Design Criteria for Federal Buildings: A Perspective on Opportunities for Increasing the Quality and Efficiency of Federal Design and Construction (1985)

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A Perspective on Opportunities for Increasing the Quality and Efficiency of Federal Design and Construction

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Federal Construction Council
Building Research Board
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National Research Council

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This report was prepared as part of the technical program of the Federal Construction Council (FCC). The FCC is a continuing activity of the Building Research Board (formerly the Advisory Board on the Built Environment), which is a unit of the Commission on Engineering and Technical Systems of the National Research Council. The purpose of the FCC is to promote cooperation among federal construction agencies and between such agencies and other elements of the building community in addressing technical issues of mutual concern. The FCC program is supported by 13 federal agencies: the Department of the Air Force, the Department of the Army, the Department of Commerce, the Department of Energy, the Department of Health and Human Services, the Department of the Navy, the Department of State, the General Services Administration, the National Aeronautics and Space Administration, the National Endowment for the Arts, the National Science Foundation, the U.S. Postal Service, and the Veterans Administration.

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PREFACE

Federal design criteria encompass a range of general and specific requirements to be met in the design and construction of buildings for use by the federal government. Design criteria reflect the technical needs and preferences of the agencies constructing buildings as well as the explicit functional and operational requirements associated with the planned occupancy. In many cases, federally constructed facilities reflect unique or unusual requirements not paralleled in the private sector. Properly developed and maintained, design criteria can embody and transmit for practical application an agency's cumulative knowledge, experience, and wisdom about building design and engineering. Such design criteria are used to guide the design of new facilities or the rehabilitation of existing ones. They serve as a set of requirements that architects and engineers--whether federal employees or private-sector contractors--must ensure a building meets.

Design criteria, in essence, are concerned with many aspects of building performance. Because federal buildings are not necessarily subject to state or municipal building codes and may not be held to various privately developed standards for building construction (or because such buildings may be used for purposes for which no satisfactory private standards exist), federal design criteria also frequently serve these purposes and may consider health, safety, and welfare as well as functional building performance.

The many different agencies and departments of the federal government must contend with a variety of programmatic needs and building requirements--some highly specialized and unique to the particular agency mission--and have done so in differing ways within markedly different administrative, budgetary, and policy contexts. The result is that there is now a proliferation of federal design criteria with at least two unintended and undesirable consequences:

- Confusion, overlap, and lack of uniformity in design and construction requirements--To many observers, especially to private-sector design professionals who regularly render services to different federal agencies, there appears to be little or no coordination among the design criteria employed even where functional requirements and life safety issues are similar. Further, some federal design criteria,

particularly those pertaining to matters already adequately addressed by state, local and privately promulgated model building codes, differ needlessly from those employed in the private sector that are intended to accomplish the same aims, adding to the cost and difficulty of federal building design work performed by professional designers.

• Unexploited opportunities for improved design knowledge and enhanced building performance--As trustee of public funds and an owner in perpetuity of most of its facilities, the federal government must have special concern for building performance. It has unique stewardship responsibilities with respect to public physical facilities, and is well positioned to help discover new ways to ensure that buildings are safe, functionally and economically efficient, and well-equipped to avoid costly obsolescence. Current federal design criteria do not always reflect these unique responsibilities and opportunities and are, in many cases, developed by single agencies, often without benefit of experience from others in public and private life who are engaged in similar pursuits.

Citing the need for a fresh look at building design criteria used within the federal government and at the processes by which they are developed, several agencies who sponsor the Building Research Board's Federal Construction Council (FCC) asked the FCC's program committee to act accordingly. As a result, the Committee on Federal Construction Design Criteria was established in February 1984.

This committee report is directed toward identifying areas in which the federal government can better develop, manage, and use building design criteria. The committee sought not only to ensure that design criteria continue to reflect the best knowledge of how to design facilities that are safe, efficient, and economical but also to point to ways in which the federal government's unique stewardship role can be extended and improved with likely benefits to the building community at large and the general public.

CONTENTS

EXECUTIVE SUMMARY

Building design criteria can be the embodiment of the best present knowledge about ways to provide facilities that are safe, pleasant, efficient, and supportive of the activities they are intended to house. As contained in the many manuals, specifications, design guidelines, and other means used by the federal government to record and convey them. Design criteria govern the manner in which architects, engineers, and others--whether commissioned or employed by the federal government--do their work. As recently acknowledged by the President when he presented the first Presidential Awards for Federal Design, the federal government is the largest builder and user of design services in the country and has unique responsibilities and opportunities to strive for and encourage design excellence.

Within the National Research Council's Commission on Engineering and Technical Systems, the Federal Construction Council (FCC) of the Building Research Board (BRB) identified both serious problems and exciting opportunities in the present state of building design criteria used within the federal government. The FCC asked the BRB to form the Committee on Federal Construction Design Criteria in order to foster excellence and economy in design. The Committee sought to:

- Review and recommend needed changes in the current design criteria practices of various federal agencies, taking into account the views and experiences of architects, engineers, and other designers with significant federal design experience, and
- Identify opportunities for improving design knowledge and enhancing building performance through more effective development, management, and application of building design criteria.

To these ends, the committee interviewed and held discussions with design professionals who represented a wide range of disciplines and experiences with design projects for various federal agencies. The committee also obtained detailed reports from the various federal agencies about the ways in which they presently develop, apply and update design criteria. Based on these undertakings and the considerable knowledge and experience of its members, the committee reaffirmed

1

OVERVIEW

THE SCOPE OF BUILDING DESIGN CRITERIA

In broad terms, design criteria are requirements or guidelines, conveyed in written or graphic form, whose purpose is to instruct, advise, or inform architects, engineers, and other professionals about the desired attributes or features of building designs or about the procedures to be used in developing and communicating a building design. In all their various forms, design criteria are expressions of the standards on which decisions or judgments may be based. They become the basis for design decision making.

Design criteria may address: the functional needs a building design must fulfill; the specific performance tests a building or its components must satisfy; the ways in which design information is to be communicated or conveyed; the sizes, shapes, and appointments of particular rooms, suites of rooms, and other spaces; the characteristics of specific pieces of building equipment and components; standard details for certain building features the desired performance characteristics of particular building systems or subsystems; prescribed features or components; and various matters related to contractual obligations and building product specifications.

Within the federal government, design criteria are published in a wide variety of manuals, policy directives, design guides, standards documents, specification guides, equipment schedules, test methods, handbooks, and other documents. As suggested by Table 1, there are substantial differences in the type, number, and scope of design criteria documents published by federal agencies, which, in part, reflects the volume and complexity of the buildings constructed by each agency. Table 2 suggests the specificity and uniqueness of criteria as developed and applied by individual federal agencies, in this case the Naval Facilities Engineering Command (NAVFAC).

There also are project-specific documents, often referred to as architectural or building programs, that contain guidance developed to suit the purposes and needs of particular projects. For purposes of this report, design criteria are distinguished from building project program documents. Although a building program may contain or make reference to design criteria, it is a document that outlines requirements specific to a single, particular project. A typical building

TABLE 1 Number of Criteria Documents of Various Types Published by Federal Agencies

	Basic/General Criteria		Detailed/Supplemental Criteria		Guide/Master Specifications		Standard/Definitive Drawings		Other Criteria Documents	
Agency	Document Type (No.)	Approx. No. of Pages	Document Type (No.)	Approx. No. of Pages	No. of Specifications	Approx. No. of Pages	Document Type (No.)	Approx. No. of Pages	Document Type (No.)	Approx. No. of Pages
AoC	None*	0	None	0	0	0	None	0	None	0
CoE	DoD criteria(1)	380	Design guides(20) Technical manuals(190)	2600 5700	280	4200	None	0	Turnkey family housing manual(1)	144
DoE	General criteria(1)	360	None	0	0	0	None	0	None	0
GSA	Orders/ handbooks(7)	1400	Design guides(8)	560	250	5000	None	0	Standard test methods(11)	520
NASA	General criteria(1)	320	Safety manual(1)	80	350	5250	None	0	None	0
NAVFAC	DoD criteria(1)	380	Design manuals(96) "P" pubs.(13) NAVFAC instruction(8)	9600 1300 40	290	7250	Standard(150) Definitive(578)	150 578	Standard specs.(7) Standardization documents(617)	175 12340
USPS	A-E contract instruction(1) Design requirements(2)	59 113	Handbooks(3)	60	9	270	Standard (7 Vols.)	420	None	0
VA	Construction standards(110)	2200	Design guides(80)	1200	350	5250	Standard (4 Vols.)	720	Equipment guide lists(63)	630

* The AoC references the District of Columbia building code and NFPA 101.

TABLE 2 Excerpts from the NAVFAC Index to Design Criteria[a]

