerely,

  
Ralph S. Spillinger

Copy to: L. Stanley; National Academy of Sciences

Now on p. 4.  
Now on p. 16.

Now on p. 25.  
Now on p. 25.  
Now on p. 26.

Now on p. 28

Now on p. 29

Now on p. 30.

Now on p. 31.

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