DOCUMENT RESUME

ED 044 796 EA 003 149

AUTHOR Broadbent, Geoffrey
TITLE Systems and Environmental Design.
PUB DATE Oct 70
NOTE 12p.; Paper presented at Environmental Design Research Association Conference (Pittsburgh, Pennsylvania, October 28-30 1970)

EDRS PRICE EDRS Price MF-$0.25 HC-$0.70
DESCRIPTORS Building Design, *Design, *Design Needs, *Environment, Environmental Technicians, Glossaries, Human Living, *Systems Approach, *Systems Concepts

ABSTRACT

Design, which is basically a decisionmaking process, requires certain information. Although the nature and quantity of information needed vary greatly from task to task, the designer could be greatly assisted if some means were devised to help him decide which information is essential for his particular task. In the design of buildings, the architect requires not only the basic data concerning building technology, but also information about the cultural and physical contexts of the structure, the objectives of the client, and the requirements of the users. The union of these data constitutes the Environmental Design Process, and is an application of general systems theory to architectural design. Systems approaches appear to provide the best method of incorporating information from diverse fields into building design to create a structure that is aesthetically and functionally rewarding. (Document may reproduce poorly in hard copy because of marginal legibility.) (RA)

1970 ENVIRONMENTAL DESIGN RESEARCH ASSOCIATION CONFERENCE

Pittsburgh: October 28/30

Systems and Environmental Design

Paper by Geoffrey Broadbent
Head of the Portsmouth School of Architecture, England.

Abstract

The paper opens with a discussion of design processes for general application and questions their viability with reference to differences in the range and complexity of information required for designing in different fields. It refers to the author's Environmental Design Process as an attempt to control the flow of information into architectural design and suggests that this is a special case of a more general structure within which all the factors relevant to the design of buildings can be plotted systemically. The nature, difficulties and advantages of systems thinking in general are discussed and the paper concludes with reference to systems applications in the architectural education programme at Portsmouth.

Introduction

The first ten years or so of design method studies have been concerned largely with the identification and description of generalised procedures which could be used by designers in different fields. That was a worthwhile aim, but for many reasons - some of which have been discussed at previous EDRA meetings - it seems unlikely now to be realised. Designers in different fields certainly will share common techniques - derived from operational research, systems analysis, cybernetics, information theory, creativity studies and so on, but the ways these are put together into coherent design processes probably will vary from field to field.

Information for the Designer

The nature, quantity and quality of the information required in design varies greatly from one field to another. Architecture and chemical engineering for instance, have much in common (see Gregory 1969). Both are concerned with more or less closed vessels within which environmental conditions have to be controlled and with means of transporting people and chemicals between these vessels. But whereas the same chemicals, in similar quantities, will behave consistently in the same environment, the architect knows that individuals will show quite different responses to the environment he designs. They will differ in physiological responses, not to mention the aesthetic and symbolic values which, whether he likes it or not, they bring to the perception of architecture.

Differences, arise then because range and complexity of the factors which have to be taken into account vary greatly from one field to the other. It is virtually impossible in any design field, but especially where "human" values have to be taken into account, to ensure that all the relevant factors have been considered, interrelated with others in the decision making process, and allowed to play their appropriate part in determining the final design.

So most design processes, as distinct from design techniques resolve themselves into attempts to control this flow of information, on the twin assumptions that if the designer has too little information, then his decisions will be inadequate, whilst if he has too much, then he may have the greatest difficulty in actually reaching a decision. Some design theorists (e.g. Alexander 1969) assume that given the same problem, all designers, eventually, will collect the same information, knowing intuitively when to stop. Others, such as Drucker (1955), in the field of management, suggest that no decision-maker ever can have all the information which theoretically he needs, that his skill, in fact, lies essentially in making viable decisions on the basis of incomplete information. Others again, such as Jones (1969) have written of the "information explosion" which afflicts the designer whose enthusiasm for "briefing" leads him to pursue every piece of data to its logical conclusion, whilst government agencies, research institutions and the technical press in many countries, provide the raw material for such an explosion by their unremitting production of reports, analyses, working papers, statutory constraints, design check lists, and so on. Best (1969) has analysed three contrasting design processes in terms of information flow - Alexander's, Aalto's and a student's of design method, concluding that in each case, and in different ways, the designer had to effect a homomorphic reduction of the information available before he could cope with it in his designing. Needless to say, the chosen process of reduction itself affected considerably the nature of the final design.

Clearly it will help the designer if some means can be found of helping him decide what information is essential to his task, thus helping him collect precisely what he needs, but at the same time protecting him from the information explosion. A simple check list will not be enough. He needs a rather more comprehensive structure which also tells him what to do with the information he has collected. The Environmental Design Process, which I described to the Portsmouth Symposium of 1967, was intended to be just that, and whilst it has been described in detail elsewhere (Broadbent 1969); the premisses on which it was based are relevant here.