DEFINITIVE DRAWINGS (V = VALIDATED)
DD-80091 EQUIPMENT SCHEDULE PUBLIC WORKS TRANSPORTATION (MAY 80 V)
DD-817075 RECEIVER TRANSMITTER BUILDING; VHF - UHF COMMUNICATIONS BUILDING (MAY 80 V)
DD-817076 TRANSMITTER BUILDING FOR NAVAL AIR STATIONS (MAY 80 V)
DD-817077 REMOTE TRANSMITTER BUILDING TYPES A B C D AND E FOR NAVAL AIR STATIONS PLANS (MAY 80 V)
DD-817078 REMOTE TRANSMITTER BUILDINGS TYPES A B C D AND E FOR NAVAL AIR STATIONS ELEVATIONS, SECTIONS, AND GROUNDING (MAY 80 V)
DD-817194 350 SEAT THEATER AND RECREATION BUILDING (FEB 77 V)
DD-817206 TRANSIT SHED (NOV 80 V)
DD-817248 CONTROL TOWER PLANS, CONTROL ROOM SECTION (JUN 80 V)
DD-817249 CONTROL TOWER SECTIONS AND PERSPECTIVE (JUN 80 V)
DD-817250 CONTROL TOWER WITH ELEVATOR (JUN 80 V)
DD-873522 EDUCATION CENTER (SEP 80 V)
DD-873538 GROUND CONTROL APPROACH CREW FACILITY (SEP 80 V)
DD-873541 CARRIER BERTHING QUAY WALL (MAY 78 V)
DD-873550 AIRCRAFT LINE OPERATIONS BUILDING AND LINE CREW SHELTER (NOV 80 V)
DD-873552 RAILROAD EQUIPMENT MAINTENANCE SHOP (MAY 80 V)
DD-873580 FLEET RECOMMAISSANCE LABORATORY LAYOUT AND EQUIPMENT (MAY 80 V)
DD-873581 BULKHEADS TYPICAL PIER CONSTRUCTION MOORING DOLPHINS (MAY 78 V)
DD-873591 AVIATION TECHNICAL TRAINING BUILDING NAVAL AIR RESERVES (FEB 77)
DD-873593 NAVAL AIR MOBILE TRAINER MUNITIONS ORDNANCE AND REARMING TRAINING (MOR) BUILDING (FEB 77)
DD-873597 MULTIENGINE PATROL PLANE TRAINING BUILDING (FEB 77)
DD-873601 DELIVERY RETRAINING DETACHMENT BUILDING (FEB 77)
DD-873650 TRANSIT SHED (TERMINAL USE) (FEB 77 V)
DD-896064 REGISTERED PUBLICATIONS ISSUING OFFICE (JUN 75)
DD-947244 FLIGHT SIMULATOR BUILDING TYPE A AND B (FEB 77 V)
DD-947245 HEAVY ATTACK TRAINING BUILDING (FEB 77 V)
DD-947247 INSTRUMENT TRAINING BUILDING TYPE A AND B (FEB 77 V)
DD-947248 INSTRUMENT TRAINING BUILDING TYPE C (FEB 77 V)
DD-947249 ALL WEATHER TRAINING BUILDING (FEB 77 V)
DD-947284 SECURITY FENCES (FEB 80 V)
DD-947285 FLAGPOLE DETAILS (SEP 80 V)
DD-1006432 PRIMARY LIGHTING PROTECTION DESIGN FOR ORDNANCE HANDLING FACILITIES RAILROAD SIDING (MAR 81 V)
DD-1006433 PRIMARY LIGHTING PROTECTION DESIGN FOR ORDNANCE HANDLING FACILITIES MARSHALLING YARDS (JAN 81 V)
DD-1038013 PUBLIC WORKS TRANSPORTATION OPERATIONS AND MAINTENANCE FACILITY SITE PLANS (MAY 80 V)
DD-1038014 PUBLIC WORKS TRANSPORTATION OPERATIONS MAINTENANCE FACILITY REFUELER AND FUEL SERVICE FACILITY 4 GENERAL REPAIR BAYS (MAY 80 V)
DD-1038015 PUBLIC WORKS TRANSPORTATION OPERATIONS AND MAINTENANCE FACILITY 14 GENERAL REPAIR BAYS (MAY 80 V)
DD-1038016 PUBLIC WORKS TRANSPORTATION OPERATIONS AND MAINTENANCE FACILITY 32 GENERAL REPAIR BAYS (MAY 80 V)
DD-1038017 PUBLIC WORKS TRANSPORTATION OPERATIONS AND MAINTENANCE FACILITY 48 GENERAL REPAIR BAYS (MAY 80 V)
DD-1041105 PRIMARY LIGHTNING PROTECTION DESIGN FOR ORDNANCE HANDLING FACILITIES BUILDING - DESIGN CRITERIA (MAR 81 V)
DD-1041106 PRIMARY LIGHTNING PROTECTION DESIGN FOR ORDNANCE HANDLING FACILITIES BUILDINGS - EXAMPLES NO. 1 AND NO. 2 (MAR 81 V)
DD-1041107 PRIMARY LIGHTNING PROTECTION DESIGN FOR ORDNANCE HANDLING FACILITIES BUILDINGS - EXAMPLES NO. 3 AND NO. 4 (MAR 81 V)
DD-1041108 PRIMARY LIGHTNING PROTECTION DESIGN FOR ORDNANCE HANDLING FACILITIES BUILDINGS - EXAMPLE NO. 5 (MAR 81 V)
DD-1041109 PRIMARY LIGHTNING PROTECTION DESIGN FOR ORDNANCE HANDLING FACILITIES CRANE ON PIER AND WHARF DESIGN CRITERIA (MAR 81 V)
DD-1041110 PRIMARY LIGHTNING PROTECTION DESIGN FOR ORDNANCE HANDLING FACILITIES CRANE ON PIER AND WHARF EXAMPLES NO. 1 AND NO. 2 (MAR 81 V)
DD-1046687 MOORING SYSTEMS FOR OCEANOGRAPHIC DATA BUOYS (MAY 78 V)
DD-1068473 AIRFIELD LIGHTING CENTERLINE APPROACH LIGHTING SYSTEM GENERAL DETAILS (MAR 75)
DD-1068474 AIRFIELD LIGHTING CENTERLINE APPROACH LIGHTING SYSTEM VAULT AND SCHEMATIC WIRING (MAR 75)

[a]The citations above are a small portion of the total number of highly specialized design criteria developed and maintained by one federal agency.

SOURCE: Naval Facilities Engineering Command (1983)

program covers such matters as desired functional requirements, tentative square foot area allocations, adjacency relationships, and operational characteristics. The purpose of a building program is to formalize and make precise the statement of the needs of a particular facility.

In most cases, design criteria are thought of as dynamic--i.e., subject to change and revision as needs change, as circumstances change, or as technology advances. The forms of design criteria vary as widely as the matters they are intended to take into account. They are often a reflection of the particular and sometimes unique needs of an agency and its federal mission and are nearly always a reflection of the knowledge and experience acquired by that agency in building design and construction. In short, they are intended to reflect an agency's best judgment, given the agency's needs and responsibilities, about how facilities and parts of facilities should be designed and expected to perform.

THE USES AND USERS OF DESIGN CRITERIA

The design criteria of principal interest in this report are those used to guide federal building design work that is performed by architects, engineers, and others commissioned or employed by the federal government to render professional design services. In most applications, these design criteria serve as the basis upon which design professionals must develop building plans and specifications. They are the standards to which the building design will be held and, as such, act as design constraints and design directives.

The agency members of the FCC identified six reasons for the development of agency-specific design criteria to be used in this way:

- To ensure that special or unique needs and desires are properly filled--The military agencies, for example, have devised criteria for such special structures as ammunition magazines about which private-sector architects and engineers would not be expected to know in detail. Similarly, the U.S. Postal Service has developed criteria for supervision galleries in mail-sorting facilities and the Department of Energy has developed criteria for critical elements of nuclear facilities.
- To ensure that problems resulting from past design deficiencies, errors, or omissions are not repeated--The military agencies have developed special requirements for underground insulated piping systems and energy monitoring and control systems that reflect experience gained from past difficulties with such systems. For similar reasons, the General Services Administration has developed criteria for building substructures. As a response to problems encountered almost universally, nearly all agencies have developed special criteria for built-up roofs.
- To ensure that satisfactory designs will be produced even when project personnel are not fully experienced or qualified--Because

properly qualified design expertise is not always available on every project for a variety of reasons, agencies attempt to document design criteria so that less qualified firms and personnel will have access to the experience and judgment of more seasoned professionals.

- To ensure compliance with federal procurement regulations--The building product and materials specification practices used in the private sector often permit the identification of brand-names or special requirements that serve to restrict competition. Such practices do not comply with the Federal Acquisition Regulations, which are the primary regulations governing federal agency acquisition of facilities using appropriated funds. Because it is difficult to write nonrestrictive specifications that also protect the interests of the federal government as the building client, several agencies publish guide specifications that satisfy the law and serve as a model for use in federal work by private-sector design professionals.
- To avoid the resolving of design problems that have been dealt with satisfactorily in the past--In cases where buildings require facilities similar or identical to those developed successfully for use in other buildings, agencies provide detailed design criteria and sometimes even standard construction plans and details. These measures seek to avoid unnecessary expenditure of effort on design problems that have previously been solved.
- To ensure public safety, health, and welfare--Because much federal construction does not fall under the jurisdiction of a state, municipal, or other local building code authority, federal design criteria embody many of the life-safety and health provisions that normally would be covered by such codes.

With the exception of its special concerns for competitive procurement procedures and its special status with respect to the life-safety and health requirements that normally are imposed by local building codes, the federal government's interests in and needs for design criteria differ little from those of private-sector building owners. Because of its public stewardship responsibilities, however, the federal government has a special obligation to ensure that its building design criteria are as effective and clear as possible and reflect the best knowledge available about building design and management practices.

Given this situation, it obviously is desirable for the federal agencies to eliminate criteria that are needlessly complex, that duplicate suitable private-sector design criteria or standards, or that are outmoded. Increased coordination and technical information sharing among federal agencies, which eventually might result in trimming the number and variety of federal design criteria, also would ease and make more effective the contributions of private-sector design professionals working on federal projects. Such interagency information sharing and coordination also might raise the general level of quality of building design criteria.

2

SOURCES OF DESIGN CRITERIA

Advances in building design criteria can be based on scientific and technical research and analysis carried out within universities, private industry, and federal laboratories; direct measurement and technical consensus as reflected in various voluntary standards-making processes; and professional experience and judgment deriving from involvement with many buildings over long periods of time. The federal government currently does not appear to be fully utilizing these sources of information.

SCIENTIFIC ANALYSIS AND RESEARCH

The empirical basis for building design criteria is being expanded through studies and research projects carried out in a variety of settings for a variety of purposes. For example, as a result of recent concerns with energy efficiency, extensive investigations of the thermal performance of building envelope and enclosure systems have been carried out by industry, academia, and the federal laboratories. Some results of this work pertain to desirable attributes of such systems given certain climatic conditions and internal occupancy demands whereas other results identify thermal anomalies and failures within specific wall and roof assemblies. The information from this research, much of which has been rigorously scientific, could be incorporated into design criteria either as the basis for generic performance specifications, or as guidelines for the design and detailing of particular enclosure systems and subsystems. It also could be used to develop tests for construction quality control and procedures for inspection and acceptance review. However, no formal procedures exist by which federal agencies, or, for that matter, private-sector design professionals are apprised of such scientific and technical research and its results even though much of it is carried out at the expense of the federal government. Further, research organizations do not have formal procedures for disseminating the results of their scientific and technical research. Thus, there is need for better building research reporting, which would draw on a variety of public and private sources and would provide information

about how to obtain research details. Further, direct links between the building research and development processes and the managers of design criteria within the federal agencies need to be reinforced and, in some cases, established.

