PROGRAMING THE BUILT ENVIRONMENT:

THE BEC APPROACH

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Abstract

A system is defined whereby it becomes necessary - in order to ensure satisfactory functional performance in a facility - for the designer to have an understanding of the potential ways in which the facility will be asked to perform at occupancy as well as in the future. The designer must have at his disposal a complete description of the users' requirements; in other words - problem definition. Built Environment Co-ordinators Limited (BEC) specializes in project co-ordination using the systems approach in the planning of facilities. The BEC team includes architects and engineers, combined with construction and management specialists in a totally integrated operation.

Introduction

The following paper describes an approach to facilities programing which has evolved through five years of self-conscious applications in the field. Hopefully, this evolution will never be complete, as the cycle of application and redesign of the process is regarded as necessarily an open system. Techniques, as well as the approach itself, are consciously tested with each application to a real problem. Thus, the methodology described below represents only how far we have progressed at the time this is being written.

Fundamental to the BEC approach are the following principles:

1) The creation of a humane man-made environment sympathetic to man's needs and equal to his technological abilities requires a precise evaluation of the problem before attempting the just economical solution.

2) Once built, a building becomes an environmental conditioning agent for its users. This group <u>depends</u> upon the building which it inhabits. Therefore, buildings should be planned and designed with the potential of behaving in ways which satisfy the needs of their users. In order to understand the nature of these needs, it becomes important for the designer of the building to have a conceptual understanding of the building-related behaviour of the user group.

3) Our present world view allows us to regard both man-made artifacts and social organisms as systems. Thus, a building (artifact) and the users of a building (social organism) are recognized as being inter-dependent parts of an organized whole. The built environment, in terms of this paper, is understood to be the system which is composed of the sub-system "building" and the sub-system "user", existing within their environmental context. The definition of the attributes and boundaries of the system known as the "built environment" is dependent upon the needs of the individual member of the user group, as well as the needs of the group itself over the life span of the building. The user is the primary element. The capital facility available to him is only a secondary element.

4) With the continuing acceleration of growth and change rates within all sectors of our society, the time problem in architecture is becoming increasingly relevant. Buildings conceived as static expressions of a need which existed at one point in time, rarely succeed in satisfactorily meeting the needs of successive users throughout their life histories (up to 50 years) without significant investment in time and money to accomplish a virtual metamorphosis of substance and organization. This problem becomes more acute when the needs of the users are highly specific and technologically dependent as, for example, in the case of laboratory buildings.

5) Facility programing is not just a prerequisite for good design. It functions as a co-ordinating element throughout the duration of the project, providing a reference by which the designer can measure the success of his solution throughout design and working drawing stages. Similarly, a facility program can serve as an "owner's manual" to aid the user in his continual replanning of the building during its life span.

The Problems to be Solved

There are two basic problems in facility planning:

1) The problem of planning and design of particular buildings now which function adequately in the future; i.e. for the life of the building.
2) The problem of providing for the detailed, specific environmental requirements of the particular initial users of the facility.

The first problem usually constitutes the first phase of the total problem definition; the second problem, the second phase.

The First Phase: The Time Problem in Architecture

In the past, architects have simply treated the time problem as the need to provide physically long-lasting structures. This was justified in an age which saw little change in user needs for a particular building during its lifetime. Buildings were designed with a generous allotment of space for activities. Also, the fact that less mechanical devices were involved meant that functional or technological obsolescence was not a serious problem. On the whole, buildings managed to successfully live out their natural life span.

Today, however, buildings are designed to space standards which provide less space per activity. In addition, as standards of service provision in buildings continue to rise, increasingly complex and specialized equipment is being developed and placed on the market. Often, in order to achieve "efficiency", architects are designing buildings which are tailor-made for particular functions. Unfortunately, those functions often change before construction of the building is complete.

Increasingly, the problem has become that of sheltering an organization which has a rate of growth and change so great that it makes its buildings obsolete before they decay naturally[1]. Thus, the useful life span of some types of buildings is growing shorter and more wasteful. In order to overcome this tendency, consideration must now be given to the creation of buildings which are adaptable in ways which increase this useful life span.

The perception of buildings as changeable environments poses a challenge for the person involved in the definition of the organization and substance of those buildings. The dilemma is obvious, for once a building has been designed to overcome gravity and the local fire code, it is already a substantial structure with long-lasting immovable elements, thus creating a long term environment for short term uses.

