NISTIR 4801

Office Workspace for Tomorrow DOT Workshop (November 13-14, 1991) Contributed Papers

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Abstract

This report contains a series of papers prepared for a Department of Transportation (DOT) workshop conducted November 13 and 14, 1991. The workshop was held to assist the Department in planning a new Headquarters Building. Eighteen experts, representing various disciplines associated with building design and use participated in a workshop, and prepared papers prior to the meeting. The present report contains these papers. A followon report (NISTIR 4802), will describe the workshop proceedings.

Workshop presentations covered the following topics: workstation design process, programming tradeoffs, workstation standards and criteria, ergonomics, human resource issues, leading edge workstation design, impact of new technologies on office and workstation design, lighting, environmental technologies, information and data systems, building design, facility management, forecasts of the office-of-the-future. These issues were discussed by panel members, and with representatives from the Department of Transportation and other federal agencies.

Keywords:

Architectural programming, building design, building environment systems, design module, furniture, information systems, lighting, office-of-the-future, office technologies, telecommunications, workstation design, workstation standards

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Disclaimer

Many workshop participants alluded to commercial products and systems used in buildings in their submitted papers and during the workshop proceedings. The identification of these products in this report does not constitute an endorsement by the National Institute of Standards and Technology NIST), the Department of Commerce, nor the Department of Transportation.

Acknowledgements

Planning, organizing, and conducting the workshop was made possible by many people. I am grateful to the staff of the Headquarters Building Acquisition Project Office, Office of the Secretary, Department of Transportation for the assistance that they provided, and the encouragement given to me for all aspects of this project. Particular thanks is due to Melissa Allen and Angelo Picillo for initiating this activity and providing valuable suggestions during the entire course of this activity. Kathy Baxter deserves special mention because of her valuable hands-on contributions to all aspects of this project.

Special thanks are due to Marshall Graham for assisting in the detailed planning of the workshop and arranging for the participation of several key participants. The exemplary contribution of Kreon Cyrus, the workshop moderator, also is acknowledged.

The logistics of organizing the workshop, preparing materials, and coordinating with participants, required a major effort. Jennifer Wright of NIST accomplished all of these tasks with great professionalism and her contribution is gratefully acknowledged.

Above all, I want to thank all of the workshop participants for sharing their expertise by means of prepared papers, workshop presentations, and the lively discussions that formed a valuable part of the workshop activities.

Preface

The November 13-14 workshop was conducted at the request of the Headquarters Building Acquisition Project Office, Office of the Secretary, Department of Transportation (DOT). The DOT is in the process of planning a new Headquarters Building to house the senior staff of the Department. With the completion of an initial programming activity, identifying the staff members to be housed in the new building and estimating the space required to accommodate these employees, they determined the need to obtain more information on a variety of issues, before proceeding with some of their detailed planning activities. In particular, they wanted to foster an open discussion on trends in office design, office system technology, systems furniture design, workforce composition, and workgroup interactions. Another important topic to be addressed was the influence of workstation standards on the building module, and conversely, the influence of the building module on workstation standards. The tradeoffs associated with each approach were to be explored.

The workshop was not intended to be a problem-solving session. Rather, it was meant to generate discussions of issues which have an impact on the design considerations for the new Department of Transportation Headquarters Building project.

In preparation for the workshop, participants were asked to prepare papers on a variety of topics to be addressed during the meeting. The present report consists of a compilation of these papers. A follow-on report (NISTIR 4802), will consist of an edited transcript of the workshop proceedings, including discussions among participants and question-and-answer sessions among workshop participants and attendees.

Introduction

Designing a modern, well equipped office building requires the expertise of many diverse disciplines. The workshop was designed to obtain the views represented from as many of these disciplinary areas as feasible in a two day session.

The first topic addressed is the 'design process'. Tim White discusses programming tradeoffs associated with design decisions made on the basis of workstation standards or on building modules. Marshall Graham describes the use of forecasting tools, including computer modeling, to analyze organizational functions, space requirements, workstations, and variations in module and workstation sizes.

Workstation standards and criteria are then examined from the standpoint of the end-user. Alan Hedge describes the ergonomic considerations of workstation design, especially environmental considerations of thermal comfort, air quality, and individual control systems. Michael Hooker deals with an environmental issue that has been one of the greatest sources of complaint among building occupants - lighting. Cecil Williams then describes the special needs of the future workforce, focusing on issues such as accommodating the aged, minority groups, the disabled, and the need for special purpose spaces in buildings such as child-care and exercise facilities.

Lee Bloomquist then forecasts the evolution of workstation design from the furnishings used today to the likely configurations to be available when the DOT headquarters will be ready for occupancy; estimated for the year 2000.

The impact of new technologies on office and workstation design is the next subject to be treated. Peter Valentine describes new voice and communication systems and video conferencing, while Herbert Rosenheck discusses information and data systems, and networking, today and in the future. Vivian Loftness presents an overview of new technologies and design approaches in the United States, the United Kingdom, France, Germany, and Japan. Finally, Valentine Lehr examines environmental technologies from an engineering practices viewpoint, stressing feasibility issues.

Building design is then examined from an architectural standpoint. Robert Cioppa describes the evolution of the office and the impact of technology on present and future office and building design.

The next issue addressed is the experience of the private and public sectors in designing high technology office buildings. What worked and what didn't work, and why? Stephen Binder summarizes his experiences at Citibank, with corporate responsibilities for real property management. Similarly, Edward Toran discusses the impact of technology on the design of offices, and facility management issues at Metropolitan Life. Martin Duby then describes his work at the General Accounting Office (GAO), which is in the process of modernizing their building, housing approximately 5,000 people, primarily professionals. The paper by Arthur Rubin, describes the design process and experiences of TRW with their new headquarters building, one of the most technologically advanced office buildings in the world.

The last group of papers forecast the future of the 'electronic office'. Don Avedon describes new information technologies and their implications for workstation and office design. Gilbert DeCouvreur examines human resource issues that will impact how office work will be performed in the future. Amy Wohl forecasts information technology developments and their likely impact on future workstations and offices. Finally, Duncan Sutherland provides a unique view of the 'office of the future'.

MANAGING THE RELATIONSHIPS BETWEEN BUILDING SHELL DESIGN AND WORKSTATION PLANNING

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1. Purpose

The purpose of this paper is to briefly outline some of the significant areas of interaction between the design of the building shell and the selection and layout of open-office workstations.

Specifically, the paper will explore the tradeoffs associated with optimizing workstation selection and layout versus optimizing the design of the building shell. The particular charge to the author was to discuss "Programming Tradeoffs: Design Decisions Starting with Workstation Standards; Design Decisions Starting with Building Planning Modules." The author has expanded the discussion to include other kinds of interactions and tradeoffs between the workstations and the building shell.

2. Approach

The tradeoff question will be explored by first outlining some of the criteria typically associated with good building shell design and with good workstation planning. Then areas of potential conflict between the two sets of criteria will be pointed out, that is, it will be shown how building and workstations may meet fewer of their criteria if they are placed in a subordinated role during programming and design. Finally, the importance of anticipating workstation layout during building planning and the importance of workstation adaptation to the building design will be discussed, recognizing that although programming moves from user needs to workstation specifications to building performance requirements, project delivery typically moves from building shell design to workstation layout to user adaptation to workstation.

3. Building and Workstation Criteria

We begin our discussion by outlining some of the criteria normally associated with good building shell design and good workstation design. What do the building and the workstations "prefer" and what kinds of logic tends to apply to each in terms of maximizing economy, efficiency and functionality? The brevity of this presentation requires that the discussion be necessarily generalized and deal with tendencies rather than with the specifics of any particular project.

3.1 Building Criteria

While there is no doubt that the primary role of the building is to support the occupants in the performance of their activities, there are also criteria that have to do with the success of the building in its own right. The list below includes some of the planning principles for producing an economical and efficient building shell design. The list order is not meant to imply priority.

- Maximum building volume on the site, given site and code constraints and programmatic requirements.

- Maximum usable floor area, given the building enclosure.

- Maximum square footage on each building floor to reduce vertical circulation and maximize horizontal adjacencies and floor area for the given building height.

- Minimum reasonable plenum depth and floor-to-floor height to achieve maximum floor area per building height and building skin area.

- Simple exterior wall configuration to reduce total building skin area for construction economy and energy conservation.

- Modularity of exterior skin and window treatment.

- Sizing and positioning of exterior windows in response to solar orientation and views from inside.

- Dimensional continuity between structural bays, ceiling grid and exterior wall pattern.

- Regular structural bays for construction economy.

- Structural spans that respond to the economics of the column and beam material.

- Regular ceiling grid that registers with the structural system and exterior wall module.

- Pattern of ceiling lighting, air grilles, speakers and fire sprinklers that meets performance standards and respects the ceiling grid system.

- Ceiling plenum that allows the various ceiling-related systems to meet performance standards without undue routing and placement complication.

- Clear, simple circulation paths that provide maximum flexibility for space layout and that connect functionally-related areas and vertical circulation.

- Minimum square footage devoted to circulation in order to maximize the net-to-gross efficiency of the building.

- Collection of stairs, elevators and mechanical shafts into cores for construction economy, user convenience and workstation layout flexibility.

- Minimum core area in order to maximize the net-to-gross efficiency of the building.

- Interior wall partitions that are independent of the structural span pattern and yet that register with the ceiling grid.

- Wall partition locations that maximize the flexibility of the workstation planning.

3.2 Workstation Criteria

This list outlines some of the principles of workstation planning that promote user-responsiveness, economy and functionality. Again, there is no hierarchy implied by the order of criteria in the list.

- Each workstation size and configuration responsive to user attributes, activities and required furniture and equipment.

- Type and position of furniture and equipment convenient for user.

- Comfortable chair, surface heights, sight lines and reach patterns.

- Appropriate technology and ambient environment provided at each workstation.

- Adequate filing and storage space.

- Appropriate level of audial and visual privacy.

- Freedom from interruption, distraction and debilitating conditions.

- Appropriate level of security.

- Access to exterior views and natural light.

- Adjacency to functionally-related areas.

- Simple direct routes to destinations and to vertical circulation.

- Contiguous pattern of organizationally-related workstations.

- Identity for each workstation and for significant workstation groupings.

- Egalitarian treatment of areas by windows and at building corners.

- Minimal interior building obstructions that would impede workstation layout flexibility and hinder individual workstation integrity.

- Maximum opportunity to configure workstation patterns in the most functional manner.

- Avoidance of disruptive pathways through workstation layout.

- Relief from monotonous workstation layout patterns.

- Adequate and well-placed shared space.

- Ability to change individual workstation type, size and configuration over time.

- Ability to alter functional zone locations and workstation layout over time.

4. Areas of potential conflict between building and workstation criteria

Next, we will deal with the potential negative effects upon the building when it is compromised to accommodate the workstation criteria and upon the workstations when they are compromised to accommodate the building criteria. By negative effects we mean a reduction in the number of criteria met for building and workstations respectively.

Problems with the building when we optimize the design response to the workstation criteria

If we imagine a design process that first attempts to optimize satisfaction of the workstation criteria and then tailors the building to the workstation planning decisions, we may anticipate certain kinds of problems with the building design. These problems have to do with diminished success in satisfying the building design criteria and may include:

- Unequal square footage on the various floor levels in order to accommodate the workstation block diagram, resulting in a more complex building shape, increased building skin, increased floor levels and less economical construction.

- Inappropriate overall building shape and mass in relation to site, image goals and code regulations.

- Irregular structural bays resulting in inefficient spans and dimensional coordination problems between the structure, ceiling grid and exterior wall modularity.

- Structural clear spans that use the structural material uneconomically and that increase the building's floor -to-floor height.

- Difficulty coordinating the idiosyncratic layout of ceiling lighting, air grilles, sprinklers and sound speakers.

- Decreased building net-to-gross efficiency due to less efficient circulation system.

- Incongruity between interior wall partitions and the structure-ceiling-exterior window modularity.

- Particularized building design that doesn't accommodate future workstation changes.

Problems with the workstations when we optimize the design response to the building criteria.

When the order of our design attention is reversed, so that we first attempt to satisfy building criteria and then adapt the workstations to the building shell, we find that this may create certain problems for the workstations:

- Individual workstations that suffer from obstructions or whose configurations are compromised because of fixed building elements.

- Inappropriate furniture in a workstation in order for it to fit in an inflexible building area.

- Mismatched lighting/air grille grid with workstation layout.

- Compromised audial and visual privacy due to building constraints on workstation layout.

- Insufficient user access to natural light and exterior views.

- Separated functional zones that should be adjacent.

- Complicated circulation paths within the workstation layout.

- Difficulty establishing the identity of organizationally-related workstation zones.

- Reduced flexibility in achieving the optimum overall workstation layout.

- Compromised locations for shared spaces.

- Reduced flexibility in changing the workstation layout over time.

- Wasted floor areas that cannot be put to any programmatic purpose.

- Workstation layouts that tend to bury users too far from workstation zone edges.

5. Balancing building anticipation of workstations and workstation adaptation to building

The ultimate purpose of a building and workstation system is to support the users in the performance of their jobs while being economical to acquire and own. Despite this mission, workstations can never completely accommodate all the idiosyncratic needs of individual workers because of the necessity for workstation standardization, and buildings can never accommodate all the idiosyncratic workstation layout requirements of organizations because of the necessity that certain contextual, economic and technical building design criteria be met. The degree of misfit between user and workstation and workstation and building may be lessened when user, workstation and building make anticipatory and adaptive gestures toward one another. Specifically, the user must perform his/her job while adapting to the workstation; the workstation system design anticipates the ways the user will perform his/her activities while at the same time the workstation system adapts to the building shell; the building design anticipates the criteria for workstation planning while also satisfying its own contextual, economic and technical criteria.

We will conclude this discussion by looking at some of the ways that building designs anticipate the needs of workstation systems and the ways that workstations adapt to the givens of the building shell.

5.1 Building anticipation of workstation planning

Some of the ways that the building design can anticipate the needs of the workstations and can facilitate the space planning that typically follows the design (and often the construction) of the building shell are outlined below:

- Clear floor areas that are simple in shape and reasonable in proportion.

- Floor configurations that ensure that all workstations are within reasonable proximity to exterior windows.

- Minimal freestanding interior columns.

- Floor to floor dimensions and exterior window heights that allow appropriate natural light access to all workstations.

- Use of atriums that ensure adequate natural light to large floor areas.

- A ceiling grid pattern that provides sufficient density of lights and air grilles to serve any workstation pattern.

- Clear separation of task lighting (at the workstation) and general ambient lighting (ceiling, uplighting at walls and columns).

- Exterior window pattern that need not influence the layout of the workstations.

Some of these strategies for anticipating workstation planning in the building's design involve compromising the building criteria mentioned earlier. The general intent in this exercise is to plan the building in such a manner that it "gets out of the way" of the workstations, that is, the building shell systems become independent from the workstation system so that the workstations must negotiate the fewest building-related constraints possible.

5.2 Workstation adaptation to building shell

Although the project programming process normally progresses from understanding user needs to formulating workstation standards to establishing building requirements, attention to the specifics of interior space planning often does not happen until the building shell is designed. This means that the building shell was planned without knowing the particular workstation layout that will eventually be housed in the facility and that the building's anticipation of the workstation planning was in general rather than specific or tailored terms. This also means that the planning of the workstations must adapt to the constraints of the building shell. Some of the ways that workstation planning may adapt to the building shell are listed below:

- Deliberately violate the geometric mandates of the building (fracture the patterns) in order to create new precedents that are sympathetic with workstation criteria.

- Shift the orientations of individual workstations in order to manipulate the dimensions of workstation clusters.

- Manage the workstation-to-workstation relationships and overall patterns to fit workstation clusters into available space.

- Locate flexible activity space at the edges of the workstation clusters to minimize the friction with the building at those points.

- Use perimeter circulation as a strategy for mediating between the building and workstation patterns.

- Choose workstation systems that offer the most flexibility for alternative patterns and grouping configurations.

- Match discontinuities in the workstation patterns (files, conference areas) with building obstructions (walls, columns).

- Generally, hold workstations away from exterior walls, windows, interior walls and columns.

- Match the floor areas needed for the block diagram with the available building floor areas.

- Fill odd-shaped floor areas with flexible activity zones (lounge, waiting).

- Avoid dependence on ceiling for task lighting by providing task lighting at each workstation.

- Employ workstation grid shifts to slide around building obstacles.

As in the case of the building's anticipation of the workstation criteria, these strategies for adapting the workstations to the building shell often involve a compromise of the workstation criteria listed earlier in this paper. The goal of the workstation adaptation process is not only to create a plan that works for the users and the organization but that also enjoys a sense of deliberateness and fit in its relation to the building shell.

(A further discussion of the topic by this author, and other workshop participants, will appear in a companion publication containing the workshop proceedings (NISTIR 4802).

SPACE PROGRAMMING: FORECASTING STAFF AND SPACE REQUIREMENTS

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1. Introduction

The computer's time has come in all fields of business and personal life. Use of the computer is as diverse as there are functions in business operations. This article discusses the basic concept of planning, and presents two of the major areas of space planning for which computer applications have been developed to assist the facilities manager during the early stages of the space planning process.

- The planning process
- Programming (organization, forecasting and standards)
- Space size standards (computer gaming)
- Space requirements report
- Initial space planning (vertical stacking and basic floor layouts)
- Summary

Each of these factors lends itself to one form or another of computer use, whether statistical, database, or graphic.

An additional element of computer use that provides a powerful tool for accounting for the use of space is discussed in another article titled "Computerized Space Management."

2. The planning process

Planning (a function that is statistical in nature) was done manually until 20 years ago during the planning for the Sears Tower in Chicago. Determining space requirements is now often carried out on a microcomputer even for the largest company, and a range of computer programs are used by large and small design companies and facilities managers.

Years ago, the methods for planning new office space for a company, or a new office building included the development of rough estimates of size. Too often, the decision for establishing the size of a building - the floor area and number of floors - was based on the architect maximizing the building size for a site that had already been preselected. In the case of planning for office space in multi-tenant buildings already designed, a space may first be leased, and then staff and departments forced into the space.

Gradually during the past 20 years, planning has developed into a strategic science as business and administration practices have improved. As the understanding of business operations has increased, the demand for data to support facilities decisions has also increased. Parallel to these increases, advanced statistical tools have developed, including those related to the expanded use of decision support systems (DSS).

In addition, this planning for new facilities involves time-consuming and difficult manual preparation of information for decision making by management. As projects increase in size and complexity, more extensive documentation is required to justify the need, size and cost of the project. To develop and update that type of data by hand has become too formidable.

This article outlines an approach used to develop many of the answers in the programming and planning cycles and describes the way the computer is used to help in these processes.

The use of the computer in the planning process started about 20 years ago with the planning of Sears Tower in Chicago (the highest building in the world) the author managed that project as an executive of an interior planning and design firm, and supervised the development of a minicomputer-based computer-assisted drafting system (CAD) named MAN/MAC. The Sears project was the first in which a computer was used extensively during the design/planning/building processes for the following functions:

- To analyze space requirements
- To analyze adjacencies
- To draft base building plans for use in planning and working drawings 396,000 square meters (4.4 million square feet)
- To draft all interior space working drawings 198,000 square meters (2.2 million square feet)

With the development in recent years of powerful microcomputers, microcomputer-based CADD (computer-assisted design and drafting) systems and relational database software are now available on this level of equipment. Of course, organizations with very large databases, and with a need to expand the program capabilities from basic space requirement reporting to extended CADD with multiple interconnected workstations, as well as extensive facilities management applications requirements, may still require the extended power and speed of the minicomputer or mainframe level of equipment.

Since those early beginnings, the development of computer technology has taken quantum leaps. Many companies have developed programs to permit space requirements analysis, recording and reporting.

Seven major factors in the planning phases of a facilities project include:

- Organization structure
- Staff forecasting
- Office space standards
- Miscellaneous (support) space
- Alternate standards and space requirements comparisons
- Space requirements report
- Department adjacencies.

3. Programming

Programming includes forecasting of both the organization and the numbers and types of staff for an organization.

3.1. Organization

For years, architects and planners have stated that "a major factor to consider in facilities planning is that form follows function." Function in a company or institution is best personified in the macro sense by its organization structure. To develop an understanding of any organization and to maintain control of all operations and units of that organization during the planning stages, an organization chart should be obtained from the client or prepared by the planner.

Today, preparation of such a chart can be done by entering elements of the chart into the microcomputer using one of a number of programs that include charting capabilities. Many companies are large with extensive and complex organization structures. Using a large plotter, it is possible to prepare overall organization charts on large-size mylar sheets. This can be more efficient than producing organization charts on smaller output devices, which then require added time for matching and pasting multiple pages to complete the overall chart of organization. Once the organization chart is in the computer memory, it can be updated and changed, and control notations can be added rapidly.

It is also effective to prepare the organization chart in book form, building it by pages in hierarchical format. Software such as the space requirements and stacking and blocking program from Micro-Vector includes the ability to produce computer generated organization charts automatically from the entry of each organization element, and electronically interconnecting these elements with their staff and space requirements and the department affinities.

Several of the newer computer programs for use in facilities management have integrated this charting ability with the statistical database for staff, space and furniture control.

3.2. Staff forecasting

Organizations are made up of units or functions that are staffed by PEOPLE. One of the most difficult tasks for any company is to project its staffing requirements. As difficult as this task is for the immediate future (often done for one-to-three year periods during the budgeting process), the difficulty involved in projecting the number of staff for longer periods of five-to-30 year periods is well known by all who have tried. However, in the absence of a perfect crystal ball, there are techniques that have been helpful.

At best, any forecasting of staff as the basis for facilities planning will be an educated guess. However, in the absence of a perfect crystal ball, this educated guess is better than no analysis at all. For this purpose, there are several statistical techniques that have been helpful.

- Trending historical growth patterns and extrapolating these data into the future using straight line, central tendency or weighted average forecasting techniques. Once trends have been determined, they can be compared to management's own forecasts for verification or modification.

- Relating staff to production, sales or marketing records or forecasts and extrapolating trends to the future.

- Relating executive and management staffs to operating staffs based on work load and supervisory control standards.

One technique that I have found to be successful adds to these methods a system of staffing control totals applied to all segments of the company. This method, which can be used for either micro or macro planning, works as follows:

- If an organization has several levels of structure, first determine the total projected numbers of staff for the total organization, using one of the techniques mentioned above, such as past trends or sales and marketing forecasts.

- Then, using this number as a control (control total), determine the projections for the second hierarchical level of each of the organization's divisions, based on past trends of divisions' performances, the size proportion of each division to the total company staff, and expected sales or operating performance patterns or changes.

- Next, using the control total for each of these divisions, determine the total staff projections for each department within the division, and continue to the lowest level units in the organization, using the same control total approach as before, these control totals for each hierarchy level, are presented to management, and to any operating or planning committee suggested by management.

- At that point, the supervisor of each organization unit is given the control total of staff that he or she will be allowed and the supervisor is asked to distribute those staff positions among job categories needed to operate his organizational unit. It will be the supervisor's responsibility to distribute his staff positions consistent with the functions he must carry out, and with the budget he has available for his departmental operations.

To be successful, every micro and macro plan forecasting method requires at least the following elements:

- Methods for gathering information
- A statistical method that is used on a continuing basis, so that comparison data can be provided for extended periods
- A method for gaming the data (answering a series of 'What if' questions)
- Imagination
- And above all - luck.

Obviously, the further into the future one projects, the least secure can be the level of confidence in the results. However, the results will, at best turn out to be reasonably accurate, and at worst to be better than no estimate at all.

Finally, when establishing any micro or macro plan, it is interesting to establish ranges of forecasts. It sounds as if such an approach is a method for the facilities manager to hedge his bets. However, if ranges of forecasts are presented with adequate and well thought out scenarios upon which they are based, they can be extremely useful in the final decision-making process by top management of the organization.

Through the procedure of computer gaming, it has become possible to evaluate unlimited numbers of variations in space requirements that may affect the building process. As a result of the modeling of alternate space size standards for staff levels, equipment and functions, the computer can produce comparative data in summary form in minutes. From these data, computer graphics comparison charts and graphs can be produced, in black and white, in color, or as presentation slides. The use of some of the better developed decision support systems (DSS) software can be helpful in this process.

4. Space size standards

For more than 40 years, space standards have been used as a key tool in planning and designing office space. In many instances, the space standards for a company were proposed by the planner/designer/architect, only to be overruled by company management who wished to use the office/workstation as a perquisite for selected employees in place of, or in addition to, salary increases. In government offices, it was not unusual in past years to see offices that were larger than offices in private industry, as a means of compensation for the then lower salaries paid to government employees.

At the First International Symposium On Facilities Management held May 11-12, 1989 in Washington D.C. sponsored by the International Facility Management Association (IFMA) of the United States through a grant from Herman Miller Inc., Ed Rondeau of the Contel Corporation and a past president of IFMA, reported on the State of Facility Management in the United States. He said:

> *"Facility Managers are promoting, with senior management support, corporate facility standards for open plan space, including ... office sizes ... Standards provide the basic quality product which all employees will receive. Standards save time, provide service and quality at fixed known costs ... and in many cases, can ensure that space requirements are not created based upon the whim of each internal customer's desires."*

This statement would appear to hold true regardless of the size of the company.

Often, the space standards for offices for a company that has leased space in a particular building, were forced into specific sizes and shapes by the outer configuration, module, corridor system, columns, and/or core arrangement of the building. In earlier years, before buildings were designed to make effective use of open planning and systems furniture, staff were placed into rooms that were often too large for their needs. The effect was more space being used to house the staff, resulting in higher cost to the company for rental and maintenance of physical facilities.

Planning techniques have come a full circle since the years just before World War II.

- Large companies placed employee desks in large open areas, lining them up one behind the other in rooms often called bullpens.

- In the 1940's and 1950's, there was a trend to design buildings with a corridor through the center and private offices lining each side of the corridor. This was especially true in Great Britain.

- Toward the end of 1950's and into the 1960's, the concept of the open plan was promoted by a German firm and known as the Bureaulandschaft, or office landscaping.

- The total open plan that developed was not well liked by many staff members, and starting in the 1960's the office furniture manufacturers developed the workstation concept, using the bank screen partition (lower than ceiling height partition).

- Today, the use of systems furniture, which encompasses a wide range of functional and ergonomic ideas from all of the above approaches, has swept the office field in America, and the concept is spreading to all other countries of the world.

The development of systems furniture was originally advanced by the furniture manufacturers rather than as a result of the specific needs of the user. However, the result has been tremendously successful. Because systems furniture makes use of less-than-ceiling height partitions, the office and workstation sizes are not forced by the building configuration. Therefore, a wide range of sizes can be used, restricted only by the panel and desk sizes that are made available by the manufacturers. In fact, the manufacturers, understanding the need for flexibility in sizes, has made these panel and workstation desk units in a wide range of sizes, leaving it to the needs of the client and the ingenuity of the planner to determine the office sizes.

4.1 Concept of space size standards

The primary assumption that is made in formalizing space requirements is that repetitive or similar functions exist within an organization - whether for people, for equipment or for support functions - which can be accommodated in equal-size units of space. For those repetitive functions, space size standards can be established that can be applied across department lines, entered into a computer's memory as a look-up file, and recalled whenever units of these kinds are to be used within a department or organizational unit.

At the same time, there are other functions, operations, equipment, or position classifications that are not repetitive. For these special spaces, specific amounts of space are calculated and are entered into the computer system on an individual basis each time that they occur.

4.2 Office space size standards

Space standards are applied to any type of space that is repeated for the organization, be they offices, equipment or special purpose areas. However, much attention is placed on the most important level of space, and often the largest amount of space, for any new office facility - the space required to house people. Office space size standards represent the specific amounts of space that are to be allocated for each of the company's personnel types, defined by position titles (either in a formal or an informal personnel classification system). Standard areas are applied to the staff numbers that have been projected for each of the position types within each organizational unit. The resulting tabulations show projections of the amount of space that will be required to house the organization's staff that has been identified for that unit.

After discussions with the head of each organizational unit or department, top management and the executive leadership of the organization, several basic concepts should be established at the early stages of the project for determining the space size standards as they relate to people, including the following:

- Sizes of workstations should be related to the needs of those who are to occupy them.

- The working environment should be comfortable and pleasant for those who are to occupy them.

- The amount of space should permit the most effective functioning of staff during their working day.

- The sizes of workstations should reflect the image of the client consistent with the ability to pay for that image.

- Sizes and types of work areas or offices should be similar in all divisions for similar position categories with similar work to be performed.

- A major factor in the employment pattern of various companies is that there is an increasing proportion of professional staff and knowledge workers among its employees. High quality staff are difficult and expensive to find, to recruit and to train. Therefore, in addition to high salaries, adequate office environment becomes an important perquisite to retaining quality staff.

- Sizes and types of offices should permit - and even enhance flexibility for furniture, and changes in organization, staff types or numbers.

- Standards should permit future decisions as to the type of furniture, design concepts within offices, design concepts for total space, and arrangement of offices or workstations into various planning arrangements, to enhance staff operating practices and the company's management philosophy.

4.3 Functional needs of the user

Three factors in the selection of sizes for space standards, have major bearing on the space standard sizes:

- Equipment and functional work area and document storage may determine the sizes of the work area. For example: excluding circulation factors, in past years, clerical staff were placed at standard desks, with work areas as small as 3.25 to 3.91 square meters (35-42 net usable square feet). Today, with the addition of computer terminals and often computer printers and additional equipment, the clerical information worker is often housed in 4.2 to 7.81 square meters (45-81 square feet). The average area has increased from 3.53 to 6.03 square meters (38 to 65 square feet).

- Middle management and upper executives, on the other hand, often were found to have excessive space for their functional needs, and their work areas have gradually been reduced.

- In addition, the standard work space for many of these levels of staff has been changed from one of private offices to the use of specially designed systems furniture with partition heights ranging from 183 to 247mm (60 to 81 inches.

The work area sizes and the level of design quality become a reflection of the image that the company wishes to project. Therefore, companies wishing to project an image of affluence, and/or an image of benevolence to its employees, would have larger space standards than others that design standards based on function alone.

4.4 Internal company politics

In recent years, there has been a diminution of the pressures to provide larger offices to individuals in a company because of their level of position or their stature within the company. Although this still happens occasionally, in most instances, the average professional worker accepts smaller space, so long as he recognizes that he has been given space equal to that of other staff at a similar work and pay level.

James Hickey, Executive Vice President of Steelcase, talks about the factors that should be considered during the process of specifying the furniture system for new offices. He says:

> *"The functions that are to be carried out in a workstation should determine the type and size of workstation that would be specified for a classification of individuals in a company. As part of that function, is the type and amount of equipment to be installed in the work area. Today, there is a move in most companies - both large and small - to provide more of the staff members with office automation equipment, especially computer terminals. As a result, the design of the work area must provide for both flat work surfaces for standard office activities, and a properly designed space for the computer equipment. These could include both a terminal, and in some instances a printer and storage for paper to be used."*

Office automation has extended the role of the information worker of today from the professional and executive to the clerk and secretary. There is also a wide range of staff in the professional category, who are included in the category of information worker. All of these, from clerk to executive today make extensive use of the new automation technologies and must be provided with adequate space for ever expanding office automation equipment.

Space standards for these categories of workers have been reducing in size for the executive, whose office was already large enough to accommodate the new equipment, and increasing in size for the clerk, secretary and professional information worker, whose workstations have often been too small to fit the ergonomically planned workstations of today.

Table 1 presents information about 62 companies that were surveyed by the author as part of an international study of offices conducted by the New Office Promotion Association (NOPA) of Japan. The companies of the sample were sorted into five major size groups plus a separate grouping of eight Japanese companies that were located in the New York area.

The tabulation shows the total number of staff in each size group, as well as the average size of company, the average total amount of space for each of the groups, and the average area per person (total usable space divided by the number of employees). To validate the results, the author deleted those companies with the highest and the lowest average area per employee, and the results are shown in the last column.

This table shows that:

In spite of the wide variation in size of company, and in the amount of square feet in the company, the average area per person remained fairly constant, ranging from 19.7 to 22.3 square meters (212 to 240 square feet). When those companies with the highest and lowest area per person were omitted from the sample, the results were even closer - 20 to 21.7 square meters (215 to 234 square feet) per employee. These data appear to confirm that the area per staff member is not dependent upon the size of the company.

Developing space standards for companies is more a process than a product. The planner/designer must ask many questions at the start of a project and gather many types of information. The information relates to the physical configuration of the building into which the company is to move. As mentioned earlier, the configuration of the building may force the space standards to certain sizes. This is especially true if the company staff contains more professional members than support staff.

Past experience by the consultant and discussions with office planners and furniture vendors show that, in addition to the functions and equipment for which a workstation is designed, there can be a number of factors that determine the average area per person in any office. These can include:

- If the type of business, or the organization structure, results in a high ratio of professional staff to clerical staff, the individual offices or workstations will be larger.

- If the company moves to a suburban location, top management of the company may permit the offices to be made larger and the environment improved, in order to appease the staff members who may not have wanted to move away from the city location.

- Also, if the company moves to a suburban location, rent and cost of operating the space will be lower than in the central city areas, and so larger space standards and circulating areas may be permitted. In addition, special purpose spaces may be added, such as: food services, health club facilities, or employee lounges, resulting in larger average areas per employee.

- If the company has large amounts of special purpose areas, such as computer centers, conference rooms, test areas, mail rooms, lounge areas, reception rooms and lobbies, food services, etc., these add to the average area per person.

- If the company wants to present an image of success, it may include large amounts of circulation space (aisles, corridors and hallways), as well as the building lobbies and floor reception areas.

Space in any office environment can be described in two ways.

- Microspace is the employee's personal work area, including the desk, seating, and personal equipment used by the individual to carry out daily tasks and the internal circulation need to function within that space.

- Macrospace is the total office environment. It is made up of all spaces, including personal work stations, support space around it, intra-departmental circulation space between workstations and offices, interdepartmental circulation to permit movement between departments, and equipment and support spaces for all operating purposes.

Space standards are usually applied to the microspace defined above or for specific items of equipment that will require floor space.

4.4.1 Space allocation

There is no correct answer to the question of how much space should be allocated to specific tasks, or to the level of a position within a company's hierarchy. There are, however, three major concepts that should be considered in any planning study with respect to the development of space size standards.

Theoretically, the size of the space standard should be directly determined by the work to be performed, the amount of equipment required to perform that work and the amount of paper or other work products that must be retained at the workstation at any one time. It could often be true that workers lower in the organization hierarchy could require more space than a manager or an executive who often may only require a desk for himself or herself, a chair for a visitor and a communications device, such as a telephone and/or a computer terminal.

However, from a practical point of view, and based on company politics, it has been the practice for higher level staff to be given larger office spaces. The executive, who commands a higher salary and for whom the company wishes to present an image of importance, will almost always be allocated larger amounts of space.

4.4.2 Flexibility issues

In order to permit the greatest amount of flexibility in office areas, it is recommended that the fewest possible number of different space standard sizes be established. In this way, it is possible to change staff positions or organizational structures, move departments from one location to another, and promote staff with little change in the office arrangements or sizes. Experience has shown that this approach can save large amounts of money that would otherwise be spent on costly renovations as a result of these changes.

4.4.3 Changes in workstation design

Finally, it should be recognized that the advent of office automation - especially reflected by the personal computer located in the individual workspaces for many staff - requires a different approach to the design of the workstation change in design, and in the amount of equipment that is being used by each individual, may in some instances require larger amounts of space in the standard. In other instances, it may result in the ability for the occupant of a workstation to perform well in smaller amounts of space.

Some of the major changes in space requirements as a result of office automation has been in a reduced need for filing and storage of paper and records. Although we are far from becoming the paperless office, there are often major opportunities to reduce the amount of space used for these functions.

5. Miscellaneous and support space

Although staff workstations represents about 60 to 70 percent of the total space of the office operation for an average company, the type and amount of support space is also very important.

The type and amount of support space for each organization unit of a company should be determined by interview, site surveys and observation of present operations, review of new services to be performed, and review of the effects that new technologies could have on staff functions, equipment or operations. Wherever possible, space standards for the amount of space for each type of support space should be established. If standards are not practical, individual amounts of space would be calculated for each special-purpose support area for a department. These data are included in each department's space requirements at the same time that staff work areas are calculated.

6. Circulation factors

In additions to the basic offices and special areas, the space requirements for any organization must include circulation factors. These can be divided into the following two types:

- Intra-departmental circulation represents the amount of space required to permit circulation between offices, workstations and support services within a department or unit. As a rule of thumb, 15 percent of space added to the basic total for a department will satisfy this need.

- Interdepartmental circulation represents the amount of space required to permit circulation between departments. As a rule of thumb, 10 percent of space added to the total of the basic space and the intra -departmental circulation space just added will satisfy this need.

A special condition arises whenever large special areas are included in a requirements project, such as cafeterias, computer centers, health clubs, auditoriums, laboratories, file rooms, etc. Since these special areas already include internal circulation, the computer should be programmed not to add the 15 percent of intra-departmental circulation space for them.

7. Alternate examples (computer gaming)

Through the procedure of computer gaming, it has become possible to evaluate unlimited numbers of variations in space requirements that may affect the building process. As a result of the modeling of alternate space size standards for staff levels, equipment and functions, the computer can produce comparative data in summary form in several minutes. From these data, computer graphics comparison charts and graphs can be produced, in black and white, in color, or as presentation slides. In addition, a comprehensive series of additional reports can be produced to assist in the facilities management decision-making process by using better developed decision support systems (DSS) software.

These special gaming programs that have become available through the advent of the computer helps management to determine the staff levels, space size standards, and circulation factors (in relation to the total amount of space) that best reflect the atmosphere and image that the company wishes to portray to its staff and to those outside the company with whom the company does business.

7. Space requirements report

The results of the steps listed above can be generated as a computer printout, either on the computer's CRT screen or on paper. These printouts are produced from the look-up table of the space standards applied to the database about the department, including quantities of staff, equipment, functions, standards, and circulation factors.

7.1 Levels of reports

Because they are computer based, these reports can be generated in varying levels of detail for the three major levels of management - supervisor, middle management and top management.

7.1.1 Supervisors

For supervisory level staff and for the facilities management departments, these reports should be in detail for each department for use in verifying each element of staff, equipment and special functions to be planned for a department.

7.1.2 Middle management

For middle management, reports would be produced in summary form by division, or groups of departments, for which they are responsible. In addition, computer programs can provide data in many different formats to provide specialized information for the middle manager and for the facilities manager. These special reports can include tabulations of the number of each office space standard and special piece of equipment that will require floor space. This information will allow the planner to consider alternate sizes or alternate operating practices that can affect the space requirements for the future.

For example, calculations of the locations and amounts of files together with the amount of space that they occupy, can provide management with information that, as a result of a cost-benefits analysis, may result in the need for development of a records management system to reduce the number of files and records storage rooms (and therefore reduces space needs) that exist or will be planned for the future.

7.1.3 Top management

For top management, broader scale summary reports that show concepts and overall patterns of growth are desirable computer programs should have the ability to produce a selected range of summary reports, together with graphic representations of the data. Summary reports should be designed to relate both to space as an end product, and to space related to business and financial information determined by company operations formats should be both pre-designed to permit the data to be trended by month, quarter and year, and yet flexible enough to permit answers to special requests by company management.

7.2 Examples of reports

Examples of reports that should be produced for the space requirements analysis include:

7.2.1 Tabulations and graphs of personnel estimates

These reports would show the present and projected numbers of staff by department and division. A second type of report could show the pattern of growth rates that are projected for the departments and divisions for review by the company's top management.

7.2.2 Position categories by office type and space standards

This report provides a profile of the planning guide for establishing the type and size of space for each of the position categories of the company obtained as a result of analysis of company information and by departmental interviews.

7.2.3 Comparison of present and proposed space standards with other companies

This type of report helps company management to relate decisions about space-size standards to the type and amount of space that are used by similar companies in the region.

They can use these data to assure the company's employees that their offices are equal or superior to those of other companies. If they are not equal to others, the company management can at least be forewarned that questions about the facilities may be raised by their staff.

7.2.4 Detailed department report

Detailed information for each department to include space requirements information for staff, miscellaneous and circulation space.

For staff space:

- Number of staff for each class of position
- Space standard category and space size
- Total space for each class of staff position
- Subtotal of space for all staff members

For Miscellaneous space:

- Number of items for each type of special space, equipment, furniture or item that is not already included within a staff office listed above

- The amount of space for each item (either based on a standard space - such as for files, or based on calculation of the space by planning methods)

- Total space for each line of special items

- Subtotal of space for all miscellaneous items

Circulation space:

- The intradepartment and interdepartment circulation space should be listed at the appropriate space on the report, together with subtotals and department totals for each department

7.2.5 Summary department report

This report would provide a listing of all departments in any organizational structure that makes sense for the company or for the planning function report would include:

- The departments listed alphabetically or in number order, if a number code is used by the company.

- The total amount of space would be listed for any of the planning years that were included in the calculation.

- Subtotals should be shown for organizational groups, such as divisions or number sequence units reporting to specific executives.

- The grand total of all space should then be shown.

7.2.6 Comparison report for alternate space standards

- An analysis report should show the departmental and division subtotals and the grand total of all space for alternate space standards that might be applied, and for the planning years included in the forecast.

7.2.7 Area per employee

This report shows the average amount of space that would be allocated to each staff member for each of the planning years - by individual department, by subtotals of any groupings that are desired, and by grand total.

7.2.8 Miscellaneous reports

There can be many other reports made available to management, using the database of information prepared for the space requirements analysis process.

8. Initial space planning

Space planning uses several techniques that help to translate the forecast data into preliminary planning concepts. These concepts in turn will be translated into preliminary design for the project planning concepts include:

- Department affinities
- Building stacking diagrams
- Floor block layouts

8.1 Department adjacencies

Department affinities, which in turn are used as a basis for establishing the locations of each organizational unit in relation to the building structure and to each other.

The use of computers to generate department locations in a building was first accomplished about 20 years ago by two programs called KRAFT and ALDEP. Since that time, many programs have been written that merge the computer's analytic and graphic capabilities to identify and present the departmental adjacency requirements to company management and are used to assist the planner to place departments and sections in logical locations on different floors of a multifloor building (building stacking) and to lay out departments and staff members on one floor in a logical plan arrangement (block layout).

As a result of interviews, or a computerized traffic study, department adjacencies are identified and rated (usually on a 3 or a 10-point scale) for every departmental unit and entered into the computer. A graphic program draws one of two types of graphic representations of these data. One is a 2x2 adjacency matrix with selected symbols entered into each cross-referenced box to show the adjacency importance for each department second method produces a bubble diagram that shows in plan form the strengths of relationships between departmental units.

When approved by management, these adjacency requirements become one of the factors for determining the locations of departments within a building project, either on a single floor or as a building stacking plan showing the floor locations for each departmental unit.

Department adjacencies can be determined in several ways. One method used by the writer a number of years ago consisted of a computerized traffic survey. Every employee of a large organization was asked to take a prepunched IBM card every time he/she visited another department, and to drop the card at the department visited. (The same method was used for every document that was sent to any other department.) When tallied, the results showed the number of extent of traffic between departments, and by logic, the adjacency relationships that should prescribe the location in the building for each department.

Not So! Discussions with top level management defined other adjacency relationships that were preferred in spite of the 'card carrying' information. Therefore, in most studies today, adjacency requirements are determined by interview with knowledgeable department managers, adjacency matrixes are prepared, and these become the basis for the stacking and floor layout plans only after review with top management of the organization.

8.2 Building vertical stacking

The stacking process is used to assist a planner to place departments and organization units in logical locations on different floors of a multifloor building and in different buildings of a multiple-building project are a number of computer graphic programs that produce the end product rapidly and in graphic form on the computer monitor. These programs use the affinity matrix described above, and the square-foot area projections described earlier, to systematically assign organizations to free space on floors of a building profile, checking that each floor can contain all of the space for a department to be assigned to it, or that the department can be divided between floors.

The results of each trial show not only the location of each department, but also color codes groups of departments that for divisions. A tabulation of the space and staffing totals shows the statistical results of the department locations, providing the facilities manager with a picture of the quality of the computerized result manager can then move various departments in order to satisfy special interests or internal politics of the company.

The success in locating departments results in a total affinity score, with the lowest score of varied arrangements designating the best result. Changes can be made interactively by the planner on the computer graphics monitor, and the results are seen instantly, both in graphic and statistical format scores are also used when making adjustments to the stacking plan that is produced by the computer program to show if the change results in a better or worse arrangement.

The results of each iteration can also be output in hard copy on a plotter or computer printer, even in color, if such equipment is available.

8.3 Block layout on floor plans

Once the floors on which each department should be located have been determined and approved by management, the location of each department on the floors can be established. Here again, several computer programs have been developed that distributes each department's space within the boundaries of a building core, showing the results in color on the computer monitor, and allowing the results to be output to a pen plotter or dot matrix printer.

