Part I

The Management of Design Process

Introduction

One of the first tasks attempted by design methodologists was the development of new, systematic design procedures. In the early 1960s these new procedures began to emerge in all the different professional specialist areas of design. The four papers here in Part One represent engineering design, urban design, industrial design, and architectural design. They are drawn from the period of the early to middle 1960s, starting with two of the seminal papers—those by Jones and Alexander—given at the first 'Conference on Design Methods' in London in 1962.

Jones' 'A method of systematic design was one of the first attempts to provide a completely new way of proceeding with design. It did not, however, attempt to replace every aspect of conventional design; it was based on the recognition that intuitive and irrational aspects of thought have just as important roles to play in design as logical and systematic procedures. The method was aimed particularly 'at the area that lies between traditional methods, based on intuition and experience, on the one hand, and a rigorous mathematical or logical treatment, on the other'.

This clear intention to supplement, rather than to supplant, traditional design methods was often ignored by the early critics of systematic design procedures, who tended to assume that the 'systematic' must be the enemy of the 'intuitive'.

What Jones was proposing was a way of organizing the design process so that logical analysis and creative thought—both assumed to be necessary in design—would proceed in their own different ways. His systematic design method attempts to recognize and to separate the two ways of thinking by the use of clear, externalized procedures, rather than leaving them as internal mental battles for the designer. In particular, his Method attempts to leave the designer's mind as free as possible for random, creative ideas or insights, by providing systematic methods for keeping data, information, requirements, and so on, outside the memory.

Typical aspects of this method of systematic design therefore include keeping separate records for ideas or solutions and information or requirements; not suppressing random inputs, but storing them for later evaluation; systematically sorting the interactions between problem factors; delaying the choice of a final solution until the problem is fully explored and potential solutions are evaluated; and combining partial solutions into a whole, rather than the reverse procedure of conventional designing.

The method permits, and even enourages, random, unstructured thinking (e.g. use of a 'random list of factors' and 'creative thinking'). It provides a rational framework within which the irrational has its own space and time. The framework consists essentially of a procedure of three stages—analysis, synthesis, and evaluation—and within each stage Jones offers a variety of techniques appropriate to the main task. The three-stage process of analysis–synthesis–evaluation became widely accepted as a basic model of the systematic process of design.

Alexander's paper on 'The determination of components for an Indian village' was drawn from the research for his Doctoral thesis, and his later book, *Notes on the Synthesis of Form*. Part of this research drew upon biological analogies of organisms and environments for the relationship between design forms and their contexts. His use of the term 'environment' in this paper therefore refers to the general problem context—i.e. the design requirements of the village he is designing as a case-study. This Indian village is taken as an example of 'a city in miniature', for it is city planning or urban design which is the focus of his attention.

Because the basic components into which any artefact can be subdivided determine the essential nature of that artefact, Alexander addresses 'the general problem of finding the right physical components of a physical structure'. He seeks to conceptualize new components; to design totally new, more appropriate artefacts, structures, and systems. A radically new structure for a city, for example, cannot emerge from simply rearranging the accepted conventional components. Alexander's concern, therefore, is to find a way of formulating components which does not rely on preconceptions of what

those components should be; the components should derive from a thorough analysis of the environment they have to fit. This leads him to doubt the value of most systematic design approaches (such as applications of linear programming or decision theory techniques), which take existing solution components as their starting points and therefore merely rearrange those same components.

> Systematic techniques [he writes] just because they need to operate on known units, usually beg the real question of design, and so achieve little more than a second rate designer does. The fundamental change which a structure undergoes at the hands of a great designer, who is able to redistribute its functions altogether, cannot take place if its components stay the same.

Alexander's own design method therefore starts from scratch with observation of the problem context and an exhaustive listing of requirements. Then one has to decide for each pair of requirements whether or not they interact, or are dependent. 'Two requirements are dependent if whatever you do about meeting one makes it either harder or easier to meet the other, and if it is in the *nature* of the two requirements that they should be so connected, and not accidental.' The subsystems of the problem context are then derived by partitioning the linked requirements into independent subsets. Since this is a large and complex task, Alexander derived a computer method for doing this, based on graph theory. The result is the formulation of a set of subsystems of the environment; the remaining task is to design components to match the subsystems.