It becomes one of the programmer's tasks to identify those characteristics of the building's required performance which can be considered to be permanent and those which can be considered to be temporary.

The following factors influence this permanence:

1) The rate and type of change in the user organization's needs
2) Space quality and quantity standards adopted for the building
3) The amount and type of mechanical equipment in the building
4) The degree of customization required in the building, in both spaces and services
5) The rate and type of change in the environment in which the building exists
6) Built-in mechanisms for updating the building.

The basic departure point for planning a time-sensitive building is that the components of a building undergo differential obsolescence. As Helmut

Schulitz points out:

> The difference between the average life span of buildings (40-60 years) and the life cycles of building components (4-100 years) shows how uneconomical it has been to construct buildings as fixed entities, where obsolescence of the whole package depends upon the most short-lived component[2].

In order to accommodate the variability and adaptability required for the long term success of a building, the spaces within the building can be defined as either multi-strategic or specific (see Figure 1).

A multi-strategic space has built-in potential for a specific range of accommodations. Usually, however, a multi-strategic space can satisfactorily accommodate only one particular activity at any one time. (This is in contrast to the multi-purpose space which is designed as a complete statement of the generalized needs of a range of activities.) A multi-strategic space is not complete at any one time in that it has the potential to become something else; i.e. it is evolutionary. As multi-strategic spaces tend to accommodate activities within their generic descriptions, they are also referred to as generic spaces.

Specific spaces can be divided into two groups: specific spaces with permanent functions, and specific spaces with temporary functions. The former category includes lobbies, washrooms, mechanical rooms, elevators, and stair towers. These spaces are not likely to change. However, as a number of these spaces are dependent upon mechanical equipment, they are susceptible to obsolescence through technical innovation. The second type of specific space is the space which requires a specialized environment in order to adequately accommodate its intended uses. These uses are not permanent. Examples of this type of space are special laboratory areas and special storage areas. Generally, these space components are dependent upon technology and techniques and, as such, are subject to rapid obsolescence. Specific spaces with temporary functions are difficult to update simply through rearrangement. Usually, a renovation or replacement of systems serving this space is required. The specific space with a permanent function generally requires major replacement of its contents and servicing.

In order to deal with the indeterminate level of building-related growth and change of users' needs, a process of ongoing planning may be necessary. Such planning addresses itself to the problem of adjusting an existing building to changing user needs, or changing environmental needs during the lifetime of the facility. This process is homeostatic.

Ongoing planning maintains the quality of architectural accommodation for user needs through constant adjustment to the organization and substance of the building. This process is not necessarily maintained by the professional planner or designer. (For example, changes such as furniture rearrangement usually only involve the user.) However, as ongoing planning can only function in ways which have not been ruled out by the initial planner of the building, and as the long term success of a building depends upon ongoing planning, all aspects of this planning should be the concern of the initial programmer and designer.

The Second Phase: Detailed Performance Criteria

The second level of the problem - providing for the specific environmental requirements of the particular group using the building at move-in time - is closely related to the first level of the problem; i.e. they are inter-dependent.

The description of the necessary long term attributes of the proposed facility emerges from a detailed understanding of the immediate needs of the users, combined with an understanding of the probable ways in which the facility might be used in the future. The second phase document contains detailed descriptions of the following:

1) Activities to be performed, including operation, operator(s) and equipment
2) Interrelationships of all activities
3) Performance criteria for the environment and its controls required for each activity
4) Performance criteria for physical enclosure required for each activity area
5) Provisional equipment and furniture schedules related to total program of activities
6) Special provisions for equipment and fitments specifically related to complex activities
7) Service requirements for all activities particularly related to site selection.

In addition, the following information concerning the context of the problem is often included:

1) A time schedule for the project related to the users' needs
2) A detailed budget related to each activity item in the program and the time schedule
3) A report on pertinent legal implications for development of the project.

The primary purpose of the second phase document is to give the architect and/or engineers all information required for detailed design development of the project.

The Generic Activity Concept

In order to determine the physical attributes of multi-strategic space, it is useful to regard the potential activities only by their generic description. This focuses our attention upon essential, rather than elaborative, criteria.

