A plain man's guide to systematic design methods

Systematic design method has suffered like so many modern tools of thought from an aura of mystique that obscures its real purpose and value. Geoffrey Broadbent [A], Head of the Portsmouth School of Architecture, sets out to abolish the mystery and to describe the contribution design method can make to solving architectural problems

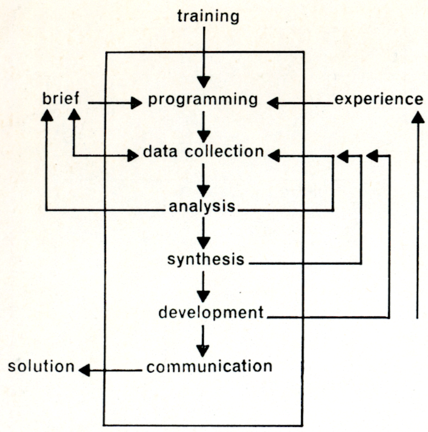
Most of us, trained in schools of architecture before, say, 1960 think of design method as part of the new puritanism. Like management, systems building and the change to metric, it seems to take the fun out of being an architect; it has a formidable mystique. It possesses its own jargon – terms like analysis, synthesis, and evaluation; and it seems to be operated by means of charts, diagrams and other devices that do not look much like architect's drawing, and certainly bear little obvious relationship to real buildings. Not only that, its chief practitioners, on the whole, are not really architects either. Some of them are engineers, industrial designers, mathematicians or psychologists. Those who are architects tend to be teachers, and we know what George Bernard Shaw said about teachers: 'He who can, does. He who cannot, . . .' And certainly there is no indication that systematic design methods have really helped any architect to design a major project. So what is it all about?[1]

It started, really, after the Second World War, when certain techniques that had been used in weapon design became available for other purposes under the general heading of Operational Research. This is usually abbreviated to OR and, like many other studies developed during that war, it is based on mathematics.[2] Its purpose, in fact, is to apply scientific method to what had become known as 'problem-solving', and an early example will show how it works. Enemy submarines seemed to have a remarkable chance of survival when aircraft dropped depth charges on them (Sargeaunt, 1965).[3] These depth-charges were set to fire at 100 ft under water, on the assumption that a submarine would crash-dive when the aeroplane came into sight. But once a submarine had started to dive, it was extremely difficult to locate, and some submarines stayed on the surface; explosions deep under water had little effect on them.

The problem, therefore, was to sink more submarines, and a group of scientists was called in to solve it. They rephrased the problem, which became to 'increase the number of kills per explosion'. They could have conducted experiments, trying out different fuse settings on enemy submarines – or even on some of our own, but that would have taken too long. Instead they started to collect information ('data collection') on all recorded encounters between aircraft and submarines. They then analysed this information, classified it, assembled collections of figures for each 'variable' – the speed of the aircraft and its height, the position of the submarine, the fuse setting – and built up equations into which different values could be inserted for each variable in turn. As a result of this, they concluded that the most effective possible fuse setting (the 'optimum'), would be 25 ft. It so happened that for safety's sake, the fuses could not go off above 35 ft, but even at this setting, the number of submarine 'kills' doubled, and when new fuses became available that could be set to 25 ft, the number increased by seven times.