At present, most design criteria and buildings codes are the embodiment of past experience and, when available and known to those responsible for their development, research findings. As documents based essentially in historical experience, they cannot and do not serve to anticipate problems and opportunities that have not occurred previously. Thus, when building projects encounter new elements outside the realm of past experience (such as the application of new materials, or existing materials being applied in new ways), present codes and criteria are not especially helpful in guiding design efforts.

Stronger links between the research and development community and the managers of design criteria within the federal agencies would help to overcome these difficulties. The use of design criteria data bases as repositories of new knowledge is essential to the process of applying engineering science to building.

VOLUNTARY CONSENSUS STANDARDS

Although by no means flawless or altogether efficient, a process does exist within the building community by which technical consensus is reached on building design standards and criteria. This consensus process is firmly established within such organizations as the American National Standards Institute (ANSI) and the American Society for Testing and Materials (ASTM). Unless there is compelling reason to do otherwise, such as the absence of demonstrable insufficiency of existing voluntary private-sector standards, efforts should be made to ensure that federal design criteria draw from or make reference to these private industry standards.

Recent executive orders and administrative guidelines have directed federal agencies to make wider use of voluntary consensus standards and to participate more directly in the process of their development. In cases where the federal agencies are faced with special problems or needs not presently addressed by such standards and criteria, the resources of the voluntary consensus bodies may effectively be brought to bear.

Advantages of the voluntary consensus process are that it provides a focus for the most recent relevant technical information, professional judgment, and experience and draws a variety of interested parties together to reach agreement on specific technical issues. It also tends to surface the most timely private industry experience and information available on particular topics and takes into account the broad building industry context in which voluntary standards will be used.

Standards and standard test methods developed in this way frequently become the basis for the building design criteria and building codes that are used widely in the private sector and, are thus familiar to architects, engineers, and other design professionals.

PROFESSIONAL EXPERIENCE AND JUDGMENT

Building design criteria are continually reshaped and influenced by the experience and judgment of those who design, manage, and use buildings. As suggested above, the voluntary consensus standards process represents one systematic way in which this experience and judgment is captured and put to use as part of the professional knowledge base for building design and construction.

Many private companies with building construction programs also maintain design criteria. They strive to assure that collective design experience and judgment is garnered and embodied in written criteria documents and to enforce these criteria so that future buildings will represent improvements on and lessons learned from past buildings.

Few formal procedures now exist among federal agencies to garner the experience and judgment of a cross-section of qualified building design and management professionals for regular review and updating of building design criteria. Few agencies have effective procedures for involving their own employees in regular review, purging, and updating of criteria let alone for involving outside expertise in such deliberations.

BUILDING DESIGN CRITERIA IN THE FEDERAL GOVERNMENT

The agencies of the federal government draw their building design criteria, to greater and lesser degrees, from essentially the same sources identified above. Although the specific needs and preferences of federal clients may differ occasionally from those commonly encountered in the private sector, there are many similarities, and the motivations for maintaining and using design criteria differ hardly at all.

This committee reviewed the design criteria and related practices used by the federal agencies that participated in this study through liaison representatives, and it conducted interviews with design professionals long experienced with federal design clients. These activities, and the committee members' own substantial experience with federal design criteria, suggest two major areas of concern:

- Serious problems exist with federal building design criteria that need immediate attention. These center on a lack of coordination among agencies that contribute to an unnecessary proliferation of redundant, cumbersome and dated or superfluous design criteria and on the overlap of federal requirements with satisfactory codes, standards, and criteria that are used in the private sector. There are also deficiencies in criteria review procedures, the ways in which criteria and instructions are transmitted to outside design professionals, and the manner in which design criteria are organized.
- Near- and longer-term opportunities exist for enhancing the quality of federal agency building design criteria. New developments in technology and the design knowledge base have made advances possible that should become part of the substance of federal design criteria as well as the procedures by which they are developed and maintained.

The remainder of this report elaborates on steps that can be taken to address each of these areas of concern, and reaches specific conclusions about how the federal government can better organize and manage building design criteria to achieve excellence in the design, economy, performance, and quality of its buildings.

3

OPPORTUNITIES FOR EXTENDING THE KNOWLEDGE BASE FOR DESIGN CRITERIA

A range of recent developments and advances in building science and technology offer potential for the rationalization and sharpening of building design criteria. The federal government is in a position to avail itself of these developments (indeed, it has provided the major funding and motivation for a number of them) and to put them into practice as a regular part of formulating, refining, and implementing criteria for building design. All of these developments, a few of which are summarized here under broad headings, can contribute to the expansion and strengthening of the available knowledge and information upon which design criteria are based.

BUILDING DIAGNOSTIC TECHNIQUES AND EVALUATION METHODS

Instrumented Building Performance Assessment

This field employs a host of instruments and techniques to determine the actual, in-place performance and condition of building systems, components, and subsystems. Advances in the tools and techniques available for assessing physical conditions and in-service performance of buildings and their components have opened new opportunities for linking building design criteria with experience based on documented empirical evidence. Performance data and other information, obtained from actual installations through the use of new diagnostic tools and techniques, can be fed directly into the processes of facility programming and design. Such approaches have been used successfuly by the Office of the Chief Architect of the National Park Service and are being implemented by faciltity management personnel in private companies. Portable, reliable, and easily used instruments are available at low cost. They can be used for a variety of purposes including:

- Acceptance testing of building equipment, components, and assemblies to determine whether installations are in accordance with plans and specifications;

- Performance monitoring of building systems and assemblies to determine whether they are operating as desired;
- Monitoring of buildings to assess rates of wear or deterioration, particularly with respect pertains to deformation of structural components;
- Troubleshooting of specific performance problems (e.g., the pinpointing of water leaks in roofs or thermal bridges through exterior walls) that otherwise would be costly or difficult to diagnose; and
- Collection and processing of data on certain aspects of actual building use and management, (e.g., as actual times and levels of occupancy) for incorporation into future facilities programs.

Ways should be found to incorporate new diagnostic tools and techniques with the formulation and implementation of federal design criteria, especially when these techniques could help to provide a solid experiential basis for standard details and programmatic requirements. In this way, diagnostic tools and techniques can be thought of as critical instruments that can be used to establish "feedback" in the design process. This in turn is essential to a process that would seek continually, and at all stages of the design development process, to determine whether design criteria are being met satisfactorily.

Although testing programs are routine for assessing such things as concrete strength when a building is under construction, the range of design criteria presently tested for is very limited. In principle, it is both possible and desirable to evaluate a wide range of building performance attributes; a program on building diagnostics recently completed by the Building Research Board has identified many elements of building preformance that can be tested using diagnostic procedures.

Post-Occupancy Evaluation Techniques

This discipline introduces a wide variety of diagnostic instruments and techniques, often including surveys, interviews and observational methods, to the evaluation of buildings in use. As the term is most widely used and understood, post-occupancy evaluation seeks to exploit the potential for linking knowledge gained from the behavioral and social sciences with architectural and design decision making. Careful assessment of facilities in actual use can help to: fine-tune existing buildings; refine facilities programs and needs statements; guide the design of similar future buildings; and, in general, provide substantive feedback on design decisions and approaches that can be used to refine and update design criteria.

Post-occupancy evaluation is concerned not only with assessing human performance and satisfaction in buildings, but also with determining the efficacy of certain physical design measures and approaches in meeting a range of client objectives for a facility. To the degree that building design criteria are hypotheses about how certain features within a building will work or how people will respond to certain physical settings, post-occupancy evaluation offers the means to test hypotheses and to assure that design decisions for future buildings are based on the knowledge gained through such testing and feedback.

Although not yet a complete and firmly established method of inquiry and analysis, post-occupancy evaluation has been developed to the point where certain methods and techniques can be applied immediately to produce beneficial results. The potential exists for federal agencies to adopt post-occupancy evaluation as a formal part of their facilities design and management processes for the express purpose of gaining information and feedback that can be used to modify and refine design criteria for new facilities and for fine-tuning of existing ones. It is important for agencies to develop the potential of post-occupancy evaluation.

The federal agencies also could continue to play an important role in extending and adapting techniques of post-occupancy evaluation for buildings. These contributions to the knowledge base can be expected to influence the design professions, at the very least through those professionals who perform services for federal agencies, and to provide benefits for other building clients and users.

Performance Simulation Methods and Techniques

A major purpose of simulation used in building design is to test the consequences of alternate courses of action. The advent of computers has greatly expanded the designer's ability to test the probable and possible consequences of various design decisions before they have been implemented and become difficult or impossible to adjust. Although software developments in this field have tended to lag behind advances in the capabilities of hardware, especially with respect to building design, many new techniques do exist that allow designers and their clients to evaluate the costs and benefits of certain design alternatives.

This potential is particularly well developed in relation to building energy use as evidenced by the widespread availability of various thermal network simulation computer programs and less complex programs that permit architects and engineers to test the possible energy consequences of design alternatives. Also available are programs to simulate and test a variety of other operational factors including such elements as internal building circulation, the behavior of wind and other external environmental factors, critical functional adjacencies, and patterns of occupant egress under emergency conditions.

These techniques, and others that are being developed, have broad applicability to both the formulation and the implementation of federal building design criteria. Computer-based simulations could aid in developing design criteria for system and subsystem performance and also could be used during the design and design review processes to determine whether or how such criteria are actually met in various building designs. Such approaches are currently being used on a limited basis for fire egress studies and fire code compliance reviews. In addition, the potential for development of an integrated computerized data base on all aspects of building design, construction, and management currently is being addressed by a Building Research Board committee on advanced technology for building design and engineering.

TECHNICAL AND PROFESSIONAL REVIEW AND ADVICE

The agency reports provided to the committee (summarized in Appendix A) suggest that few formal procedures apparently exist within federal agencies for the systematic reviewing, updating and purging of building design criteria. Where such procedures do exist, they frequently overlook opportunities for contributions from technical experts and experienced design professionals. Greater efforts should be made by the agencies to avail themselves of such technical expertise and advice.