Generally the basic functional characteristics of most operational or human activities do not change. The amount of activity (i.e. users, production) and equipment may change but the basic function is relatively static. By identifying the generic characteristics of each activity, it

GENERIC ACTIVITY	WORK WITH LARGE APPARATUS		BENCH WORK CHEMICAL & PHYSICAL		DESK ACTIVITY	
MULTI-STRATEGIC SPACE	INDUSTRIAL TYPE SPACE		LABORATORY TYPE SPACE		CLASSROOM/OFFICE TYPE SPACE	
SPACE SUB-TYPE	HEAVY	LIGHT	WET	DRY	OFFICE	CLASSRM
Min. Clear Height	20'	15'	10'	10'	9'	9'
Floor Loading	200lb/SF	150lb/SF	100lb/SF	100lb/SF	50 lb/SF	50 lb/SF
Min. Planning Module	30'x 30'	20'x 20'	10'x 10'	10'x 10'	5'x 5'	5'x 5'
Access (W x H)	20'x 15'	15'x 15'	6'x 7'	6' x 7'	3'x 7'	3'x 7'
Lighting Levels	30 FC General + Task Lighting		50 FC General + Task Lighting		50 FC General 80 FC Special	
Finishes	Durable Washable		Washable, Nondust Noncorrosive		Standard	
Acoustic	NC 45		NC 35		NC 25	
HVAC	Fresh Air Unit Heaters		Ducted System		Ducted System/ Convection Units	
Piped Services	HCW, Fire Protect. Air, Sewage		HCW, Fire Protect. Gas, Air, Vac, Sew		HCW, Fire Protect. Sewage	
Electrical	Max. 600V req'd		Max. 450V req'd		Max. 220V req'd	
Special Requirements	Hydraulic Power Sump Pits		Special Filtration Fumehoods		Audio-Visual/ Computer Lines	

FIGURE I Example of Multi-Strategic Space Criteria

is possible to determine the most stable relationships. This ensures that activities are inter- and intra-grouped in the most functional manner. Separation required for administration purposes (identification of operational expenditures) can be ascertained and provided for within the flexibility range.

As the concept of "generic" space develops, the phase one document can serve as the description of the type of spaces required in the proposed facility without going into the detailed, particular needs of each activity.

Note: The development of the generic space descriptions should not occur until enough relevant data has been gathered to establish the full range of activities, including categorizing detail.

Methodology

The basic steps in programing are:

1) Problem recognition
2) Problem definition (conceptual)
3) Creation of research strategy
4) Selection of data gathering techniques
5) Data gathering and analysis activity
6) Translation of information into usable form
7) Development of conceptual models (level one problem)
8) Development of detailed performance criteria (level two problem)
9) Evaluation of appropriateness of uses of research findings by designers
10) Review of process.

The implementation of the above steps requires a carefully controlled procedure. The objective of this procedure is a series of sequential developments which necessitate a continuous test of feasibility and review of accuracy for approval by the users. A typical sequence is set out below:

1) Briefing meetings with key senior personnel to introduce the programing concept and to determine a policy framework for interviews.

2) Review of existing documents to determine completeness and deficiencies of information.

3) Development of an overall study schedule to co-ordinate all parties involved in study work.

4) Preparation of user interview list for approval of senior personnel (management).

5) Review and summary of applicable standards for use during interviews.

6) Direct interviews with the person most familiar with the activity.

7) Submission of draft interview reports (preliminary data sheets) to the relevant user within 48 hours for their approval.

8) Summary of users' needs, with growth projections and preparation of supplemental data.

9) Submission of data for management review.

10) Preparation of activity relationship diagrams.

11) Preparation of complex relationship diagrams.

12) Submission of diagrams to senior users and management for approval.

13) Evaluation of site requirements relative to codes, by-laws and relevant requirements of the local area.

14) Investigation of civic requirements regarding services and utilities.

15) Summary report on site requirements and submission to relevant authorities for review and general approval.

16) Analysis of the relationship of the users' requirements and site requirements.

17) Preparation of master relationship diagram to show interrelationships.

18) Investigation of possible directions and development of series of models to show potential, including operating aspects (maintenance, security, etc.)

19) Review of models with management to determine preferred model.

20) Development of preferred model and preparation of master relationship diagram to show final relationships.

21) Review of proposed model with management level for general approval of nature, organization and scale (personnel and facility).

22) Complete cost and schedule analysis of preferred model.

23) Review of cost and schedule implication with management for approval of model.

