

BUILDINGS AND CORPORATE STRATEGY:
TOWARDS A MANAGEMENT SYSTEM MODEL

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Los Angeles, California, 1983

Submitted to the Department of Architecture in Partial Fulfillment of the
Requirements of the Degree Master of Science in Architecture Studies at the
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

June 1985

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Submitted to the Department of Architecture on May 10, 1985, in partial fulfillment of the requirements for the degree Master of Science in Architecture Studies.

ABSTRACT

This thesis focuses on buildings as a subject of attention and inquiry in a corporate setting. It attempts to draw implications for the design of a management system to deal with the special nature of buildings as a resource.

The concepts presented are grounded on organization theory and corporate planning theory. The emphasis and examples are from a research/consultation project for the construction and real estate division of a large corporation.

The study is presented in four parts. First, the question "what makes a good building?" serves as a starting point for a reconnaissance of different roles and perceptions that define the human environment for the management system. Understanding these perceptions is important in dealing with tensions and conflicts that arise within the organization that may impact the value of buildings as a resource. Here, special attention is given to the perceptions of architects and managers.

The second part examines the special circumstances surrounding buildings as a corporate resource in order to derive conclusions about their role in strategic planning. Three levels of decision making are presented as part of a strategic planning model: corporate, division and function. It is argued that in this scheme, a construction and real estate group in the corporation is a function level operation. The types of decision making associated with the group are presented.

The third part presents a learning/adapting management system and examines its main elements. Drawing upon work in environment-behavior, statistical quality control and decision support systems (DSS), it defines an integrated model of a management system for building-related activities. Examples of the use of the DSS are given.

The fourth and final part takes a look back at the territory covered and a look forward to suggest future developments of the model.

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PURPOSE

The purpose of this thesis is to develop a model for a management system tailored to the needs of a construction and real estate division (C/RE) of a corporation. The objective of the model is to inform corporate design practices and facilities management decisions. It emphasizes the need to create an integrated climate for decision-making, and to maintain a research-like attitude towards building-related practices. Corporations, universities, government organizations and any other institution that builds and operates a building stock would be interested in the work here presented.

By reason of the subject-matter, the material presented is interdisciplinary in nature. It brings together knowledge from several fields of study, primarily architecture and management. Exploring the interface between these two fields around the topic of buildings has been both a necessary means of approaching the research, and an end in its own right.

APPROACH

The "real-life" origin of this thesis has influenced not only its contents, but also the tone of the writing. Theories and models found in the literature are examined more for their potential use as building blocks of a larger model, than for their intellectual appeal. Although enough "distance" is maintained to critically analyze some of these ideas, the interest is mainly to put them forth.

The subject of this study is treated at two levels. At one level, fairly self-contained notions and tools are presented and extended for dealing with sub-aspects of the problem at hand. These could be termed "concepts". At another, higher level, a conglomerate of interrelated ideas are presented which constitute what could be termed a "model" or "system". Their coming together defines the strategic "management-system model". The distinction in terminology is basically intended as a convention to bridge problems of semantics often

encountered in research reporting. Obviously it is an artificial distinction and the ideas labeled as models at one level could be thought of as concepts at an even higher level of generality.

BACKGROUND AND ACKNOWLEDGEMENTS

In mid-1984 the Laboratory of Architecture and Planning of the Massachusetts Institute of Technology was engaged in a research and consultation project for a construction/real estate division (C/RE division) of a large corporation. The object of the work was to develop an approach that would allow the corporation to learn from its existing buildings to improve their operation and the design of new buildings. The assignment was summarized in the catch question: "what makes a good building?"

The core team for this research reflects the broad scope of the assignment. Michael Joroff, Director of the Laboratory of Architecture and Planning at MIT managed the research and contributed his planning and management experience. Ranko Bon, Assistant Professor of Economics in Architecture at MIT contributed the economic and business expertise. (Prof. Bon brought me into this research and is also my thesis advisor).—John Zeisel, a sociologist, Director of Building Diagnostics Inc. (BDI), was engaged for his expertise in environment-behavior issues and in evaluating buildings-in-use. Three research assistants completed the team: Cynthia LaCasse, a sociologist-researcher staff of BDI; Marc Maxell, a student in the Masters of Architecture Program at MIT; and myself.

Several of the ideas presented in this thesis are the result of the work of the core team. I can claim to be a contributor to the analysis required for their application and to their synthesis into a unified strategy. Special, separate credit should be given to three of the major concepts presented in this thesis as follows:

Model of Building Effectiveness-- John Zeisel
Indicators of Building Effectiveness -- Ranko Bon
Life-Cycle Learning Concept -- Michael Joroff

By writing this thesis, I put myself in a position of interpreting and connecting, in different ways, the concepts developed by the core team. I had the opportunity to introduce relevant material found in the literature, and to apply it as I saw fit. Thus, while my intention is to give full credit to the members of the research team for the use of their ideas in this thesis, I also take full responsibility for its flaws.

I would like to thank my advisor Ranko Bon for his consistent support throughout the writing of this thesis. His clear thoughts and affable personal style make him as much a friend as a teacher. I also owe gratitude to Michael Joroff for the responsibility and confidence he placed upon me through the research project on which this thesis is based. A final word of gratitude goes to my wife, Monica Brana, for the countless opportunities she has given me her support throughout my studies.

INTRODUCTION

As business firms expand and diversify, and as public agencies and other non-profit organizations continue to provide services to ever-growing numbers of people, the number of organizations that own and operate buildings, and the number of buildings they administer will continue to increase. Although in most cases independent A/E firms are contracted to design and construct the buildings, the complexity and sophistication of building planning, design and construction, and facilities management have resulted in specially set-up functional groups within the organization to plan and manage these activities. About fifty percent of the "Fortune 500" firms have their own construction and real estate (C/RE) group.¹ These groups may range from small task-groups set up to manage building projects, to entire divisions that manage multi-million dollar annual construction budgets and large real estate portfolios.

To carry out its goals, business corporations engage in "strategic planning" as a means to effectively allocate their scarce resources -- financial, managerial, physical and human. The word "strategic" connotes a competitive drive consistent with the realities of organizations operating in a changing environment. According to Peter Lorange, strategic planning is the process by which "...adaptation, integration and management development are [used as] vehicles for changing an organization in an intended direction."²

The planning, design, construction and operation of buildings present a set of characteristics that place special demands on the management system of the corporation. Buildings are typically a large portion of a corporation's assets whose effective value as a resource depends largely upon the care that goes into their design and operation. As the spatial matrix in which the organization

¹ Quoted from Ernest Buckman's lecture: "Property Management: An Emerging Science", MIT/Center for Real Estate Development, 1 May 1985.

² Lorange, Corporate Planning: An Executive Viewpoint, p. 2.

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grows and adapts to its environment, buildings affect the lives of all in the organization, and are objects of professional activity for many.

The above suggests that an organization could benefit from an analysis of the special circumstances surrounding buildings in relation to strategic planning. It further suggests that integration of the many elements of such analysis into a model for practices would be of great relevance.

General models for corporate planning and operation emphasize the allocation of resources and the flow of information for decision-making through the management system as central to the effective implementation of plans. A model concerned with the relationship of buildings to strategic planning would have to take into account these generic elements of general planning models alongside the technical and other specific aspects of buildings.

The human dimensions of the problem are as important to this model as they are for any other management problem. Individual perceptions; the need for identification with organizational goals; the need to make the most out of each person's skills and relative position within the organization, have to be considered. Of special relevance are the roles and perceptions of the key actors in building design and construction -- business managers and architect, and in building occupancy -- facilities manager and user.

Obviously, the ultimate goal of the management system model is to help the organization produce better buildings. A description of the environment of the model could thus begin with a base-level examination of individual perceptions centered on the question "what makes a good building?". The following chapter tries to throw a conceptual net around this elusive question in the context of a corporation.

CHAPTER 1

THE HUMAN ENVIRONMENT

Architecture, Management and the Design Process

The issues of interest to architects and to managers of business organizations are seldom looked at under the same light. But, with the exception of housing, most of the buildings architects do are for organizations of one type or another. If we consider that these projects are under the control of the management of the organizations, it becomes clear that there are areas in which the professional interests of these two groups come together.

This coming together has often been described as confrontational: managers who represent business clients do not fully trust the judgement of architects, for they fear that architects do not understand the priorities of business decisions and have a tendency to make the wrong trade-offs in allocating resources. Similarly, within the architectural profession, a commonly-held view is that the role of the architect is to heroically uphold and defend the values of art from the insensitivity of business-clients. Buildings are the embodiment of a design process in which these perceptions come to play.

There are vast opportunities for exploring grounds of mutual interest to the two professions. An important criterion to evaluate the skills of an architect is his or her ability to make the best use of scarce resources. Furthermore, a great part of an architect's work has to do with coordinating and managing the resources available to him/her, including the work of others. At the same time, a prime responsibility of a manager is the best use of the resources of his organization, including its durable assets -- of which buildings are a major portion. The overlaps suggest a common ground on which to begin to build the basis of a better working relationship leading to better buildings, both from the perspectives of the organization and the architect.

INDIVIDUAL PERSPECTIVES

What Makes a Good Building? Four Different Perceptions

The question "what makes a good building?" might easily be labeled an ill-posed question of little research value, and discarded with an equally loose answer: "it depends". Yet, the question resides in the minds of every building owning/managing organization.

In assessing a building, business managers tend to use "hard" bottom-line figures together with "soft" notions about productivity and motivation. Designers will often cite new formal concepts, elegant technical solutions and an overall pleasing spatial experience as the criteria to measure building quality. For facilities management, the building is "good" if "it works" -- its systems do not break down too often and it is reasonably easy to manage and rearrange. Lastly, the user will assess a building on how it feels as a place to inhabit, and how it supports his or her tasks. Thus, "good" is not the same for everyone; it is not easy to define -- let alone measure. Developing a set of criteria to answer the question "what makes a good building?" requires consideration of the four different perceptions mentioned above.¹

¹ Strictly speaking, there are other actors and roles that come to play in the building process (planning-occupancy). Among others directly involved are engineers and contractors. Indirectly, regulatory agencies, interest groups,

From Architecture to Management: Four Functions of a Building

It is possible at this point to introduce some concepts that begin to structure our thinking about the problem. One such concept is that of "functions of a building", developed by architect and industrial designer Ezra Ehrenkrantz.¹ According to Ehrenkrantz, the role of buildings has evolved towards increasing complexity as they have acquired new levels of meaning, or "functions" in society. He classifies these into four types:

1. The Economic function
2. The Aesthetic function
3. The Environmental function
4. The Behavioral Function

Ehrenkrantz outlines the gradual development of these functions throughout history, pointing out that building as an activity has tended to be dominated by one or another of the functions. Architectural historians have tended to reinforce the aesthetic function over the others by what Ehrenkrantz calls the "fruit-cake syndrome" -- tracing the evolution of architecture through carefully selected examples that emphasize (predominantly external) form. The aesthetic function, and one might add aesthetic/symbolic function, is the oldest of the four. It is exemplified by the Egyptian pyramid, the Mesopotamian ziggurat, the Greek temple, and so on. The development of the behavioral function

lenders, the public at large, etc. are also one way or another connected to building as an activity. Since the intention here is to concentrate on buildings within the context of an organization, no separate attention is given to these "outside actors" -- except for the architect. This is not such a significant omission, however, since at the level of perceptions, their views will be represented in the organization. The architect is given separate consideration among "outsiders" because of his/her role as leader of the design team.

¹ Ezra Ehrenkrantz: lecture, MIT, October 25, 1984.

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coincides with the reign of Christianity in the western world and the rise of royalty -- both phenomena requiring the congregation of many people in the interior of buildings. Examples are the gothic cathedrals and the palaces of the nobility. The third or environmental function, according to Ehrenkrantz, is typified by the Jefferson house; but, most generally, it could be linked to the effects of the industrial revolution. The origins of the economic function is connected to the development of capitalism and, more recently, to the development of large business organizations. Today, buildings serve all four functions in society. The challenge is to make them perform as well in one as in the other three. According to Ehrenkrantz, the pressure to perform is an effect of society's increasing ability to measure and, one might add, to the many new and expanding fields of specialization.

It is possible to extend Ehrenkrantz's concept of functions and their historical evolution into the realm of organizations and the different actors therein. First of all, note how closely Ehrenkrantz's functions correspond to the criteria adopted by people in the four roles presented above: business manager, architect, facilities manager, and user. The functions that buildings have acquired in society have a parallel in the realm of organizations and, most importantly, they are represented by quite distinct groups of individuals. This is not too surprising. Organizations are social systems. Roles within them tend to be highly specialized, with different interests structurally built into them.

From Management to Architecture: Four Conditions for Individual Development

A corresponding set of concepts to those of Ehrenkrantz can be found in management theory. Russell Ackoff, of the Wharton School of Business (University of Pennsylvania) cites four conditions as necessary for an individual's development in general, and in the corporate environment in particular; these are:

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1. The scientific/technological function of society or the pursuit of truth.
2. The economic function of society or the pursuit of plenty.
3. The ethical-moral function of society or the pursuit of good.
4. The aesthetic function of society or the pursuit of beauty.

Ackoff states that these conditions must be present in an organization to achieve its fullest potential. He goes on to state that the aesthetic function "requires the more extended treatment because it is the less understood..." and that "it has long been assumed that aesthetic and management functions have little to do with each other."¹

In the context of organized social groups, the perceptions of different actors count, since they are determinants of behavior: "...man reacts to his environment according to his 'apperceptions'. That is, as he perceives it in light of previous knowledge"² Apperceptions are moulded by training and position, or role, in an organized setting. The actions of these individuals will further be determined by a natural drive toward self- fulfillment.

These basic considerations begin to define the human context in which a C/RE group operates. Before going on to propose how the management system model can begin to effectively operate in this environment, let us go back to our parallel discussion between architecture and management, since this is the relationship that will be of most interest in the use of such a model in the building process.

¹ Ackoff, Creating the Corporate Future, p. 39.

² Frankel in The Making of Decisions, p. 172.

Architects and Managers: the Roots of Different Perceptions

It is not unfair to say that by and large architects tend to have little concern for the economic function of buildings. For the most part, they regard it as something peripheral to their professional mission.

For most design professionals, and specially architects, design is an object- rather than a process- oriented endeavour. The activity is of interest to the extent that it allocates physical resources to fairly fixed, predetermined relationships with each other. As soon as the notion of change is introduced the problem is no longer of much interest.

Let me illustrate this generally accepted assertion with an example. A team of researchers of a large corporation carried out a survey among different actors involved with a particular building to evaluate the importance of a list of criteria about what makes a good building. The responses of the architect who designed the building and the facilities manager (FM) who operates the same reveal their different apperceptions towards change. The survey asked them to distribute a total of 100 points among ten criteria (location, security, services, acoustics, exterior, flexibility, interior, comfort, cost, and schedule). The architect assigned five (5) points to "flexibility", as compared to fifteen (15) assigned by the FM. Then, they were asked to evaluate the building along the same criteria using a 1 to 7 scale of ascending performance. Here, the architect rated the flexibility of the building a six (6), while the FM rated it a four (4).

In relation to the range of values assigned, both cases represent the extreme opposite of each other. When compared to the facilities manager, who must live with the building, the architect is biased against the building's ability to change:

- As a decision criteria he underestimates its importance, while,
- As an assessment criteria he overestimates its performance.