There would be distinct advantages to formalizing such review procedures and scheduling them regularly, concentrating both on the special and unique requirements of individual agencies and on more general criteria that are common to most forms of construction and may be embodied, although in varying ways, in the design criteria of many different agencies. Systematic design criteria review and consideration by technical committees and professional societies could be accomplished at relatively low cost and would introduce technical information that might otherwise be missed. An effort should be made to identify and involve especially well qualified individuals for this purpose.

Forging systematic links with the technical committees of various professional societies (those from within the building community as well as from the fields of medicine, industrial engineering, and psychology among others) also would begin to provide better access to the results of current privately supported research and development programs. This approach also would help to assure greater familiarity with federal design criteria among private-sector professionals.

PERFORMANCE AND MANAGEMENT INFORMATION SYSTEMS

Computers have greatly enhanced the ability to assimilate and manage building performance information. The consequences of this new and powerful tool is only beginning to be felt within the building design and management communities, but the results are already profound. Large corporate owners of facilities have found it possible not only to schedule and monitor very closely the progress of routine building maintenance tasks in ways that previously would have been impossible, but also to integrate the results of experience gained over time with the programming of designs for new facilities or the upgrading of existing ones.

There is potential within the federal agencies for an unprecedented linking of information from actual building use with the formulation and maintenance of design criteria. Performance data bases can be established--or, where they already exist, can be adapted--and maintained in ways that feed directly the process of deriving design criteria. Such information systems also could be used to respond to inquiries from designers and their clients in ways that would be useful during the design development process.

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CONCLUSIONS

OPPORTUNITIES FOR IMPROVING PRESENT DESIGN CRITERIA PRACTICES

The federal agencies responsible for building construction and management can improve both the substance of their design criteria and the ways in which their criteria are developed, updated, and applied. These improvements will simplify the work of the federal agencies and the design professionals they employ and should discernably reduce the administrative burdens surrounding the design and construction of federal buildings. Clearer, more current and better communicated design criteria also should lead to improved facility design. These aims can be brought about through the adoption of new and improved management practices, increased cooperation and information sharing among agencies, and increased use of voluntary consensus codes, standards, and criteria.

NEED FOR NEW ATTITUDES TOWARD BUILDINGS AND DESIGN CRITERIA

Opportunities, also exist to use building design criteria in helping to bring about a needed change in attitudes toward building design, construction, and management. The basis for this new set of attitudes is a fundamental concern with introducing rigorous performance evaluation to the processes surrounding facilities design and use. Among other things, the federal agencies need to do a better job of guiding design professionals in the use of existing criteria, rather than leaving such decisions to chance, and of monitoring the application of design criteria on specific projects.

The advent of computer-aided memory and telecommunications systems has placed within the building community's reach the ability to gather, process, and apply information about building performance in unprecedented ways. It is now possible to link, very directly, information about building performance with the processes of design criteria development and application. In addition to the new potentials created by hardware developments, advances are being made in the technical understanding of how buildings and their components behave under conditions of use, and in the ability to devise and apply new assessment and diagnostic techniques for that purpose. The knowledge base

that shapes building design criteria can be expanded and strengthened appreciably by taking advantage of these developments.

The federal government, by virtue of its unique public stewardship responsibilities and its status as owner/developer/manager of large numbers of buildings, is ideally positioned to assimilate the techniques that are presently available for such purposes as well as to develop new ones. In essence, the federal government can help to lead a movement--borrowing where necessary and appropriate from private building community experience and example--toward new levels of excellence in buildings.

Design criteria and guidelines, because they serve as the embodiment of collective professional and scientific knowledge and judgment about preferred practices, can and should serve as integral elements in these efforts. Federal agencies with active construction programs should give highest priority to the improvements in design criteria suggested here because criteria are the principal means available for guiding design and construction programs.

THE POTENTIAL BENEFITS OF IMPROVED DESIGN CRITERIA AND GUIDELINES

Obviously, more efficient processes for developing, communicating, and applying design criteria should lead to more efficient design and construction, and may lead to earlier project completion times to reduced project costs, and, because chances for error and confusion would be reduced, to better overall facilities. These are goals worth attaining, but there are other, even more substantive benefits that would result from an improved design criteria knowledge base and management practices. The National Bureau of Standards and others have documented thoroughly the benefits to government and other employers associated with increases in worker productivity and have demonstrated clear relationships between productivity and such environmental factors a thermal comfort, acoustical privacy, and visual comfort. Post-occupancy evaluations and other investigations conducted by Canada's Department of Public Works, assisted by U.S. researchers, has begun to suggest new relationships between worker absenteeism, and illnesses and building-related environmental factors.

This Canadian work, which is but one example of approaches being tried, has led to new and revised design criteria for Canadian federal buildings that will help to overcome previous difficulties as well as to new procedures and requirements for assessing buildings while they are occupied and in use. The information gained from these activities will continue to be used in the revision of design criteria, which themselves will become increasingly concerned with human performance and comfort factors as well as with the physical attributes of building systems.

It is in this realm of human satisfaction and well-being that improved building design criteria that address new areas of concern in ways that have previously not been possible hold great promise. The benefits of a better building design criteria system to the federal government and, therefore, to the general public will come in many

forms including: increased safety, durability, and serviceability; operation and maintenance cost savings; increased occupant satisfaction and productivity; reduced likelihood of improper functioning and associated costly repairs; and reduced incidence of premature facility obsolescence.

The committee urges that of design criteria documents be considered to be "living" instruments that are constantly revised, extended, refined, and purged as warranted by advances in building technology and developments from building research and by increases in knowledge about their effectiveness through systematic feedback and evaluation.

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RECOMMENDATIONS FOR IMPROVING THE DESIGN CRITERIA DEVELOPMENT AND CONSTRUCTION MANAGEMENT PROCESSES

THE USE OF MODEL BUILDING CODES

Many existing federal building design criteria address matters that are related to public health, safety, and welfare (e.g., fire safety, seismic safety, and structural adequacy). In most instances these concerns already are addressed satisfactorily in the model building codes,[1] that are known to most design professionals and are widely used as the basis for state and local building codes. While codes serve better to encapsulate past experience than to lead to new and more effective building solutions, as discussed in the first section of this report, they are the best that is available in most cases. Wherever possible, federal agencies should purge their design criteria of provisions that needlessly duplicate provisions of these model codes. They should specify by reference, as some agencies presently do, the use of one of the three model building codes for specific projects, preferably choosing the one that is used in the locale of the project in question.

If no local building code exists or if the local building code is not derived from one of the three model codes, agencies should nonetheless specify by reference the use of one of the model codes. In cases where the provisions of the model codes do not meet a unique project requirement, special provisions should be addressed in separate addenda to the model code on a project-specific basis.

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[1]The model building codes are: the Uniform Building Code published by the International Conference of Building Officials (ICBO), the Standard Building Code (formerly the Southern Standard Building Code) published by the Southern Building Code Congress (SBCC); and the Basic/National Building Code published by the Building Officials and Code Administrators International (BOCAI). These model code organizations actually publish several different code documents. ICBO, for example, publishes a package of seven documents, including a Mechanical Code, a Housing Code, a Sign Code, a Dangerous Building Code, a Dwelling House Pamphlet and a Short-Form Uniform Building Code. The SBCC and BOCAI also publish similar groups of documents.

CODE COMPLIANCE REVIEWS AND INSPECTIONS

Although the idea of having local building code officials perform building code compliance reviews and inspections for federal projects poses certain problems (e.g., has potential difficulties, such as determining who would pay the costs and assume the responsibilities and professional liabilities) and may not be appropriate for certain military projects, there are reasons why it may be desirable in some case. Local code officials generally are experienced with local construction practices and are well-versed in local code provisions.

Design professionals and contractors who are active in a locale's private construction market are familiar with local building code provisions and building permit application and approval procedures, and if federal agencies placed their projects on a comparable footing, design professionals would not need to learn new procedures to accomplish similar ends.

In any case, it is essential that the personnel designated to review, inspect, and approve code-related provisions during the design and construction stages be properly experienced and qualified professionals.

OTHER BUILDING INDUSTRY CODES AND STANDARDS

A number of other organizations publish building design standards, that pertain primarly to health, safety and welfare.[2] These documents address single aspects of building design and construction, and they often are incorporated by reference in both model codes and local building regulations.

Similarly, standards and test methods for construction materials and products are promulgated by such organizations as the ANSI and ASTM. These, too, are familiar to most design professionals and should be incorporated by reference where applicable within federal design criteria. Provisions that are duplicative of such satisfactory industry codes and standards should be purged from federal building design criteria.

The practice of issuing general instructions that tells architects and engineers that they should conform to the provisions of a model building code or a local building code unless federal criteria are more restrictive or stringent does not achieve the desired result. The design professional still must determine which is more stringent or restrictive and decide which is applicable, undermining the real purpose behind the use of the model codes, which is to introduce an

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[2]Examples are the Life Safety Code of the National Fire Protection Association (NFPA), the National Plumbing Code of the American Society of Mechanical Engineers (ASME), and Building Code Requirements for Reinforced Concrete of the American Concrete Institute (ACI).

element of simplicity and standardization. A better practice would be for the agency to issue addenda by specific reference to the model or local code, indicating where a more stringent or restrictive provision must be applied.

FACILITY PROGRAMMING

A properly developed facility program is the ideal means for initial communication between client and design professional on needs and expectations. Generalized criteria alone cannot assure a satisfactory result but must instead be part of an overall statement of performance goals, functional objectives, and desired building attributes directed toward a specific building. On every building project of consequence, a detailed building program is essential. The architectural or building program sets forth detailed performance objectives, space requirements, functional relationships and adjacencies, and so forth. In short, a properly developed building program is the brief against which the architects and engineers perform.

Many fundamental decisions that have great bearing on the ultimate performance of government buildings are made during the earliest and most preliminary of project planning stages and often before professionals have been retained for execution of the building design. It generally is recognized that a relatively small extra investment in more careful and detailed preliminary project planning will result in substantial later savings and performance improvements; yet, little attention has been devoted to these earliest stages of planning and programming. In cases where federal agencies do not have personnel able to prepare adequate programs, the services of outside professionals should be retained for this purpose.

The committee notes and supports the FCC's efforts in 1985 and 1986 to study ways to improve the preliminary project planning process for federal buildings and expresses its hopes that these efforts will result in better building programs for use with private design professionals.