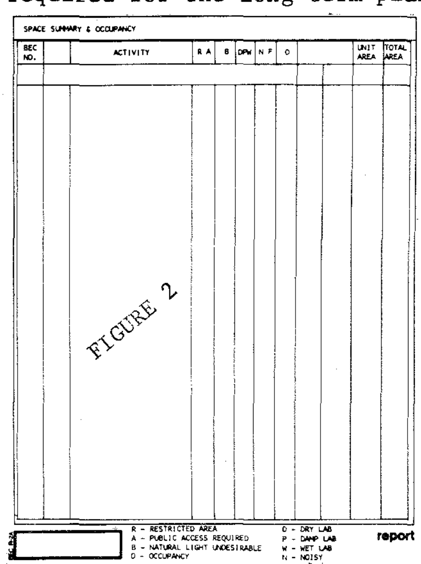
24) Preparation of complete summary study documents.

THE SYSTEM

The following survey forms and data sheets illustrate a typical procedure employed in the programing methodology described above. Only a sample of the forms developed by BEC are represented here as each application requires some modifications in the system. Checklists and project control documents are not included.

Phase One Documents

These forms are employed in the description of the generic activity data required for the long term planning of the facility.


SPACE SUMMARY & OCCUPANCY

BEC NO.		ACTIVITY	R A	B	DPW	N F	O			UNIT AREA	TOTAL AREA

FIGURE 2

R - RESTRICTED AREA
A - PUBLIC ACCESS REQUIRED
B - NATURAL LIGHT UNDESIRABLE
O - OCCUPANCY
D - DRY LAB
P - DAMP LAB
W - WET LAB
N - NOISY

report

Space Summary Form (see Figure 2)

This section of the program summarizes generic space information. It indexes all physical activities identified by the users and categorizes them according to generic activities. This information allows the designer to appreciate the nature and distribution of the spaces required in the new facility.

Data sheets for each activity listed on the Space Summary form are contained in the final section of the report. These data sheets give specific detailed information for each activity including equipment and services (see Figure 4).

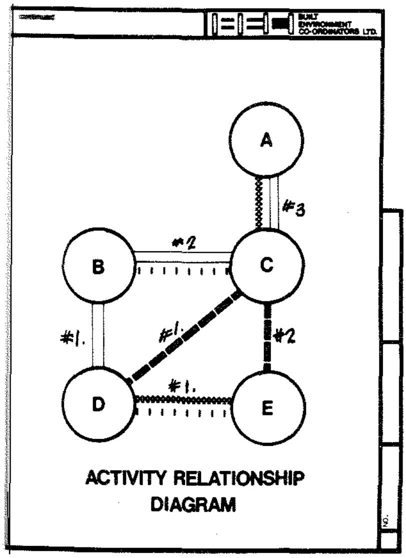


FIGURE 3

<u>Relationship Diagram</u> (see Figure 3)

These relationship diagrams are specifically intended to tie the series of individual activities together and establish the inter-connection patterns both vertically and horizontally which should predetermine the three-dimensional volume of the building.

Three types of relationships - plus a non-relationship - have been determined to date. These include the following:

Relationships:
1. pedestrian movement patterns
2. equipment movement patterns
3. services and utilities distribution patterns

Non-Relationships:
1. incompatibility
2. interference aspects
3. growth considerations.

All relationships are evaluated to determine a level of priority.

Pedestrian — individual

group

Pedestrian movement patterns can be evaluated according to the following:

1) Priority #1 - 30' horizontal movement or 15 seconds travel time
2) Priority #2 - 50' horizontal movement or 30 seconds travel time
 - 1 floor vertical movement or 30 second travel time
3) Priority #3 - horizontal or vertical movement - 60 seconds travel time.

Equipment

The nature of equipment being moved to or out of the activity area should be clearly identified, and the nature and size of access points.

Services/Utilities

The type, location, size and form of utility or service connection between activities must be clearly established where operational characteristics of the activity may be affected.

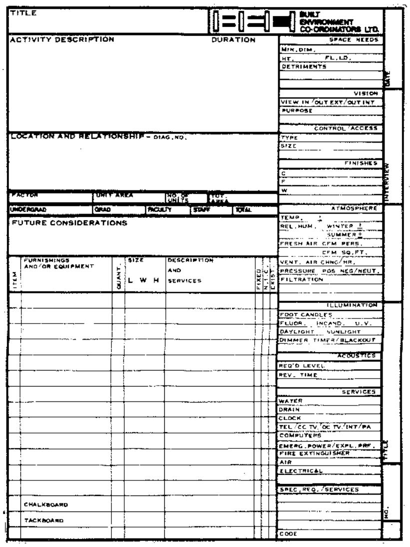


FIGURE 4

Activity Data Sheet (see Figure 4)

These data sheets cover all special information required to describe the individual activity including space, services, and atmospheric requirements.