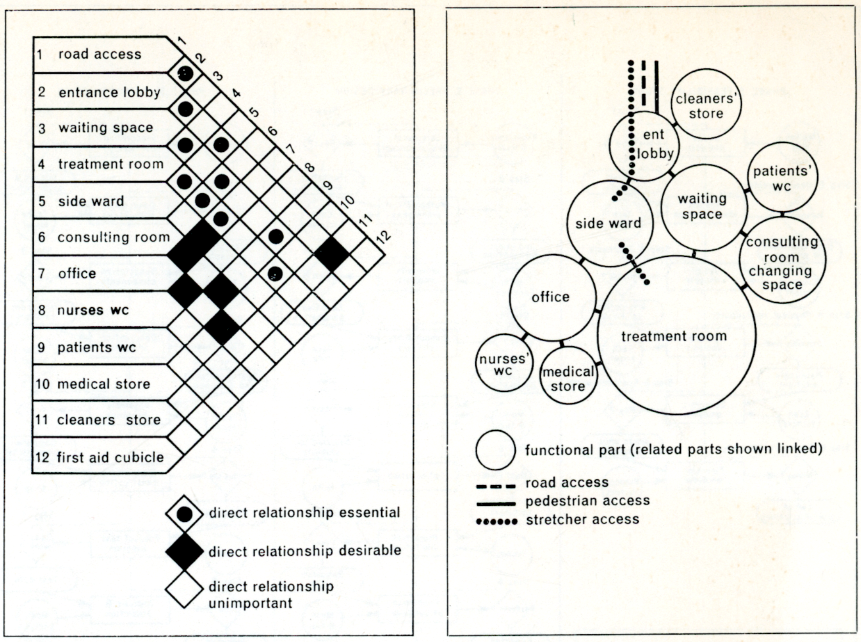
It is not surprising, therefore, that when the war was over, some designers felt that such methods could be applied to more peaceful pursuits, such as the design of buildings. The techniques themselves received a massive boost at the end of the 1940s when electronic computers became available, and for 20 years or so the belief has been growing that operational research has a great deal to offer the designer, which indeed is true. The central feature of operational research, which it shares with management and certain other fields, is the 'decision sequence' – a check list, if you like, of the order in which certain operations should be carried out. The actual names of these operations are not very important, but the following sequence is typical:

briefing – in which the designer finds out what his problem is, and collects information about it;
analysis – in which the information is sorted out, classified and otherwise put into usable form;
synthesis – in which a variety of solutions to the problem is generated;
evaluation – in which the various solutions are tested, and one of them selected for development;
implementation – in which drawings and other material are prepared, so that



1 Bruce Archer's original Design Process (1963). But it is now becoming clear that this is a simple decision sequence, as used in operational research, management and many other fields. We all make decisions in this way – data collection, analysis, synthesis, and so on – although an individual sequence may be so rapid that we hardly notice the stages of which it is composed. But a design process consists of hundreds, maybe thousands of such sequences put together in ways that are determined not by some abstract flow-chart, but by the nature of the design task itself.

Source: Archer, Bruce, 'Systematic Method for Designers' (reprint from *Design*, London, Council of Industrial Design, 1965)



2 Many people still believe that design process is simply a matter of substituting charts and diagrams, such as the above examples by Alan Murray and Derek Middleton, for the perspectives and other sketches which architects, traditionally, have used in design. But there is more to it than that; it is a matter of being *systematic* about the choice of a medium to work in. A full design process might cover the full gamut of design *analogues*, from a highly abstract computer programme, which is useful, say, for working out traffic patterns, to a couple of orange boxes and a drawing board, which might be admirable for mocking-up a new kind of desk.

Source: Jones, J. Christopher, 'Design Methods compared 2: Tactics', *Design*, 213, September 1966; (originally the work of Alan Murray and Derek Middleton of the CEGB Architects' Development Group and reproduced by permission of the CEGB from its 'Design guide for medical centres').