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Given the care that the corporation who owns the building places on selecting its architects and spelling out its design requirements, the difference in perception is quite significant. It reveals the resilience of a-priori definitions of "what makes a good building". It also reveals the potential implications that these definitions may have in practice.

Architecture, as a form of art, is closely connected to notions of permanence and immortality. Architects would like their work to be "time-less" -- forever preserved in the state of "perfection" in which they were conceived. The fallacy lies in equating "permanence" with "staticism". The confusion leads to the conclusion that for something to remain it must **not** change.

This implicitly held notion about architecture makes crisis when confronted with the reality of organizations. For organizations change is of the essence. An organization that fails to keep pace with its environment through adaptive change is bound to be short-lived. Change is synonymous with survival -- an organization's permanence. Good management is an exercise in continually leading change.¹

Ehrenkrantz is not talking about management when he refers to the need of architecture to embrace the economic function of buildings; neither is Ackoff talking about buildings when he refers to the value of aesthetics in management. However, the perspective that their concepts bring into the problem is important for understanding the schism between those trained to think in physical dimensions and those who must think in time dimensions -- between designers and managers. A "good" building requires the combined

¹ For a very interesting and revealing empirical study on the importance for organizations to change and adapt to their environment, see "Corporate Evolution, a Micro-Based Analysis", by David L. Birch, and Susan McCracken, MIT Program on Neighborhood and Regional Change, January 1981. This study drew on a collection of over 5.6 million case histories of corporations, big and small. It analyzes patterns of growth and decay during the period 1960-1976. It gives substantial support to the model of firms as adaptive, learning systems, versus the biological model of firms as maturing, aging systems.

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efforts of both during the design process, and an attitude of planning for the life-cycle of the building.

The human environment in which the making of good buildings operates is further defined by on-going developments in the architecture profession in general and in corporate office design in particular. Architects acknowledge that the profession is in transition, and that they must recover some of the ground lost in past decades to other professions. One direction that has begun to emerge is towards extended services to organizations: programming, post-occupancy, evaluation, re-arrangement, etc. (This move has been facilitated by the emerging use of computers in the production of building drawings and contract documents. This information can then be maintained and referred to for changes in the building after construction). In turn, many business firms are increasingly recognizing the value of good design -- including the role of architecture in projecting an image for the organization.

Both architects and managers sense a need for change. In the realm of building design, what one group seems to deem necessary, the other is generally deemed to have sufficient of.

PERCEPTIONS AND EXPECTATIONS

In its operating environment, a C/RE group will have to deal with the human factors described above on two very important fronts: on the "inputs" of many actors that impact the building; and, on the "outputs" of the building that impact those who inhabit it. Let us examine these two fronts separately.

Integrating Perceptions into Action

Researchers of organization theory have often pointed out that to achieve implementation it is often more important to reach consensus on a course of

action than to try to find the optimal course of action.¹ Organizations must channel the efforts of many individuals along set directions.

A problem often encountered in organized social activities, such as building, is an unclear definition of goals. In some instances, the goals may be so broadly defined (i.e. "design a functional building", "provide a flexible design", "operate the building at top efficiency") that people cannot relate alternative decisions to them. Simon captures the essence of the problem:

"High-level goals provide little guide for action because it is difficult to measure the degree of their attainment, and because it is difficult to measure the effects of concrete actions upon them [They] are thus not operative -- nor do they provide the common denominator ... essential to a choice among alternatives. Decisions tend to be made, consequently, in terms of the highest-level goals that are operative -- the most general goals to which action can be related in a fairly definite way, and that provide some basis for the assessment of accomplishment."²

In absence of the operative goal, the perceptions of the decision-maker may not always lead to conclusions most satisfactory to the organization. For an organization to function effectively, it is important for each person to have an explicit definition of the goals (ends) to be achieved, and a broad latitude of the ways to achieve them (means). In absence of this, there is little opportunity to discuss trade-offs.

It is not uncommon to encounter problems of this type. An example involving a C/RE group of a large corporation demonstrates how the vertical integration of ends does not always materialize very well. A project manager complained that it was not always clear to him what was important in the building. In a major readaptation of a headquarters building he calculated a budget based on the estimated cost of all items in the program for the project.

¹ Simon, The Sciences of the Artificial, p. 166.

² Simon, Administrative Behavior, p. xxxvi.

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Upon presentation of the project to the approval committee, the budget was reduced by several million dollars, without a list of the items that had to be cut. Without a very clear sense of the building in relation to the planning objectives of the corporation, the project manager was faced with the difficult decision to determine what was important. Under direct pressure from the inhabitants of the building, there was a high risk that the manager's prioritization would not best serve the strategic objectives for which the building was being readapted. People at the level of facilities management, or regular employees would have an even more difficult time in determining what is important "at the top". Yet, their perceptions and actions (or lack of it) can have a strong influence on the effectiveness of a building during operation. (Please refer to the case example in Appendix One).

Often times a similar problem arises with the design criteria provided to the architect. A lack of explicit definition of what is important or/and a poor description of the interrelationship of elements in the building would leave the trade-off decision on the hands of the architect who, by reason of not being fully knowledgeable about the functions of the building, can easily make poor trade-offs.

Enhancing Individual Experience

Buildings should be places that bring people together in more than physical terms. They should reinforce the positive aspects of the corporation's "culture" -- such as "a search for excellence" or "a sense of good teamwork", etc. The exterior image of the building; the type of offices, furniture, and office equipment people get according to rank; the support spaces available in the building (i.e. conference rooms, cafeteria, etc.) are all important elements in encouraging the kinds of integrating behavior that best serves the goals of the firm. Good design can be "good business" if it is conducive to a more cooperative spirit in the organization.

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It is important not to have a misunderstood idea of "economy" override the other functions of the building. In any "good" building there are qualities which are, to a certain degree, the soul of the building. These are aesthetic and experiential qualities that contribute to the way the building is perceived as an environment for human interaction to unfold -- the presence and use of natural light, a "special" space in the building, the good use and workmanship of materials, etc. These qualities, for the most part defy reductive analysis. Still, they are the essence of architecture. Many problems in the building will be overlooked by the users if the building is rich in these higher qualities. If an environment is conceived in purely mechanistic terms (i.e. a "machine" for activities), its users will also regard it as such. But, people expect machines to perform perfectly; they are bound to react more readily to the inevitable problems that exist -- slow elevators, small offices, etc.

A "good" building accommodates the need for people to exercise a certain degree of control over their environment -- specially in the case of office buildings. Overly defining a person's work-space affects a split between person and environment that leads to disadaptation. Attempting to resolve this condition by further tailoring the environment for the user only aggravates the split.

The adaptability of people and their need to personalize their environment, can be used to the benefit of the organization. The availability of task lighting, surfaces that allow tacking, movable furniture, the ability to open windows, the possibility to introduce plants and art work, etc., can greatly contribute to making a "good" building from the user's perspective. The following points summarize some fundamental ideas for preventing common problems of perception:

- * Establish clear goals for the project that can be communicated clearly to the project management team.

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- * Provide the designers of the building with performance criteria rather than simply design directions. Specially in items of great importance for the success of the building, provide a reason behind the specification.
- * Institute a four-dimensional attitude toward buildings -- specially in the architect and facilities management.
- * Institute a system of incentives in project and facilities managers that encourages long-term performance of buildings.
- * Maintain a system of allocating office space that is well understood and perceived as equitable by the users of the building.
- * Give people in the building an opportunity to adapt their personal space to their needs.
- * Provide aesthetic experiential qualities in the building -- a special space that brings people together, attractive circulation, etc.

SUMMARY

A wide latitude of interpretations about what makes a good building exists in an organization. The interpretations correspond to different perceptions and positions within the organization and the role that buildings play for achieving individual goals. The question of "what makes a good building?", ill-posed as it may be, makes explicit issues that concern to all building owners, introducing a higher level of consciousness to an organization's practices.

In the process of design, the definition of priorities by managers and designers is central. (Hopefully, the definitions and priorities of users and facilities operators are also represented). A model of practices by a C/RE group in a corporation seeks to integrate these perceptions and enhance individual quality of life.

CHAPTER 2

THE ORGANIZATIONAL FRAMEWORK

Further definition of the model requires raising the level of the exposition to issues of corporate structure. Analysis of the organizational environment of the construction and real estate group (C/RE) defines the "macro" environment for the model. Two concepts will serve to introduce the organizational framework in which the management system operates: the concept of the "building resource" and the concept of a "life-cycle approach to building design".

The Building Resource

Strategic planning deals with the allocation of resources for achieving organization-wide goals. Through resource allocation a corporation "provides a blue print for the actions that each group in the organization will be expected to carry out in the near term."¹ This involves a previous process of selecting among alternative courses of action -- often times under a fairly large degree of uncertainty as to outcomes. Flexibility in business programs is essential to generate alternative courses of action as new opportunities or threats develop, and to be able to shift and allocate resources accordingly.

Because they are fixed in space, and because they extend in time, buildings cannot be "shifted" nor "allocated" in the same sense as other resources. Between planning and occupancy of a new building a minimum of eighteen months to two years elapse, a period which, under a corporation's time horizon cannot be considered short-term. Even by the time a new building is ready for occupancy, the function to be housed in it will most

¹ Lorange, Corporate Planning: An Executive Viewpoint, p.47.

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likely have undergone significant changes. Although options other than new construction are also available, like leasing and buying, they are by no means quick solutions to the need for building. They involve search, negotiation, some construction, and contractual commitments that by no means are quickly arrived at. At times, corporate policies further limit choices regarding allocation of this resource. For example:

- * Policies about ownership of production facilities. Given the specialized nature of production functions, it is necessary for some corporations to have full control over ^{THEIR} ~~IS~~ production facilities. This, of course, eliminates the possibility of short-term lease solutions to space needs for buildings of this type.

- * Policies of equity position in all leased buildings. As a prime tenants the commitment of large corporations to lease space in a new building brings about substantial benefits to the project (i.e. better financing terms, shorter leasing up period, lower vacancies rates). By moving to an equity position in the buildings they lease, some corporations are trying to internalize some of the external benefits that their presence as tenants generate.

Notwithstanding the clear strategic advantages that a corporation would derive from these policies, they make more patent the need to meet short-notice requirements for space from an existing supply of its building resource. Thus, in terms of business planning buildings, unlike other resources, are not allocated to function; but rather, functions are allocated to them. Buildings are sizable investments and an important part of the capital assets of most corporations. Due to their longevity and significance as investment, buildings must bear the test of time in any operation.

When a new building is constructed, it is customary for the corporate division requesting the building to perform a financial feasibility calculation of the value the new facility will represent. However, the real marginal costs and benefits of a building can not really be determined by return on investment techniques. The income stream of a building that, say, houses a production

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function, cannot easily be separated from the R&D, Marketing, Corporate and other operations that work in conjunction with the production function. Consideration of buildings as discrete units of a resource is fallacious. In a corporation with many buildings, buildings are a systemic resource. The value of each is inherently connected to that of the whole. The strategic nature of buildings resides in the network-like capacity of operations that they offer to the corporation, and in their ability to continually support such operations inspite of unprogrammed changes.

Life-Cycle Approach to Building Design

The design of a building is guided by design criteria tailored to presently felt needs. Although an attempt is always made to design for a likely future, it is impossible to anticipate all possible changes. Even when some requirements can to some extent be predicted, it is not always possible nor cost-effective to design for them. The most a designer can hope to do is to incorporate in the building the capability to accomodate change -- a necessary task, yet difficult and often times expensive.

But, initial design is not the only determinant of a building's value as a resource. Changes during operation are crucial in its long-run performance. A facilities manager put it as follows: "I can either make or break a building; keep it running or destroy it." In other words, regardless of the effort and resources that go into making a building -- including provisions for making it adaptable -- actions by those running the building will be decisive in the long-run. Building operation is a process by which a building is constantly "designed" with respect to its use over time. A state of readiness (physical and administrative responsiveness) of the building resource requires a life-cycle approach to building design -- maintaining and upgrading the adaptive capacity of the building through renovations, periodically assessing its effectiveness as a corporate resource, drawing up preventive maintenance plans, learning from

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experiences in other buildings, and feeding back this knowledge to the design and operation of other buildings.

A model for strategic operation of the buildings in a corporation rests, to a great extent, on the knowledge that the organization can accumulate from its own practices and experiences. A fundamental component of the strategic operation of buildings is to maintain parallel operation research functions. The goal of this function would be to compile and distribute knowledge to those actively involved with the building resource. This is an issue of both individual development and organization development. This study will return to the issue of research and knowledge capturing. First, it is necessary to begin an examination of the intra-organizational issues involved.

INTRA-ORGANIZATIONAL PERSPECTIVES

Strategic Planning and Levels of Decision-Making

Whereas the perception differences presented in the previous sections center on individuals, their experiences and roles, organizational structure differences center on the hierarchical branching of general objectives into "subsidiary objectives".¹ The branching becomes the path which decisions and resources travel from strategic planning to technical implementation.

The goal of strategic planning is to support decision-making for the continual evolution of the organization towards effective accomplishment of its activities, or its "mission". As part of a strategic planning model, Lorange

¹ Simon, Administrative Behavior, p. 190.

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identifies three levels of corporate strategic planning.¹ Figure 2.1 shows these levels and a C/RE's group position in a typical corporate structure.

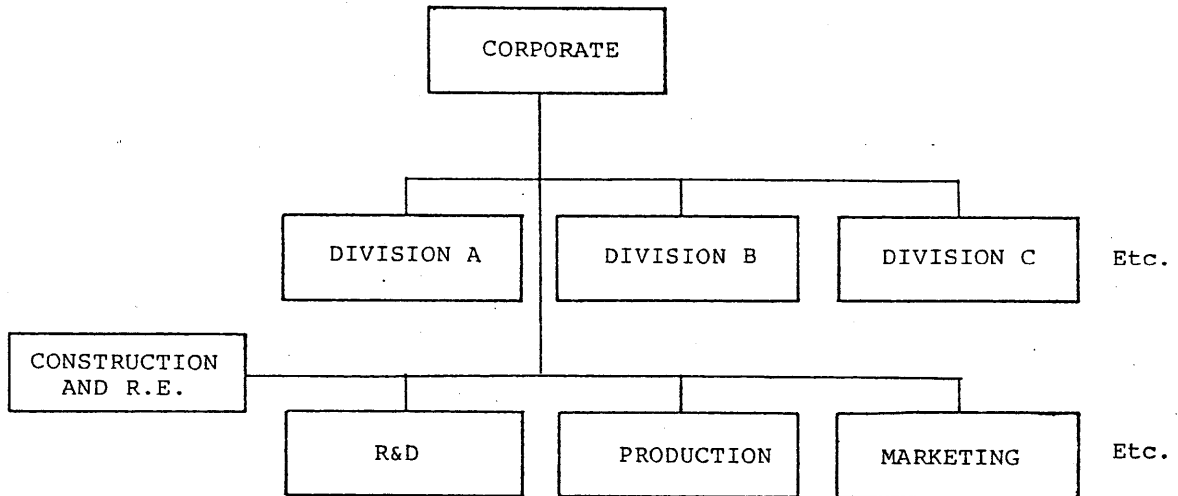


Figure 2.1

Management Levels of Strategic Planning and the C/RE group.

1. **Corporate level:** In charge of portfolio strategy, concerned primarily with strategic resource flows for a reasonable pattern of businesses. The key issue at this level is to design a balanced business plan: short versus long-term objectives, profitability versus risk, etc.
2. **Division level:** In charge of business strategy, responsible for the success of a (line of) business. The key issue at this level is to improve the

¹ Lorange, Corporate Planning: An Executive Viewpoint, pp 18- 20.