CONSTRUCTION PROJECT MANAGEMENT: DESIGNATING AND CARRYING OUT OVERSIGHT RESPONSIBILITIES

The nature and quality of construction project management influences greatly the results of design efforts and the application and interpretation of criteria. A split in project management responsibilities between a "project manager" and a "contract manager" was created by the recent federal procurement reforms established under Executive Order 12352. The former has a more technical orientation and is generally the individual most familiar with specific agency requirements and needs in relation to the construction project at hand. The latter is oriented more toward the legal and financial aspects of federal procurement and may have little or no experience with design- and construction-related technical matters.

The result, in many instances, has been a division of influence and responsibility that has been detrimental to the progress of work and the quality of the final design, not least because the government representative has been placed in a position of diminished authority.

Federal agencies need to strengthen and centralize the role and skills of designated government project managers, preferably by employing highly qualified registered design professionals and by vesting in them complete responsibility for project execution from inception through completion. Project managers should have access to a full range of professional development opportunities, thus keeping them abreast of technical and management developments. Project managers should have authority for: development of building programs, statements of work and scoping of professional design services, continuing liaison with hired project personnel. delineation and interpretation of applicable project design criteria, and carrying out of post-project evaluations.

Ultimately, persons in these positions of responsibility also should have a direct role in efforts to develop, purge, update, and manage agency design criteria, since theirs will be the most directly applicable experience available within the agency.

DESIGN CRITERIA DATA BASES AND ACCESS SYSTEMS

The coordination, consolidation, and dissemination of design criteria and guidelines used throughout the federal establishment could be made more effective by a centralized clearinghouse or library, preferably taking advantage of computer-aided storage and retrieval systems. This undertaking is worthy of participation by all federal agencies with construction programs of any consequence. It would yield benefits not only to the agencies themselves, but also to the private building sector, which also experiences a degree of overlap, confusion, and redundancy in design criteria.

In large measure, the profusion of conflicting design criteria is a consequence of the building community's general inability to reach uniformity and agreement on the use of basic terminology, formats, and forms of provisions. This has impaired efforts even to compare, let alone achieve unformity or compatibility in, design criteria developed by different groups for different purposes.

Any serious effort to manage the large array of building design criteria will call for the application of principles from information science, including the development of an overarching language or classification system capable of handling the many necessary variations and special considerations encompassed by criteria. This superstructure should have the properties of a highly comprehensive indexing system capable of being searched and accessed with key words and phrases.

The establishment of a computer-based library of federal design criteria can proceed apace with development of an appropriate indexing and classification system and may indeed help to spur its creation and use. The data base should become accessible to architects and

engineers working under government contract. It should also serve as a means by which the agencies begin to compare design criteria and, where appropriate, work toward consolidating, purging, and achieving compatibility in criteria.

A first step in this process, which already has been taken by several agencies but could be taken in concert on the basis of simple agreed-upon conventions, may be for individual agencies to assemble computerized listings of design criteria and to make those listings available to design professionals on microcomputer floppy disks or via linked terminals. One advantage of this step would be the ability to identify and select relevant criteria via key words, thus reducing the amount of superfluous information that is presently transmitted in document form. Possibilities should also be explored for the creation of an ANSI standards committee (and eventual standard) on conventions in building design criteria in which federal agency representatives would be encouraged to participate actively.

INTERAGENCY COOPERATION AND INFORMATION SHARING

There is a clear need for greater collaboration and information sharing among federal agencies, particularly where there are distinct similarities in their construction programs. Among the objectives to be served here, simply by greater communication on a regular basis, are: a reduction in the proliferation of unnecessary new criteria, a movement toward greater uniformity in at least the format of design criteria used by various agencies, increased awareness of findings from research projects and experience gained in project applications, and improved understanding of common problems and opportunities.

Given the level of interest and concern about design criteria expressed by agency laison representatives, it is apparent that an opportunity exists to establish a special interagency task force on design criteria, possibly through the Building Research Board's Federal Construction Council, whose purpose would be to assist in formulating a detailed action agenda and in carrying it out. The attentions of such a task force, however, should not focus only on questions of management streamlining and improvements, although those are important; as substantial a challenge exists in implementing ways to expand the knowledge base that shapes building design criteria.

GLOSSARY

Several terms that have special meaning within the building community are used throughout this report and are defined here.

Criterion: In general, a standard upon which a decision may be based or a yardstick against which something may be measured. As used within the building community, criteria have come to encompass a wide range of performance requirements and design standards. In this report, the term is intended to include written and graphic materials whose purpose is to instruct, advise, or inform architects, engineers, and other design professionals of the desired or required attributes or features of a building design or of the procedures to be used in developing and communicating a building design.

Guideline: A document, or portion of a document, intended to provide guidance to or to instruct a designer on a preferred design approach; usually less fixed or specific than a criterion or specification.

Performance specification: A specification that states the need to be met, the level of performance to be achieved, and the method(s) to be used to determine whether the desired performance has been achieved without prescribing the materials or means to be employed in achieving the desired performance.

Prescriptive specification: A specification that prescribes the materials to be used, the methods to be employed, or the exact nature of the design to be implemented; unlike a performance specification, a prescriptive specification leaves little room for alternate approaches.

Program: (also architectural program or building program): A statement, usually in the form of a bound document, that details the requirements for space, equipment, special facilities and other features associated with a single, particular building project; the program, which may be prepared by a design professional on behalf of a client/owner, often sets forth area allocations for various functions and may establish required functional adjacencies. It is a statement of needs to be met by the building.

Specification: **A written statement setting forth the desired or required characteristics of a building material or installation; it often includes a highly particular product or materials description and preferred or required methods of construction, application or assembly.**

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APPENDIX A

CURRENT AGENCY PRACTICES REGARDING THE DEVELOPMENT AND USE OF DESIGN CRITERIA

In order to learn about the current practices of federal agencies regarding the development and use of design criteria, the committee asked for and received briefings from the eight agency liaison members of the committee. The committee also received detailed information on current agency practices through written questionnaires that the liaison members arranged to have answered.

The liaison member from the Architect of the Capitol's office reported that, by law, the Architect of the Capitol (AoC) is the architect-engineer of record for all projects under his jurisdiction and that any private A-E firm he retains becomes his associate. The AoC expects private A-E firms to use the commonly accepted standards and practices of the profession, modified as necessary through mutual agreement, to satisfy the goals and requirements of the specific projects. Consequently, the AoC does not publish standard design criteria.

The other seven agencies represented on the committee all prepare and publish design criteria of some type, and the information they provided to the committee regarding their criteria documents is summarized below. It should be noted that most of the agencies reported that they have no information on the cost of developing and maintaining criteria documents; therefore, the subject is not discussed below. The updating of criteria also is not discussed because almost all agencies reported that they review and update virtually all criteria documents regularly on the basis of feedback from post-occupancy evaluations, comments from users of the documents, and technological developments.

CORPS OF ENGINEERS

The Army Corps of Engineers (CoE) reported that it publishes four categories of criteria documents: design guides, technical manuals, guide specifications, and a permanent procedure manual for one-step

"turnkey" negotiated contracts for Army family housing.* Information provided by the Corps on these documents is summarized below. The Corps also reported that it follows the general construction criteria of the Department of Defense; however, those criteria are not published by the Corps and are not discussed here.

CoE design guides are issued in manual form with both narrative and graphic data to describe the functional layout, space allocation, and special features of various types of facilities. These guides provide information to assist designers in providing an adequate facility for use by the Army and its personnel. The CoE publishes about 20 design guides with an average of 130 pages each and has used such guides for approximately 9 years. Most of the design guides are prepared by private A-E firms working under the direction of a CoE field office. Design guides are based on input from users, research by the preparing organization, and professional judgment. Before being approved and published by CoE headquarters, the guides are reviewed by various CoE field offices. The guides are intended to be used primarily by those responsible for planning and designing various types of Army facilities, especially private A-Es, and they are given to every design team when a project is initiated. Design guides provide designers with specific information on what the Army desires and requires in specific types of facility. The use of design guides is mandatory, but only in the sense of a reference source.

Technical manuals are published by the Adjutant General for the Army to provide design guidance to field offices and to private A-Es hired by the CoE. Many of the manuals are prepared jointly by the Army, Navy, and Air Force. The CoE has 190 technical manuals with an average of 30 pages each. Such manuals have been used by the CoE for approximately 30 years. Manuals are prepared by both CoE personnel and hired A-Es. They are based primarily on agency experience and industry practice. The manuals are reviewed and approved by CoE headquarters before being submitted to the Adjutant General for publication. The manuals are used by Corps field offices and private A-Es when designing Army facilities. Some requirements in technical manuals are mandatory and some are optional; however, CoE field offices have authority to grant waivers to mandatory requirements.

Guide specifications are published by the Corps for use by its field offices and private A-E firms in developing contract specifications. The CoE has published about 280 guide specifications with an average of 15 pages each. Guide specifications have been issued by

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*The CoE reported that its criteria development effort is highly decentralized and that no one Corps office is aware of all CoE design criteria. It is possible, therefore, that some CoE criteria documents might not have been reported on; however, the number of oversights, if any, is probably insignificant.

the CoE for approximately 30 years. They are prepared either by CoE personnel or by private A-Es. Completed specifications are reviewed, approved, and published by CoE headquarters. The specifications are based primarily on the experience of the CoE and on industry practice. The use of CoE guide specifications by designers is mandatory; however, field offices have authority to grant waivers.

The Permanent Procedure Manual for One-step "Turnkey" Negotiated Contracts for Army Family Housing is a special document that has been prepared and published by the Sacramento District Office of the Corps of Engineers to establish criteria and procedures for the design and construction of family housing under "turnkey" negotiated contracts. The 144-page manual has been used for approximately 14 years. The current edition was prepared in 1980. It was reviewed and approved by CoE headquarters before being published by the Sacramento District Office. The manual is based on research, agency experience, industry practice, and the professional judgment of the authors. It establishes minimum standards for Army family housing, describes the scoring system used to evaluate proposals submitted by bidders, and is used for developing designs and specifications for new family housing projects at Army installations. Use of the manual is mandatory as directed by the Congress. Waivers may be obtained only from the Office of the Secretary of Defense with the approval of the Congress.