The same algorithms that used the affinity programs are expanded for laying out the department spaces on the resulting floor plan for each floor. The result should not be considered as a final solution, since there are many elements of design that must still be taken into consideration, including the specific dimensions of each workstation, the relationship of internal circulation space to the workstations, and the special design layouts that coordinate the offices and service functions within each department's space. Variations in these data may change the shape of the space on the floor plan that the computer has produced. However, the layout that is produced can be used as a starting point for the designer, to be carried to the next stage of design - the space study.

9. Summary

The computer is a tool of incredible strength, speed and versatility facilities manager, space planner, architect and designer have an opportunity today to add this technology to their bag of tools. Most companies already have one or more microcomputers in use. Programs that can carry out the steps described above are not expensive. With care, proper planning and staff training, the computer can become an invaluable assistant in the facilities practice for the small, as well as the large practitioner, and for internal use within companies, and its use in the planning process should be seriously considered.

(A further discussion of the topic by this author, and other workshop participants, will appear in a companion publication containing the workshop proceedings (NISTIR 4802).

Appendix Space Requirement Reports

Figure 1 shows the number of staff by organizational unit for several years, including: Present staff, staff for the probable move-in date, and staff for 5 or 10 years after move-in. The dates used should be determined by the consultant and the client, based on the expected project size, the status of planning when forecasting occurs, the expected construction timetable, and the expected life cycle of the facilities.

For a large project, such as for DOT, where many agencies are part of the project, a series of graphs are needed, with one overall graph showing the staff totals for each of the 12 major agencies as a single line. Then, a separate graph for each agency, showing the growth pattern expected for each organizational segment of that agency.

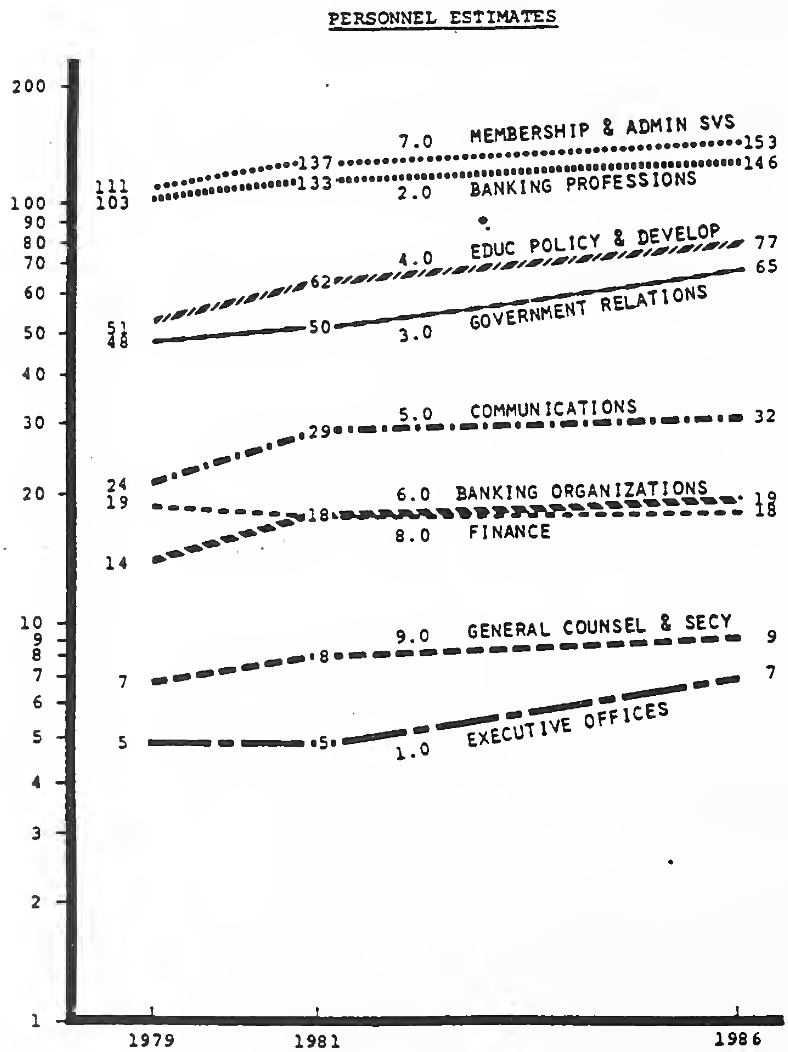

Figure 1. Personnel estimates - graph

Figure 2 shows the growth estimates for the same data as seen in the graphic form (Figure 1) for the present and planning years. In addition, statistical percentages can give management a feeling for the rates of growth projected for each element of the agencies. These percentage analyses are shown in two parts.

PERSONNEL ESTIMATES AND GROWTH RATES

Code	Group Name	Personnel 1979	1981	1986	Percentage Increase 1981 Over 1979	1986 Over 1981	1986 Over 1979	Average Annual Increase 1981 Over 1979	1986 Over 1981	1986 Over 1979
1.0	Executive Offices	5	5	7	- %	40.0%	40.0%	%	8.0%	5.7%
2.0	Banking Professions	103	133	146	29.1	9.8	41.7	14.6	2.9	6.0
3.0	Government Relations	48	50	65	4.2	30.0	35.4	2.1	6.0	5.1
4.0	Educ. Policy & Develop.	51	62	77	21.6	24.2	51.0	10.8	4.8	7.3
5.0	Communications	24	29	32	20.8	10.3	33.3	10.4	2.1	4.8
6.0	Banking Organizations(a)	14	18	19	28.6	5.6	35.7	14.3	1.1	5.1
7.0	Membership & Admin. Svs.	111	137	153	23.4	11.7	37.8	11.7	2.3	5.4
8.0	Finance	19	18	18	-	(5.3)	(5.3)	-	(1.1)	(.8)
9.0	General Counsel & Secy.	7	8	9	14.3	12.5	28.6	7.2	2.5	4.1
	Total	382	460	526	20.4%	14.3%	37.7%	10.2%	2.9%	5.4%

(a) Includes Urban Development & Bankpac

Figure 2. Personnel estimates - table

1. Percentage Increase: This shows the relative amount of increase between the present staff and the staff expected at move-in date, the staff increase expected from the move-in to a selected building use period in the future (this could included several future dates), and the overall increase from the present time to the final date of building use.

2. Average Annual Increase: This shows management the average rate of growth for each organizational unit of the agency. Because the years used for the dates shown earlier may not be of the same duration, the average annual growth rate will give a clearer picture of the relative growth pattern for each organization section for each of the projected growth periods.

These data will give management a clear picture of the variations in growth patterns projected for each organization unit of each of the agencies. From these data, it is often possible to identify false expectations for each unit that may have developed for many reasons. These could include poor forecasting by agency heads, limited information about the future expectations of the agency, differences in management expectations of the organization manager, and even differences in the desire of aggressive managers to show larger forecasts than less aggressive managers.

Figure 3 compares present and proposed office space standards with other companies. It is a good practice to ask the questions: What are others companies doing? What are the other agencies in government doing? How does your space relate to the GSA guidelines? Do they meet them? Are they lower? Are they higher? Where do they compare?

COMPARISON OF OFFICE SIZES BETWEEN CLIENT
AND HEADQUARTERS OF OTHER ORGANIZATIONS

Other U.S. Organizations					Office	CLIENT OFFICE SIZES				
						Existing Sizes		Proposed Sizes		
1	2	3	4	5	Type	Low	High	ALT A	ALT B	ALT C
300	300	300	210	300	A	209	262	300	280	250
300	225	182	180	150	B	130	170	225	210	156
240	150	168	180	150	C	120	156	150	140	120
180	150	150	120	120	D	117	169	150	140	120
180	150	150	120	120	E	126	216	150	140	120
110	100	100	90	80	F	117	156	100	90	80
110	100	110	90	80	G	63	110	100	90	80
110	100	100	120	80	H	42	100	100	90	80
65	75	65	60	60	I	75	100	75	70	60
65	75	54	54	54	J	60	80	75	70	60
45	75	35	54	45	K	65	65	65	60	45

Figure 3. Comparison of office sizes - table

These comparisons are made for the different position category levels. The major problem in obtaining these data is to relate the position titles of DOT with similar position titles in other organizations. Of course, the comparison to the GSA standards is comparatively simple, since the Federal government position grade system is fairly well established. The comparison to positions in the private sector is much more difficult.

Figure 4 presents the comparison of office sizes in graphic form. This graph shows comparative sizes for each office type level, so management can readily review the status of each level of position in relation to other companies.

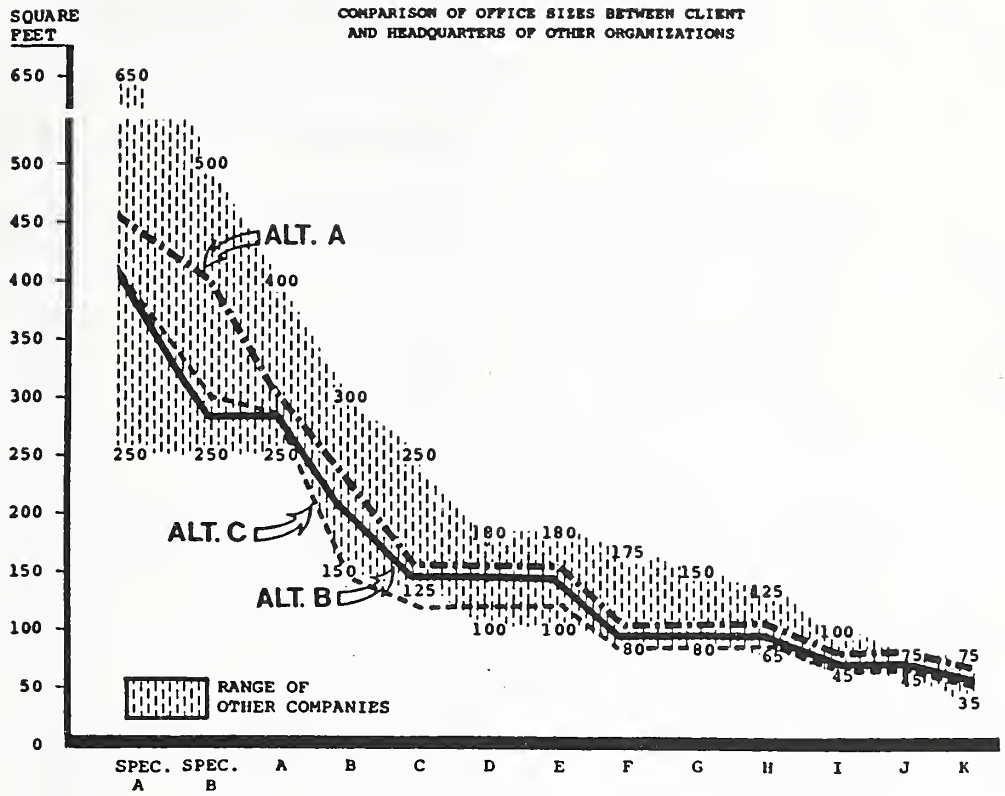

Figure 4. Comparison of office sizes - graph

Figure 5 shows staff position categories by office type and space standards. This tabulation shows how many people are expected to occupy a particular size of office, a particular kind of workstation, or enclosed offices by position category. This gives the planners a feeling for the results of the allocation of office types while different staff members work with individual departments. Major variations in the decision process become evident from this type of presentation.

After these data are reviewed, it is possible to vary the results by computer gaming, both by consolidating office types for different job titles, or by changing the allocation of office types for specific job titles in individual departments. By the use of computers, it is also possible to rapidly change the input data, as changes are made in the organizational structure. For example, if FAA is apt to increase in size and require more space in a flexible arrangement in this building complex, or if the Coast Guard might need more or fewer types of space, the changes to the planning database can be seen easily and changes can be implemented, with the results being available almost instantly.

As planning information is modified, management and the planning team can see the results as changes take place. Finally, as will be seen later, as the numbers and positions of staff of each organization show changes, by gaming, the possible effects on total space needs would be seen.

NUMBER OF OFFICES BY DEPARTMENT AND OFFICE TYPE

	DEPARTMENT	SPEC. & A		B 400		C 280		D 280		E 140		F 140		G 140		H 140		I 100		J 140		K 80		L 80		M 65		N 48		O 48		P 100		NO OFFICE		TOTAL	
		79	84	79	84	79	84	79	84	79	84	79	84	79	84	79	84	79	84	79	84	79	84	79	84	79	84	79	84	79	84	79	84	79	84	79	84
1	EXECUTIVE	10	10									2	2	1	1																	5	5			18	18
2	LAW					1	1	2	2					8	10											3	3	2	2	6	8					22	26
3	PUBLIC AFFAIRS/PUBLIC RELATIONS			1	1	5	3			2	2	1	1					6	13			1	1			2	2	7	10	1	1					26	34
3-A	PUBL AFFAIRS/PUBL RELAT - CREATIVE SERVICES									1	1									3	3			5	7					1	1					10	12
4	FINANCE																																			-	-
5	CONTROLLER			1	1																					1	1									2	2
5-A	CONTROLLER - FINANCL ANAL & OPER PROJ									1	1							6	7			1	1					2	3	5	6					15	18
5-B	CONTROLLER - GENERAL ACCOUNTING									1	1	2	2					3	2			9	13					1	1	15	16					31	35
5-C	CONTROLLER - CREDIT							1	1			6	6					2	2									5	5	4	5					18	19
5-D	CONTROLLER - AUDIT INSUR & SECUR					1	1											1	1							1	1									1	1
5-E	CONTROLLER - AUDIT INSUR & SECUR - INSUR							1	1			2	2			1	1	2	3									1	1	3	3					10	11
5-F	CONTROLLER - AUDIT INSUR & SECUR - AUDIT							1	1	3	5	11	15					15	20			8	10			1	1	4	6							48	55
6	TREASURY					1	1			4	4							7	7			12	13					1	1	4	4					29	30
7	TAX			1	1																					1	1									2	2
7-A	TAX - TAX PLANNING & ADMINISTRATION							4	4	2	2			3	3	1	1	4	6	4	6	2	2			2	2	2	2	4						28	15
8	CORPORATE OFFICE ADMINISTRATION			1	1																					1	1									2	2
9	PROPERTY DEVELOPMENT																																				
9-A	PROPERTY DEVEL - REAL ESTATE							1	1					9	10															5	6					15	17
9-B	PROPERTY DEVEL - STORE PLANNING & CONST							1	1			2	2	3	3	10	12			7	8							3	3	4	4					30	31
10	FEDERATED STORES REALTY, INC	1	1			1	1	5	3	2	2			6	6			3	4			2	2							9	12					27	31
11	ORGANIZATION PLANNING & DEVELOPMENT			1	1	1	1	1	1					4	4			7	9			1	1	1	1	1	1			15	14					30	33
12	SYSTEMS RESEARCH & OPERATIONS			1	1																					1	1									2	2
13	SYSTEMS RESEARCH & DEVELOPMENT					1	1			6	6															4	4									11	11
13-A	SYST RES & DEVEL - ADMINISTRATION																	2	2							1	1	10	12					2	2	15	17
13-B	SYST RES & DEVEL - COMPANY INFO SYSTEMS									3	3							21	19			107	104											8	5	139	131
13-C	SYST RES & DEVEL - DIRECTOR DIVISION SERVICES																	6	6			4	3													10	9
13-D	SYST RES & DEVEL - NATIONAL DATA CENTER																	4	1			30	18					2		1	1					37	20
13-E	SYST RES & DEVEL - PLNG & HOME OFF SYSTEMS																	1	1			10	19			1	1			4	5			8	4	24	30
13-F	SYST RES & DEVEL - TECHNICAL SUPPORT									1	1							8	9			35	32													44	42
14	OPERATIONS SERVICES/PURCHASING							1	1			4	4			7	8	9	11									7	7	1	1					29	32
15	SELLING SERVICES							1	1					4	4			11	14									2	2							18	21
16	FOOD OPERATIONS											1	1			1	1			2	3			2	2					2	2					8	9
17	RESEARCH PLANNING & DEVELOPMENT			1	1																					1	1									2	2
17-A	RES PLNG & DEVEL - AREA RESEARCH					1	1			8	4	6	8					11	12			8	10	4	5	1	1	8	9	2	2					44	52
17-B	RES PLNG & DEVEL - CONSUMER RESEARCH							1	1			1	1	1	2			5	6			5	4			1	1	5	5	2	3					19	23
17-C	RES PLNG & DEVEL - CORP PLNG & DEVEL					1	1			4	4	5	6					5	6			10	26			5	3	8	6	18	21					59	73
17-D	RES PLNG & DEVEL - ECONOMICS					1	1			1	1			5	7			8	9									2	3	2	3					19	24
17-E	RES PLNG & DEVEL - MKTG & ADVTG RES									1	1							3	6			3	4							2	3					8	15
17-F	RES PLNG & DEVEL - RESCH INFO & SVS					1	1			1	1			5	5			11	18			6	8			1	1	3	4	1	1					29	35
18	CORPORATE OFFICE MANAGEMENT/MAGE & DELVRY							1	1					2	2							2	2			2	2	1	1							8	8
18-A	CORP OFF MGMT - HOME OFFICE EMPLOYMENT											1	1					1	1			2	2					5	4	3	3					10	11
18-B	CORP OFF MGMT - ADMIN SERVICES											1	1											1	1					1	1					3	3
18-C	CORP OFF MGMT - ADMIN SER - COMMUNICATIONS																	1	1															2	2	3	3
18-D	CORP OFF MGMT - ADMIN SER - COMPOSER																	1	1			3	3							2	2					6	6
18-E	CORP OFF MGMT - ADMIN SER - FOOD SERVICE																																	8	8	8	8
18-F	CORP OFF MGMT - ADMIN SER - HOUSEKEEPING																	1	1															29	29	30	30
18-G	CORP OFF MGMT - ADMIN SER - PRINT SHOP																	1	1			1	1											12	12	14	18
18-H	CORP OFF MGMT - ADMIN SER - RECEPTION																																	4	5	4	5
18-I	CORP OFF MGMT - ADMIN SER - RECORDS																	1	1			1	1							4	7			1	1	7	10
18-J	CORP OFF MGMT - ADMIN SER - SUPPLY/MESS																	1	1			1	1											7	7	9	9
18-K	CORP OFF MGMT - ADMIN SER - SUPT BLDG																	1	1															3	3	4	4
18-L	CORP OFF MGMT - ADMIN SER - TRAVEL																	1	1			4	4													5	5
66	SHARED BUILDING SERVICES																																	11	11	11	11
	TOTAL	11	11	7	7	13	13	19	19	36	37	45	52	51	57	20	23	172	200	16	20	279	283	11	16	29	28	75	86	119	142	5	5	81	89	1,008	1,089

Figure 5. Number of Offices by Department and Office Type

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These data also can be presented in detailed and summary department reports showing numbers of staff, types of spaces or categories, total spaces for each staff position, and then by subtotals. Again, all of these activities should be considered part of a total process, continually maintained in a database, and updated - whether monthly or quarterly; changing so you know where you are at every stage in the planning cycle.

Figure 6 presents an example of a detailed computer tabulation of one organization unit. The tabulation is made up of several segments.

1. Office type space. This section includes information about staff members and shows the number of staff, the office space standard and the detailed amount of space for each staff type. After the list of staff positions and the amount of space for each category, there is a subtotal of space for all of the office type categories.

2. Miscellaneous space. Everything else that goes into the building besides space for people is included in this category of items. These include equipment not included in the individual offices of staff members and special purpose spaces, such as storage, reception, conference areas or rooms, etc. Wherever possible, space standards for the amount of space for each type of support space should be established. If standards are not practical, individual space requirements would be calculated for each departmental special-purpose support area. These data are included in each department's space requirements at the time that staff work areas are calculated. As for the office category above, a subtotal of space is calculated by the computer program.

3. Circulation space. In addition to the basic offices and special areas, the space requirements for any organization must include circulation factors. These can be divided into the following two types:

- Intradepartmental circulation represents the amount of space required to permit circulation between offices, workstations and support services within a department or unit. As a rule of thumb, 15 percent of space is added to the basic total for a department will satisfy this need.

- Interdepartmental circulation represents the amount of space required to permit circulation between departments. As a rule of thumb, 10 percent of space added to the total of the basic space and the intradepartmental circulation space, will satisfy this need.

Several variations can be introduced into the computer gaming process for these data. For example, variations in space size standards can be provided as a look-up table, and the amount of space for every position category for every department can be varied instantly in the computer.

Even within the guidelines of the GSA standards, there are variations that each agency may be able to use. When we discuss offices, we do not necessarily mean enclosed spaces. There is no evidence that for management positions, 180 square feet is better than 11.15 square meters (120 square feet), and that someone occupying 11.15 square meters (120 square feet) can't carry out his or her everyday functions.

SAMPLE DEPARTMENT REQUIREMENTS

EXECUTIVE DEPARTMENT

FEDERATED DEPARTMENT STORES, INC   ALT F(MOD)   3/19/77

1 EXECUTIVE

TITLE/FUNCTION	TYPE	SIZE	1977 PRESENT AUTH	1979 UNITS	1979 AREA	1984 UNITS	1984 AREA
OFFICE SPACE							
CHAIRMAN OF THE BOARD	SPECA	950	1	1	950	1	950
EXECUTIVE ADMIN ASSISTANT	C	140	1	1	140	1	140
EXEC SECRETARY (IN EXEC AREA)	P	100	1	1	100	1	100
PRESIDENT	SPECB	850	1	1	850	1	850
VICE CHAIRMAN	SPECC	750	1	4	3,000	4	3,000
STAFF ASSISTANT TO VICE CHAIRMAN	F	140	-	1	140	1	140
EXEC SECRETARY (IN EXEC AREA)	P	100	-	4	400	4	400
EXECUTIVE VICE PRESIDENT	A	400	1	1	400	1	400
EXEC SECRETARY (IN EXEC AREA)	P	100	1	1	100	1	100
EXECUTIVE VICE PRESIDENT	A	400	1	1	400	1	400
STAFF ASSISTANT TO EVP	F	140	2	2	280	2	280
EXEC SECRETARY (IN EXEC AREA)	P	100	1	1	100	1	100
EXECUTIVE VICE PRESIDENT	A	400	1	1	400	1	400
EXEC SECRETARY (IN EXEC AREA)	P	100	1	1	100	1	100
EXECUTIVE VICE PRESIDENT	A	400	1	1	400	1	400
EXEC SECRETARY (IN EXEC AREA)	P	100	-	1	100	1	100
SUBTOTAL OFFICE SPACE			14	23	7,860	23	7,860
MISCELLANEOUS SPACE							
ALTERNATE ARRANGEMENT FOR LOCATION IN EXECUTIVE AREA							
VICE PRESIDENT - LAW	C	-	1	1	-	1	-
CONTROLLER	C	-	1	1	-	1	-
TREASURER	C	-	1	1	-	1	-
SR VICE PRESIDENT (IN EXEC AREA)	A	-	6	6	-	6	-
EXEC SECRETARY (IN EXEC AREA)	P	-	6	6	-	6	-
RECEPTION (IN EXEC AREA)	EXREC	-	3	3	-	3	-
MEETING FACILITIES							
BOARD ROOM(MIS STRATEGY)*					2,000		2,000
PROJECTION/STAGING					500		500
BOARD ROOM RECEPTION					200		200
CONFERENCE CENTER(90 PEOPLE)*					3,740		3,740
CONFERENCE ROOM A(8 PEOPLE)	CONFA	140	-	2	280	2	280
CONFERENCE ROOM B(16 PEOPLE)	CONFB	280	-	1	280	1	280
DINING FACILITIES							
CHAIRMAN DINING ROOM	CHDIN	30	-	10	300	10	300
SPECIAL DINING ROOM	SPDIN	150	-	2	300	2	300
EXECUTIVE DINING ROOM A	EXDIN	25	-	50	1,250	50	1,250
EXECUTIVE DINING ROOM B	EXDIN	25	-	40	1,000	40	1,000
DINING SERVICES					1,655		1,655
EXECUTIVE FLOOR RECEPTION					600		600
EXECUTIVE VISITOR OFFICE					280		280
EXECUTIVE LAVATORY - MALE					180		180
EXECUTIVE LAVATORY - FEMALE					180		180
SAUNA, SHOWER, MASSAGE					200		200
FLOOR MAIL & REPRO CENTER					400		400
FLOOR FOOD & DRINK VENDING					120		120
* DUE TO LARGE SIZE, AREA SHOWN EXCLUDES INTRADEPARTMENTAL CIRCULATION SPACE OF 15%. CIRCULATION SPACE IS SHOWN AT BOTTOM OF DEPARTMENT ONLY.							
SUBTOTAL MISCELLANEOUS SPACE					13,465		13,465
SUBTOTAL					21,325		21,325
INTRADEPARTMENTAL CIRCULATION 15 PERCENT					3,199		3,199
SUBTOTAL					24,524		24,524
INTERDEPARTMENTAL CIRCULATION 10 PERCENT					2,452		2,452
TOTAL DEPARTMENT AREA					26,976		26,976

Figure 6. Sample Department Requirements

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Also, some staff levels employees occupy a space averaging about 7.43 square meters (80 square feet). It is often difficult to justify the difference between 7.43 square meters (80 square feet) and 9.3 square meters (100 square feet) in terms of the ability to carry out functions.

As technology changes, it is difficult to determine the rationale for justifying larger or smaller work areas. For example, in one organization with whom I have recently been working, the typical worker uses more than one computer terminal at a workstation. As a result, more desk and computer surface is needed. However, in the future, as computer technology changes, more powerful, multi-function computers may make it unnecessary to have more than one computer terminal.

In addition, the changing concepts of the computer screens may eliminate the large depth CRT monitors in favor of flat screens that can be attached to a wall surface. In the future, computer screens may be made of flexible material, attachable to any surface, or might be an image located in the air, in any direction desired by the user (holography or heads up displays).

The results of this gaming process that provides space requirements alternates based on alternate space standards will be seen in later illustrations.

Variations in circulation factors may occur because of the configuration of the building shell, or in differences in the style of space being planned.

The following figures show various types of summary reports.

Figure 7 shows a tabulation produced by the computer, of the total space requirements resulting from the application of alternate space size standards described above. The exhibit shows alternate total space requirement for each major organizational group for various projection years. As can be seen in the exhibit, totals and subtotals for any structure of organization is possible.

COMPARISON OF ALTERNATE SPACE REQUIREMENTS

DEPARTMENT	SUMMARY OF PERSONNEL REQUIREMENTS			SUMMARY OF SPACE REQUIREMENTS: ALTERNATE A		ALTERNATE B		ALTERNATE C	
	1979	1981	1986	1981	1986	1981	1986	1981	1986
EXECUTIVE OFFICE	5	5	7	2,716	3,038	2,444	3,881	2,419	2,902
SUBTOTAL	5	5	7	2,716	3,034	2,444	3,001	2,419	2,968
BK PROF - ADMIN - EXECUTIVE DIRECTOR	5	6	7	2,340	2,720	2,216	2,543	2,088	2,404
BK PROF - ADMIN - COORDINATION	1	3	4	473	609	423	751	500	625
BK PROF - ADMIN - PROF SERVICE	19	22	26	3,403	4,023	3,326	3,713	2,933	3,202
BK PROF - CORPORATE - ADMIC/COMMUN BANKER	7	7	9	2,272	2,844	2,116	2,597	1,924	2,369
BK PROF - CORPORATE - BANK INVEST/MARKET	4	8	4	1,443	1,502	1,382	1,408	1,179	1,198
BK PROF - CORPORATE - INTL/CORRES/COMMUN	4	12	12	2,562	2,562	2,404	2,404	2,113	2,113
BK PROF - OPERATIONS - BANK PERSONNEL	8	9	9	2,980	3,120	2,772	2,849	2,544	2,671
BK PROF - OPERATIONS - USA/MACHA/STUS/IOP	23	27	31	5,474	6,228	5,133	5,842	4,525	5,159
BK PROF - RETAIL - BANK CASH/INSTALL LENC	10	10	10	2,470	2,499	2,493	2,522	2,292	2,283
BK PROF - RETAIL - MKTG/COMPL/CORP PLNG	6	9	9	1,854	1,854	1,734	1,734	1,506	1,506
BK PROF - TRUST	10	11	12	2,768	3,045	2,585	2,842	2,319	2,552
BK PROF - NEW (2 DIVISIONS)	0	9	11	1,972	2,262	1,852	2,123	1,561	1,806
SUBTOTAL	103	135	144	30,471	33,424	28,630	31,378	25,452	27,968
GOVT RELATIONS - EXECUTIVE	4	4	4	1,703	1,824	1,620	1,739	1,456	1,575
GOVT RELATIONS - AGENCY RELATIONS	7	4	12	1,737	2,471	1,842	2,332	1,427	2,041
GOVT RELATIONS - FEDERAL LEGIS RELATIONS	13	13	17	2,611	3,356	2,453	3,154	2,136	2,749
GOVT RELATIONS - TRUST SERVICES (A)	5	5	6	1,191	1,486	1,129	1,410	977	1,233
GOVT RELATIONS - ECON & POLICY RESEARCH	9	9	12	2,229	2,591	2,102	2,459	1,837	2,155
GOVT RELATIONS - RETAIL BANKING	5	6	7	1,359	1,635	1,293	1,546	1,106	1,303
GOVT RELATIONS - TAXATION (A)	5	5	7	1,209	1,419	1,128	1,311	963	1,309
SUBTOTAL	48	50	65	12,039	14,980	11,357	14,151	9,902	12,405
E P & D - EXECUTIVE DIRECTOR	3	3	3	1,499	1,499	1,417	1,417	1,290	1,290
E P & D - PROGRAM EVAL & EDUC RESEARCH	7	10	13	2,034	2,696	1,914	2,531	1,649	2,190
E P & D - PROGRAM DEVELOPMENT	7	9	13	1,740	2,306	1,636	2,144	1,421	1,879
E P & D - EDUCATIONAL RESOURCES	4	4	4	843	843	785	785	659	659
E P & D - EDUCATION & FIELD RELATIONS	26	32	37	6,516	7,553	6,100	7,072	5,607	6,502
E P & D - FUND FOR EDUC IN ECONOMICS	4	4	7	1,005	1,705	949	1,604	823	1,401
SUBTOTAL	51	62	77	13,687	16,602	12,801	15,553	11,449	13,921
COMMUNICATIONS	24	29	32	6,525	7,472	6,171	7,081	5,551	6,418
SUBTOTAL	24	29	32	6,525	7,472	6,171	7,081	5,551	6,418
BANKING ORGANIZATIONS	14	14	19	4,650	4,927	4,353	4,611	3,805	4,131
SUBTOTAL	14	18	19	4,650	4,927	4,353	4,611	3,805	4,131
MEMB & ADMIN SVS - EXECUTIVE	2	3	3	963	963	905	905	829	829
MEMB & ADMIN SVS - CONVENTIONS/MEETINGS	26	33	41	8,749	10,443	8,212	9,767	7,541	8,996
MEMB & ADMIN SVS - PUBLICATIONS/PRINTING	11	13	13	3,247	3,399	3,034	3,170	2,773	2,912
MEMB & ADMIN SVS - PERSONNEL	9	11	12	2,527	2,805	2,406	2,672	2,176	2,419
MEMB & ADMIN SVS - LIBRARY SERVICES	9	10	11	8,855	8,855	8,855	8,455	8,655	8,655
MEMB & ADMIN SVS - OFFICE SERVICES (A)	20	24	26	6,742	7,017	6,447	6,924	6,504	6,621
MEMB & ADMIN SVS - MEMBER RECORDS & INFO	24	31	33	5,870	6,400	5,554	6,071	4,952	5,432
MEMB & ADMIN SVS - SURVEYS & STATISTICS	5	7	8	2,830	2,850	2,497	2,705	2,257	2,452
MEMB & ADMIN SVS - MEMBERSHIP SERVICES	5	5	4	1,282	1,406	1,206	1,398	1,867	1,266
SUBTOTAL	111	137	153	40,935	44,230	39,348	42,473	37,016	39,962
FINANCE - FINANCIAL DIRECTOR	2	2	2	2,918	3,001	2,804	2,909	2,830	2,918
FINANCE - FINANCIAL SERVICES	5	5	5	917	917	848	848	696	696
FINANCE - ACCTG & FINANCIAL REPORTING	12	11	11	1,265	1,265	1,164	1,164	1,012	1,012
SUBTOTAL	19	16	16	5,100	5,183	4,898	4,981	4,540	4,626
GENERAL COUNSEL & SECRETARY	7	8	9	2,584	3,000	2,449	2,923	2,145	2,594
SUBTOTAL	7	8	9	2,584	3,080	2,449	2,923	2,145	2,594
SHARED SERVICES	0	0	0	14,920	16,894	14,381	16,185	14,149	16,834
CONFERENCE CENTER	0	0	0	10,500	11,006	10,373	10,854	10,234	10,890
SUBTOTAL	0	0	0	25,420	27,900	24,474	27,039	24,383	26,724
TOTAL	362	440	526	144,331	161,444	137,117	153,103	126,748	141,729

Figure 7. Comparison of Alternate Space Requirements

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Figure 8 shows similar data in the form of a comparative, stacked, three-dimensioned bar graph. It shows the total amount of space for an agency for each of a series of planning years and for each of four alternate sets of space size standards. These data can be produced by any standard database or spreadsheet programs currently on the market. These data were produced by the Quattro Pro program, and graphs can be produced in seconds from the tabular data.

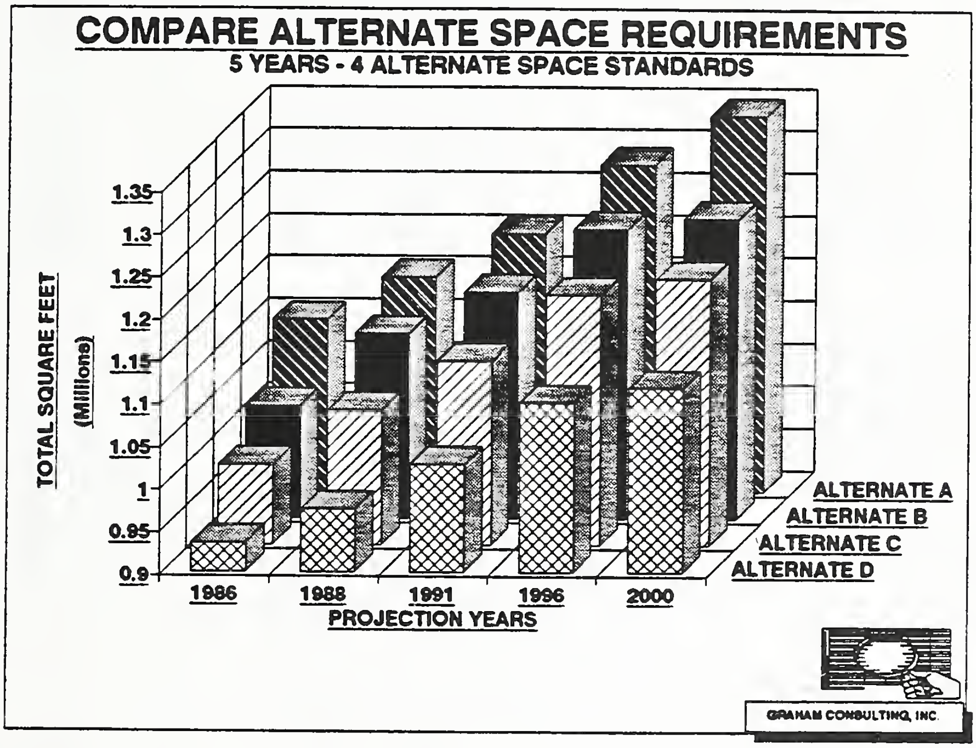

Figure 8. Comparison of alternate space requirements - graph

The ability to examine data in this comparative format permits management to apply judgments to this whole process to see where changes might be made. These data are particularly useful to top management, depicting overall trends, and trends within individual organizational elements of Agencies or the Department as a whole.

Once these data are collected in a project database, calculating the space per person for individual organizational units, or by subtotals of groups and totals for entire agencies, becomes a by-product of the computer and gaming process. It is easy to analyze these data to make comparisons among individual groups.

Figure 9 shows the average area per person for any planning year, showing the effects that various alternate office space size standards would have on each department.

AVERAGE AREA PER PERSON BY DEPARTMENT
(ALTERNATE A)

DEPARTMENT		1981 UNITS	1981 AREA	1981 AVERAGE AREA	1986 UNITS	1986 AREA	1986 AVERAGE AREA
1.00	EXECUTIVE OFFICE	5	2,716	543	7	3,438	491
	SUBTOTAL	5	2,716	543	7	3,438	491
2.01-A	BK PROF - ADMIN - EXECUTIVE DIRECTOR	6	2,360	393	7	2,720	388
2.01-B	BK PROF - ADMIN - COORDINATION	3	673	224	4	809	202
2.01-C	BK PROF - ADMIN - PROF SERVICE	22	3,603	163	24	4,023	167
2.02-A	BK PROF - CORPORATE - AGRIC/COMMUN BANKER	7	2,272	324	9	2,800	311
2.02-B	BK PROF - CORPORATE - BANK INVEST/MAREF	8	1,483	185	8	1,502	187
2.02-C	BK PROF - CORPORATE - INTL/CORRES/COMMUN	12	2,562	213	12	2,562	213
2.03-A	BK PROF - OPERATIONS - BANK PERSONNEL	9	2,980	331	9	3,120	346
2.03-B	BK PROF - OPERATIONS - UBA/NACHA/STDS/I&P	27	5,474	202	31	6,228	200
2.04-A	BK PROF - RETAIL - BANK CARD/INSTALL LEND	10	2,670	267	10	2,699	269
2.04-B	BK PROF - RETAIL - MKTG/COMPL/CORP PLNG	9	1,854	206	9	1,854	206
2.05	BK PROF - TRUST	11	2,768	251	12	3,045	253
2.06	BK PROF - NEW (2 DIVISIONS)	9	1,972	219	11	2,262	205
	SUBTOTAL	133	30,671	230	146	33,624	230
3.01	GOVT RELATIONS - EXECUTIVE	4	1,703	425	4	1,822	455
3.02	GOVT RELATIONS - AGENCY RELATIONS	8	1,737	217	12	2,471	205
3.03	GOVT RELATIONS - FEDERAL LEGIS RELATIONS	13	2,611	200	17	3,356	197
3.04	GOVT RELATIONS - TRUST SERVICES (A)	5	1,191	238	6	1,486	247
3.05	GOVT RELATIONS - ECON & POLICY RESEARCH	9	2,229	247	12	2,591	215
3.06	GOVT RELATIONS - RETAIL BANKING	6	1,359	226	7	1,635	233
3.07	GOVT RELATIONS - TAXATION (A)	5	1,209	241	7	1,619	231
	SUBTOTAL	50	12,039	240	65	14,980	230
4.01	E P & D - EXECUTIVE DIRECTOR	3	1,499	499	3	1,499	499
4.02	E P & D - PROGRAM EVAL & EDUC RESEARCH	10	2,034	203	13	2,696	207
4.03	E P & D - PROGRAM DEVELOPMENT	9	1,788	198	13	2,346	180
4.04	E D & P - EDUCATIONAL RESOURCES	4	843	210	4	843	210
4.05	E P & D - EDUCATION & FIELD RELATIONS	32	6,518	203	37	7,553	204
4.06	E P & D - FUND FOR EDUC IN ECONOMICS	4	1,005	251	7	1,705	243
	SUBTOTAL	62	13,687	220	77	16,642	216
5.00	COMMUNICATIONS	29	6,525	225	32	7,472	233
	SUBTOTAL	29	6,525	225	32	7,472	233
6.00	BANKING ORGANIZATIONS	18	4,650	258	19	4,927	259
	SUBTOTAL	18	4,650	258	19	4,927	259
7.01	MEMB & ADMIN SVS - EXECUTIVE	3	963	321	3	963	321
7.02	MEMB & ADMIN SVS - CONVENTIONS/MEETINGS	33	8,799	266	41	10,463	255
7.03	MEMB & ADMIN SVS - PUBLICATIONS/PRINTING	13	3,247	249	13	3,399	261
7.04	MEMB & ADMIN SVS - PERSONNEL	11	2,527	229	12	2,805	233
7.05	MEMB & ADMIN SVS - LIBRARY SERVICES	10	8,855	885	11	8,855	805
7.06	MEMB & ADMIN SVS - OFFICE SERVICES (A)	24	6,762	281	26	7,017	269
7.10	MEMB & ADMIN SVS - MEMBER RECORDS & INFO	31	5,870	189	33	6,400	193
7.11	MEMB & ADMIN SVS - SURVEYS & STATISTICS	7	2,630	375	8	2,850	356
7.12	MEMB & ADMIN SVS - MEMBERSHIP SERVICES	5	1,282	256	6	1,486	247
	SUBTOTAL	137	40,935	298	153	44,238	289
8.01	FINANCE - FINANCIAL DIRECTOR	2	2,918	1,459	2	3,001	1,500
8.02	FINANCE - FINANCIAL SERVICES	5	917	183	5	917	183
8.03	FINANCE - ACCTG & FINANCIAL REPORTING	11	1,265	115	11	1,265	115
	SUBTOTAL	18	5,100	283	18	5,183	287
9.01	GENERAL COUNSEL & SECRETARY	8	2,588	323	9	3,080	342
	SUBTOTAL	8	2,588	323	9	3,080	342
0.55	SHARED SERVICES		14,920	**		16,894	**
0.66	CONFERENCE CENTER		10,500	**		11,006	**
	SUBTOTAL		25,420	**		27,900	**
	TOTAL	460	144,331	314	526	161,484	307

Figure 9. Average Area per Person by Department

GRAHAM CONSULTING,

Figure 10 presents a variation of presentation for the same type of information - total area by organization and agency, and the average area per person for the same data, using three alternate space size standards.

ESTIMATED SPACE AND AREA PER PERSON
(Usable Square Feet)

	Personnel			Present Space	AREA REQUIREMENTS Alt A		Alt B		Alt C	
	1979	1981	1986		1981	1986	1981	1986	1981	1986
Executive	5	5	7	1,830	2,716	3,438	2,444	3,001	2,419	2,988
Banking Professions	103	133	146	18,300	30,671	33,624	28,630	31,370	25,452	27,968
Govt Relations	48	50	65	8,990	12,039	14,980	11,357	14,151	9,902	12,405
EP & D	51	62	77	8,430	13,687	16,642	12,801	15,553	11,449	13,921
Communications	24	29	32	6,090	6,525	7,472	6,171	7,061	5,551	6,410
Banking Organ	14	18	19	2,140	4,650	4,927	4,353	4,611	3,885	4,131
Membership & Admin Svs	111	137	153	24,090	40,935	44,238	39,340	42,473	37,018	39,962
Finance	19	18	18	3,810	5,100	5,183	4,896	4,981	4,544	4,626
General Counsel & Secy	7	8	9	1,280	2,568	3,060	2,449	2,923	2,145	2,594
Shared Services	-	-	-	18,850 (a)	25,420	27,900	24,674	27,039	24,383	26,724
TOTAL	382	460	526	93,610	144,324	161,484	137,147	153,123	126,748	141,729

	Present Space	ESTIMATED AREA PER PERSON Alt A 1981	Alt A 1986	Alt B 1981	Alt B 1986	Alt C 1981	Alt C 1986
Executive	366	543	491	488	428	483	426
Banking Professions	178	230	230	215	214	191	191
Govt Relations	187	240	230	227	217	198	190
EP & D	165	220	216	206	202	184	180
Communications	254	225	233	212	221	191	200
Banking Organ	153	258	259	241	242	215	217
Membership & Admin Svs	217	298	289	287	277	270	261
Finance	201	283	287	272	276	252	257
General Counsel & Secy	183	323	342	306	324	268	288
Shared Services (b)	(49)	(55)	(53)	(54)	(51)	(53)	(51)
AVERAGE	246	314	307	298	291	276	269

Notes

(a) Includes new space for library and EP & D
(b) Average area per person is based on total staff for ABA.

Figure 10. Estimated space and area per person

Figure 11 shows how computer graphics can provide the means for a rapid comparison between the space requirements for the planning years and the actual space available in any building - both existing space and planned future space, to be built in any time period. This figure depicts a company project, where the estimated space requirements fit the planned building project with no reserve space being built, if Alternate A space size standards were to be used. In this case, the building construction of 2,843 square meters (306,000 usable square feet) was designed to last until the year 1999.

However, the exhibit also shows that if the Alternate B space size standards were to be used, the first building size would only last to the year 1992, unless the reserve amount of space were to be built - providing 3,586 square meters (386,000 square feet of space).