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competitive position of the business, to concentrate on future developments that seem attractive, to develop business activities complementary to other existing activities, such as utilization of plant and equipment, and so on.

3. **Function level:** In charge of strategic programs, responsible for variables in the domain of a particular function (i.e. marketing, manufacturing, R&D, etc.) within a business. The key issue at this level is to achieve widespread coordination among the functions.

A C/RE group occupies a special position within a corporation's structure. It is neither a division, in the sense that its activities are not part of a business of the corporation; nor is it a production function, as these are normally understood. But, in the framework of strategic planning, the management of the building-resource by the C/RE group would clearly be a function-level operation.

As part of the corporate strategic planning model, the activities of the group have to be directly connected to the management objectives of the corporate divisions. Through continuous contacts, the C/RE group has to insure that the division will have the building resource necessary to carry out its plans. The group must work closely with the divisions to interpret these plans in terms of building requirements. The group must do this keeping a perspective view of the goals of the corporation at large.

The corporation operates in a changing and complex environment. It must constantly learn and adapt to the conditions therein. The strategic goal of C/RE group is to provide an understructure of stability, or dynamic balance, between the plans of the corporation and its physical/operational environment.

The C/RE group also operates in a changing environment: new functions must be supported, new technologies emerge (both in the primary operation and in buildings), locational factors change, tax and investment regulations create new opportunities and close others, people develop new expectations or "norms" within the corporation as to the quality of the work-place, the "image" of the corporation needs to be reinforced through building design, the good-will of

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the community at large is affected by the impact of the corporation's buildings on the environment, and so on. The C/RE group obviously needs to be "strategic" in fulfilling its responsibilities; buildings should never become a bottleneck for the plans of the corporation.

It is possible to identify a whole range of tasks and decisions related to the responsibilities of such group. Some of these are fairly programmed; others are not well structured. These decisions can be classified into three types.¹ These are shown in figure 2.2.

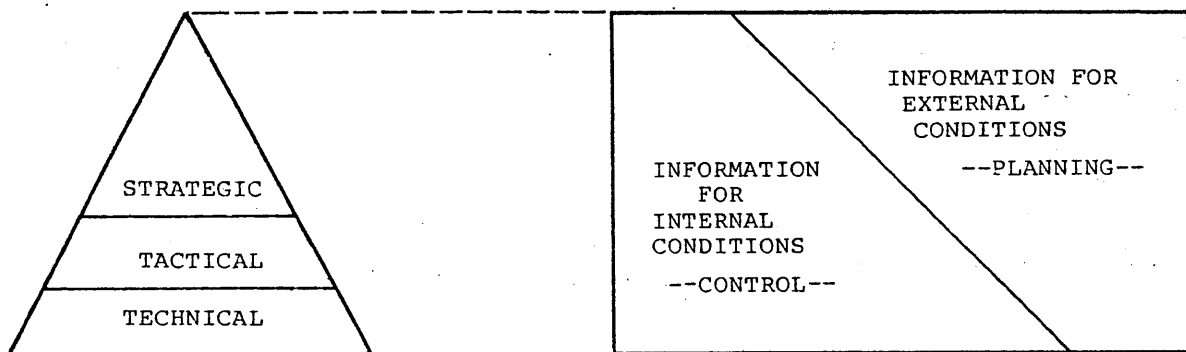


Figure 2.2
Types of decisions making

¹ The definitions of the three generic types of decision-making and the diagram are from Burch, Strater, Grudnitski, "Information Systems: Theory and Practice", pp. 51-54

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Strategic level: Strategic decisions have a comprehensive orientation and seek to plan for the future. The goal of this type of decision for a C/RE group is to design a strategy for the building resource tuned to the corporate strategic plan. The activities at this level include: setting of long-term goals for the entire collection of buildings of the corporation, setting sub-sidiary performance goals for each building, maintaining a balance between the supply of the building-resource and present and foreseeable demands, preparing tax strategies, selecting location (taking advantage of regional advantages, incentives, etc.), deciding about leasing, buying or renovating, and so on. These decisions involve substantial planning and little control. They would be made by the upper level management of the C/RE group in close contact to corporate management and divisional management.

Tactical level: Tactical decisions pertain to short term activities and the allocation of resources for the attainment of objectives set at the strategic level. These include, project planning and management, budgeting, scheduling, setting guidelines to monitor the performance of buildings, etc. They involve a balance between planning and control activities. Professionals, such as architects, planners, engineers, lawyers, etc. would be among those called upon to make these decisions.

Technical level: Technical decisions are those that rely on fixed standards and procedures to perform functions whose results are fairly predictable. This would include, overseeing the operation of individual buildings, training of facilities managers, testing of innovations in the buildings, assessing the performance of building components, monitoring user satisfaction, and so on. Decisions at this level require a substantial amount of control and relatively less planning. Professionals, specialists and technical staff would be found here. These people would have to be in close contact to the sites on a continuous basis. Depending on the exact structure of the C/RE group, some of these functions would be performed by personnel at the site. In other cases technical staff from the C/RE group might rotate from site to site to work with facilities management on setting up monitoring and preventive programs.

DEFINING AN OPERATIONAL REALM

The Relationship of the C/RE Group to the Corporation

The making of "good" buildings is a subsidiary goal to the strategic objectives of the corporation. Thus, the C/RE group should be less concerned with the directions than with the most effective way to get there. This demands "...a parochial commitment to one's special task."¹ A key ingredient for the success of the C/RE group is, then, to integrate its operations to the overall plans as much as possible while retaining its highly specialized viewpoint. Excessive detached professionalism could lead to dysfunctions and conflicts, specially in the group's relationship to the divisions.

As it has already been argued, buildings are a time-dimensioned resource of the corporation. They are not intermediate products in a production line. The difference is important for it implies a long-term versus a one-time involvement. During the planning, design and construction of a building, the C/RE group could easily overpower the user division in decisions about the building. Then the user division would take over the building with a sense that, somehow, it was short-changed. There is a danger that a "consumerist" attitude may arise on the user's behalf, and a corresponding "need to cover one-self" may arise on the C/RE group's behalf. This could lead to self-servient tactics which only undermine concerted action.

For example, it was found that a significant portion of a post-occupancy evaluation carried out by a C/RE group on its buildings was to have the user division "sign-off" on the building. That is, to have it acknowledge that the building was designed and built as required, and that, therefore, any mismatch between the building and the needs of the division were the division's own fault.

¹ Lorange, p. 144.

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Obviously, the user division may at times mis-represent its own needs. But it should be the C/RE's group responsibility to work with the division to help define its needs during the planning phase and periodically adjust the requirements throughout the design and construction phases. This calls for a substantial involvement of the user division during these phases-- actively participating in programming the building and in reviewing the design documents. Similarly, the C/RE group should be involved with the building during its operation -- actively assessing its performance and preventing premature obsolescence.

The special characteristics of buildings as a resource -- namely their immobility and permanence -- require a continual input of the services of the C/RE group. There are obvious advantages in maintaining an on-going relationship between the R/CE group and the user divisions. On the one hand, facilities management of each building can supply invaluable detailed knowledge about a building -- what works, what doesn't and why. The C/RE group, in turn, enjoys the benefit of learning from many buildings over an extended period of time. Thus, it can transfer knowledge from site to site and from past to present. The benefits would also accrue during the design of a new building, since the C/RE group will bring the knowledge of buildings-in-use to bear on the new design.

It is thus necessary to overcome a tendency to draw a sharp distinction, in terms of involvement, between project delivery and building operation. A substantial break in involvement would cause the building to be seen as a "product" that the R/CE group puts together for the user. The "deliverer-customer" roles are not the best in terms of integrating the building activities of the group and the strategic requirements of the user.

A better model for a relationship between the C/RE group and the user division is that of a coach and its team. The team plays the game, but the coach provides a strategy and interjects new advice as the conditions of the game demand. The roles of coach and team would be alternated. During the design process, the user division would be the coach; during the operation of

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the building the C/RE group would take up this role. The relationship between the C/RE group and the buildings should be that of a family doctor and his/her life-long patients. The model for the corporation and its buildings is that of an admiralty and a fleet of ships.

Building Effectiveness as a Relative Notion

The operational realm of the C/RE group in the corporation can be further established by elaborating upon the relative judgement implicit in the question "what makes a good building?".

The notion of "good" can not exist independent of what is "normal" or "bad". It demands comparison. Comparisons may be "internal" to the corporation or may be "external" to a corporation (involving buildings operated by other organizations). In the former case, the interest is to assess the quality of a building with respect to the corporate "building stock" as well as the performance of the line staff working on specific projects. In the latter case, the interest is to assess the C/RE's own performance, or its "competitive effectiveness" within the broad professional scene -- these concepts are presented in the sections that follow.

Internal Comparisons: Notion of a Building Stock

A great number of issues about building design and operation go beyond the circumstances of individual buildings. Many generic issues exist, and their knowledge is a valuable specialty in its own right. A fundamental notion advanced by this study refers to the need to consider the collection of buildings in the corporation, or its building stock, as the prime and foremost concern of a construction/real estate group.

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The operation and management of a single building or of a site would not normally be the central role of such group; the operation and management of a building stock would, however. The distinction is one of perspective and level of responsibility in corporate structure. It may appear subtle, but it is in fact critical since it begins to clarify distinct attitudes, roles and responsibilities.

While facilities management must be involved with the issues of single buildings and care for them over their life-cycle, the C/RE group must be intimately involved with issues of the building stock as a long-lasting and critical corporate asset. The group is thus the keeper of the building stock.

External Comparisons: Notion of Competitive Effectiveness

A C/RE group within a corporation does not compete in an open market for the projects it develops, but it does need to be "competitive." The cost and quality of the services it provides to the corporation must be in line with what is available in the market. It is important for a C/RE group to be able to compare its practices and standards to others in the field. If there was an area of performance in which the group was lacking, it would not be easily detectable by internal comparisons among the buildings it delivers. Only through assessment of its work and contact with the state of the art could it establish its competitive effectiveness.

It is important for a C/RE group to have a sense of its performance over time, and to maintain and improve performance from project to project. Two advantages that derive from having an internal group manage construction for a corporation are:

- * The group has an opportunity to acquire an intimate knowledge of the corporation's needs.

- * The group can learn from its many buildings while they are in use.

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Both of these are connected to the ability of the group to carry out operational research and assessments of its own practices and buildings.

SUMMARY

Buildings are a unique and very important resource for most corporations. In terms of a three-level strategic planning model (corporate, division, function) a construction and real estate group that plans and manages the building resource can be considered a "function". Its responsibilities are to support the requirements of the divisions in carrying out their strategic business plans. This involves interpreting the building needs of the corporation and maintaining a continuous involvement with the building stock. Since the group operates in a highly specialized and variable environment, it needs to be both competitively effective and strategic.

It is important to define the appropriate levels of involvement and realm of operation of the C/RE group. Relative advantages to the corporation from managing its own projects and buildings derives from the deep knowledge it could accumulate through practices and research of its buildings-in-use.

CHAPTER THREE

A LEARNING MANAGEMENT SYSTEM

The previous sections presented the special circumstances that characterize buildings as elements of strategic planning and the larger organizational framework within which a C/RE group carries out its operations. It is now possible to turn our attention to issues at the "micro" level. That is, to examine and propose some of the internal operating characteristics of the C/RE group as a strategic function.

At several points this study has made reference to a learning process as a way for the C/RE group to better integrate its practices to corporate plans, and as a way of improving performance of the C/RE group itself. In turning our attention inward, emphasis will be given to this important concept.

The Need for Adaptation and Learning

The management system should make it possible for the C/RE group to pursue its ideal of producing good buildings with increasing effectiveness under both constant and changing conditions. It needs to be a learning-adapting system. Ackoff provides a definition of these terms:

"To **adapt** is to respond to an internal or external change in such a way as to maintain or improve performance. To **learn** is to improve performance under unchanging conditions."¹

¹ Ackoff, Creating the Corporate Future, p. 126-127.

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Under these definitions adaptation is a response to change, while learning is a change of response. Simon integrates the two terms into a single definition:

"... learning is any change in a system that produces a more or less permanent change in its capacity for adapting to its environment."¹

The fine differences of these definitions are of no major importance. What is relevant is the emphasis they put on maintaining a constant dialogue with the environment as a means of improving performance. The underlying reliance is thus on feedback from previous and existing practices and feedforward on emerging environmental conditions.

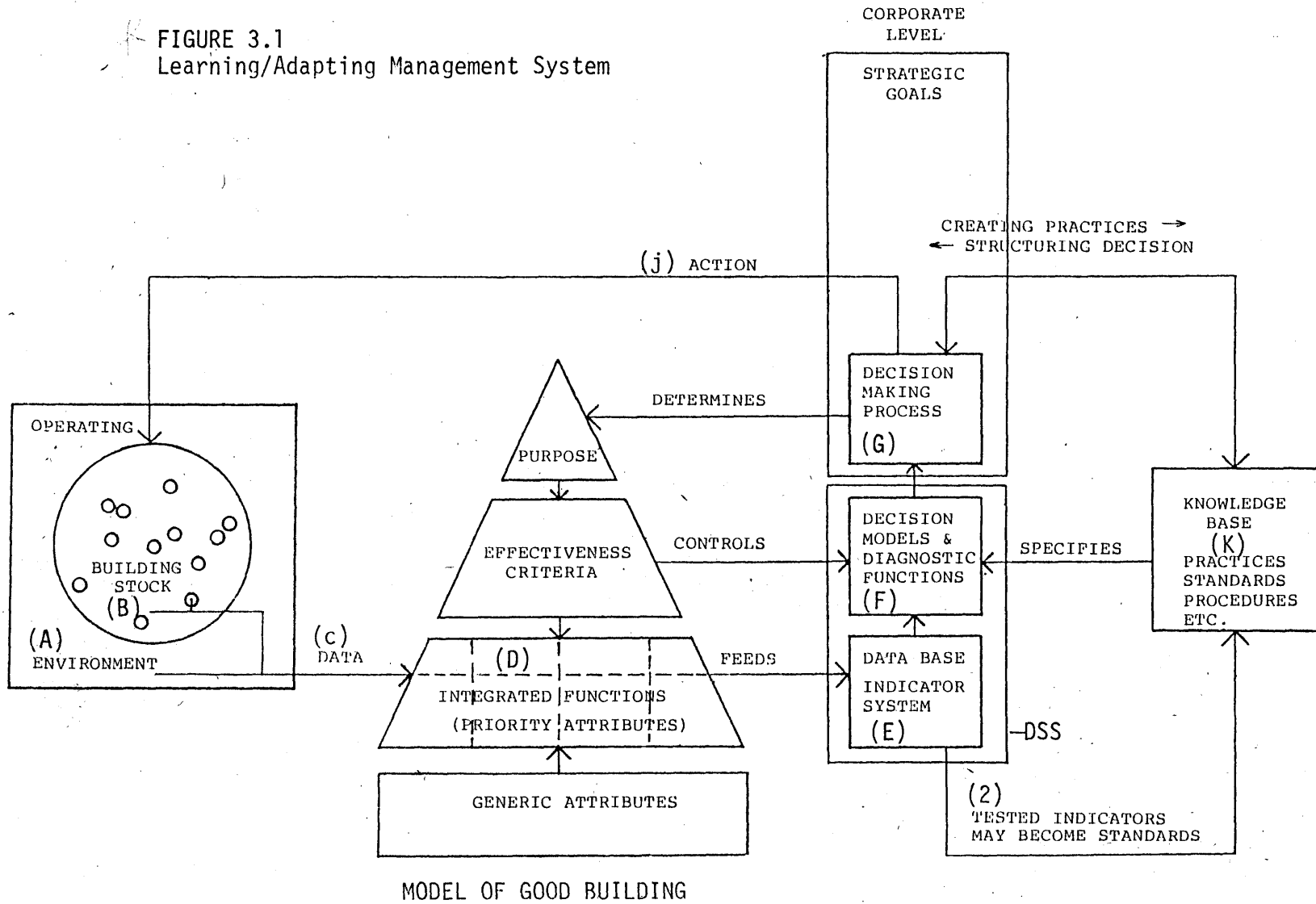
In the context of a C/RE group, adaptation can be considered at two levels. At one level, there is a need for each building to "adapt" to the new functional requirements of the organization, including the changing expectations and perceptions of people about their working environment. The C/RE group will share this responsibility with facilities management for each building. At another level, the C/RE group, as the keeper of the building stock, would be concerned with learning about its buildings as a portfolio.