Environmental Design Process

It is based, as one might expect, on a series of assumptions, deriving in this case from the historic origins of architecture as described by Clarke (1952), Mongait (1961) and others in the mammoth hunters' tent and other primitive forms of dwelling. Invariably when man started to build, he put the available materials together to form a shelter, in such a way that the indigenous climate at a particular (and inhospitable) place was modified, thus providing internally conditions within which human activities could be carried out conveniently and in comfort. I assume that architecture still possesses this primary function, although the concept of climate may be extended to include social, political, economic, cultural and aesthetic climates, in addition to the physical one, whilst the notion of comfort may be broadened to include other forms of sensory stimulus; certain activities will need a "stimulating" environment. In order to design a building, therefore, one needs three kinds of information; concerning the pattern of activities which it is to house, the available site, and its indigenous climates, and the technology of building available for reconciling the two.

The process goes on to describe how this information can be used in the design of buildings and with certain modifications that has been used quite extensively in architectural education. It allows inexperienced students to design buildings well, because among other things, it forces them to consider interaction between the various kinds of information available to the building designer. But that also suggests a possible limitation; it is directed specifically towards the design of buildings, on particular sites, according to particular sets of functional requirements, so that it may result in a fit between building and activities which is so close that changes in use become difficult. It is intended to lead also towards physical solutions, in terms of built form - and is unlikely therefore, to result in a new pattern of organisation, a vehicle of some kind, a life-support package or some other non-building solution.

These limitations led to the search for a more generalised approach - keeping strictly within the field of environmental design. Markus (1969) suggested the basis for such an approach in the structure for building appraisals which he described to the Portsmouth Symposium, against which certain aspects of the building fabric, and of human demands on that fabric, are plotted in terms of four "systems"; the building system, the environment system, the activity/behaviour system and organisation objectives. This classification is extremely useful, within its defined limits, because it deals in the interactions between different classes of factors, but it leaves out any references to the site, adjacent buildings, climate, and so on, into which the building may be placed, on the grounds that by definition any "system" operates within an "environment" and that the latter therefore needs no further description. There are certain advantages, however, in describing this physical environment so that the pressures it imposes on the building's design can be taken into account. They can be subsumed overall within an environmental system. Interactions between people - the client's requirements, the users' needs (physical, social and psychological), can be taken to form a human system. The architect's task, then hinges on the design of a building system which will reconcile and interrelate the two. The overall pattern of interrelations between these three systems then can be plotted on a chart (Chart 1).

This chart could be expanded in many ways. Certainly we should analyse each system as Markus does, in cost/benefit terms, and one could elaborate each of the systems further, not to mention the subsystems within them. But before we do this we should test each addition against a simple question: "Does this

CHART I - INTERRELATIONS IN BUILDING DESIGN

ENVIRONMENT SYSTEM		BUILDING SYSTEM		HUMAN SYSTEM	
CULTURAL CONTEXT	PHYSICAL CONTEXT	BUILDING TECHNOLOGY	INTERNAL AMBIENCE	USER REQUIREMENTS	CLIENT OBJECTIVES
	The site as given in terms of:	Modifications of external environment to provide suitable ambience for specified activities by means of:	Provision of physical conditions for performance of activities in terms of:	Provide for specified activities in terms of the following needs:	Return for investment in terms of:
Social Political Economic Scientific Technological Historical Aesthetic Religious	Physical characteristics: climatic geological topographical	Available resources in terms of:- cash materials labour/equip.		Organic: hunger & thirst respiration elimination activity rest	Prestige Utility Provision for change Housing of particular activities so as to encourage user motivation. Security
	Other constraints: land use existing built forms traffic patterns legal	Structural systems mass planar frame	Structural mass visible surfaces space enclosed	Spatial: functional (inc.fittings) territorial	
		Space separating system: mass planar frame		Locational: static dynamic	
		Services system: environmental information transportation	Sensory environment lighting sound control heating/vent	Sensory: sight hearing heat & cold smell kinaesthetic equilibrium	
		Fittings system: furnishing equipment		Social: privacy contact	

(G H Broadbent, adapted from T L Markus: Building-Environment-Activity-Objectives model) new factor affect, in any way, the shape of a room, the size of a window, or any other aspect of the physical form of the building?" It is tempting, for instance, to add to the section on human needs further appetites, instincts, interests and ideals. But no human instinct, as far as I know, ever affected, say the shape of a window; such proliferations merely confuse the issue rather than clarifying it.

The chart will encourage us to do several things. It suggests, for instance, that the Environmental Design Process is only one way out of the many which are possible, of treating in sequence the various factors which must be considered in the design of a building. But provided that one covers all the factors eventually, and considers the interactions between them, the order in which one takes them is immaterial. It seems quite legitimate, for instance, to start with the building fabric system, moving later to the human and environmental systems; this has been the approach of much of so-called systems building.