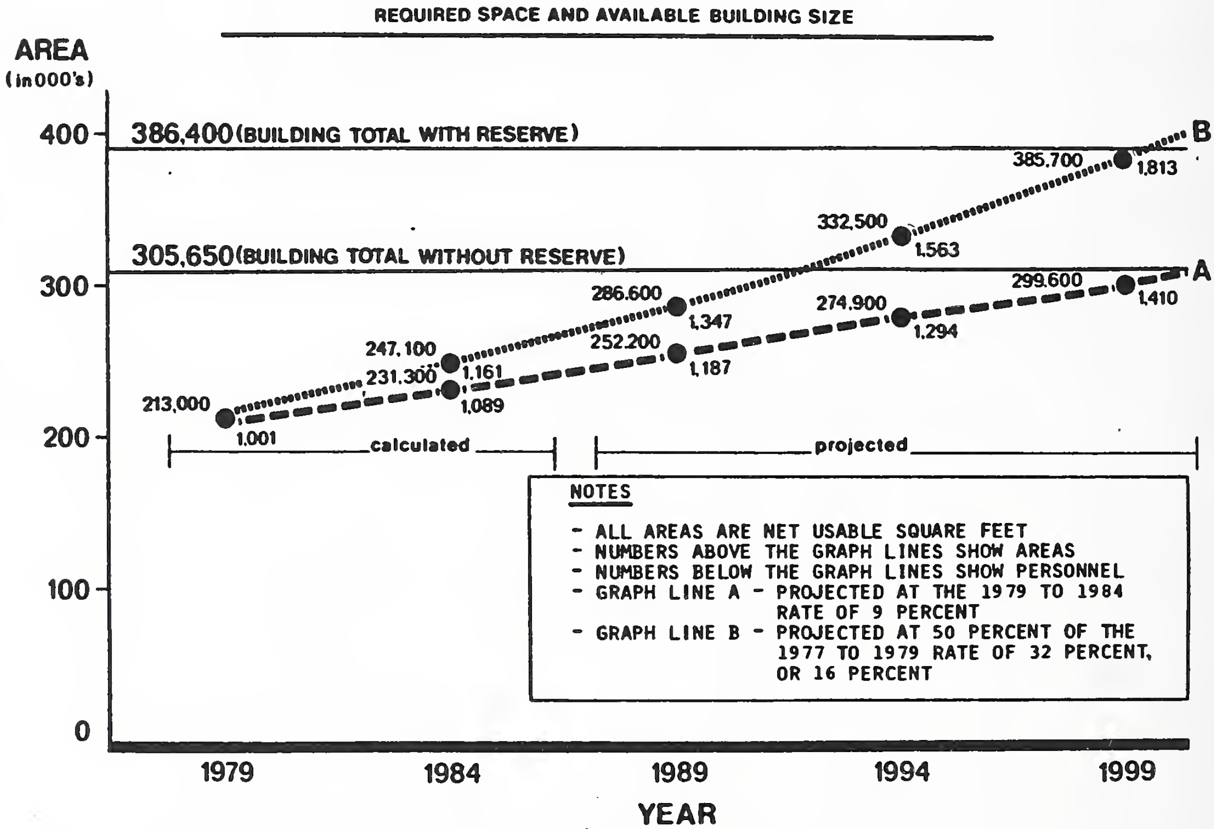

Figure 11. Required space and available building size

WORKSTATION ENVIRONMENTAL FACTORS - THE 1990s - THE DECADE OF THE ENVIRONMENT

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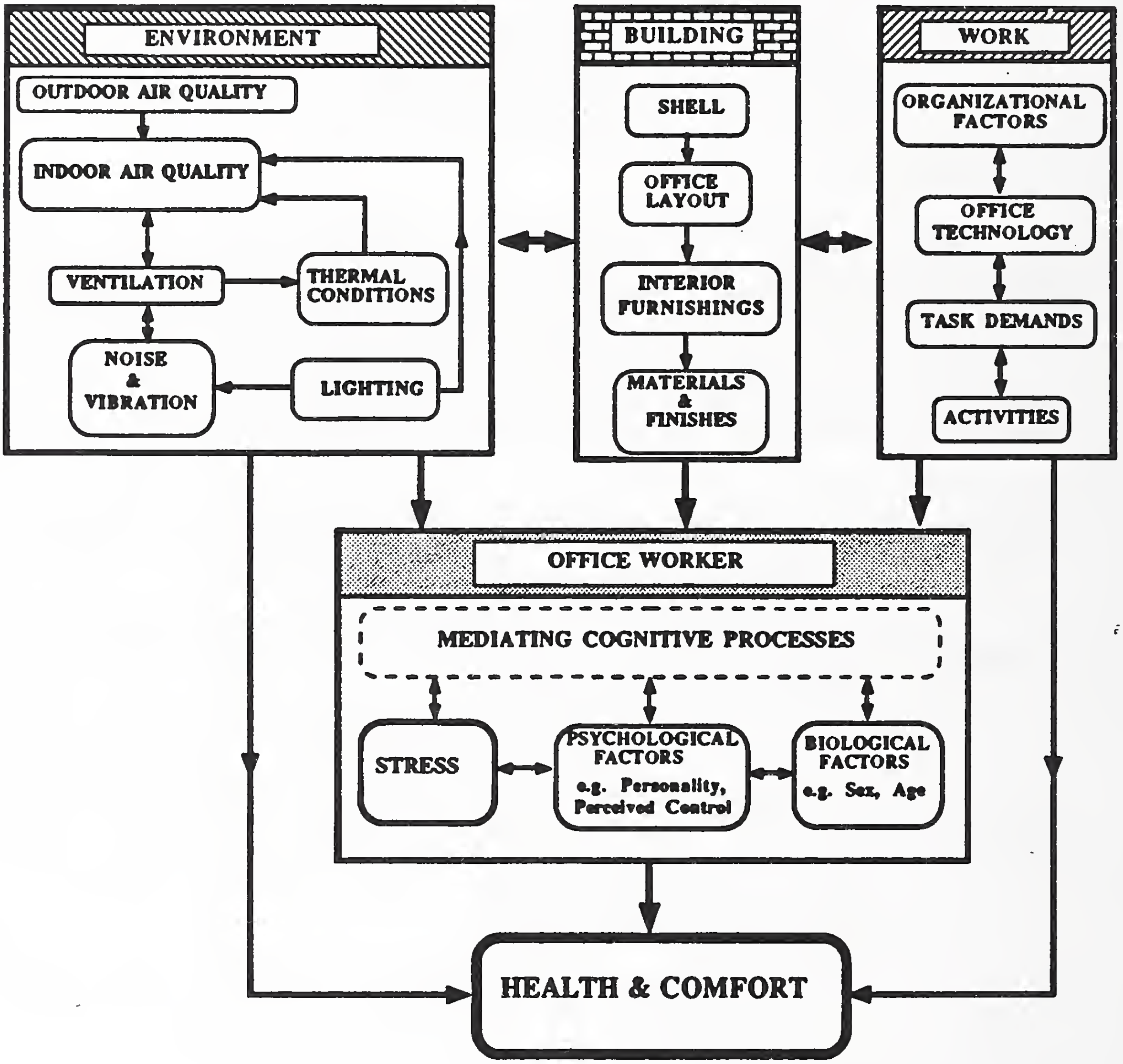
1. Background

The 1990s has been called the decade of health and the environment, and worker expectations regarding the conditions necessary to support healthful and productive working are rapidly changing. At the same time new demands are being placed on the office workplace by changing computer, communications, and office technologies. But many problems are accompanying these changes to the office and studies show that a large majority of employees frequently complain about their work environment.

The modern office can contain many physical and psychological stressors (Hedge, 1989: see figure 1). Physical stressors include poor lighting causing eyestrain, poor indoor air quality causing building-related illness, and poor workstation ergonomics causing musculo-skeletal injuries. Over 50% of office workers report problems of eyestrain. Complaints of building-related illness and sick building syndrome affect growing numbers of office workers. Cases of cumulative trauma disorders, such as carpal tunnel syndrome injuries among computer users, are increasing at an alarming rate. Anxieties are growing about the risks, real or imagined, of leukemia, brain tumors, and miscarriages associated with exposures to the electro-magnetic fields (EMF) generated by computers. Psychological stressors include anxiety about office risks, lack of control over physical conditions, inability to adjust workstation dimensions, and lack of visual and auditory privacy in poorly planned open offices. Stress reduces our body's capacity to fight infections, and increase risks of cardiovascular illness.

A successful office building is one capable of responding to the changing demands of new computer and communications technologies, as well as the growing needs and expectations of an organization's most valuable asset, their employees. (Figure 1)

Figure 1. Systems model of the office environment (Hedge, 1989)



2. Ergonomic Design of Offices

In an attempt to improve office productivity, information technology (computers and communications systems) has been widely introduced. The average company invests around $9,000 per worker in these technologies. Yet a proportional rise in white collar productivity has yet to be seen. Often the introduction of information technology has both negative and positive consequences. The negative effects invariably result from the poor ergonomic design of the workplace. To minimize these problems, the type of office furniture used to support computer technology is particularly important. Ergonomically designed office chairs should allow each person to adjust the seat and the height of the lumbar support. Ergonomically designed office desks should allow users to adjust the height of the worksurface, especially where computer keyboards are being used. Computer keyboard trays should allow for a negative slope keyboard to minimize the risks of carpal tunnel syndrome. Good workstation ergonomics allows the workplace dimensions to be tailored to fit each user's requirements in an integrated way.

In addition to adjustability of the physical dimensions of the workstation, users must be educated in how to make improvements to the ergonomics of their own workplaces. Many organizations continue to pay little attention to workstation ergonomics and how much this ignorance currently costs companies in general through reduced productivity and increased illness and absenteeism can only be guessed. Current estimates suggest that improving the ergonomic design of the office environment, including better design of the environmental conditions, may improve productivity by 10-15% (Sullivan, 1990).

3. Office Environment Conditions

Although modern offices usually appear to be clean and safe environments in which to work, a number of investigations have shown that a variety of indoor environmental factors can adversely affect the comfort, health, and productivity, of office workers. Among these factors those of lighting and indoor air quality are particularly important.

3.1 Office Lighting

Computer users frequently report problems with office lighting such glare on the computer screen and eyestrain. Research has studied the effects different lighting systems designed to alleviate these problems. Hedge (1991) compared the effects of direct parabolic lighting and lensed-indirect lighting on reports of comfort, health, and productivity by computer users. The results showed that the lensed-indirect lighting significantly reduced screen glare and other complaints about lighting; raised levels of satisfaction with lighting; reduced the incidence of complaints of eye symptoms; and increased self-reported productivity. Similar results have been reported in other comparative lighting studies (Sullivan, 1990; Krois et. al., 1991)

3.2 Ventilation and Indoor Air Quality

Indoor air quality problems in office buildings are thought to seriously affect the health and productivity of many workers. Poor office ventilation may stem from poor maintenance and inappropriate operation of the ventilation system; from inadequate ventilation system design to cope with changes in occupancy and technology; and/or from poor planning of the office layout with respect to the office ventilation system. Given the high churn rate of many corporations, mismatches between the location of people and the location of the air supply to their workspace are commonplace. Several solutions to this ventilation problem have been tested.

3.3 Task-ventilation systems

A growing number of office buildings are being built with raised floors because of the greater flexibility in wire management which this provides. Access floors can also be used to route ventilation ducts or can even act as an air plenum. Task-ventilation systems use floor modules to deliver supply air to workers. The rate of air delivery and sometimes the direction of supply air can be controlled by workers. The floor modules can easily be relocated when the office layout is changed and this gives great flexibility in office ventilation. Task ventilation modules typically are the size of an access floor panel. There are several configurations of task ventilation modules but they often have a fan and in some systems a number of adjustable air supply diffusers. Research has shown that facilities managers and office workers react quite favorably to task ventilation (Hedge, Michael & Parmelee, 1990). Task ventilation modules typically cost between $100 - 300 per worker.

3.4 The Personal Environments System

Perhaps the most ambitious personalized ventilation system currently available is the Personal Environments System. This uses a personal environment module (PEM) fitted beneath the desk/worksurface of each workspace. Air is delivered to each PEM either by ducts running in a spine between the office partitions, or directly via a raised floor. The PEM is attached to the workstation and using a raised floor offers the greatest flexibility. Each PEM filters the air locally through an electromechanical filter, and continuously varies the amount of mixing of central supply air with local office air, depending on the temperature requirement of the occupant (e.g., when the worker is too warm, the PEM provides more cool supply air to the workspace, when the worker is too cool the PEM recirculates more of the warmer local office air). Because the air is filtered at the workstation, this local re-circulation probably does not create major problems of pollutant accumulation. Each PEM is controlled from a small desktop module and this gives individual control over air and radiant temperature.

The air temperature supplied to that workspace is controlled by varying the air mixing and radiant temperature is controlled by a floor standing radiant panel heater to the rear of the workstation that can be switched on or off to deal with problems of cold legs and feet. Air is supplied at face level to each user via two supply diffusers at each corner of the worksurface, and the direction of air delivery can be varied. Users also can control the rate of air delivery, the level of local task lighting, and the level of pink noise from a sound masking system built into the PEM, for improved individual acoustic privacy.

Finally, an infra-red motion detector senses when the workstation is vacant and switches the environmental services to a minimal level of operation, thereby reducing energy costs. This detector also senses when the workstation is re-occupied, at which time environmental services are returned to their previous settings to maintain occupant comfort. It has been calculated that if the PEM system improves productivity by 4%, the payback time is only two years. The first building to be fully equipped with a personal environments system recently has been completed and evaluative research is underway. The potential disadvantages of this system are its initial costs (over $1,000 per worker just for the PEMs) and the costs of re-organizing office layouts when PEMs have to be moved.

3.5 Breathing-zone Filtration systems

HVAC systems usually cannot swiftly respond to the presence of indoor contaminants released intermittently from localized sources. Breathing-zone filtration (BZF) systems are designed to protect workers from such exposures to intermittent and localized sources of chemical, physical, and biological contaminants. BZF augments the performance of the HVAC system.

Airflow 2000 is a BZF system comprised of a furniture-integrated fan-filter unit with a fiber pre-filter to remove larger particulates (20% efficient), a H.E.P.A. filter to remove smaller particulates and microbiological contaminants (99.97% efficient at removal of particles 0.3 micrometers diameter), and an activated carbon filter to remove volatile organic contaminants. Under user control, air is locally re-circulated through these filters in the worker's breathing-zone (30" to 84" above the floor) at each workstation. This continuous air movement also results in better mixing of office air with supply air and this reduces air temperature and lowers carbon dioxide levels. Hedge, Martin & McCarthy (1991) found that installation of a BZF system on 2 of 4 floors in a sick building resulted in significant reductions in particulate counts and significant improvement in perceived indoor air quality.

Because BZF systems like the Airflow 2000 system function independently of the HVAC system, they move with the office furniture. BZF systems add about $150 to the cost of a workstation and they offer an effective means of improving indoor air quality for workers without undertaking extensive renovation of the building ventilation system.

4. Conclusions

The technologies described show that it is possible to make major improvements in the environmental quality of offices. Because some 92% of the 45 year life cycle costs of an office building are personnel costs, such improvements in office environmental quality have important economic benefits by ensuring better comfort and health for workers and greater workforce productivity. As we progress through a decade where both the white-collar workforce and the gold-collar workforce of highly skilled knowledge workers will be in increasingly short supply, the environmental quality of offices will have a key effect on the success of personnel recruitment and retention, and consequently may be a major factor in the future success of the organization.

But there are no simple solutions. The complexity of modern office buildings exceeds the knowledge and skills of any single profession, and the creation and maintenance of healthful working conditions requires input from professionals in architecture, interior design, mechanical and electrical engineering, ergonomics, industrial hygiene, human resources, and facilities management.

Experience repeatedly has shown that when facility design is done in a piecemeal way, workers seldom show strong satisfaction with their workplace. Also, quick fix solutions often create additional environmental problems. Eventually, worker performance will be detrimentally affected and absenteeism and associated health costs may rise. Ultimately, workers will vote with their feet; turnover will increase and recruitment will suffer. Improving the environmental quality of the office is a priority for many organizations as they plan facilities into the next century.

Creating a workplace with high environmental quality is much more than designing an aesthetically pleasing space: it requires the successful integration of efficient space planning, ergonomic furniture solutions, and effective environmental conditions with individual and group needs, and those of the corporate culture. Designing healthy, creative and productive workplaces demands the successful integration of at least the diverse aspects shown in figure 2.

Investing in environmental quality creates workplaces which attract and retain top personnel, support productivity, and nurture the creativity of these highly skilled professionals in healthy and satisfying settings.

(A further discussion of the topic by this author, and other workshop participants, will appear in a companion publication containing the workshop proceedings (NISTIR 4802).

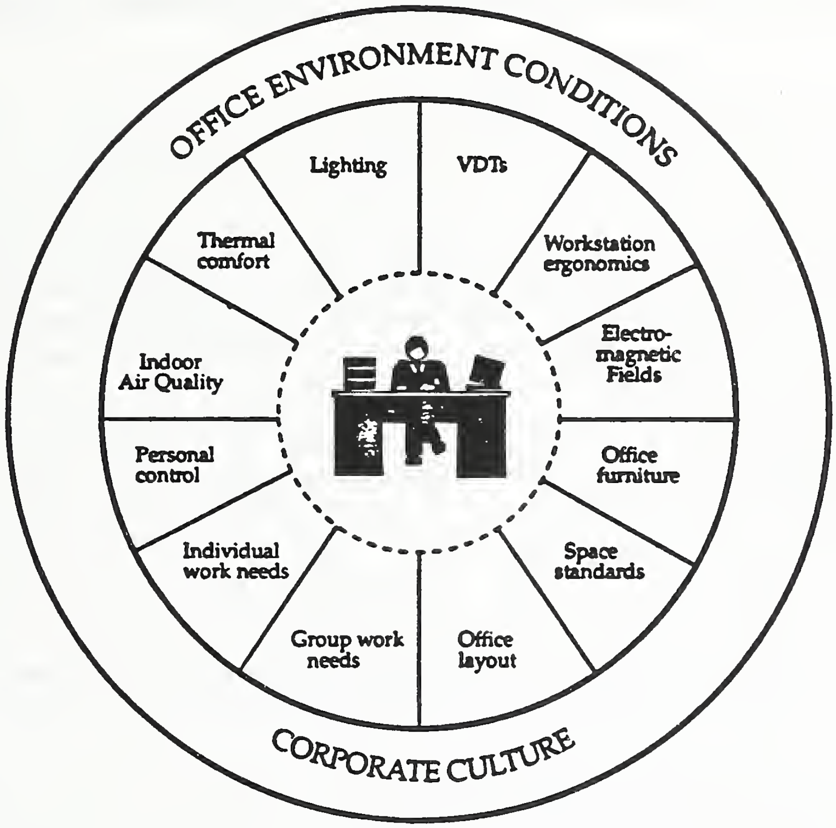


Figure 2. Office environmental and organizational factors which can impact on the worker

References

Hedge, A. (1989) Environmental conditions and health in offices, International Review of Ergonomics, 3, 87-110.

Hedge, A., Michael, A.T., & Parmelee, S.L. (1990). Improving thermal comfort in offices: the impact of underfloor task-air ventilation, In Proceedings of the 34th Annual Meeting of the Human Factors Society}, Vol. 1, Santa Monica: Human Factors Society, 537-541.

Hedge, A. (1991) Healthy office lighting for computer workers: a comparison of lensed-indirect and direct systems. Healthy Buildings - IAQ 91}, ASHRAE, 61-66.

Krois, P.A., Lenorovitz, D.R., McKeon, P.S., et. al.(1991) Air traffic control facility lighting, In Proceedings of the 35th Annual Meeting of the Human Factors Society}, Vol. 1, Santa Monica: Human Factors Society, 551-555.

Sullivan, C. (1990) Employee comfort, satisfaction and productivity: recent efforts at Aetna. In S.L. Sauter, M.J. Dainoff & M.J. Smith (eds.) Promoting health and productivity in the computerized office: models of successful ergonomic interventions}, Chap. 3, pp. 28-48, (New York: Taylor & Francis)

PLANNING CONCERNS FOR LIGHTING A LARGE OFFICE COMPLEX

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1. Background

The problems associated with lighting in the modern office environment center around the significant use of computer technologies and the associated ergonomic problems which are associated with prolonged view of the CRT screen. Not often mentioned, but in my opinion of equal importance, is the psychological impact of this environment and style of work on the worker's morale and therefore their productivity. I believe that as we automate our workplaces, packing personnel into ever more crowded and larger buildings doing more and more solitary work, the value of aesthetic design in providing for the needs of the individual becomes of equal difficulty and importance to solve as the very technical problems posed by the CRT screens and their associated visual and ergonomic requirements. The key is first to properly define the issues intrinsic to an environment of this nature and then to clearly create strategies for a team process aimed at positively solving not only lighting problems, but interior, architectural, acoustic, and thermal problems as well, in a cohesive manner.

Planning discussions for a large office complex often include concerns for technological advancement. It must be assumed that workplace requirements will change over the planning period due to technology changes. Additional questions are raised in terms of lighting equipment changes.

2. Changes in lighting technology

Over the past few years significant changes have occurred in the area of lamps, fluorescent ballasts, and lighting controls. New fixture designs are introduced annually, with changes being made in both the photometric performance of the fixture and its aesthetic appearance. While these advancements are of prime importance to the engineering of the lighting system, they have not truly resulted in significant changes to the actual provision of light. The conceptual means available to the design team for delivering light to the worker remain virtually unchanged.

The changes in lighting design technology have actually had much more impact on the final environment than any of the hardware advancements of the past twenty years. In the early days, predicting the performance of a lighting scheme was based upon very inaccurate mathematics and the experience of the designer. Even a year ago it was virtually impossible to predict the result a lighting system would have on a partitioned office environment. Only a complete full size mock-up would deliver the complete performance story. Today, with calculational improvements and the successful development of near field photometry, the designer can completely model all of the factors in the partitioned office in a manner allowing for exacting design of lighting intensity and distribution. Systems for computer graphic prediction of color rendering are in the works and are already beginning to be experimented with in actual lighting design applications.

Research over the past two decades has taken us into great concerns for not only the quantity of light but its quality as well. We have been through consideration of factors such as Equivalent Sphere Illumination. Research today provides the metric of Relative Visual Performance. Several legislative measures have been proposed and enacted in an effort to insure appropriate illumination in the office environment. These metrics all are attempts to express the obvious. Visual acuity, performance, and comfort are tied intrinsically to the intensity, distribution, color and pattern of light being appropriately balanced and composed within the environment.

These advancements are much more valuable to the project team in the planning process. Whatever changes occur in lamp, ballast, and fixture technology will have to be considered at the time of specification, but will most likely not affect the layout of equipment or decision as to design technique.

3. Office configurations and layouts

The configurations typical of the modular office, consisting of multi-sized workstations, clerical filing and support areas, conference areas, reception and lounge areas, and traffic paths indicates a modular approach to the lighting system design. Each area poses unique lighting problems which first must succeed on a micro level and then be integrated into the macro level without creating lighting and aesthetic problems within the whole. Virtually all methods of lighting can be designed to solve the micro problem of each area, but will behave radically different when it is attempted to combine the schemes into the macro environment. It is from the macro point of view that the schemes will perform in significantly different ways and primary choices will be made.

Each alternative method, layout, and fixture choice will affect the lighting quality within the visual environment and will modify the acoustics and architecture of the environment. Consideration of fixture surface, shape, and location must be made in conjunction with the acoustic and aesthetic plans for the environment.

When we plan the office we are often trapped in a false sense of design security as each discipline plans their system using the term "modular" and "planning module". It has been my experience that projects succeed or fail because of the success of the design in responding to inevitable breaks in the stated module. It is dangerous to carefully plan lighting for a group of CRT workstations and not to carefully consider the impact that adding a conference area or support zone, inevitably inserted at the installation time, will have upon the visual environment. Not only must the design function in the strict and regular world of the "planning module", but to be truly flexible, it must respond in a number of different configurations, many of which are not truly modular.

4. Visibility and visual comfort

Visibility and visual comfort are functions of contrast and color. I generally recommend that criteria for luminance contrast and color hold considerably higher importance than criteria for illumination or even luminance levels. If an environment is balanced in terms of luminance, much lower levels of illumination will still allow for equal visibility of the task material and equal, or in many cases improved, worker performance. Improvements in performance are attributed to the lower levels of glare and its accompanying eyestrain, and to the psychological factor of the environment being more "comfortable" to work in.

To balance luminance contrasts, a two pronged attack is used. We illuminate not only the obvious worksurfaces, but also the less obvious surrounding vertical and horizontal surfaces. The level of this illumination is also varied with the reflectance and texture of these surfaces, thereby resulting in a balanced and aesthetically pleasing result.

Color remains a critical consideration in the office environment. We do not operate in a black and white world. While most discussion of visibility in the US is centered on vision in a black and white field of luminance, significant differences have been suggested by researchers in Europe and the Orient. I have experimented with their data and conclusions and am generally in concurrence that the amount of visual clarity in an environment is more directly affected by the color rendering capabilities of the lamp than it is affected by the amount of illuminance or luminance. This phenomena has been used with success in our installations which have been fitted with the highest color quality lamps. These installations, also fitted with energy management and daylighting dimming controls, operate in general at lower illumination levels than if fitted with the more traditional cool white or even specification grade triphosphor lamps.

5. Ambient lighting

The first component of the system is to provide a scheme of ambient general light. This system should provide enough light for circulation between areas and general office maintenance tasks. If planned properly, the system can also visually reinforce the pattern and arrangement of workstations, support areas, and circulation aisles.

There are four basic equipment alternatives for the provision of this ambient lighting system: Recessed lensed and parabolic fixtures, suspended direct and direct/indirect systems, suspended indirect and indirect/direct systems, and systems using furniture integrated and/or freestanding indirect units. As stated before, all systems can be arranged successfully. The differences will become apparent in the application of the scheme to the planning module. If, however, the planning module is adjusted to work with the lighting module, all schemes will provide acceptable lighting. If on the other hand, the lighting must respond to a relatively fixed planning module and area adjacencies, certain schemes will demonstrate significant superiority.

6. Individual (task) lighting

The majority of the office environment will consist of individual workstations housing the individual, their computer (terminal), chair, a minimal desk with overhead cabinet, a surrounding low partition, and little else. Typical paper desk tasks require significant illumination levels generally in excess of 360 lux (35 footcandles). Each individual may or may not need this light and therefore local control of this light has an positive impact on energy consumption. For these reasons and due to the difficulties encountered in controlling shadows at the workstation worksurface, a locally controlled task light is required. This fixture should be provided with user controlled on/off, dimming capability, and ideally adjustment of focus and distribution. These adjustments provide the worker with exacting control over the quantity and specific location of the task lighting in their workspace.

Each individual works in different physical positions and has different visual requirements for lighting. Instead of trying to design for a "standard" worker, allow for the individual to tailor to their own needs. In a "paperless" environment, this workstation can reduce in size to as little has 65 square feet. Thus personalizing this environment by providing the worker with individual control over their immediate lighting has both tangible and intangible results.

Lighting the CRT in the workstation is relatively a straightforward geometrical problem. Visualizing the screen as a mirror which will reflect anything in its mirrored field of view simplifies the understanding of the problem. Since it is virtually impossible to design a functional work environment in which no luminous reflections are visible to the screen, it is best to attempt to provide a very uniform low level brightness to the screen. The final solution will involve not only the design of lighting position, distribution, and intensity, but the architectural and interior design of varied texture, hue and brightness of all vertical surfaces within the worker's field of view. Surfaces may be added or deleted within the field of view to allow for resting the eye.

7. Lamp selection

The choice of lamp is perhaps the most significant component of the system. New lamps are continually being introduced. The trend in fluorescent lamps is away from T-12 to the smaller diameter T-8 lamp. The tube configuration provides higher lamp efficacy. Because of its diameter it will also allow for more controlled and efficient reflector and lens design. From a maintenance point of view, the T-8 offers significant advantages. The T-8 lamp is only manufactured in higher color rendering versions. However, at this time the highest color rendering lamps remain in the T-12 family. We can expect this to change within the next few years.

8. Daylight integration

It is important that connection is made between the solitude of the computer workstation and the rest of the natural world. This is done in part by the introduction of daylight into the work environment. This must be carefully coordinated with the contrast balance of interior shape and finish, as well as artificial lighting. The rules of contrast balance must be adhered to in the use of daylight. Glass transmission values and chromaticity must be balanced with the rest of the building. Controls, consisting of photocells and dimmers must orchestrate the artificial lights to maintain the contrast balance throughout ever changing conditions. In addition to maintaining a productive visual environment, these controls will result in operational cost savings.

Scheme considerations must include: CRT workstation compatibility, energy conservation, flexibility, initial costs, life-cycle costs, integration with other building systems, worker health and safety issues, worker comfort and productivity, aesthetic value, maintenance, general functionality.

9. Lighting and the building module

The building module is very much affected by lighting and the specific choice of technique in a well planned project. The lighting is completely integrated into the space and its functional pattern. All too often the building module is determined exclusive of lighting. The lighting is then applied in a reactive manner to the architectural and interior design. Many times this reactive process can result in good solutions, I believe through luck as much as anything else.

I recommend that planning incorporate lighting from the onset, allowing a proactive process. In this process, prior to establishment of any modules, each individual discipline explores the options of their systems in both micro and macro viewpoints. Once this has been accomplished, architecture, interior design acoustics, HVAC, electrical, and lighting, each successful on their own micro level are integrated into a functional and aesthetically positive composition in the micro and macro viewpoints of the planning module. This process will result in continual change and adjustment by each member of the team and will most likely result in plans which have little resemblance to those solutions originally proposed. This new module will also result in a space which truly meets the needs of tomorrow's productive workforce.

(A further discussion of the topic by this author, and other workshop participants, will appear in a companion publication containing the workshop proceedings (NISTIR 4802).

HUMAN RESOURCE ISSUES IN THE OFFICES OF THE YEAR 2000

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In the global economy of the 1990's and beyond, human resources, not buildings, will be the competitive edge, both for companies and countries. Because of the economic competition of the information explosion, the quality and innovativeness of human resources will spell the difference. In the U.S., we have the richest mix of ethnic groups, racial groups, and global experience that the world has ever known and it is this richness of mix that is the potential for our survival.

But offices must do a better job of addressing new ways of organizing work, accommodating technology and expressing the personal values and aspirations of the people who work in them or we will not be able to capitalize on this mix to maintain our competitive edge. Our focus must always remain on the question, "How do we free or unleash the potential of our employees?"

We know that when work processes or physical places come before people, the result is stress, job dissatisfaction, poor mental health, and failure is inevitable. Therefore, building design or machine capability will not be the dominating feature of the effective work place. Human productivity requires a more realistic perspective than simply crowding more people into a designated space.

There is a message in the fact that as we look at the history of office design we find little change. Surely, there are more machines, certainly more information is available; however, the nature of work still involves getting together to solve problems around providing products and services in ways that remain fundamentally unchanged from decade to decade.

But the organizational attempts to utilize human resources will probably affect office design more than technology or building sciences because the real changes have only been in the handling of information.

The attempt to release workers to use the vast amount of information available has led to an effort to decentralize work places - to push decision-making further down into the hands of the organization rather than at the top. (This trend mirrors the global trends toward the collapse of dictatorships and collectives.) The trend in office design is clearly toward a decentralized, customer-oriented model where continuous learning, flexibility and change are the hallmarks.

We are already hearing about "self-managed teams," "autonomous work groups," many growing from the "quality of work life movements" of the 1950-60's.

This change in hierarchy and organizational behavior will have enormous implications for the configuration of workstations. There will be the need for:

- Project rooms where projects can be assembled by teams working together rather than in individual offices.

- Offices will be clustered with removal partitions to provide both privacy and the opportunity to work together.

- Greater access to information, linked to larger and larger networks, but not limited by where there happen to be electrical plugs because of building design.

- Moveable, collapsible, portable will become more descriptive of the furniture needed for these spaces.

- Teams will need to understand how to learn and practice together. How can work teams become more like athletic teams or art ensembles such as dance troupes, orchestras, etc.?

- Continuous training and development will become an intrinsic part of "work".

- Greater participation at all levels of management including facility design.

Because of the need for these highly developed skills and the declining birth rate in the U.S., the 1990's and 2000's will have the highest labor market in decades. We will be recruiting people who did not work in the 1980's - the elderly, the early retired, immigrants, more women, minorities in greater numbers, the handicapped.

Incidentally it has been said that the American Disability Act (ADA) of 1991 might be the most significant piece of legislation ever to affect the work place. Attention to the requirements of the ADA will lead to greater awareness of the need for accommodating work space.

- Work surfaces that raise and lower easily

- Wheelchair access

- Accommodations for the hearing impaired and the visually impaired such as sound amplified telephones and equipment that is identified by braille.

- Accommodating the mentally and emotionally impaired will require enormous creativity in management practices.

What about the impact of the aging workforce - people being needed in the workplace because of their sills and the slowed rate of trained young people entering the workforce? (In spite of the aging of our workforce, the U.S. will have a younger population than either of its competitors - Europe and Japan). Another paradox of the older worker is that the elderly have a per capita income higher than the average American. (They are 1/6 of the population but they own 1/3 of all household net worth and 40% of the financial assets, so competition for their services will be keen.)

Implications for the workplace:

- Many of the "young" elderly need to care for aging parents -- 300 companies have started programs to help employees care for the elderly.
- Brighter lighting because of poorer eyesight.
- More attention to ergonomics because of eyesight.
- Need for voice amplification on telephones and computers for the declining hearing acuity of the elderly - and the impact that will have on open office design.
- Better signage.
- Brighter colors because the lack of visual acuity.
- Greater contrast in colors on floor coverings to denote steps and ramps, etc.

With an increasing aging workforce, there is an emphasis on living longer - health becomes an issue. Insurance costs are skyrocketing so there is a resurgence of attempts at preventive vs. curative health practices in the workforce - wellness centers.

- Workplaces are setting aside space for weight training and aerobics, exercise, running/walking tracks, sometimes swimming pools.
- Because stress will continue to exist, there will be "meditation" or "cool off" rooms where people can go to be by themselves, and get away from the press of people and duties.

- Greater demand for healthy foods in the cafeteria (greater refrigeration spaces because of fresh foods - different counters for salads than for steam tables needed for salisbury steak).

- Ergonomic considerations.

Implications of women in workforce:

- DOT currently has 48%, expect that to be even higher (workforce 2000 report says 61% of women will be at work - making up 41% of the workforce) (may get as high as 8-10).

- Toilet facilities

- Daycare facilities probably will be needed for the younger employees because 75% of women are in prime childbearing years.

- These facilities might be in conjunction with those provided for elder care.

- More daycare and pre-school education will be heavily subsidized and regulated.

- Distinctions between male and female jobs will blur (decline) so furniture will need to accommodate a wider range of body size - such as the familiar label "secretarial chair".

- More employees will work parttime, have flexible hours and will perform at least part of their work from their homes
  - because women will need to integrate this work with childbearing and rearing.
    - This will continue even after children are grown because then families will have responsibility for aging parents.

An article in the Wall Street Journal is quoted as saying:

> *"The working woman is lifting millions of families out of the middle class".*

A large majority of the female employees will be single heads of households.

- More women in the workforce have contributed to a change in management philosophy from being "in control of an enterprise" to leadership in order to bring out the best in people, so they can respond quickly to change.

- Offices will reflect these changes by having fewer status symbols - such as corner offices, larger offices, private offices, etc.

- Supervisors and managers will be teachers, facilitators and coaches.

Implications for an increase in diversity in the workplace. (35% now at DOT)

During the next several years African-Americans, Hispanics and other minorities will make up a large part of the expansion of the labor force.

- We will see a continuation of a trend to emphasize racial and ethnic pride and culture.

- There will be more decorating of work spaces and a wider latitude in terms of what is permitted in offices. (A backlash against uniformity)

- Cognitive, emotional, and personality factors are other areas for greater diversity that must be accommodated.

- Cultural differences will become more obvious as more organizations move people across the globe.

Along with greater diversity of the workforce itself will be greater diversity of work patterns - longer hours, etc.

People are expected to be most flexible of all buildings systems. Yet we are not making the most of our most valuable and most expensive resource.

The office of the 2000's must have at its core the nature of human diversity, doing an enormous variety of tasks. The workspace must have the flexibility to accommodate that variety.

(A further discussion of the topic by this author, and other workshop participants, will appear in a companion publication containing the workshop proceedings (NISTIR 4802).

TRENDS THAT AFFECT THE DESIGN OF FURNITURE AND FURNITURE SYSTEMS

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1. Summary

The office furniture industry must achieve these goals: accommodate a diversity of technologies, people, and activities; reduce furniture life-cycle costs; increase office worker productivity - all with very high levels of aspiration.

A framework for doing that must be established. Within that framework, scenario-building can then prescribe the following trends:

- Trends in workstation furniture design: size, materials, flexibility, wire management.

- Functions that will affect workstation design in the future: seating.

- The effects of office technology on workstation components: design and configuration, size, accessibility.

- Issues such as accommodating the elderly, handicapped, and part-time workers.

The rest of this paper will, first, characterize a general problem statement, and then state it in detail from the customer's point of view. Next, we cite research that has observed partial solutions. We present hypotheses from research that explain the successes, and how those successes might be extended to other domains. Next, some design approaches are cited as starting points. Last, we present how research at Steelcase implements these approaches in terms of the above-listed trends.

2. Problem statement

"Productivity figures attest to this: non-manufacturing productivity . . . came to a virtual standstill in the mid-1970s" (Roach 1989:84). We see a flat curve, with slope essentially zero. Like quality, where even one component failing in quality leads to total system failure in quality [Q1 times Q2 times Q3 . . . = 0, if any Q is zero], continually improving productivity - as a first estimate - also looks like a multiplicative function. Failing to address even one factor in the system, "people, processes, and technology - including facilities," [People times Processes times Technologies times Facilities = 0 if any term is zero] leads to a failure to increase productivity.

Businesses are responding to the "office productivity problem" by developing a new practice called "re-engineering." This practice addresses the problem by re-designing the business processes in conjunction with the development of new information systems. By first improving a process, then using computers to complement it, the pitfall of having automated a preexisting, inefficient process is avoided (Hammer 1990).

Re-engineering is an important trend, but it neglects an important part of the equation: facilities.

In contrast, particular case studies support a management model that does account for facilities. In this model, building on core competence requires managing three concurrent themes over time and space: 1) project activities serving customer needs; 2) functional career development among peers; 3) re-engineering. Concurrent management of these themes requires both the mobilization and the dedication of people and other critical resources (Miller and Bloomquist 1991).

The evolution of our national infrastructures through the ages of farming, manufacturing, and now, an age where knowledge means wealth (Matsushita 1988:41, U.S. Senate 1989:179) brings us to the verge of a new generation of management practice. To account for all the elements in the model (above) this practice requires the foundation of an emerging, interdisciplinary science - one that addresses the "virtual office." [(The "virtual office" expands the "need for a behavioral science," as described in Brookes and Kaplan (1972:373).]

3. Observations from research: partial solutions

Observing work is the first step in a scientific approach, and in the case of the office furniture industry, observing must take the viewpoint of the customer. Add to that: the customer is a complex organization. Individuals, groups, and the firm itself are all entities that can establish a viewpoint of performance. In this sense, the "customer-centered" viewpoint must be focused on their "aggregate" unmet needs. These aggregate, unmet needs are: health, safety, and comfort; lower life-cycle operating costs; and productive [where "productivity" is defined as the ratio of output to input: p=o/i]. Customer-centered measures of performance must be understood in this "aggregate" sense. It means including the Chief Executive Officer (CEO). [In this paper, we cite only objective research observations, not opinions from surveys. The intention is to avoid having to consider the problem that what people say and what people do can be very different things (Johnson 1991)]

4. The customer viewpoint and an overview of this section

This paper addresses the customer's point of view as it is understood from "Concepts for a DOT Headquarters Building at Union Station": first, there is the desire for effective teamwork - a productive work force that works together. There is the need to solve transportation problems of enormous scope, from which comes the desire to attract workers who are the brightest, the most qualified, the most experienced, and the most creative available. They will be users of modern computer technology.

To satisfy that desire for intellectual productivity and effective teamwork in an environment with modern computer technology, there are certain trends to which the office-furniture industry must respond. They are described in this paper under the three main headings following this section-- "General Observations . . . ", "One Successful Approach . . . ", "Extending the Success . . . ".

In the first section, research is cited that helps us understand how to serve the customer's desire for a productive work force - one that works together and practices effective teamwork using computer technology. Next, that desire must be understood within the context of a problem-solving task with significant intellectual challenges: certain trends in work force composition and work group interaction are elaborated that show a connection between physical arrangements and the measured productivity of organizations solving such problems. Hypotheses are applied to the case studies used as examples.

The result is a trend toward Activity Settings (Stone and Luchetti 1985) or a modification of Landscape Planning (Brookes and Kaplan 1972), where space is used as a tool for team projects instead of being used as a tool for maintaining regional, organizational hierarchies. This implies a new paradigm in the process of laying out and arranging physical space. The office furniture industry must respond.

4.1. General observations of effective teamwork - a productive work force working together

There are general characteristics of white-collar work that must be understood in order to drive product design in furniture workstations. This section cites research about some of those characteristics. The research provides directions for product design and business practice.

4.2. Knowledge workers

Working together is the key trend that will enable knowledge workers to solve the problems of our future. Nobel prize winners collaborate more than those who do not win Nobel prizes (Shrage 1990:46). Product development organizations that adopt organizational designs based on high levels of collaboration compete more effectively in both time-to-market and productivity than those that do not (Clark and Fujimoto 1991:247-285). Generally: where the problem is to very quickly acquire, create, and apply knowledge to increasingly complex and unexplored frontiers, business cases indicate that a team having learned to learn together - having collaborated in learning - will penetrate the unexplored faster and more efficiently than all its competitors (Greene 1990:50,52).

Knowledge-workers also require times of private concentration (DeMarco 1987:35). In one case, a real-world study of knowledge workers captured this requirement, and the office design satisfied it. Productivity increased by 11% (Jones 1991:227).

All this forces a simple conclusion. For knowledge workers, both the need for intellectual collaboration and the need for private concentration must drive the design of productive offices.

4.3. Support staff

But 57% of white-collar workers are support staff, not knowledge workers (Roach 1991:84). Though our economy is right now losing a million of these jobs per year while gaining 400 thousand per year for knowledge workers (Business Week 1991:94), office trends must also accommodate this group and the way it will work. Projections by the Office of Technology Assessment imply that this portion of the white-collar staff may to some extent comprise a "growing contingent work force of part-time, temporary, and casual employees," where "flexibility for the firm comes through a smaller core of more highly skilled employees, coupled with contingent workers" (U.S. Congress 1987:255).

A social scientist tells the story of how, after a particular application of computer technology was adopted, office design was applied in an unsuccessful attempt to increase productivity in this group of workers (Zuboff 1984:138):

> *"One powerful means that managers used to communicate and enforce new patterns of conduct was the material organization of the office - the placement of people and furniture. . . . The line manager with direct responsibility for the office discussed the use of furniture to shape new behaviors . . . "*

In this case, management believed that stopping the behavior of talking while working at a combination of repetitive paperwork and repetitive computer work would increase efficiency. Furniture panels were used to isolate workers from each other so they could not talk.

Multiple complaints resulted, focused on "bodily suffering." In particular, there were complaints of "back pain." (Zuboff 1984:141) Zuboff's research supports a conclusion: office design for support staff - a group that is subject to becoming a "contingent work force" - cannot overlook the need for communication, as well as the need for physical comfort and safety.

4.4. One successful approach and hypotheses that explain the success

The office layout that McCue (1978) designed for software knowledge-work increased productivity by 11% (Jones 1991:227). This section presents some hypotheses about why. Research is cited that can be used as the basis for product design and business practice.

4.4.1. Organizational design

First are hypotheses about organizations dealing with large software projects. Due to the fine granularity in expertise - currently about 40 specialties (Jones 1991) - and the well-understood division of work required for large software projects, projects in that field of knowledge-work are effectively mapped onto traditional organization charts. That is, an attempt to map such an organization from a matrix point of view would simply draw the same traditional hierarchy twice, rather than drawing one set of functional hierarchies and another set of project managers, both having access to the same people.

This does not happen in every organization. For example, to map projects onto the traditional organization chart in a car industry where the organizational design is based on "heavyweight product-managers" (Clark and Fujimoto 1991:254), it is necessary to superimpose networks of teams over the functional hierarchies . A true matrix results.

However it happens, we want to consider a result similar to the way Churchill maintained his knowledge of World War II - he had a room he would go to for each theater of action. All the models, paper, and people that were working on that theater could be found by going there.

4.4.2 Projects mapped onto space - mobility between "theaters of learning"

When projects become mapped onto space, simple benefits result.

What is written on the boards remains on the boards. What is tacked onto the walls remains tacked onto the walls. Hardcopy relevant to the task remains in the space. Ad hoc meetings with variable numbers of participants supplement scheduled meetings because the space is always available. Coffee breaks become occasions to visit. Protocols for occupying, then evacuating, the collaborative space disappear. Meetings run as long as they have to.