THE MANAGEMENT SYSTEM: A CONCEPTUAL DESIGN

Figure 3.1 is a conceptual representation of a learning/adapting management system for the strategic management of the building stock. The integration of the practices of the C/RE group to the strategic planning system of the corporation is represented together with other elements for adaptation and

¹ Simon, The Sciences of the Artificial, p. 118.

FIGURE 3.1
Learning/Adapting Management System



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learning. A brief description of the whole system will be followed by a discussion of each of its main parts.

Strategic management of the building stock obviously requires observation of the context within which the buildings operate (A). Data from the buildings (B) is collected during their life-cycle, from: project records, operation records, audits, assessments, special studies, user questionnaires, and so on (c). A "model of good building" guides the collection of data. For each building, the model identifies its main performance requirements or "priority attributes". The data collected makes it possible to determine to what extent the building's attributes support the strategic objectives of the corporation. The evaluation takes into consideration the performance of the building along its four functional dimensions (D). The data from many buildings is "compressed" into "indicators of building effectiveness" to form the data-base (E) of a "decision-support system" (DSS). Tests are then done on the indicators to determine:

- (1) Indicators which are better descriptors of building performance and thus should continue to be collected and used in decision-making.
- (2) Values of indicators which consistently characterize "good" buildings, and thus could be used to define new standards for practices.
- (3) Indicators that provide little information and thus should be eliminated, replaced or modified.

The DSS is further made up of a diagnostic function (F) which monitors a number of pre-determined symptoms important to the effective performance of the building stock. The model of good building specifies the controlling criteria for each building or building type as a function of the strategic purpose of the specific building. With the use of decision models and statistical data manipulation capabilities, the DSS formats the data into several standard reports. The system also alerts the user about presymptomatic conditions not described as part of the standard requests. Informal inquiries to the system are also made by users introducing other criteria or requesting non-standard information. The knowledge generated by the users as part of

informal inquiries can be re-used by the DSS in further diagnosis. The information then feeds a negotiated decision-making process connected to the strategic goals of the organization (G). From here, decisions flow back to the buildings in the form of actions (j), and to the "knowledge base" or long-term memory of the organization (K).

THE OPERATING ENVIRONMENT

The operating environment constitutes all the external factors that affect the work of the C/RE group and its buildings. Most of these factors have already been presented and only a brief recapitulation is warranted.

The environment is given by: the perceptions and aspirations of individuals who participate in the design process and/or work in the building; the strategic objectives that the firm has for the building; the opportunities and threats that develop in connection to economic conditions, government regulation, investment incentives, regional factors to be considered in location and design, and so on. The environment also includes the intra-organizational links that exist between the C/RE group and the user divisions. The nature of this relationship, the level of involvement, etc.

KNOWLEDGE BASE

The knowledge base of the system comprises all the practices and procedures that regulate the operations of the C/RE group. These are the documents that spell out the responsibilities of different sub-functions within the group and the way they interrelate. The knowledge base could also be referred to as the organization's long-term memory, for it reflects many years of organizational development and learning.

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The knowledge base of a C/RE group would specify the nature of the relationship of the group to the rest of the corporation. It would contain procedures for all phases of project planning and management, technical information, design criteria, etc. Independent of the need to develop management capacity, it is important for the C/RE group to develop practices that do not rely too heavily on skillful individuals. The organization should not be caught in a vulnerable position due to the absence of one or a few key people.

Much of the time, activities in an organization do not adhere completely to the written procedures. Informal networks are used instead. However, these procedures provide a common frame of reference to a shared understanding of the organizations mode of operation essential for the continuity of the management system.

THE MODEL OF GOOD BUILDING

This model was originally developed by John Zeisel under the name of Post-Occupancy Evaluation (POE) model for his work in health care facilities. It consists of three main elements which, in order to emphasize their hierarchy, are arranged vertically in a triangle. These are: purpose, effectiveness criteria, and priority attributes. The interrelationship among these elements and the use of the model can be summarized by Zeisel's own description of the rationale behind the model to fellow environment-behavior researchers:

"Methodologically environment-behavior researchers must develop techniques to weight the different purposes that employees, residents, managers, owners, and architects might identify for the same building or type of building. The particular combination of purposes that a building represents determines what makes it an effective building, and thus what criteria to use in determining its effectiveness.... [The

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effectiveness criteria can, in turn]... be used to select appropriate priority attributes to concentrate on and to measure".¹

The model identifies four classes of attributes as shown in figures 3.2 and 3.3: (1) Physical systems, (2) Management and Operations (3) Occupancy and Well-Being and (4) Building Economics.

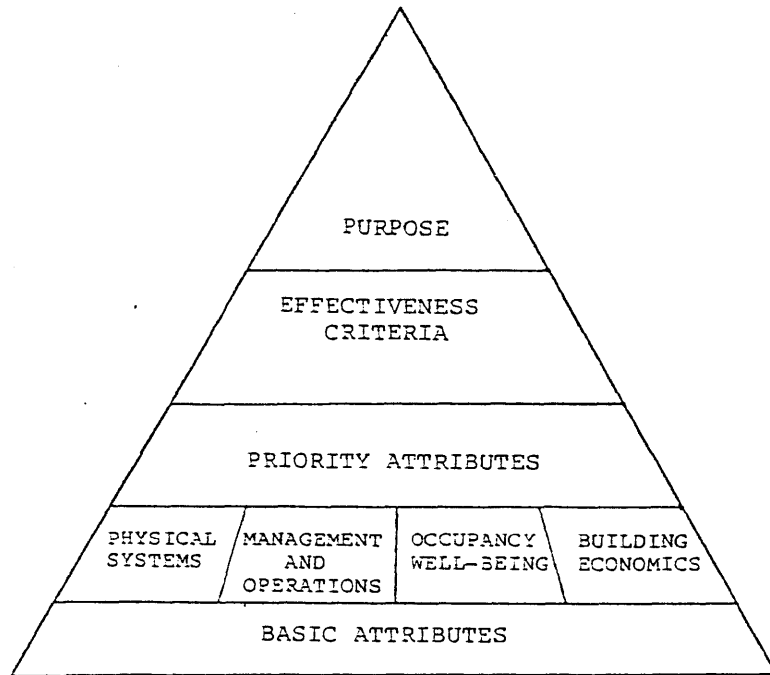
Two important characteristics of the model make it appropriate for inclusion in a learning-adapting management system: (1) it focuses building assessment on the goal or "purpose" that it has for the organization. (2) it gives a holistic interpretation a building as a social system.

A conceptual modification of the POE model is necessary for the purpose here intended. The modification has to do with the classification of attributes into distinct classes. Zeisel's classification of attributes into four types parallels Ehrenkrantz's concept of four functions of a building. Both stem from a desire to expand consideration for buildings beyond physical phenomena. But, while Ehrenkrantz's functions center on an aggregate notion about performance, Zeisel's are "...to concentrate on and to measure".

Determining a building's performance by measuring attributes in four distinct classes introduces the methodological difficulty of aggregating the values into integral measures of performance. Zeisel does not suggest how this might be done. Algorithms based on relative weights could conceivably be generated, but this would add tremendous complexity to the assessment process, let alone the difficulty of justifying one weight against another. Another difficulty with the classification in regards to measurement is made apparent by the following example. Under this classification, an interior partition system is a "physical systems" attribute. However, it is evident that a partition system should not only be well-built physically, but it should also be economical, serve its

¹ Zeisel, John, "Building Purpose", unpublished paper for a speech at the Architectural Research Centers Consortium Workshop on "The Impact of the Work Environment on Productivity, AIA, Washington D.C., 17-19 April 1985.

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PHYSICAL SYSTEMS

LOCATION
SITING
SITEWORK
STRUCTURE
ENCLOSURE
AESTHETICS
MECHANICAL
ELECTRICAL
CEILING
LAYOUT
MATERIALS
FURNITURE
ETC.

OCCUPANCY WELL-BEING

SATISFACTION
PHYSICAL HEALTH
WORKABILITY
PRODUCTIVITY
FEELINGS ABOUT BLDG. IMAGE
WAYFINDING
EQUIVALENCE (FAIRNESS)
THERMAL COMFORT
LIGHTING COMFORT
ACOUSTIC COMFORT
AIR QUALITY COMFORT
ETC.

MANAGEMENT & OPERATIONS

SPACE MANAGEMENT
SYSTEMS MAINTENANCE
REARRANGEMENT
HEALTH AND SAFETY
HOUSEKEEPING
SECURITY
ETC.

BUILDING ECONOMICS

CAPITAL COSTS
LIFE-CYCLE COSTS
ACTUAL VERSUS PREDICTED COST
INVESTMENT PAYBACK
BENEFITS TO SALES
BENEFITS TO RECRUITING
REVENUES
OPERATING COST
ETC.

ZEISEL'S MODEL AND ATTRIBUTES CLASSES

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space-defining function, create a pleasant place to work, allow for easy rearrangement, and so on.

A further objection to the classification is that they are not clearly defined. To have "aesthetics" a "physical systems" attribute, in the same class as "site work", seems out of place. Thus, it is better not to base operationalization of the model on attributes belonging to different classes. Instead, the attributes should be regarded as aspects of the building having to perform along four different dimensions. An interpretation closer to that of Ehrenkrantz's functions. The POE model's classes are useful, nonetheless, in generating a list of generic building attributes from which to identify those that should be given priority. The objective would be to develop an approach to measure that makes it possible to relate the performance of different aspects of a building in many dimension. For example, the ratio of satisfaction derived by a user from a partition system to the cost of the system.

THE DECISION-SUPPORT SYSTEM

The Decision support system is a very important element of the management system here envisioned and requires extended description. The scope of this description will be limited to developing an approach to carry out operational research on the building stock, emphasis is given to the data base of the system.

Definition and Purpose of the DSS

A decision-support system is a "...computer based system used to support the needs of managers for data and analysis."¹ Decision support systems have been developed and used over the last fifteen years. The capabilities of a DSS are described by Treacy as follows, (see figure 3.4):

"Through an interaction and display facility that may include a command and data query language, report writing, and color graphics facilities, a manager can access a base of data, perform statistical, arithmetic, and other data manipulation functions, and create explicit models of his firm, his competitors, and the industry and economy."¹

From project planning and records, operation records, building assessments and special studies a lot of data about the buildings are generated. In many cases these data serve a limited purpose within the organization such as cost control or budgeting. A goal of the DSS would be to tap an existing stream of information about the buildings to support management in establishing trade-off for new projects and in operating the existing building stock.

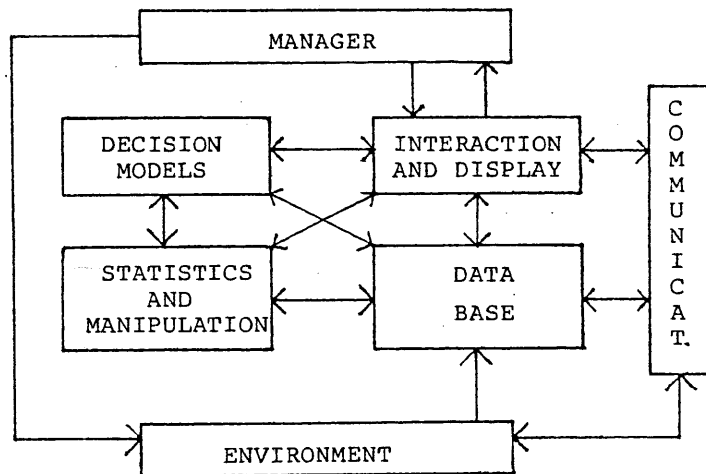


Figure 3.4
Model of DSS Capabilities.

¹ Treacy, p. 3-4.

Note: New developments in expert systems (ES) are believed to hold the future of DSS technology. ES software is expected to improve the four basic capabilities of a DSS. Until now DSS have been able to manipulate quantitative data only. Through the use of ES software, the DSS may be expected to "...call upon data in text format and utilize its semantic contents for analytical purposes." [Treacy].

THE DSS DATA BASE

Building Assessment Measures to Support Decision Making

A fundamental issue in the delivery and operation of a building stock, is the ability to make well informed decisions. Many important trade-offs underlie the concept of efficiency and effectiveness in buildings: How much to spend on a building initially and during its life-cycle? What is the relationship between these expenditures and building effectiveness? How can trade-offs be established in budgeting for a building? What is the marginal return of each dollar spent on design consultants in terms of building quality and user satisfaction? How do the buildings of the corporation compare to each other? How do the buildings of the C/RE group compare to other buildings?, and so on. These questions, and others of interest to require objective measures of performance.

A direction that management is tempted to pursue is to try to compute revenues over expenditures for individual buildings in order to use this ratio as a relative indicator of building performance. This approach has significant appeal for management, for it represent a clear "bottom-line" measure. But, for the purpose of informing decisions, this ratio is neither readily obtainable nor of great operational value.

In a large organization a building supports a complex and diversified set of functions. Most of these functions are interconnected to others in different buildings and sites. A building also contributes to the image of the corporation, creating non-accounting benefits -- or costs. The assignment of revenue and expenditure figures to a building for other than accounting purposes would be an elusive, if not a completely arbitrary task. Here the interest is to assess the performance of buildings, rather than the performance of business functions within and accross building boundaries. It would be a

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fruitless task to try to establish economic measures of effectiveness for buildings using an approach based solely on revenue/expenditure ratios.

Furthermore, even if such single ratio could be derived, it would not suffice to address questions such as those stated above. No bottom-line measure of effectiveness can inform all types and levels of decisions, nor can it provide the necessary feedback for adaptive action where and when it is needed. As it has already been pointed out, different actors at different levels and with different roles within the organization bring vastly different perspectives and concerns to bear on the questions. For a system of measures of effectiveness to be of practical use it must be able to establish links between the quality of a building and the decisions and actions available to the actors involved. It must also connect decision-making to the kinds of knowledge about buildings available to the organization.

Such evaluation technique should not obscure the fact that what is ultimately being evaluated is management itself -- individually and as a system. Quantitative measures and assessment techniques cannot replace the managerial skills necessary for the planning and control of each building and project. Neither can they substitute for a negotiated process of decision-making based on corporate policies and practices.

Buildings are durable assets. Their present state and performance are the result of decisions in the past. Their future performance will be the result of decisions in the present. It is important to acknowledge the time dimension of buildings, and the role of management in safekeeping the value that they represent to the corporation. The purpose of building assessments is to support on-going decision-making and to evaluate the impact of past decisions.

