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Functional Programming/Research Planning for High Technology Federal Office Buildings

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
National Engineering Laboratory
Center for Building Technology
Washington, DC 20234

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Center for Fire Research
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Prepared for:
Public Buildings Service
General Services Administration
Washington, DC 20405

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FUNCTIONAL PROGRAMMING/RESEARCH PLANNING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

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U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, *Secretary*
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ABSTRACT

The General Services Administration (GSA), Public Buildings Service (PBS) is engaged in the development of a new design approach for Federal buildings referred to as "high technology" (high-tech). The approach emphasizes the consideration of new, emerging and innovative uses of existing technology applications in building system design, construction and operation. In order to develop design programs for high-tech building projects, there is a need for PBS to identify programming issues that address new, emerging and innovative uses of existing technologies, and there is a need for PBS to develop a plan of research in support of its high-tech design approach. Under a memorandum of understanding with GSA, the National Bureau of Standards' (NBS), Center for Building Technology (CBT) assisted PBS by providing technical support through the development of programming issues and research needs for high-tech office buildings. The programming issues and research needs developed by NBS represent the identification of programming and research topics to be considered by GSA during its programming and research planning activities.

ACKNOWLEDGMENTS

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1.0 INTRODUCTION

1.1 Background

The General Services Administration (GSA), Public Buildings Service (PBS) is engaged in the development of a new design approach for Federal buildings referred to as "high technology" (high-tech). The new approach emphasizes the consideration of new, emerging and innovative uses of existing technology applications in building system design, construction and operation. Particular emphasis is placed on the use of automation and advanced communication technologies applicable to office work environments.

In order to develop design programs for high-tech building projects, there is a need for PBS to identify programming issues that address new, emerging and innovative uses of existing technologies. In addition, there are areas where advantages may be realized through high-tech applications but the applications are constrained or prevented because of insufficient testing and/or in-use performance data. As a result, there is a need for PBS to develop a plan of research in support of its high-tech design approach.

1.2 Objective and Scope of the Report

Under a memorandum of understanding with GSA, the National Bureau of Standards (NBS), Center for Building Technology (CBT) assisted PBS by providing technical support through the development of functional programming statements (FPS) and research needs (RNS) for high-tech office buildings.

The programming statements will be used by GSA as reference information input to its building design programming process. A design program serves as a guide to architects, engineers and space planners in making decisions by informing them of the performance goals, objectives and criteria that a building design must meet. The research needs statements will be used by GSA as input to its research planning process. The research plan will consist of a schedule of research in support of the GSA high-tech design approach.

The programming and research needs developed by NBS represent the identification of programming and research topics to be considered by GSA during its programming and research planning activities. The issues and needs are not intended to be final design directives nor final research proposals.

The development of the programming issues consisted of the identification of new, emerging and/or the innovative use of existing technologies related to various parts of the building system.

Section 2.0 contains the set of functional programming statements developed by CBT and the Center for Fire Research (CFR).
The research needs were developed from constraints to or prevention of immediate application of certain of the programming issues, and from the CBT staffs' familiarity with the insufficient testing and/or lack of in-use performance data for various technologies having potential applications in Federal office buildings.

1.3 Organization of the Report

This report is organized in three sections:

Section1, the current section, provides a general introduction, including the objective and scope of the report.

Section 2 contains the functional programming statements developed by CBT and CFR staff members.

Section 3 contains the research needs statements development by CBT staff members.

Section 4 contains a summary of the report and reiterates the intended use for the statements that have been developed.

2.0 FUNCTIONAL PROGRAMMING STATEMENTS

2.1 Introduction

The functional programming statement sheets contained herein are organized according to the categories of design directives found in a GSA design program. Although no statements were developed for categories one, two and five, the complete list of design directive categories is as follows:

1. Building concept. Design decisions include overall shape and image of the building, its height, and configuration of floors, including location of the core.

2. Site development. Includes relationship of proposed design to existing structures, building placement and decisions about access and egress to buildings, locations of parking areas and planned outdoor use places, a landscape plan, and circulation issues including where people will enter the site.

3. Building infrastructure. Includes decisions about foundations, structural systems, and plenum areas within the building.

4. Building enclosure. Design decisions regarding windows, walls, insulation, vapor barrier systems, and facade treatment issues are included in this section.

5. Space allocation. Decisions relate primarily to interior space planning issues and include space needs, spatial adjacencies, spatial groupings, circulation, and growth projections.

6. Building systems. Includes all other major building systems: energy, HVAC, electrical and communication, lighting, acoustics, and elevators.

2.2 Statements

The statements are presented on the following 31 pages with each statement formatted separately in a standardized layout.

FUNCTIONAL PROGRAMMING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

FUNCTIONAL PROGRAMMING STATEMENTS

PROGRAMMING ISSUE:
Base Isolation System -- Seismic Safety and Protection

Building Systems Involved:
Building Infrastructure (Foundations and Superstructures)

Issue Statement:
For buildings located in zones with high probable seismic risk, structures such as public office buildings should be designed to resist large lateral forces induced from strong earthquake motions. Based on current codes and standards [1], seismic design may be considered satisfactory if an earthquake causes no loss of life. Damage sustained by the building, however, may vary from minor to irrepairable.

Possible Applications:
The concept of "base isolation" has been developed and applied to buildings. By implementing a base isolation system, the lateral design forces can be greatly reduced. This can ensure safety of the structure.

Other System Integration Requirements:
1. There may be larger relative displacements across the base isolation system than is the case for conventional design. Therefore, utility connections, electrical and mechanical equipment must be designed to accommodate such movements.

Constraints to Application:
1. The technology is relatively new to the building industry. Hence, it may add to the design and construction costs (even though the cost of structural members can be reduced).

2. The long-term performance of base isolation systems has not been documented [2].

3. Human response to floor vibration should also be considered [3].

Actions Necessary for Application Feasibility:
Engineering design firm(s), manufacturer(s), and contractor(s) must be selected to ensure proper design and construction of the base isolation system. Special details for inspection, maintenance, and replacement of the components of the system must be planned at the design stage.

Points of Contact and/or Resources:
S.T. Wu, 301-921-2198, CBT/NBS

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[1] See FPS-5.
[2] See RNS-1.
[3] See reference NBS SP 474, "Building for People," by Rubin, A. and Elder, J., 1980.

FUNCTIONAL PROGRAMMING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

FUNCTIONAL PROGRAMMING STATEMENTS

PROGRAMMING ISSUE:
Base Isolation System -- Seismic Safety

Building Systems Involved:
Building Infrastructure (Structural Components)

Issue Statement:
In-situ measurements are needed to verify the effectiveness of the base isolation system (when the structure is subjected to earthquake excitation or wind loads).

Possible Applications:
Measurements require installation of accelerographs on floors or foundations above and below the base isolation system. Strain gages are also required on critical structural elements.

Other System Integration Requirements:
1. These devices may be included as part of the integrated system (if selected) for the building management, e.g., for fire safety, security, and thermal control.

Constraints to Application:
1. Cost may be the only constraint to including this instrumentation.

Actions Necessary for Application Feasibility:
1. Select instrumentation based on measurement capabilities, limitations, reliabilities, costs and installation details.

2. Calibrations may have to be performed periodically.

3. The locations of the measurements must be properly determined.

Points of Contact and/or Resources:
S. T. Wu, 301-921-2198, CBT/NBS

E. V. Leyendecker, 301-921-3471, CBT/NBS

FUNCTIONAL PROGRAMMING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

FUNCTIONAL PROGRAMMING STATEMENTS

PROGRAMMING ISSUE:
Epoxy-coated Steel Reinforcing Bars

Building Systems Involved:
Building Infrastructure (Foundations, Structure)

Issue Statement:
Steel reinforcement embedded in concrete can corrode when the concrete is infiltrated by certain inorganic salts, especially those containing chloride ions. Salt water exposures are well known to be aggressive, greatly accelerating the corrosion of steel. Corrosion of reinforcing steel results in cracking of concrete and eventually its disintegration. Epoxy coatings have been demonstrated to effectively protect steel reinforcing bars from corrosion while not disturbing the structural integrity of the reinforced concrete.

Possible Applications:
Epoxy-coated reinforcing bars should be used in those portions of a building where its concrete may be exposed to marine environments, deicing salts, or other sources of inorganic salts.

Other System Integration Requirements:
None.

Constraints to Application:
1. Epoxy-coated reinforcing bars may cost up to 100 percent more than uncoated reinforcing bars.

2. Only certain epoxies can be used and good quality control practices must be followed in coating reinforcing bars.

Actions Necessary for Application Feasibility:
Make contact with coaters who can apply appropriate epoxy coatings to steel reinforcing bars to determine cost and availability at specific construction sites.

Points of Contact and/or Resources:
James R. Clifton, 301-921-3458, CBT/NBS

Clifton, J.R., Beeghly, H.F., and Mathey, R.G., Nonmetallic Coatings for Concrete Reinforcing Bars, Nat. Bur. Stand. (U.S.), Bldg. Science Series 65, August 1975.

Clifton, J.R., "Bond and Creep Characteristics of Coated Reinforcing Bars in Concrete," **American Concrete Institute Journal**, 80 (1983), 288-293.

FUNCTIONAL PROGRAMMING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

FUNCTIONAL PROGRAMMING STATEMENTS

PROGRAMMING ISSUE:
High-strength Concrete

Building Systems Involved:
Building Infrastructure (Foundations, Structure)

Issue Statement:
High-strength concretes with compressive strengths as high as 83 MPa (12 x 10^3 psi) are commercially available. Use of high-strength concrete facilitates innovative design and the reduction of dead-weight loading through reduced sizes of structural members.

Possible Applications:
Structural members of a building, particularly for columns in high-rise buildings.

Other System Integration Requirements:
Unknown.

Constraints to Application:
1. Availability of high-strength concrete at specific construction sites.