THE DEPARTMENT OF ENERGY

The Department of Energy (DoE) reported that it publishes one criteria document, General Design Criteria Manual (DoE Order 6430.1). This manual provides general design criteria for use in the acquisition of DoE facilities. It currently contains approximately 400 pages and has been in effect in various forms for approximately 20 years. The manual is utilized by in-house designers as well as hired A-E firms. It contains some mandatory requirements and some recommendations. The manual is not intended to impose unnecessary design restrictions or discourage design innovation. DoE field organizations have authorization to deviate from some aspects of the criteria when minor deviations are necessary or advantageous; other deviations require prior DoE headquarters review and approval.

The Director of Projects and Facilities Management serves as the focal point for the development, improvement, and interpretation of the manual. The process of improving or developing the criteria is coordinated by the DoE General Design Criteria Planning Board, which consists of representatives from both DoE headquarters and field organizations. The field organizations generally rely on the expertise of in-house operating contractors for support. The incorporation of design-related "lessons learned" into the general design criteria is encouraged and expedited through the General Design Criteria Planning Board and the DoE Design Information Exchange System.

GENERAL SERVICES ADMINISTRATION

The General Services Administration (GSA) reported that it publishes four categories of criteria documents relating to the design of government facilities: orders and handbooks, design guidelines, guide specifications, and standard methods of test.

Orders and handbooks are published to convey official GSA policy on various matters relating to the design and operation of federal facilities. Such documents are related to laws, executive orders, regulations, and fundamental GSA policies. The documents are published in loose-leaf form as officially approved manuals. Seven GSA orders and handbooks relate to the design of facilities (GSA publishes a number of handbooks and orders that do not deal with design and are not discussed here). They average about 200 pages each and have been issued by the GSA for many years. The orders and handbooks are prepared primarily by GSA staff, but consultants are sometimes hired to provide input on specific items. These documents go through a complex clearance process that involves obtaining the comments of GSA regional offices and major program offices. All orders and handbooks must be approved by a high GSA official (e.g., the Public Buildings Service Commissioner or the GSA Administrator) before being published. They are based primarily on the experience of GSA staff. GSA orders and handbooks are used primarily by GSA personnel; however, portions of some documents are given to A-Es. The documents include both mandatory requirements and nonmandatory guidelines. The requirements that are based on laws, executive orders, and regulations cannot be waived unless the applicable law or regulation provides for waivers, which is rare. Waivers usually can be obtained for GSA requirements, but the method for obtaining a waiver varies depending on the importance of the requirement.

Design guidelines are published to provide guidance to designers on specific technical issues. Most focus on a single issue. Theoretically, design guidelines convey information to implement policy and do not establish policy per se; however, there are exceptions to this rule. The GSA has published 8 design guidelines averaging 70 pages each and has issued such documents for many years. Five of the eight guidelines were prepared by private consultants, and the balance were prepared by GSA staff with, in some cases, the assistance of personnel from other agencies. Design guidelines must be approved by the Public Buildings Service Commissioner before publication. The guidelines are based on a combination of research and GSA experience. They are used by both GSA design personnel and private A-Es hired by the GSA. The guidelines are mandatory only to the extent that they identify mandatory GSA orders and/or federal laws, regulations, or executive orders.

Guide specifications are published by the GSA to serve as guides or models for the preparation of project specifications. The specifications are published in loose-leaf form and are distributed on word

processing diskettes to some regional offices. There are approximately 250 GSA guide specifications averaging 20 pages each and covering all 16 standard divisions of construction specifications. In the past, the GSA prepared its own guide specifications, in most cases using GSA personnel. Recently, however, the GSA entered into an agreement with the American Institute of Architects (AIA) to use the AIA MASTERSPEC guide specification service. The MASTERSPEC text is edited by GSA central office personnel to include GSA requirements and is then distributed to GSA regions as GSA guide specifications. Approximately 200 of the 250 GSA guide specifications are being replaced by MASTERSPEC-based specifications. The major factors considered in preparing guide specifications are government procurement regulations, standard practice in the construction industry, and GSA experience. Guide specifications are used on all major projects by both A-Es and in-house designers. Designers are expected to edit the guide specification text to produce project specifications. Except for a few provisions that are identified by notes to the specifier, the requirements outlined in GSA specifications are not mandatory.

Standard methods of test are published by the GSA to describe special performance tests for various products and systems for which no national voluntary standard tests exist. The documents are similar in format to American Society for Testing and Materials (ASTM) standard tests. GSA has published 11 documents of this type, one of which is 500 pages long and the remainder of which are 1- to 2-page documents. Two of the documents were developed by a consultant and the balance by the National Bureau of Standards. They originally were developed and published in the 1970s as part of the GSA building systems program, but they later were issued as separate documents. The GSA will withdraw a test document whenever a nationally recognized test method that serves the same purpose is published. The documents are referenced in GSA guide specifications. They are used primarily by product manufacturers and/or laboratories to conduct tests to verify the performance of a product or a system proposed for use on a GSA project. When referenced in a specification, their use is mandatory and instructions regarding their use are included in the specifications.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

The National Aeronautics and Space Administration (NASA) reported that it publishes three types of design criteria documents: its Facilities Engineering Handbook, its Safety Manual, and a series of guide specifications.

The Facilities Engineering Handbook (NHB7320.1b) is published by NASA to provide both general and specific guidance on the design of facilities, site development, and master planning. The current edition of the handbook contains 320 pages. The first handbook was published about 10 years ago. New editions of the handbook are prepared jointly by in-house personnel and private consultants. They are reviewed by

various NASA offices prior to being published. The criteria are used by both in-house designers and private A-Es. The criteria generally are not mandatory except for references to national codes.

The Safety Manual (NHB 1700.1) is published by NASA to establish basic safety policies and requirements for all NASA activities, including the design of NASA facilities. (NASA also publishes other manuals that address specific safety concerns but none of those currently available deal with facilities.) The safety manual has been in use for many years and the current edition has about 100 pages. It is prepared and updated by the NASA Office of Safety Reliability and Quality Assurance with input from all interested parties, including facilities engineers, facilities managers, and safety personnel. It is used by private A-Es, in-house designers, construction inspectors, and contractors. The safety requirements presented in the manual are mandatory, and no waivers are granted. The document identifies the codes to be used in design and the safety procedures to be followed during construction.

Guide specifications, called "Specsintact," are published by NASA for use as model specifications by A-Es and in-house designers in preparing contract specifications. NASA has published approximately 350 individual specifications averaging 15 pages each and covering all 16 standard divisions of construction specifications. NASA has used guide specifications for approximately 20 years. New sections of specifications are prepared and existing sections of specifications are reviewed and modified by in-house personnel or private A-Es hired for the purpose. Copies of Specsintact are made available to all designers of NASA facilities, both in-house designers and private A-Es. Their use is mandatory for projects costing over $75,000.

NAVAL FACILITIES ENGINEERING COMMAND

The Naval Facilities Engineering Command (NAVFAC) reported that it publishes eight categories of design criteria: guide specifications, standard specifications, definitive drawings, design manuals, P-Publications, NAVFAC instructions, standard drawings, and standardization documents. Like the CoE, NAVFAC also is required to conform to the construction criteria of the Department of Defense.

Guide specifications are published by NAVFAC to be used as models in the preparation of project specifications. Guide specifications establish minimum requirements for construction materials, workmanship, and maintenance. NAVFAC has published approximately 290 guide specifications averaging 25 pages each and covering all 16 standard construction divisions. NAVFAC has used construction guide specifications for over 40 years. The majority of NAVFAC guide specifications are created and updated by the design offices in NAVFAC's six engineering field divisions (EFDs). Draft specifications are circulated to various NAVFAC offices and to industry for comment prior to being submitted to NAVFAC headquarters for review, approval, and publication. Guide

specifications reflect current practices in the construction industry as well as the results of research carried out by the Navy Civil Engineering Laboratory and the National Bureau of Standards. NAVFAC guide specifications are used as the basis for project specifications on virtually all Navy construction projects. Use of the guide specifications is mandatory; if however, justified, some specific requirements can be waived by NAVFAC headquarters and others by EFDs.

Standard specifications to accompany standard drawings (see below) have been prepared for a small group of specialized structures that must be specially constructed to meet rigid Navy operational requirements. Standard specifications are complete packages of specifications for a particular item. Unlike guide specifications, they are expected to be used as contract documents without editing. NAVFAC has published 7 standard specifications averaging 25 pages each. Standard specifications have been in use for more than 25 years. They are prepared by both private A-Es under contract and in-house personnel and are coordinated with various offices in the Navy prior to publication. Standard specifications reflect Navy requirements, A-E research, and NAVFAC headquarters' experience. The use of NAVFAC standard specifications is mandatory whenever standard drawings are used.

Standard drawings (with accompanying standard specifications) are prepared and published by NAVFAC for certain specialized structures that must meet rigid Navy operational requirements. NAVFAC has prepared approximately 150 standard drawings and has used such drawings for more than 25 years. Standard drawings are prepared either by private A-Es under contract or in-house personnel. They are coordinated with EFDs and other Navy offices prior to being published and distributed. Standard drawings are used by private A-Es and Navy personnel in preparing contract documents for facilities for which the drawings have been made. The use of standard drawings for magazines is mandatory. Other types of standard drawings may be modified as necessary to meet specific requirements; however, waivers can be granted only by NAVFAC headquarters.

Definitive drawings are issued by NAVFAC to define functional and engineering requirements for buildings and structures needed on a repetitive basis. Definitive designs provide a uniform basis for the planning and design of such facilities. Pertinent legal and administrative limitations are incorporated in the definitive designs. NAVFAC has used such drawings for 12 years and has published 578 separate drawings. Definitive drawings are prepared by both A-Es and in-house personnel. They are approved for distribution by the NAVFAC Assistant Commander for Engineering and Design. They are used (together with NAVFAC design manuals and guide specifications) by both A-Es and in-house personnel to develop project plans and specifications for repetitive facilities. The use of definitive drawings is mandatory, and waivers can be granted only by NAVFAC headquarters.