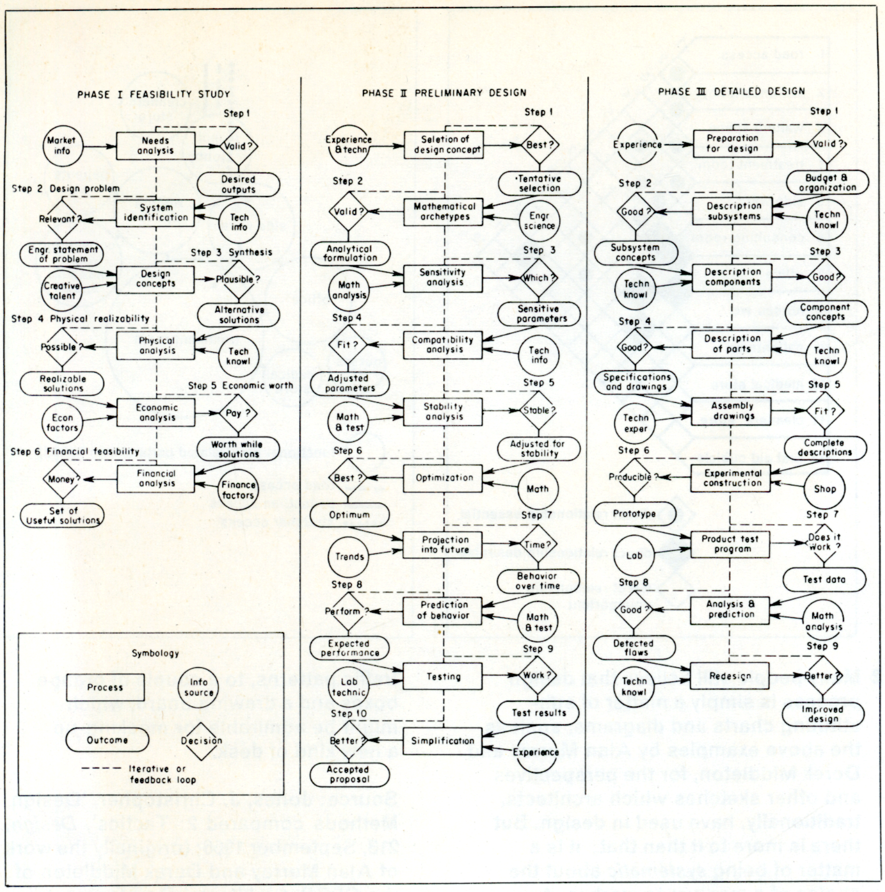
the design can be put into production.

At first, this was called 'the design process', and some people found that design could be made to work in this way (fig. 1).[4] Most designers, after all, do collect information on their problem before they start to solve it, and they tend to play around with design ideas before they commit themselves to an actual solution. But using this method – where all the information is collected in one fell swoop at the beginning of the job – designers found themselves faced with an 'information explosion' (Jones, 1967)[5]. They found, in fact, that they simply could not cope with the vast mass of data they had collected; very often, therefore, they lapsed into old, and apparently unsystematic ways of designing – using their experience as designers to decide what was relevant and what was not. Often they did this by the time-honoured method of producing a sketch on the back of an envelope, which is one way, at least, of resolving the complexity of an architectural problem[6] (fig. 2).[7]

But this was a contradiction of the next phase of design process, which was to generate not one good solution, but a range, a variety, from which the best could be chosen. Many designers found this difficult. It seemed to them somehow insincere to play with ideas rather than to concentrate on one correct solution achieved by a flash of inspiration. So further techniques were offered them, for fostering 'creativity', for generating wide ranges of ideas of varying degrees of excellence.[8] Brainstorming was one of these, in which groups of people sparked off ideas against each other.[9] It worked surprisingly well so long as people observed the essential rules: not to criticize half-baked ideas as they were emerging, but to build on them in the hope of achieving 'combination and improvement'. Synectics was even better. The word itself was coined by William Gordon.[10] It means 'the joining together of different and apparently irrelevant elements', and it drew on the essential mechanisms by which the human brain does generate creative ideas, consisting essentially of crossing old ones and of drawing analogies. Henry Moore, for instance, 'crossed' a woman and a landscape to achieve the reclining figure – a 'creative' idea that he then developed in various ways over the next 20 years or so. The joy of synectics is not that it converts everyone into an instant genius, but that it encourages any of us to work at our best whenever we need to.

But having got a range of 'creative' solutions to the problem (and 'problem' in this sense could be anything from the first sketch of a new cathedral to the design of a window catch) the difficulty was to know what to do with it. Nobody really paid much attention to the fourth stage of this design process which was evaluation – a rather haphazard affair.[11] The trouble was that like briefing it was too massive – there was an evaluation explosion, just as there had been an information explosion. It became clear, therefore, that the design process as understood – a five-phase sequence of events – did not really help the designer much. It simply presented material to him in lumps which were far too large for him to handle.