2. Dynamic properties of high-strength concretes have not been well characterized.

Actions Necessary for Application Feasibility:
Make contact with concrete companies to determine availability, performance, warrantee, and cost of high-strength concrete.

Points of Contact and/or Resources:
James R. Clifton, 301-921-3458, CBT/NBS

American Concrete Institute, 313-532-2600, Detroit, Michigan

Proceedings, Workshop on High-Strength Concrete, University of Illinois at Chicago Circle, Chicago, IL, December 2-4, 1979.

FUNCTIONAL PROGRAMMING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

FUNCTIONAL PROGRAMMING STATEMENTS

PROGRAMMING ISSUE:
Design Philosophy on Seismic Safety

Building Systems Involved:
Building Infrastructure (Structural Systems)

Issue Statement:
In practice, structural members are designed to withstand the forces induced by seismic excitations prescribed by building codes. The philosophy behind each building code is different, therefore, the reliability of structural safety is also different for structures subjected to severe earthquake motions. It is important that more rational design provisions be selected for "hi-tech" building projects.

Possible Applications:
Selection of either of the following documents as the basis for seismic design (they are more up-to-date provisions):

1. ATC 3-06, "Tentative Provisions for the Development of Seismic Regulations for Buildings," NBS SP 510, 1978

2. NBSIR 81-2195, "Draft Seismic Standard for Federal Buildings," NBS Report, 1981.

Other System Integration Requirements:
1. The seismic qualification (and design) of mechanical/electrical systems, utility supply systems, piping and equipment should also be based on the structural response data obtained with the present design philosophy.

Constraints to Application:
None.

Actions Necessary for Application Feasibility:
Experienced engineering design firms have to be selected to perform seismic analyses and designs based on selected design provisions.

Points of Contact and/or Resources:
E. V. Leyendecker, 301-921-3471, CBT/NBS

S. T. Wu, 301-921-2198, CBT/NBS

FUNCTIONAL PROGRAMMING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

FUNCTIONAL PROGRAMMING STATEMENTS

PROGRAMMING ISSUE:
Building Diagnostics -- Structural Performance

Building Systems Involved:
Building Infrastructure (Floor Systems)

Issue Statement:
Floor vibrations due to long unsupported spans, high wind or machines/equipment may cause not only discomfort to occupants but also damage to structural members. Measurements of floor response will provide information for any required corrective action and development of design criteria.

Possible Applications:
To monitor floor response in terms of accelerations over a frequency range of 0 - 50 Hz and identify when corrective action is warranted.

Other System Integration Requirements:
1. These devices may be included as part of the integrated system (if selected) for the building management, e.g., for fire safety, security, and thermal control.

Constraints to Application:
1. Cost may be the only constraint to including this instrumentation.

Actions Necessary for Application Feasibility:
1. Select instrumentation based on measurement capabilities, limitations, reliabilities, costs, and installation details.

2. Calibrations may have to be performed periodically.

3. The locations of the measurements must be properly determined.

4. Measurements of the preoccupancy conditions of the building will be needed.

Points of Contact and/or Resources:
S. T. Wu, 301-921-2198, CBT/NBS

E. V. Leyendecker, 301-921-3471, CBT/NBS

FUNCTIONAL PROGRAMMING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

FUNCTIONAL PROGRAMMING STATEMENTS

PROGRAMMING ISSUE:
Building Diagnostics -- Wind and Live Loads

Building Systems Involved:
Building Infrastructure (Superstructures Including Roof Subsystem)

Issue Statement:
To characterize the structural systems based on the floor accelerations as stated on FPS-6, the collection of wind and live load data will be useful. (Problems such as human sensitivity can also be evaluated based on these measurements.)

Possible Applications:
Installation of devices such as anemometers, strain gages, and interfacing recording systems.

Other System Integration Requirements:
1. These devices may be included as part of the integrated system (if selected) for the building management, e.g., for fire safety, security, and thermal control.

Constraints to Application:
1. Cost may be the only constraint to including this instrumentation.

Actions Necessary for Application Feasibility:
1. Select instrumentation based on measurement capabilities, limitations, reliabilities, costs and installation details.

2. Calibrations may have to be performed periodically.

3. The locations of the measurements must be properly determined.

Points of Contact and/or Resources:
R. D. Marshall, 301-921-2170, CBT/NBS

B. R. Ellingwood, 301-921-3471, CBT/NBS

FUNCTIONAL PROGRAMMING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

FUNCTIONAL PROGRAMMING STATEMENTS

PROGRAMMING ISSUE:
Glazing and Antireflective Coatings

Building Systems Involved:
Building Enclosure (Windows)

Issue Statement:
Space heating through use of southern exposure windows can be an effective energy conservation mechanism. To increase effectiveness, it is desirable to use antireflective coatings or films on the interior of such windows to reduce heat losses.

Possible Applications:
Southern exposure windows.

Other System Integration Requirements:
Summer shading mechanism.

Constraints to Application:
None. Glass products with antireflective materials are commercially available. Even though test methods and standards are not available, manufacturers have limited performance and durability data that would be helpful in assuring quality.

Actions Necessary for Application Feasibility:
1. None for glass products (unless testing standards are necessary).

2. For organic (plastic) glazing, research is needed to ensure longevity.

Points of Contact and/or Resources:
L. Masters, 301-921-3458, CBT/NBS

Clark, E.J., Roberts, W.E., Grimes, J.W., and Embree, E.J., Solar Energy Systems - Standards for Cover Plates for Flat Plate Solar Collectors, Nat. Bur. Stand. (U.S.), Tech. Note 1132, December 1980.

Clark, E.J. and Roberts, W.E., Weathering Performance of Cover Materials for Flat Plate Solar Collectors, Nat. Bur. Stand. (U.S.) Tech. Note 1170, November 1982.

Energy-Effective Windows, Nat. Bur. Stand. (U.S.), Spec. Pub. 512, April 1978.

Frohnsdorff, G., Masters, L.W., and Martin, J.W., **An Approach to Improved Durability Tests for Building Materials and Components**, Nat. Bur. Stand. (U.S.) Tech. Note 1120, July 1980.

Hastings, S.R. and Crenshaw, R.W., **Window Design Strategies to Conserve Energy**, Nat. Bur. Stand. (U.S.) Bldg. Sci. Ser. 104, June 1977.

Waksman, D., Streed, E., and Seiler, J., **NBS Solar Collector Durability/Reliability Test Program Plan**, Nat. Bur. Stand. (U.S.) Tech. Note 1136, January 1981.

Yancey, C.W.C., **Materials Research Activities at the National Bureau of Standards (1975-1982) Pertaining to Active Solar Heating and Cooling Systems**, NBSIR 83-2782, November 1983.

FUNCTIONAL PROGRAMMING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDILNGS

FUNCTINAL PROGRAMMING STATEMENTS

PROGRAMMING ISSUE:
Security Glazing for Windows

Building Systems Involved:
Building Enclosure (Windows)

Issue Statement:
Windows are usually the easiest element in a building security system to breach. High security glazing materials have been developed to provide increased resistance to penetration. These glazing materials consist of laminated layers of glass and plastic films.

Possible Applications:
High security glazing materials are appropriately used when a high level of building security is desired and the windows are vulnerable targets.

Other System Integration Requirements:
None.

Constraints to Application:
1. Criteria have not been established for selecting high security glazing materials.

2. Special window framing is required.

Actions Necessary for Application Feasibility:
1. NBS is developing performance criteria to aid in the selection of high security glazing. These criteria will address combined thermal and mechanical attack.

2. Additional work may need to be carried out on notch crack sensitivity (i.e., effect of scratches on resistance to impact).

Points of Contact and/or Resources:
James R. Clifton, 301-921-3458, CBT/NBS

FUNCTIONAL PROGRAMMING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

FUNCTIONAL PROGRAMMING STATEMENTS

PROGRAMMING ISSUE:
Single-ply Membranes

Building Systems Involved:
Building Enclosure (Roof)

Issue Statement:
Premature failures of built-up roofing membranes occur more frequently than any other major building material, resulting in moisture penetration into buildings and loss of thermal efficiency. Single-ply membranes appear to be more durable than built-up membranes and more cost effective. It has been predicted that within the next 10 years single-ply materials will largely replace built-up roofing membranes.

Possible Applications:
Single-ply membranes are intended for use on low-sloped roofs. Undoubtedly they can be used wherever built-up roofing membranes are in service.

Other System Integration Requirements:
Same as required for built-up roofing membranes.

Constraints to Application:
1. There is a lack of consensus standards to form the bases for selecting single-ply membranes.

2. Methods need to be developed to determine the quality of seams constructed in the field.

Actions Necessary for Application Feasibility:
1. Make contact with manufacturers/distributors of single-ply roofing materials to establish features, performance, durability, cost, warrantee and installation details.

2. Make contact with ASTM D8 subcommittee dealing with single-ply membranes.

3. Many available single-ply membrane materials are listed in the RST (Roofing/Siding/Institute) 1983 Handbook of Single-Ply Roofing Systems.

Points of Contact and/or Resources:
James R. Clifton, 301-921-3458, CBT/NBS

Walter J. Rossiter, 301-921-3109, CBT/NBS (information on ASTM Committee D-8)

National Roofing Contractors Association

Cullen, W.C., Rossiter, W.J., Mathey, R.G., and Clifton, J.R., **Low Sloped Roofing Research Plan**, Nat. Bur. Stand. (U.S.) Spec. Publ. 659, April 1983.

Rossiter, W.J. and Mathey,R.G., "A Methodology for Developing Tests to Aid Service-Life Prediction of Single-Ply Roofing Membranes." Paper presented at the NBS/NRCA 7th Conference on Roofing Technology, Gaithersburg, MD, April 14-15, 1983.

Rossiter, W.J. and Mathey,R.G., **Elastomeric Roofing: A Survey**, Nat. Bur. Stand. (U.S.) Tech. Note 972, July 1978.