A System of Indicators of Building Effectiveness

The approach suggested here was developed by professor Ranko Bon, (MIT, 1984) as part of a research project. It consists of a system of measures.

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or indicators, that can describe many aspects of building performance, and inform decision making across many actors. The indicators are in the form of values and ratios of descriptive data about the building. Starting with a relatively small number of primitive indicators, new ones can be derived through simple algebraic operations. The value of indicators may be used as dependent or independent variables to study degrees of correlation between them. The objective is to have a repertoire of data which are neither too disaggregated (i.e. user complains about glare in an office) to support conclusions, nor too aggregated (i.e. total revenues over expenditures ratio) to identify useful relationships between decision variables and their results. (See Appendixes Two-A and Two-B).

The great advantage of Bon's concept of indicators resides in the relative independence with which they can be manipulated to yield information. It frees C/RE's management dealing with strategic type of decisions to consider issues at an abstracted level of detail from the vicissitudes that facilities management must deal with. As such, it serves as a tool to generate and compress knowledge about the building stock in order to feed it back into the process of building operation and renewal, as well as into the design and construction of new buildings. There are three basic goals that the system of indicators could be expected to attain:

1. Facilitate the safekeeping and improvement of the original quality of individual buildings.
2. Facilitate the development of strategies to monitor, and manage the building stock.
3. Support C/RE Group decision-making for new projects and buildings.

These goals can be achieved by the following operations made possible by the indicators:

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- * Creating common basis for comparing the performance characteristics of different buildings; identifying problems and exemplary buildings from the corporate building stock.

- * Making explicit the potential correlation between alternative decisions and their outcomes; pointing to and clarifying trade-offs; establishing relationships between decisions and outcomes not previously discovered.

- * Providing parameters to monitor alternative project set-ups (budgets, schedules, contracting arrangements, etc.).

- * Providing parameters to monitor the performance of new building components and innovations.

- * Serving as a powerful tool for operational research; helping answer outstanding questions and suggesting new areas for inquiry.

Data Requirements

A continual supply of purposely selected data would be required to attain the goals of the indicator system. The emphasis should be on "appropriateness". As researchers of organization and information theory have noted, most often in decision-making the "scarce" resource for management is not "information" but "attention" [H. Simon et al]. It has also been noted that decision-makers tend to suffer from an overabundance of information, both relevant and irrelevant. A manager can not divide his or her attention equally among all the sources of information available. There is a need to segregate and aggregate information in a valid way. To compress it. The system of indicators would filter and condense a lot of existing information into forms that relate decisions with results. It would reduce redundancy and increase the utility of data collected through building assessments and control records.

A Learning Management System

The data required by the indicator system can be classified into two types: initial and operational. For each type, there are four parameters for data collection:

- (1) Financial (dollars)
- (2) Time Related (Dates , escalation indexes, etc.)
- (3) Space (area, volume)
- (4) People (numbers, satisfaction indexes, etc.)

The five groups constitute a typology of information requirements and determine the dimensional units for quantification.

Building Stock Strategic Planning and the Indicator Based DSS

The philosophy behind the indicator-based DSS system is one of constant inquiry and learning as a means of maintaining and improving management performance. As much as the indicators are part of an action-oriented model, they are an operational research tool. Not only are they intended to provide relevant information to decision-makers, about the building stock, but they can also be instrumental for addressing issues which will inevitably arise as the context in which a C/RE group operates continues to change.

Single, building-wide effectiveness measures are informative only when they are used to investigate the relationship among specific variables of the building's performance, and when this relationship is contrasted to that of comparable buildings and the building stock. In other words, the indicators of building performance can be used to investigate the "variability" of different parameters in a building sample. This can serve as the basis for a "statistical quality control" of the building stock. The underlying philosophy is that, of course, no two buildings are ever exactly alike. By deriving a tolerance range within which measurements "normally" occur, it is possible to identify values outside the norm, or "outliers". It should again be stressed that quality is a relative notion. The tolerance range should be internally derived from meaningful samples of comparables.

An approach to management based on the building stock and using statistical quality control techniques would serve as a tool for strategic planning. This tool would be consistent with the C/RE group's role as keeper of the building stock, and its full faculties within the corporation. In term of the distribution of values of indicators two goals can be identified here:¹

¹ These two "strategic" options were suggested by Ranko Bon as part of his indicator system.

A Learning Management System

- * "Shifting" the entire distribution towards the more desirable range. (Improving the effectiveness of the building stock).

- * "Tightening" the distribution so that building performance is more consistently effective. (i.e. Avoiding "over-kills" and sub-standard buildings).

Strategic decisions towards these goals would include the whole array of real estate options available to the C/RE group: decisions about new construction, leases, acquisitions, divestiture, and so on. Further elaboration in this direction is beyond the scope of this study.

A Learning Management System

SUMMARY

In order to maintain and improve performance in a changing environment, the management system of a construction and real estate group must incorporate adaptation and learning processes that support decision making. The system should be explicitly connected to the strategic goals of the corporation, from which it would derive a definition of what is a "good" building.

Through the assessment of its own buildings and practices, the C/RE group can continuously develop its capacity for producing and operating good buildings. A decision support system (DSS) based on indicators of building effectiveness could be a valuable tool for generating knowledge and strategies for a more effective building stock.

CONCLUSION

This study explored several concepts that begin to define a theoretical base for considering the special case of buildings in a corporate context. Within this, an attempt was made to situate the activities of a C/RE group in the context of corporate planning. Buildings were presented as embodiments of processes involving different actors. Physical dimensions and temporal dimensions were said to characterize the perceptions of architect and manager respectively. While this difference is a source of possible conflicts, the mirror-like interests of architects and business managers should be regarded as an opportunity for structuring a synergetic relationship during the design process. Similarly, during occupancy, organizational practices and incentives should institute shared perceptions and comprehensive approaches to building-related decisions. The concept of four functions of a building can be of use to an organization's administration of its buildings as a complex social phenomenon. People have aspirations which are often translated into expectations about their working environment. A building should try to satisfice these aspirations.

From a wider perspective, that of the strategic planning needs of the corporation at large, buildings can be regarded as a resource. In managing this resource, a C/RE group relates to the rest of the corporation on two levels -- that of the management of the business divisions it supports and that of facilities management. The role of the C/RE group is to plan and manage this resource along directions set by the strategic requirements of the corporation. An important part of this is to master an ability to translate business needs into building requirements. A parallel requirement is to maintain the strategic value of the building stock. Through continuous involvement with its buildings, and by working with facilities management, the C/RE group can accumulate and disperse knowledge about building-related practices from site to site and from past to present. A management system that incorporates research activities can materialize the potential advantages that a corporation could derive from

Conclusion

such a group; namely, the ability to develop a deep understanding of the building needs of the corporation.

It is important for a C/RE group to have tools and methods for constantly learning and adapting to its operating environment -- both within the corporation and outside of it. A consensus and goal-oriented model of good building, together with quantitative techniques can strengthen the learning capacity of the management system. In this study, the use of a decision support system was advanced as an approach leading to both a more informed and cohesive decision making process, and a wealth of new insights into building practices.

Evidently the model presented here is one of many possible for a corporation's handling of its buildings. Other models, such as a corporation contracting out the care of its buildings to an outside contractor are also possible. Whichever model is used, if the corporation takes a conscious, purposeful approach to controlling its building stock the advantages could be substantial. Strategic planning and management of the building stock would allow the firm to take full advantage of this important resource. The difference lies in considering the strategic value of buildings and explicitly putting them "on the agenda" in the process of planning.

The model discussed here takes one cut through the problem. Namely, through the interpersonal and intra-organizational issues that define the climate of operation of a C/RE group. As such, the model could be said to deal with organization design more than with technical-financial issues of buildings. These latter aspects are, nonetheless, subsumed under the assumption that the C/RE groups will have highly trained professionals to deal with them. From the point of view of a high level manager of the group, issues of organization design will seem more critical. It becomes necessary to coordinate the talents of many people who are often "too close" to the problems at hand to perceive their interconnections. At a high level, too, contact with corporate issues will be more relevant and the question of how to best connect the activities of the group to corporate interests will emerge as vital.

Conclusion

This thesis covers new grounds and is quite broad in scope. Few sources can be found that treat the topic more or less directly. Thus, there was a need to assemble the pieces and define the territory. A lot of knowledge had to be amassed and given fairly new forms. For this reason, the topics were not all treated to the same level of detail. A lot of emphasis was given to the role of people's perceptions about building. Substantial effort also went into illustrating the applicability of the indicators as a diagnostic tool (see examples on appendix two). The former derives from a strong desire to advance a coherent view of architecture consistent with the realities of organization clients. The latter from the need to demonstrate the use of a fairly abstract concept. The many loose ends, I hope, might serve as further topics of research in their own right. Their coming together in this thesis could serve as benchmarks to guide future work.

Several of the concepts presented could serve as departure for future research. Among these the most interesting might be:

1. Further definition of the meaning of "strategic planning" for building design/management.

- The issue of corporate image. What is the role of buildings?
- Strategies for decision-making for buying, leasing, selling, renovating, etc. What indicators should be generated to inform these decisions?
- Real estate portfolio options and the model. How can options best be coupled with strategic plans?

2. The design of the DSS for building design/management.

- The information requirements of the system (other than the indicators) could be determined based on what would be useful to the organization. What should the system be expected to do and what should it not?

Conclusion

- The user interphase with the system could be specified. What capabilities would be more interesting? What existing software and hardware could best perform these functions?
- Construction of the entire DSS program.

3. The concept of indicators of building effectiveness.

- More indicators relating different dimensions of building effectiveness (behavior, environment, aesthetic, economic) should be developed and tested for large building samples.
- The indicators should be classified as providing technical, tactical or strategic information. Related to this, the true meaning of each indicator should be analyzed, their reliability, the limits of their applicability.
- The use of the indicators need not be restricted to a single organization. Exchange of information among building owners could be beneficial to all. A building managers periodical (such as "The Real Estate Review") could publish the value of indicators for different building types and regions to inform the practices of businesses, architects and facilities management.
- The indicators could provide more accurate ranges of values useful in setting up a building project -- specially in relation to assumption-making.

APPENDIX ONE

BUILDING AS A NETWORK OF ACTORS

A Case Example

A premise advanced by the first chapter of this study is that a corporation is in itself a model of society at large. For this reason, the "functions" of a building in society, as identified by Ehrenkrantz, are represented in the corporation in the form of roles associated with different groups of individuals. Because of different training, personal interests and organizational position and incentives, these people tend to specialize or be concerned about a narrow definition of the purpose of a building. The example here presented illustrates an actual case of how these roles come into play.

Until recently the management of facilities had been regarded as an activity requiring purely technical training, and thus the domain of mechanics, electricians or plumbers. However, it is becoming clear that facilities management can greatly affect the value of buildings as a corporate resource. As a result, the activity is rapidly professionalizing. It is not enough to "keep a building running", it is also necessary to see the building in the context of the organization at large. This requires a perspective vision of the role of the building through time, and an understanding of the complex network of decisions that ultimately determine the building's effectiveness.

In the early years of occupancy, facilities management of a corporate headquarters was faced with the need to make more office space available. The floor plan of the building was such that at the intersection the main corridor running long-wise and secondary corridors running width-wise spaces were formed with access to exterior windows. (See figure A- 1)

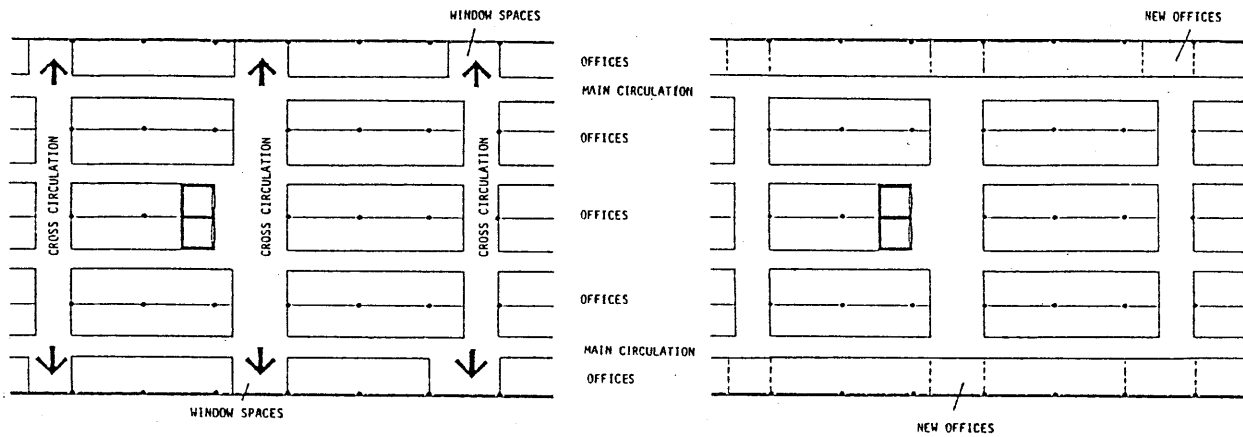


Figure A-1
Office building plan, before and after.

As a solution to the need for additional office area, a decision was made to enclose these spaces, cutting off the visual connection of the corridor to the outdoors. Given that facilities management operates under a very-short time horizon, (facing a great number of problems on short notice), the solution may seem quite satisfactory. Under narrowly defined "economic" and "functional" priorities, the solution may even appear commendable: new office space was created out of "under-utilized" space. However, under the corporation's longer time horizon, and other priorities, the "solution" generated serious problems of its own.

The new offices deprived the main circulation of the natural light that penetrated the building at those points, causing great disorientation and a general loss of perceived quality in the interior of the building. It also led to

the dissatisfaction of employees, and to a lower image of the corporation being projected to visitors -- clearly causing a dis-service to the objectives of the firm. Among many employees who had worked in the building the not-too-kind joke spread about the need to "survive" the building.

There were many attempts to improve the building's interior, including painting, carpeting, the addition of new signage to help people find their way, etc. but the problem remained largely unsolved. Later, other circumstances seriously compounded the problem leading to major and costly readaptation of the building. No doubt that the poor quality of the interior space greatly reduced people's tolerance for other inconveniences (such as a lack of sufficient conference space). Several important issues can be raised from this experience:

- * Why was the building layout so vulnerable to change? Why were there spaces that, although critical for the quality of the building, could be perceived and treated as "left-over" spaces? (i.e. Design issues)
- * How was the decision to move more people into the building arrived at? Was there an awareness of the trade-offs involved and of the pressure the decision placed on the building's capacity? (i.e. Business management issues)
- * What other alternatives were there for creating additional office space in the building? Why did an "emergency" solution (as this surely must have been) become a permanent change in the building? (i.e. Facilities management issues)
- * Why is it that there was no "memory" of how the problem had come about in the first place among people in the building? To what extent did the fact that the building has a large percentage of "transient" population (employees who come from branch offices, stay from one to two years in the building and go back) delay effective action on the problem? (i.e. Building user issues)

Many other issues could be raised. Those presented here are sufficient to illustrate how strongly the decisions and actions of different groups of people interact, and how together they affect the effectiveness of a building. Although

the example emphasizes the need for facilities management to take a wider perspective for problem-solving. the same point can be generalized to the other actors of the building process as well.

Buildings are a very special kind of asset within the corporation. Its management involves a balance of performance along all of its functional dimensions and amid the perceptions and actions of a large number of actors who often act at odds to each other. It involves reconciling decisions and actions during their life-cycle which may directly impact organizational goals.