"Activity Description"

This space briefly describes the character of the operations and, if possible, the step-by-step procedure and time (daily) involved. If someone has to sit for three hours in one place in comparison to fifteen minutes, the visual environment will have different requirements.

"Location and Relationship"

Other areas or operations (special equipment) which would be most conveniently located adjacent to or nearby this activity are indicated. These other areas may be part of some other administrative grouping.

"Personnel"

The number of persons shown on the activity data sheet is the typical number of occupants. This may mean that because one person spends part of each hour in several rooms with other personnel, the total number of bodies listed will exceed the actual number of personnel.

"Future Considerations"

Probable growth and change in the activity is projected for five years hence, wherever possible.

"Furnishings and Equipment"

Major items which require special services, are heavy, require special environmental conditions, or take up floor area are listed. Future requirements, as well as present, are listed.

Right Hand Side of Form

The various items listed here (such as "Space Needs") are marked "standard" if requirements are normal. If the requirements are special, then appropriate data is recorded.

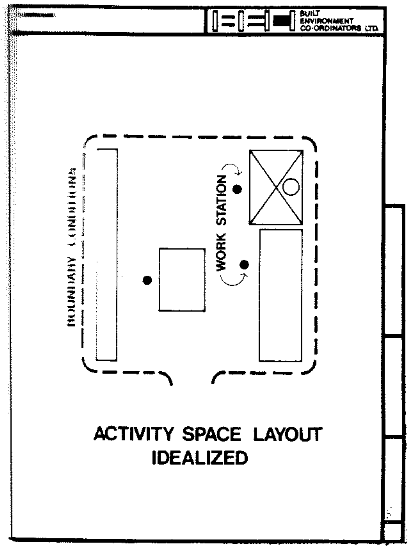


FIGURE 5

Activity Space Layouts (see Figure 5)

Idealized layouts pertain only to formalized activities involving fixed arrangements of equipment or fixed internal operational procedures (such as that involved in preparing a sample using several pieces of equipment). The preparation of the idealized layout pertains only to the movement patterns, maintenance, clearance spaces, etc. required for the formalized operation. Idealized layouts are employed in the description of specific spaces.

Prototypical layouts are intended as a guide to the architect showing a preferred layout for a particular type of generic operation such as a research chemistry laboratory, or undergraduate chemistry laboratory for a certain number of students. The prototypical layout describes the multi-strategic space.

Boundaries

As a result of the analysis of the activities documented on the data sheet (see Figure 4), a minimal area with a critical dimension in one direction can be determined for each activity. This establishes boundaries for the space required for the activity.

One should always avoid the unconscious practice of equating an "activity" with a room. The major concern of the users is identification of boundary conditions (i.e. electrical shielding, acoustic separation, vibration isolation) and the identification of relationships (i.e. pedestrian/equipment movement and service utility connections).

Controls

The environment required for an activity may determine the controls which must be established at the boundary of the activity area. This could include acoustic separation, electrical shielding, or atmospheric control systems. The programmer establishes a performance specification for the enclosure of the activity at its boundary. Where an activity is the source of a potentially detrimental environmental condition, the condition is usually contained at the source.

Floor Area

In order to develop a realistic floor area for each activity space, it is important to review the idealized floor layout with the individual user. This floor layout should be developed by reviewing the actual activity and documenting it on the data sheet. The idealized layout is developed by looking at each item of equipment and its relationship to other items of equipment, thus generating the following information:

1) Major items of equipment and floor area required
2) Exact relationships, clearances of major items of equipment
3) Work areas adjacent to various pieces of equipment
4) Maintenance areas related to each piece of equipment
5) Material feed areas, etc. related to each piece of equipment
6) Location and floor area of support equipment, tables, desks, chairs, vacuum racks in relation to major equipment
7) Pedestrian movement in and around equipment, clearances, etc.
8) Movement of mobile equipment
9) Logical point of pedestrian access to equipment area
10) Logical access point for equipment delivery and removal
11) Access point of all utility/service/material supply connections to equipment or activity area.

The resulting layout may be an irregular shaped form. Generally, when the idealized layout is complete, minimal dimensions can be determined in either direction. If an activity does not require a room all to itself, this is clearly indicated.