FUNCTIONAL PROGRAMMING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

FUNCTIONAL PROGRAMMING STATEMENTS

PROGRAMMING ISSUE:
Diagnostic Monitoring of Mechanical Equipment

Building Systems Involved:
Building Systems (HVAC)

Issue Statement:
Routine inspection of mechanical systems is a costly process. Likewise an unexpected failure in a mechanical component can result in expensive emergency repairs and/or temporary loss of building use with the attendant reduced user's productivity. A rational approach to both maintenance scheduling and detection of potential equipment failure is diagnostic monitoring of the signal emitted by mechanical equipment.

Possible Applications:
Energy management, building security, fire and smoke management and communication systems.

Other System Integration Requirements:
Communication, HVAC, security, fire and smoke management.

Constraints to Application:
1. Complexity may delay start up.

2. Debugging may be required prior to achieving efficient operation.

3. Installation costs may be high.

Actions Necessary for Application Feasibility:
1. Survey the availability of diagnostic monitoring systems to determine their application, operating characteristics and cost as related to routine mechanical equipment operation.

2. The long-term servicing requirements and durability must also be established.

Points of Contact and/or Resources:
Simone L. Yaniv, 301-921-3783, CBT/NES

FUNCTIONAL PROGRAMMING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

FUNCTIONAL PROGRAMMING STATEMENTS

PROGRAMMING ISSUE:
Lighting Controls, On-off Regulation; Task/Ambient Lighting

Building Systems Involved:
Building Systems (Lighting)

Issue Statement:
While most lighting systems in buildings are manually controlled, many new buildings are being designed with computer-operated controls. An intermediate approach is suggested here -- one that would be based upon centralized computer control of ambient lighting, with individually controlled task lighting, tunable by means of a dimmer. This latter system would enable the operator to adjust lighting conditions for performance of different tasks, e.g., video display terminal or paper-based.

Possible Applications:
This system would be appropriate for all office-based activities.

Other System Integration Requirements:
The ambient system requires integration with other management systems of the building.

Constraints to Application:
Possible user resistance to automated controls.

Actions Necessary for Application Feasibility:
None, off-the-shelf equipment is available.

Points of Contact and/or Resources:
Arthur I. Rubin, 301-921-2246, CBT/NBS

FUNCTIONAL PROGRAMMING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

FUNCTIONAL PROGRAMMING STATEMENTS

PROGRAMMING ISSUE:
Building Management System - Integrated HVAC, Security, and Fire System

Building Systems Involved:
Building Systems (Energy Management and Control System (EMCS), Building Security, Fire Protection and Building Automation)

Issue Statement:
The increasing size and complexity of buildings and the diversified capabilities of building management systems justify their installation. Although building management systems installed during the past had unsatisfactory results in reliability and start-up, the newer systems with better system architecture and improved components and software can make the system quite useful in plant operation, building energy reduction, space condition control, fire and security management.

Possible Applications:
The integration of energy management, HVAC system operations, HVAC system maintenance, data acquisition and management, fire and smoke management, security management, and system alarms.

Systems should have state-of-the-art sensors, distributed EMCS (with stand-alone field interface devices), direct digital controls, and conventional/adaptive algorithms for HVAC system controls.

Other System Integration Requirements:
1. The building management system should be a system integrating EMC, fire, and security.

2. The fan operation of the air handling systems, duct smoke dampers, outside air, and exhaust air dampers must be integrated with fire and smoke controls.

3. The architecture of the system should be similar to that shown on the following diagram. With this architecture the EMC does not interfere with the occupancy of the building at the building start-up or during down time. The fire system overrides the other two systems when necessary.

4. All three functions (EMC, fire, and security) should be stand-alone and have their own processors with individual functioned multiplexers connected to them. These satellite processors are integrated by a central processor which provides global control and data management.

5. The building management system must be secured from interference so that the fire and smoke controls remain functional at all times.

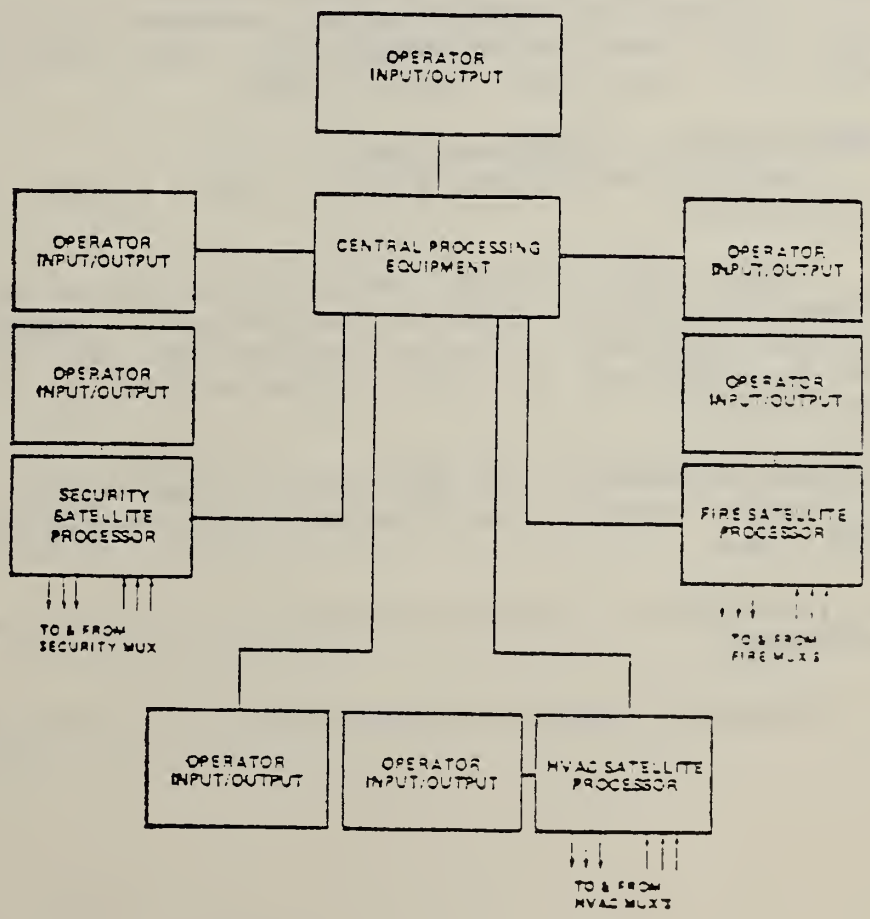
Constraints to Application:
1. Due to the complexity of the building management system, especially in the EMC part, delayed start-up, long time debugging, and malfunctioning during operation of the system may occur.

Action Necessary for Application Feasibility:
Specifications of the system must meet the following: subsystems must be compatible, the fire part of the system must meet applicable fire codes and/or national standards, and the system architecture be as described below. It is of the utmost importance that the building design A/E be thoroughly familiar with the latest developments in building management systems.

Points of Contact and/or Resources:
Building management systems are available from all large building control manufacturers and others.

James Kao, 301-921-3844, CBT/NBS

Suggested Architecture



FUNCTIONAL PROGRAMMING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

FUNCTIONAL PROGRAMMING STATEMENTS

PROGRAMMING ISSUE:
Advanced HVAC Systems and Control Strategies

Building Systems Involved:
Building Systems (HVAC)

Issue Statement:
Numerous HVAC subsystems and control strategies which have been proven to be energy efficient in private and public sectors applications have the potential to be used in proposed GSA buildings. These subsystems include heat recovery, heat pump systems, solar applications and thermal storage applications. The main deciding factor in their application to a building is economy and, to a lesser degree, the complexity of their operation. Variable air volume systems should be used whenever possible.

Possible Applications:
All the subsystems listed above have the potential for application.

Other System Integration Requirements:
1. No specific requirements, however, like other HVAC systems, they may need to be compatible with building architectural, structural and electrical systems.

Constraints to Application:
1. Cost of installing some of these systems may be a constraining factor.

2. Since the energy saving benefit can only be realized if these systems are operated as designed, and since the operation of these systems are more complex than for conventional systems, the availability of operating personnel may also be a constraining factor.

Actions Necessary for Application Feasibility:
1. Life cycle cost analysis should be performed in deciding their use.

2. Thorough training program should be given to the operating personnel.

3. Complete operating manual should be available.

4. An A/E firm with strong experience in HVAC system and control design should be selected.

Points of Contact and/or Resources:
J. Kao, 301-921-3844, CBT/NBS

FUNCTIONAL PROGRAMMING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

FUNCTIONAL PROGRAMMING STATEMENTS

PROGRAMMING ISSUE:
High Efficiency HVAC Equipment

Building Systems Involved:
Building Systems (HVAC)

Issue Statement:
With varying loads, the most efficient way for turbo-machinery to match the load and capacity is to vary the speed. The recent advancement in motor speed controls make speed control of some turbo-machinery used in HVAC systems more practical.

Possible Applications:
Air handling fans (as used for VAV systems), large chilled water pumps, and centrifugal refrigeration machines are possible candidates.

Other System Integration Requirements:
None, except with electrical systems in an ordinary design sense.

Constraints to Application:
1. The cost of variable speed motor controller may still be a factor preventing their use.

2. With variable speed motors the associated flow systems are inherently complex. Therefore, the design and operation of these systems are more complex.

Actions Necessary for Application Feasibility:
1. An engineering feasibility study, including a life cycle analysis, should be performed to analyze the economy and system stability.

2. Because of the increased complexity of the variable flow systems, designers with experience in variable speed equipment and systems should be chosen.

Points of Contact and/or Resources:
James Kao, 301-921-3844, CBT/NBS

FUNCTIONAL PROGRAMMING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

FUNCTIONAL PROGRAMMING STATEMENTS

PROGRAMMING ISSUE:
Building Operation Local Area Network

Building Systems Involved:
Building Systems (Communications)

Issue Statement:
In order to reduce redundancy and to establish compatibility between various building management and control systems (energy, fire safety, security, etc.), there is a need to share data produced by various building sensing and communicating devices and to simplify the associated communication wiring. One means for meeting the need for compatibility between management and control systems is through the use of a local area network (LAN) that supports both video and data transmission.