APPENDIX TWO-A

SYSTEM OF INDICATORS OF BUILDING EFFECTIVENESS

The system of indicators would have to be generated for the specific needs of the C/RE group. The table on the next page gives a few examples of some indicators that could be generic to most systems.¹ As in Bon's system, the indicators here presented are divided into five sub-groups depending on how they are generated. These are:

- (1) **Initial Project Indicators.** - Obtained from project planning and control records. These indicators would be collected only once. They would include both actual and estimated data (costs, date of completion, population, relative quality sought for the building, etc.)
- (2) **Building Operation and Management Indicators.** - Obtained on a periodic basis from the operations of the building.
- (3) **System Indicators.** - General data required to operate the system.
- (4) **Constant Derived Indicators.** - Obtained from combinations of the initial project indicators. Generated only once.
- (5) **Variable Derived Indicators.** - Obtained from combinations of all groups of indicators. Generated periodically.

In practice, a greater number of indicators in groups 4 and 5 is desirable (they do not require additional data gathering). But, since the indicators in these two last groups would be most closely tailored to the specific demands of the C/RE group, only a small number of them is included in this abbreviated list.

¹ Excerpted and adapted from unpublished research by professor Ranko Bon, MIT school of Architecture and Planning, 1985.

1. INITIAL PROJECT INDICATORS		
AECAC	-A/E and C/RE charges actual cost	\$
BLFAC	-Building finishes actual cost	\$
BLSAC	-Building systems actual cost	\$
BSHAC	-Building shell actual cost	\$
COCOD	-Construction completion date	d
FUFAC	-Fitting-up and A/E fees actual cost	\$
INOCOD	-Initial occupancy date	d
GROTA	-Gross outside area	sf
NEPRA	-Net productive area	sf
PRCEC	-Project contingency estimated cost	\$
RELBO	-Relative building quality	-
SIDAC	-Site development actual cost	\$
SIDEC	-Estimated site development cost	\$

*BLTAC	(BSHAC + BLFAC + BLSAC)	\$
	-Building total actual cost	
*CONAC	(SIDAC + BLTAC + AECAC)	\$
	-Construction actual cost	
*PRTAC	(CONAC + FUFAC)	\$
	-Project total actual cost	
2. OPERATION AND MANAGEMENT INDICATORS		
BULOC	-Building operating cost per year	\$/y
NUBUO	-Number of building occupants	p
REARA	-Rearrangement area	sf/y
SITOC	-Site operating cost per year	\$/y
USATF	-User satisfaction (1-5 scale)	n
3. System Indicators		
ESCLN	-Building cost escalation index	n
NBLDG	-Number of buildings in a sample	n
PRESO	-Present date	d
YDATE	-Yearly Date	y

*BLOPY	(PRESO - INOCOD)	d
	-Building operating period	
4. CONSTANT DERIVED INDICATORS		
*AECAT	(AECAC/PRTAC)	\$/s
	-A/E and C/RE charges over project total actual cost	
*BLFAS	(BLFAC / BLTAC)	\$/s
	-Ratio of actual building finishes cost to actual building total cost	
*PRTAF	(PRTAC/GROTA)	\$/sf
	-Project total actual cost/sf outside area	
*SIDVC	(SIDAC - SIDEC)	\$
	-Variance between actual and estimated site development cost.	
5. VARIABLE DERIVED INDICATORS		
*BOCGF	(BULOC/GROTA)	\$/sf/y
	-Building operating cost per sf of gross outside area per year	
*CUMOC	(ROCTC * BLOPY)	y/y
	-Ratio of cumulative building operating cost to escalated project total cost	
*EPTAC	(PRTAC * ESCLN)	\$
	-Escalated project total actual cost	
*NEPPO	(NEPRA / NUBUO)	sf/p
	-Net productive area per building occupant	
*REAPO	(REARA / NUBUO)	sf/p*y
	-Ratio of rearrangement area per year to building occupants	
*ROCTC	(BULOC / EPTAC)	1/y
	-Ratio of building operating cost to escalated project total actual cost	
*USPNA	(USATF / NEPRA)	n/sf
	-User satisfaction per net productive area	

(*) Indicators generated automatically by the system

APPENDIX TWO-B

USING THE INDICATORS

This appendix illustrates how the indicator system could potentially be used. It is envisioned that the DSS data base would contain the values for a large number of buildings in the corporation. This data base would be updated periodically and coupled with analytical and graphic capabilities to serve as a major source of information to C/RE group in managing the building stock. The group would direct inquiries to the DSS in order to extract knowledge from its own practices.

Design of the data base system would require further study. The purpose of this section is to provide a vision of the system at work and to demonstrate its potential value. The examples here presented are "scenarios" rather than actual examples. Emphasis is on the type of inquiries the system could inform, rather than on the numbers themselves.

The information stored in the data-base would come from a number of internal and external sources. The former would include project planning and control records, and building operation records. The latter include professional literature, contractor estimates, professional organizations, (such as the Building Owners Management Association, BOMA), and other such sources.

Framing the Questions

For the sake of illustrating the use of the system, a hypothetical design has been assumed. The design simulates an on-line interface between the user and the data base of indicators. The following is a list of actions by the user and responses of the system. (See "SCREEN 0").

1. User : Logs on and calls the data base program.

System : Displays menu.

2. User : Selects building(s) to study by specifying the appropriate sample request, and then either:

(a) Selects by name the indicators to be used, specifying which one should be the independent variable (x-axis) and which should be the dependent variable (y-axis). It would also be possible for the user to specify a variable for the z-dimension and request rotations of the display.

(b) Lets the system select the indicators by: specifying the type of common characteristics of the buildings ("control for" menu); selecting the type of governing characteristic along which to order the sample ("function of" menu).

System : Displays a pre-formatted line prompting for additional information on the characteristics of the sample to be used, and:

(a) Points to the "control" and "function" characteristics associated with the indicators selected by the user.

(b) Selects the appropriate set of indicators to address the inquiry and displays their names.

3. User : Fills in the additional information requested.

System : Performs analysis to inform the request and displays the results graphically and numerically.

4. User : Requests system to display a range of sample buildings within some specified threshold value. Requests additional information on those buildings outside this range, and/or goes on to other analysis.

System : Displays the information requested.

5. User : Requests additional information on those buildings outside the medium range. These "outliers" are interesting since they are either the "good" or the "bad" buildings in the sample.

System : Searches for project and operation data on the building in question.

EXAMPLES

Three examples of the use of indicators in the framework of the above schematic system design are given here. The first example is the longest, taking

(SCREEN 0)

Building Sample	Control for	Function of		Indicator menu		
All	NW	Size	Quality	Size	Quality	X :
Hq	NE	ICost	OCost	ICost	OCost	Y :
Ofc	SW	Age	Period	Age	Period	Z :
Lab	SE	Popul	Location	Popul	Location	P :
Site	Blg					Default

(INDICATOR)

(GRAPHIC FIELD)

(INDICATOR)

For ___ buildings ___ to ___ (sf) completed ___ to ___ (yr)
(PREFORMATTED SYSTEM REQUEST)

___ % of sample about the ___
(SAMPLE-RANGE SPECIFICATION)

Analysis options

Analyze Compare Correlate Regress Fit Profile Quit.
(ANALYSIS OPTIONS MENU AND NUMERIC RESULTS DISPLAY)

a hypothetical user of the system through a series of six "screens" to investigate specific aspects of the performance of an office building. The information used in this example would be abstracted from project records. The second is three screens long and it investigates the relationship between initial cost and operating cost for several buildings. Example three is only one screen long. It investigates the relationship between the ratio of the combined charges of the C/RE Group and outside consultants over the total project cost, to a non-economic measure of performance -- user satisfaction. The values used in these examples are all hypothetical.

EXAMPLE 1

How does office building "x" compare to other buildings in terms of total project cost per square foot?

A person using the indicator data base might begin by comparing "x" to office buildings outside the corporations. The most basic comparison that could be made is to relate an overall measure of building quality to total building cost. The following set-up would be possible:

(SCREEN 1)

Sample: A sample of comparable office buildings for which data is available and building "x". The sample may be composed of 85% of all the cases about the median value for all buildings in the data base. This would eliminate extreme cases that may distort the range's value as a measure of normalcy. (This kind of normalization of the sample would be advisable for most analyses; thus, it could be a default function of the system, with an allowance made for overriding or resetting the default).

Independent variable: RLTBQ

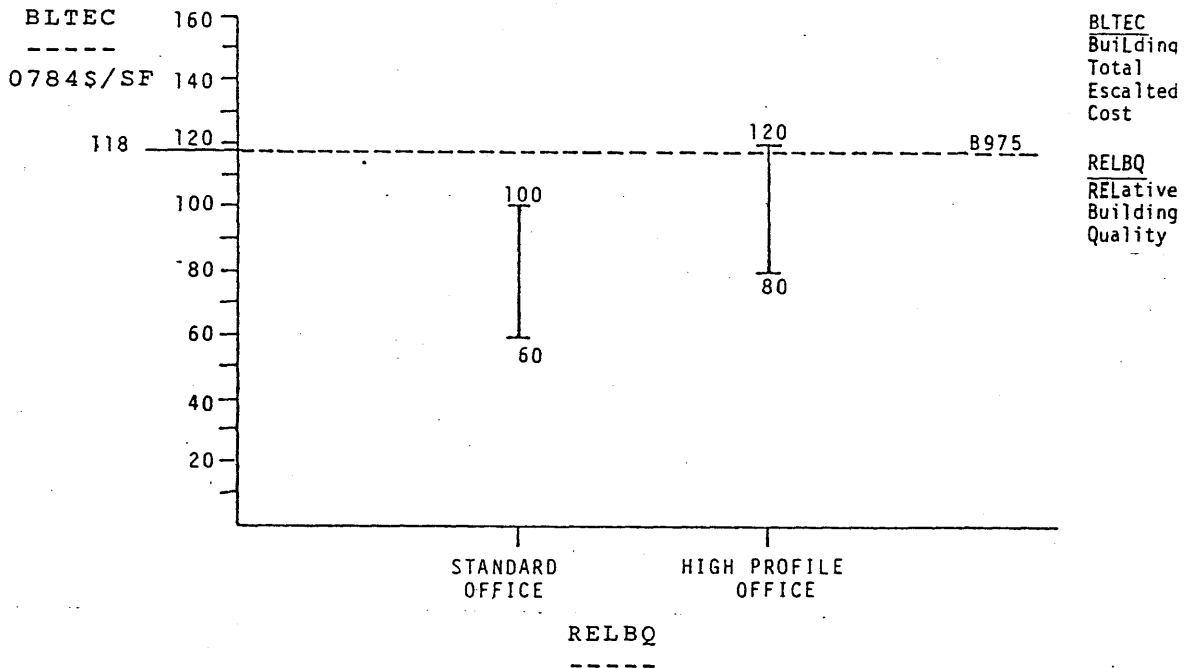
Relative building quality. For example, conventionally accepted quality labels used for office buildings -- "standard" versus "high profile".

Dependent variable: BLTEC

Building total escalated cost per square foot. (To a common base year: July 1984 dollars)

(SCREEN 1)

Building Sample	Control for	Function of	Indicator menu
All	NW	Size Quality	X :RELBQ
Hq	NE	ICost OCost	Y :BLTEC
OFC	SW	Age PERIOD	Z:
Lab	SE	Popul Location	P:
Site ___	Blg X		Default



For building XX and OFC NON-C/RE buildings

85% of sample about the MEDIAN

Analysis options

Analyze Compare Correlate Regress Fit Profile Quit

The graph on screen one shows that the cost of a well- built standard office building ranges from \$60 to \$100 per square foot, for the basic shell, service core and public spaces. The comparable figures for a high-profile corporate headquarters building range from \$80 to \$120 per square foot. The cost per square foot escalated to July 1984 dollars of building "x" is \$118.

Clearly, "x" falls in the upper part of the latter range, while it is outside the former range by a substantial margin. Let us assume that "x" has an area of raised floor and some laboratory-support infrastructure. Thus, the building would not be a standard office building, but it would not be a high-profile headquarters building either. Even though it would be difficult to establish "x's" relative quality, building "x's" costs would not compare favorably.

The user may then want to know more about the building's history. He may wish to locate "x" in the context of the total building activity managed by the C/RE Group. Knowing that "x" was completed in 1982, he could select to see the number of projects completed during the six year period from 1978 to 1983. The period thus defined would contain most activity which overlapped with the planning, design, construction and project close-out of building "x". The manager could exclude from the sample projects that are too small. A new set up of sample and indicators would be selected:

(SCREEN 2)

Sample: All buildings by the C/RE Group 30,000 sf or larger completed between 1978 and 1983. Identify building "x".

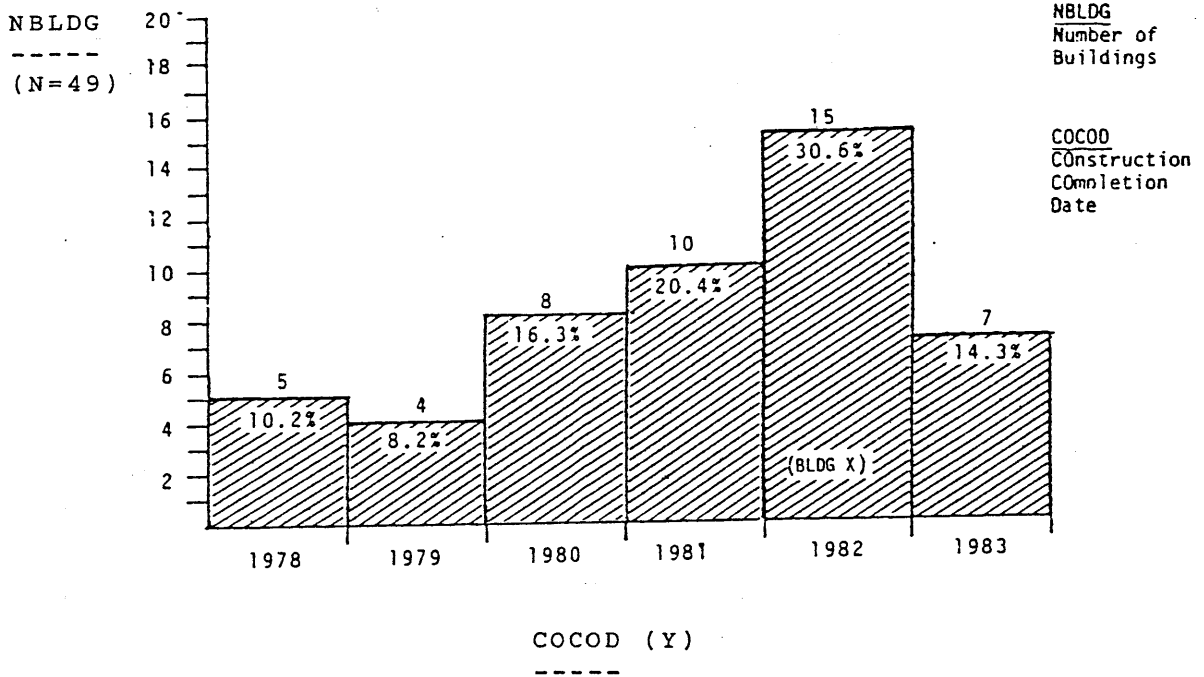
Independent variable: COCOD
Construction Completion Date

Dependent variable: NBLDG
Number of buildings in each year-class

The resulting frequency distribution shows a total of 49 buildings in the sample. It also shows a substantial peak of activity during 1982, when fifteen

(SCREEN 2)

Building Sample	Control for	Function of	Indicator menu
ALL	NW	SIZE Quality	X :COCOD
Hq	NE	ICost OCost	Y :NBLDG
Ofc	SW	Age Period	Z :
Lab	SE	Popul Location	P :
Site	Blg X		Default



For all buildings 30K to + (sf) completed 78 to 83 (y)

Find building X

 % of sample about the

Analysis options

Analyze Compare Correlate Regress Fit Profile Quit

out of the forty- nine buildings, or 30% of the total sample, were completed. This means that the year building "x" was completed, the C/RE Group saw the largest building activity.