And this was characteristic of most techniques from OR, when they were presented to the designer straight. No one really tried to think out how relevant they might, or might not be for his purposes. Typical of them was Critical Path Method – a type of network analysis, devised for the Polaris missile programme.[12] It is based on the assumption that when many people each have to feed a small part into a large project, some of them will have to complete their tasks before others can even start. In certain cases, a delay in one job will hold up several others – and this may hold up the whole project. So all the jobs are plotted on to a chart in sequence, and a line is drawn which connects these particular jobs – the 'critical path'. But if the chart is drawn and used as intended, these critical jobs will be treated with special care. Some of them may be completed before time rather than after. And if they are, the whole sequence of critical jobs will change, so the chart will have to be redrawn. The purpose of a network analysis, therefore, is to make itself redundant; yet some design theorists have



3 A typical attempt to plot the design process using the symbols of computer programming, from Asimow. Most designers believe, quite rightly, that their brains cannot operate efficiently to such a rigid schedule and Asimow's description of this as a design 'morphology' introduces a piece of unnecessary jargon. Design 'process' would be a perfectly adequate term for it.

Source: Asimow, M., *Introduction to Design*, New Jersey, Prentice-Hall, 1962

plotted generalized networks showing a critical path for all design problems which has led to a curious misunderstanding as to what the method is about.

Nor is this the only technique from OR that has been misused; and some of the most effective, such as Linear Programming, have hardly been used at all. On the whole, in fact, the techniques that have been adopted are not the most useful, but those that have the most impressive jargon. Certainly the terms that architects have traditionally used sound almost naïve by comparison. 'Model', for instance, becomes much more respectable when you qualify it with 'analogue', 'symbolic' or 'iconic'.[13] Only the last of these actually looks like a small-scale version of your building (iconic has to do with images); the other two kinds of model might take the form of electric circuits in a computer, or simply of strings of figures. One design methodologist, forced to admit that the symbolism of a church was important, salved his puritan conscience by describing its appearance as 'iconographic function'.[14] 'Design parameters', too, sound far more impressive than 'things you can measure', and 'optimum' seems curiously better than 'the best'. The trouble is that once you take away the terminology of operational research, design looks very much like it did before (fig. 3).[15]

Nor is OR the only field that has been misused in this way. Any parent whose children attend even a mildly progressive school will know about the 'New Maths' which seems to consist of overlapping ovals, of 'U's in strange positions, and of lines connecting dots like some tangled cat's cradle.[16] In the same way, another series of techniques has become available under the names of Set Theory,[17] Graphs,[18] Topology,[19] and so on, which looks as if it ought to be useful in design. And again, if properly used, it is.

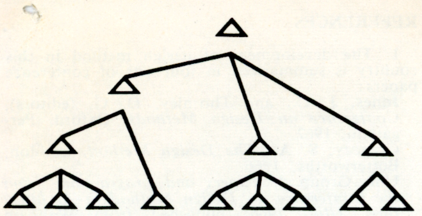
The high priest of this approach is Christopher Alexander, a mathematician turned architect from Cambridge. His avowed intention – a highly laudable one – is to free the architect from habits and prejudices in the hope that new ways of designing will emerge. I apologize in advance for his jargon, which can be rather formidable: he deals in 'forms' and 'contexts'.[20] A 'form' is what you are designing, and its 'context' is the range of pressures, of every kind, that determine what it should be like. So if you find out everything about the context, it should be possible to find a form that will 'fit' it perfectly. Iron filings fit the magnetic field in which they are placed; and the appropriate 'forces' ought to determine the forms of what we are designing in similar ways.