Possible Applications:
Consideration should be given to using a dual cable LAN connecting all sensing and communication devices used for building management and control. Possible LAN topologies to use are bus and partially connected mesh. Carrier Sense Multiple Access with Collision Detection (CSMA/CD) is the proposed communication protocol. Broadband coaxial cable employing frequency-division multiplexing is the proposed transmission medium.

Other System Integration Requirements:
1. The design of the LAN cabling system should prevent voltage hazards by contact between communication circuit elements and electrical system elements.

2. The LAN installation should minimize the chance for the occurrence and spread of fire and the generation and spread of smoke within a building.

3. Consideration should be given to cable insulation if it is located in spaces used for the transport of environmental air.

4. Adequate space to safely service LAN equipment and cabling should be provided throughout a building.

5. LAN cable and equipment weight should be considered in determining structural requirements where applicable.

6. Protection against the affects of high electromagnetic-radiated fields should be considered in the design and installation of the LAN.

7. LAN components are designed to operate within specified gaseous and particulate environmental limits.

Constraints to Application:
1. Although the IEEE 802 committee is working on standards for the data link and physical layers or network nodes, standards do not exist for the higher levels. As a result, when an installation requires that various devices be supported, the requisite multiplicity of interfaces at higher levels may not be possible.

2. When physical security or other requirements necessitate redundancy of the various functions performed by the network, costs may be prohibitive.

3. The cost of multiplexing associated with a dual loop coaxial cable may be significantly more than a transmission medium design predominantly composed of twisted pair copper cable.

Actions Necessary for Application Feasibility:
1. Procurer must determine LAN requirements:
   A. Required services
   B. Network traffic characteristics
   C. Reliability requirements
   D. Network growth
   E. Maintenance requirements

Points of Contact and/or Resources:
George E. Turner, 301-921-2140, CBT/NBS

Intelligent Building Information Systems, 1225 Jefferson Davis Highway, Arlington, VA 22202, 703-486-5627

Nathan Steele, President, SES, Inc., 7310 Ritchie Highway, Glen Burnie, MD 21061, 301-787-0745

Rosenthal, Robert, ed., **The Selection of Local Area Computer Networks**, Nat. Bur. Stand. (U.S.) Spec. Publ. 500-96, November 1982.

FUNCTIONAL PROGRAMMING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

FUNCTIONAL PROGRAMMING STATEMENTS

PROGRAMMING ISSUE:
Fire Safety

Building Systems Involved:
Building Systems (Fire Protection)

Issue Statement:
The object of this program statement is to develop an innovative fire safety approach that makes optimum use of the newest equipment and concepts while producing the maximum flexibility for other technologies and building uses.

The design and equipment concept presented herein proposes a major departure from current practices to provide safety with increased economy and the flexibility needed for a high technology application. The system described is an integrated arrangement presented as a package. If the package is used in part, instead of in its entirety, special studies will be necessary to determine the impact on the safety objectives of GSA. The system presented here, however, has sufficient depth of redundancy and safeguards that it is believed that the system will produce levels of safety that meet or exceed normal GSA objectives.

Attached is a draft of a completed fire safety section of a GSA project directive sheet. It was used as a convenient method in summarizing the items. Some of the key concepts include:

a. Structural system. The proposed approach eliminates the fire resistance and smoke tightness requirements for the structural deck, including the secondary bearing members for that deck. The approach also reduces in fire resistance for the principal bearing members from the traditional two hour fire resistance to a fire resistance of approximately 45 minutes. This will permit the design of a floor and ceiling system which can be readily accessible from both top and bottom and can carry all of the building utilities and simultaneously be used as either a supply or return air plenum. The elimination of fire resistance will also eliminate the need for either asbestos or asbestos substitute fireproofing material for the deck.

b. Sprinkler system. The concept involves a very special sprinkler arrangement that is critical to the intended fire safety. It is proposed that two separate sprinkler systems be provided, one covering the interstitial spaces between the floor deck and ceilings and the other covering the general area of the

building. It is further proposed these systems be provided with the newly developed fast response off-on sprinkler systems. The systems are to be separately integrated with building utility water supply with no valves that may shut down the sprinkler system without simultaneously taking essential utilities out of service. A diagram of a possible arrangement is included on page 34. This is to assure that the sprinklers are treated as an essential building utility and any shutdown results in prompt emergency-type repairs as would be applied to a loss of power or domestic water. Further, it is intended that each sprinkler system be tied to separate utilities so that one may be taken down without taking down the other. Water flow alarm is to be provided on each floor of each system with devices that both detect and measure flow.

c. Smoke control. The concept envisions a smoke control system zoned so that the floor involved in fire operates in a negative pressure mode and the rest of the building operates as a positive pressure. This is felt important in view of the deletion of requirements for smoke tightness of the floor decks.

d. Emergency communications and controls. The fire safety system visualizes using all of the various environmental sensors that the high technology application will bring as a means of fire detection. It is intended that the system be arranged to be "smart" so that the control center will have exact information on sources of detectors, levels of detectable quantities where analog arrangements are involved, and the amount and general location of any water flow taking place in sprinkler systems.

e. Furniture. It is proposed that consideration be given to special furniture control. The building control center software would be provided with the most current fire growth models and state-of-the-art capability to predict the potential impact of fire from rate of heat release data on the furniture involved. Such data would require some testing. The object being to maintain the furniture fire potentials low enough to prevent the possibility of flashover and to assure that the maximum fire be in the range of approximately 20 minutes in all spaces not designated and designed to handle special hazards.

Possible Applications:
The application of the type of system proposed covers the full scope of elements listed. The primary reasons for such application rest in the need to have flexible point-to-point access for wiring and utilities in a high technology building. Flexible accessibility can be provided from a full access floor and ceiling arrangement. In addition, the concept can provide maximum flexibility for a space utilization. There also is a possible cost saving due to the elimination of the heavy concrete slabs. The amount of the cost of the saving, however, depends upon the approaches taken in seismic protection.

Other System Integration Requirements:
1. This approach needs to be integrated with structural, mechanical, electrical, space assignment, and building management integration operation.

Constraints to Application:
1. This approach is considered to provide reasonable and effective fire safety. However, it is based on the professional judgment of the NBS engineers involved. Development of an analytical confirmation would involve a major research effort.

Actions Necessary for Appliication Feasibility:
1. Since this approach involves a deviation from the enumerated fire safety requirement contained in GSA handbooks, it is proposed under the criteria and procedures found in Chapter 1-2c of GSA Handbook, Building Fire Safety Criteria (PBS P 5920.9 CHGE 18, October 24, 1980).

2. The approach is sufficiently conservative so that the basic concept can be maintained even if some of the elements are found to be infeasible or otherwise undesired. Some elements are, however, critical to the concepts. Reevaluation will be essential if any changes are desired.

3. Coordination with almost all other design areas (structural, mechanical, electrical, architectural) is necessary.

4. Rate of heat release testing of typical furniture items will be necessary to implement the proposed furniture control aspects of the approach.

Points of Contact and/or Resources:
Harold E. Nelson, 301-921-3175, CFR/NBS

PROJECT DIRECTIVE - FIRESAFETY

SHEET 1 OF SHEETS

DS

PROJECT TITLE: High Tech Buildings

PROJECT NUMBER:

NUMBER AND STREET | CITY | STATE

SECTION I - STRUCTURAL FEATURES

STRUCTURAL FIRE RESISTANCE		General		Hazardous Areas	
WALLS	BEARING	≈ 45 min.		(Individual	
	NONBEARING	No Req.		enclosure	
COLUMNS				fire res. On	
BEAMS	PRIMARY	≈45 min.		case by case	
	SECONDARY	No Req.		basis)	
DECKS	FLOOR	No Req.*			
	ROOF	No Req.			

*Floor deck and ceiling are total access.

FIRE WALLS

None unless needed for exposure protection

FIRE PARTITIONS

Smoke tight on each floor (no fire resistance)

VERTICAL OPENINGS AND SHAFTS

Smoke tight (no fire resistance)

PANEL, CURTAIN, AND SPANDREL WALLS

Smoke stopped at floor deck

CEILINGS Free access--Void (interstitual) elec., plumbing, and other utilities. Also return air

FIRE STOPS

Smoke stops as necessary for smoke control system

FIRE DOORS

Auto. closing (by detection system)

DOOR HARDWARE

STAIRWELL DOORS

Auto closing with hold opens (easy access doors)

BUILDING EXITS

SMOKE CONTROL DOORS

Auto closing

OTHER - SPECIAL

UTILITIES/STRUCTURAL INTERFACE

Use interstitual, cable allowed in interstitual

ATTACHMENTS AND ADDITIONS

EXPOSURE PROTECTION

As needed

SECTION II - OCCUPANCY LIMITATIONS

Occupancy Classes per Fig. 3-1 PBS PS920.9	special furniture control based on energy load (Necessary computer model in building control computer)				
GROUP I					
GROUP II					
GROUP III					
GROUP IV					

GENERAL SERVICES ADMINISTRATION

GSA FORM 123-K PAGE 1 (REV. 5-7)

PROJECT DIRECTIVE - FIRESAFETY (Continued)

SHEET 2 OF SHEETS

DS

PROJECT TITLE

PROJECT NUMBER

NUMBER AND STREET | CITY | STATE

SECTION III - INTERIOR CONSTRUCTION AND ARRANGEMENT REQUIREMENTS

INTERIOR FINISH

Ceilings = Class A; Walls = Class A,B, or C*
Carpeting = No special requirements
*Combustibles added to energy load.

PARTITIONS

No special requirements*

*Any combustibles added to energy load

EXIT (OR OTHER EMERGENCY MOVEMENT) FACILITIES AND ARRANGEMENTS

Two stairs, sized on dynamic flow calculations. Stairs designed as accessable inviting and normally open. Smoke enclosure at time of fire.