A question may already be posed about whether the unusually high number of projects on line together with "x" may have had something to do with the building's cost. Could management have been overloaded? could this be a partial explanation?

A frequency distribution of the cost of all buildings during the period in question might be the next step in the investigation. The user may want to divide the projects into six or seven classes according to cost. He or she then may wish to know the range of costs, the number of buildings in each different cost class, and the location of building "x" in the distribution. The new set up would be:

(SCREEN 3)

Sample: Same as above

Independent variable: PRTAF

Project total actual cost per square foot escalated to a common date, July 1984.

Dependant variable: NBLDG

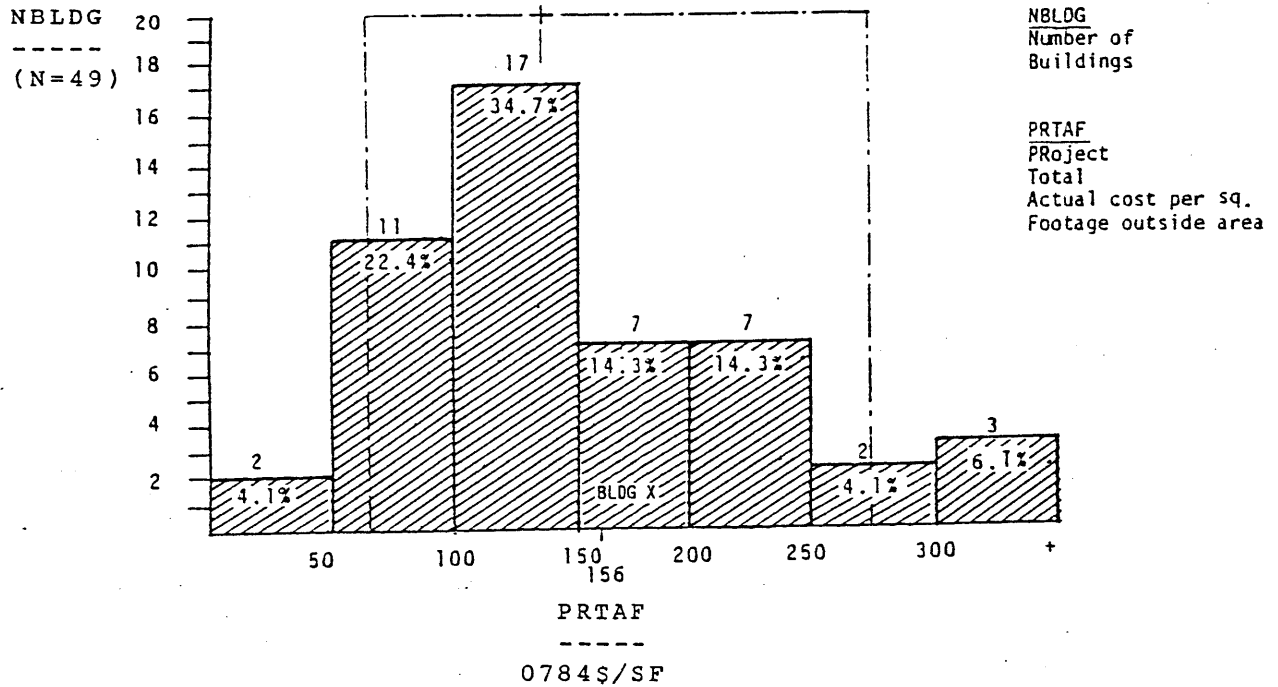
Number of buildings in each cost class.

The resulting histogram shows that even compared to other buildings and standards, building "x" cost is slightly above the median. It is, however, within the 85% range of all buildings in the sample about the median. Thus, building "x" can not be labeled an "outlier". With respect to this sample, building "x" is neither an exceptionally "bad" nor a "good" building.

It may be interesting at this point to locate building "x" within the other buildings completed in the same year (1982). The data base may be asked to provide the range of costs for the buildings according to the year they were completed. The set up would be as follows:

(SCREEN 3)

Building Sample	Control for	Function of	Indicator menu
ALL	NW	SIZE Quality	X :PRTAF
Hq	NE	ICost OCost	Y :NBLDG
Ofc	SW	Age PERIOD	Z:
Lab	SE	Popul Location	P:
Site ___ Blg ___			Default



For ALL buildings 30K to + (sf) completed 78 to 83 (y)
 Find building X

85% of sample about the MEDIAN

Analysis options

Analyze Compare Correlate Regress Fit Profile Quit

(SCREEN 4 & 5)

Sample: Same as above.

Independent variable: COCOD
Construction Completion Date

Dependent variable: PRTAF
Project total actual costs per square feet. (Base July 1984 dollars).

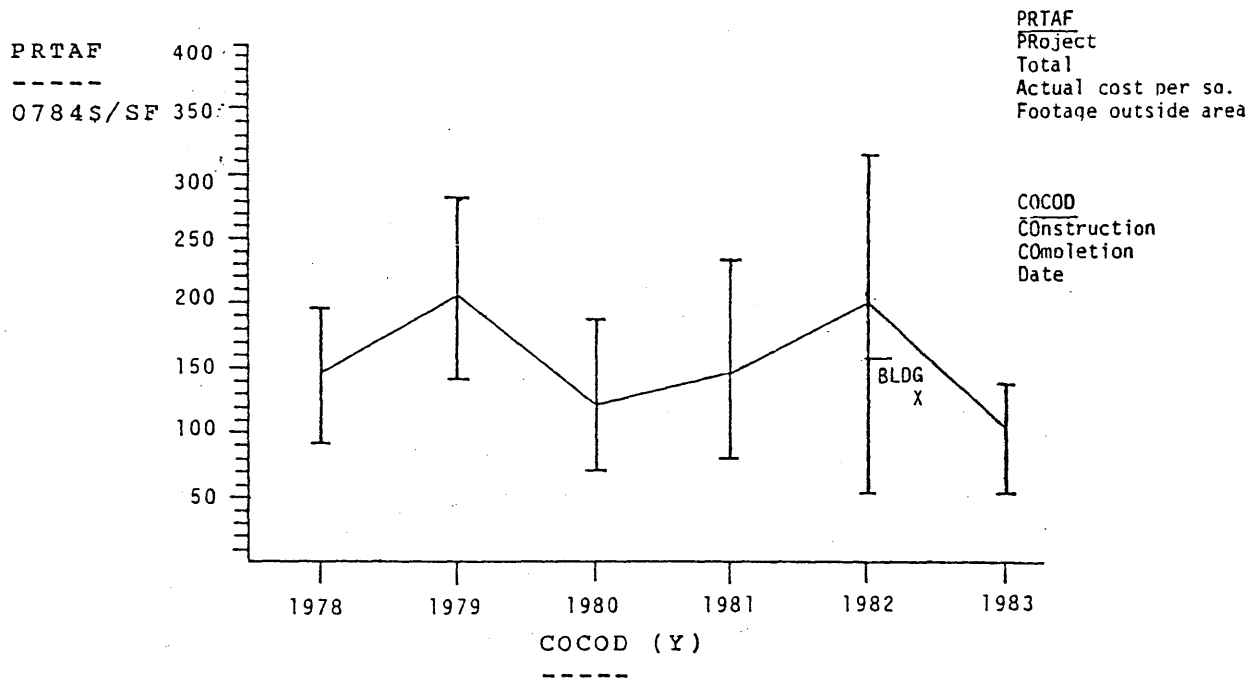
The graph shows that building "x" is below the mean for its range (SCREEN 4). Thus, in terms of the building activity in 1982, the building is not a "bad" building, it is rather on the "good" side. Another very interesting characteristic of the data emerges from the graph. Significant fluctuations on the cost ranges are found. During 1982, specially, the range widens noticeably. The most expensive building in the sample and also the least expensive are found in this range. It is also noteworthy that for 1980, 1981, and 1982 the range of cost progressively widens. This trend recalls the shape of the graph on screen 1, where the number of project completed during those same years grew steadily.

The correlation between the shape of graph one and graph three is too significant to go unnoticed. Superimposing the two graphs (SCREEN 5) shows that, for each year, indeed the range of costs follows closely the number of projects. Increasing the number of projects in a year widens the range of costs proportionally. In this example the C/RE Group built its most expensive projects during 1982; it also built some of its least expensive. That same year, the analysis has found a definite correlation between the number of projects the C/RE Group has on line and the range of cost of those projects.

This would not be such an unusual circumstance. The bigger the sample / the wider the distribution is a natural statistical condition. What would be significant is that the increase in activity dilated the cost range mainly upwards. Would this also be a natural condition or would it reaffirm our earlier belief that the increase in activity overloaded management capacity? -- an investigation of the circumstances under which the projects were built may be warranted at

(SCREEN 4)

Building Sample	Control for	Function of	Indicator menu
ALL	NW	SIZE Quality	X :COCOD
Hq	NE	ICost OCost	Y :PRTAF
Ofc	SW	Age Period	Z:
Lab	SE	Popul Location	P:
Site	Blg		Default



For ALL buildings 30K to + (sf) completed 78 to 83 (y)
Find building X

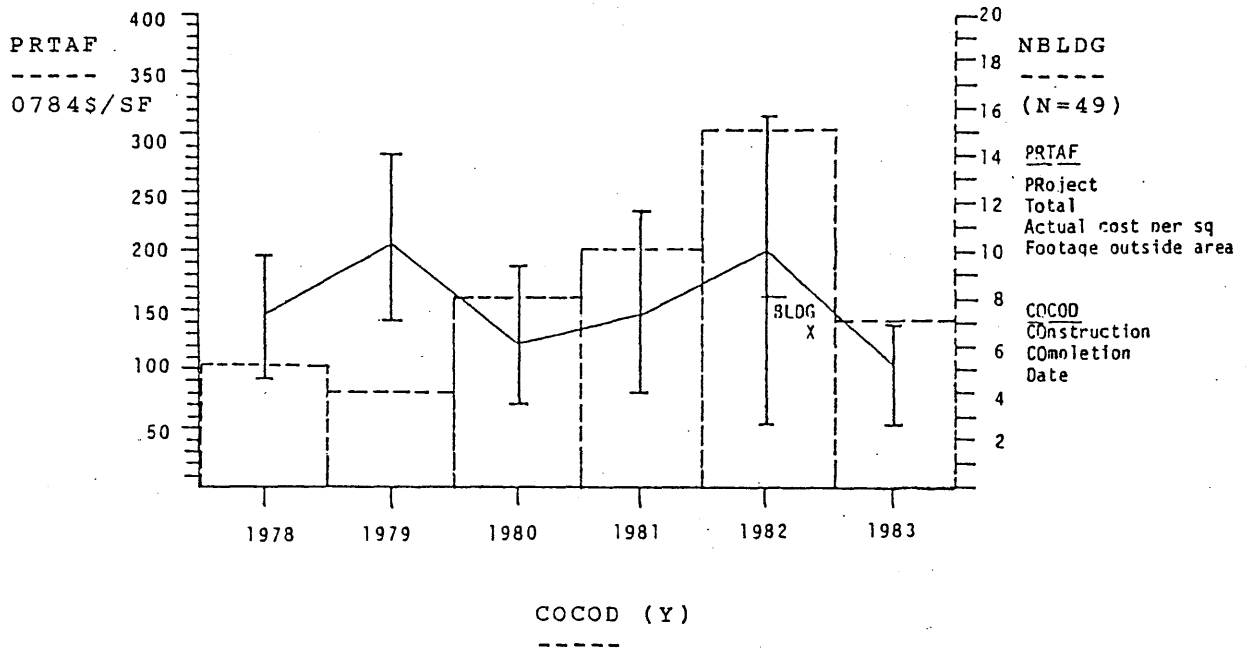
85% of sample about the MEDIAN

Analysis options

Analyze Compare Correlate Regress Fit Profile Quit

(SCREEN 5)

Building Sample	Control for	Function of	Indicator menu
ALL	NW	SIZE Quality	X :COCOD
Hq	NE	ICost OCost	Y :PRTAF
Ofc	SW	Age Period	Z :
Lab	SE	Popul Location	Y':NBLDG
Site ___ Blg__			Default



For ALL buildings 30K to + (sf) completed 78 to 83 (y)

Find building X

___ % of sample about the ___

Analysis options

Analyze Compare Correlate Regress Fit Profile Quit

this point. How many staff were involved in the activity in each year? Were there allowances made to increase staff capacity in relation to increased project activity? These questions could be of revealing interest for planning future practices.

From analysis of the data another important observation can be made. During 1979 the cost range is not significantly larger than in other years of similar activity, but it is significantly higher. During 1979 the least number of projects were built, but the highest median is observed, and the second highest top range value. Why is this so? This fact stands out even more than the cost of building "x". The search would thus have unexpectedly led to the discovery of another interesting line of inquiry for the C/RE Group.

EXAMPLE 2

How does the ratio between building operating cost and initial cost change over the building life-cycle?

Better building systems and components, higher quality materials, better detailing, all would tend to reduce the operating cost of a building, while adding to its initial cost. The existence of an inverse relationship between the two costs would involve a trade-off that is normally made, yet seldom made explicit. Can higher initial expenditures be expected to bring higher user satisfaction? How strong is this relationship? These could be important issues in budgeting for a new project.

One way to approach this question would be to determine the degree of correlation that there might be between the initial and operating costs for a large number of the building of the corporation. It could also be useful to investigate the performance of a building of interest, for our hypothetical building "x", in relation to the overall sample.

(SCREEN 6)

Sample: All buildings of the corporation 30,000 sf or larger completed between 1978 and 1983. Identify building "x".

Independent variable: PRTAF

Project total actual cost per square foot of outside area.

Dependent variable: BOCGF

Building operating cost per square foot of gross outside area.

In this example the analysis shows that buildings whose initial cost are substantially lower have noticeably higher operating cost. The correlation becomes weaker as initial costs increase, up to a point when it tends to level off. When asked to display outliers, the system would identify those buildings whose values substantially fall outside the middle range. In this example building "x" is taken to be an outlier.

As a second line of inquiry, the user might want to study the history of changes in operating cost over initial cost of building "x", and compare it to that of similar buildings on the same site. The analysis would be:

(SCREEN 7)

Sample: All support buildings on the same site as building "x" between 20,000 and 500,000 sf completed during 1978 and after.

Independent variable: YDATE

Year of completion.