The knowledge workers who are grouped around the collaborative space break away from meetings into their nearby private spaces to concentrate (see Oppenheim 1987). The privacy supports a state of "flow" in concentration (Csikszentmihalyi 1990, DeMarco 1987). About one sixth of their time [Software teams spend 50% of their time interacting (Hauptman 1986:6); 33% of that interaction is dyadic (Panko 1990:2)], they meet one-on-one with someone. It can be in their office or in the collaborative space. The physical proximity significantly increases the frequency of communication within the entire group (Allen 1977).

The learning that is inextricably tied to the group's mutual socialization, or "mutual enculturation," (Brown et al. 1989) maps onto the physical space around these collaborative spaces. That is, research has shown that individuals are more happy when they are with a group (Csikszentmihalyi 1990). This provides motivation to enculturate into a group, and research shows that individuals learn things tacitly as well as explicitly when they go through such a process of enculturating into a "community of practice" (Brown). This can be more effective than didactic classroom education. The office plan we are considering takes advantage of that more-effective kind of learning. The traditional layout paradigm - that maps the organizational chart onto physical space (Saphier 1968) - does not take advantage of that kind of learning.

This "project mapped" type of arrangement also permits new "interpersonal connections" for decision-making (for the importance of interpersonal connections, see March and Olsen 1989). In contrast to various project teams sequencing through a formal, central conference room making presentations, managers can walk around and socialize to make decisions - using the fact that the knowledge about a project is mapped directly onto physical space, not necessarily mapped onto a phone number or an e-mail address. Ad hoc viewings of the progress of the team can be had simply by going to the collaborative space, where physical memory is available on tackable and writable surfaces and in the materials kept there. Ideas that are physically displayed gain attention by the simple probability of visits by key people. Probabilities like this activate ideas in memory (Anderson 1991:91). The ideas are less likely to be forgotten when it's time for a decision.

These are hypotheses about what has worked in this case to increase productivity by 11%. How might these hypotheses be applied to collaborative knowledge-work in different fields, that are not as well understood, or as amenable to planning as is software engineering? What happens, say, when team members of various skills are gathered from different functional hierarchies, and the teams develop products and components for cars, as described by Clark and Fujimoto (1991)?

4.4.3 Extending the success to other domains

Take Clark and Fujimoto's description of the high-productivity, "heavyweight product manager" development organization (253-285). In this organizational design, the product manager's authority spans various teams who are working on the product. The teams exist within various functional hierarchies. It is a matrix.

The functional managers in each hierarchy are responsible for the "capability development" of their workers, but the product manager is responsible for the product, which is the actual content of each of his team's work. The model drawn (254) shows that more than one product team might be active in any functional hierarchy, each team working on a different product, each with a different product manager.

Clark and Fujimoto talked with some heavyweight product managers (261).

> "*I seldom stay around my desk. There are so many places I have to visit personally. Since I am asking other engineers to do favors for me, I shouldn't ask them to come to me; I should go talk to them. This job cannot be done without wearing out my shoes.*
>
> *I hold a brief meeting with some five assistants in the morning on project status. After that, I leave my desk mostly. It is not rare for me to go over to product engineering and chat with the young people there.*
>
> *I am walking around functional units for coordination and liaison during the daytime, asking questions, and cheering people on. I come back to my desk only in the evening.*"

Though Clark and Fujimoto did not study the physical environments of these knowledge workers, it seems that areas are required to support one-on-one interactions, and that physical mapping of the teams' collaborative knowledge-work onto dedicated collaborative spaces would help. As the product managers walk about, persistent displays of knowledge-work in each collaborative space would accommodate the variation in their times of appearance.

There are problems, of course. When the collaborative spaces are to be dedicated to particular projects, variations in when teams are formed, team size, and how many products are being worked in parallel create a complex problem in allocating collaborative spaces with closeby individual spaces. When individuals within the functional hierarchies are multiplexed between projects, the problems of allocation become even more complex. Concepts like activity settings (Stone and Luchetti 1985) become attractive as solutions for mapping projects onto space.

If the office environment is finally made flexible enough to match all these requirements - additionally accommodating the presence of new types of computer technology - a parallel flexibility is required in the process of laying out and changing the office arrangement. To apply what has worked to increase productivity in software engineering will require a new paradigm.

4.4.4 Design approaches to solving the problem - space planning

Clark and Fujimoto (1991) describe a trend toward the heavyweight product manager design of certain organizations. Their data show that this may be the most productive way to develop products in the car industry. In such a design, they anticipate that a "working engineer is allowed to work on more than one project" (284).

This trend is a challenge to the office furniture industry. When looking at a diagram of the organization chart, we could see the product-oriented organizational design as a number of superimposed networks of teams that cut across the traditional, functional hierarchies - the matrix. Now there seem to be two possible ways to map physical space.

First, there is the traditional way, which tells us this: when we think about the "organization chart . . . the ideal office layout is an extension into three dimensions of this chart" (Saphier 1968) - that is, consider the "adjacencies" of communication patterns, then place the traditional hierarchies onto the physical space.

But with organizational designs trending toward teams that are oriented to product development - and other kinds of knowledge-work - we could just as well say that the ideal office layout is an extension into three dimensions of the projects under a product manager. Thinking this way, we list projects under a product manager, and map them onto dedicated collaborative spaces with adjacent workstations - similar to McCue (1978). We can allocate space for team members and visitors around each collaborative space. We can call this a trend toward Activity Settings (Stone and Luchetti 1985).

We immediately get all the benefits that contributed to the 11% increase in productivity in our example. The challenge for the office furniture industry is to engineer systems that deliver the best performance for these applications at the lowest, lifetime cost.

This kind of challenge may seem too big to think about. But, again, consider the example. The number of knowledge workers affected by that facility change was 1000. Say the salary averaged $25,000. An 11% increase in productivity means $25,000 times 1000 times 11% - or about $2.5 million more, per year, of available knowledge-work.

If the problems an organization faces are large, and require creative solutions, that is a significant increase in capability.

4.4.5 Trends in workstation furniture design: prescriptions to match the above hypotheses

With all this said, trends in workstation furniture design become more prescriptive than descriptive. Some issues, like seating, are too complex to discuss here, and must be the subject of further communications. Other issues are covered in other papers (Cornell et al., Miller, Miller and Bloomquist, Weller, West, Zimmer and Cornell).

Size of the workstation becomes a question of lifetime cost traded off against measurable productivity increases. If we had the tools, we could test designs that balance the cost of square footage in a given configuration of private and collaborative spaces against the value in increased knowledge-work. If we had the measurements, we could prove the results beyond the field of software engineering. There is a need for these kinds of tools.

Materials will have to be recyclable.

Flexibility in collaborative spaces will have value even when applied to one group (Zimmer 1990). Flexibility also drives requirements of wiring and cabling support (Miller 1991). Technology as it affects the design, configuration, size, and accessibility of workstation components must also be applied without hindering flexibility. Our research project on computer-supported collaborative work (Cornell 1989) is one effort to understand these trends by experimentation. The idea addresses user re-configurability within clusters.

Trends in wire management are that users are demanding greater flexibility, lower lifecycle costs, easier installation, and change management. There is an accelerating acceptance of fiber optics to the desk; this and the trend to unshielded twisted pair is reducing the usage of coaxial cable and shielded cable. There is great interest in wireless LANS, both radio and optical; there is furious development activity by suppliers, but it's too soon to predict the outcome. Power requirements, now at 3 to 5 watts per square foot, are going to 8 to 10 watts per square foot around 1995. (Weller 1991) A new utility called Local Operating Network that manages power and other utilities heralds the concept of "intelligent furniture systems" (Miller 1991).

None of this should be done without considering the elderly and the handicapped worker. Adjustability has been established as the requirement that accommodates technology such as wheelchairs (West). We can expect that such technology will evolve. To deal with these evolutions, CAD tools that account for all ergonomic limits must be the rule. Virtual reality is one answer.

In fact, user visualization and simulation will be required to design the space and evaluate its intended operation.

5. Conclusions

We have recommended directions in the office furniture industry. The recommendations are based on cited, objective observations and hypotheses gathered from research. A case study of a certain type of organization and task shows that physical arrangements have increased knowledge-work productivity by 11%. Research provides hypotheses about why this happened, and how the benefits might be carried over to other types of organizations. Achieving the benefits requires that the office furniture industry respond by observing, objectively, from the customer's viewpoint on performance.

Further, we believe that fundamental changes in work, work processes, and technology will require a new response from space planners and facility managers, as well as the office furniture industry. Here is the challenge: work in offices will move toward knowledge-work, organizations will re-engineer themselves, and computers will become ubiquitous- all this, in a time when global competition will unquestionably drive us to understand "the growing value of knowledge" (U.S. Senate 1989:179).

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References

Allen, T. "Managing the Flow of Technology". MIT Press: Cambridge, MA, 1977.

Anderson, J. "The Adaptive Character of Thought." Lawrence Erlbaum. Hillsdale, NJ, 1991.

Brookes, M. and Kaplan, A. "Office Environments: Space Planning and Affective Behavior". Human Factors, 1972, V.14. 371-391.

Brown, J. S., Collins, A., Duguid, P.. "Situated Cognition and the Culture of Learning". Educational Researcher. January-February, Business Week, October 21, 1991. p. 94.

Clark, K. and Fujimoto., T. "Product Development Performance: Strategy, Organization, and Management in the World Auto Industry." Harvard Business School Press: Boston, MA, 1991.

Cornell, P., Luchetti,R., Mack, L., Olson, G. "CSCW: Evolution and Status of Computer Supported Collaborative Work". Cognitive Science and Machine Intelligence Laboratory. University of Michigan, 1989.

Csikszentmihalyi, M. "Flow: The Psychology of Optimal Experience". Harper: NY, 1990.

DeMarco, T. and Lister, T. "Peopleware: Productive Projects and Teams". NY, Dorset House, 1987.

Greene, R. "Implementing Japanese AI Techniques: Turning the Tables for a Winning Strategy". McGraw Hill: New York, 1990.

Hammer, M. "Reengineering Work: Don't Automate, Obliterate". Harvard Business Review. July-August, 1990.

Hauptman, O. "Floor Lay-out for Effective Software Production: Appying the Implications from the Optimal Communication Pattern of a Software Project Team". MIT Sloan School of Management, Management in the Nineties Project, 1986.

Johnson, V., From the 3M Meeting Management Institute: "Computers and People- Technology Poses New Responsibility for Managers". Successful Meetings Magazine. NY, August, 1991. .

Jones, C. "Applied Software Measurement: Assuring Productivity and Quality". McGraw Hill: NY, 1991.

March, J. and Olsen J. "Rediscovering Institutions: The Organizational Basis of Politics". Free Press: NY, Page 45 and Chapter 3, 1989.

Matsushita Electric Works, CRS Sirrine, "Officing: Bringing Amenity and Intelligence to Knowledge Work". Libro Port Co.. Tokyo., Japan, 1988.

McCue, G. "IBM's Santa Theresa Laboratory-- Architectural Design for Programmer Productivity". IBM Systems Journal. V. 17, no. 1. p. 462, 1978.

Miller, W., "Utilities Structure and the Intelligent Furniture System". Steelcase, Inc.,1991.

Miller, W. and Bloomquist, L. "Concurrent Management. Working Paper". Steelcase, Inc., 1991.

Oppenheim, L. "Making Meetings Matter: A Report to the 3M Corporation". 3M Meeting Management Institute. Austin, Tx., 1987.

Panko, R. . "Patterns of Organizational Comunication". (Presentation at the 1990 OC3 Conference in Austin Tx). University of Hawaii, 1990.

Roach, S. "Pitfalls on the "New" Assembly Line: Can Services Learn From Manufacturing?" Morgan Stanley. NY, 1989.

Roach, S. "Services Under Siege - The Restructuring Imperative." Harvard Business Review. September-October, 1991.

Saphier, M.. "Office Planning and Design". McGraw Hill: NY, 1968.

Shrage, M. "Shared Minds: The New Technologies of Collaboration". New York: Random House, 1990.

Stone, P., Luchetii, R. "Your Office is Where You Are". Harvard Business Review. V. 63. No. 2, 1985.

U.S. Congress. Office of Technology Assessment." International Competition in Services". OTA-ITE-328. Washington, DC: U.S. Government Printing Office. July 1987.

U.S. Senate. Committee on Commerce, Science, and Transportation; Subcommittee on Science, Technology, and Space. National Science and Technology Policy. 101st Cong., 1st sess., 1989. S. Hrg. 101-580.

Weller, G. "Perspectives on Wire and Cable Management." Steelcase, Inc., 1991.

Zimmer, L. and Cornell, P. "An Examination of Flexible Group Work Spaces in the Open Office". Proceedings of the Human Factors Society 34th Annual Meeting, 1990.

Zuboff, S. In the Age of the Smart Machine: The Future of Work and Power. Basic Books: NY, 1984.

PERSPECTIVE OF WORKSPACE TECHNOLOGIES FOR FUTURE PLANNING

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1. Background

Since the development of the first office workspaces, the functions/routines of office workers - both management of staff - have been relatively stable. Notwithstanding the changes in technological devices, the efforts are stable in terms of office work process and how office workers need to deal with information. More simply put, the routines of collection, manipulation, sampling, crunching, collating and displaying the information results have not basically changed, only the tools employed to perform the tasks, along with the volume of information available to the individual.

What has changed rather dramatically and with increasing frequency are the technological devices employed to perform these routines. What is presented here is a perspective of both the routines and the evolution of the technologies in order to provide a forecasting mechanism for workspace planning.

One way to think about "office workers" is to view them as managers, processors, and transcribers of information throughout the various levels of any information. These routines are practiced by all employees, from clerks to presidents, with varying degrees of information content and requirement. Automation of these routines may exist only at the clerical level, or may extend to the top of the organization.

Changes in technology and the nature of the tools to execute routines will have impact at three levels:

2. Impacts on changes in technology and tools

2.1. Direct impact on the user, user training, career pathing, recruitment, organization, personnel policy and organization, management of information, content and systems, goal achievement and measurement, etc.

2.2. Direct impact on workspace size and configuration, ability to support the devices and handle moves and changes, upgrades, connectivity, occupancy cost, adjacencies, free addressing and occupancy multi-usage, plus all the human factors associated with quality of space/air/safety and contributions to workspace environments.

2.3. Impact on building structure, shell and core issues directly affecting and supporting both users and their selected technologies, i.e. floor systems, risers, power distribution, equipment space, distance limitations, etc.

Changes in the nature of the tools, technology devices, and software can be represented as changing over time by organizing our vision of devices in three broad time elements (Table 1):

Yesterday 60's	Today 80's & 90's	Tomorrow Future
Calculators	PC's w/spreadsheets	Natural language interface
Typewriters	Word Processing	Speech to text
Mainframe/ Dumb Terminals	Data Frames Workstations Workgroups	Integrated Networks Local/wide
Message Slips Message Centers	E-Mail Voice Mail	Video mail
Switchboards	Automated Attended	Personal Communication
Paper filing	Disk storage	Imaging
Accounting Ledgers	Lotus 1-2-3	Multitasking
Post Office	FAX Federal Express	Video networks Networked systems Direct transfer
File folders	PC memory	Image processing

Table 1. Changes in information transfer

3. Perspective on technologies

Technological advancements and changes in office automation and planning for the increasing amounts, complexity and type of user technology is becoming an integral part of building and workspace design. The trend in information and telecommunications technology is to deliver increasingly sophisticated services and capabilities to the desktop. With the increasing numbers of terminals, intelligent workstations, and complex telecommunications services found in modern offices, the entire building is becoming a "computer center". The design, development and construction of the buildings' interior and work areas require some of the same considerations that apply to computer data center design. The key to the success of the future building design will be the provision for sufficient flexibility, functionality and adaptability to accommodate tomorrow's technology without literally tearing the walls down.

3.1 Industry trends

3.1.2 Communication systems

Technology forecasts and industry trends suggest that voice, data, image and text will be handled via combination of very high speed/fault tolerant versatile systems and services including PBX's, computers, gateways, bridges, routers, controllers, multiplexors, servers, local area and wide area networks via a fiber backbone as well as radio and satellite platforms with interconnectivity to multiple host computer systems.

3.1.3 Design implications of more electronic devices

The ratio of people to distributed electronic devices can be expected to grow from to at least a 1:1 ratio or greater by the high volume users in the work area. These include stand-alone and linked personal computers (PC's) of all types and sizes, powerful terminals, workstations, printers, all of which will be driven by interconnecting networks, each with their own speeds, protocols and capabilities while managed by a single network management system. The result will be a continuing increase in distributed heat load and power consumption both in the data center, distributed computer rooms, distributed wire/cable closets, and at the workstation.

3.1.4 Space implications

Advances in computer technology, in the form of electronic compression of hardware will decrease the space requirements or "footprint" for a given capacity of direct access storage (DASD), expressed in gigabytes (millions) or central processor units (CPU) expressed in MIP's (millions of instructions/second), and tape media expressed in characters per inch density.

3.1.5 Support spaces

There is a continuing trend of additional needs and soft-ware complexity of applications which translate to increases of physical devices. This results in increased space, heat load and power consumption. The industry data center ratio of raised floor areas to electrical/mechanical support areas have been typically designed at a 3:1 ratio. That ratio is steadily narrowing to a 2:1 ratio to accommodate mainframe product requirements. There have been longer term forecasts predicting a 1:1 relationship.

3.1.6 Disaster recovery of data

There is increased management attention regarding disaster recovery and backup of operations and data base systems in the building design not only in the data center environment but also at the workstation including automatic backup at the device and server levels. Buildings with mission critical functions are considering enhanced interface with remote hot sites, facilities, sophisticated and high speed networks, monitoring of all control functions (central and remote) including the building management system, security, life/safety, fire protection systems, and certain operational computer and network systems (whether internal or outsourced).

3.1.7 Connectivity

Special attention is being focused on connectivity of wire/cable from the building to the various communication lines, services, etc. including redundant service line sources directed from different central offices with independent grids.

4. Design impacts and flexibility

Support requirements for the systems overlap several disciplines and can severely impact the building core and shell design. The building infrastructure must provide for the flexibility to accommodate migration of personnel, office layouts, system obsolescence as well as a broad array of moves, adds and changes to user system requirements/applications, wire/cable, devices, connectivity, furniture and fixtures.

The key systems and technology attributes causing change include:

- The major changes in communication network technology, protocols, speeds, media options and standards as well as the ability of these networks to interconnect and "talk with" each other.

- Distributed systems architecture which places increasing complexity, problem solving and communication capabilities at the workstation level.

- The integration of technology and interaction with the base building systems and sophisticated intra and inter-building backbone wiring schemes.

- The ever increasing need for cost effective and timely relocation of personnel and technology components within their space.

- The need for users to replace part or all of their systems in order to avoid technological obsolescence and satisfy user demands.

All of the defined system will in turn be dependent on the building's ability to provide an adequate supply of air, power, distributed closets, special accesses, shared information services areas, riser and plenum capacity, etc. With each approach there are a multitude of facility issues that must be addressed to support the selected options as noted below.

4.1 Computer resources

- Technology impacts and hardware/software migration and volume growth.

- Distributed computer rooms and departmental shared information oriented work areas

4.2 Communications

- An array of communications will include data, voice, image, covering user applications, security, building management systems, life safety, operational control/diagnostic centers, help desks, etc.

- Multiple communication systems may include satellite, microwave, local area networks (LAN), broadcast and paging systems, video conferencing, wide area networks (WAN), PBX,
Centrex, voice response units (VRU), high frequency radio, cellular, wireless systems, etc.

- Multiple communication services from telephone companies, bypass vendors, outsourced private and public networks, cable television, etc.

4.3 Wire management

- Wire/Cable horizontal and vertical distribution and connectivity including closets, risers, wire trays, conduit and plenum distribution.

- Ceiling, raised floor, wall, and duct distribution.

- Standard connectors, receptacles, termination blocks frames, panels and smart hubs.

- Physical and logical wire/cable management systems, labeling conventions and tagging,

- Wire/cable type, quality, characteristics, shielding and collocation.

- Integration of information-based services with other building wire/cable based systems.

- Intra-building cable backbone, interfaces and access methods.

4.4 Connectivity

- Connectivity is dependent on both physical and logical protocol standards and speeds.

- Wire/cable connectivity is dependent on bandwidth requirements and connector standards.

- Interfaces between computer and device resources is accommodated via routers, gateways, bridges, servers, multiplexors, controllers, data switches,

- Incoming/outgoing media for data and voice communication services will change the conventional methods for termination in building service entry vaults.

4.5 Facilities

- Redundant Uninterruptible Power Systems (UPS) and emergency power.

- Redundant air conditioning units, chillers, pumps and cooling towers for data center.

- Special lighting controls, power source and capacity, dedicated circuits, grounding.

- Special fire protection and suppression systems.

- Special purpose furniture, fixtures and cabinetry.

- Special adjacency needs related wire/cable distribution to closets, risers, computer resources as well as system and proximity requirements.

- Utility and clean power requirements can amount to from 600 to 1200 watts per workstation or 5-6 watts per square foot (not including lighting).

- Special grounding systems with emphasis on harmonics and other power criteria.

- Shared facilities strategically located throughout the building with special wire/cable, receptacle, and connectivity requirements to accommodate end user requirements including rooms such as project, conference, video studios,convenience, printer/copy, terminals, and computer peripherals.

SPECIFICATIONS FOR THE SUPPORT OF TECHNOLOGY IN FURNITURE SYSTEMS

1. Space

The furniture system should have a shelf or tray designed to accommodate a typical personal computer chassis so that it is off the worksurface and yet easily accessible to the user when seated at the keyboard. This shelf or tray should:

- Be horizontal or vertical and should ideally be located under the worksurface. The following dimensions are for a generic personal computer chassis:

    - Horizontal 203mm H x 610mm W x 508mm D (8" H x 24" W x 20" D)

    - Vertical 610mm H x 203mm W x 508mm D (24" H x 8" W x 20" D)

- Be open in both the front and rear to allow for ease of installation and ventilation.

- Be positioned so that the rear edge is at least 305mm (12") from the panel at the rear of the worksurface.

- Be able to support a minimum of (?) pounds.

- Have and access panel for access to the on/off switch.

- Have an access panel in the worksurface for reaching cable connections of the personal computer chassis. This panel should extend from rear of shelf to the rear of the worksurface and match the width of the shelf.

The furniture system must provide a PC monitor mounting, preferably off the worksurface, that is adjustable in all directions. The mounting should:

- Be capable of holding a monitor that is (?)" H x (?)"W x (?)"D.

- Be capable of supporting monitor weighing approximately (?) pounds.

- Have the capability to have a full range of motion in all directions, including tilting up and down, so that the primary viewing area of the monitor is between zero and sixty degrees below the plane passing through the eyes of the operator.

- Be centered in relation to the position of the user.
- Be located no more than 1.22 meters to 1.83 meters (4' to 6') from the computer chassis.

The furniture system worksurface must have sufficient depth to accommodate the following personal computer accessories:

- A digitizing pad approximately 432mm x 356mm (17" x 14"). It must be able to be located to either the right, left or center of the worksurface when facing the monitor.

- A personal computer keyboard, up to 559mm W x 229mm D (22" W x 9" D), located at the worksurface center when facing the monitor. The area where the keyboard is located should be adjustable for height, tilt and distance from the user and should (optionally) incorporate wrist rests as part of the design.

- A personal computer mouse and mouse pad approximately 229mm x 203mm (9" x 8"), located directly adjacent to the keyboard for both left and right handed users.

- A laser printer with multiple paper trays, positioned so that the paper trays can be changed without moving the printer. The approximate dimensions of the printer are 508mm W x 610mm D (20" W x 24" D.) The clearance required to remove the paper tray is approximately 508mm (20").

2. Power

The furniture system must:

- Have the flexibility to deliver a full 20 amp dedicated isolated ground circuit to every workstation.

- Have the flexibility to share a 20 amp dedicated isolated ground circuit with two to four workstations (four is maximum).

- Provide separate dedicated clean power (isolated ground) circuits in addition to shared circuits for convenience power.

- Provide a minimum of two duplex outlets for the clean power.

- Have the flexibility to located these outlets above or below the worksurface in 152mm (6") increments.

- Providing protection from Electro Magnetic Interference (EMI) for the voice and data cables that could be installed in the same raceway.

- Provide the option of using pre-wired electrical distribution systems or being field engineered and using other means of electrical distribution.

- Provide a set of switches, located conveniently for the user when seated, to turn on or off all of the technology equipment at once or selectively turn on or off individual pieces of the technology equipment.

- Be constructed of anti-static material to prevent injury to the user or accidental damage to the technology equipment.

- Provide (optionally) built in surge protection for technology equipment.

3. Voice and data cable distribution

The furniture system must:

- Have the capacity of delivering a minimum of three 4-pair cables and one fiber optic cable to each workstation (with up to four workstations joined in common cable runs).

- Each 4-pair cable has an outside diameter of approximately 483mm (19").

- Each fiber optic cable has an outside diameter of approximately 6mm (.20").

- The fiber optic cable will require a minimum of a 2" bend radius wherever the cable changes direction (including the connection to the raceway).

- Provide a knockout or opening for a communications outlet with the capacity to accommodate four separate connections. An alternative would be to provide two knockouts or openings with two connections each.

- Be compatible with other manufacturers of voice/data outlets, such as the AMP communications outlet.

- The raceway depth must be at least 76mm (3") to accommodate standard types of outlets and connecting hardware.

- This same 76mm (3") depth will be required wherever the voice/data outlet is located, i.e., in the panel just above or below the worksurface.

- Have protection from EMI caused by power distribution within the same raceway.

- Have the capability of distributing cable so that outlets can be located just below work surface, in the raceway near the floor or any other location that might be necessary in 152mm (6") increments (above and below the work surface).

- Have the flexibility for reconfiguration so that existing cables can be reused without retermination.

- Utilize connections at the entry to the raceway or panel that are capable of locking in some fashion to prevent accidental disconnection or exposure of communication cables.

4. Cable management

- There are three type of cables that must be managed within the workstation. They are power cables, equipment to equipment cables and equipment to communications outlet cables.

- The management of these cables can be accomplished with a system that routes the cables under the worksurface or with a channel or tray at the rear of the work surface. If a channel or raceway is used it must provide a minimum of 3871 sq mm (6 square inches) of space and have a cover.

- Power cords must be managed and routed separately from equipment and communications cables.

- If the route of the power cables parallels any communication cables, protection from EMI must be provided.

- The furniture system must be able to accommodate the following types of computer cables:

    - Printer cables - outside diameter approx. 12.7mm (1/2")
    - Monitor cable - outside diameter approx. 9.5mm (.30")
    - Mouse cable (digitizing pad cable) - outside diameter approx. 6.4mm (.25")
    - Network connection - flat cable approx 6.4mm (.25") wide
    - Telephone connection cable - flat cable approx. 6.4mm (.25") wide

- Access grommets must be at least 63.5mm (2 1/2") in diameter to accommodate cable connectors.

5. Storage

The furniture system must have storage areas for the following types of computer supplies and accessories:

5.1. 133.4mm (5 1/4") and 88.9mm (3 1/2") disks

- Space should be enclosed to minimize exposure to dust
- Space cannot have any magnets
- Space should be lockable

5.2 Paper storage for personal printer

- 216mm x 279mm (8 1/2" x 11")
- 216mm x 356mm (8 1/2" x 14")

5.3 Storage area for additional paper trays for personal printer - 254mm x 406mm (10" x 16")

6. Reconfiguration

The furniture system must have the flexibility to reconfigure individual workstation with different features for different technology equipment without disturbing other workstations.
Examples of this type of reconfiguration are:

- Relocation of both electrical and communications outlets without disassembling other workstations,

- Installing different configurations of worksurfaces to accommodate different technology equipment.

- The furniture system must have the flexibility, during a major reconfiguration, to keep communications and electrical rewiring to a minimum. The installation of cabling should ideally be accomplished without the need to pull the cable through closed raceways. The system should allow the cable to be removed and reinstalled without retermination.

(A further discussion of the topic by this author, and other workshop participants, will appear in a companion publication containing the workshop proceedings (NISTIR 4802).

MAJOR DESIGN CHANGES FOR THE OFFICE OF THE FUTURE

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This paper has been adapted from two sources: a book entitled "The Japanese Approach to Tomorrow's Workplace" (Hartkopf et.al. 1991), to be available through Butterworth Publishing; and an article "The Intelligent Office" (Loftness, Hartkopf, and Mill 1990), published by Progressive Architecture, September 1990.

1. Introduction

Traditionally, the intelligent office building has been defined by the introduction of a long list of new products in telecommunications, electronics, security, automation and building control systems. Although the U.S. has been a leader in the development and packaging of high tech products and images, the buildings to house these technologies have not advanced significantly. Indeed, after 10 years of use, the original definition of the intelligent building has proven insufficient for prompting the productive high-tech work environments anticipated by building owners and building occupants today.

A better definition would stipulate: Intelligent office buildings will provide for unique and changing assemblies of recent technologies in appropriate physical, environmental and organizational settings, to enhance worker productivity, understanding, communication, and overall satisfaction. Three critical conditions should be demonstrated in new office design towards fulfilling the goal established in this definition.

First, the intelligent office building accommodates a compatible package of recent technologies, resolving the full range of hardware for managing:

- External signal propagation
- External power
- Telephone systems
- Internal signal propagation
- Computers - capacity, speed and networking
- Peripheral "inputters", processors and "outputters"
- Environmental management systems
- Personnel management systems
- Building management systems, including diagnostics and maintenance automation
- Command centers.

Too often architects rely on past knowledge of traditional telephone and power wiring that can be installed after design is essentially complete; far short of understanding the full range of technologies.

Second, the intelligent office building insures the appropriate physical and environmental settings for the range of hardware anticipated, thereby resolving the level of long term flexibility or adaptability needed in:

- Structure

- Enclosure - walls, windows, roofs, basement

- Building geometry, from massing to orientation to horizontal and vertical plenum space to overall spatial organization

- Major conditioning services such as heating, ventilation, and air conditioning, as well as power, lighting and fire

- Interior elements such as ceiling, partition, floor and furniture systems.

The 1985 BOSTI study (Brill, et al. 1985) and the 1985 ORBIT II study (Davis, et al. 1985) were the first to identify the building and organizational responses necessary to accommodate intelligent building products.

Third, in the intelligent office building these physical components are not only evaluated independently in relation to the range of hardware to be accommodated in the building, but in their integrated state, to ensure that all crucial environmental conditions are provided:

- Spatial quality, including physical safety and security
- Thermal quality
- Air quality
- Acoustic quality
- Visual quality
- Building integrity versus rapid degradation.

The "high tech" building must be evaluated for its suitability in accommodating the immediate electronic enhancements, as well as for its reliability and adaptability in accommodating future technologies and the anticipated level of long term user requirements. Recently, the National Academy of Sciences report on the Electronically Enhanced Office (NAS 1988) explored the relationship of intelligent building products and the physical and environmental responses needed.

To achieve these three conditions (indeed levels of innovation), the "intelligent" office building must reflect an unprecedented series of new steps in the buildings delivery process:

- A long term mission statement written with "expert" input anticipating the capacity for change

- Clear goals for short and long term budgets

- A team decision making process involving a range of experts with decision making power from the project's outset (for cost effectiveness and performance)

- A performance design and construction contract with testable specifications

- A controlled building diagnostics process for quality assurance through design and construction

- An expert commissioning stage, to lead into long term expert maintenance and operation

- A growing use of field evaluation techniques and user questionnaires (POE) to assess the overall performance of the integrated system for the building occupancy.

Most critically, however, the intelligent office building must clearly improve the quality of the workplace for the individual, representing a major philosophical change in office design. After all, what is the electronically enhanced office intended to facilitate, if not organizational effectiveness, worker speed, understanding, communication, productivity, and user well being?

2. An evolving list of major design changes

The Advanced Building Systems Integration Consortium (ABSIC) at Carnegie Mellon University is a university - industry cooperative effort focused on translating these critical conditions for creating the office of the future into a working list of building design and management changes. With knowledge of the expanding range of new technologies facing the workplace, ABSIC has distinguished fifteen new design directions, profiled in the following pages. These design directions are already in evidence in innovative buildings in various countries (see figure 1), and provide opportunities for developing new products and processes, and integrating them into the design of tomorrow's workplace.

2.1 Distributed versus central servicing systems

In Japan and in Germany, significant development has been made in distributed heating, ventilating, and air conditioning systems for servicing multiple work zones with independent controls. Multiple, distributed telecommunications networks also have undergone development. The multiple systems enable independent metering, independent time of use, and greater control in the face of constantly varying loads; and, if the distributed systems are modular and repetitive, very reliable maintenance. Although the emphasis has been on distributed prime movers, the opportunities for linking highly efficient central systems with decentralized equipment for local distribution and control are significant.

Major Design Changes Towards the Electronically Enhanced Office	Japan				Germany				United Kingdom			N.America			
	Toshiba	NTT	ARK Mori	[illegible]	[illegible]	[illegible]	IAM	[illegible]	Lloyd's	[illegible]	[illegible]	[illegible]	TRW	[illegible]	[illegible]
1. Distributed HVAC/PLEC systems	●	●	⊕	●	●	●	⊕	●	●	⊕	⊕	●	●	⊕	●
2. Distributed vertical cores for HVAC/PLEC	●	●	●	●	●	●	⊕	●	●	●	⊕	●	●	⊕	●
3. Innovative horizontal distribution	⊕	⊕	●	●	●	●	⊕	●	●		⊕	●	●	●	⊕
4. Fresh air architecture	⊕	●	⊕	⊕	●		●	●		●			●	⊕	●
5. Thermal balancing - envelope & interior		●			●			●	●				⊕	⊕	⊕
6. Daylight/artificial light balancing			⊕	⊕	⊕		●	⊕	●	●	●	⊕	●	●	●
7. Moveable tether, pigtail services		⊕			●	●		●	●			●	⊕	⊕	
8. Individual environmental controls		⊕		●	●	●	⊕	⊕	●	⊕		●	⊕		
9. New workgroup concepts		⊕			●	⊕	⊕	●	●		⊕	⊕	●	⊕	●
10. New workstation concepts		⊕		●	⊕			⊕	●				⊕	⊕	⊕
11. Innovation in shared facilities and services	⊕	⊕	●	●	●	⊕	⊕	●	●	⊕	⊕	●	●		●
12. Innovative team facilities management		●	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕		⊕	●		●
13. Architecture/CAFM for iterative learning		⊕		⊕	⊕	⊕			⊕				⊕		⊕
14. Innovative process: team decisionmaking	⊕	⊕	⊕	⊕	●	⊕		⊕	●			●	●	●	⊕
15. Resource mangement	●	●	●		⊕	●			⊕			⊕		⊕	

● Fully implemented ⊕ Partially implemented

Figure 1. A host of major design changes for the Office of the Future are in evidence in innovative buildings around the world.

In Japan and Germany, multiple-zone HVAC was evident in all the buildings studied, with highly accessible distributed mechanical rooms introduced throughout the building (see figure 2). The "cell body" system in the Umeda Center Building demonstrated the most refined multi-zone system, with 12 heat pumps per floor, enabling small clusters of workstations to have independent control of air temperature and air speed.

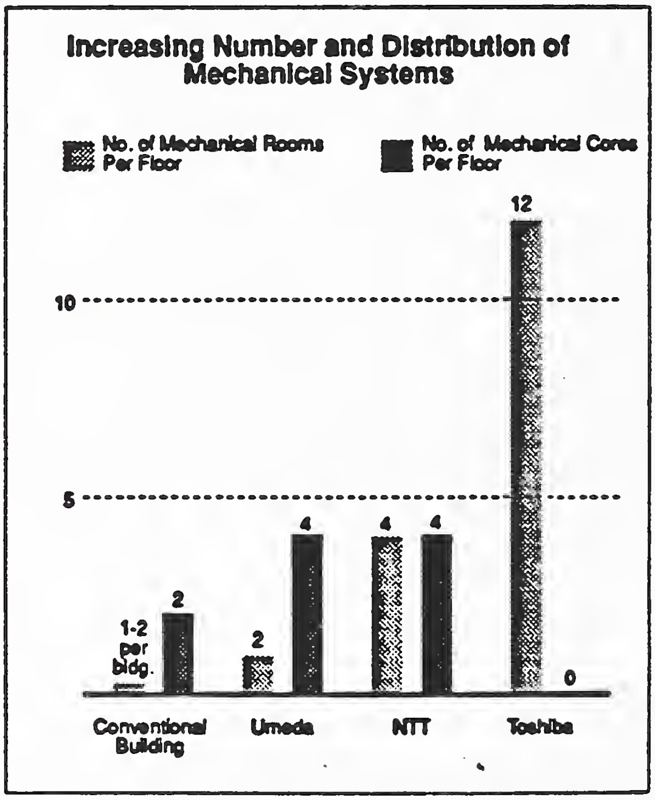

Figure 2 The Advanced offices in Japan demonstrate a significant shift away from the single mechanical HVAC room per building - to as many as 128 rooms

In the U.S. there has also been a shift towards multiple zone HVAC systems, a move away from four or five zones per floor to local fan-coils and dual duct systems or at least multiple VAV controls that offer better local management of air temperature.

2.2 Distributed cores versus central cores for vertical distribution of services

Even with central HVAC and telecommunications systems, there is a movement in the U.K., Germany, and Japan, toward multiple vertical cores to support accessible and efficient distribution of environmental conditioning, power, and data. These cores are oversized and strategically placed to service manageable work groups without excessive horizontal runs. In some cases, the multiple cores have been moved to the building perimeter to facilitate access and growth, and to free up usable floor space, such as in Lloyd's of London.

The Toshiba Headquarters, for example, incorporates two distributed cores for HVAC, four distributed cores for power, four for telephone, four for data, and two for servicing distributed mainframe rooms. These core spaces, as well as the fire stairs, elevators, toilets, and kitchenettes, line the shared circulation areas, with easy access and maintenance through continuous "cupboard walls". Indeed, the core area stretches from the east to the west facade, with all office areas facing predominantly north and south.

2.3 Open horizontal distribution plenums: floors versus ceilings

American manufacturers and designers have developed a range of solutions for horizontal distribution from cable trays overhead, to poke throughs, trench systems, and raised floors below. However, further development is needed in flexible and expandable horizontal cable management technologies and their effective connection with the work surface.

Given the immense quantity of existing office area, ceiling distribution systems of HVAC and telecommunications will always maintain a significant market. However, in the advanced workplace, there is a growing emphasis on raised floor technologies for the horizontal distribution of cables and of conditioned air. There are some misconceptions that raised floors increase floor-to-floor heights. In fact, the effective integration of raised floors with mechanical systems can actually reduce the amount of horizontal plenum space needed (see figure 3). Not only does raised floor distribution provide ease of access, growth, and change (of both cable and HVAC), but also good performance of floor air supply systems in relation to many ceiling "down-draft systems" (minimizing short-circuiting and pollution migration). Raised floor distribution also simplifies the final connection of power, data, and air directly to the desk and worker, to more effectively support today's constant churn and layout changes (see figure 4).

The second variable in relation to the horizontal distribution of HVAC and telecommunications from the building cores is the final connection to the workstation. A number of advanced buildings demonstrate innovation in this area, including pre-chased wall systems for direct connection to floor or ceiling plenums, and pre-chased furniture systems for direct connection to floor plenums. A critical subset of this direction is the modularity of the floor and ceiling system as well as the density of ports (light, heat, telecommunications, power) for the reconfiguration of interior wall and furniture systems.

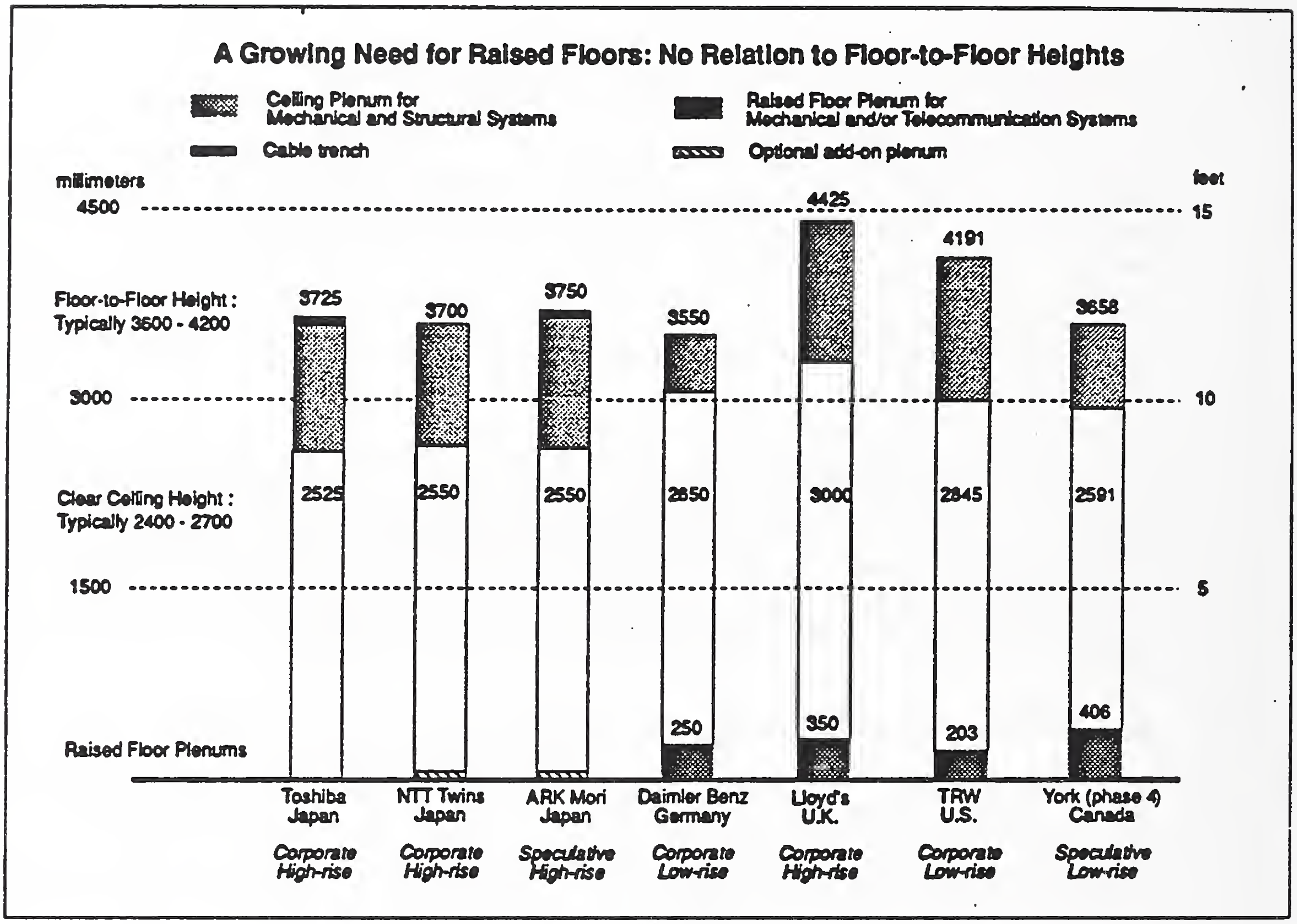

Figure 3. Raised floors do not demand higher floor-to-floor heights, especially in HVAC is incorporated under the raised floor.

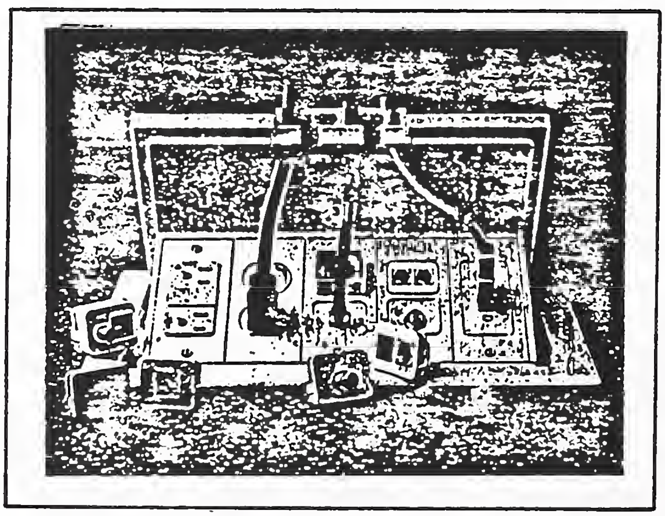

Figure 4. The AMP floor box provides excellent access to power, data, and voice networks, with an adequate number of modular and interchangeable outlets.

It should be emphasized that a team approach enables strong three-dimensional skeletons or servicing trees to be established prior to interior floor planning. These servicing trees allow appropriate decision making about type, configuration, size, and density of workstations as well as their access to HVAC, data, power and telephone networks.