	FLOOR(S)/SPACE	AREA (Sq. Ft.)	EXPECTED POPULATION	EXIT DESIGN POPULATION
BUILDING POPULATION				

SEGREGATION OF HAZARDS

Yes

PLACES OF CONFINEMENT

None Involved

SPECIAL AREAS	(Hazard, criticality, treatment, use)
TRASH ROOMS	1-hr., sprinklered
COMPUTERS	No special requirements
COMMUNICATIONS	
FLAMMABLE LIQUIDS	None involved
FLAMMABLE GASES	
ASSEMBLY AREAS	
CAFETERIAS	
RECORDS	Metal containers
HELIPORTS	

SECTION IV - MECHANICAL SYSTEMS

WATER SUPPLY

SOURCE(S): 2 source (2 sections of public supply) combination domestic fire system. No valves in fire protection portions or at junction with common source.

CAPACITY (Volume & pressure): By demand

TOTAL CAPACITY

OUTSIDE HYDRANTS AND MAINS

FIRE DEPARTMENT APPLIANCES

FIRE DEPARTMENT CONNECTIONS

INTERIOR HOSE CONNECTIONS

PROJECT DIRECTIVE - FIRESAFETY (Continued)

SHEET 3 OF SHEETS

DS

PROJECT TITLE

PROJECT NUMBER

NUMBER AND STREET | CITY | STATE

SECTION IV - MECHANICAL SYSTEMS (Continued)

AUTOMATIC SPRINKLER PROTECTION	SPACES TO BE PROTECTED	TYPE OF SYSTEM	DESIGN DENSITY
	Entire building including int[illegible]titual spaces.		
	Two separate systems from tw[illegible]urces (see diagram)		
	Fast response, off/on heads -	staggered	
	Plastic pipe acceptable		
	Supply is valveless		
	Water flow by floor, rate detected		

FIRE PROTECTION WATER DISTRIBUTION SYSTEM

Combined with domestic

SPECIAL EXTINGUISHING SYSTEMS

AIR CONDITIONING

No fire dampers

SMOKE CONTROL SYSTEMS

Zoned by floor (exhaust fire floor, supply only to rest of bldg.)

HEATING SYSTEMS

GAS PIPING AND APPLIANCES

INTERNAL COMBUSTION ENGINES

SECTION V - ELECTRICAL SYSTEMS AND EQUIPMENT

TRANSFORMERS	TYPE	LOCATION(S)	PROTECTION
PUBLIC UTILITY SUPPLIED			
IN CONTRACT			

OUTSIDE SUBSTATIONS AND TRANSFORMERS	TYPE	DISTANCE	PROTECTION

DISTRIBUTION SYSTEMS | UNDERFLOOR SYSTEM, S)

WIRE CLOSETS (AND OTHER VERTICAL PASSAGES)

LIGHTNING PROTECTION

EXIT LIGHTS Special, responds to fire information to flash and indicate safe path

EMERGENCY LIGHTING High and low elevation lights

EMERGENCY POWER		
	SOURCE	CAPACITY
	STARTING METHOD	TIME TO ON-LINE
	CIRCUITS AND EQUIPMENT ON EMERGENCY SYSTEM	

GENERAL SERVICES ADMINISTRATION GSA [illegible] 1234 PAGE 3 [illegible]

Elevators - Lobby smoke barrier, load cell to tell if evacuees are waiting.

PROJECT DIRECTIVE - FIRESAFETY (Continued) | SHEET 4 | OF SHEETS | DS

PROJECT TITLE | PROJECT NUMBER

NUMBER AND STREET | CITY | STATE

SECTION VI - EMERGENCY COMMUNICATIONS AND CONTROLS

EXPLAIN

INPUT

MANUAL: Phone, Data terminals, Seattle type pull boxes

AUTOMATIC: Building environmental controls, Smart smoke detectors, sprinkler water flow.

OUTPUT

AUTOMATIC

ALARMS IN BUILDING	TYPE	COVERAGE
	Voice	Total

EQUIPMENT CONTROLS: Smoke Control, pumps, etc.

SIGNALS OUT OF BUILDING	FIRE DEPARTMENT	OTHER (Specify)
	Yes	GSA Centers

OTHER (Specify):

MANUAL

ALARMS AND SIGNALS	EQUIPMENT CONTROLS
	Yes

OTHER (Specify):

STATUS

ANNUNCIATION	PRINTERS/RECORDERS
CTR in Control Center and on floors	
TROUBLE INDICATIONS	**REAL TIME SYSTEMS DATA**
Yes	Yes

OTHER (Specify): Real time fire involvement mapping

RELIABILITY FEATURES

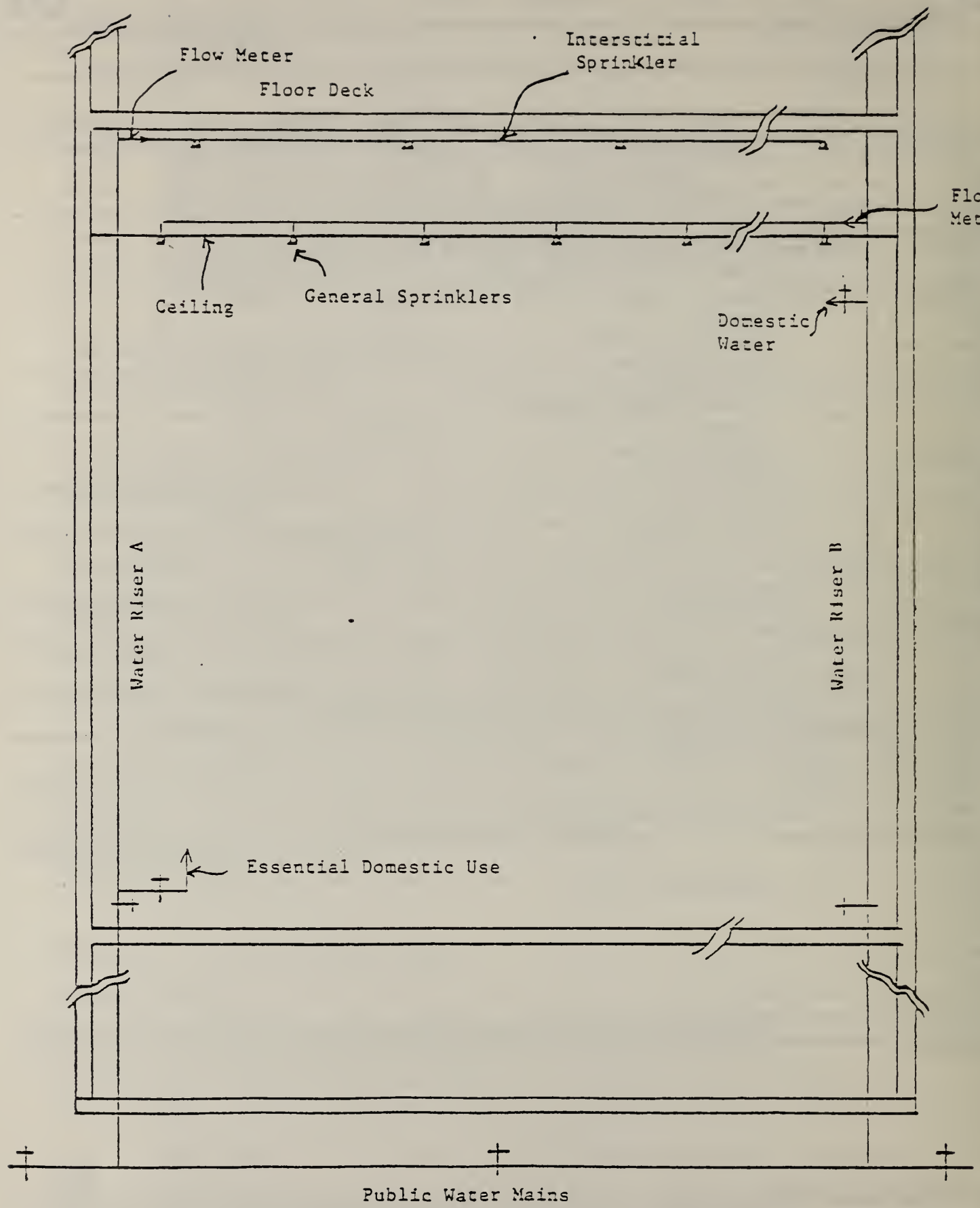
SECTION VII - EMERGENCY PLAN

EXPLAIN

SECTION VIII - COORDINATION WITH NONFIRESAFETY SYSTEMS

EXPLAIN

APPROVED	ACCIDENT AND FIRE PREVENTION DIVISION	DATE



RISER DIAGRAM OF PROPOSED WATER SUPPLY AND SPRINKLER ARRANGEMENT

3.0 RESEARCH NEEDS STATEMENTS

3.1 Introduction

The statement sheets contained herein are organized, to the extent possible, according to the categories of GSA design directives. The complete list of design directive categories can be found on page 3.

3.2 Statements

The statements are presented on the following 26 pages with each statement formatted separately in a standardized layout.

RNS-1

RESEARCH PLANNING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

RESEARCH NEEDS STATEMENT

RESEARCH ISSUE:
Evaluation of the Long-Term Performance of the Base Isolation System (BIS)

Building Systems Involved:
Structures implemented with BIS

Problem Statement:
The short-term performance of BIS has been simulated with numerical analysis as well as with shake table tests. It is known that the lateral design forces in the structural system can be greatly reduced (see attachment). Nevertheless, the long-term performance of BIS through the life span of the structure has to be evaluated and predicted to ensure structural safety in the event of strong earthquake excitations.

Technical Approach:
The approach will be:

1. identification of the qualified base isolation systems or devices

2. development of the methodology, including modeling (tests if needed)

3. preparation of the report(s).

Product:
Report(s) giving the results of the investigation.

Implementation:
Presentation of the results at conferences, in journal publications, and interaction with industry and research organizations.