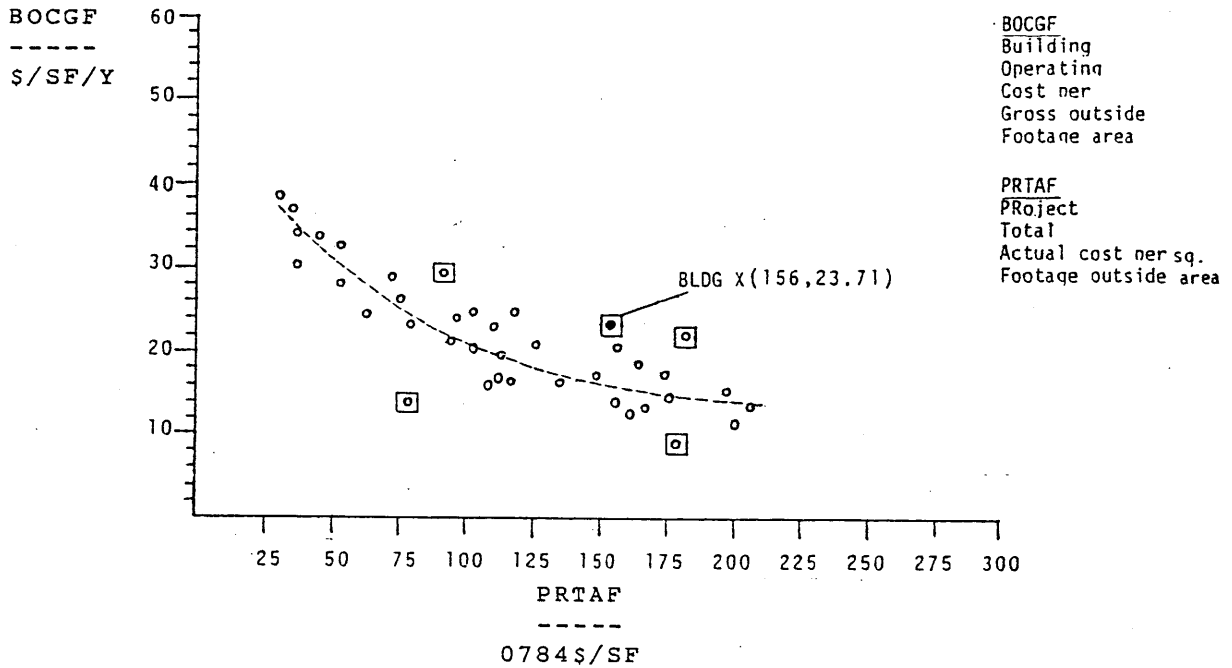
Dependent variable: ROCTC

Ratio of building operating cost to escalated total project cost.

The graph allows for comparisons of the changes in operating cost for given calendar years. The graph shows fairly constant rates of change among buildings. In this case external factors such as the cost of heating fuel may be the prime determinants of the change from one year to another. Buildings

(SCREEN 6)

Building Sample		Control for		Function of		Indicator menu
ALL	NW	SIZE	Quality	Size	Quality	X :PRTAF
Hq	NE	ICost	OCost	ICost	OCost	Y :BOCGF
Ofc	SW	Age	Period	Age	PERIOD	Z :
Lab	SE	Popul	Location	Popul	Location	P :
Site	Blg					Default



For ALL buildings 30K to + (sf) completed 78 to 83 (y)

Find building X

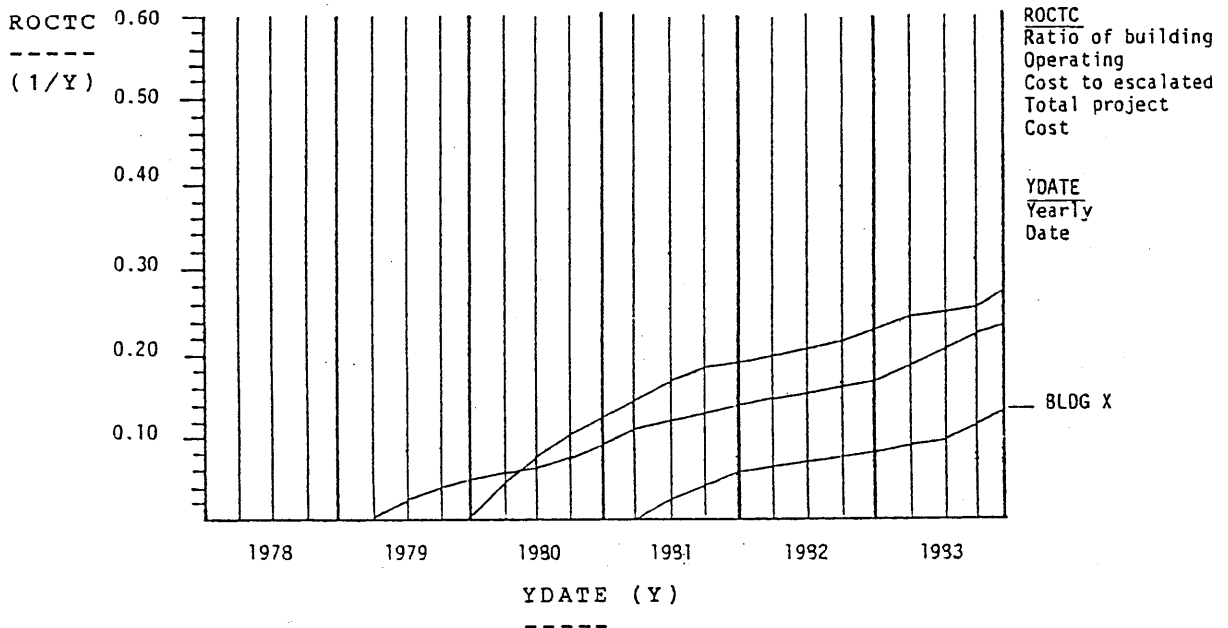
85 % of sample about the MEDIAN

Analysis options

Analyze Compare Correlate Regress Fit Profile Quit

(SCREEN 7)

Building Sample		Control for		Function of		Indicator menu
All	NW	SIZE	Quality	Size	Quality	X :YDATE
Hq	NE	ICost	OCost	ICost	OCost	Y :ROCTC
Ofc	SW	Age	Period	Age	PERIOD	Z :
LAB	SE	Popul	Location	Popul	Location	P :
Site 09 Blg__						Default



For S09 buildings 20K to 500k (sf) completed 78 to + (y)

Find building x

 % of sample about the

Analysis options

Analyze Compare Correlate Regress Fit Profile Quit

which are more energy efficient would tend to have a more regular graph, while those which use a lot of energy would be more subject to fluctuations.

The graph of building "x" is shown as sloping very sharply up during 1982, leveling off during the first two quarters of 1983 and then sloping up again.

It is reasonable to expect that operating costs will vary depending on the age of the building. Thus, rather than comparing costs per calendar year, it might be more revealing to compare the cost for each year in the buildings' lives. The set-up would be:

(SCREEN 8)

Sample: Same as above.

Independent variable: BLOPY
Building operating period, in years.

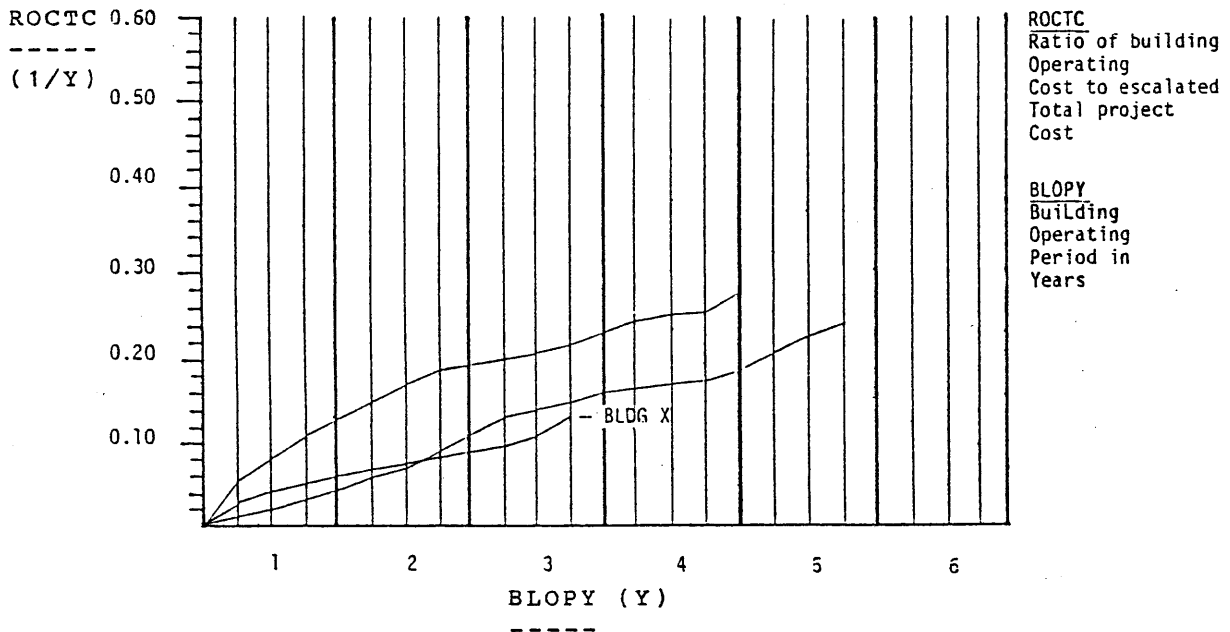
Dependent variable: ROCTC
Ratio of building operating cost to escalated total project cost.

In this case the lines all start from a common origin, making it easier to identify relative differences. Building "x" cost during the first year is not the highest, but during the second and third year it shows a clear rising trend in relation to the other two buildings. Its graph also exhibits more fluctuations. This could be an indication of problems. The building's systems may not be operating smoothly, or there may be a lot of non-routine maintenance. It could also be a reflection of the fact that activities in the building have yet to normalize. Moving into the building may have been slow, thus reducing the cost of operation during the first year. New functions may have moved in at year two, accounting for the rise in operating cost at this time.

Although the numbers are fictitious, they are an example of the use of the indicators to inform issues about initial versus operating cost in both the project planning and operation phases.

(SCREEN 8)

Building Sample		Control for		Function of		Indicator menu
All	NW	SIZE	Quality	Size	Quality	X :BLOPY
Hq	NE	ICost	OCost	ICost	OCost	Y :ROCTC
Ofc	SW	Age	PERIOD	AGE	Period	Z :
LAB	SE	Popul	Location	Popul	Location	P :
Site 09 Bldg__						Default



For S09 buildings 20K to 500k (sf) completed 78 to + (y)

Find building X

___ % of sample about the ___

Analysis options

Analyze Compare Correlate Regress Fit Profile Quit

EXAMPLE 3

What is the relationship between the relative cost of professional services and user satisfaction?

In this example the intent is to illustrate how the indicator system might be used to identify the correlation between economic and a non-economic dimension of building performance.

It is safe to assume that the quality of a building is connected to the amount of care, time and effort spent by those who participate in its design and supervise its construction. What is not clear is to what extent these two might be correlated. The issue becomes even more interesting in the context of the trade-offs involved. Given a limited budget, money spent in professional services is not available for other requirements of the projects. Professional services are, nevertheless, a relatively small fraction of the total cost of a building -- especially if the operating costs are taken into consideration. In terms of initial costs, professional charges may range anywhere from five to fifteen percent or more. To what extent is it advisable to raise these ratios? Can the C/RE Group draw some lessons from its own experience? In order to approach these questions assume that a measure of user satisfaction were available for a large number of buildings. This would have been collected through the use of 1-5 scaled surveys distributed to the users in the building. These numbers could then be correlated with the ratio of professional charges to initial project cost for each case. The set-up would be:

(SCREEN 9)

Sample: All buildings 50,000 sf and above completed during 1975 and 1983.

Independent variable: AECAT

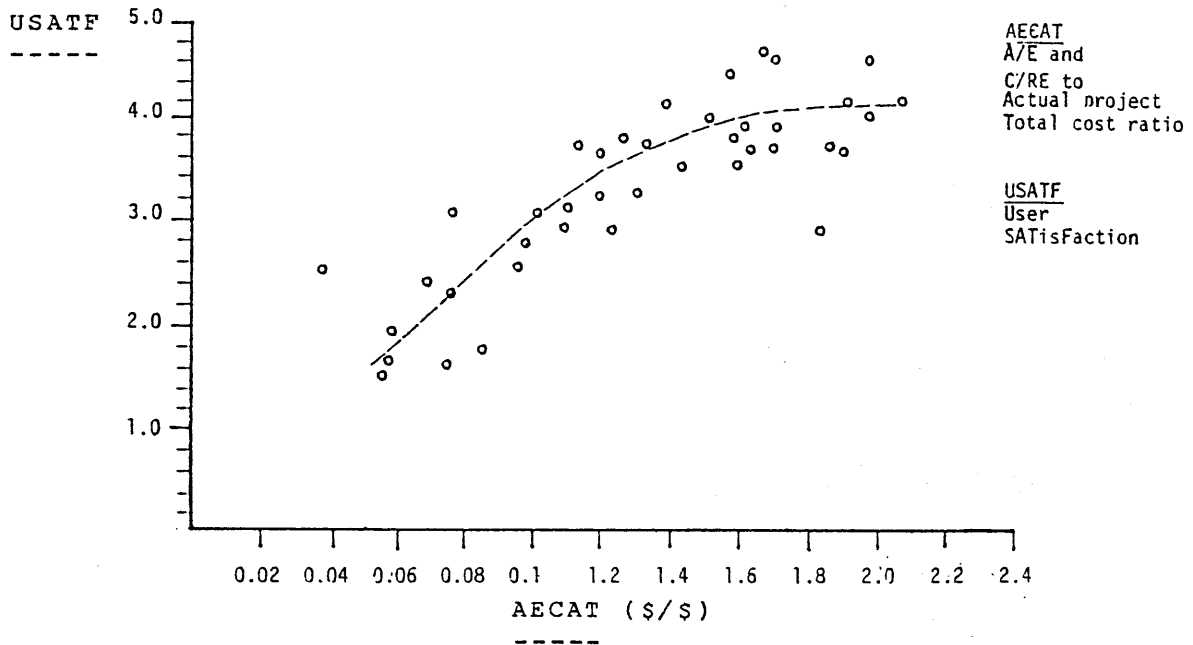
A/E and C/RE charges as a ratio of total project cost

Dependent variable: USATF

Measured on a one to five scale of ascending satisfaction.

(SCREEN 9)

Building Sample	Control for	Function of	Indicator menu
ALL	NW	SIZE Quality	X :AECAT
Hq	NE	ICost OCost	Y :USATF
Ofc	SW	Age PERIOD	Z :
Lab	SE	Popul Location	P :
Site	Blg__		Default



For ALL buildings 50K to + (sf) completed 75 to 83 (y)

Find building _____

90% of sample about the MEDIAN

Analysis options

Analyze Compare Correlate Regress Fit Profile Quit

Appendix Two-B

A graph with the shape as the one here presented would confirm the assertion that a direct positive correlation exists between the two variables. But, the points resulting from each pair of values tend to form a fairly "fussy" cloud. A higher proportion of professional services may be a contributing factor to user satisfaction but it is not in itself a sufficient condition. Also, notice how in the higher range of the independent variable the shape of the curve begins to level off. Additional increases in professional services have diminishing marginal effect on user satisfaction. The graph also shows a number of outliers in this region. For these cases, the high ratio of professional services may be a result of special difficulties encountered in the project.

It may be possible to get a different degree of correlation by controlling the sample make-up; for example: eliminating from the analysis projects that were specially problematic, restricting the size of projects in the sample, breaking up the sample according to the characteristics of the contracting arrangement used in the project (i.e. fast-tracking, design built, etc.), breaking up the sample according to the C/RE team managing the project, and so on.

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