In the Indian village example, Alexander lists 141 basic requirements. Following his method, these are grouped into twelve independent minor subsystems, which can be combined into four major subsystems. For each subsystem he provides a diagrammatic concept for a matching component.

Alexander's work was very influential, and his method of hierarchical decomposition of a set of problem requirements was used in many other design fields.

A third influential, early contribution to design methodology was a series of articles on 'Systematic method for designers' by L. Bruce Archer published in *Design* magazine during 1963 and 1964, and later republished by the Design Council. Almost the whole text is reprinted here, except for the substantial checklist of design procedure (which ran to some 13 printed pages) and the accompanying network flow diagrams showing the relationships between the 229 activities in the checklist.

Archer's context is industrial design, and his opening comments on the nature of designing reflect this orientation. For him, design activity is based on the formulation of a prescription or model which represents the intention to create some artefact, and the activity must include some creative step. He distinguishes designing from artistic creation, musical composition, scientific discovery, and mathematical calcula-

tion. He makes it clear that systematic designing does not imply automatic designing, and also argues that rigorous analysis does not necessarily result merely in statements of the obvious—any 'obviousness' is only apparent in retrospect.

Archer's model of the design process is more complicated than many others. His complete checklist contains 229 activities, in nine major stages from 'preliminiaries' to 'winding-up'. However, the core of his model is a six-stage process: programming, data collection, analysis, synthesis, development, and communication. 'In practice', he writes, 'the stages are overlapping and often confused, with frequent returns to early stages when difficulties are encountered and obscurities found.' Thus his diagrammatic model of the design process contains many feedback loops. Simplifying even further, his model reduces to 'a creative sandwich', with a central creative phase sandwiched between more objective phases of analysis and execution.

Although he is a strong advocate of rigorous and thorough analysis, Archer recognizes that perfect and complete information is rarely available in the real world, and that it is therefore not possible to wait until an analysis has been conducted of *all* the potentially relevant data before the designer has to act. The designer's previous experience, and knowledge of case histories, is important in formulating a reasonable course of action on incomplete evidence, and in fact, 'Making a first approximation on the basis of prior experience enormously reduces the scale of the problem solving effort.' However, he also says that 'It is axiomatic that any rational method for solving design problems must offer means for arriving at decisions on the basis of evidence'. and he therefore stresses the collection and organization of information so that the designer can make sensible decisions.

The opening analytical phase of Archer's systematic design procedure essentially comprises: identifying the design goals; identifying the constraints; preparing a list of sub-problems; and rank-ordering the sub-problems. 'The result, however, is a statement of the problem, not of the answer', and the bread of objective and systematic analysis must be followed by the meat of the 'creative leap'. Archer insists that there is 'no escape' for the designer from creatively formulating his own design ideas. Creativity is part of the very essence and nature of designing: 'After all, if the solution to a problem arises automatically and inevitably from the interaction of the data, then the problem is not, by definition, a design problem.' The 'creative leap' to a potential solution is then followed by the 'donkey work' of constructing development models, which can be drawings or other analogues, representing a particular embodiment of the general solution idea.

There are several similarities between Archer's view of design and that of Luckman, in his paper 'An approach to the

management of design', although the context for the latter is architectural design and the viewpoint is that of an operational researcher. Luckman emphasizes the analysis of information, requirements, and constraints, which the designer translates, with the help of experience, into potential solutions which meet the required performance characteristics of the artefact being designed. He also insists that 'some creativity or originality must enter into the process for it to be called design', and that 'if the alternative solutions can be written down by strict calculation, then the process that has taken place is not design'.

Luckman's model of the design process is based on the three-stage process of analysis–synthesis–evaluation. However, his view is not that this is a simple, complete, linear process, but that it recurs at different levels of design detail; the designer is continually cycling through analysis–synthesis–evaluation, proceeding from the more general problem levels to the more specific. At each level, Luckman perceived from his observations of architects, the components of a solution are always highly interdependent, and the designer's difficulty therefore lies in finding a compatible set. There is no guarantee that optimum sub-solutions will combine into an overall optimum solution. It was this problem that Luckman addressed with his systematic design procedure, AIDA—the analysis of interconnected decision areas.