Design manuals are published by NAVFAC to convey to architects and engineers NAVFAC design policy on various aspects of design. They are published in loose-leaf form. NAVFAC currently has 96 design manuals averaging 100 pages each. Such manuals have been in use for many years. Approximately 85 percent of design manuals are prepared by A-Es and the remainder are prepared by in-house professionals. Drafts of manuals are reviewed by EFDs and NAVFAC headquarters personnel prior to publication by NAVFAC. The manuals are based on the standards and practices of professional societies and trade associations. They are intended to be used by both A-Es and NAVFAC personnel. Some requirements presented in design manuals are mandatory and some are merely recommended. Most mandatory requirements can be waived by NAVFAC headquarters; however, in some cases, waivers must come from the Department of Defense.

P-Publications are prepared and distributed by NAVFAC to provide guidance for the planning of Navy facilities. The documents include both design information and planning guidance. NAVFAC has published 13 P-Publications averaging 100 pages each. Such documents have been used for many years. The process for preparing such documents is similiar to that followed for design manuals. The documents serve the same general purpose as design manuals except that they are used during the planning stages of a project rather than during the design stage.

NAVFAC instructions are prepared and disseminated to implement design policy and guidance from higher authority (e.g., the Secretary of the Navy and the Chief of Naval Material) or to establish interim guidance regarding some specific matter. NAVFAC currently has eight such instructions averaging five pages in length. Such documents have been used for more than 25 years. They are prepared and published by NAVFAC headquarters personnel with the approval of the Assistant Commander for Engineering and Design or a higher authority. Such documents are used by all NAVFAC organizations involved in the construction process.

Standardization documents are military and federal specifications and nongovernment standards that are referenced in NAVFAC guide specifications. These specifications and standards establish procurement-related requirements for specific items that are used on NAVFAC construction projects. NAVFAC has the preparing activity responsibility for approximately 617 military and federal specifications. These documents average 20 pages in length and have been issued for many years. The majority of the military and federal specifications are prepared by in-house personnel, but a few are prepared by private contractors. The documents are prepared in accordance with established Department of Defense standardization and specification program procedures that require coordination with various military activities and with industry. When completed, they are approved by NAVFAC and forwarded to the Naval Publications and Forms Center in Philadelphia for printing, distribution, and stocking.

U.S. POSTAL SERVICE

The U.S. Postal Service (USPS) reported that it publishes five categories of design criteria: instructions for contract architect-engineer services, (Real Estate) handbooks and management instructions, design requirements, standard drawings, and guide specifications.

Instructions for contract architect-engineer services describe USPS requirements for design services (e.g., preparation of drawings, specifications, and cost estimates) and design submittals; establish USPS policy on the use of codes, federal regulations, and standards; describe USPS data to be furnished; and list additional optional services that might be required of an A-E. The instructions are published in loose-leaf form in one 59-page document. Such instructions have been issued by the USPS (and its predecessor, the Post Office Department) for many years. The instructions are prepared and published by the USPS Real Estate and Buildings Department with input from many USPS professionals (architects, engineers, attorneys, realtors, contracting officers, and construction managers). Use of the documents by A-Es is mandatory. Requirements based on federal laws, executive orders, regulations, and basic USPS policy cannot be waived. Waivers for other USPS requirements are occasionally granted by contracting officers.

RE handbooks and management instructions are published by the Real Estate and Buildings Department to establish USPS policy and standards for compliance with the Architectural Barriers Act, Postal Inspection Service requirements for security of the mail, Occupational Safety and Health Administration standards, and National Fire Protection Association codes. Three documents of this type, each averaging 20 pages, have been published by the Real Estate and Buildings Department. Such documents have been used for approximately 10 years. The documents are prepared by USPS staff in cooperation with appropriate authorities. Some are published in typewritten form and others are printed by the U.S. Government Printing Office. The documents are used by both USPS personnel and private A-Es doing work for the Postal Service. Compliance is mandatory and waivers cannot be granted; however, the Inspection Service sometimes approves alternate designs for security features of postal facilities.

Design requirements are published to identify requirements for site development, building design, space conditioning, plumbing, fire protection, and electric service. The documents are published in loose-leaf form. Two documents in this category have been published; one contains 88 pages and the other, 25 pages. Such documents have been in use approximately 10 years. They are prepared by USPS professional staff and approved by the General Manager, Design Management Division, Real Estate and Buildings Department. The documents are used by USPS personnel as well as private A-Es and developers working on USPS projects. Compliance with the requirements is mandatory; however, waivers can be granted by the Manager of the Design Management Division.

Standard drawings are developed and published by the USPS Real Estate and Buildings Department to standardized the design and construction of unique features of USPS facilities (e.g., look-out galleries, mailing vestibules, post office lobbies, fixed mechanization designs, and protective bumpers). Most of the drawings are published in an 8-1/2 inch by 11 inch format. Seven sets of drawings, each containing an average of 60 drawings, have been published. Such drawings have been in use for approximately 20 years. The drawings were originally prepared by the Post Office Department and the Army Corps of Engineers. They are periodically revised by USPS employees and reissued. Standard drawings are given to all A-Es hired by the USPS. Although A-Es are not required to use the standard drawings, they must be able to demonstrate that any alternative design proposed is at least as economical, safe, and functional as that described in the standard drawings.

Guide specifications have been prepared by the USPS for certain specific elements of construction that are of special concern to the USPS (e.g., site surveys, subsurface explorations, workroom flooring, mailing vestibule doors, platform dock ramps, fixed mechanize mail systems, and general requirements). Nine specifications averaging 30 pages each have been published. Such specifications have been in use for approximately 10 years. Guide specifications are developed only for elements that are of special concern to the USPS. They are prepared by USPS personnel and are published in loose-leaf form. The guide specifications are provided to all A-Es hired by the USPS. Use of the Division 1 guide specifications is mandatory; the other guide specifications are used as applicable.

VETERANS ADMINISTRATION

The Veterans Administration (VA) reported that it publishes five general categories of criteria: construction standards, miscellaneous written criteria, master specifications, equipment guide lists, and standard details.

Construction standards are short written directives regarding certain mandatory features to be provided in VA facilities. The VA currently has approximately 110 construction standards averaging 20 pages each and divided into nine topic areas: architectural, structural, and site planning standards; plumbing standards; utilities standards; equipment standards; air-conditioning, ventilating, refrigeration, and heating standards; steam generation and outside steam distribution standards; electrical and elevator standards; construction details and multidiscipline standards; and fire protection standards. Such standards have been in use for many years. They are prepared by the Research Staff of the VA Office of Construction. Their purpose is to establish uniform design requirements. The use of the standards is mandatory for all VA facilities. Waivers must be approved by the Director of the VA Office of Construction.

Miscellaneous written criteria have been published by the VA to provide general guidance to A-Es on how to design various parts of VA facilities. Such criteria are discipline-oriented. The VA has published approximately 80 guides of this type averaging 15 pages each. Such guides have been used for many years by the VA. They are prepared by various professional discipline offices in the VA Office of Construction (i.e., architecture, plumbing, sanitation, air-conditioning and refrigeration, steam generation, structural, site planning, electrical, energy, cemetaries, and estimating). All A-Es hired by the VA are given copies of the design guides and are expected to use them.

Master specifications are used by A-Es and the VA staff in preparing project specifications. The VA has published approximately 350 specification sections, each containing approximately 15 pages. Such specifications have been in use for more than 40 years. The specifications are prepared by specification writers in the various technical divisions of the VA. They are used in preparing all VA construction documents. Their use is mandatory to the extent that they are applicable to the various projects. Waivers may be granted if the A-E or other user can demonstrate that an alternative approach would be beneficial to the VA.

Equipment guide lists establish the specific pieces of equipment to be incorporated in various types of rooms in VA facilities. Some 63 lists of this type, averaging about 10 pages each, have been published by the VA. Such lists have been in use for many years. They are developed by the Criteria Staff of the VA Office of Construction with the concurrence of the Department of Medicine and Surgery. Use of the lists is mandatory.

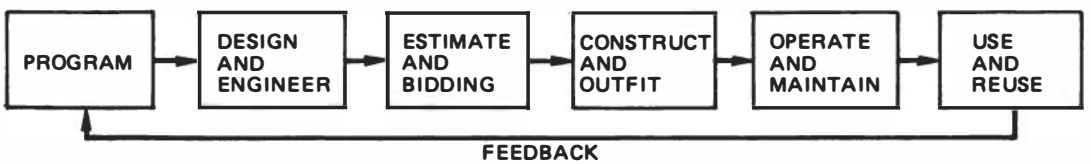
Standard details are predrawn details of various specific elements of VA facilities and are incorporated into project drawings. The VA has published four volumes of standard details; one each on architecture, civil engineering, mechanical engineering, and electrical engineering. The volumes contain an average of 180 pages each. The details are developed by VA personnel. Their use is mandatory if applicable to a particular project; however, deviations are allowed.

APPENDIX B

THE ROLE OF DESIGN CRITERIA IN THE CONSTRUCTION PROCESS

The building process can be thought of as a framework that contains a "system" in which various actors participate and represents the entire spectrum of activities required to get a satisfactory building produced and used. In this framework, various controls need to be introduced to assure the managers of and the participants in the system that it is performing satisfactorily. Some of these controls provide for public safety, health, and welfare; some reflect national consensus standards concerning optimum performance and design; and some reflect the special needs of the client. As in any good "systems design," a method of obtaining "feedback" in order to continuously improve the system is required.

Although there are many variations on how the building system works, the general pattern (both in public and private work) is something like the following:



Each phase of this system normally is undertaken by a different set of actors, although on small projects the entire system may be implemented by an in-house team employed by the client agency. It also should be noted that the use of "feedback" varies greatly and, in some instances, no formal feedback process exists.

It should be understood that many design criteria documents are accumulated sets of "protective measures" developed in response to problems encountered in previous projects. They are intended to prevent similar problems from being repeated in the future.

DESIGN REQUIREMENTS

For a building to perform satisfactorily it must be structurally and mechanically sound as well as fire-safe. Its load-bearing walls must not collapse, its external shell must not leak, and its environmental control systems and internal servcice systems must work. The building's interior usable space must be suited, in both configuration and environment, to the activities to be carried on within it. These sets of design requirements are distinct in the sense that if the building collapses, there is no longer any need to be concerned with the interior. On the other hand, if the structure is sound, there are often many inventive ways to shape interior spaces to fit the functional requirements. The two requirements of physical soundness and interior suitability have superimposed on them the additional requirements associated with economic efficiency. A design solution will have to reflect the availability and cost of materials, energy consumption patterns, and the technology for constructing it--including the availability of a workforce with the needed skills. The building's location will have to take into account the cost of transportation, communications, security, and the costs of maintaining and operating the facility also must be considered. Finally, the building must be visually attractive and must not adversely affect its surrounding environment.