Impact:
A rational basis will be developed for the evaluation of long-term performance of the BIS. The results will be useful to industry as well as to GSA in the planning and design of public office buildings located in high seismic index zones.

Milestones:
1. Identify the qualified base isolation systems/devices - 3 months.

2. Develop the methodology and models for the evaluation - 12 months.

3. Complete the report with recommendations - 15 months.

Attachment
Base Isolation System: Schemes and Effects

The concept of "base isolation" is to decouple the building structure from strong earthquake ground motions by a special scheme. With the scheme, transmissions of horizontal accelerations into the structure can be greatly reduced. A brief description of this modern device and its effects on the base isolated structure are given below.

1. The Schemes

There have been various schemes developed to fulfill the goal of isolating structures from strong ground motion. An effective scheme should have a damping mechanism and a device that provides rigidity under low load levels. One such scheme, recognized as a lead/rubber bearing system, is shown in Fig. 1 (Ref. 1). This scheme has been developed and used in New Zealand. There are various schemes being developed in other countries, e.g., Greece, Yugoslavia, South Africa, and France (Refs. 2-5). In this country, similar types of schemes have been developed and tested, see, Refs. 1 and 6.

The Effects on the Structural System

A fail-safe base isolation system has been designed for a five-story building at the University of California, Berkeley. The system was tested on a shaking table with different kinds of simulated earthquake motions. Frame accelerations for the El Centro input signal with different isolation conditions are shown in Fig. 2. As can be seen from the figure, the lateral design forces on the structures are reduced greatly. Details of this test can be found in Ref. 7.

References

1. Kelly, J.M., "Aseismic Base Isolation: Its History and Prospects," Joint Sealing and Bearing Systems for Concrete Structures, ACI Publication SP-70, Detroit, 1981.

2. Ikonomou, A.S., "The Earthquake Guarding System," Technica Chronica, Vol. 41, 1972.

3. Roth, A., et al., "Erbebenischerung im Bauen: Das Schulhaus `Heinrich Pestalozzi' in Skopje, Jugoslavien," Neuen Zurcher Zeitung Beilage Technik, 1970.

4. Plichon, C., "Hooped Rubber Bearings and Frictional Plates: A Modern Antiseismic Engineering Technique," Proceedings, Special Meeting on the Antiseismic Design of Nuclear Installations, Paris, France, 1975.

5. Delfosse, G.C., "The GAPEC System: A New Highly Effective Aseismic System," Proceedings, The Sixth World Conference on Earthquake Engineering, New Delhi, India, 1977.

6. **Engineering News-Record**, "Law Building Can Roll with Punch," August 4, 1983.

7. Kelly, J.M. and Hodder, S.B., "Experimental Study of Lead and Elastomeric Dampers for Base Isolation Systems in Laminated Neoprene Bearings," Bulletin of the New Zealand National Society for Earthquake Engineering, Vol. 15, No. 2, June, 1982.

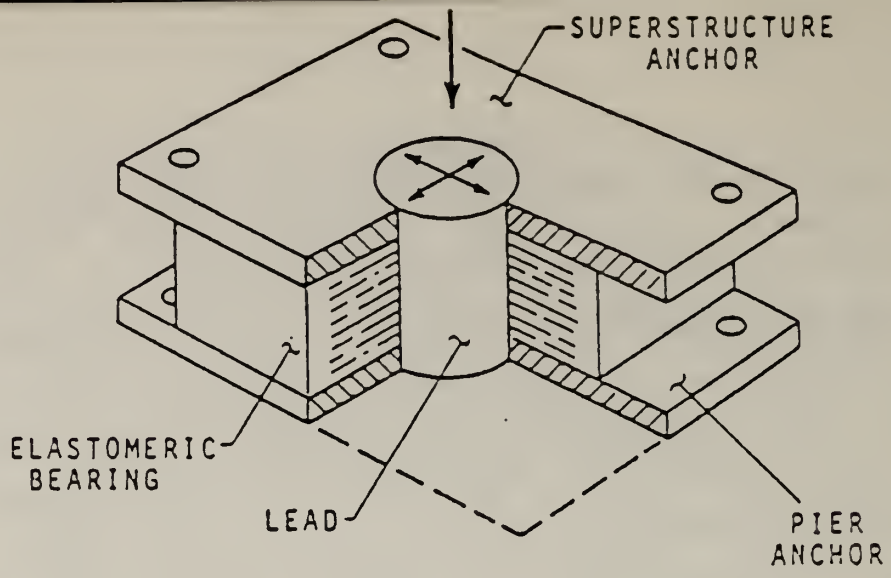


Figure 1. The lead/rubber bearing of the New Zealand System(Ref. 1).

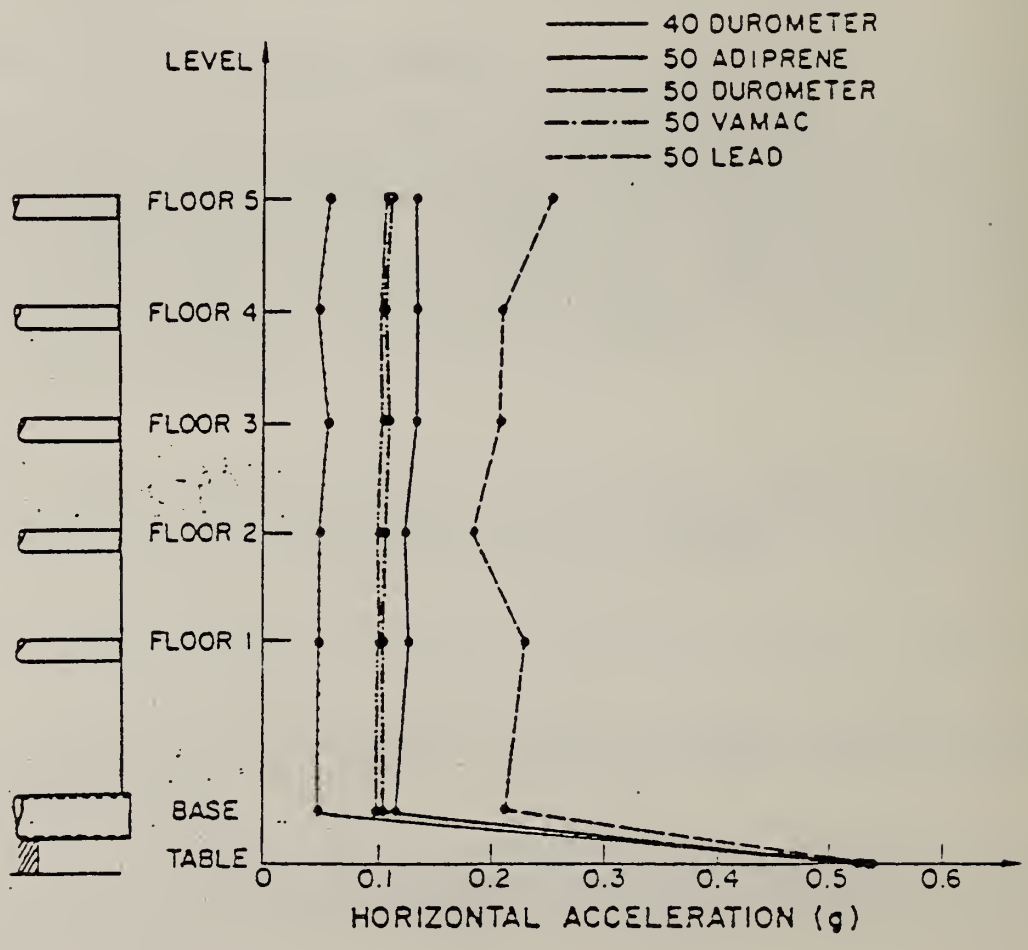


Figure 2. Frame accelerations for El Centro input signal with different isolation conditions(Ref. 7).

RNS-2

RESEARCH PLANNING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

RESEARCH NEEDS STATEMENT

RESEARCH ISSUE:
Optimum Dynamic Parameters for Structures with Absorber Systems

Building Systems Involved:
Structures including superstructures and absorber systems

Problem Statement:
Structural optimization has been investigated extensively in the past two decades. Optimization of dynamic systems with absorbers has considered primarily single degree-of-freedom systems and emphasized selection of absorber stiffness and damping. With recent developments in absorbers (e.g., the base isolation system) for mitigating strong earthquake-induced responses, structural optimization for multidegree-of-freedom systems should be studied. The basis for selecting the objective function should not be limited to only the weight of the building and more significant constraint conditions should be imposed (e.g., consideration should be given to the displacements of the mechanical and structural systems as well as to acceleration of the structural system).

Technical Approach:
1. Determine the significant parameters for the selected objective functions for various types of absorber systems.

2. Develop analytical models including the proper selection of the constraint conditions.

3. Evaluate sample problems based on the approach developed.

4. Provide guidance or criteria for the design process.

Product:
Report(s) presenting the results of the study.

Implementation:
Presentation of the results at conferences, in journal publications, etc. Results of this type of study may be helpful for an economical design of the current Long Beach, CA project.

Impact:
The approach and the results of the study will provide useful information to the building industry for the economical design of structures.

Milestones:

1. Determine the significant parameters for the selected objective function - 3 months.

2. Develop the model including the selection of the proper constraint conditions - 12 months.

3. Evaluate the structural systems (case studies) - 15 months.

4. Report with guidelines - 18 months.

RNS-3

RESEARCH PLANNING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

RESEARCH NEEDS STATEMENT

RESEARCH ISSUE:
Building diagnostics

Building Systems Involved:
Multiple

Problem Statement:
Problems of shortcomings in the performance of building materials are frequently not detected until considerable damage has occurred. An example of this is a leaking roof. With recent advances in nondestructive evaluation technology, it may be feasible to incorporate NDE tools into buildings to provide diagnostic data.

Technical Approach:
1. Develop criteria for NDE and other tools which may aid in diagnosing problems or impending problems.