Systems Approach

This concern for interactions between a multiplicity of factors has come to be known as a system approach, which tends to be confusing, because over the past ten years or so, the word "systems" has acquired quite different connotations for designers in different fields. In the United States it is associated largely with urban systems; problems of land use, locational analysis, transportation and so on are generalised in terms of mathematical models, so that individual cases can be subject to analysis by computer. We are familiar with this usage in the UK but we still use the word more often in the context of systems building. Another popular usage is concerned with information systems; generalised structures against which information can be classified - often for computer storage and retrieval - whilst there is a growing, if less specific interest, in the application of systems thinking to psychological and/or social issues.

Anyone who uses the word "systems", therefore, is liable to be misunderstood. Certainly it is a very flexible word; for which my Oxford dictionary suggests three major uses. In the first place, it refers to a complex whole consisting of interconnected things or parts, such as a planetary system; secondly it may be applied to a body of organised knowledge, such as the Hegelian, or some other system in philosophy, and thirdly, it may indicate a scheme of classification such as the UDC system, CI/SfB, a system of notation and so on. So, clearly the data structures use is legitimate - it matches the third definition, but one wonders to some extent about the urban systems and systems building approaches. It is a matter of what one means by wholes, parts and interconnections. Alexander discusses this usage in a very sensitive essay (1968) describing also the concept of "generating systems" - kits of parts, with the rules for using those parts, such as language, building systems, or even the genetic code.

A notable attempt to clarify, once and for all, the general concept of systems, is described in General Systems Theory (GST) by von Bertalanffy, who claims to have invented it, c. 1935 - 37.

> "Whilst in the past, science tried to explain observable phenomena by reducing them to an interplay of elementary units investigable independently of each other, conceptions appear in contemporary science that are concerned with what is somewhat vaguely termed "wholeness", i.e. problems of organisation phenomena not resolvable into local events, dynamic interactions manifest in the difference of behaviour of parts when isolated or in a higher configuration, etc., in short, "systems" of various orders not understandable by investigation of their respective parts in isolation." (von Bertalanffy 1955)

At this level of definition, GST may seem vague, inconsequential and tentative compared, say with cybernetics, which has a hard core of technological achievement to its credit. Both are concerned with the drawing of analogies between living organisms and machines - in both directions - but whereas cybernetics - according to Weiner (1947), is concerned specifically with the science of control and communication, GST takes a much broader view.

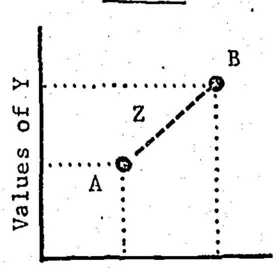
Von Bertalanffy claims that the feedback systems of cybernetics are merely a special case, however important, within the overall range of self-regulating systems which GST studies. Von Bertalanffy himself was concerned with the mechanisms by which a given embryo will develop into a particular kind of organism, with ways in which the organism grows to a particular size, maintains itself as a whole within a constantly changing environment, seeks out particularly goals in a purposeful way and so on. This involves a study of the ways in which information necessary for the organism's development is passed into it genetically and used to control that development.

Distinctions are drawn in general systems theory, between closed systems and open systems. The former might consist, say, of sealed vessels containing certain chemical processes. In time, such processes will reach a state of maximum entropy, a state of equilibrium in which no further reactions can take place. No energy is needed to maintain this state, nor will energy be released by it.

An open system, by contrast, will be open to its environment. Material will pass into, through and out of it and energy will be exchanged. But whilst this flow of material and/or energy will vary, according to the state of the environment (an animal may find itself without food for several days) the system as a whole will maintain itself in a state of near-equilibrium. GST has its own version of feed back, known as homeostasis. This concept was first described by Cannon (1939) who was concerned with the ways in which living organisms maintain themselves with reasonable constancy even though they interchange material and energy with the environment - they are "open" to it, whilst their bodily structures are inherently unstable, subject to constant growth, damage and repair. Homeostasis applies particularly to those mechanisms by which material and energy within the organism are maintained within rather fine limits affecting, say internal temperature, osmotic pressure, salt and other chemical concentrations in the blood, posture and so on. None of these remains entirely constant in the living organism which is why Cannon used the word homeostasis instead of equilibrium.

But we are still lacking in a rigorous definition of system; Angyal (1941) takes us some way towards this in considering the differences between a system and a relationship. A relationship, according to Angyal, needs only two members, between which relations can be established in terms of position, size, colour, shape or other observable factors. Compound relationships may also be formed in which A is related to B, B to C and so on. But they still do not form a system unless, overriding all these relationships there is a "whole" of some kind, within which the various elements are distributed and to which each participates by virtue of its position in the whole. For Angyal, a system is a distribution of members within a dimensional domain. The members are not significantly connected except with reference to the whole.

Fig. 1



The crucial differences between a relationship and a system are indicated in Fig.1. in which the linear relationship Z, between A and B, tells us nothing about their position in the system, whereas co-ordinates about X and Y enable us to locate them precisely within the whole.