All of these requirements pertain to the building's performance. They give rise to broadly stated performance goals. These goals are, in turn, transformed into specific performance requirements (i.e., concerning what is required, for whom, why, where is it needed, and when is it used) that can serve as a guide to designers.

Next it is necessary to identify the performance criteria that will be used to determine whether the requirements are being met and then the associated evaluative techniques for measuring the ability of various alternatives to meet the requirements (e.g., if comfortable working conditions are required, it is likely that an acceptable temperature of the space will be one of the criteia and that a dry bulb temperature measurement device can be used as the evaluative method). Once the criteria for acceptable performance are identified, it is important to establish the range of measured values that will be considered to satisfy the criteria (e.g., if temperature is a criterion, an acceptable range may be from 65 to 80°F. This range is established by physical, physiological, psychological, sociological, and economic requirements.

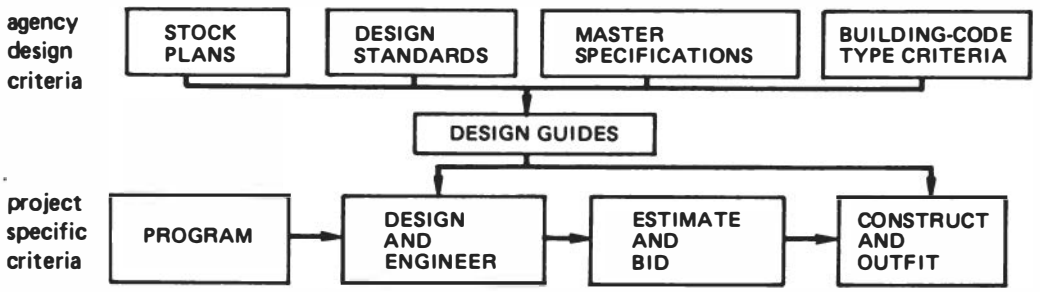
DESIGN CONTROLS

During the programming and planning stage for a project, the specific design requirements begin to be formulated. There are two sets of requirements--those that determine the physical soundness of the building and those that determine the suitability of the building to its purposes. The requirements for physical soundness and safety generally are covered by building codes. Suitability requirements

generally are unique to each building and are a part of the program rather than the design criteria.

It would be beneficial to the entire process if these design requirements were written in performance terms and if the goals that these requirements were intended to meet also were made explicit. Thus, if a military client were to set out requirements for bachelor officers' quarters (a BOQ), the program should indicate the goals it was trying to achieve in providing such a facility, not just the space needs.

Most important, the program document should provide a means of evaluating various design solutions to see if the goals have been met. This is done in traditional practice by having a project manager for the client (or perhaps a committee) review the architectengineer's (A-E's) design proposal and evaluate the design in a more or less subjective manner. Although this procedure provides a means of judging the proposed design in the interest of the client, it tends to be arbitrary and does not provide a basis for later evaluation, feedback, and systems improvement. The DD1391 form prepared for Department of Defense projects contains the basis for developing these more explicit goals, requirements, and evaluation criteria.

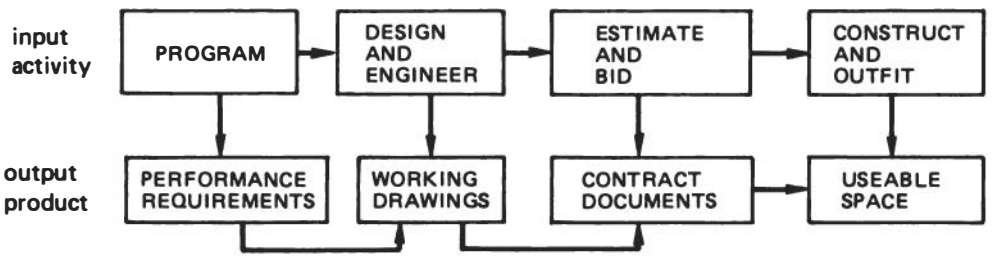


The box labeled "design guides" in the following diagram is the product of a variety of controls and procedures that should be used by an agency for all projects it undertakes. For most projects these are the key documents for determining the range of services required for the A-E community. Some agencies retain an outside consulting firm to prepare these documents and, in most cases, the design guides are primarily references to other sources of criteria. Some clients (e.g., Georgetown University and the Architect of the Capitol) have relatively brief documents and nevertheless obtain satisfactory results. Even if the document is brief, it should contain all three elemtns: goals, requirements, and evaluation criteria.

In some agencies, the design guides include "stockplans" for which the A-E is simply expected to provide site adaption. The goal of

course, is to prevent "re-inventing the wheel" each time a specific type of facility is designed, and for facilities that are more or less "routine" (e.g., barracks) or for facilities in which carefully developed layouts have been created (e.g., tank maintenance shops). there is some justification for this approach. There is, however, the danger of not being open to new and better ideas and it might be wise to provide, along with any such standard plans, the design goals, requirements, and evaluation criteria that stock plans are intended to satisfy so that A-E firms would have a basis for proposing alternatives for consideration. This also would make it more likely that completed facilities could be evaluated to detemine if changes needed to be made in future design guides.

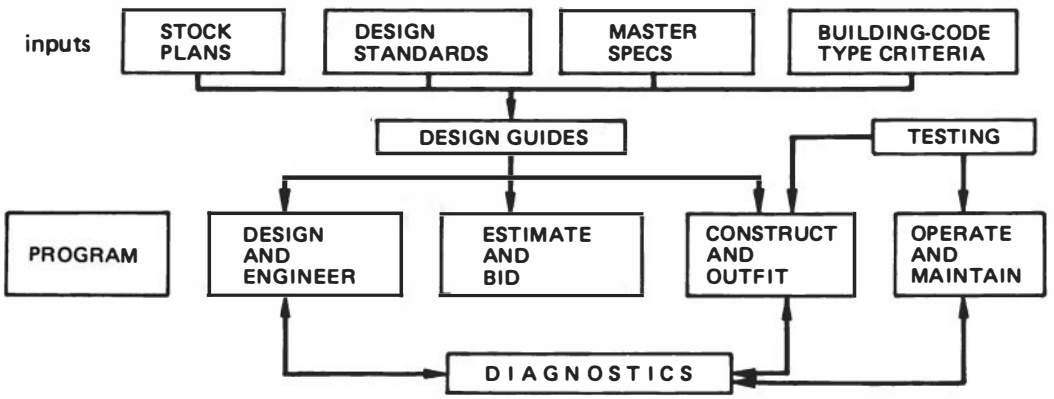
The "program" and "design and engineer" stages usually are organized around two distinct phases in the life of a project. In military programs, all projects are carried to the "definitive design" stage before a budget request is made to Congress. This helps assure the client agency that the proposed facility has been carefully thought out and that the cost estimates prepared for the proposed facility are reasonably accurate. In most cases these definitive designs are done by private A-E firms but for some projects that are developed by the in-house agency staff. In either case, the determination of a satisfactory definitive design involves more than a simple schematic for the building; it also includes consideration of structural, HVAC, electrical, and lighting subsystems. As the building community develops the ability to measure less concrete factors like "user satisfaction," these factors also can be incorporated at this stage of design review. The recent history of energy conservation goals has highlighted the need to consider user satisfaction as well as equipment efficiency. The further development of diagnostics--especially post-occupancy evaluation techniques--is required to make improvements in determining user satisfaction. It seems obvious that the three elements of the program document mentioned above are important to gaining nonarbitrary review at this stage in the project development.



Working drawings, contract documents, and usable space are well understood products in the traditional process. If the program document containing performance requirements has been prepared with goals, requirements, and evaluation criteria made explicit, it becomes more likely that conflicts between the later stages have a sounder

basis for being adjudicated. Recent attempts by the General Accounting Office to have agencies bring legal action against A-Es for design errors and omissions illustrate the rather arbitrary nature of the traditional methods of adjudicating many kinds of conflicts.

For example, the fact that so many buildings were designed with energy monitoring and control systems (EMCS) that did not work properly is evidence that, in many cases, there was no effective link between the energy conservation goals of the agency, the design criteria, the working drawings and specifications, and the operating instructions for the building. In fact, most buildings were not provided with manuals of instructions for the operating engineers and no training was provided for them. This example illustrates a deficiency in the existing framework and highlights something that should be considered in any future model.



Although testing programs are routine for assessing such things as concrete strength when a building is under construction, the range of design criteria tested for is very limited. The emerging program on building diagnostics being developed in part by a Building Research Board advisory committee will begin to provide the capability for evaluating many more aspects of the intended performance of the building and its components. In principle, it should be possible for any element of the design criteria subsystem to be evaluated by a diagnostic procedure, including the overall performance of the building in meeting the performance intentions of the client. This overall performance diagnostic should be able to be applied to a building that is still in the design; diagnostics then would be applied to a "virtual" building (one that is complete on paper but not yet actually built), as well as during the construction stage, upon completion of the building, and during the use of the building (as a form of a preventive maintenance). As the capacity for performing diagnostics becomes more fully developed, it becomes even more clear that the design criteria are a subsystem of obtaining a satisfactory building since these criteria form the basis for determining which diagnostic routines should be applied.

A post-occupancy evaluation form of diagnostics is receiving increased attention for use when a building has been completed and the new functions are being performed. In essence, this should be a form of diagnostics that is applied to the complete building, but in current practice it tends to be limited to two quite different types of tests. Some agencies conduct inspections of the equipment and components of the building to determine whether they are in compliance with the original specifications (e.g., they test the efficiency of the HVAC equipment). Others conduct interviews with the usersoccupants of the building to determine whether there are any complaints. When there are complaints, an attempt is made to modify conditions in the existing building. What is normally missing is a closing of the "feedback loop" that would enable the client agency to modify its design guides to avoid such problems in the future. It is this feedback loop between diagnostic and post-occupancy evaluation and the original program development stage that holds the promise for creating a "design system" that is capable of continuous and effective improvement.