2. Provide the technical basis for use of building diagnostics through laboratory and field data.

Product:
Research reports presenting the results of the studies and including criteria for building diagnostics will be produced.

Implementation:
Through publications, presentations to the building community and interactions with standards setting organizations.

Impact:
1. Reduce maintenance costs.

2. Improve building performance.

Milestones:
1. Analyze building diagnostic needs - 3 months.

2. Identify promising diagnostic methods - 9 months.

3. Laboratory and field data collection - 12 months.

4. Report on criteria for selecting useful diagnostic methods - 36 months.

RNS-4

RESEARCH PLANNING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

RESEARCH NEEDS STATEMENT

RESEARCH ISSUE:
Expert systems for selecting coatings and paints based on consideration of protective requirements and weather conditions

Building Systems Involved:
Building Envelope

Problem Statement:
Often sufficient information is not readily available on materials performance and durability to make decisions on selecting durable coatings and paints materials. Expert systems can be potentially effective in making high quality decisions in the selection of durable materials. Expert systems are computer programs which mimic the reasoning of human experts.

Technical Approach:
The knowledge of experts on the performance and durability of coatings and paints will be recorded in the form of a knowledge base and heuristic rules. They will be encoded in a computer program which can give recommendations at or near the level of human experts thus facilitating and improving the selection process.

Product:
An expert system for selecting coatings and paints will be developed and its usefulness demonstrated.

Implementation:
The expert system will be implemented through its use in selecting coatings and paints.

Impact:
Development and use of the expert system will result in improved selection of coatings and paints, thereby reducing expenses and problems caused by poor material performance.

Milestones:
1. Development of a knowledge base and heuristic rules - 36 months.

2. Development of an expert system - 48 months.

RNS-5

RESEARCH PLANNING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

RESEARCH NEEDS STATEMENT

RESEARCH ISSUE:
Expert system for selecting fenestration/envelope based on consideration of thermal and acoustic performance of window systems

Building Systems Involved:
Fenestration/Envelope

Problem Statement:
The thermal integrity of glazing may be achieved without any significant increase in the degree of noise insulation. However, the thermal performance and acoustic characteristics of window systems may be integrated to achieve both energy efficiency and noise isolation requirements. Expert systems have the potential for effectively assisting in making high quality decisions relative to the selection and design of fenestration systems.

Technical Approach:
The knowledge of experts in making decisions about thermal and acoustic design criteria for glazing will be recorded in the form of a knowledge base and an heuristic approach for decision making developed.

Product:
An expert system for computer-aided thermal/acoustical design of fenestration systems will be produced.

Implementation:
The system will be implemented through its use in selection of fenestration systems having project specific compatible and complementary acoustical and thermal performance.

Impact:
Development and use of an expert system for the selection and design of fenestration systems will result in cost effective thermal and acoustical performance of fenestration.

Milestones:
1. Develop knowledge base and heuristic rules - 36 months.

2. Develop expert system - 48 months.

RNS-6

RESEARCH PLANNING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

RESEARCH NEEDS STATEMENT

RESEARCH ISSUE:
Glazing and antireflective coatings

Building Systems Involved:
Windows

Problem Statement:
Significant heat gains can be obtained through effective use of southern exposure windows. Glass, combined with antireflective materials or coatings, has performed well according to manufacturers. But other glazing materials, such as plastics, could offer cost, weight and optical benefits over glass and could be formed with antireflective materials (as opposed to the add-on materials used with glass). A barrier to their use is lack of test methods to help assure durability.

Technical Approach:
The approach would involve 1) identifying performance requirements, 2) developing test methods, based upon laboratory studies, to measure performance according to the requirements, and 3) assisting in implementing the use of the methods by interactions with the building community and standards setting organizations.

Product:
Report(s) presenting the results and the proposed test methods will be produced.

Implementation:
Presentations at conferences, publication of results, interaction with standards setting organizations.

Impact:
The test methods will help provide for increased use of substitute materials.

Milestones:
1. Identify performance requirements - 3 months.

2. Report with preliminary test methods - 12 months.

3. Report with final test methods - 30 months.

RNS-7

RESEARCH PLANNING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

RESEARCH NEEDS STATEMENT

RESEARCH ISSUE:
Expert system for selecting roofing materials based on consideration of design and weather conditions. This system will be a prototype system which demonstrates the benefits of developing and using expert systems.

Building Systems Involved:
Roofing Systems

Problem Statement:
Often sufficient information is not readily available on materials performance and durability to make decisions on selecting durable roofing materials. Expert systems can be potentially effective in making high quality decisions in the selection of durable roofing materials. Expert systems are computer programs which mimic the reasoning of human experts.

Technical Approach:
The knowledge of experts on the performance and durability of roofing materials will be recorded in the form of a knowledge base and heuristic rules. They will be encoded in a computer program which can give recommendations at or near the level of human experts thus facilitating and improving the selection process.

Product:
An expert system for selecting roofing materials will be developed and its usefulness demonstrated.

Implementation:
The expert system will be implemented through its use in selecting roofing materials.

Impact:
Development and use of an expert system will result in the improved selection of roofing materials, thereby reducing expenses and problems caused by poor material performance.

Milestones:
1. Development of a knowledge base and heuristic rules - 36 months.

2. Development of an expert system - 48 months.

RNS-8

RESEARCH PLANNING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

RESEARCH NEEDS STATEMENT

RESEARCH ISSUE:
Database on material performance

Building Systems Involved:
Major building materials, e.g., coatings and paints, roofing materials, concrete and masonry, and metals exposed to weathering

Problem Statement:
Well-documented information on the in-service performances of building materials is rarely available. The availability of such information would aid in the selection of more cost-effective materials. Computer databases need to be established to store the information, thereby making it available to those responsible for making decisions on material selection.

Technical Approach:
1. Identify the properties, characteristics, and features of building materials which, when documented, will indicate the performances of specific building materials.

2. Develop recommendations on evaluation methods.

3. Select and format database systems.

Product:
A methodology for establishing a database on the performances of building materials will be developed.

Implementation:
The methodology will be implemented by using it to document the performance of major building materials in "high-tech" Federal office buildings.

Impact:
A significant cost savings will result because use of the database will assist in selecting materials of proven performance. Also, the database can aid in the making of decisions regarding whether a material should be repaired or replaced.

Milestones:
1. Identification of properties, characteristics and features of building materials which should be documented - 3 months.

2. Develop recommendations on material evaluation methods - 6 months.

3. Select and format database - 12 months.

RNS-9

RESEARCH PLANNING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

RESEARCH NEEDS STATEMENT

RESEARCH ISSUE:
Substitute materials for building materials containing asbestos

Building Systems Involved:
Flooring and Building Envelope

Problem Statement:
Asbestos fibers have been incorporated in a variety of building materials. The literature contains extensive documentation addressing potential health effects associated with exposure to airborne asbestos fibers. (Since NBS has no medical expertise, there has been no attempt to evaluate this documentation.) Some of the products containing asbestos are given in the attached table. If properly identified and selected, substitute materials can be used in building construction. The substitute materials should be the technical equivalent of the building materials containing asbestos.

Technical Approach:
1. Identify asbestos-containing building materials used in the construction of GSA buildings.

2. Establish performance requirements for substitute materials.

3. Develop recommendations for selecting substitute materials based on performance requirements.

Product:
Report giving recommendations for selecting substitute building materials will be developed.

Implementation:
Results of the study will be published.

Impact:
A technical basis will be developed to assist GSA in selecting building materials which do not contain asbestos.

Milestones:
1. Identify asbestos-containing building materials used in GSA buildings - 6 months.

2. Develop performance requirements for substitute materials - 12 months.

3. Report giving recommendations for selecting substitute materials - 18 months.

Taken from "Guidelines for Assessment and Abatement of Asbestos-Containing Materials in Buildings," NBSIR 83-2688, 1983

Table 1.3 Nonfriable Matrix Bonded Composite Products Containing Asbestos[1/,2/]

Subdivision	Generic Name	Asbestos (% by weight)	Dates of Use	Binder/Sizing
Cementitious Products	extrusions	8	1965-1977	portland cement
	panels:			
	corrugated	20-45	1930-present	portland cement
	flat	40-50	1930-present	portland cement
	flexible	30-50	1930-present	portland cement
	flexible perforated	30-50	1930-present	portland cement
	laminated (outer surface)	35-50	1930-present	portland cement
	roof tiles	30-20	1930-present	portland cement
	clapboard & shingles			
	clapboard	12-25	1944-1945	portland cement
	siding shingles	12-14	unknown-present	portland cement
	roofing shingles	32-20	unknown-present	portland cement
	pipe	20-15	1935-present	portland cement
Paper Products	corrugated:			
	high temperature	90	1935-present	sodium silicate
	moderate temperature	70-35	1910-present	starch
	indented	98	1935-present	cotton and organic binder
	millboard	85-85	1925-present	starch, lime, clay
Roofing Felts	smooth surface	10-15	1910-present	asphalt
	mineral surface	10-15	1910-present	asphalt
	shingles	1	1971-1974	asphalt
	pipeline	10	1920-present	asphalt

1/ Table was taken from reference [5].

2/ The Navy prohibits use of these products when acceptable nonasbestos-containing substitutes have been identified.