It is clear then, that most uses of systems are concerned with wholes and with the ways in which a whole is greater than the sum of its parts. Such thinking was called "holistic" by J C Smuts (1961), biologist and one time premier of South Africa, who used this term because he believed that in living organisms at least, it stemmed from some kind of life-force. We may prefer "wholistic" as having fewer connotations of piety, but whatever we choose to call it, holism has its difficulties. Others, long before Smuts, had been concerned with wholes, Aristotle and Hegel, each had tried to establish a philosophy in which the whole of human knowledge would be inter-related in one vast system. Popper (1957) and others have criticised these aims on the grounds such wholes can never be the subject of scientific enquiry. He questions the possibility of considering even a limited concept like "society" in holistic terms. For if each part is related to every other, and some parts will be related to things outside that particular society, then before very long one will be concerned with the whole of human knowledge, which as one tries to encompass any part of it, is constantly changing in other directions. Clearly this is a serious hazard when systems thinking is applied in design; it is liable to trigger a further information explosion.

One further difficulty with systems is that they tend to be hierarchical. Weiss (1969) comments on the reasons for this. The brain, for instance, contains a vast number of cells, estimated at some 10^{15}; many of them die during the course of a lifetime, yet the nervous system continues to function systemically. That suggests an overriding pattern of organisation which, to survive change and decay must be hierarchical. The whole is more than the sum of its parts because of this organisation - if the pattern is disrupted, then the system ceases to work effectively.

This hierarchical view of systems - in which each component has its rightful place and must keep to that place - permeates all systems thinking. It is noticeable for instance, with increasing political concern for problems of conservation, pollution and so on, that the ecologists who have the public ear, want very much to confine man within the ecological niche they have determined for him. Nor is this sinister aspect of systems thinking particularly new. Oponents of the Nazis in Germany used to speak of Der System, a political structure in which everyone knew his place, and kept to that place if he wanted to stay out of trouble.

Reasons for Taking a Systemic View

If the concept of system is fraught with such dangers, why should we want to pursue it? The answer, for environmental design, is that most of design failures arise from our refusal to take a systemic view. Such failures do not worry the designer - he has an easier time of it when he takes a fragmented view of his task - but they do worry the user, who may suffer abominably when parts of the environment which the designer considered separately, begin to interact when the system is brought into use.

A simple example which Musgrove (1966), and I (1971) have discussed, concerns the laboratory experiments which were used to set up daylighting standards in British Schools (Weston 1962). Children were asked to read algebra texts, under laboratory conditions, where it was easy to set up a configuration in which subject and light source were arranged in specific physical relationships. Emission from the light source could be adjusted within very fine limits and the level of illumination at the working plane, or even on the book, could be measured very precisely. The subjects' performance, in terms of reading speed and accuracy could be measured at different levels of illumination, and furthermore, objective measurement could be supported by verbal statements. As a result of all this - and other experiments to establish standards to sky luminance - a daylight factor was devised which ensured that even in the worst case, each pupil could see 2% of the sky from his desk.

Yet to provide the daylight factor thus established, the whole of one wall in each classroom has to be glazed substantially to a height of ten feet. And because one environmental factor - daylighting - was considered in isolation, other problems arise. Heat loss, solar heat gain, glare, distraction, noise penetration and so on are all affected by window size, and this has lead to serious criticisms, by the users, of post-war British schools (Manning 1967).

Analogous problems seem to arise wherever the classical method of physics - the isolation and manipulation of a single variable - is applied to the investigation of man's relationship with his environment. Such experiments essentially are non-systemic.

Other problems arise whenever, say, decisions on a building's structure are made in isolation - without reference to the environmental control properties which different building materials may or may not possess. This accounts for the inherent deficiencies, in terms, of environmental quality of most light-and-dry building systems.

Even greater problems may arise when single aspects of the urban system are isolated and treated analytically. This is particularly true where transportation networks are designed without reference to the social and psychological problems which traffic noise, and other forms of environmental pollution will cause (Pahl 1968).

If we are to avoid this kind or problem, then we shall have to take a systemic view of design. The difficulty, as we have just seen, is that many studies which have the word systems in their title - such as urban systems and systems building, are essentially non-systemic. One truly systemic approach might be to think in cybernetic terms, observing in use the things we have designed, monitoring where they are going wrong and using the information thus obtained as feedback into a new design process. The RIBA Plan of Work (1965) envisages feedback of this kind (Markus calls it feed-forward) as the final stage of the design process. It is fairly common also to describe the whole design process in cybernetic terms, so that every decision is monitored, its effects observed and fed forward to form part of the information on which further decisions are based. Matchett uses such a feedback process in his course on Fundamental Design Method (1969) whilst Beer (1966) has outlined a cybernetic process for the design of a factory.