2.4 "Fresh Air" architecture

There are many aspects of the human requirement for environmental contact, ranging from the need for fresh air, sunshine, and view, to the need for a sense of time, season, and place. With the introduction of central heating and cooling, however, the office workforce has been removed further and further from the outside environment, in some cases entering a building at 8:00 a.m. and not emerging to see the light of day for ten or more hours. Focus on the environmental needs of building occupants has diminished to such an extent that building-related illnesses and dissatisfactions have been directly tied to poor environmental contact.

Despite the flexibility of large open plan offices, the cost-saving abuses of the concept have led to unbearable work environments with no outside contact and inadequate mechanical and environmental control. The failures are as much physiological as psychological, resulting in a shift in some countries toward increased environmental contact, increased system/environmental interfaces and control, as well as more contact with natural finishes, daylight, and outside air.

Indeed, there is a rapid movement away from building floor plates the size of football fields (that must be totally mechanically conditioned), toward highly articulated buildings with the potential for natural ventilation and daylighting, especially in Germany and Sweden.

In Japan, several efforts toward increasing the quality of environmental contact are common to many new intelligent building projects. Buildings are clustered to create outdoor landscaped areas for walking, sitting, and eating, in lieu of indoor recreational "malls." Each building deeds a significant percentage of ground space and financial investment to create these outdoor landscaped areas (gardens, not paved plazas) as an integral part of the entry sequence, lunch and coffee areas, and work-break garden areas. Operable (unlocked) doors provide easy access from several parts of the building to the open-air green spaces, at ground level and on rooftops. Smoking is forbidden throughout the office areas, with dedicated, well-ventilated smoking rooms on each floor. Finally, office windows face only north and south office exposures for effective views and shade and experimentation with operable windows is beginning.

2.5 More effective thermal balancing between envelope and multiple interior zones

There is an odd misconception that the greatly increased interior heat gain in today's automated office has displaced perimeter heating demands. In fact, the growing internal heat loads have only increased the disparity between interior and perimeter loads, demanding a more refined response to both conditions. Indeed, entirely new concepts are needed to deal with thermal balancing in an office where one work group may have extensive heat-generating equipment, another minimal equipment, and a third serious losses from envelope locations. To compound the problem, the location of these work groups could change on a monthly basis. As a result, the Office of the Future demands developments in load balancing technologies, toward reducing load variations and developing adaptable, multi-zoned mechanical systems, with local sensors and controls.

The load balancing concepts in use in Germany, Japan, and the U.K. include air flow windows routing return air through the envelope; multiple heat pumps fed by closed water loops, enabling waste heat from one system to be a source for the next system; and flywheel construction in which fans pre-chill or heat vast areas of exposed capacitance (typically concrete) with off-peak energy or borrowed energy from other parts of the building. Heating loads can also be kept to a minimum through well-insulated facades, including innovative glazing assemblies.

2.6 More effective balancing of daylight and artificial light

The use of computers combined with the desire for increased environmental contact (to reduce worker's stress from long hours in front of computer screens) has heightened the need for effective daylight/electric light balancing. Totally new lighting concepts are needed, combining low ambient light levels (from daylight and electric light sources) with task light levels determined locally by the time of day and the activity. Lighting system innovations include continuous dimming fixtures, individually switched (on/off) fixtures, easily relocatable tether or pigtail fixtures, and shielded fixtures in which neither the image of the bulb nor the lens is reflected on the worksurface or the computer screen.

With overhead electric lighting at reduced levels (or off), the management of daylight glare and brightness contrast becomes even more critical, demanding a host of new products and integrations. A number of innovations have been developed in various countries, such as diffusing glass, prismatic glass, electrochromic glass, diffusing blinds, self-shading inwardly- sloping glass, light shelves, and exterior shading devices. (See figure 5).

2.7 Introduction of movable, tether, or pigtail services for heat, conditioned air, light, power, and data

The concept of fixed-grid, fixed-density systems for HVAC, data, and lighting has proved problematic in advanced offices due to the rapid changes in occupancy activity, location, and density. There are also indications that the fixed-grid, fixed-density systems are more expensive in first costs (unnecessary investment) and operating costs than flexible-grid, flexible-density concepts, such as tether or pigtail services. Tether services can provide conditioned air, light, or data connections for the individual workplace from a series of distributed controllers with tether or star connections. This allows for "port" location changes depending on the length of the tether and modularity of the ceiling or floor (see figure 6). Alternatively, a pigtail (expandable ring) system allows for the introduction of additional ports (e.g., lights, power, or HVAC controllers), at

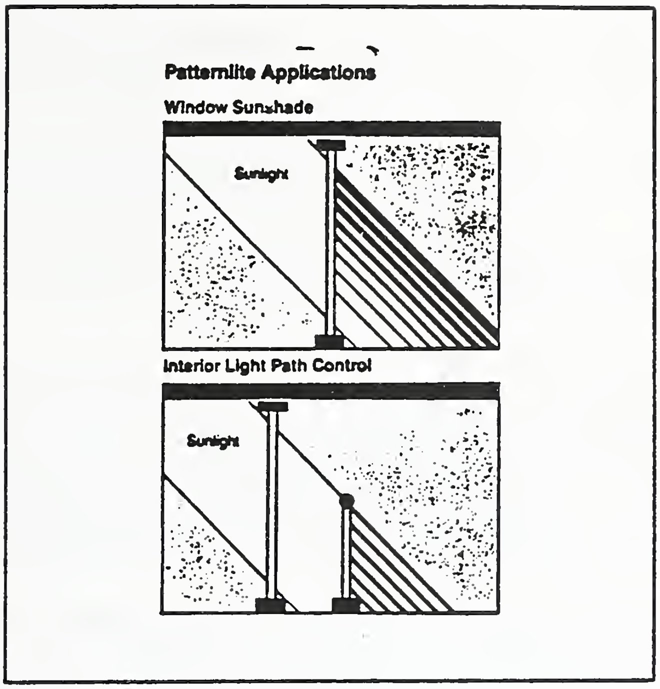

Figure 5. PPG Patternlite glass and Azurlite glass greatly reduce glare and improve views.

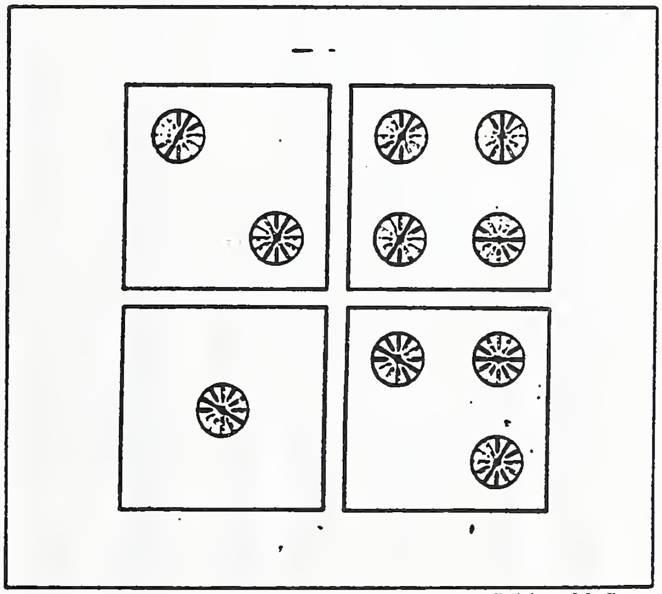

Figure 6. The Marble raised floor tiles are available with floor diffusers in various configurations.

any location within the existing chain. Both the tether and pigtail systems provide for continuous changes in workstation location and overall density, as well as changes in type and quantity of electronic equipment.

Examples for easily moving HVAC, lighting, and data connections in floor and ceiling plenum spaces were evident in innovative buildings in North America, Germany, and the U.K., and France (see again figure 1).

2.8 Introduction of individual environmental controls for temperature, air, and light

Today's advanced office has a growing need for more local environmental control, due to the significant variations in activities and equipment found between workstations. Specifically, the local control of conditioned air and task/ambient light has become most important in order to respond to the stresses caused by the rapid introduction of office automation equipment. Worker reactions to the inadequacies in the open office plan have led to a stronger desire for personal control over environmental conditions (see figure 7).

Considering the Conditions Around Your Particular Desk, How Often Do You Find:

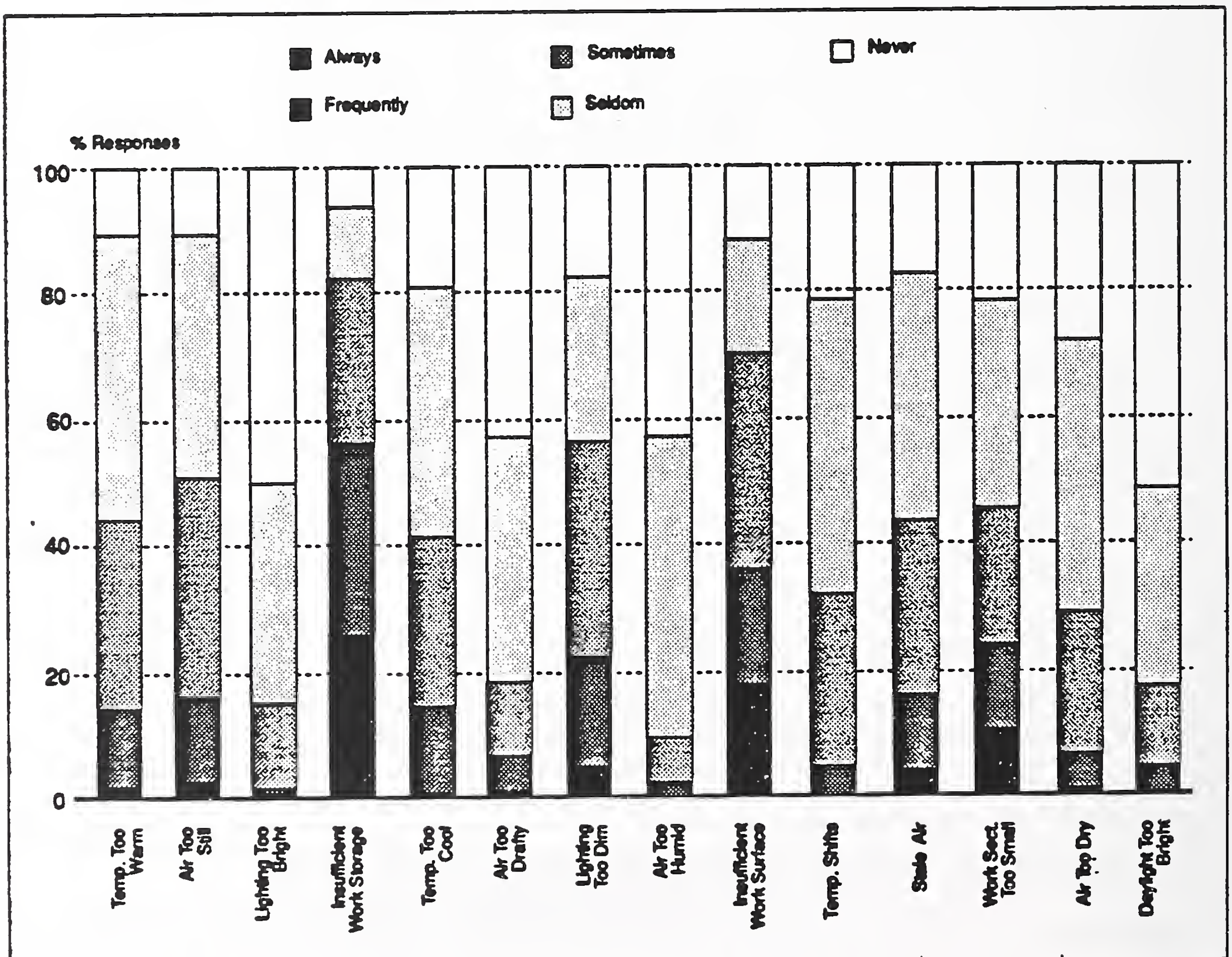

Figure 7. Workers are expressing a growing interest in controlling certain environmental conditions — such as air movement, air freshness, and cooling — to deal with the changing conditions of the advanced office. (This chart is based on questionnaire responses in the Pacific Bell Building).

Johnson Controls Personal Environments system (see figure 8) has, for the open office workstation, introduced individual control of temperature (both air temperature and radiant temperature), of conditioned air (direction and speed and outside air content), of ambient and task light (on/off and dimming), and even of background sound. Although further study is needed, this individualized control has neither sabotaged the central system nor increased the total energy demand. Instead, the individualized control has helped in relieving the thermal and visual stresses in the automated office, enabling ambient energy savings, as well as more effectively providing for individual differences in setting comfort.

The Umeda Center Building by the Takenaka-Komuten construction company in Osaka, Japan, is another far-reaching effort in regard to individual controls. Through the introduction of multiple HVAC systems with direct access to outside air, and independently wired lighting controls, the 3.2 meter-square "cell body" workspace (whether open or enclosed) can be independently managed by the occupant. The individual worker can easily control lights (on/off), air supply (on/off), and even air temperature. Admittedly, temperature is controlled on a larger grid, approximately 20 meters square, to be negotiated between five or six workstations. Individual control is provided by either telephone or computer dial-up, and cannot be overridden by central management. Indeed, the building's central computer only monitors individual actions, for a better understanding of variations in individual needs toward system optimization in future building projects.

As a result of these individual control options, complete enclosure of individual offices or densely shared computer facilities can be pursued as needed in the open office plan, with assurance of adequate thermal, air, and visual environmental quality.

3. Introduction of new workgroup concepts

The introduction of the landscaped office in the 1960s created a worldwide commitment to the economies and "community" of the open plan office. However, the abuses and inadequacies of the concept (excessive vastness, spatial confusion, difficult wayfinding, noise, thermal and air quality failures, lack of daylight and view for many) have contributed to alternative movements in office planning. Indeed, the design of the open plan office may not function to promote effective working relationships. Social psychologists have speculated that work groups of over 20 people will not form a strong community, and that work groups of over seven people cannot relate to a collective agenda at the same time (see figure 9).

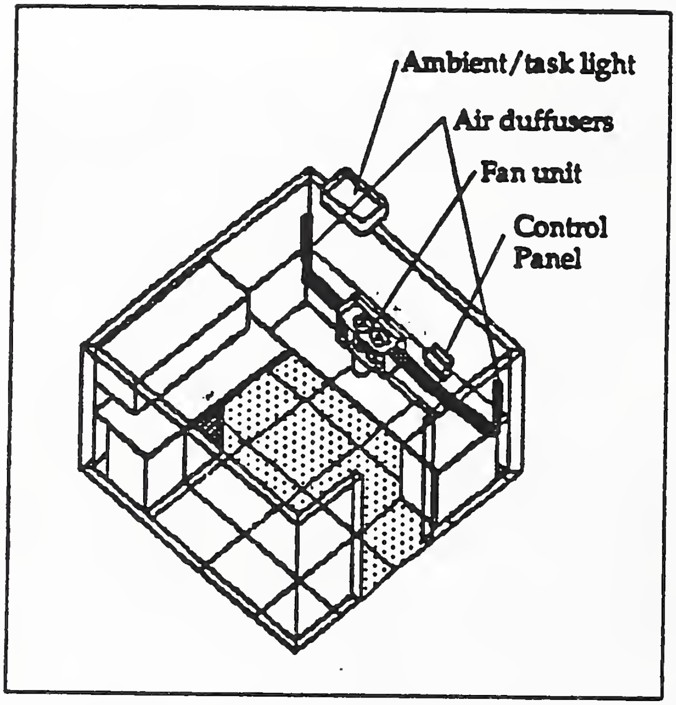

Figure 8. The Personal Environments from Johnson Controls provides individual control of temperature, air speed and direction, task light, and background sound within each open office workstation.

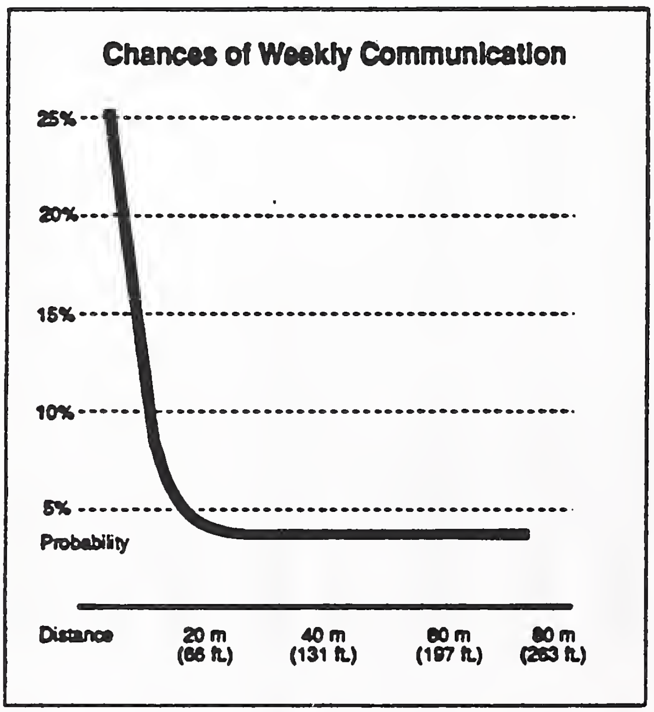

Figure 9. Distances contribute significantly to the level of communication between office workers, suggesting that effective working groups are quite small (Officing, 1988)

In some advanced buildings, these findings have led to smaller, more articulated open office areas housing 20 or so workstations, with greater proximity to daylight and view as well as shared services. Other alternatives can be seen:

- The concept of small closed offices (caves) for personalization and permanent possessions, and collective workstation areas for group projects (coves), such as the R&D centers of Steelcase and Apple Computer (Becker 1990);

- The concept of workstation on wheels where permanent possessions are housed within a mobile unit to be wheeled to the most appropriate location for a specific project (to a workgroup area, to a quiet zone, to a computer or CAD workstation, to a window) such as at the Digital Marketing Headquarters in Finland;

- The concept of unassigned (free address) workstations and shared workstations in larger workstation modules, shared by sales forces that spend a majority of the time on the road

- The acceptability of home offices and on-the-road offices for a significant percentage of the work week (sometimes accompanied by enforced hours in the office, from 10:00 a.m. to 2:00 p.m., for example)

- The re-emergence of closed offices as the only acceptable workplace for the "gold collar" worker (Levin 1988).

This reconsideration of the vast, efficient open office has also influenced building massing in a number of new projects. Vertically extruded "high-rise" offices, in which inter-floor communication is restricted to the elevator and garage, are being re-evaluated. Instead, the creation of social centers and service/support centers have appeared, surrounding open stairs and atria. There is also a re-emergence of traditional campus or village planning with lower rise walk-up buildings, mixed use planning, heavily landscaped areas, and shared services and amenities.

4. Introduction of new workstation concepts

Another aspect in the evolution of workstation concepts is the furniture design itself. Beyond the individual environmental controls previously described, a series of individual spatial controls and fittings now enable the workstation of the future to be tailored to the individual's physique, psyche, and work style. These "necessary amenities" include ergonomic chairs; adjustable supports for screens, paper copy, and keyboards; variable-height work surfaces; innovative storage systems; variable-height acoustic enclosures; task lights, and new, integrated electronics and cable management. (See figure 10).

Ergonomic Chairs
- Adjustable seat height, forward tilt of seat "waterfall" - Locking mechanism - Swivel on five caster base - Adjustable back height/position for lumbar support; variable support - Footrest, if work surfaces are not adjustable - Dimensions and padding of seat and back - Adjustable height arm rests
Anthropometric Work Surfaces
- Adjustable height/position keyboard support - Thin, low-impact keyboard and wrist support - Adjustable height/position screen support - Typing document holder - Pole mounted pull down screens and keyboards (off worksurface) - Mobile computer stands - Worksurface adjustable height/tilt

Figure 10. Today's workstation must include high-quality ergonomic chairs and anthropometric worksurfaces to deal with the physiological stresses in the electronic workplace.

Significant development in the advanced office settings in the United States center around workstation furniture. Each individual now has access to a vast range of electronic peripherals (phones, mini or micro personal computers, printers, fax machines), supported by newer ergonomic furniture systems (see figure 11), cable management floor systems, and for the first time in modern offices - the prospect of individual environmental control.

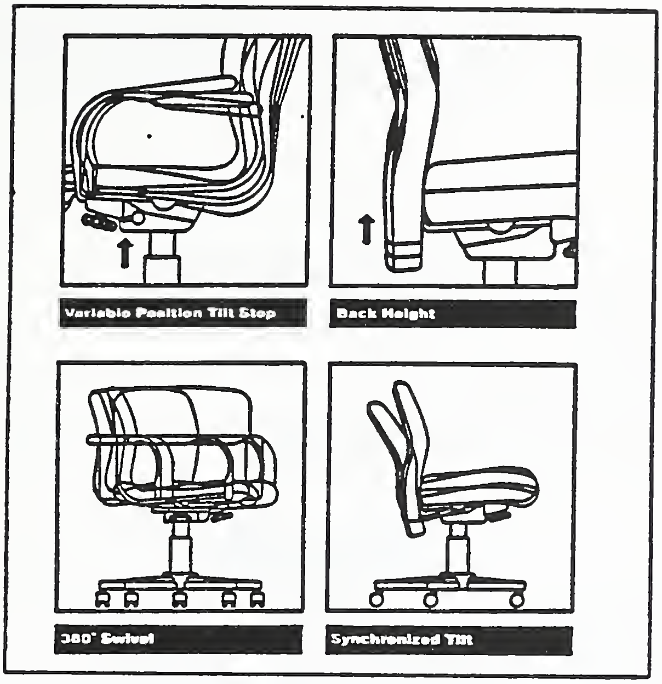

Figure 11. The Bulldog chair by the Knoll Group Westinghouse meets the new San Francisco standards for ergonomic workstations and incorporates new low v.o.c. outgassing plastics by Mobay.

5. Shared facilities and services for changing uses and changing technologies

The American "Intelligent Office" is beginning to show the effects of increased memory capability, with mainframe rooms being replaced by mini-VAXes and microprocessors at every workstation, linked through local area networks. The shift away from mainframes and dummy terminals does not diminish the number of shared facilities, however, with a growth in group spaces for interactive work, shared equipment, and improved social settings.

In addition to the desktop electronics intended to improve communication and productivity in the advanced office, there are also significant changes in the type and number of shared facilities and services in the modern office. (See figure 12). Shared services today include fax and telex facilities; copy and production facilities; coffee areas and eating facilities; conference facilities with telecommunication equipment; shared main frames, or shared rooms and servicing for individual mainframes and processors ("black box parks"); postal and mailing facilities; office automation display and purchasing centers (hardware and software); furniture rental and installation services; and accessible landscaped areas for meeting, eating, and relaxing. Portable teleconferencing packages are now available with cable TV, microphones, telephone, fax, and electronic blackboards to enable groups in two cities to meet simultaneously. These shared facilities and services provide economies of scale that starter high-tech companies cannot afford alone, as well as providing knowledge about new office automation options and expediting advancements.

Developments in shared services in the modern office
- Postal and fax services - Copy and production services - Public relations and newsletter services - Coffee areas/cafes - Vending machine areas/food carts - Cafeteria and restaurants - Party and take-home food services - Garden and park areas - Terraces - Atria - Health clubs - Medical suites/doctors - Conference facilities - Portable conferencing equipment - Computer/OA training - OA display centers (hardware and software) - Shared mainframes - Shared servicing for OA equipment - Banking facilities - Travel services - Car maintenance services

Figure 12. A range of shared facilities are offered in advanced buildings, to attract starter high-tech companies, to improve organizational capability and to support individual well-being.

There are new concerns that follow many of these new shared services. Inadequacies in number, location, and environmental quality (heat, light, noise, air) are seen in computer clusters and printing/fax areas throughout the office world, and must be further addressed.

6. Introducing architecture and software for team management: the building management trio

At least three individuals - the facilities manager, the personnel manager, and the technology manager make decisions about the flux and change in the modern office, often with inadequate collaboration (see figure 13). The constant alterations of technology and of the space that houses it, along with the rapid redistribution of the workforce in high-tech offices, demands a far more refined system for making spatial decisions. Moving workstations (personnel managers' territory) and adding office equipment (technology managers' territory) impacts not only the design of the spatial layout but the data and power network, the air conditioning, and the lighting (facility managers' territory). Yet these three players often have vastly different positions in the organization and maintain separate inventories, specifications, and maintenance schedules.

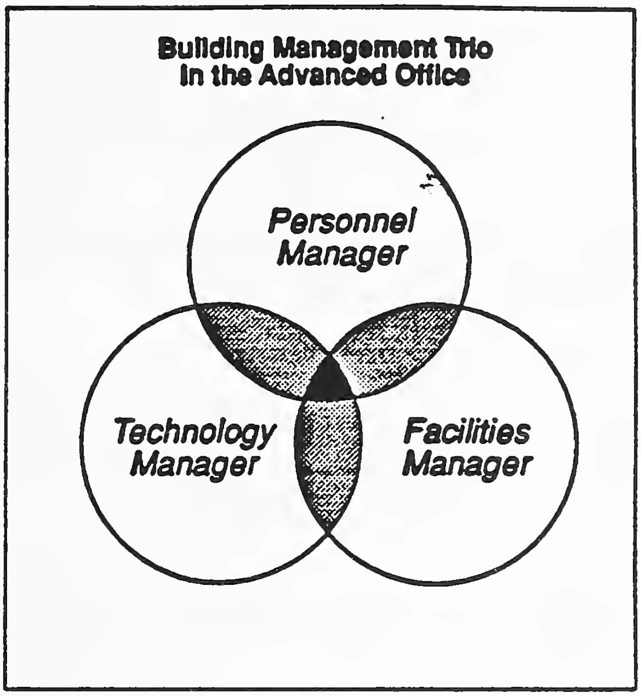

Figure 13. Toward improving workplace performance and satisfaction; the interactions among people, facilities, and technology must be reflected with a management team of personnel, facilities, and technology managers.

The social, economic, and technical consequences of office churn should be considered by the management trio collectively. To support decision making, computer-aided facilities management (CAFM) packages should be developed to maintain information on a building's hardware, cable networks, environmental control systems, and architectural systems (structure, envelope, vertical chases, horizontal plenums, workstation components). This information should allow for access, modification, reconfiguration, or relocation of people, settings, and technologies while indicating any thresholds or limits to change. The CAFM and the expertise in the management trio (now working as a team) will enable decisions that consider the cost, disruption, and workability of a change, prior to its enactment.

The "equal peers" or team structures in Japanese businesses are well suited to collective decision making about new office layout and automation. For example, the NTT cornerstone listing 130 designers is the most striking representation of team design.

Without question, all those affected by major purchases or decisions are consulted to contribute to those decisions. Even without the formal structuring of CAFM software packages, adequately responsible decisions can be made without serious side effects (such as thermal, acoustic, spatial, structural, and power inadequacies). The introduction of formal decision making structures and software for team management of office automation and churn should be set in place for all modern offices.

7. Introducing architecture and software for interactive learning: expert systems for occupants, facilities managers, and building designers

One of the greatest challenges for individual control over environmental systems is the impact it has on the overall performance (including energy and cost effectiveness) of the building as a whole. A number of advanced buildings now demonstrate the design and operational strategies that can evolve from interactive learning between managers, designers, and occupants of buildings (Hartkopf et al. 1990).

In the case of the Lloyd's of London Headquarters, input as to occupant temperature settings allows for the modification of central air temperatures. Input about daytime temperature fluctuations (with changes in occupancy density) led to the development of a night ventilation system using the building mass as a flywheel. In Germany, the Colonia building demonstrates a unique dialogue between facility management and occupant management of the operable windows. Whenever the central air conditioning system is cooling, a light turns on in the office area to suggest that closing the window will allow the system to work more efficiently. When the chiller is off, the occupants are encouraged to open and shut windows depending on their local comfort needs. In the United States, the Smart House project demonstrates another concept for interactive learning, with the use of automatic power factor controllers triggered by ˜communication˜ between appliance and outlet.

In their advanced office building projects, the Japanese have heavily invested in programs to iteratively optimize resources. Reducing total energy use, shaving peak power demands, maintaining system efficiency, and minimizing water usage are all goals of facility management. The college-educated facilities management group supported by extensive, well-calibrated, and well-maintained monitoring equipment continuously evaluates and tunes the building systems. Optimization and improvements result from an ongoing process of comparison and competitive assessments between building subsystems, between tenant spaces, and between buildings projects. The results of these assessments are then applied to subsequent, further refined building projects.

A unique investment in interactive learning can be seen in the ARK Mori building, in the form of a mobile environmental diagnostic system. This mini "robot" has a range of calibrated sensors to enable the facilities managers to evaluate the thermal, humidity, acoustic, and air quality conditions in any occupied space. The mobile diagnostic unit provides long-range input into the overall performance of buildings in the ARK Hills Complex, as well as enabling quick response to occupancy and facilities concerns.

In the future, a host of "smart" building technologies and expert software will enable occupants to communicate more clearly with central systems, facilities managers, and eventually with building designers.

8. Innovative process: design by a team of peers

The design process for the Office of the Future will emphasize team decision-making from conception through occupancy. A range of new steps must be developed within the building delivery process towards creating high performance integrated design, including:

- Mission statement and performance budget
- Performance program
- Collective client problem identification for up-front decision making
- Specification of a project manager
- Performance selection of entire design team
- Creation of team decision making process
- Integrated performance studies of existing advanced buildings and building delivery processes
- Concept development by team for innovation
- Design development testing through expert analysis/peer review
- Working drawing testing through expert analysis/peer review
- Full scale mock-up testing of repetitive, highly innovative configurations
- Diagnostics against standards through the construction process
- One-year commissioning, including expertise and accountability carry-over
- Integrated building management: facilities, technology and personnel

In America, there have been a few examples of a shift in the design process towards team decision making, to ensure the creation of the truly "intelligent office". Most notable is the TRW headquarters project in Cleveland, where a full time project manager coordinated a team of equal decision makers including exterior architects, interior architects, mechanical engineers, telecommunications engineers, and the building constructor. This design team was fully involved from early conceptual design through one year of commissioning to ensure an office headquarters with the latest in technology and the physical and environmental setting needed to support the technology.

9. Resource management

In meeting the needs of the global marketplace, resource management will be a key requirement of the office of the future. The definition of limited resource will be all encompassing to include first costs; energy/fuel costs (including cost of increased production); operation and maintenance costs; labor costs; material/embodied costs; and other resource costs including maintaining clean water and clean air.

In the area of energy conservation, adopting state-of-the-art developments will be a requirement in tomorrows workplace, ranging from: improved generator efficiencies (COP, heat recovery), alternative source efficiencies (ground source) and peak load shaving; improved distribution and zoning efficiencies (e.g. EMCS, load balancing); to improved terminal unit efficiencies (e.g. people sensors, split task-ambient systems). A host of new innovations in both individual components and integrated systems will become available for effective energy resource conservation. (See figure 14).

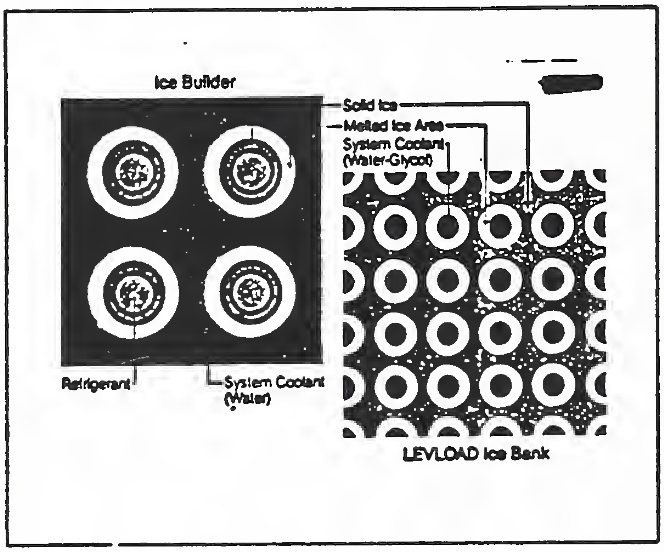

Figure 14. A Calmac ice-storage unit enables off-peak electricity at lower cost to the utility and the consumer, to supply cooling for the electronic office

In Japan, significant attention is given to day/night and seasonal load balancing. The NTT Twins building has a massive off-peak water storage system for cool water storage at lower electric prices. The Toshiba Headquarters and ARK Mori Building demonstrate strategic peak power shaving strategies through energy management software. These efforts, in addition to the massive grey water system in Toshiba, demonstrate the Japanese continued commitment to resource conservation - be it fuel, power, water, or air.

Controlling operation and maintenance costs will also be critical, with investments in: high quality materials and detailing; easy accessibility through systems integration and exposure; self-diagnosing systems (to anticipate and prevent failure); and in improved building material preservation and reutilization (raw material and embodied energy costs). The Office of the Future will recognize the ˜Cost of Ownership˜, securing 1-4% of current plant value for facilities operation and maintenance, inviolate year after year.

Each of these innovations, as well as grey water management, fresh air management, and natural habitat management (including sustaining rich agricultural land) will enable tomorrows' workplace to advance without further depleting natural resources from around the world.

10. Toward defining major changes for the "Office of the Future"

Clearly, this list of major design changes is evolving. Developments in technology as well as in work responsibilities and relationships are constantly expanding, and the ability of buildings to accommodate these changes is continually being challenged. Interdisciplinary field evaluations of advanced office buildings around the world are critical to developing our understanding of tomorrow's workplace.

(A further discussion of the topic by this author, and other workshop participants, will appear in a companion publication containing the workshop proceedings (NISTIR 4802).

References

Becker, F., "The Total Workplace: Facilities Management and the Elastic Organization", Van Nostrand Reinhold, NY, 1990.

Brill, M., with Margulis, S, Konar, E. and BOSTI, in association with Westinghouse Furniture Systems, "Using Office Design to Increase Productivity", Vol. 1, Buffalo: Workplace Design and Productivity, Inc., 1985.

Chiu, M., "Office Investment Decision making and Building Performance", PhD thesis, Dept of Architecture, Carnegie Mellon University, Pittsburgh, PA, May 1991.

Davis, G., Becker, F., Duffy, F., and Sims, W., "ORBIT-2 Overview Report", Norwalk: Harbinger Group, 1985.

Hartkopf, V., Loftness, V., Mill, P., Siegel, M., "Architecture and Software for Interactive Learning About Total Building Performance", presented at the 3d International Buffalo CAD Symposium, Buffalo, NY, March 23-25, 1990.

Hartkopf, V., Loftness, V., Mill, P., "The Japanese Approach to Tommorow's Workplace", to be published by Butterworth Publishing.

Levin, D., "Smart Machines, Smart Workers - 'Gold Collar' Force Vital to Automation", New York Times, October 17, 1988.

Loftness, V., Hartkopf, V., Mill, P., "The Intelligent Office", Progressive Architecture, Sept 1988.

"Electronically Enhanced Office Buildings", National Academy of Sciences, Building Research Board, National Research Council, Washington, DC, 1988.

"Officing: Bringing Amenity and Intelligence to Knowledge Work", Matsushita Electric Works and CRSS, Osaka, Japan, 1988.

Bernaden, J. and Neubauer, R., ed. "The Intelligent Building Sourcebook" Fairmont Press, Lilburn, GA, 1988.

Atkin, B., ed. "Intelligent Buildings", Halstead Press, NY, 1988.

Goumain, P., ed. "High Technology Workplaces", Van Nostrand, NY, 1989.

THE SOPHISTICATED USER AND HIS IMPACT ON TOMORROW'S OFFICE AIRCONDITIONING SYSTEMS

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1. Introduction

It is very clear that the public is becoming ever more sophisticated with regard to air conditioning systems and is demanding ever greater levels of comfort and convenience. This increased awareness of personal comfort is making and will continue to make a major impact on the way in which air conditioning is provided in the office space of tomorrow.

The basic understanding of the current situation begins with the question "What is comfort?" A simple answer might envision a certain temperature and humidity condition. While that response might satisfy some people, no single point can provide the sensation and feeling of comfort to all. In fact no single point is even capable of satisfying the same person throughout the year or even through a single day. Thus the concept of comfort is, at best, a moving target, with even a broad range of combinations of temperature and humidity values failing to meet each individuals expectation of a proper environment. We have all heard the typical office story of three workers sitting in close proximity, with one extolling the "pleasant sensation" of the office while a second complains that it is too hot, and the third, wearing a heavy sweater, is perpetually cold. This situation is regrettably a common occurrence, and while it might have been an acceptable employment environment years ago, today it is an increasing cause of irritation, and a rallying cry for improvement.

In a similar manner, the average office worker has become increasingly concerned with the acoustical environment of his workplace, and ever more demanding of suitable sound levels. The need for improved systems is clear. Not only will the work staff of tomorrow demand more, but these improvements make good economic sense. Numerous studies have demonstrated that the worker who considers himself "comfortable" is more alert, productive, and content. At the same time, studies have demonstrated that most tenants demand improved HVAC systems, and are willing to pay to get them. For the owner/developer the message is clear, competition will demand more sophisticated systems, and the increased investment costs to achieve them are recoverable by an increased rental return.

How then can the users of office space, with their wide range of personal requirements for comfort, some in conflict with each other, be accommodated? This question must be looked at in terms of short, intermediate and long range strategies.

2. Strategies for improving occupant comfort

Certainly, the most logical approach to meet a wide variety of individual requirements is to utilize a system which has a vastly increased number of control zones. Many of today's offices still utilize a single zone per floor, or if multiple zones are employed, each zone will handle 1,115 square meters (12,000 square feet) or more. In applications such as this, a single control device can easily control the environment for well over 100 people. With this number, substantial differences in the comfort spectrum will be represented, almost guaranteeing discomfort to some.

Even if all the persons in a control zone this large had the same comfort concept, the normal variations of temperature (and possibly of humidity) due to lighting, equipment, solar and occupancy loads would yield significant local variations and subsequent zones of discomfort. Thus providing more control zones is a viable alternative for improving comfort levels to meet the increased levels of expectation.

Several strategies are possible in this regard. Some deal with making the typical existing system more responsive by, for example, converting it into a VAV system. Others deal with the manner in which the system is controlled, and seek improvements via this route. An even more promising short term strategy is to develop a personal work station with the HVAC system included as an integral and fully integrated sub-component of it. Thus, the air conditioning could be introduced locally, directly serving the worker, and fully controllable (with regard to temperature, and volume) by the user to his concept of comfort. This is somewhat analogous to the individual air outlets for passengers in aircraft, but I hasten to say that the aircraft model is so primitive and crude that one should not imagine this as a type of real or suitable solution. Such an individual workstation zone would have to introduce air at very low noise levels, with low terminal velocities, and with the ability to vary temperature as well as volume.

2.1 Intermediate strategies

In the intermediate term, the question of how we measure comfort comes into play. Especially important here is the question of whether a thermostat is an appropriate control device. Technology already has the ability to achieve far more sophisticated levels of sensing, and certainly new techniques of monitoring individual comfort must evolve. A real possibility is a sensing device to monitor skin temperature and skin moisture, with these parameters adjusting, with an algorithm, the performance of the air conditioning.

2.2 Long-term strategies

In the long term, the ever increasing power of the microchip and the computer offers hope of identifying and tracking each building occupant, and of continually modifying the climatic conditions in his personal zone to assure each occupant of his own personal comfort. To achieve this level of operation, it will be necessary to transition from our current level of technology using ducts and diffusers to a more distributive concept, but even here several potential scenarios are already being discussed.

As the user/consumer of office space grows in sophistication and demands more personal comfort and safety, it will be essential that the type of HVAC system responds to achieve the user's expectation. These trends and realities will have an impact on all types of new construction, especially on the sort of project which the DOT is planning on undertaking. For example, the integration of the HVAC system into the workstation is an idea whose time has come. This type of approach has already been pioneered both in Europe with floor outlet air distribution systems positionable to accommodate work positions, and with high tech trading floor designs which integrated fancoil units into workstations to accommodate the very high heat gains without resorting to excessive air quantities from central systems. Further, this scheme gives a real hope of providing flexible comfort conditions for each worker at the location where they spend the majority of their most productive time. The impact of this type of system will affect not only the workstation, but the design of the entire system. The best analogy would be the task/ambient lighting approach where general lighting accommodates the transient requirements while the work (task) area is provided with a custom individualized illumination.

3. Common spaces

While the objective of personal comfort is achievable at the workstation, the traditional problems will persist in common areas such as the lobbies and in conference rooms. The lobby situation is, of course, not critical since, for the most part, this is a transient area with residency times so short that the "feeling" of discomfort will probably not develop. Conference rooms are another matter. In these spaces, groups of people with varying opinions of what comfort is convene and reside for substantial times. This requires that a common system "condition" the space in order to achieve "comfort" for the most people. Clearly, the best hope here is in the area of controls. Direct digital controls with multiple sensors, logic circuits and algorithms to set up operations for maximum comfort levels are possible and in development.

4. Advanced sensing systems

In the future, sensing of parameters other than only temperature and humidity will not only be desirable but also commonplace. In Japan, there is considerable current research into comfort (at this time only in the sleep mode) and the patterns of brain Alpha waves. It is conceivable that, one day, remote sensing of brain waves will reset the HVAC system. In the interim, while it might be desirable to catalog each persons' individual preferences for control purposes, this approach has limited value since a persons own comfort requirements vary widely with time.

5. Cost considerations

Improved comfort of course has its costs. Any of these strategies will increase the installed cost of the system, but, at the same time, operational savings are possible because of the ability of matching loads and output much more carefully. This type of technology is also more complicated that the current way of doing things. This makes maintenance more difficult and costly, and makes the possibility and nature of failure of greater concern.

The issue now, especially in this period of recession, is whether there is enough user pressure and market volume potential to drive the product development needed for these innovative improvements.

(A further discussion of the topic by this author, and other workshop participants, will appear in a companion publication containing the workshop proceedings (NISTIR 4802).

THE INTERRELATIONSHIP BETWEEN OFFICE TECHNOLOGY AND ARCHITECTURAL DESIGN

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1. Background

The history of the design of the office workplace has had numerous influences. Initially the strongest felt were those that affected the simplest building systems - its structure, its internal circulation, its heating and ventilation. One only has to consider the consequences of renovating a building built prior to 1930, to understand the progress of the workplace of today has undergone. Such a renovation would entail the introduction of modern systems for HVAC, lighting, fire protection and electronic communication and upgrading of elevator controls.

However, there would remain an architectural legacy which could not be changed. Its structure may be of steel but with close column spacing, its fenestration - its windows - might correspond on the outside to some decorous stylistic preference but have little to do with a modern office module.. Likewise, the floor to floor dimension probably never anticipated room for such elements as raised floors, HVAC systems and recessed lighting.

After World War II all of the building systems that so dominate the architectural approach to the office building of today were introduced. In addition to these systems - long-span steel and concrete, lighting, communication, raised floors - corporations demanded larger floor plate sizes to accommodate large functional groups. Floor sizes grew from an average of 929 to 1394 square meters (10,000 to 15,000 square feet) in the 1930's to 1,858 to 2323 square meters (20,000 to 25,000 square feet) by the 1970's, and 3,252 to 3716 square meter (35,000 to 40,000 square foot) plates demanded by the 1980's.

In total, then, all these systems may be viewed as a response to the needs demanded by the office worker's environment. Until the 1970's, the environment was inhabited by enclosed offices and a majority of open office pool areas. When one considers the open office landscaping systems of today, it is difficult to imagine that they were developed as alternative solutions to the open office pool areas, but that is the case. And they were intended to provide a measure of personal privacy and improved environment that a desk in an open space could not. In the area of work space, it has proved to be very successful. The average workstation was able to adapt to the tremendous electronic equipment demands. And coupled with a raised floor or cellular deck system, it introduced a high level of flexibility.

As with most successes, the workstation concept was applied universally in some corporations both to open pool areas and as a substitute for private offices. The problems of such an application became quickly apparent. Open workstations could not provide a high level of privacy; hierarchical problems developed; stations consumed more space and became more elaborate, all in an effort to substitute for a private executive office. The main advantage of this application was elimination of light and view blocking office walls along the perimeter. It was a very egalitarian solution offering the highest quality environment for all workers.

It also allowed architects an unusual freedom of expression with regard to the building exterior massing, and a varied treatment of window areas. As long as one stayed within a core to wall depth of 12.2 to 13.7 meters (40 to 45 feet), every imagined exterior expression could be used.

The architectural design process is often viewed as designing from the outside in. The ground rules were clear - a 1.5 meter (five foot) module along the wall - 9.1 meter (30 foot) column centers, or better yet, no columns at all - 12.2 to 13.7 meters (40 to 45 feet) from core to the outside wall - 3.96 to to 4.27 meters (13.0 feet to 14.0 feet) floor to floor - no floor plates less than 2,323 square meters (25,000 square feet), except at the top, where the "crown" is.