The key to all this, of course, is to find out what those forces are. The first step, in the gospel according to Alexander, is to break the problem down into its tiniest parts, so as to find the individual forces, the 'misfit variables' that act on each part, and to break the problem down, he uses Graph Theory. The simplest graphs are 'trees' which have trunks, branches, twigs, and so on; each misfit variable is an individual twiglet in the 'decomposition' of the problem (figs. 4 and 5). The most complete description of this method occurs in a book called *Notes on the Synthesis of Form* (1963),[21] in which Alexander takes the design of a village in India, for 600 people. He detects 141 possible misfit variables, and some of them read rather strangely to us:

'3. Rules about house door not facing south;
6. Wish for temples;
7. Cattle treated as sacred, and vegetarian attitude;
16. Women gossip extensively while bathing, fetching water, on way to field latrines;
78. Shade for sitting and walking.'

He then takes each of these variables, and notes its 'links' with every other variable. Two variables are linked if, in satisfying one of them by the way you actually design the building, you also affect the other. Links may be 'positive' or 'negative'. Obviously the facts that women gossip and of the need for shade are connected, but neither of these has much to do with the fact that cattle are treated as sacred.

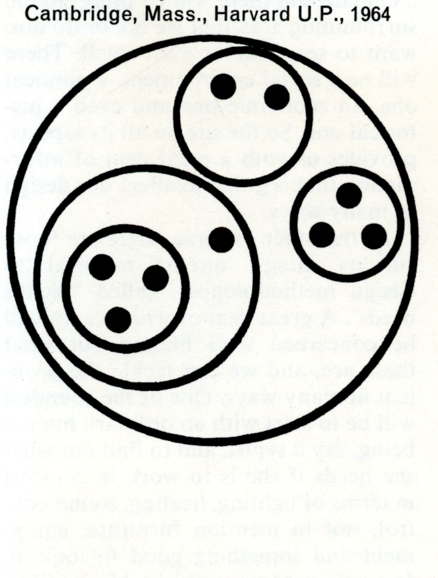
To make his method work, however, Alexander has to treat these 'interactions' in very simple terms. Either two

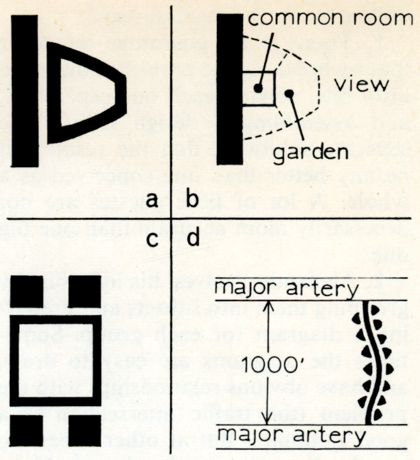


4 Alexander uses the 'tree' or the 'semi-lattice' of Graph Theory to represent a 'section' through the decomposition of his design problem, and the Venn diagram of Set Theory to represent it in 'plan'. The 'tree' has a trunk, branches, twigs, and so on. Each twiglet represents a 'misfit variable' in the decomposition. It is a powerful tool, but Set Theory is even more powerful.

5 A 'set' consists of any collection of things whatsoever that have certain properties in common, and it can be divided into 'subsets' in accordance with these properties. Think of the ways, for instance, in which a pack of cards can be divided – by colour (into two subsets), by suit (into four subsets), by face-value (into thirteen subsets), and so on. Alexander decomposes his set of misfit-variables in precisely this way.

Source: Alexander, Christopher, *Notes on the Synthesis of Form*, Cambridge, Mass., Harvard U.P., 1964





6 The solution to each subset of Alexander's misfit variables is represented by means of a diagram. Here are the first four of twelve such diagrams by which he 'solves' the problem of urban loneliness by clustering the various parts of a house around a communal 'fish tank', into which people can see from the street. You are supposed to sit there, in full view of passers-by, whenever you feel lonely and want people to call on you.

Source: Alexander, Christopher, 'The City as a mechanism for sustaining human contacts', *Transactions of the Bartlett Society Volume 4*, 1965–66

variables interact, or they do not; it is as simple as that. In his village example, each variable interacts with a dozen or more others, and they tend to form groups, or 'subsets' of variables. There are 12 such groups in the village example, and Alexander prepares a diagram for each one, a simple, geometrical expression of what must be done to make the variables fit. Sometimes the diagram is easy to draw. In one example (not connected with his Indian village), Alexander investigates a traffic intersection. He could find the number of cars going in each direction, and turning from one direction to another; the traffic flow would then be represented by arrows, pointing in appropriate ways and varying in thickness according to the number of cars. A wide arrow would indicate many cars, a narrow arrow few, but eventually this diagram could be translated, with very little change, into an actual plan of the intersection, with road widths in proportion to the widths of the arrows. There would be a very close relationship, in this case, between the diagram and the actual road pattern.