Table 1.3 (continued)

Subdivision	Generic Name	Asbestos (% by weight)	Dates of Use	Binder/Sizing
Asbestos-Containing Compounds	caulking putties	30	1930-present	linseed oil
	adhesive (cold applied)	5-25	1945-present	asphalt
	joint compound		1945-1975	asphalt
	roofing asphalt	5	unknown-present	asphalt
	mastics	5-25	1920-present	asphalt
	asphalt tile cement	13-25	1959-present	asphalt
	roof putty	10-25	unknown-present	asphalt
	plaster/stucco	2-10	unknown-present	portland cement
	spackles	3-5	1930-1975	starch, casein, synthetic resins
	sealants fire/water	50-55	1935-present	caster oil or polyisobutylene
	cement, insulation	20-100	1900-1973	clay
	cement, finishing	55	1920-1973	clay
	cement, magnesia	15	1926-1950	magnesium carbonate
Asbestos Ebony Products		50	1930-present	portland cement
Flooring Tile and Sheet Goods	vinyl/asbestos tile	21	1950-present	poly(vinyl)-chloride
	asphalt/asbestos tile	26-33	1920-present	asphalt
	sheet goods/ resilient sheet	30	1950-present	dry oils
Wallcovering	vinyl wallpaper	6-8	unknown-present	--
Paints and Coatings	roof coating	4-7	1900-present	asphalt
	air tight	15	1940-present	asphalt

RNS-10

RESEARCH PLANNING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

RESEARCH NEEDS STATEMENT

RESEARCH NEEDS:
Teleconferencing: acoustic criteria

Building Systems Involved:
Teleconferencing Facilities

Problem Statement:
Teleconferencing facilities offer the potential to increase building users' productivity by allowing direct communication without the need to assemble staff at one location at a scheduled time. Moreover, the success of teleconferencing is dependent upon adequate acoustic environment in the conference room. Acoustic criteria for teleconferencing rooms must be developed and integrated with teleconferencing system design.

Technical Approach:
Develop acoustic criteria for teleconferencing facilities based upon a literature search and a review of existing facilities/systems characteristics.

Product:
Acoustic criteria for the design of teleconferencing rooms will be developed.

Implementation:
The criteria will be implemented through the design of teleconferencing facilities, publications, presentation to the building community and interaction with standard setting organizations.

Milestones:
Develop acoustic criteria for the conferencing facilities - 36 months.

RNS-11

RESEARCH PLANNING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

RESEARCH NEEDS STATEMENT

RESEARCH ISSUE:
HVAC system data base and operating manual

Building Systems Involved:
HVAC (including EMCS)

Problem Statement:
There are many variables which change a building's thermal load. These include weather variables (temperature, humidity, solar, wind, ground altitude, etc.), building construction (mass, thermal insulation, location, orientation, geometrical arrangements, etc.), and user factors (usage, loading, loading variations, etc.). When the thermal load variations are met with HVAC system changes (temperature, flow rate, system status, system efficiency, etc.), it is very difficult for the building operators to tune the systems to their optimum conditions (in terms of energy consumption, equipment maintenance, space conditions, etc.). Therefore, an operating manual to optimize HVAC system performance is needed.

Technical Approach:
A simplified energy program, such as the Carrier E20-II, will be used to calculate building energy consumption. The building construction and the weather variables will be varied to combine with the HVAC control strategies to generate the building performance data base.

The building performance data base will be used to develop a manual for the HVAC system operating personnel. The manual will emphasize HVAC system operations and control setting adjustments to achieve optimum energy performance of buildings.

Product:
A manual for operating personnel on optimizing HVAC system performance will be produced.

Implementation:
The manual will use simple charts and illustrations to be easily used by HVAC system operating personnel. It may be used for GSA buildings and other government and private buildings.

Impact:
Better space conditions and more energy efficient HVAC operations will result from the development of this manual.

Milestones:

1. Generate the building performance data base - 6 months.

2. Manual for HVAC system operating personnel - 12 months.

RNS-12

RESEARCH PLANNING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

RESEARCH NEEDS STATEMENT

RESEARCH ISSUE:
Improve variable air volume (VAV) system controls

Building System Involved:
HVAC Systems

Problem Statement:
The VAV system has been generally recognized as the most energy efficient air handling system. In actual installation, there are numerous problems associated with the system, such as not meeting zone load variations, poor system pressure responses, noise, and improper space pressure balance. Although some of these problems may be traced to inadequate engineering during design and construction, guidelines for VAV system design centered around system controls will assist the designers in simplifying the design procedures and improve the system performance.

Technical Approach:
VAV systems will be categorized by the building load characteristics, air distribution system arrangements and VAV system types. In each group, fan pressure variations in the entire duct system, as well as the pressure in the building, will be investigated in detail. Guidelines of fan systems and space pressure controls will be developed for each group.

Product:
A report on improving VAV system controls will be produced.

Implementation:
The guideline on improving VAV system controls will be available to GSA design engineers and A/E firms engaging in HVAC system designs. The obstacle of selecting VAV systems will be lessened.

Impact:
More acceptance of VAV systems can be expected and better space environment control can be achieved.

Milestones:
1. Investigate possible VAV systems by buildings - 3 months.

2. Generate pressure data - 6 months.

3. Report on improving VAV system controls - 12 months.

RNS-13

RESEARCH PLANNING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

RESEARCH NEEDS STATEMENT

RESEARCH ISSUE:
Outside air management and indoor air quality

Building Systems Involved:
HVAC (including EMCS), Fire Protection

Problem Statement:
A large part of building energy consumption is for treating the outside air which is delivered to occupied spaces as fresh air. A detector, such as for CO_2, which senses the occupant load may be used to control the amount of outside air to be admitted to the building. Thus, a large amount of energy may be saved.

Technical Approach:
1. A reliable occupant sensing system (CO_2 or other parameters) will be researched and developed.

2. The method and logic of integrating the sensing system into the HVAC control system and/or building management system will be developed. Included will be locations of sensors, damper operations to comply with occupant and building needs, integration with other EMC algorithms (such as economy cycles), and fire/smoke management.

Product:
A report on outside air management using occupant-related sensors will be produced.

Implementation:
The results of this investigation will enable GSA to modify its policy on outside air management. The building outside air management may also be implemented through ASHRAE and building code authorities.

Impact:
Considerable amount of building energy use may be eliminated.

Milestones:
1. Investigate occupant sensing system - 6 months.

2. Develop the logic and method for implementing control systems - 9 months.

3. Report results - 12 months.

RNS-14

RESEARCH PLANNING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

RESEARCH NEEDS STATEMENT

RESEARCH ISSUE:
Postoccupancy evaluation of computer-based building operating systems

Building Systems Involved:
Computer-Based Systems

Problem Statement:
Many computer-based systems are now in place in Federal and private sector buildings, but no systematic effort has been made to evaluate the potential wealth of experience that has been accumulated by building users. This experience would constitute a major resource for those making design decisions concerning new buildings and the retrofitting of the existing building stock.

Technical Approach:
A sample of buildings, building systems, and subsystems should be examined by an appropriate interdisciplinary research team to determine what "has worked" and what "has not worked" and why. The systems examined should encompass energy management, operational, safety and security and the integration of these various systems. Interviews should be conducted with users, designers and facility managers, and appropriate physical measurements should be made to quantify findings.

Product:
A handbook will be produced, suggesting approaches for the design and implementation of computer-based building systems and subsystems.

Implementation:
The handbook will be distributed to GSA/PBS personnel for further distribution to the design community serving the Federal Government.

Impact:
More effective use will be made of the information available concerning computer-based systems in buildings -- resulting in higher productivity and cost savings to the Federal Government.

Milestones:
1. Development of detailed research plan - 12 months.

2. Completion of handbook - 36 months.

RNS-15

RESEARCH PLANNING FOR HIGH TECHNOLOGY FEDERAL OFFICE BUILDINGS

RESEARCH NEEDS STATEMENT

RESEARCH ISSUE:
Simulation of a building circulation system to be used as a support utility to the fire safety and security systems

Building Systems Involved:
Fire Safety and Security

Problem Statement:
Tactical responses to emergency incidents are generally infrequent throughout the operating life of most buildings. As a result, the building operators and guard force do not have an opportunity to quickly and inexpensively explore the many types of responses that can be employed for various emergency incidents. Therefore, there is a need for an analytical tool that can quickly develop and communicate tactical responses to a great many types and severities of fire safety and security incidents in a building operator training mode.

Technical Approach:
1. Determine the extents of the fire safety and security systems (detection and communication devices and response strategy).

2. Develop a model of the facility of concern using a high level simulation language.

3. Validate and test the model.

4. Document the model and train building operators in its use.

Product:
1. A fire safety and security incident simulation and response recommendation model.

2. Model documentation.

Implementation:
The model will be installed as an on-line utility for the building fire, security, and/or integrated management system.

Impact:
Provides fire safety and security personnel with the means to describe an incident and receive optional tactical responses that may be employed.

Milestones:

1. Develop a modeling approach - 9 months.

2. Validate and test the model - 12 months.

3. Document and report the model - 24 months.

4.0 SUMMARY

This report has briefly explained the high-tech design approach being developed by PBS. In addition, the objective and scope of the potential NBS technical support to PBS have been described. The results of the NBS support were presented in the form of functional programming statements and research needs statements.

The functional programming statements were organized according to the categories of the GSA design directives found in design programs. Although no statements were developed for categories one, two and five (see page 3), seven statements were developed for building infrastructure, three statements were developed for building enclosures, and seven statements were developed for building systems.

The research needs statements were also organized to the extent possible, according to the design directives categories. No statements were developed for categories one and two, however, two statements were developed for building infrastructure, six statements were developed for building enclosures, one statement was developed for space allocation, and five statements were developed for building systems.

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10. SUPPLEMENTARY NOTES

__ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

The General Services Administration (GSA), Public Buildings Service (PBS) is engaged in the development of a new design approach for Federal buildings referred to as "high technology" (high-tech). The approach emphasizes the consideration of new, emerging and innovative uses of existing technology applications in building system design, construction and operation. In order to develop design programs for high-tech building projects, there is a need for PBS to identify programming issues that address new, emerging and innovative uses of existing technologies, and there is a need for PBS to develop a plan of research in support of its high-tech design approach. Under a memorandum of understanding with GSA, the National Bureau of Standards' (NBS), Center for Building Technology (CBT) assisted PBS by providing technical support through the development of programming issues and research needs for high-tech office buildings. The programming issues and research needs developed by NBS represent the identification of programming and research topics to be considered by GSA during its programming and research planning activities.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only the first letter of proper names; and separate key words by semicolons)
architectural programming; building programming; research planning

13. AVAILABILITY

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