The reality is very different.

Such an approach is really a simplification. A building which truly responds to its interior program must develop many elements - module, structural span and column positions, working floor depths, utility spaces, and finally, community spaces.

2. The building module

Module - or the rigorous grid which binds all elements of an office building together has been the most studied unit of planning in modern architecture. The module has been expanded to order floors, structure ceilings, lighting, furniture, to the extent that we speak of "modular" houses. In effect, it is an attempt to regularize planning, organize growth and otherwise clean up our human act.

Its exact size or spacing has been tinkered with for decades and because of the proliferation of speculative office buildings, has achieved a kind of "gentleman agreement" to be kept at 1.52 meters (five feet). This dimension, if one thinks about it, relates to nothing in particular other than an office width of 3.05 meters or 4.57 meters (10 or 15 feet), and a nominal desk width of the same size. It is clear that besides the office space along the building's perimeter, not one other thing relates to it. Ceilings and lighting were regularized at 610mm x 1.2 meters (2' x 4') or 610mm x 610mm (2' x 2'). Workstations do not have any real module other than the one recreated when a standard station size is fixed.

The important element of a module is that it be convenient for planning purposes. The reduction of a module to its smallest reasonable component is the key to flexibility. For example, a 762mm (2 foot 6 inch) module offers double the possible combinations of office planning than 1.52 meters (5'0"). The logic can be extended to achieve a type of syncopation of uneven divisions within a larger module of ten feet for even more combinations of layout.

3. The building core

The placement of the core is the next perhaps more important element of building planning. When we do work in Europe, and Germany in particular, the core to outside wall dimension is limited by a very human concern, that of natural light. No one may work more than a prescribed distance from a ywindow. That's hardly the case in the United States, where the core to outside wall is strictly a question of adding up dimensions; office depth + corridor + three workstations + corridor to equal 13.7 meters (45 feet) + or -. Aligned on both sides of a core, the large bulk office building quickly became unmanageable in the aesthetic of the modulated box.

The careful placement of core to outside wall is a key. But we can begin to look at this dimension in another way as a kind of super module, if you will, with extensions dividing a large floor plate into bars of flexible space. The resultant spaces offer light on both sides, and can achieve the same result as bulk spaces.

4. Flexibility

In an attempt to allow office space to accommodate change, interior designers and architects have applied technology from laboratories, computer rooms, hospital planning. Raised floor systems, interstitial spaces, multiple utility closets were used as a type of overlay technology for the office space. A combination of these can be used to lessen storey height, supply air, and provide flexibility.

5. The building as a community

Finally, the office environment is not complete without a developed sense of community or corporation. Over the years, owners and architects have employed a number of devices to instill or symbolize this unity of organization. Atria or central courtyards were prevalent at one point - the theory being that if persons could see one another, they were united by their stares. Community activity spaces were offered - cafeterias, exercise facilities, etc. By themselves such spaces are important benefits to any work environment. But it was not until the most basic of human organizing elements was applied to them that they became integral to the sense of corporate community - the notion of street, or linear circulation, and a gathering place - did positive interaction take place.

The final word about the interplay between interior design and planning is a challenge - to investigate and reapply basic humanist concepts to the workplace, to meet the challenge of developing technology and the concern for ergonomics and healthful environments.

(A further discussion of the topic by this author, and other workshop participants, will appear in a companion publication containing the workshop proceedings (NISTIR 4802).

CITIBANK EXPERIENCES

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1. Background

Our Court Square structure in Long Island City is a building for the next century. Its statistics include: 50-storey tower, 199.64 meters (655 feet) high, a four-storey low-rise amenities building with a 30.5 meters (100 foot) high glass rotunda, 133,493 square meters (1,436,950) rentable square feet, and a cost under $175 per square foot. It was built in 23 months from ground breaking. This limited our carrying costs and contributed to keeping the building costs relatively low.

Its amenities include: staff dining, upgraded dining, fitness center, restaurants, a branch of the Public Library, florist, convenience stores, and direct access to three lines of the New York City Subway System. And, of course, two branches of Citibank, one, all-electronic, on the street level, and the other one, a full service branch, one level below grade, with direct access to the subway.

And, it is populated by some 3,000 plus staff members.

However, what makes this building the best one we have ever built?

Flexibility.

All our positive and negative experiences in planning, designing, and constructing office facilities for the bank were reviewed. Not only did we examine our other buildings, but we determined how successful they were in terms of ongoing facility management, and day-to-day churn work. We learned equally from our past successes and shortcomings.

I will now cover the techniques that we implemented to achieve a building that is as flexible as possible. Our advanced planning for the construction and interior was essential in allowing us to conduct our everyday business efficiently and effectively.

2. Approach

- All work was managed with an in-house employee, responsible for project management.

- Virtually all of the work was designed with 10 different consulting firms. This procedure allowed for a variety of design solutions without delays due to one firm attempting to complete all necessary drawings.

- The core and shell architect designed fifteen of the interior floor plans.

- A large communications task force kept all employees informed. Their activities included:

    - A newsletter
    - Slide presentations with questions and answers
    - Group tours for every employee to be relocated
    - Video tape of the building and surrounding neighborhood
    - Informational packages for supervisors to discuss at internal staff meetings

- Pre-occupancy evaluations reflected a very negative reaction from the staff to the move due to relocation from midtown Manhattan to Queens (another borough, 2.4 kilometers (1.5) miles away)

- Post occupancy evaluations showed highly positive reactions by the staff after the move (The relocation task force won an award for this outcome.)
    - The task force was comprised of members ranging from the corporate policy committee, to mail clerks.

3. Construction

- The tower design includes triple serrated corners which allow up to twelve corner offices.

- A five foot window module is used, which readily accommodates the space standards of 9.3, 13.9, 23.2, and 18.6 square meters (100, 150, 200, and 250 square foot) offices.

- There is a 13.7 meters (45 feet) clear span from the building core to the exterior.

- All floors are raised 152mm (6 inches). The core is 152mm (6 inches) higher than the dropped tenant space, which allows the entire floor to be level, without any ramps.

- The raised flooring is comprised of concrete tiles. This construction technique mitigates the typical problem associated with raised floors - a hollow sound.

- Mechanical distribution is in the ceiling space, with beam openings accommodating duct runs. There are no convectors at the floor level.

- Wiring is laid out on a 3.05 meter by 3.05 meter (10 foot by 10 foot) grid, under the raised floor, on top of the slab, for immediate wiring access and to facilitate wiring changes.

- A parking structure was constructed, housing 762 cars. This was required due to the building being outside of Manhattan.
    - This is less parking space that might normally be required, but the site is served by three subway lines and a commuter railroad.

4. Interiors

- A modified open plan was used as a planning guideline.

- Leveraged purchase contracts with contractors were re-investigated.

- Fourteen furniture lines from five furniture manufacturers were studied for: quality, suitability to the new space standards, pricing, delivery, etc.

- A matrix was produced, based on four principal standards; pricing and comments for each line of furniture were included in the table.

- Full-height office zones were designated, so that if private offices were required, their location was fixed.

- New suggested guidelines were produced, reflecting a universal space standard approach.

- The number of standards employed was reduced from 13 to 4 - one for senior staff, and three for all others.
    - These standards are to be employed worldwide.

- Stacking and space allocations were first based on a generic building type, then individual adjacencies were worked out.

- Customer businesses were grouped, although they are unrelated and had no locational preferences.

5. Lessons Learned

- Advanced planning is essential. This is one reason why the new DOT headquarters should be successful.

- Universal planning is the solution to true flexibility. The eventual goal is to churn staff without touching the workstation..We were fortunate with our standards.

- The building became the test case to prove that a limited number of workstation standards work, and provide true flexibility.

- Furniture selection should be limited to one or two furniture lines for a given building. Our final building contained twenty floors of furniture from one manufacturer, and fifteen floors from another one. However, the other 15 floors had furniture from four other manufacturers.

- Our goals are the same as your goals

    - Build in the most modern, flexible technology
    - Increase building and staff efficiency and productivity
    - Reduce on-going facility administration costs
    - Provide the staff with a twenty-first century work environment

And finally, an axiom for planners:

Good planning, carefully executed, is often mistaken by others, including our supervisors and staff, as dumb luck.

(A further discussion of the topic by this author, and other workshop participants, will appear in a companion publication containing the workshop proceedings (NISTIR 4802).

WORKSTATIONS TODAY AND TOMORROW: DESIGN AND USE

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The following points are in response to some issues being addressed for the workshop:

1. Workstation standards for the large-sized general office area

As a part of an in-house Space Master Planning Study in 1984-1985, we developed new workstation standards to reduce their footprints and to better utilize the inventory of panel enclosures.

To explain the process, MetLife's furniture environment was collected throughout the more than 100-year existence of this large company.

About ten years ago, MetLife selected to give their interiors a more uniform look. It provided enclosure panels in a neutral "oatmeal" color to cover the varied furniture stock. Beige storage components, such as open shelves and flipper-door units, came with the system and were attached to panels. The panel system selected had a very simple panel-to-pole connection detail that could be easily installed and changed without special tools or hardware inventory.

The company also decided to continue using stand-alone furniture (desks, tables, files) rather than getting involved in system furniture (such as hanging work surfaces) attached to panels.

In the long run, this principle allows the use of standardized furniture pieces from different manufactures in competitive market situations. In most typical space revisions, all panel and furniture relocations can be handled by a small in-house crew without bringing in specialized outside help. We believe that this system proved to work very efficiently for us.

The gradual introduction of new cubicles and expansion of regular grid patterns of workstation clusters, together with other factors in the organization of the company, lowered the churn in physical workstation revisions from approximately one third of the Home Office population annually to less than a quarter. The population in those years was about 9,000 people, down from an older number of 20,000.

The size of the new modular cubicles for all open office areas was derived from a study of the numbers and types of panels on hand in 1984.

In that situation, the thousands of existing panels of different sizes could have supported several modular grids. We wrote a software program that took existing panel sizes into account (all between two to five feet long, in 6" increments), as well as the space needs of people on all levels and hundreds of job descriptions. We then simulated different relationships between workstations, floor area footprints and the panel inventory.

The people-space requirements were developed based on a series of interviews conducted in every department in the company which took roughly three months to complete.

The numbers crunch produced an optimal common denominator, a 914mm (3-foot) modular grid, as the basis upon which different panels could be best used. Work functions were accommodated in six primary workstation sizes. Other special types could be derived from them. That created the following sides of cubicles: 1.83, 2.74, 3.66 meters and 305mm (6', 9', 12' and 1') long.

Any such studies and standards, obviously, are the outcome of certain historic circumstances in the situation of a company. MetLife's standardization choice was given by their business outlook in the mid-eighties, the configuration of three adjacent Home Office buildings, changes in population and work requirements, wiring and new equipment technology, spread of personal computers, investments made in furniture and panel inventory, etc.

In other words, there is no one ideal answer, size or type of standards; the outcome should always reflect any company's own economic situation and other interests in given circumstances. These interests are mostly intensified when standing in front of some new venture, and usually will also be a reaction to a previous unsatisfactory situation. Budget allowances and business perspectives will influence other planning and design aspects including the corporate culture.

At MetLife in 1984, as a response to experiences with previous guidelines, the base planning unit was a 1.83 x 1.83 meter (6'x 6') square that could house a desk, chair and typewriter return or PC stand. The next higher size was a 1.83 x 2.74 meter (6'x 9') workstation that repeated the same furniture allowance as the 1.83 x 1.83 meter (6'x 6') plus an additional level of components (i.e. worktables, files, a credenza, bookcases or visitors' chairs. A gradual build-up of requirements resulted in sizes of 2.74 x 2.74 meters (9'x 9'), 2.74 x 3.66 meters (9'x12'), 3.66 x 3.66 meters (12'x12') and 3.66 x 4.57 meters (12'x15'). Later a 2.74 x 4.57 meters (9'x15') footprint was also used. The respective sizes of cubicles then became 3.35, 5.02, 7.52, 10.03, 13.38, 16.72 and 12.54 square meters (36, 54, 81, 108, 144, 180 and 135 square feet).

Full-scale mock ups of the most common workstation types were set up and employees were welcomed to tour them and get comfortable with them.

2. Work areas and office rooms at the building perimeter

Another challenge was the application of modular layout grids in existing buildings, some of them with a non-modular design of ornate exterior walls and very irregular window spacing.

To establish office room sizes with constructed drywall partitions, once the building perimeter was measured out, we calculated a variety of possible common denominators. The CADD computer was used not as a drafting tool but more as an aid in decision making. By experimenting with .914 and 1.22 meter (3' and 4') modules it was finally determined that modules around 1.04 meters (3.5 feet) yielded less waste. This was fine-tuned to a 1.13 meters (3'-4 1/2") base and then doubled to 2.26 meters (6'9") as the smallest planning unit.

As a result, the width of private offices was based on a 4.09 meter (13'5") unit [two 2.06 meter (6'-9") units], leading also to a width of 6.20 to 8.23 meters (20'4" and 27'0"); the depth was approximately 5.49 meters (18'). The office areas were approximately 22.6, 33.9 and 45.15 square meters (243, 365 and 486 square feet).

3. Recent workstation experiences and tendencies

In theses last years there has been a trend towards downsizing corporate interiors.

MetLife is widening the use of open office areas which is reflected in workstation assignments. The cubicle workstation sizes remain unchanged at this time, given the inventory of re-usable furniture and panel enclosures. The whole system is flexible enough to allow special configurations, mainly if needed for a larger number of workstations.

A furniture replacement policy is stimulated by the need for ergonomic principles.

The layout tendency in new buildings or large sized-renovations is to concentrate clusters of cubicles "away from windows", to allow perimeter traffic space, and to limit the use of private offices.

Individual layouts will, of course, depend on the architecture of floor outlines.

(A further discussion of the topic by this author, and other workshop participants, will appear in a companion publication containing the workshop proceedings (NISTIR 4802).

GAO FACILITY MODERNIZATION PROGRAM

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1. Some Background and History

The need for a GAO Building can be traced to GAO's first annual report, for fiscal year 1922 which concluded *"...the supreme need of the General Accounting Office at the present time is a building which will house its entire personnel .. and its records"*. The building, finally completed in 1951, is an example of "Depression Modern", a massive seven story block building with neither interior courts or wings; each floor comprising approximately 1,858 square meters (200,000 square feet. Two important technological developments before World War II made it possible to build a block structure like the GAO Building; air conditioning and fluorescent lighting. Although a few government buildings before GAO, were air-conditioned, at the time of its completion the GAO Building was the largest air-conditioned building in the District of Columbia and second in size to the Pentagon in the United States. Also, while not an innovation, the flat slab construction in the GAO Building was an important technological factor, allowing heavy loads on each floor anywhere in the building.

When the new building originally was designed, its designers envisioned the need for large spaces for files. Thus the building when completed in 1951 had enclosed offices with windows along the outer walls, but with much of the inner space unpartitioned. With the passage of the Budget and Accounting Procedures Act of 1950 much of the GAO's audit activity could be performed at sites located in the departments and agencies being audited. The almost overwhelming need for file storage space was no longer present. So GAO had a building too large for its staff needs (7000 downsized to approximately 5000), many of them working outside of Washington, and its internal structure designed for the past rather than for the present.

The first major renovation effort began in 1972 after more than 20 years of building use. Over a period of 6 years, old plasterboard partitions and metal partitions were replaced with partitioning configured in ways which gave most staff private work space. New ceilings, lighting, and carpeting were installed, as well as new office furniture and additional HVAC capacity.

By the latter years of the 1980's, the need to update the office areas to accommodate emerging office technology concurrent with the existence of asbestos ductwork which hampered this effort, led to a second major renovation and remodeling effort. The current modernization program is affording an opportunity to not only satisfy specific facility deficiencies in power and HVAC support, but also the Comptroller General's goal of a first rate facility which would contribute substantially to effective achievement of GAO's mission.

2. Program Planning Assumptions

Initial GSA planning Assumptions were driven by several constraining standards and design solutions. Functional requirements when considered against then existing space utilization standards which could only be satisfied through extensive use of open systems furniture workstations. Initial layouts assumed approximately one thousand workstations per floor (90% open, 10% private drywall).

These assumptions were revisited upon the passage in 1988 of PL 100-545, the GAO Building Transfer Act, which gave the Comptroller General exclusive control over the GAO Building. A fresh examination of initial design solutions was performed utilizing the following design objectives:

- Develop facility design standards which present the character and nature of the GAO. They should reflect the qualities inherent in the advice and assistance the organization provides to the Congress: professionalism, intellectual excellence, integrity, and responsiveness.

- Develop facility design standards which effectively link people and technology in a pleasant, comfortable work environment.

- Design reception areas, major conference space, and other common space reflecting a consistency of building features to firmly establish a GAO facility image and identity.

- Develop an internal space design concept and utilization standards, which reflects a generic approach allowing for interchangeability of tenant occupancy with only minor alterations.

- Implement flexible state-of-the-art computer and communications capabilities to effect improved and productive sharing of information among both work groups and major organizations.

Additionally, the Buffalo Organization for Social and Technological Innovation (BOSTI) was commissioned to study existing and proposed standards and make recommendations for office layouts.

BOSTI developed a function-based activity and work-behavior profile from interviews with several groups of GS-13 through GS-15 staff members. It then derived design requirements from these profiles, and generated several office plan alternatives designed from the "inside-out". These designs were then modified to fit the space planning constraints of the GAO Building. Given this process, the recommendations which followed were determined by both utility to the occupant and support for efficient space planning. The requirements for these offices and BOSTI's recommendations were as follows:

2.1. For GS-13 through GS-15 offices:

- All offices should be fully private .. that is, have four walls and a door, with walls opaque at least to door height.

- Because of the building's 2.32 square meters (25 square feet) bay size, a 9.29 square meter (100 square foot) office would "just" accommodate the needs of GS-14 auditors, but not of GS-14 or GS-15 lawyers who need more storage. In space planning with various size offices, this 9.29 square meter (100 square foot) office would not improve the space utilization rate over, say, a 12.08 square meter (130 square foot) office, that is, no space planning economies come with use of the smaller office. Because of this, and the need for a separate and larger design for lawyers, the 9.29 square meter (100 square foot office was not recommended.

- GAO's organizational culture permitted all GS-13 through GS-15 staff to be housed in a one-size-fits -all office. One possibility was a 12.08 square meter (131 square foot) (net) office which would comfortably accommodate the needs of GS-13, GS-14 and GS-15 auditors and lawyers, and other job types. If status distinctions were desired, they could be achieved through choice of materials and quality of furniture rather than through adding non-functional space.

- Use systems furniture componentry within non-systems private offices to support GAO's extensive needs for storage, and to save floor area.

- Building the storage support hardware into the permanent non-systems walls, rather than using systems furniture panels inside the offices. This would both save the space the panels would occupy and be a more sturdy method of installation. The sample workspaces were designed so that only 2 (of 4) walls needed to support wall-hung storage units.

2.2 For GS-12 and Under

- A one sized-fits all open office systems furniture workstation of approximately 6.96 to 8.36 square meters (75 to 90 square feet) could accommodate GS-12's and under, and such a size would be useful in space planning on this floor plate as well.

3. Changes in planning assumptions

Based on review of the BOSTI study and a re-analysis of building space utilization and organizational stacking, changes were made in planning assumptions as follows:

- Adoption of BOSTI's recommendation of a one-size-fits-all office size standard and related furniture solution for GS-13 thru GS-15 staff: (See Attachment I)

- Adoption of floor occupancy objectives as a planning framework: (See Attachments II and III)

- Development of a revised building stacking (occupancy) plan: (See Attachment IV)

- Revision of generic floor design requirements incorporating office standards and floor occupancy objectives. Note: The process did result in slight adjustment of final drywall office counts approximating a 60% - 40% split between private and open-office workstations. (See Attachments V thru XIII) for layout and detail sketches.

- Revision of building interior design standards.

- Development of a GAO Building Design Manual, incorporating generic design standards as well as standards for furniture and accessorization.

The above charges in program planning assumptions were developed within the broad framework of the GAO Building design objectives while holding schedule and budget as constants.

4. Implementation Plan Assumptions and Current Program Status

4.1. Program Phasing and Implementation

The prospectus for "...repair and alteration" of the GAO Building assumed modernization activities would be performed under occupied (approximately 80%) conditions. Implementation assumptions were based on the following: - substantial completion of project within five to six years.

- Maximum consolidation of GAO audit site staff in main building at earliest practical date, (approximately 1000 staff at 30 sites).

- Minimum number of interim moves. To the extent practical, organizations would be moved directly to final planned space assignments.

- Take necessary steps to vacate one complete floor. A full floor represent an optimum work package size, (one half undergoing asbestos abatement, the other build-out).

- Acquisition of single contract authority, for a contract to be awarded competitively, to assure continuous and aggressive progress with a single contract team.

A move scenario was developed, (involving 20 - 30 individual projects), which would empty one complete floor (the fourth). Work then in process and projects necessary to completely vacate the floor were organized and designated as Phase I. Phase II included all remaining full floors (4, 2, 5, 6, and 3) each of which constituted a discrete work package.

4.2 Method of Contracting

Program phasing, especially considering GSA's continuing responsibilities and involvement, and the existence of a commercial facilities manager, then in place for a five year performance period, required a flexible method of contracting. Additionally Congressional approval of "single contract authority" and its attendant requirement for competition required a design and packaging concept that afforded a basis for meaningful competition while offering sufficient flexibility to accommodate change over its five year life. The following principles and standards were applied to minimize risk and maximize flexibility:

- GAO Building occupancy objectives, to include office and workstations standards.

- Development of a generic building floor plate design allowing for interchangeability of tenant occupancy with only minor alterations.

- Development of complete building design and specification package upon which competitive solicitation would be based.

- Utilization of the CFM contractor to directly support and perform Phase I activities. The CFM could act as the construction management only, during Phase II providing the support necessary for GAO to conduct the competitive attachment.

- Utilization of the CFM contractor to directly support and perform all demolition and asbestos abatement activities. This would ensure early return of building floor to "shell" condition, and preclude delay of build-out contractor.

- Utilization of a single systems furniture vendor and related services for entire building.

5. Current Status of Program

As of today Phase I is substantially complete with a full half of the fourth floor having been demolished and fully abated. Approximately 80 people are awaiting move-out to swing space within the next three months. Work on supporting HVAC and electrical systems is now underway and in phase with the build-out schedule. Phase II construction activities are planned to commence in mid-February, 1992.

6. Some Unique Factors Contributing to Program Success

While phase II work has not yet commenced, progress to date has indicated that program objectives are clearly attainable. Several contributing factors to this prognosis are worthy of review at this time:

- Absolute commitment of the building owner to a program which supports higher order organizational objectives of recruiting and retaining quality staff. A quality workplace, including day care, fitness, parking, and other amenities is a critical part of any employee compensation and benefit package.

- The length of the Comptroller General's term, fifteen years, which allows for the stability and consistency to complete a multi year program.

- Direct ownership (custody) of the facility reflecting GAO's independence from the Executive Branch. Enabling legislation did not impose GSA standards on GAO. - Congressional agreements to use SLUC (rent) payment as offset to modernization budget thus insuring stable, continuous budget authority.

- Availability of commercial facility manager to provide construction management, technical, and acquisition support.

- Empowerment of program manager with authorities necessary to carry out program responsibilities.

7. Some Problems; Some Solutions

7.1 Wire Management

While planning for voice and data wiring did result in a generic solution, other requirements for building system support lagged far behind. This was partly an organizational responsibility issue, partly a function of the timing of the design of these systems. Support is required for the following systems by their individual users:

- Voice
- Data (LAN)
- Security
- Fire protection
- HVAC controls
- Video

It was concluded that no opportunity existed for a single multi-media cabling or wiring solution, Rather the following "wire management" plan is now being implemented.

- Proceed with voice and data generic scheme (fibre optic backbone with twisted pair connections to individual workstations).

- Assume phone and PC networking capacity at each workstation.

- Provide wire tray system with adequate capacity to support individual user requirements.

- Proceed with generic wiring schemes for security, fire protection and building systems.

- Develop institutional wire management capability to perform the following functions:

  - Documentation and update of wiring standards.

  - Inventory management of building wiring and maintenance of documentation.

  - Coordination of capacity sharing.

  - Coordination of major installation requirements.

  - Operational support of individual systems would be provided by user.

7.2 Asbestos - A Blessing and a Curse

In order to upgrade building HVAC, electrical, and telecommunications systems extensive work would be required around asbestos ductwork and asbestos contaminated materials in the ceilings. Virtually all the horizontal ducts in the several-mile long ductwork system are composed of nearly 100% asbestos. Renovation cannot be performed above the drop ceiling except under asbestos conditions. Any abatement plan must assume work would be done under occupied conditions and in a timely manner so that space can be turned over to a general contractor in a "shell" condition. The existent of this asbestos condition defined the overall scope of the modernization program. A plan was developed which assured the following:

- Abatement activities would be confined to vacated floor after tenant move-out and after severing of floor from building's HVAC system. (See Attachment XIV)

- Demolition and abatement activities would be responsibility of CFM contractor which would coordinate work with O&M activities.

- GAO's asbestos abatement program would continue to perform air monitoring of occupied space and interface with concerned tenants.

7.3 Floor Plate Size - A Design Challenge

Attachment I provides excerpts from a BOSTI report, "GAO Planning and Design Guidelines". These recommendations were generally followed during development of the generic floor plan.

7.4 Open vs. Private Drywall Offices

Initial design solutions assumed private office down through the GS-15 level, (approximately 10% - 90%). This was driven in large measure by GSA's utilization standards and partly by the relative attractiveness of a systems furniture solution. Upon reconsideration it was decided to adopt BOSTI's recommendation.

8. Overview of Problems

To develop high performance workspace for GAO, two major problems need to be addressed: 1) The floor area is exceedingly large, presenting special problems, and 2) the offices are outdated and do not support the work that goes on in them very well.

Overly Large Floor Area: GAO's floor plate is enormous. (Each floor contains 1,858 square meters (195,000 square feet), about five times the size of the average one.) It was originally designed for storage, but now houses people doing knowledge-based work in office settings. Stemming from the original "warehouse" design of the building, each floor has some unusual physical characteristics which give rise to a number of problems, which are:

a. There are very long horizontal travel distances between places on the floor (the building is 198.1 meters (650 feet) long in one direction).

b. Because of the large area and the small perimeter, there is excessive distance to window light and views to the outside. (The average distance to a window from any point on the floor is 30.5 meters (100 feet.))

c. The floor houses 750 people in relatively few office types. So there is, automatically, great repetition of identical physical features - a boring, monotonous, perhaps slightly numbing environment, and one that make people feel too anonymous.

d. A maze of similar corridors and spaces and lack of differences or landmarks makes it difficult for people to find their way through the building, especially for visitors and new employees.

e. Because of the lack of diversification among areas on the floor, there is little physical identity for workgroups, reducing workgroup cohesion.

f. Despite the fact that the floor has a generally regular grid 7.62 by 7.62 meters (25' by 25'), many of the bays, and in a random pattern, are "irregular" and contain elevators, ducts and stairs, which can cause problems with deploying workspaces across the floor in a way that permits efficient space utilization.

Given this, we must develop planning guidelines that will address the special problems caused by the very large floorplate and the repetition of identical elements.

8.1 Outdated Offices

While the nature of office work and the tools for doing that work have changed dramatically over the past twenty years, no major changes have occurred in that same twenty years in the planning, design, or furnishing of GAO's offices. To a large extent, there is now a "misfit" between the nature of the work and the design of the offices that support that work. Since much research shows us that office planning and design have direct effects on the productivity and quality of worklife for individuals and workgroups, continuation of such a "misfit" will continue to reduce GAO's organizational effectiveness.

Given this, we must develop a modernized environment for GAO that can be used as a means of recruiting, rewarding and retaining high-performers. This means that the environment should be designed specifically to support the work of people in all job categories, and to support the work and interaction occurring in workgroups. To this end, the planning and design of the floor and all spaces and subsystems in it should utilize research findings about the impact of office design on productivity and quality of worklife, and use benefit-cost analyses, wherever possible, to help make decisions.

8.2 Summary of Strategies for Use in Planning and Design

In approaching the problem of planning this large area for a large population, using some urban design strategies has been useful as a starting point for the large area and population of both seem somewhat analogous. At the same time, where urban design strategies are not useful, we have discarded them. All the strategies we deem useful are described below, starting with those dealing with the largest area, the floorplate, and going down to the smallest area, the individual office.

8.2.1 Strategies for the entire floorplate

a. Subdivide the floor into understandable "pieces".

To reduce the apparent size and complexity of the floorplate, organize it into a set of physically defined sub-areas, each with a clear center and clear boundaries, and a hierarchy of places within it. Establish four to six "neighborhoods" on the floor, each reached by the most major circulation path, each of which is composed of "blocks" of offices, which surround and lead to a central "plaza".

b. Clear and hiearchical circulation pattern.

Establish a circulation pattern which helps accomplish several objectives: both subdivides the floor and connects its parts; aids in orientation and wayfinding by letting people know where they are and where they are going; and reduces the apparent length of travel distances. This can be accomplished through the use of a three-level circulation hierarchy of "boulevards", "main streets", and "side streets", in descending order of size.

8.2.2 Views and daylight for everyone.

Because of excessive distances to windows, and the decreased opportunities for outside views, it is important to provide views and daylight for everyone at several times during the day. Thus, a substantial portion of the windowed perimeter should be set aside for more public use, such as circulation, meeting places and lounge areas. Boulevards, the widest and most used of circulation paths, should end with clear views out windows.

8.2.3 Build correct ratio of workspace types for each department.

There will be about a half-dozen different workspace types which accommodate all the major function-based job categories within GAO. Each division may have somewhat different ratios of those job categories. It is intended to build, in each department's general area, the general ratio of workspace types appropriate for each department. When departments reorganize, it is intended that they try to move people rather than offices, 60% of which of which are fixed-construction private offices. (If ratios change over time, and if these changes create problems, the mix can be changed because the space planning strategies can accommodate such change.)

8.2.4 Simplify space planning

Space planning occurs both before move-in and then may occur each time a division experiences a major reorganization. To assure least difficult space planning, now and in the future, design all offices so they utilize perfectly the 7.62 by 7.62 meters (25' by 25') bay and grid; so that groups of offices form "blocks", so that each block's plan automatically includes circulation in two directions; and so that planning can accommodate floorplate irregularities as they occur.

8.2.5 Strategies for Neighborhoods

a. Make each neighborhood identifiable

To help people find their way around, each neighborhood should be different from all others in at least two ways - at its edge and at its center.

b. Support space in each neighborhood

To assure sufficient space for administrative activities, amenities and services, dedicate 15 to 20% of the total area within each neighborhood to support space. This would be best located in the same central location as the neighborhood central plaza.

c. Develop a central plaza for each neighborhood

To make use of support space efficient, and to reinforce the identity of each neighborhood, design a unique, identifiable, central open space plaza around which is clustered frequently used administrative and support services. The plaza is paved, lit softly, and contains the neighborhood's information kiosk, and seating and natural elements such as plants. Each neighborhood's plaza is distinctly different in character, aiding people in finding their way around. The plaza provides a place to "shop" and do business, to be an informal meeting place, and for people to relax.

d. Reduce travel distances

To reduce real travel distances to administrative and support services, distribute these in sub-centers across the floor, locating them around each neighborhood's central plaza. To reduce the perceived length of travel, ensure that circulation paths change direction reasonably often.

e. Recognizing people in the streets

To reduce feelings of anonymity and increase the sense of community and feelings of security, no corridor should be longer than 19.8 to 22.86 meters (65 to 75 feet), which is the maximum distance at which people's faces can be recognized - so all corridors will be short enough so that people will see who else is there.

f. Increase visual width of streets

Given that 60% of all offices are private, with four walls to the ceiling, and that the ceiling height is nine feet, some streets may have a claustrophobic feeling. To reduce this, consider designs for private offices which have a substantial glazed area above the opaque portion of the walls, which would visually extend the corridor's space; and consider street designs which occasionally widen and are left unfurnished, introducing variety in widths.

8.2.6 Strategies for workgroups

a. Maintain reasonable proximity of co-workers

It is desirable to locate people reasonably near those they need to interact with frequently - with a principle called "workgroup integrity". Many individuals are, however, engaged simultaneously in multiple projects, or work with others who do, and thus people may be involved in several function-based workgroups at one time (and as well, have a different reporting, or administrative affiliation). This pattern of multiple and changing affiliations suggests a reasonable, but loose, proximity should be maintained rather than attempting to have "perfect" adjacencies. This is largely accomplished by moving people when necessary, and never or seldom moving offices.

8.2.7 Strategies for individual workspaces

a. Design fewest appropriate workspace types

To simplify facility management, develop the fewest possible workspace types or "footprints" which are compatible with the concept of functionally appropriate designs.

b. Workspace design based on function more than status

Design workspaces based primarily on analysis of the occupant's activities and functions and less on status or title. Wherever it is important to communicate status, consider using quality of furniture and materials rather than floor area or layout as a status communicator. Assign people to workspaces based on a simple, self-administered analysis of activities checklist.

c. Design for both paper and electronics

To accommodate differences in work patterns which are both personal and job related, design offices to support both an extensive use of paper and electronics, and with individual options that allow the emphasis of either work mode.

(A further discussion of the topic by this author, and other workshop participants, will appear in a companion publication containing the workshop proceedings (NISTIR 4802).

GAO Square Footage Guidelines	
Personnel Classification	Office Size (Square Feet)
Private Office	
ACG (office)	450
ACG (conference room)	225
Director	
SES/Major Office Directors	450
SES/Issue Area Directors	250-300
SES/Senior Associate General	"
Counsel, SES/Associate General	"
Counsel, SES/Deputy Directors	"
GS-15/Office & Center Directors	225-250
Band III/GS-15	150
Band II/GS-13-14	130-150
Open Workstation	
Band I/GS-12 and below	60-80
Secretarial and others	60-70

Attachment II

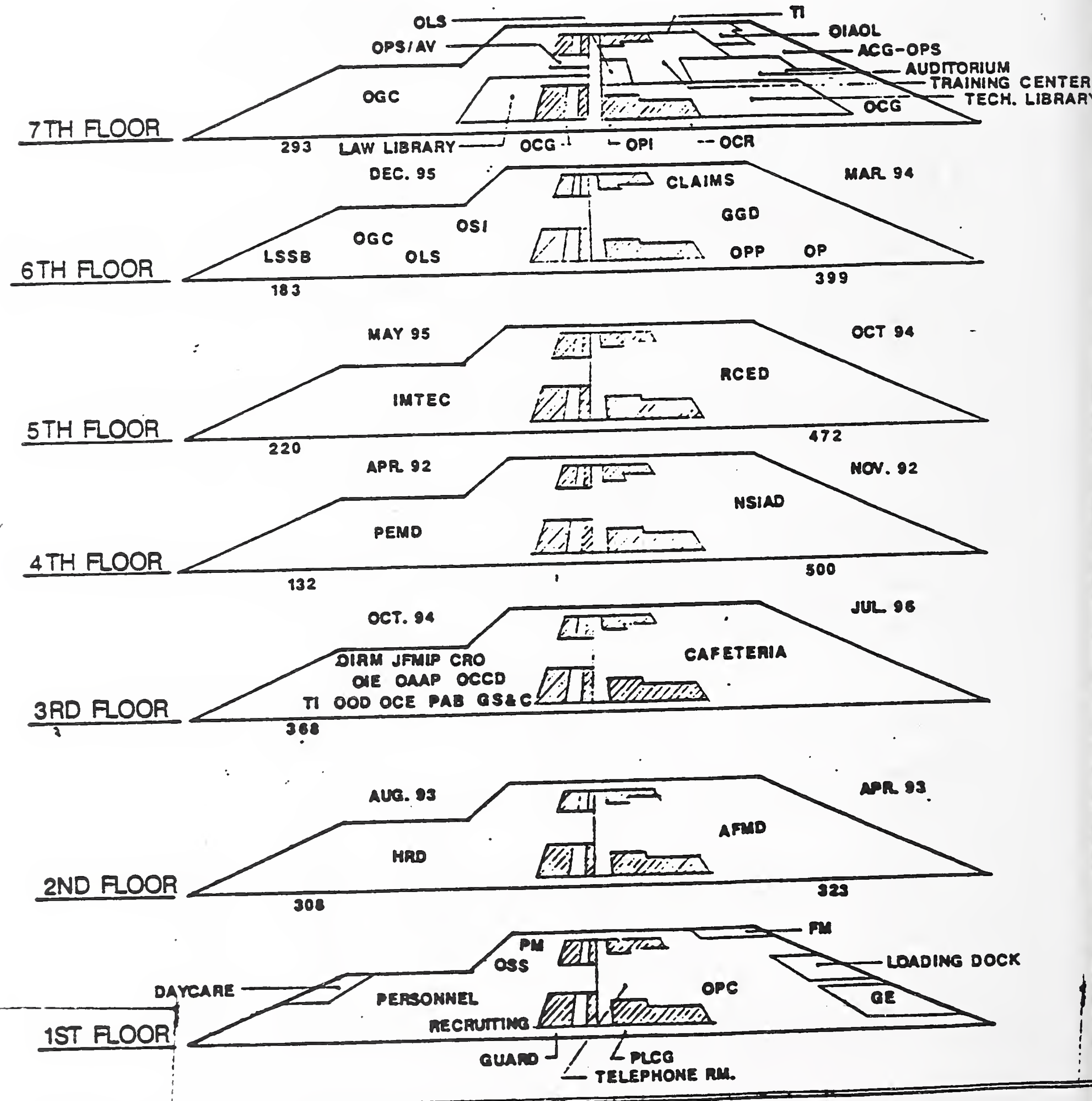
GAO Occupancy Objective for Permanent Space Allocations*

	Private offices						Open Stations	
Space (sq ft)	450		225-300		130-150		60-80	Approximate Totals
Floor								
First	2	+	30	+	220	+	150	400
Second	6	+	50	+	400	+	300	750
Third	4	+	20	+	180	+	150	350
Fourth	6	+	50	+	400	+	300	750
Fifth	6	+	50	+	400	+	300	750
Sixth	6	+	50	+	350	+	250	650
Seventh	15	+	35	+	200	+	50	300
Total Personnel								3950

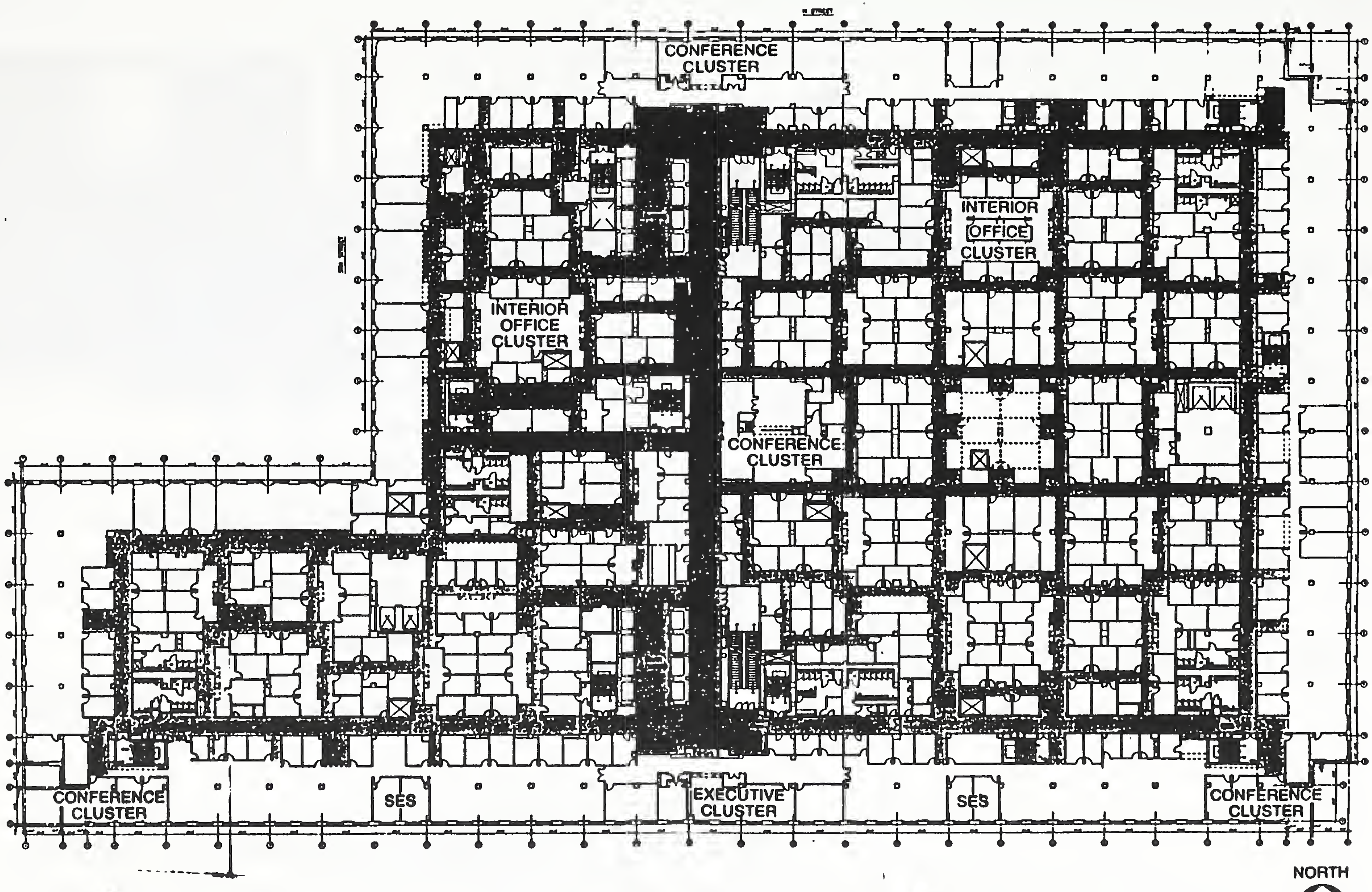
* Includes 10 percent growth factors per floor