His problem is therefore represented by a series of diagrams – 12 in the case of the Indian village – each representing a way of reconciling a number of variables. And, just as he started the process by decomposing the problem into individual variables, so Alexander now builds up his solution by combining these diagrams, using his judgement as to how they should be modified to fit into each other, until eventually one grand diagram is produced that represents the plan of the entire village.

Since he produced his original thesis, Alexander has suggested several modifications to it. He now says, quite rightly, that the Graph Theory 'tree' is too simple to express the complex ways in which most real design problems have to be broken down. In a beautifully written essay, 'A City is not a Tree' (1966),[22] he suggests that it really is a 'semi-lattice', which is a much more complex sort of graph. But in several other papers he elaborates a very curious trait, which is to make some highly charged, emotional statement about urban life, to translate this into a series of diagrams and finally, to give it 'objective' authority by expressing it in terms of algebra. Typical of these statements is: 'People come to cities for contact . . . yet . . . almost all of them live in a state of endless inner loneliness.'[23] 'Inner loneliness' soon becomes 'autonomy withdrawal syndrome' and Alexander's solution to it is to provide each house with a central see-through living room, rather like a fish tank. And if you sit in your fish tank on Sunday afternoon, that is an invitation to casual passers-by to drop in. But we are not that lonely in our house, are you? (fig. 6).

In a more recent paper he says: 'Congestion is choking cities . . . economic and social development is frustrated'[24] – all this, because cars cannot travel at 60 miles an hour. Alexander's solution is to build parallel motor ways across the city at two- or three-mile intervals. The city must be carved up in this way because 'people like their cars . . . even when cars become obsolete . . . people will always insist on . . . some equivalent form of individual vehicle'. Nor does it matter, apparently, that eccentrics like me prefer to walk across the city. We are told that 'pedestrian access . . . adds nothing to what remains of neighbourhood community'. So Alexander's solution in each case is a drastic revision of the urban pattern that may ease the point at issue (assuming that it actually is a problem), but will tend to make urban life even more intolerable in a dozen other ways.

But the appeal to mathematics seems to have silenced criticism, especially in the United States, even though the method itself has grave deficiencies of logic, especially in its developed forms. Alexander claims that his fit and misfit variables are absolute, objective and in no way dependent on human judgement. As Janet Daley has pointed out (1967),[25] he believes that all judgements are 'arbitrary' whereas many of them are simply 'non-factual', which is quite a different matter. Certainly Alexander's own judgements – on loneliness and traffic problems – tend to be very arbitrary indeed, and most real designers are capable of far more balanced judgements. There are, however, difficulties in the method itself:

1. There is no guarantee whatever that by breaking the problem down into little bits, solving each one separately, and assembling a design from these separate solutions, that the result will be any better than one conceived as a whole. A lot of little guesses are not necessarily more accurate than one big one.

2. Alexander 'solves' his little bits by grouping them into subsets and preparing a diagram for each group. Sometimes the diagrams are easy to draw, and have obvious relationships with the problem (the traffic intersection is a good example). But at other times, no simple diagram can be found. If he leaves a diagram out altogether, the solution will be incomplete and if he draws a diagram which does not quite fit the case, it will distort the design in other ways.