Note: In preparing the idealized layout for phase one, no attempt is made to identify nature, size and exact location of electrical or service connections, floor loading locations, structural or structure support connections or details of the equipment itself. This information can be readily left until a later date. Similarly, no attempt is made to generate the detailed equipment list for bench-mounted equipment. This occurs in phase two.

Phase Two Documents

The information contained in the phase one document is expanded in phase two to include greater detail regarding the needs of specific activities of the initial users of the facility. The following data sheets are added to the system:

Equipment Inventory Sheet (see Figure 6)

This sheet is used for long lists of specialized equipment which will require specialized facilities for housing. It is also set up to permit the preparation of preliminary budget analysis. Generally, it covers the three basic types of furniture, which are:

1) Heavy equipment: built-in, with major services such as autoclaves
2) General scientific equipment: bench-mounted or moveable, requiring special services
3) Miscellaneous (non-scientific or technical) furniture.

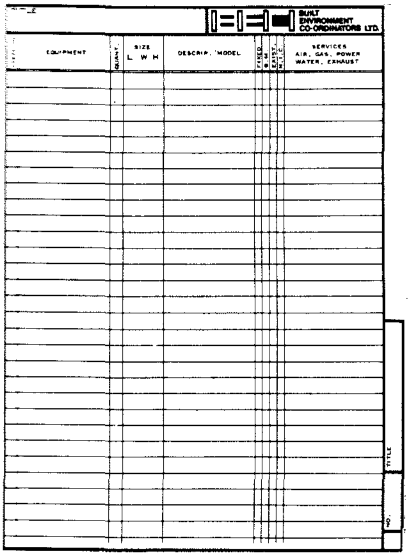


FIGURE 6

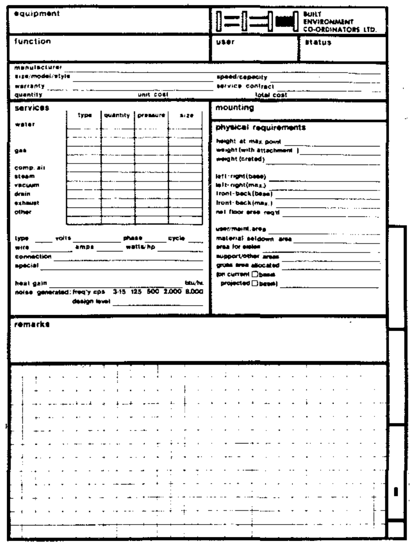


FIGURE 7

Equipment Data Sheet (see Figure 7)

For each individual major piece of equipment a separate data sheet is prepared setting out all physical criteria, service requirements, and idealized layout conditions, plus budget and manufacturer information.

Phase Two Appendices

In addition to the above, the following appendices are often included:

1) A master project schedule which can later be developed into a CPM diagram
2) A total project budget including individual equipment items
3) Heat gain summaries
4) Electrical load summaries
5) Plumbing load summaries
6) Special structural conditions
7) Program recapitulation (space allocation and changes)
8) Gross area calculations
9) Legal and code restriction summaries
10) Bibliography.

Conclusion

Architects, in spite of good intentions, have not been completely successful in satisfying all of the building industry. This lack of success is based on two problems. The first is a traditional disinterest in schedules, budgets and management matters. Generally (and perhaps unfortunately) architects have been interested primarily in the design of fine buildings with an aversion to more materialistic matters such as business. The second problem involves receiving instructions from a client relative to the provision of architectural services. Too often, the brief to the architect is just that - "brief". If it isn't brief, it is usually the opposite: five or six inches of program documents incorporating great redundancy and verbosity in language which is least convenient to the architect.

BEC has attempted to contribute to the resolution of some of these problems. We feel that the architect is the professional in the building industry who is theoretically trained to co-ordinate the efforts of all the members of the building industry team. The position of co-ordinator entails serious responsibilities which the majority of the architectural profession has hesitated to undertake in the past. We think it obvious with the changes that are occurring today that this responsibility is now being recognized and accepted. Accordingly, in order to assist, we have sought and developed the expertise set out above in problem definition (predesign) and management expertise.

Notes

[1]Weeks, J., Indeterminate Architecture
Trans. of the Bartlett Soc. (London, Vol. 2, 1963-4)

[2]Schulitz, H.C., Structure for Change and Growth
Architectural Forum (March 1971, p. 60)