Attachment III

MODERNIZATION PROGRAM REVISED STACKING ASSUMPTIONS

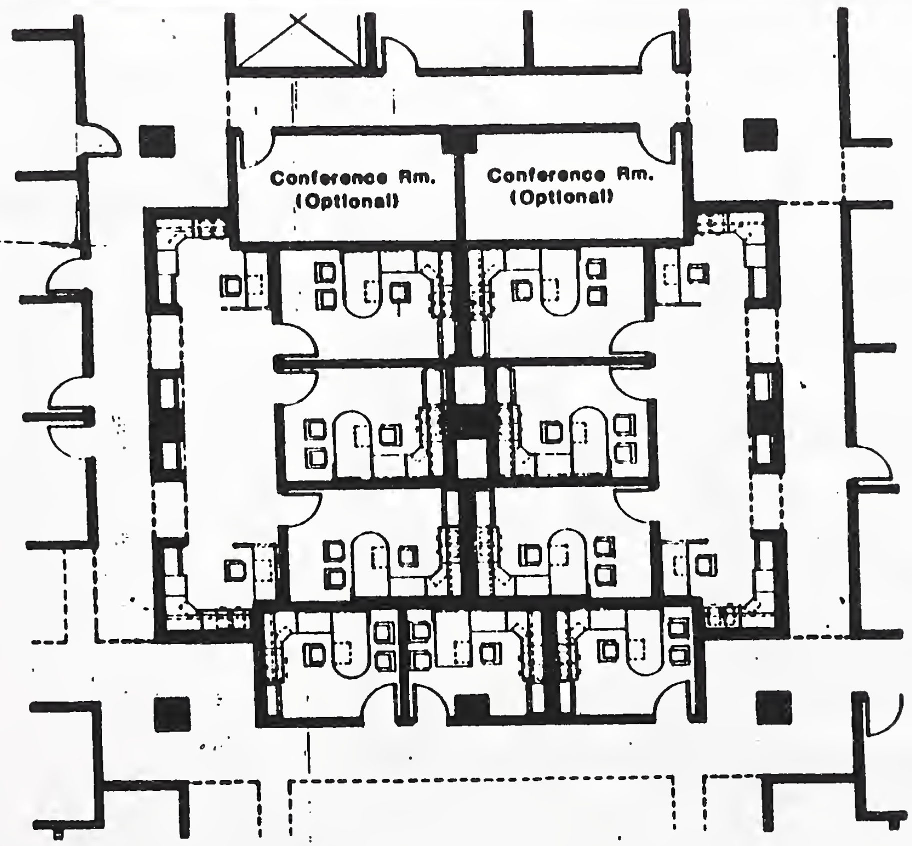


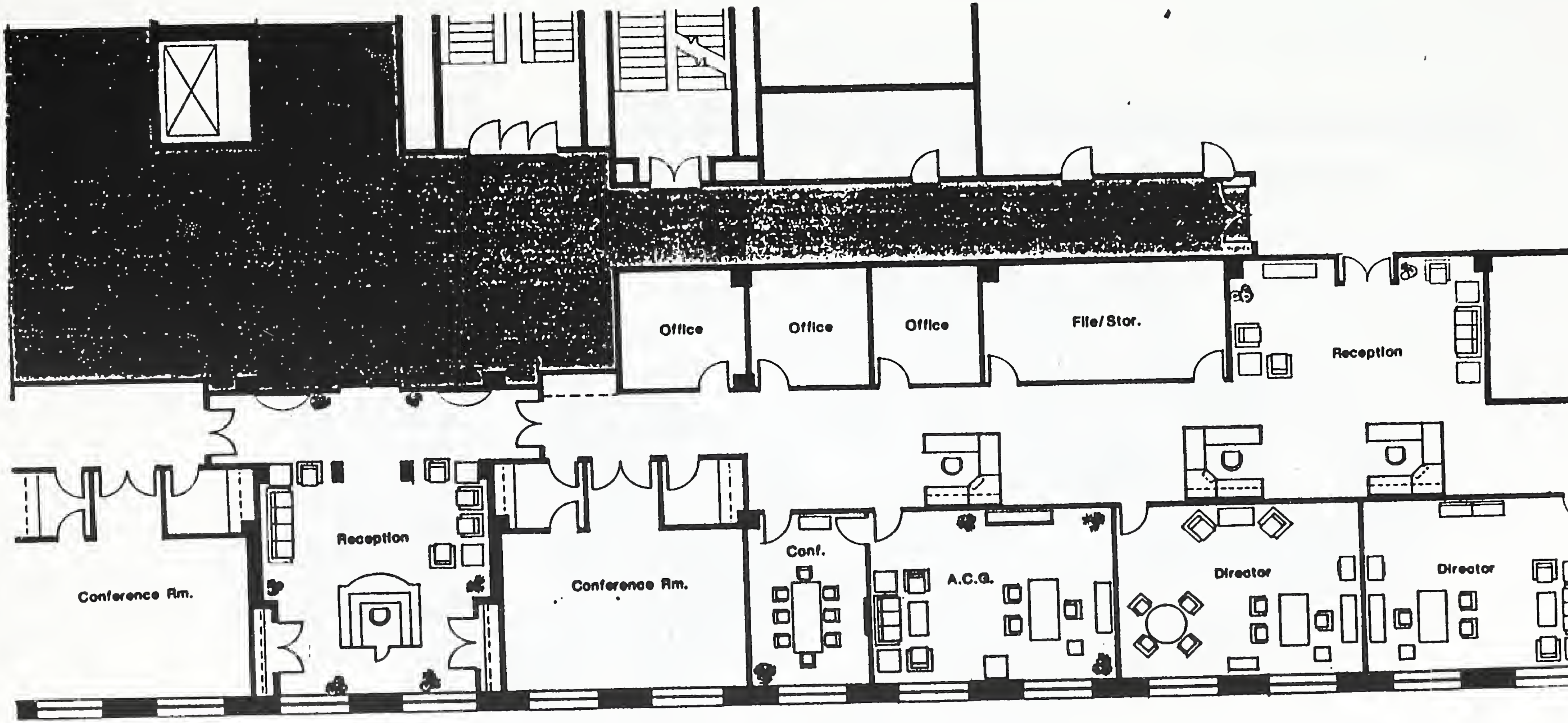
GENERAL ACCOUNTING OFFICE MASTER PLAN



GAO GENERIC 4TH FLOOR PLAN - SCHEME B

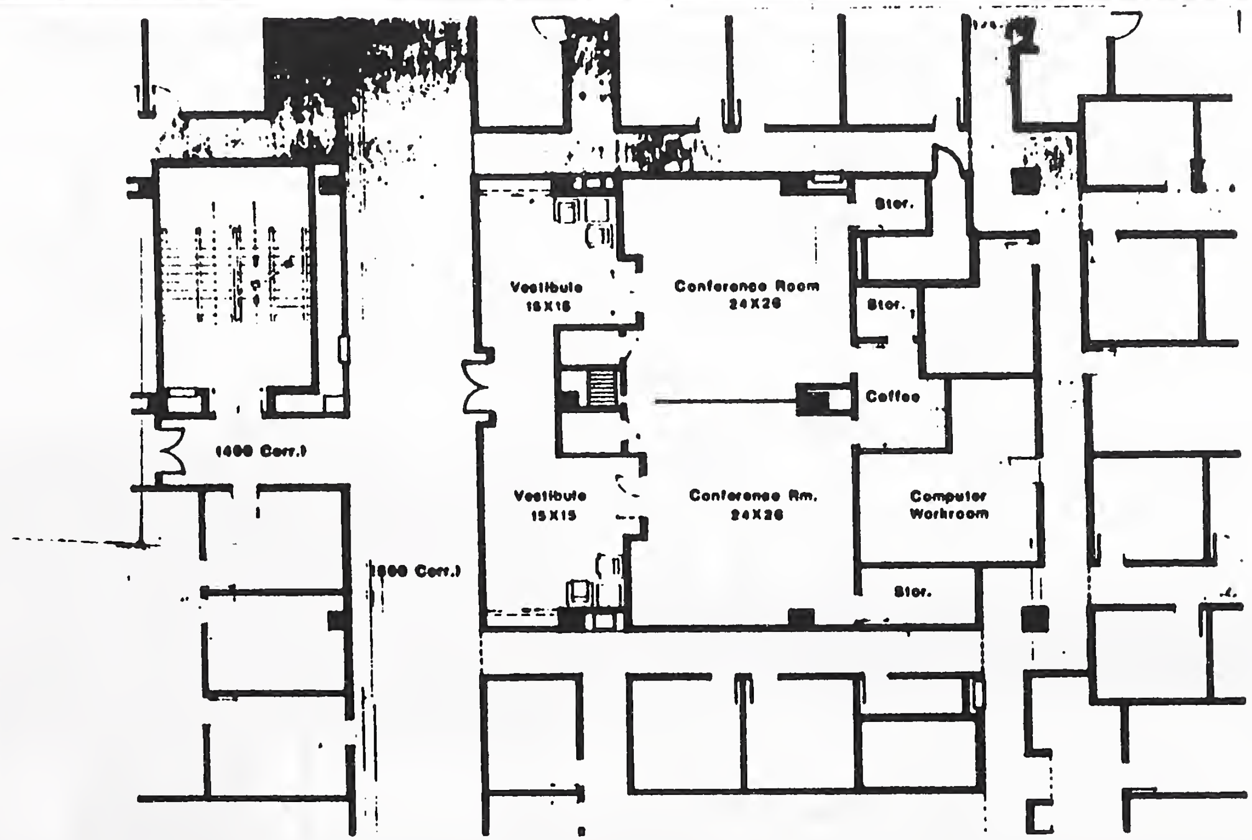
GAO Interior Office Cluster





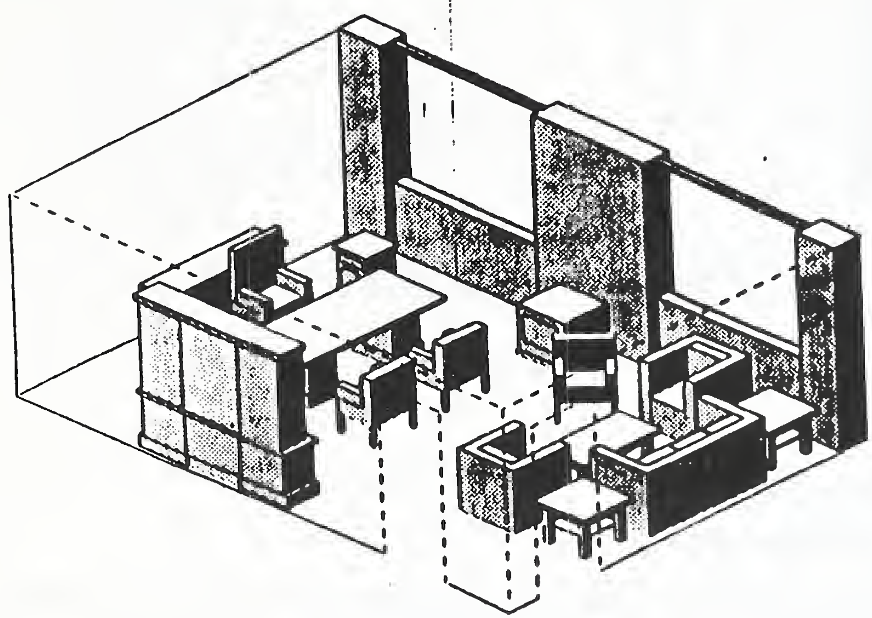
EXECUTIVE CLUSTER
(CENTER LOCATION)

GAO Conference Cluster

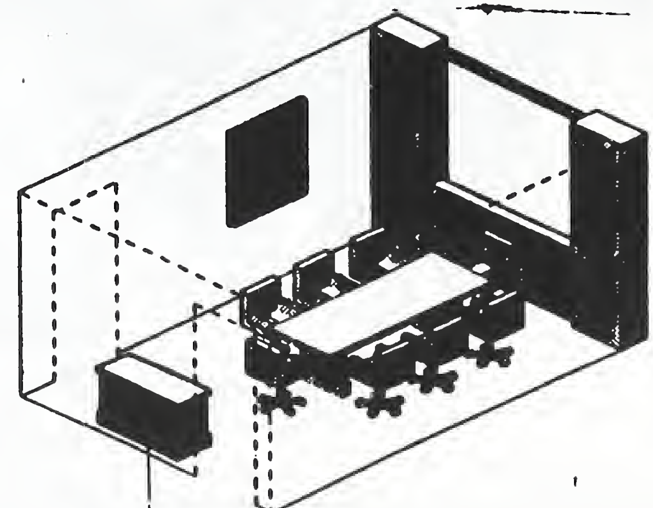


GAO Assistant Comptroller General (A.C.G.) Office

Office



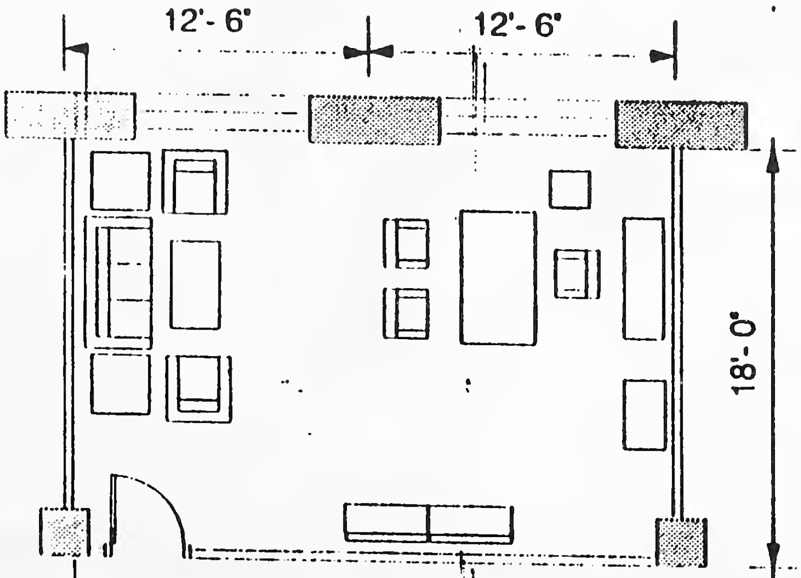
Adjoining Conference Room



GAO SES/Major Office Directors

Accessory Standards:

Lamps: 3 max. Plants: 2 max. Artwork: 3 displays max.



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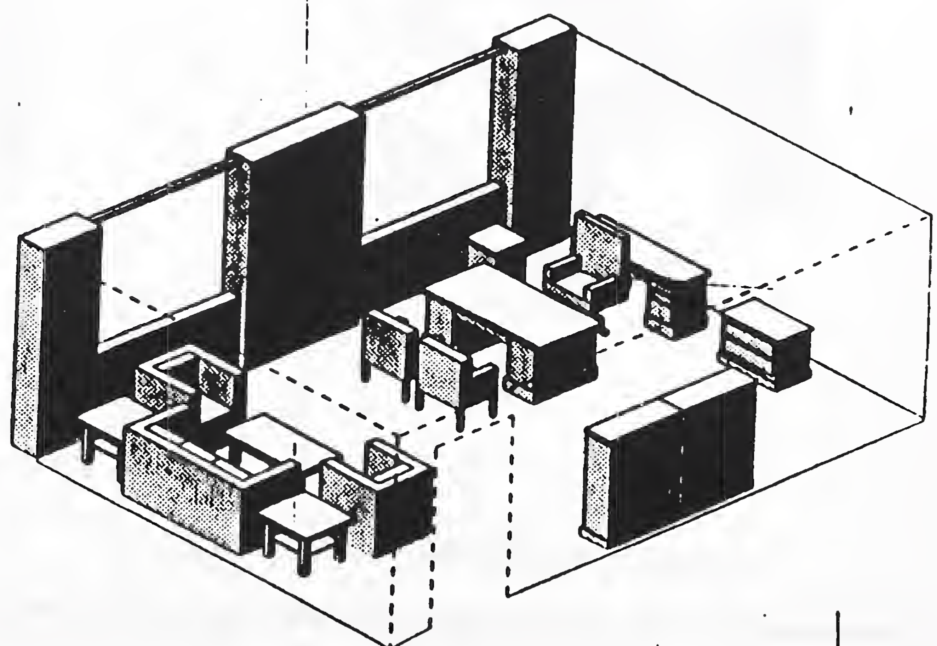
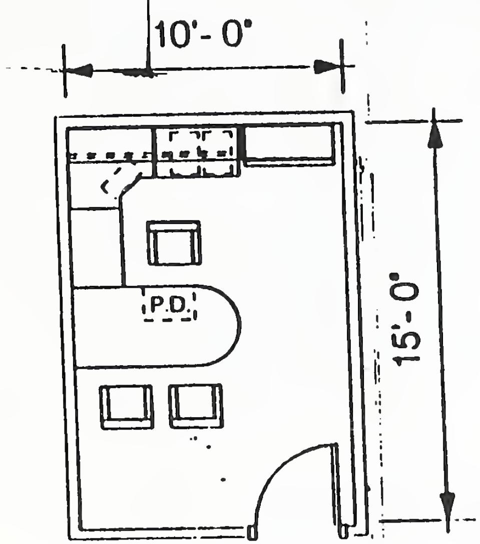


GAO Band III - Private Office

Accessory Standards:

Lamps: none Plants: none Artwork: 1 max.



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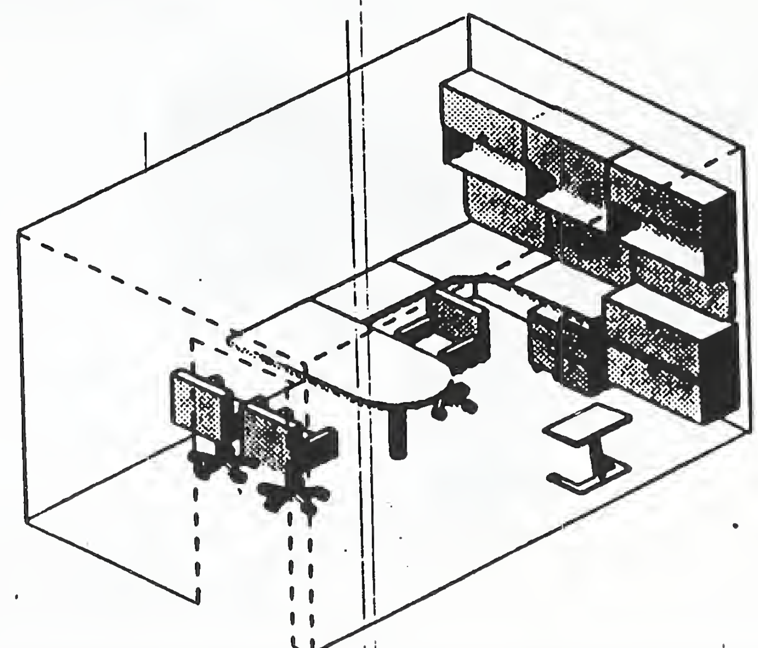
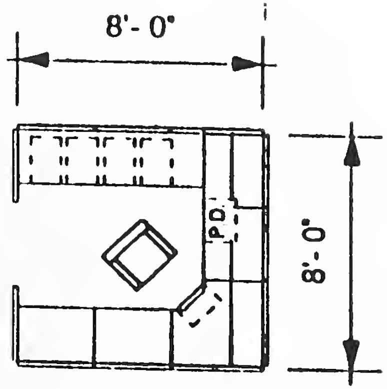


GAO Secretarial Station

Accessory Standards:

Lamps: none Plants: none Artwork: none



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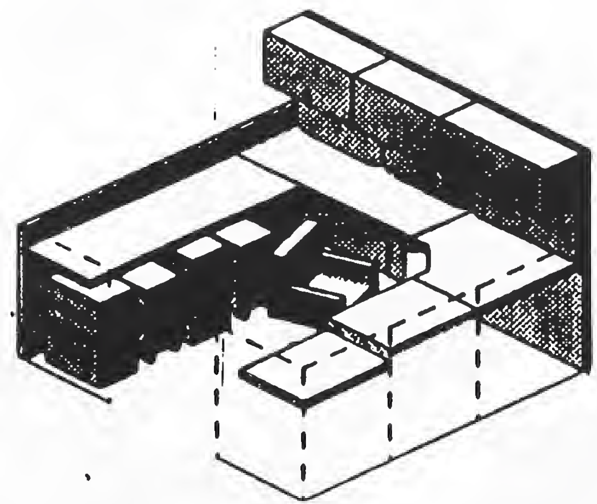
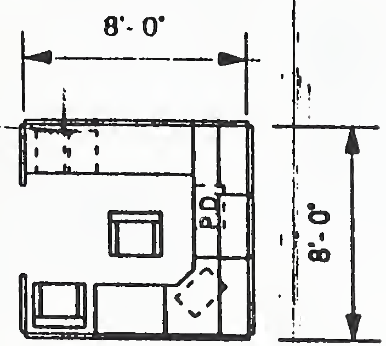


GAO Band I - Professional

Accessory Standards:

Lamps: none   Plants: none   Artwork: none



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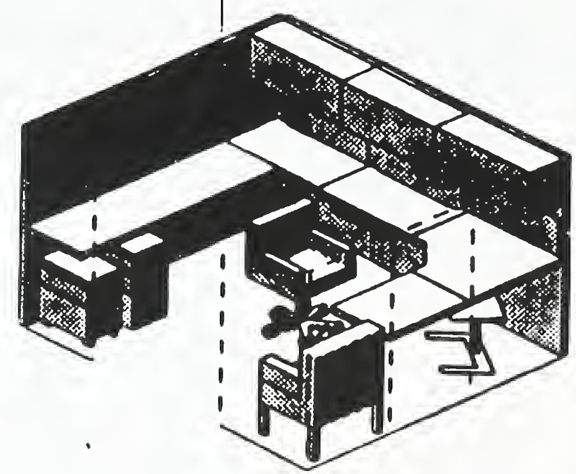


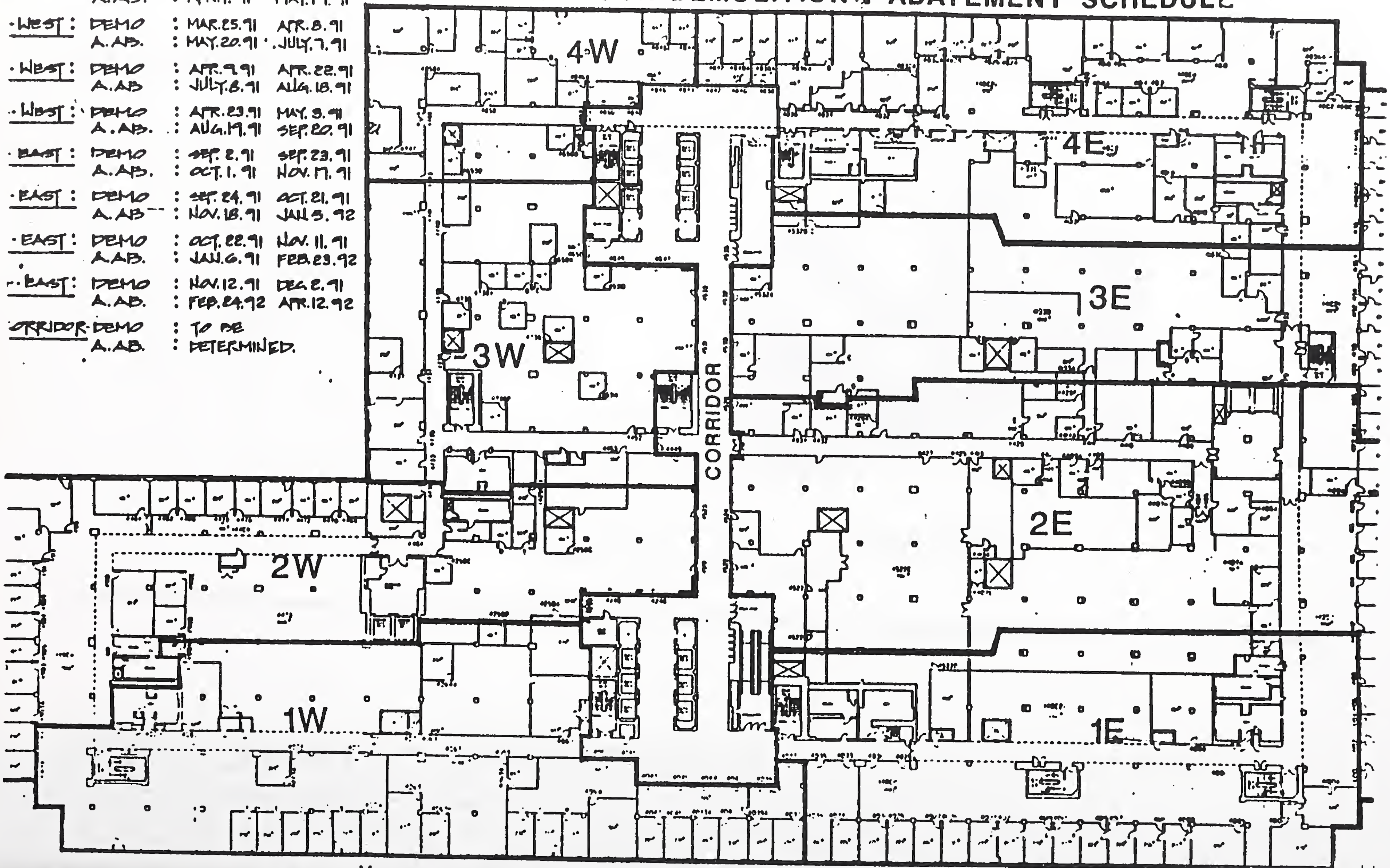
12 FEB 91

CHEDULE :

		START	FINISH
WEST :	DEMO	MAR. 1. 91	MAR. 22. 91
	A. AB.	APR. 1. 91	MAY. 19. 91
WEST :	DEMO	MAR. 25. 91	APR. 8. 91
	A. AB.	MAY. 20. 91	JULY. 7. 91
WEST :	DEMO	APR. 9. 91	APR. 22. 91
	A. AB.	JULY. 8. 91	AUG. 18. 91
WEST :	DEMO	APR. 23. 91	MAY. 3. 91
	A. AB.	AUG. 19. 91	SEP. 20. 91
EAST :	DEMO	SEP. 2. 91	SEP. 23. 91
	A. AB.	OCT. 1. 91	NOV. 17. 91
EAST :	DEMO	SEP. 24. 91	OCT. 21. 91
	A. AB.	NOV. 18. 91	JAN. 5. 92
EAST :	DEMO	OCT. 22. 91	NOV. 11. 91
	A. AB.	JAN. 6. 91	FEB. 23. 92
EAST :	DEMO	NOV. 12. 91	DEC. 2. 91
	A. AB.	FEB. 24. 92	APR. 12. 92
RRIDOR :	DEMO	TO BE DETERMINED.	
	A. AB.		

UNITED STATES GENERAL ACCOUNTING OFFICE
441 G Street, N.W., Washington, D.C.

FOURTH FLOOR DEMOLITION X ABATEMENT SCHEDULE



FOURTH FLOOR PLAN

THE TRW HEADQUARTERS BUILDING - DESIGNING AN INTELLIGENT BUILDING

Arthur Rubin
National Institute of Standards and Technology (NIST)
Gaithersburg, MD

The following paper is based upon an extensive interview with Mr. Jack Gearhart, leader of the TRW headquarters design project, Mr. Peter Steigerwald, facility manager, and Mr. Herbert Rosenheck, system integration specialist, during a visit to the TRW headquarters building in September, 1985. Additional material was obtained from a referenced article in Facilities Management and Design, October, 1985.

1. Background

TRW was formed as a result of a merger of Thompson Products (an automotive company and maker of airplane parts) and Ramos Woolridge, (a California aerospace, military contractor) in 1954. The major parts of the organization are run independently, with minimal intrusion from the central headquarters.

TRW consists of three sectors - Automotive Worldwide (AWW), Industrial and Energy (I&E), and Electronics and Defense (E&D). AWW and I&E have headquarters in Cleveland, E&D is located in southern California. TRW is organized in a matrix management fashion. It has long been recognized as a people-oriented company. In 1985, it was number 53 in the Fortune 500 listing.

In 1973, TRW decided that it required a new corporate headquarters building for several reasons:

1. They facilities were outmoded.
2. They didn't want to invest any more in the old facilities.
3. The old facility did not respond to changing requirements.
4. A high technology company did not have appropriate workspace.

TRW did a worldwide search for where it should locate its headquarters. They decided on the Cleveland area for several reasons. TRW had been there since 1901. The company headquarters personnel live there. Cleveland is close to large numbers of TRW customers. It is relatively close to the financial center (New York City) and the political center (Washington, D.C.) of the country. TRW considered three sites near Cleveland, before deciding on a 38 hectares (93 acre) site in Lyndhurst, Ohio, a suburb of Cleveland. It is close to their previous headquarters (11.27 kilometers - 7 miles away), 4.83 kilometers (three miles) from a county airport used by TRW, and about 1.61 kilometers (one mile) from a major interstate highway.

The site is located in the midst of a heavily wooded area of 55 hectares (137 acres). The building has four wings that stretch out from a center atrium. Conforming to the hilly site, the building has two wings with three floors, and two have a fourth floor, starting below grade. Three wings are 66 meters (216 feet) long, and the fourth one measures 87 meters (288 feet). Each wing is 33 meters (108 feet) wide. It contains 41,400 square meters (460,000 square feet) for offices and support spaces, plus 27,000 square meters (300,000 square feet) for underground parking.

The building module was standardized at six feet, which when halved to three feet would provide a flexible basis for all other building and furniture components. A 914 x 914 mm
(3 x 3 foot) module was used for the demountable wall panels used for offices, and the same dimensions were used for the ceiling grid.

Several standardized sizes were employed for closed offices; ranging from 5.5 x 5.5 meter (18 x 18 feet) for high level executives to 3.66 x 4.57 meter (12 x 15 feet) for professionals. Secretarial and support positions were placed in open areas with 1.07 meter (42 inch) partitions, enclosing either 8.83 or 9.66 square meter (95 or 104 square foot) areas.

An atrium was designed to be used as a community center, with areas where people can have informal conversations. Off the atrium are common use facilities, e.g. video conferencing, training facilities, lounge areas and pantries, the main reprographic area, network control center, dispensary, physical fitness center, and a sundry shop.

One of the basic concepts of the building was to provide a facility that would encourage staff interaction. The entry point to the building would be the escalators to the atrium, where employees would meet in a unique setting. The large dining and conference facilities, wide corridors and open vistas were to encourage free exchange of ideas in varied locations, without facility imposed limitations. Outside stair towers and atrium stairways further this idea.

2. Project Management

TRW established several criteria for a project manager:

- Know the company well
- Know company staff functions
- No architectural, design, or facility management background
    - They didn't want architectural biases intruding, or influences from the AIA or other professional organizations
- They did not want to interrupt anyone's career path; select someone near retirement
- No biases internally
- The project manager was to report directly to the CEO to avoid conflicts with line managers
- A strong project management background was needed

TRW started the project with the understanding that putting together this building is a complex undertaking and one where the involvement of the CEO is of critical importance, e.g. the CEO personally reviewed all of the basic building concepts. Monthly review meetings were held at the beginning of the building concept and site use planning stages. These day long meetings involved 30-40 consultants reporting on their work. At the end of the meeting, everyone had a clear sense of direction, and an understanding of the decisions that had been made. After conceptual work and schematics, the team presented major impact items to the CEO.

2.1 Initial planning - data collection

The project manager's responsibility was to set up and manage the activity. Early in the process, the project manager, Jack Gearhart, visited 38 projects, completed in the last ten years, to determine the lessons learned by these organizations. Four months were spent on this task. Among his findings were:

- All 38 had undersized their buildings
- They planned for certain numbers of people and functions
    - They made mistakes about functions primarily; they underestimated computer room sizes, conference areas; how buildings were going to be used, corporate facility services
- They didn't do advanced planning and analysis well
    - None included technology forecasts, or future changes in the organization
- Many did not have adequate cafeterias - resulting in reduced morale
- Most had not planned for "the office of the future"
- Project success depended on heavy CEO involvement
- End user involvement was essential, and needed from the beginning
- When interior design was performed by an architectural firm, architecture dominated
- General contractors used change orders to increase revenues; A change order plan and incentives to avoid change orders should be incorporated into project management
- Contractors should have a strong local presence; be familiar with local practice, good track records, client references

Another major source of information was from vendors. While the 38 buildings were being studied, and the word was out that the building was being planned, vendors constantly approached the project manager. He met with them only if they were willing to provide information about their products or the construction industry. He learned a great deal by these contacts, without making any purchasing commitments.

2.1.1 Lessons learned from organizational visits

An important finding was that the building construction industry is basically adversarial in nature e.g. architect vs engineer; interior designer vs architect, etc. They have no history of systems engineering or systems planning, used in aerospace for many years. As a result, things keep "falling through the cracks" because no one is responsible for them, and no one takes responsibility for what is perceived to be someone else's work. Project responsibility is often relegated to "tossing the baton over the transom".

3. Project management

A number of assumptions guided project management:

- A strong project team is needed
- A project support team should be appointed
- Spend the necessary time and resources for front-end planning
- Understand the requirements and functions
    - Do a thorough requirements analysis, including user functions, technology, space concepts
- Divide the interior and exterior design teams into two separate groups to achieve a balanced design
- Conduct a competition to select the architect
    - Four teams were selected, each given $40,000 to develop a concept; submissions became the property of TRW
- Do what makes sense for TRW, not just follow tradition

3.1 Project team

TRW did not establish an internal project team, because they knew the team would be dismantled when the project was completed. Mr. Gearhart's first hired a construction manager to provide planning, estimating, budgeting, scheduling, and project reporting for the entire project. Then a staff was hired, including an interior design firm and an architectural company. In addition, two special consultants were hired, who reported directly to the project manager. One was an architect who provided counsel on design aspects of the project, and the other was an expert on construction, construction management and local codes, trade and union practices.

The next task was team building, which he started with an off-site meeting with key team members. A primary purpose of this meeting was to break down the barriers among the members, who traditionally work in an adversarial mode.

A four legged stool was used to characterize the workings of the team. The top part of the seat of the stool was the project.

The four legs of the team were TRW, the interior designer, the exterior designer, and the construction manager.

- TRW represented the clients and provided necessary information, guidance, approving changes, and funding.

- The interior design team was responsible for interior architecture, information systems, ceiling, furniture, lighting, acoustics, controls, art, walls, floor, and work functions

- The exterior team was responsible for shell, core, public spaces, exterior landscaping, site planning, and overall design integrity

- The construction manager was responsible for providing internal (TRW) project support, maintaining contact with sub-contractors, and construction management.

Each team was responsible for a scope of work and certain areas of project responsibility. Each team had specialized consultants to support needed activities. All project team members were expected to do their own job, and help the other teams do theirs. The rungs that connect to each of the legs of the stool represent the consultants and interfaces between team legs. These interfaces were actively worked as part of the team management, so that work was coordinated and essential things did not "fall through the cracks". Ideas were to be freely exchanged, despite particular area of expertise. All participants had some responsibility for the overall design.

3.2 Project implementation

3.2.1 Criteria for the project

The overall goal for the project was that the building should serve the end-users; the technologies should assist them in performing activities. High quality was an important criterion for the project. It was not based on expense, but on value. A guiding principle was to examine decisions on the basis of, "if you were going to buy something of quality for yourself, to be used at home".

Several other criteria were identified. The headquarters environment has to help attract and motivate the best people to work and direct TRW in the future. The building has to be cost effective, compatible with the community, energy efficient (planned for 2 watts/sq ft) and compatible with the corporate image (high technology and people oriented).

Aesthetics was important as well. This included a view to the outside for as many people as possible. Amenities such as an atrium, gymnasium, an attractive cafeteria, and art work should be provided to enhance the "quality of working life".

3.2.2 Project planning

After hiring a construction manager, an interior design firm was hired to do a needs analysis, followed by the design of the interior. Interior design was given prominence over architecture because they deal directly with end-users in determining functions and adjacencies. The design approach was to be an inside-outside one.

Four packages of information - a needs analysis, site information, building design criteria, and evaluation criteria - were sent to the four architectural firms considered for the project. They were all funded to produce a model to illustrate their initial concepts of the building and use of the site. One firm was then selected to design the building and site.

3.2.2.1 Life cycle planning

The project used a 50 year life cycle as a planning framework for the building. The plan and all decisions regarding the site and building, its systems and capabilities, were tested against this 50 year horizon.

3.2.3 Award fees and penalties

An award system was implemented. It was modelled after similar arrangements that exists between the military, NASA, and aerospace companies. Each contract had an award fee, made on a quarterly basis. A team could earn an additional fee based on quarterly performance, which was evaluated on four criteria:

- Task performance
- Cost performance
- Schedule performance
- Team compatibility

If performance exceeded the norm, awards could be approximately 50% more than the negotiated price; if performance fell below the norm, the penalty could be 30% less than the original price. The performance was evaluated by the project manager, with the assistance of his consultants.

The award provision had two principal effects:

- It held each team's management attention to the task
- It was a strong vehicle the promoted communication within that organization and between the organization and TRW

3.2.3.1 Change control

A strong change control process was put into place. Only two types of changes were allowed - those requested by TRW, and those by contractors, who were not compensated for changes based on improper initial planning; they had to absorb the costs.

3.3 Mockups

A full scale mock-up of half a wing was used to test and evaluate the design. It was used to test design ideas and standard products; e.g. lighting, furniture, ceiling and floor finishes, etc. It provided the opportunity to determine how things fit together; e.g. spatial relationships. The primary benefit to the mockup was the ease with which changes could be made and their cost-effectiveness, as opposed to making changes in the completed facility. All team members were able to make evaluations before final purchases and designs were made. Employees also had the opportunity to provide feedback. The mockup study was conducted in three phases.

First, was the construction of a realistic mock-up made of foam board showing the exterior dimensions and some systems (sun shades, finish, etc) offices and workstations of various sizes and configurations. The mock-up was approximately 5000 sq ft. The interior was done to simulate the spatial experience and dimensions of the proposed space. Six raised floor systems were installed.

The next phase of the mock-up used partitions, furniture, lighting, and other components considered for use in the building. It had different carpet tiles, partitions, raised floor and ceiling systems, that were tried and evaluated.

The final phase incorporated all of the revisions made earlier, and the actual furniture and systems to be used in the new building. End-users were brought into the mock-up space after an orientation. They critiqued the various subsystems and provided important feedback information. Subsequently, each user chose the furniture components and fabric for his/her workstation, chosen from a set of standard options.

3.4 End-user involvement

TRW had a strong user involvement throughout the project. They wanted to develop a high sense of ownership and participation among building users.

They hired a psychologist to assess the corporate culture and help translate that understanding into design criteria for the interiors, the workstations and public spaces. Other responsibilities were to judge how the culture might be impacted by the new building, and might change in the future. (Two distinct cultures were being merged; one, the organization from the west coast - typically informal and "laid back", and the other, from Cleveland, a traditional one.)

About every six months, the project manager conducted a briefing for staff members, reporting on the status of the project. The design team was present to answer questions and discuss progress.

During the design process, department heads met with the CEO to discuss critical design issues and/or make policy decisions as required.

Shortly before move-in, employees were taken to the new building and taken on a tour of the building and their working spaces. An open-house was organized for the staff, their families, the local press, and the community. They also had an open-house for all of the tradesmen that worked on the project, and for project team members.

At move-in, all employees were provided with a book describing how to use the facilities, the location of various things, and a guide to using the equipment. Phone numbers were provided to call, if they had any problems.

A new facilities management group was staffed, and brought into the planning process early, with the clear understanding of their responsibilities in managing the building.

A newspaper is published periodically and distributed to all users. Questionnaires on security, food service, the convenience store and health maintenance, were used to further refine the needs of the users, and to foster user involvement and "ownership" of the building.

4. Detailed building planning

4.1. Office information systems

Office information system technology planning was an important feature of the project. The information system technology team was part of the interior design team. The planning was based on the premise that information technology was a critical component of project planning, and a major factor in the design of the building and the interior spaces.

The information system was designed as a coherent whole. One work area, off the core, was provided on each floor. Non-designated space is available in the event of future expansion. When not used, the space reverts to standard offices.

4.1.1 Information systems technology planning

Planning for accommodating information systems included the following:

- Technology forecasts and migration studies
  - TRW use of technology, impacts on building design

- Technology is one of many subsystems, each team considers technology implications from its own perspective

- Emphasize the importance of front-end planning, identify alternatives and tradeoffs; explore what-if scenarios

- Pay close attention to connectivity issues - devices that connect with one another

- Building must accommodate changes - furniture, wiring, power, new technologies, organizational changes

- Facility planning should be consistent with business plan

- TRW has about a 25% "churn rate", flexibility needed to facilitate changes among personnel

- Examine requirements for centralized computer facility consider 50 year time frame; computers in place at present

4.2 Wiring/telecommunications

Adjacent to the core on each floor in all wings is a distributed information facility (DIF), containing the basic control units for the LAN. The DIF's are stacked for vertical distribution; the access floors handle horizontal distribution of telephone and LAN cables that are easily tapped into - within 50 feet from anywhere in the building. The LAN cable carries all signals for electronic mail, word processing, remote data terminals, communicating copiers, and video. Wire connectivity was to be simplified; everything should plug into everything else.

A raised floor system was selected, as affording greatest potential for accommodating change in a cost effective way. Large vertical chases were employed for easy accessibility and to accommodate new wiring. LAN was used for data transmission, and twisted pair wiring for telephone communications. Fiber optics was examined but not selected because of the difficulty in making taps. The systems were designed to facilitate in-house maintenance and change. In connecting underfloor system, the 'readilock' system was used. It eliminates the need for specialists in wire management, communications, etc. Staff personnel can make changes. Controllers and electronic gear were situated locally for convenience.

A power network was designed for regular and clean power.

A Lexar phone system was used; only a limited capability has been utilized; most users do not know how to effectively use the entire system. Training is needed to use it to full potential.

4.3 HVAC systems

A variable air volume (VAV) system was used in interior zones. All office locations are within 3.05 meters (10 feet) from a flexible duct. Mechanical space needs are minimized by the raised floor design. Balancing of the system is a constant problem.

4.4 System integration

System Integration - voice, data, image were all looked upon as a single system. Wire closets, risers, pathways were considered from the viewpoint integration and colocation. This has implications for wire media, topology, space planning and facility management. State of the art equipment was used; it is safer than using new untested systems.

4.5 Facility management

Systems are monitored 24 hours a day and problems are corrected within a 24 hour period. Office records and management, mail distribution are under the control of facilities manager.

4.5.1 Monitoring systems

Three separate systems are employed; monitored at a single console. System provides diagnostic information; e.g. what is wrong, where, etc. The NCC Powers system was used for energy management. Additional systems were designed for safety and security.

4.5.2 Energy.

The base building is designed to operate at 2 watts per square foot. Lighting codes required design at 4 watts per square foot; unused capacity therefore exists for considerable expansion e.g. more electronic equipment at workstations.

5. What would be done differently

In reviewing the experiences with the design of the TRW headquarters building, Mr. Gearhart indicated a number of things that he would have done differently:

5.1 Project management

- Use a total systems approach in performing a requirements analysis, design, construction, occupancy and operations, regarding tasks, people and procedures

- He would have paid more attention to the "systems engineering" interface/discipline within the team.

- Do it right the first time

- Interfaces should be clearly defined from the outset of the project and throughout; more time should be spent together to monitor interfaces

- Project data books and other management techniques should be used to protect against things "falling through the cracks"

5.2 Team building

- All team members should know project objectives and expectations

- Have more team meetings with the sole purpose of team building - across all levels of participation

- Maintain open communications among team members; widespread use of electronic mail is effective

- Clearly define roles and responsibilities of all team members early in the process

- Continuity in staffing materially helps project performance

5.3 Integration of components - CAD

The CAD system was invaluable for designing the complex building - to highlight interfaces, track changes, assist in identifying and selecting among design alternatives identify gaps. The construction manager should use CAD to better document information and access it promptly. The CAD system can also be used to monitor as-built performance; LAN, power and computers. Other observations were:

- Architects, interior designers, and builders have to do a better job of integration
    - Computer aided design can help this integration if architects and interior designers use compatible systems

- Construction management process should accept CAD data and check shop drawings; contractors should use compatible CAD also

- The computer provides the control necessary and is faster at producing work, in CAD, scheduling, estimating, and measuring performance

- Interface design management should be formalized, including formal checking and a dedicated integration designer from each major contractor.

- Avoid customized elements if at all possible

5.4 Testing

All field testing - compaction, welds, torqued fasteners, steel alignment, etc, should be made by an independent firm, reporting to the owner.

5.5 Design issues

- LAN requires a total systems approach. Use proven systems; don't bet on futures.

- Use a single building automation system supplier.

- Do more electrical power system analyses regarding the impact of operating equipment on line voltages, use of UPS, and multi-wing power distribution design.

- Use manual control overrides on computer controlled lighting.

5.6 Construction

- Have more designer on-site representation to achieve timely problem resolution, subsystem integration, acceptance test reviews, and post occupancy debuggings.

- LAN cable plant should be the responsibility of the LAN supplier, with rigorous quality control of installation and checkout. Accept it as a "turnkey" system.

- Develop and monitor a strong, clean up program, a work in process and work in place protection program, and include this in the construction management contract.

- Do progressive construction quality control as work progresses.

- Identify and follow-up of long lead time items is required to avoid costly delays.

- Stress quality control early with all participants.

- Pre-test all equipment prior to delivery if possible/practical.

- All subsystems should be completed and accepted before move-in.

- Up-front, define acceptance policy, plans, roles, and responsibilities and put them into contracts.

5.7 Post occupancy

- Conduct post occupancy evaluations to build user satisfaction, identify deficiencies, and smooth transitions for users.

References

Fallucchi, A. "All Systems 'Go' at TRW's New World Headquarters", Facilities Design and Management, Oct 1985

Rubin, A. Interview with Jack Gearhart, project manager, Mr. Peter Steigerwald, facility manager, and Herb Rosenheck, system integrator of TRW headquarters building, September 1985.

NEW INFORMATION PROCESSING, STORAGE AND TRANSFER TECHNIQUES

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1. Background

More information is being created each day than the day before! This is a result of the great strides civilization is making in all areas and at all levels. Although this is wonderful, it does bring new challenges. In our case, the challenge is how to efficiently process, store and transfer this vastly increasing volume of information.

For thousands of years we have recorded information on paper, for the past 60 years much information has been recorded on microfilm and for 30 years some information has been recorded on magnetic media (tape, disks, etc.) We see the new optical disks as an additional storage option parallel with paper, microfilm and magnetic media all continuing to be beneficial as tools to help us manage information. In each case, the new media has provided an additional method of storing information and did not replace the earlier media. Today, 95% of all information is on paper, 4% on microfilm and 1% in digital form on magnetic and optical media. By the end of this decade we see a reallocation of the media to 92% being on paper, 3% on microfilm and 5% in digital form. Don't let this reallocation mislead you into thinking we will have less paper. The reduction in percentage of paper will be offset by the increase in the volume of information. For the remainder of this decade we see:

- More information being created per day
- More paper records and documents than ever before
- The continued use of multimedia for storage of information.

New electronic systems will make the storage media transparent to the user.