The intention is admirable, as far as it goes, but such processes, essentially, are concerned with the design of closed systems in the form of finite objects. GST suggests that an open system approach might be even more rewarding. One could then design for changes in use or, better still, design objects which monitor what the user is trying to do, and modify themselves accordingly. One envisages, say, a building consisting of open spaces, lightly enclosed. People arrive and start to do things; the building observes them, decides what they are trying to do and adjusts itself to fit their needs in terms of spatial enclosure, environmental conditions, equipment and so on. Much of this is feasible already from a technological point of view, and possibilities of this kind have prompted a wide-ranging interest in the School of Architecture at Portsmouth in systems thinking. We have looked at computer systems, control systems, cybernetics, eco-systems, general systems theory, information systems, language systems, psychological systems, social systems, systems analysis, systems building, systems engineering and urban systems, trying in each case to assess their relevance for environmental design education. These are all explained in the glossary, and some of them have proved already to be immensely valuable (Russell 1970).

The difficulty is that they tend to group themselves into "hard" applications and "soft" applications, which on the face of it, have very little in common. The former include computer systems, control systems, systems analysis, systems engineering and urban systems -all of which are thoroughly relevant to our courses in architectural technology. They tend to be concerned as one might expect, with the quantifiable aspects of design.

But some of our studies also tend to the "soft" end of the spectrum; this is true of ecology, perhaps the oldest systemic discipline of all, which used to be exclusively a matter of verbal description. Even now the relationships with which ecology is concerned tend to be so complex that mathematical models simply cannot be built for them.

It is not surprising therefore, that whilst the "hardliners" tend to dismiss such descriptive approaches as non-scientific, and essentially trivial the "softliners" reply quite rightly that, much "hardline" thinking as we have seen is essentially non-systemic. Yet both factions are concerned with describing reality in terms of analogies: one uses words, the other uses numbers. Echenique (1970) proposes a 3-dimensional system against which different kinds of model can be classified, and I have suggested elsewhere (Broadbent forthcoming) that all types of model - numerical, verbal, spatial representation and analogue - should be treated with equal respect. Each has its uses, and by demonstrating this within a structure such as Echenique's, it may be possible to effect a reconciliation between the "hardliners" and the "softliners". Certainly we find the full range is essential to a comprehensive design education.

Applications

Students in their undergraduate years at Portsmouth are introduced to a good many systems concepts, the fundamentals of information systems, energy transfer and movement systems, systems building, computing and quantitative methods, ecology, systematic design methods and urban systems. Much of what they are taught results from our exploration at post-graduate and research level and again, a good deal of this originates in a system point of view. We offer a series of options to post-graduate students, one of which, Integrated Building Services, applies certain aspects of systems engineering to the integration of services within the building as a whole.

We refuse to separate out computing, or even systems analysis, as separate disciplines on the grounds that these present a number of quantitative techniques which may, or may not, be useful in design. Our observation elsewhere suggests that where these are developed outside the context of designing, they tend to "take over" so that there is a progressive failure to solve real design problems. One sets up artificial problems instead because they are amenable to computer analysis, irrespective of whether anyone actually wants to solve such problems. Nevertheless, we have developed - within the context of designing - a number of programmes concerned with pattern generation, the evaluation of building designs using a simple building system, the location of activities within a two dimensional grid (in terms of "distance" and "interrelationship" measures) and various cluster routines. A space-co-ordinate program enables us to apply semantic differential techniques a) in the evaluation of buildings from an aesthetic point of view and b) in the generation of building form, by using semantic space as an analogy for physical space. Current developments are concerned with movement systems, urban systems, economic models, 3-dimensional planning models analogue computer simulation of environmental control systems, and so on. (O'Keefe 1970).

A good deal of our work on information systems has been facilitated by the installation of a microfilm retrieval system, consisting of a 3M processor camera and reader-printer, a card-to-card copies and an Ozalid production printer. These, with ancillary equipment, enable any document up to 1010mm x 760mm to be copied on to 35mm microfilm, mounted in an 80 column punched card and delivered within 40 seconds. This can then be printed out: same size, enlarged or reduced, so that whole areas of teaching and research have changed in character. It solves the inherent dilemma in professional education of whether to teach practical detail, which means that the student has little understanding of the principles on which new developments can be based - or to teach principles, which means that he has no store of practical details when he goes into practice. The microfilming system enables us to store details which the student can retrieve by applying the principles he has learned, and the critical faculty he has built up, to their selection.

The most rewarding aspect of these systems in the School of Architecture is that they begin to show links again between various aspects of environmental design which, for historical reasons, had tended to fragment. This is nowhere clearer than in the application of language systems to the study of architectural symbolism. Language in this sense, is defined as a set of symbols and a system of rules for using them (but see Glossary). Rules thus detected in the study of language can be applied in other fields as they have been in anthropology

(Levi-Strauss 1968), food and costume (Barthes 1967) not to mention architecture (Jencks and Baird 1969, Bonta 1970). In one simple study, the students considered a series of committee rooms, observing the form of each chair, and its spatial relationship with other chairs, tables and with the room as a whole! The chairman's chair, for instance might differ from the others in having arms, a higher back, deeper upholstery, and so on. These particular attributes - and the chair's location in relation to other chairs, signify the status of its user. One could also distinguish the chairs which were to be used by committee members, secretaries and observers. This kind of analysis can be applied to many aspects of architecture, and clearly it can be used in design. It is obviously relevant in the planning of a courtroom, or a suite of offices, but it is surprisingly effective in the planning of other building types. The beauty of such language systems is that they allow symbolic values and other "intangibles" to be treated by methods which are applicable also to structures, environmental standards and other quantifiable aspects of design.