A 'decision area' occurs where, at any level of detail, there is a range of acceptable sub-solutions to a particular sub-problem. Because the choice of a sub-solution usually influences, and is influenced by, other sub-solutions to other sub-problems at the same level, the majority of decision areas are highly interconnected. The AIDA method enables the designer to identify compatible sets of sub-solutions and so to make 'simultaneous' choices rather than sequential ones. Despite his belief in the role of creativity in design, according to Luckman, 'AIDA is really a systematic technique for the synthesis stage'. It expands the number of solutions to be considered in the evaluation stage, instead of the conventional reliance on considering only a few potential solutions—or even simply the first solution to emerge.

If we review these four early contributions to the development of a systematic approach to design, by Jones, Alexander, Archer, and Luckman, several common aspects become quite clear. For instance, there is considerable overlap in the reasons given for the emergence, and the necessity, of such systematic approaches. The late 1950s and early 1960s had seen increasing technological change and concomitant increasing complexity in the designer's task. Alexander refers to 'changes in technology and living habits happening faster all the time', and Luckman refers to a 'rapidly changing technological world'. There had also been the emergence of the systems approach to design, which is implicit in the procedures of all four authors, and

stated explicitly by Archer: 'The current tendency in design ... is to try to consider the whole system of which the proposed product is a part, instead of considering the product as a self-contained object.'

The aims of systematic design procedures are, according to Jones, 'To reduce the amount of design error, re-design and delay', and 'To make possible more imaginative and advanced designs.' And according to Archer, 'Systematic methods come into their own under one or more of three conditions: when the consequences of being wrong are grave; when the probability of being wrong is high; and/or when the number of interacting variables is so great that the break-even point of man-hour cost versus machine-hour cost is passed.' There is, therefore, a common concern with increasing both the efficiency and the reliability of the design process in the face of the increasing complexity of design tasks.

This common concern results in a considerable commonality of approach. In particular, for all four authors there is an emphasis firstly on extensive problem exploration and analysis to identify all the factors that have to be taken into account, and secondly on systematically establishing the interconnections between all these factors so that all the sub-problems are identified. They all also adopt the common approach of first breaking down the overall problem into its sub-problems and then attempting to synthesize a complete solution by combining partial solutions.

The fact that in four different fields—engineering design, urban design, industrial design, and architectural design—such similar approaches were being recommended lent support to the notion that there is an underlying common design process. However, the adoption of systematic design procedures was by no means a rapid and universal event thoughout the several design fields. What many designers—and design methodologists—failed to do was to heed the warning words of Jones:

> The great difficulty of introducing Systematic Design is that its advantages are not obtained unless it is carried out far more thoroughly than is likely in first attempts. Successful application is much more likely when changes in *organization* have been introduced beforehand. As with many new things it involves an acclimatization period during which things may get worse before they get better.

Further Reading

The papers by Jones and Alexander were presented at the first conference on design methods, held in London in 1962. Many other papers presented at the conference are still interesting and relevant; see the proceedings, Jones, J. C., and Thornley, D. (eds) (1963), *Conference on Design Methods*, Pergamon, Oxford.

Jones later made another significant contribution to design methodology with the first textbook of design methods: Jones, J. C. (1970),

Design Methods: seeds of human futures, Wiley, Chichester. For a more recent contribution by Jones to the management of the design process, see Jones, J. C. (1979), 'Designing designing', *Design Studies*, **1**, (1), 31–35.

The theory and background to Alexander's example of the design of an Indian village is presented more fully in Alexander, C. (1964), *Notes on the Synthesis of Form*, Harvard University Press, Cambridge, Mass. Some of the theoretical bases of this work (particularly its use of biological analogies) are criticized in Chapter 12 of Steadman, P. (1979), *The Evolution of Designs: biological analogy in architecture and the applied arts*, Cambridge University Press, Cambridge. An example of Alexander's method applied to American suburban house design is given in Chermayeff, S., and Alexander, C. (1966), *Community and Privacy*, Penguin, Harmondsworth.

A more detailed development of Archer's work is given in Archer, L. B. (1969), 'The structure of the design process' in Broadbent, G., and Ward, A. (eds), *Design Methods in Architecture*, Lund Humphries, London.

An early work on design process in engineering is Asimow, M. (1962), *Introduction to Design*, Prentice-Hall, Englewood Cliffs, New Jersey. For a methodologically orientated textbook in the architectural field, see Broadbent, G. (1973), *Design in Architecture*, Wiley, Chichester. A more general and more recent work is Nadler, G. (1981), *The Planning and Design Approach*, Wiley, New York.

Developments in Design Methodology

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