2. New media

2.1 Optical disk.

The newest storage media is the optical disk. The optical disk evolved from the video disc which was first introduced for pre-recorded motion used for entertainment and training. Then came the audio compact disc (CD) for music. This presentation concentrates on the use of optical disks for information and document automation. All optical disk systems use binary digital coding to store the information and a high powered laser light beam to record and low powered laser light beam to read-back the information. The following are the three types of optical disks used for documents:

2.1.1 CD-ROM (Compact Disks-Read Only Memory).

The CD-ROM is 120 millimeters, (4.72 inches) in diameter. The primary application is publishing. Typical publications are catalogs, directories, encyclopedias and other reference materials. A publisher replicates thousands of disks and distributes them to users much in the same way reference works on paper are disseminated to users. The user may read this type of disk thousands of times with the appropriate hardware and software. There is no wear to the disk regardless of how many times it is read since it is read with a laser light source. A CD-ROM cannot be changed. CD-ROMs are sold by many publishers with thousands of titles being available, i.e., Grolier Encyclopedia, Moody's Investor Service, Oxford English Dictionary, BiblioMed Citation Series. These publications are available to the public at a price.

CD-ROMs are also used for proprietary reference material. Mack Truck disseminates a parts catalog to its repair stations worldwide. Arthur Andersen publishers accounting reference material on CD-ROMs for their auditors. These publications are proprietary and are only available on an internal company basis and not to the public.

2.1.2 WORM (Write-Once-Read-Many)

The WORM disk is available in several sizes, 5-1/4, 12 and 14 inches in diameter, (see Table 1 for metric dimensions) is blank when purchased and housed in a plastic cartridge. This type of disk is created (written on) by the user with the appropriate hardware and software. The primary application of the WORM is all types of business documents, i.e., correspondence, invoices, vouchers, completed forms of all types, engineering drawings. Again, this disk can be read thousands of times with no degradation and the information cannot be changed. The main difference between WORM and CD-ROM is the WORM disk is created by the user and the CD-ROM by a publisher. The WORM and CD-ROM disks require different drives to be read.

Table 1 DISK TYPES AND SIZES

	Inches	Millimeters
CD-ROM/Audio	4-3/4 (4.7)	120
WORM	5-1/4 (5.1)	130
WORM	12 (11.8)	300
WORM	14	356
Erasable or Rewritable	5-1/4 (5.1)	130

2.1.3 Erasable or Rewritable Optical Disks

These systems use 5-1/4 inch diameter disks in cartridges. A typical application would be frequently changed and updated documents, i.e. legal or other documents requiring many drafts, engineering drawings. These disks would be created and changed by the user. The technology used in commercially available rewritable systems in Magneto-Optics which uses a magnetic field and a laser light source to change the polarity (positive to negative or negative to positive) of each spot which represents black and white pixels on the document.

2.2 Optical Disk Capacity

The question of disk capacity is always asked. This, however, is not a simple question to answer. The disk size, document size, compression ratio which depends largely on the nature of the documents, resolution and brand all are significant factors in determining the capacity of optical disks. Table 2 gives capacity figures for all three sizes of WORM disks in bytes and pages. This Table assumes general 216mm x 279mm (8-1/2" x 11") office documents, a resolution of 200 dots per inch (dpi) and it gives the page capacity for both 10:1 and 15:1 compression ratios. It should be noted that pages are page sides, in other words if a page has information both sides it is counted as two pages.

Table 2 OPTICAL DISK CAPACITY

* 200 dots per inch (pixels)
* 8-1/2 x 11 inch pages
* Black & White documents
* Two sided disks

Disk Size	Capacity in		Capacity in Pages	
	MB	GB	10:1	15:1
			Compression Ratio	
5-1/4"	940	0.94	20,000	30,000
12"	6,550	6.55	140,000	215,000
14"	10,200	10.2	220,000	330,000

3. New information systems

Before discussing new systems it is important to define a few terms. "Standalone" is a phrase describing a machine or device such as an office copier that performs a function by itself. A "system" or "subsystem" is a set of machines, devices (cameras, processors, readers) and sometimes software in one technology such as micrographs that performs a function(s). "Integration" is the bringing together several technologies and subsystems, i.e. data processing, micrographs, facsimile, into one total information system that allows documents and data to flow from one subsystem to another transcending technologies with the total system performing many functions. Integration of subsystems and technologies forming a total system is made possible through software and communications.

3.1 The Concept of Integration

A successful organization is the sum of its parts. But each part - an individual, work group or department - must work in tandem with the other parts, including outside organizations such as customers and suppliers. A well run organization has an integrated environment in which sharing of resources and information is a normal practice. Where are the resources? Individuals and groups located in offices inside and outside the company. Some connected by computer systems, some isolated. Where is the information (data and documents)? Some of it is in electronic form in on-line data files. Some on magnetic media some on microfilm. A great deal of it, however, is on paper stored in folders, file cabinets and off-site facilities.

Integration means that the four basic forms of information data, text, image and voice - can be exchanged among applications running on a variety of systems or subsystems. Integration from another point of view, means combining of subsystems - data processing, word processing, electronic mail, electronic imaging, facsimile and voice annotation - to provide a user information in any form, instantly, from any subsystem on a single workstation.

The user should not care, nor need to know how the document was originally created (by longhand, word processing, computer). The user doesn't need to know how the document is stored (microfilm, magnetic media, optical disk). The user requires the correct information (document and/or data) on his or her desk when it is needed - that's the job of a good integrated information management system.

The long term goal of every organization should be to develop a "total information system" by integrating all of todays separate information systems, such as, data processing, electronic imaging, OCR, electronic mail, etc. Once the integration of systems, subsystems and technologies has been accomplished consideration may then begin toward improving the entire business process, most often called workflow.

4. Individual work areas

Every knowledge worker will have a display and electronic information processing capability. These displays may be a standalone micro or a terminal to a mini or mainframe computer. There will be as many displays as there are telephones in an office. Although today every work area has power for a computer it should be surge protected. Every work area will need communication channels (part of a network) for this computer facility. Lighting in all offices should be arranged to minimize glare on display screens.

Hard copy printers will be required on a shared basis. Therefore, space, furniture and power will be required for a laser printer in a common area in each work area.

5. Central services area

Instead of central records departments needing hundreds of file cabinets and much shelving for paper records they will have jukeboxes with optical disks. Floor space of as little as 2.32 square meters (25 square feet) could accommodate the equivalent of 25 million pages of information (1,250 four drawer file cabinets). The jukebox could retrieve any of the individual pages in less than 10 seconds.

(A further discussion of the topic by this author, and other workshop participants, will appear in a companion publication containing the workshop proceedings (NISTIR 4802). -

TOWARDS OFFICE 2000: a happening or a planned evolution

AND MAN CREATED THE ORGANIZATION

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Man also devised management concepts, technologies and tools, to sustain the organizations drive for increased market share and profits.

But there were also people, with their evolving skills, aspirations and senses of value.

It is interesting that organizations are still, to a large extent, structured as they were many decades ago, with basic functions fragmented into narrow scope tasks performed by specialists under different managers whose responsibility is still primarily to control.

The advent of office technologies generated great expectations of productivity improvements, which did not materialize, in most instances. In fact, many people claim that, on the average, the massive investments in office technologies have not been cost effective. The reason why the results did not meet expectations is very well documented in a paper by Michael Hammer, published in the July-August 1990 issue of the Harvard Business Review. What most people did not realize is that speeding up the accomplishment of individual tasks did not change the fact that old ways of organizing work were inherently inefficient: the automation of an inefficient process only results in automated inefficiency.

The solutions to the "efficient office technology deployment" question are also very well documented in the above referenced paper. The problem is, of course, that they require fundamental changes: this is something most organizations are not prone to contemplate until they realize they have no choice. The lessons to be learned from the recent past can probably be summarized as follows, in a "why-what-when" sequence:

> *the major driving force for changes is usually competitiveness, in other words the need to improve productivity;*
>
> *the changes are usually not sufficiently fundamental to be significantly effective;*
>
> *changes are usually the result of "pressure for changes", in a reaction to an already deteriorated situation.*

Massive downsizings have usually been the answer, but there is obviously a limit to the "DO MORE WITH LESS" principle, when the state of the economy is such that the total capacity to hire people is significantly less than the total number of people that are laid off by those who are struggling for survival. It should be equally obvious that there are clear indications, already today, that a number of factors are likely to result in significant pressures for changes in the not too distant future. Will these be dealt with in a "too late reactive mode" or in a "in time proactive mode" is the question.

Under the assumption that everybody accepts the fact that "OUR STRENGTH IS OUR PEOPLE", let's focus on tomorrow's office worker, namely the children still in primary school or aren't even born yet. By the time they enter the workforce, they will definitely be very different, in many respects, from those who entered the workforce twenty years ago.

In terms of skills, it is fair to assume that they will be better educated, especially in the area of computer literacy. It can be expected that they will need less work experience before they can deal with difficult problems and that they will expect to be given such opportunities earlier in their careers.

Also on the subject of skills, many people claim that the educational system is too slow to adapt to technology evolution and that universities are not adequately funded. This has been openly stated for a long time. In the mid-sixties Mr. Hancher quoted a Chinese proverb, in his first address as the new president of the State University of IOWA:

> *"If you plan for one year, plant rice"*
> *"If you plan for ten years, plant trees"*
> *"If you plan for hundred years, plant education"*

The local newspaper covering the event added the following comment:

> *"In keeping with the analogy, this state has been planting too much corn for too long"*

It is of course very easy to point the finger at educational systems and governments, but in a world of rapidly evolving technologies, education cannot possibly stop at graduation. Again in the mid-sixties, a guest speaker at an engineering graduation stated:

> *"Congratulations. You are now engineers. You have sentenced yourself to be perpetual students. Half of what you know will be obsolete in ten years, and half of what you will have to know in ten years has not been invented yet"*

Those who have learned electronics with vacuum tubes in the late fifties certainly sympathize with that statement. And yet, it is claimed that companies, especially in Japan and in Germany, are spending, on the average, twice as much per employee on training than their North American counterparts. This is a serious problem that will need be addressed.

The attitude towards imposed discipline and control will also continue to evolve. Children are no longer educated as they used to be; they are also much better informed. Combining this factor with higher skills should result in increased pressures for changes in management styles. The old, and still present "management by control" will probably have to essentially disappear, but this concept is so deeply imbedded in organizational cultures that significant changes are not going to be easily accepted and truly implemented.

So many management alternatives have been advocated in the last decades that it is certainly not the lack of better alternatives that has prevented progress. But management deals with human beings: it is by definition a complex evolving subject. One day, maybe, management will be considered as a "service", with managers primarily responsible for maintaining a working climate where people can fully deploy their motivation. After all, isn't motivation the prime ingredient of productivity, not only individual motivation but also team motivation? It is unlikely that many people would argue with this statement, but how many organizations are prepared to do anything concrete about it, beyond the promulgation of a "Mission statement", and the circulation of a pamphlet on "Management philosophy", usually drafted by executives with insufficient inputs from lower ranks. It seems fair to assume that the office worker of the future will probably expect to have a stronger influence on "Management realities" than ever before: a pressure for change to be anticipated.

One can also anticipate that evolving aspirations and senses of value will result in significant pressures for changes in the future. Today's children and teenagers are already growing up in an environment where they are exposed to information on concerns and issues at an unprecedented level, in the media and in the classrooms. Today's growing concerns are centered on environmental issues, such as disappearing forests, pollution and wastes, but the overall growing aspirations for a better quality of life could also have an impact on the concept of the office of the future.

For instance, the Ontario regional office of the Canadian Department of Communications, in downtown Toronto, is presently establishing satellite offices in suburban areas, where employees are allowed to relocate, at their request, without changes to the organizational structure, specifically, without creating new positions for local managers. The decision resulted from a growing turnover rate among employees who didn't want to live in town or couldn't afford it, and no longer wanted to spend two hours or more in traffic jams every day.

Is this a sign of the future, or can it be expected that society will try to perpetuate one of the most remarkable non sense of modern life: commuting by roads to downtown offices is expensive, it generates pollution and consumes energy and, above all, it is a waste of precious time, time people could use to relax, enjoy life and eventually be more efficient at work anyway. The alternative is of course more obvious than its implications. If organizations are capable of efficiently conducting business across the country and all over the world, through telecommunication networks, it can certainly be done with suburban satellite offices.

There is also one particular type of pollution that could become a real concern for office workers: information pollution. With the deployment of superhigh speed networks, literally embracing the world, access to huge quantities of stored data will be available on everybody's desk, much more than today, because information systems will become compatible due to worldwide acceptance of international standards. However, "data" does not necessarily mean "information" i.e. "meaningful information". The problem of extracting information from a pile of scientific papers, technical reports and market studies using different semantics and symbols, is certainly a well known old problem. But the explosion in data access capability could very well turn it into a real nightmare, although it certainly has the potential of being a powerful asset. The title of a November 1983 NIST report by Art Rubin states the dilemma in perfect terms:

"The automated office - **An environment for productive work or an information factory**" (NISTIR 83-2784-1)

The world has never evolved so rapidly, in terms of technology evolution, of widespread exposure of concerns and issues and also in terms on competition. As far as the office of the future is concerned, it should be expected that pressures for changes will continue to grow. How to deal with this challenge actually provides a unique opportunity to be proactive and to adopt a global system approach rather than to treat the elements separately:

The office worker	skills and aspirations
The office	location and design
The office technologies......	cost effective deployment data versus information
The organization	management principles structures functions versus tasks individuals versus teams
Productivity	environmental and social costs

LET'S HOPE THE OPPORTUNITY WILL NOT BE MISSED AND THE SOCIAL IMPLICATIONS OF CHANGES WILL NOT BE UNDERVALUED.

(A further discussion of the topic by this author, and other workshop participants, will appear in a companion publication containing the workshop proceedings (NISTIR 4802).

IN THE NEXT TEN YEARS:

A FORECAST OF INFORMATION TECHNOLOGY DEVELOPMENTS AND THEIR POSSIBLE IMPACT ON WORKSTATION DESIGN

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1. Background

In the last ten years, we have changed the face of the office. When we entered the eighties, secretaries sat at desks with electric typewriters. Professionals and managers used paper and pencil. Words were translated into formal documents through the services of such intermediaries as word processing operators, graphics artists, and typesetters, all highly trained specialists. Only a few experts dwelt in the arcane realm of the computer.

Everything has changed with the arrival of the personal computer. Fifty million personal computers sit on office desktops and many office workers have had at least some exposure to the common applications such as word processing and spreadsheets. Offices themselves have been physically changed as we attempted to make room for computers, printers, and the miles of cable that fastens everything together.

But the office is not a static place. Technology constantly offers tantalizing new opportunities to change how we work, claiming that benefits in increased productivity, decreased cost, improved quality, ease of use, or other desirables will surely follow. Sometimes they do.

We tend to design offices with the technology that we can see today, but we then continue to use that technology until its financial value is used up. This is not as things should be.

In an ideal world, we would look at the whole time period during which our technology investment was to be used, and see first what kinds of changes were going to occur. Then we could make better decisions, planning to incorporate new technology or slightly delaying some decisions until the beginning of the next technology cycle.

The office of the nineties will be a time of rapid change. Knowing what is likely to happen will enable planners to formulate better strategies and make more durable investments.

In the tables which follow, we will summarize ten trends which are based on changes in technology and which will affect how office work stations may be designed. In fact, ultimately, they may change office work itself.

2. Ubiquitous computing

This is the concept of having computing embedded in all of the tasks individuals and workgroups do, wherever they happen to be. Computers would link information to tasks and provide status reports, task management, and automatic updating. Information transfer should ideally be instantaneous so that shared data bases are continuously updated, leading to much better decision making.

Workers might use only portable computers that they carry around with them and "dock" to communications and data facilities in the office, or a combination of portable computers in mobile situations and more robust desktops when in the office.

An important part of facilitating the convenient use of such technology will be the advent of wireless connectivity, to replace the use of telephone modem technology; a number of technologies are currently being investigated, including cellular telephone and 900-band radio frequencies.

In this vision of the near future - already being tested at Xerox's Palo Alto Research Center (PARC) - we can expect users to employ their personal devices to access both personal and organizational information, to facilitate group decision making, and to remain in constant communication with their work teams.

A more futuristic version of this vision (probably well outside of our time frame) would obviate the need for even portable devices. The computing infrastructure would be built into the environment universally (as it is in Star-Trek), much as telephones are today. Users could speak commands into the air and information would be offered in spoken or visual form, probably on flat panel screens which otherwise look like decorative objects or paintings.

2. Wider bandwidth and faster transmission speeds

The U.S. (somewhat behind Japan and Europe) is in the process of updating its intra- and inter-city telephone networks with fiber optic cable. When that process is complete, we will be able to deliver much larger amounts of information, at much higher speeds. Simultaneously (and probably to be finished at an earlier date), we are upgrading some of the Local Area Networks within our office facilities with fiber optic technology.

Increases in bandwidth and speed change the equation of where work can be done. It will not be necessary for workers to be at their desks to access data and perform work. Since new kinds of information can now be considered for distribution, users will demand a higher-powered desktop to display them properly. The technology is particularly apt to permit software and data to be delivered from central repositories where they can be maintained and secured, insuring that all users have the same, current version.

With the world literally at your doorstep (or your desktop), no human could possibly guess what might be interesting or useful in the mountains of available information. Proactive filters will act as intelligent agents on behalf of users, searching local and remote data bases for information of value, based on individual profiles, usage patterns, events, and changing needs.

3. Collaborative computing

As workstations become very inexpensive, they will have dramatically larger penetration rates, eventually reaching nearly everyone who can use them. As these workstations are joined together by various connectivity schemes and augmented by collaborative software, the focus of office computing activity will shift from individual workers to group work.

While it is hard to write about an activity that is still largely in the future, the literature of computer supported cooperative work or collaborative computing (sometimes called 'groupware', is nearly 20 years old, and some patterns have already emerged. Electronic mail is the most basic group tool, but it is largely a connector and enabler, rather than a task-directed tool. Workgroup computing will be used to permit multiple workers to collaborate on a single complex document such as a contract, a report, or a technical paper; to make decisions in groups with the assistance of voting, instantaneous updating, and all the available information brought to bear.

This multi-user computing world has different workstation requirements than its individually-oriented predecessor: large screens are needed to display information in multiple flavors and make comparisons; color is used to differentiate between versions and draw attention to the material being revised, and special interfaces may be needed to avert confusion.

4. Downsizing

The trend to downsizing is based on the idea that advances in microprocessor technology and client/server architectures and software permit us to perform complex computing tasks on smaller and less expensive computing platforms. The downsizing revolution is also about distributing data ownership and computing tools in a broader and more democratic fashion. While the data processing industry has always had a tendency to cycle between smaller and bigger systems, between more freedom and more control, between more distributed computing patterns and more centralized ones, it seems clear that the long term trend is away from monolithic machines which require enormous planning and great expertise and toward systems which are smaller, more flexible and much less expensive.

5. New interfaces

We are in the middle of reinventing how we use computers, largely to change the amount of skill required to use them at all. At the end of this process we will have enabled millions of users who think computers are too hard to use, to use them with little or no training. And we will have permanently changed the decision rules facing business as to whether or not it is worthwhile adding additional computing power when the cost of training can frequently, today, exceed the cost of the computer itself.

The new interfaces are enticing. Mice have been around for quite some time, but new mouse substitutes keep cropping up, especially those designed for use in portable machines, without the luxury of a supporting desktop on which to slide the mouse. Others are designed to be more ergonomic, more precise, or better suited for specific applications.

Pen-based computers are designed to permit the user to employ an interface he already knows well. By 1995, most computers will work with a pen interface; this won't be particularly interesting at all. The opportunity lies instead with searching out the applications for which the pen interface is particularly well suited, and marrying it to a pen-optimized operating system such as GO's PenPoint, and following the new road to its end.

Voice recognition technology is fairly stable for speaker dependent, separated words, even for fairly large vocabularies. However, continuous speech systems have been largely in the laboratories. In the 1990's these systems will emerge from the labs, depending upon large, fast workstations, and offer science fiction-like new possibilities for a man-machine interface. This will not permit the natural language like conversations, however, for such conversations assume not only continuous speech voice recognition, but also sophisticated natural language skills as yet beyond real time computing.

Gestures and body movement tracking are simply additional ways for humans to tell computers what to do. Various kinds of sensors and trackers can follow various kinds of human activities (a line drawn, a weight pressed, a fingerprint, the motion of an arm or leg) and act appropriately. Together with other interfaces, they will eventually lead to a "natural" computing environment in which the user feels entirely comfortable with the machines he or she uses.

Multimedia is a technology whose time has almost come. Throughout the 1990's we will be building the infrastructure which will allow us to change the level at which we communicate. We will be moving from a boring world in which we look at ASCII text messages through the world of print-like 'what you see is what you get' (WYSIWYG) text-only files, to a brave new world in which automated 'sprites' deliver animated messages ad your mailbox may begin to be difficult to differentiate from your home TV screen, except that it's clearly personalized for you. Of course, TV will be rushing to personalize its advertising messages, too, so the line may sometimes seem very thin.

Multimedia isn't a product. It's a series of enabling technologies that when combined, permit some interesting things to happen. The minimum platform is a fast personal computer with a moderate amount of memory and a lot of storage, preferably a CD-ROM drive. You're now ready to listen to multimedia programming - and there's already plenty of that. But creating some of your own is just starting out, unless you're a professional artist with lots of training and a huge development environment. You'll also need scanners, digital cameras, and a few other things. But the price of all this hardware is coming down fast and the authoring software to permit ordinary business people to use it for day-to-day work is beginning to arrive.

Trend	Technology Enablers	Design Implications	Application
Ubiquitous Computing	-Miniaturization -Pen Interface -Voice Recognition -Wireless Connectivity	-Small, Portable Workstation -Need for Docking -Guest Docking	-Personal Information -Access to Organizational Information -Gorup Decision Making -Communications
Wider Bandwidth Faster Transmission Speed	-Fiber Optic Networks and Telephone Systems	-Trade-off on storage location -Demand for consumer-type delivery vehicle	-Software delivery -Data delivery -Automated pro-active information searches
Collaborative Computing	-Cheaper Workstations -Ubiquitous Interconnection	-Multi-User Interface Paradigm -Larger Screens: My/your/our Information -Color to Differentiate	-Multi-Authored Documents -Group Decision Making -Real-Time Conferencing
Downsizing	-Fast Microprocessor & RISC Technology -Client/Server Architecture -Cooperative Processing Software	-Design space for Client/Server not Mainframes -Highly Distributed Computing	-Work group computing -Database -Office Work
New Interfaces	-Mice -Pen -Gestures -Body Movement Tracking	-Require Special Equipment (Pen, Microphone) -Extra Space for Mouse -New Operating System?	-Enable New Users -Forms Fill-In -Information Request (By the Public?)

Trends	Technology Enablers	Design Implications	Application
Multimedia	-Faster Processors -Cheap Memory -CD-ROM -Usable Authoring Software	-Larger Screens -Color -CD-ROM -Much Memory -Faster Processor -Voice Input/Stereo Output -More Powerful or Specialized Workstations	-Communications -Training -Presentations
New Operating Systems	-Faster Processor -More Memory -Modular Code -GUI's -New Tools	-More Powerful or Specialized Workstations	-New Horizontal Applications -New Custom Applications
Object-Oriented Operating System	-Faster Processor -Cheap Memory -New Software Technology	-More Powerful Workstations -Connectivity via LAN	-New Horizontal Applications -New Custom Applications
CASE	-New Software Technology	-More Powerful Workstations -Connectivity via LAN	-New Custom Applications More Integration
Imaging	-Faster Processors -Cheaper Memory -Optical Storage	-Larger Screens -Locations of scanners and jukeboxes	-Workflow Processing -Filing -Archival storage
New Technologies	Thin Screen Color	-Workstation Redesign	-Mobile Computing -Dynamic Controls -Aesthetics
New Technologies	Increases in Chip Integration	-Smaller, Lighter Workstation Inexpensive Dedicated Products	-Mobile Computing -Encyclopedia-on-Chip, Manual-on-a-Chip, etc.

In the office, multimedia will impact training and presentations first. Eventually, even day-to-day communications will be affected. In the home and the school, multimedia will change education and entertainment forever.

7. New operating systems and object oriented operating systems

These items get two different categories, since we are still working on new operating systems that are not object oriented. In all cases, the goal is to make it easier, faster and cheaper to develop better software. The short-term beneficiary is the developer himself who gets new software to market sooner. But the long-term beneficiary is the customer who gets better software - and who can afford to be much more flexible about customizing and updating software if those changes and updates take less time and cost less money.

Object oriented operating systems merit a whole discussion in themselves. We have almost none of them on the market today - although vendors use this term to market current products. A clear exception is the NeXT workstation environment. By 1995, we'll probably have several to choose from, causing chaos in the marketplace as we try to determine what the next standard will be.

Object oriented operating systems probably won't run much of today's software although they'll probably agree to let it run inside their environments. To actually take advantage of these new environments, you're going to need all new applications software, too. Remember the rule of thumb: applications software follows operating systems by at least two years. We're going to have a long wait.

8. CASE

We have been promoting the use of CASE tools, a software technology, for some time now. They structure the writing of software to do it more efficiently, and with better results. Now another argument for CASE has arrived. The newest hot topic on the business lecture circuit is business process re-engineering. Basically it says, look at your company's strategies and goals, and make sure that what you're doing and how you do it makes sense and supports those strategies and goals. Do it broadly not narrowly, or you may miss the point. Don't automate tasks without considering whether they need to be redesigned (re-engineered) first. Don't look just at individual tasks; look to see how tasks fit together and what the most critical issues are for your organization.

CASE tools are now arriving that help you redesign your business software after a business re-engineering process has occurred. Of course, you can continue to use CASE in its traditional way; to help you bring up custom applications in an efficient manner, with high quality.

9. Imaging

One of the first business processes to be re-engineered in many corporations undoubtedly involves imaging. This is partly because process re-engineering almost always focuses on workflow, and workflow focuses on documents and documents are - well - paper. Imaging technology lets us scan paper into an optical-disk based storage system, process it (that is manipulate the image for various tasks) and then archive that image for as long as necessary. Imaging isn't always tied to workflow processing - sometimes it's just about eliminating paper files. But the real payoff is in looking at this emerging technology from a process re-engineering point of view, and considering it fully, rather than as just a substitute for a filing cabinet.

10. New Technologies

10.1 Thin screen color

At last, after years of promises, we are finally getting color screens of substantial size that are less than 1/2" thick. This technology enables us to start thinking about completely redesigning workstations with color screens - making them into blotters on desks, pictures on walls, whiteboards, or Filofaxes. The limit is your power supply (battery technology still has a way to go) and your imagination.

10.2 Increases in chip integration

As we continue to increase the amount of processing we can place on a single chip, we decrease the amount of real estate we need for chips in workstations of every type. As a result, we can have smaller, lighter desktop workstations, portable devices and all kinds of inexpensive, dedicated products based on single chip technologies. We already have an encyclopedia on a chip. I'm waiting for a credit card sized device that you write a message on which automatically calls back to your home computer, recognizes the message, enters it into the E-Mail system, and causes it to be acted upon. Power!

These are some of the technologies that we can talk about right now. There are dozens of others we could choose to discuss like faster printing technologies, cheap color printing, intelligent translation (keyboarded and voice), expert systems for various kinds of office chores, and others. Remember that whatever is on our list this morning, next year, we will have more things to look at. The true wonder of technology forecasting is that it is dynamic, growing, and predictable only in its unpredictability.

(A further discussion of the topic by this author, and other workshop participants, will appear in a companion publication containing the workshop proceedings (NISTIR 4802).

Looking Ahead Toward the Electronic Office: What Will the 'Office of the Future' Really Be Like?

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1. Introduction

There seems to be a lot of answers at this symposium as to how the 'office of the future' might play out in the years ahead. We've been told about futuristic wiring schemes, 'intelligent' buildings, and the economic benefits of generic or 'one-size-fits-all' offices. I'm not sure we are asking the right questions. No. I'm sure we aren't asking the right questions. If we were, we wouldn't have this symposium. Why? Because DOT wouldn't be contemplating the construction of what would be one of the largest single-user office buildings in America.

The questions I have in mind are pretty basic. For example, does DOT even need a new office building? Or, does DOT need office buildings at all? These may sound like silly questions. Conventional wisdom tells us that an organization like DOT has to have office buildings. Otherwise, how could it function? Where would it put its office workers? Unfortunately, it is often the failure to ask simple questions that perpetuates offices that don't work, aren't capable of responding to the most basic physical (let alone intellectual) needs of workers, and too often serve as little more than glorified (albeit easy to manage) 'shoe boxes' for the nation's white-collar workforce. Often, it is the 'silly' questions that eventually force us to challenge our most basic assumptions. In the case of the office, these include assumptions about our deeply held beliefs about the relationships between and among time, space, and intellectual work - the underpinnings of the office of today. But I'm getting ahead of my story.

I've been asked to share my thoughts about the 'future of the office'. I will approach this task by asking, and attempting to answer, three basic, but far from simple, questions:

What is happening to today's office?

Why is it happening?

What might it all mean to those of us whose lives, in one way or another, revolve around 'the office'?

My answers to these questions will be based upon a variety of recent experiences and intellectual pursuits:

- The work I have been doing in Japan for the past five years, related to the future of the office in Japan.
- Work over the years in high-tech and design industries
- Observations about current approaches to officing in the U.S., Japan, and Europe
- Information and ideas that I have 'picked up' through rather eclectic reading in such diverse areas as the cognitive sciences, linguistics, cultural anthropology, and philosophy.

However, you should be aware of one of my biases: I don't read much about 'offices'. Grounded as most of this coverage is, in today's 'realities', I find it of very little help in parting the curtain of haze that obscures our vision of what offices might be in the future. So, forewarned is forearmed.

2. Today's offices - Background

What is happening to today's office?

The office as we know it is in its death throes. The problem is that we haven't noticed it yet, largely because it is a relatively slow and lingering death.

We sometimes lose sight of how recent a phenomenon the modern office is - or that it was essentially created from 'whole cloth'. To be sure, some aspects of the office have long (and occasionally even sordid) histories. For example, the concept of the file dates back to the days when papers where literally threaded in chronological order on suspended strings. The word 'file' derives from the Latin ford 'filum' that evolved into the Medieval English word 'filen' and the Medieval French 'filer' (to thread documents on a string). However, the form and function of the contemporary office are a by-product of the industrialization of the Western world. The office evolved in response to a unique set of business needs associated with the co-evolution of large, bureaucratic institutions such as railroads and insurance companies. It was enabled, and at the same time constrained, by available technologies. (When the seeds of the modern office were planted, there were no telephones, automobiles, typewriters, or corporate jets - things we often take for granted today.)

Just as the office had to be 'invented' in the 19th century, it is now being 'reinvented' as we approach the 21st century, in response to entirely different business needs and enabling (and constraining) technologies, and, as we shall see, a fundamental re-conceptualization of what it means to do office work.

Why is it happening?

3. The changing office

It would be facile to suggest that the only reason the office is changing is that business conditions are changing and new technologies are being introduced - in particular, the emergence of powerful computing and communications technologies. I believe that there is a much more fundamental change taking place. This change has to do with the way we think about offices.

The form and function of the office are a direct (if occasionally distorted) reflection of how we think about the relationships between and among time, space, and work. For example, why do we go to work in an office? Why doesn't the office come to us? It hasn't been simply a matter of, until quite recently, not having the necessary tools to allow us to 'telecommute'. It is also based on deeply held personal and (largely Western) societal beliefs about the conceptual separation of home and work - 'home life' and 'work life'. Such a conceptual separation didn't exist to any significant extent before the Industrial Revolution. It was the demands of factories for large numbers of complacent laborers - and the corollary and rapid growth of attendant staffs of 'white-collars' needed to support the factories that first drew people away from the home and created a physical (and, perhaps as important, temporal) separation between the things we did 'at home' and the things we did 'at work'.

As a result, we now carry around in our heads the belief, albeit often unstated, that this separation is not only natural, but somehow necessary. It has become part of the way the industrialized world, at least, does business. This occasionally manifests itself in rather bizarre ways. For example, I often hear managers remark that people who 'work' at home aren't really 'working' - even if they perform the same activities there that they would be doing 'in the office'. Maybe home-based workers just aren't suffering enough?

The foregoing example is only one of many shibboleths we carry around in our heads about 'the office'. My point is to illustrate how powerful these 'mental models' can be in terms of shaping what we believe to be 'reality', and how they can sometimes (often?) prevent us from seeing the proverbial 'forest' for the 'trees'. It is a change in one belief that appears to have sounded the 'death knell' for today's office and, at the same time, has heralded the birth of the 'new' office. This is the widely held belief that the office is, if only metaphorically speaking, a sort of factory, a place of production, a manufactory, if not of 'goods', then at least of ideas, or perhaps even of 'decisions'.

Reflect for a moment on how we talk about offices, and office work. We talk about 'office productivity' in the same terms we use when talking about 'factory productivity' as a ratio of 'input' to 'output' (even if, in the office, we are hard pressed to identify either in truly meaningful terms). We approach the introduction of technology in the office in the same ways we have historically approached the introduction of technology in the factory, by analyzing 'work process' and 'work flows', even down to the ludicrous level of measuring the keystrokes per minute of word processing operators. We talk about 're-engineering the office' just as we talk about 're-engineering the factory'. The list goes on and on. The change that is taking place, then, is a change in metaphor. The 'industrial' metaphor of office-as-information-factory is being displaced by a new metaphor: the office-as...as what? Here we quickly get into trouble because it is not clear what the new metaphor(s) will be.

I will go out on a limb and suggest what I believe will become the predominant post-industrial metaphor for the office. I will then conclude with some speculations as to the major implications this metaphorical shift might hold for those of us involved in the planning, design, management, and use of offices. First, what might this new metaphor be?

4. A new metaphor for the office

The new metaphor for the office will be, simply, the human mind. This may sound a bit strange but think about it (no pun intended, of course). It is the human mind's ability to create 'knowledge' - in a sense, 'stored' meaning seems to set us apart from most, if not all other animals. It is 'learned' knowledge that allows us to predict the future based on what has happened to us under similar circumstances in the past. This greatly improves our individual chances for survival in a 'dog-eat-dog' (or, perhaps more aptly put, 'lots-of-things-like-to-eat-us') world. Not only are we able to create knowledge to use to our own personal advantage, but we have discovered ingenious ways to share it for each other's advantage. One way is by spoken language, of course. An even more imaginative way is written language - a commonly agreed upon set of meaningful marks that we can use to share, quite literally, what's 'on our mind' with others and find out, in return, what's 'on theirs'. The key word here, of course, is meaningful.

As individuals, the meaning we extract from the 'outside world' on a moment-by-moment basis determines (along with a good bit of luck) whether we will be one of the lucky ones to pass our 'meaning extraction ability' (through our genes) along to the next generation. Put a slightly different way, and without getting bogged down in too many esoteric details, the process(es) we use to extract meaning from the environment must 'map' very well on the competitive demands of the environment. If we live in a very fast-paced, highly uncertain world; one that doesn't allow much time for reflection, we better be darned good at creating meaning, and then getting on with things. Of course, the mind is a real 'whiz-kid' in this regard, given its natural ability to create knowledge (retained meaning). This is probably one of the main reasons human beings have survived so long as a species. Let's face it, if we had to figure out whether a speeding car (or a saber-toothed tiger) is potentially 'dangerous' every time we wanted to cross a street (or go out and look for some nice juicy berries), life would be tough and probably quite short. Fortunately, knowledge (retained meaning) keeps us from having to 'start from scratch' as it were with the same 'unknown' every time we encounter it. It also allows us to share our experience with others - for, example, our children - thereby (if they listen) increasing their chances for survival, as well. (All animals, including the human variety, also come with 'pre-wired' experience or genetically retained meaning. We call it 'instinct'.)

In addition, scientific research and common sense suggest that there is no such thing as the 'generic' human mind. We all seem to share general intellectual processes (and general brain morphologies) in common. However, as individuals and, as research is beginning to show, as sexes, we can be (and often are) quite idiosyncratic in the ways in which we interact with the world. This is true not only in terms of our oft-demonstrated ability to extract conflicting, if not totally contradictory meanings from the same 'objective' data - like a memo from the boss, it is also true in terms of our individual intellectual work styles. It may even be true in terms of basic cognitive abilities like 'intuition' and 'spatial orientation'. In any case, some people seem to think better in the wee hours of the morning or late at night. Others seem to think better sitting on the beach watching sailboats than sitting behind a desk in an 8' x 10', 'one-size-fits-all' office, with no window. Some people - Winston Churchill is an example that springs immediately to mind - seem to think best while standing up. Others (and not just your stereotypical Japanese and Californians) seem to do some of their best thinking sitting on the floor.

Given our current beliefs about officing - beliefs that dictate not only our understanding as to what offices should look like but even when and where we must 'office', both individually and collectively, to be 'productive' white-collar workers, the highly idiosyncratic human mind doesn't really seem to stand much of a chance. This brings us back to the 'new' metaphor I have suggested: 'office-as-human-mind' or, perhaps we should say, 'office-as-extension-of-the-human-mind'.

Businesses are rapidly coming round to a realization that Francis Bacon knew several hundred years ago: "knowledge is power". There is a corollary realization emerging, as well, if perhaps more slowly: knowledge and information are not the same thing. This is not simply a semantic distinction. One of the most prevalent organizing principles in today's office is that of 'information flow'. The problem is that information doesn't 'flow'. Symbols (both spoken and written) 'flow' (i.e., move around) but these symbols are merely tokens that represent pre-agreed upon intellectual concepts. In and of themselves they contain no meaning. The meaning (information) is in the mind. For the symbols to be useful, meaning has to be extracted from them on a case-by-case basis, just as it has to be extracted on a case-by-case basis from any other data that we capture from the environment (or from inside our own heads using what we call 'imagination' - but that is a whole other story). As we have seen, it is not a given that the meaning you extract from a particular set of symbols is the same as the meaning I extract from exactly the same set of symbols. In certain situations, of course, this can make life interesting. It can lead to new experiences. It can lead to new insights and new understandings. It is, in fact, the basis for learning (i.e., imparting the meaning necessary for the extraction of future meaning). It can also be deadly.

The moment an organization 'decentralizes' (i.e., shares or delegates) decision making, there must normally be a concomitant increase in the amount of effort the organization exerts to ensure that there is a high level of shared meaning amongst and between decision makers. This is the only way that an organization can be sure that everyone is trying to solve the same problem or is working toward the same goal. As we have seen, simply moving more memos around - or talking 'at' each other in interminable meetings - isn't enough. By focusing on the 'management' of meaningless artifacts as the basis for organizing knowledge work (i.e., the things we normally think of as information - like memos, spreadsheets, and so forth), we are only attacking part of the problem and not the most important part at that. This, unfortunately, seems to have been the real thrust of much if not most of the hundreds of billions of dollars in new technology - including facilities that organizations, both public and private, have poured into the office in recent years in an effort to boost 'white-collar productivity', without much to show for it by most accounts. The real trick, it seems to me, is to create organizations that focus on the continuous creation and sharing of meaning at a rate that is synchronized, insofar as possible, with the competitive demands of the external world. As it turns out, given what we know about the planning, design, and management of offices, this is no mean task.

What might it all mean to those of us whose lives, in one way or another, revolve around 'the office'?

5. Implications for a new office metaphor.

With respect to the planning, design, management, and use of facilities, a number of major implications flow from a shift in metaphor like the one suggested. Clearly, our current management approach to organizing knowledge (people), based as it is on an anachronistic, industrial metaphor, is of very little value when the sine qua non of sustainable levels of service, in the public sector, and sustainable competitive advantage, in the private sector, seems to depend more and more on the continuous creation of new meaning. This will require more than simply re-engineering existing organizations. Rather, it will require the invention of totally new kinds of organizations - organizations that, as others have suggested, are based on the notion of continuous learning. But what does this really mean?

One thing it certainly means is that we will have to develop organizational and technology strategies that respect, and support, the idiosyncratic nature of the human mind - that is, if we hope to wring the 'mind's best work' out of our most important (and most expensive) organizational asset - our employees. Ultimately, we need to build support infrastructures that allow individuals and groups to work when, where, and with the tools that they, rather than 'management', feel are most appropriate for the intellectual task(s) at hand. Left to their own devices, individuals and teams may find that more (and better) work gets done outside traditional 'offices' in the future, than it does inside them today. This will be a very difficult idea for management to deal with because many (if not most) organizations still operate today on the industrial-era premise of external control and coordination - people are told when to come to work, when to go home, when to eat lunch, and when to take coffee breaks. How else can work be managed? How else can we make sure that people's time is being used efficiently? Why else would we have managers? The very notion of self-controlled, self-disciplined individuals and teams, while 'popping-up' occasionally in U.S. business magazines and the research literature, flies in the face of everything we 'know' about managing large numbers of white-collar workers (as does the notion of an organization as a support, rather than as a control, mechanism).

The net effect of all this could well mean that officing, rather than being constrained to an artificial 'work day' and a 'fixed physical location', takes place more or less continuously, with little or no regard to traditional spatial boundaries. This is, of course, the premise behind the so-called 'virtual office' - coordinated intellectual work, freed from the constraints of time and space. The implications of the virtual office from the point of view of facility planners, designers, and managers are rather staggering:

5.1 Facility management implications

From a facility planning point of view, the problem shifts from a largely techno-economic problem - i.e., how do we house (facilitate) a given number of white-collar workers, organized in a given way, at the least possible cost to what is essentially a knowledge engineering problem - i.e., given the tools available today (and probably tomorrow), what is the optimal strategy for intellectually enabling a varying number of white-collar workers, who will be continuously self-organizing, at a cost that is acceptable in the long-term? Quite a different problem requiring quite different skills.

From a facility design point of view, rather than creating finished 'solutions' into which people are placed, designers must be able to create technologically enabled infrastructures or 'tool kits' that allow individuals and teams of users to design their own work environments in 'real' time. This shifts the role of designer dramatically, from that of creator of 'solutions' to that of 'tool maker'. This is not a role likely to satisfy many traditionally trained designers, but it does present an interesting opportunity for the emergence of an entirely new profession of 'intellectual tool makers' or perhaps 'knowledge infrastructure builders'. No matter how this role is ultimately structured, it will have to embody a much closer coupling of technology, management, and cognitive sciences, than exists in most design professions (and most design professionals) today.

From a facility management point of view, it is difficult to envision where today's facility manager, emphasizing as the profession tends to do 'hard asset management', fits into the scenario I have cast here. Clearly, today's archetypal role of 'facility police' is inappropriate. Perhaps the future facility manager will play a role more like that of good kindergarten teachers - staying sane in the midst of organized chaos, while ensuring that each individual and group has the tools they need - the metaphorical wooden blocks, cardboard boxes, and watercolor paints - to allow them to do their 'mind's best work'. In an organization that continuously learns, continuous experimentation with new kinds of tools and new working relationships will be the rule, rather than today's immutable 'standards and procedures'. Change will truly be the only constant. My guess is that this is not an extension (or a simple re-casting) of the profession of facility management as we know it today. My guess is that it is an entirely new 'breed of cat'.

Why? Because it requires a radically different set of skills, and an entirely different mind set, than is presently being turned out by higher education's facility management programs (or as is promulgated by the various facility-related professional organizations like the International yFacility Management Association (IFMA), and the Japanese Facility Management Association (JFMA), etc.).

Of course, the 'office of the future' may look and function much like the office of today; it may be just a technologically 'gussied-up' cousin of the contemporary white-collar workplace. But I think not. There are too many leading indicators that suggest that the workplace of our children's children (or perhaps our children's children's children - but probably not much further out than that) will be nothing like the workplace most of us currently experience on a day-to-day basis. Too many individuals and organizations are beginning to understand the critical role that the continuous creation of new knowledge - continuous learning - plays in the global competitive equation. Here's how Japan's Ikujiro Nonaka summed it up in a recent article in the Harvard Business Review (November-December 1991: 97):

"In an economy where the only certainty is uncertainty, the one sure source of lasting competitive advantage is knowledge. [However] few managers grasp the nature of the knowledge-creating company - let alone how to manage it. The reason: they misunderstand what knowledge is and what companies must do to exploit it.

6. Conclusion

So, what will the 'office of the future' really be like? Only time will tell. But one thing is certain. If the future office is to truly be an 'extension of the human mind' - an infrastructure that enables an organization's full intellectual potential, it will depend totally on our ability as facilities planners, designers, and managers to begin asking the right questions today.

(A further discussion of the topic by this author, and other workshop participants, will appear in a companion publication containing the workshop proceedings (NISTIR 4802).

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This report contains a series of papers prepared for the Department of Transportation to assist them in planning a new Headquarters Building. Eighteen experts, representing various disciplines associated with building design and use participated in a workshop, and prepared papers prior to the meeting. The present report contains these papers.

Workshop presentations covered the following topics: workstation design process, programming tradeoffs, workstation standards and criteria, ergonomics, human resource issues, leading edge workstation design, impact of new technologies on office and workstation design, lighting, environmental technologies, information and data systems, building design, facility management, forecasts of the office-of-the-future. These issues were discussed by panel members, and with representatives from the Department of Transportation and other federal agencies. The transcript of the presentations and the discussions that followed will be published in a separate report.

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