It seems, therefore, that a systems approach, in its many ramifications, really can be used to help the designer take an overall view of his task. It may help us even to avoid the incipient danger that, because certain factors in design are easily quantifiable, they are given greater weighting in design than those which are not. In other words it gives us a way of structuring the intake of information into design in which all the relevant factors are allowed to play their appropriate part in determining the final design.

GLOSSARY OF SYSTEMS CONCEPTS*

1.0 Computer System: seems to have three distinct uses.

1.1. Integrated unit of personnel, computer hardware and sortware which are available for data processing.

1.2 Interrelated set of hardware consisting, for example, of a central processor with peripheral input, output and storage devices. Ambiguity can be avoided by describing a set of such physical units as a configuration.

1.3 Method of analysing a particular class of problem using a given set of mathematical models often sold as a package or suite of programmes.

* (The word Glossary is interpreted strictly: the entries represent my own gloss on the various concepts)

2.0 Control Systems

2.1 Application of cybernetic principles to the control of machines; described as "Automation" by D S Harder who devised a system of interlinked, self-regulated machines for the manufacture of automobile engineers(Ford Motor Company 1946).

2.2 An advanced system might consist of computer controlled machines, interlinked by a hierarchy of computers collating orders, controlling stock, programming work to different machines in man-computer dialogue with management. It may be, under these circumstances, that the uniformity of product which has been traditional in mass production leads to over-use of some machines and under-use of others, so that for the efficient deployment of machines, automation requires diversity of product rather than uniformity.

3.0 Cybernetics: see text

4.0 Eco-System

A term describing all the living and non-living components of the environment, together with the interactions between them. Ecology was probably the first discipline to take a systemic view in its concern for relationships between living organisms and their environment. It is usual to locate the components within a structure consisting of four trophic levels:

4.1 Raw materials - such as minerals in the soil, water, carbon dioxide and so on.

4.2 Producer organisms - such as plants, which utilise the sun's energy in photosynthesis to combine the raw materials, thus forming carbohydrates, fats, proteins, vitamins and so on.

4.3 Consumers - including herbivores, which utilise the producers as sources of their energy, carnivores, which feed on the herbivores (or other carnivores) and omnivores, which feed on both.

4.4 Reducers - such as bacteria and fungi which feed on dead organic matter, thus converting it back into raw materials.

In a well adjusted eco-system, these will be a homeostatic relationship between these four levels and increasing concern is being expressed, politically, at the ways in which man's activities, especially those connected with the growth of large cities, are upsetting the whole earth eco-system.

5.0 General System Theory : see text

6.0 Information Systems: Refers to three quite different concepts

6.1 The structure against which an entire field of knowledge may be classified; e.g De wey, UDC, Cl/SfB and so on. Consistent with the third Oxford Dictionary definition of sytem, but technically a holotheme.

6.2 Analogous with computer system: the entire system of personnel, hardware and software available for the collection, representation, classification, storage retrieval and transmission of information. May be manual, mechanical or computer aided; where computers are involved, it is usual to describe any input to the system as data and any output as information.

6.3 Technical term used to describe an intermediate level or organisation in the holotheme; consisting of units, assemblies, systems and combines.

7.0 Language Systems : two major uses

7.1 In the definition of language itself as a set of signs and a system of rules for using them.

7.2 In a technical sense the word systems refer to the way in which one word relates to others by virtue of shared meanings, derivations, position in a paradigm (table of declension or conjugation), rhyme and so on. Systems, in this sense, are distinguished in linguistics, which refer to the ways in which words afford structural support to each other within a sentence. Two further concepts from linguistics may help to show why language is more than a simple kit of parts with a set of rules for using them.

7.3 A linguistic sign, according to Saussure (c.1905-11) consists of two components a signifier - the word, pattern of speech sounds, marks on paper and so on by which one tries to communicate an idea, and a signified - the thought or concept which one is trying to convey. Ogden and Richards (1923) add a third component to these first two, the referent, which is the person, place or thing one is communicating about.

7.4 Our personal selection of signs from the available list was called speech by Saussure, to distinguish it from language, which is a shared, public thing - a system of values agreed by social contract. This social contract is necessary because the relationship between signifier and signified is essentially arbitrary. The letters h-u-t denote a small building; so do the sounds we utter when we read them. Initially, any other signifier would have done just as well, but the meaning of hut is now agreed so none of us can change it if we hope to be understood. Yet in systems analysis and computing generally some 3000 such relationships between signifier and signified have been fractured (Chandor 1970) i.e. new words have been coined. or old ones given new uses.

7.5 There have been several attempts recently to use the methods of structural linguistics in the analysis of architecture (Jencks and Baird 1969), which suggest that eventually, aesthetic and other "intangible" aspects of environmental design may be brought within an analytical structure compatible with those appropriate for the physiological, social structural and other quantifiable aspects.

8.0 Psychological Systems:

8.1 Gestalt theory that wholeness and organisation are basic features of all mental processes and behaviour, so that any situation can be understood only when its constituent parts have been organised into a systemic whole.

8.2 Application of cybernetics and general system theory to the analysis of psychological processes, e.g. Gibson's description of the external senses as interrelated, perceptual systems.

9.0 Social Systems: uses in ascending order of precision

9.1 Set of social units; individuals, groups, institutions and the conventions by which they are interrelated.

9.2 Use of generalised analogies from other fields, e.g. Comte's and Marx's use of evolution, Spencer's of the living organisms, and Homan's of the concept from physical sciences, to describe patterns of social organisations.

9.3 Application of cybernetics and general system theory to the analysis of social phenomena; e.g. Buckley's Sociology and modern systems theory.

10.0 Systems Analysis: development of operations research which, instead of distinguishing between individual techniques such as decision theory, theory of games, linear programming, queuing theory, network analysis, and other simulation methods deals in mathematical models which may be used for various purposes.

10.1 Generally a middle to lower management function in which these models are used in the implementation of policy decisions taken at executive level. The aim, usually is to analyse the organisation itself, or various processes so that the most effective use can be made of available man-computer systems.

10.2 The system analyst will have at his fingertips a repertoire of methods which may be used in accounting, stock control, plant allocation and so on. Given any class of problem - in management, economic or physical planning he can suggest which techniques would be most appropriate.

10.3 A typical systems analysis procedure (Chandor, Graham and Williamson, 1969) might form an effective process for re-design, rather than for de novo design; in the following stages: (1) definition of the problem (2) monitoring of the existing system in action (3) analysis of data thus collected with a view to determining requirements for the new system (4) design of the new system so as to make the best use of available resources (5) documentation of the new system and communication to those who will be affected by it (6) implementation of the new system and long-term maintenance of it.

11.0 Systems Building: Method of building by analogy with certain aspects of systems engineering, in which standardised components (doors, windows, wall panels, structural frame and so on) are designed and prefabricated in the factory in such a way that they can be delivered to site and assembled there rapidly. Given a massive programme for a single building type - schools, houses and so on, systems building allows for extensive pre-planning and bulk ordering of components in advance, with attendant production and cost advantages. May also speed up processes by which Building Regulation and other statutory approvals are obtained, on grounds that the method of construction is standardised and known. May be superceded by automated systems (see control systems) in which, uniformity of components is undesirable.

12.0 Systems Engineering: originally synonymous with engineering design (e.g in Goode and Machol 1957) systems engineering also has much in common with Operational Research (e.g in Churchman, Ackoff and Arnoff 1957). Hall (1962) distinguishes between them by suggesting that Operational Research is concerned with the application of scientific methods, process and techniques into the management functions of existing organisations, military, commercial, industrial and so on, whereas systems engineering includes the design of new enterprises, their long range planning and overall development. Design therefore, is only a part of systems engineering which will include the definition of a need, the selection of objectives, the synthesising of systems, analysis of these systems, selection of the best alternative and planning for action.

12.1 Systems engineering takes from General Systems Theory some basic definitions. "A system is a set of objects with relationships between the objects and between their attributes." (Hall 1962) and the idea that such a system will operate within an environment: "For a given system, the environment is the set of all objects outside the system: (1) a change in whose attributes will affect the system and (2) whose attributes are changed by the system".

12.3 Systems engineering, fundamentally, is a highly sophisticated development of design for mass production (based on methods devised initially by Brunel (c.1805) for making rigging blocks at Portsmouth Dockyard, extended to produce building components (Crystal Palace 1851), automobile components (Henry Ford 1911) and so on, reaching its apotheosis in the electronics industries (e.g. RCA Victor c. 1935) in which individual components - transformers, resistors, capacitors and so on, are available from stock and can be plugged into circuits laid out according to known principles. As individual components are redesigned and plugged into the circuit, so the circuit performance as a whole will improve, even though overall, its layout remains the same. The circuit will have an input, such as a radio signal, throughout it the form of electric currents and an output in the form of a current powerful enough to drive a loudspeaker. The throughput will be modified or transformed as it passes into, through and out of each component; analogies can be drawn from this into any system into which matter (goods, traffic, people), energy (electricity, heat) or information (spoken, written, punched on tape) can be made to flow, and will be transformed in the process. This is clearly true of people moving into, through and out of buildings.

13.0 Urban Systems: Abstraction from the total urban system of those aspects, e.g. land-use, location, economic growth, population growth, transportation and so on, which are susceptible to analysis by the use of mathematical models.

13.1 A typical location model showing the ways in which industry, housing and services are distributed geographically, may be used to predict the effects of future developments on the interrelationships of these three functions.

13.2 Demand for future highways may be predicted by plotting the origin and destination of communications in various modes, e.g. telephone messages, flow of people and goods, extrapolating future trends, location of new activities and predicting demands on the transport system at some specific time in the future.

13.3 Few urban systems models are sophisticated enough to take into account the psychological and social implications of land use, location, transportation and so on.

REFERENCES:

Alexander, C. A. : Notes on the Synthesis of Form, Cambridge Mass., Harvard U.P. 1964

- Systems Generating Systems, in Architectural Design, 12/68

Angyal, A. : A Logic of Systems, reprinted in Emery, F. E. Systems Thinking, Harmondsworth Penguin 1969

Barthes, R. : Elements of Semiology, London, Cape, 1967

Beer, S. : Cybernetics and Management, London, EUP, 1959

- The World, the Flesh and the Metal; the Prerogative of Systems, in Nature, 16/1/65

Bertalanffy, L. von : General System Theory, reprinted in General System Theory, New York Braziller 1969

Best, G. : Method and Intention in Architectural Design, in Broadbent and Ward 1969 (see below)

Bonta, J. P. : (in preparation) A Semiological Design Method, Buenos Aires and Portsmouth Schools of Architecture (Mimeo)

Broadbent, G. : Notes on Design Method, in Broadbent and Ward 1969 (see below)

- (forthcoming) Design in Architecture, Chichester and New York, Wiley

Broadbent, G. and Ward, A. : (eds) Design Methods in Architecture, London, Lund Humphries, 1969

Buckley, W. : Sociology and General Systems Theory, New York, Prentice Hall, 1966

Cannon, W. B. : The Wisdom of the Body, New York, Norton, 1939

Chandor, A. : A Dictionary of Computing, Harmondsworth, Penguin, 1970

Chandor, Graham and Williamson : Practical Systems Analysis, London, Rupert Hart-Davis 1969

Churchman, Ackoff and Arnoff : Introduction to Operational Research, New York, Wiley, 1957

Clark, J. D. G. : Prehistoric Europe, London, Methuen, 1952

Drucker, P. F. : The Practice of Management, London, Heinemann, 1955

Echenique, M. : Models, a Discussion in Architectural Research and Teaching, RIBA, May 1970

Emery, F. E. : Systems Thinking, Harmondsworth, Penguin, 1969

Gibson, J. J. : The Senses Considered as Perceptual Systems, London, Allen and Unwin 1968

Goode and Machol : Systems Engineering - an Introduction to the Design of Large-Scale Systems, New York, McGraw Hill, 1957

Gregory, S. A. : Morphological Analysis, some simple Explorations, in Broadbent and Ward 1969, (see above)

Grinker, R. R. : (ed) Towards a Unified Theory of Human Behaviour, New York, Basic Books 1965

Hall, A.D. : A Methodology for Systems Engineering, New York, van Nostrand 1962

Jencks, C. and Baird, G. : Meaning in Architecture, London, Barrie and Rockliff 1969

Jones, J. C. : The State-of-the-Art in Design Methods, in Broadbent and Ward 1969 (see above)

Levi-Strauss : Structural Anthropology, London Allen Lane, 1968

McLoughlin, J. B. : Urban and Regional Planning; a Systems Approach, London, Faber, 1969

Manning, P. : (ed) The Primary School, and Environment for Education, Liverpool, Pilkington Research Unit, 1967

Markus, T. A. : The role of Building Performance Measurement and Appraisal in Design Method, in Broadbent and Ward 1969 (see above)

Matchett, E. : Fundamental Design Method Training, (seminar papers) Bristol, Engineering Employers, West of England Association 1969

Mongait, A. L. : Archaeology in the USSR, Harmondsworth, Penguin, 1961

Musgrove, J. : The Dangers of Scientism, Architectural Review, July 1966

Ogden, C. K. and Richards, I. A. : The meaning of meaning, London, Routledge, 1923

O'Keefe, J. : A Brief Report on the use of Mathematics with Design Studies, Portsmouth School of Architecture, 1970 (mimeo)

Pahl, R. E. : Spatial Structure and Social Structure, London, Centre for Environmental Studies, Working Paper 10, 1968

Popper, K. : The Poverty of Historicism, London, Routledge, 1957

R.I.B.A. : Plan of Work for Design Team Operation in Handbook of Architectural Practice and Management, London, RIBA 1965

Russell, B. : Design and Systems Theory, Portsmouth School of Architecture, 1970 (mimeo)

de Saussure, F. : Course in General Linguistics, London, Peter Owen, 1960

Smuts, J. C. : Holism and Evolution, New York, Viking, 1961

Spearman, C. and Wynn Jones, L. : Human Ability London Macmillan, 1950

Weiner, N. : Cybernetics, New York, Wiley, 1948

Weiss, P. A. : The Living System, Determinism Shunned, in Koestler, A. and Smythies, J. R. Beyond Reductionism, London Hutchinson, 1968

Weston, H. C. : Sight, Light and Work, London, Lewis, 1962