But the biggest difficulty of all is the matter of fit/misfit, or rightness and wrongness. This supposes that all human beings are going to react to a situation in precisely the same way. If the solution fits Alexander, then it will fit us all, if it does not fit him then none of us should be satisfied. But human beings vary in their needs. You may be very unhappy with what I find comfortable, you may feel warm when I feel cold. And what is more, human beings have an enormous capacity to adapt to situations. Instead of the 'clarity' that Alexander wants to bring to design by means of his diagrams we may need complexity and ambiguity, so that each of us can adapt to the environment in his own way.[26]

So far, then, design method has not fared too well. I have suggested that techniques lifted straight from operational research have been used unintelligently, and so has our children's 'New Maths' homework. I shall certainly be misunderstood for saying this, so let me be quite clear. I believe that these two fields have a great deal to offer the designer; they are, in fact, crucial to the development of new design methods – provided that they can be slotted into a sequence determined by the needs of architecture itself.

It seems reasonable to look first at what the architect starts with, the way he works, and the things he obviously needs to do in design. There have been one or two attempts to do this. Dennis Thornley's first *Design Method* (1963)[27] was one such attempt, a four-stage process: programming, general study, development, refinement; Peter Levin's *Decision-making in Urban Design* (1966)[28] was another, couched in the language of Decision Theory, a branch of operational research. And the RIBA Plan of Work is yet another (1965)[29], based on the premise that all members of the design team must be involved as much as possible through all stages of the job. But all of these are concerned with the process rather than with the designer himself, and they tend to look too formal, too systematized, too cut and dried.

Yet certain things are known about design before we start. There is presumably a site, which is a hard, factual, concrete thing, and solid information can be built up about it. That must reassure the designer for a start: at 9.30 on some Monday morning he knows how to begin. But there are other kinds of site, surrounding the actual patch of ground. There are, of course, its physical surroundings – other buildings, roads, spaces, trees, the environment in which the building is going to go. Even that will take many forms: it will have a climate and there will be things in the surrounding area that we do, or do not, want to see, hear or even smell. There will be a social environment, a political one, an economic one and even a historical one. So the site, in all its aspects, provides us with a great deal of information that is going to affect our design in many ways.

At the other extreme, there are those curious things, almost mystical to design methodologists, called 'client's needs'. A great deal of what we do will be concerned with finding out what these are, and we can tackle the problem in many ways. One of the soundest will be to start with an ordinary human being, say a typist, and to find out what she needs if she is to work in comfort in terms of lighting, heating, sound control, not to mention furniture, equipment and something good to look at. In a very real sense, the building will be a device that reconciles her needs with what the site, in the raw, had to offer. In design method jargon, it will be an 'interface' between 'activity' and 'environment'. Given this premise, we can build up a design process that takes into account the needs of human activities, the spaces they occupy, the room-shapes they require, the structural pattern such room shapes suggest, the services they need; and we can plot the order in which design decisions should be made.[30] But such a process has an inherent disadvantage; it may turn out to look remarkably like what the architect thinks he does already.

Yet there will be a difference. For having defined this sequence, we shall now be in a position to draw on operational research, computing, systems engineering, the New Maths, and anything else that presents itself, and decide which techniques will be useful, and how they should be applied. Such a method, therefore, can be used at every level of sophistication. (The designer who wants to operate by traditional methods, using sketches on the backs of envelopes, can use it if he wants to. It may help him to order his thoughts.) Conversely, the mathematician turned architect can use it too, because each of its stages can be taken to the highest levels of abstraction, if that seems appropriate. But the time may not be ripe to describe a design process in these terms. It will seem so simple, after the mystique that has been building up, that no one will take it seriously, yet.

REFERENCES

1. The development of design method in this country is summarized in four sets of conference papers:
Jones, J. C., and Thornley, D. G. (editors), *Conference on Design Methods*, Oxford, Pergamon, 1962.
Gregory, S. A., *The Design Method*, London, Butterworths, 1966.
Ulm Group 4, *Papers and programmes from the Conference on Design Method in Architecture, Ulm, 1966;* published from Waltham Forest Technical College, 1966.
Broadbent, G. H., and Ward, A., *Symposium on Design Method in Architecture*, Architectural Association Papers no. 4, London, Lund Humphries (forthcoming).
The following summaries may also be found helpful:
Jones, J. Christopher, 'Design Methods Compared' 1: Strategies, *and* 2: Tactics, *Design*, 212, August 1966, *and* 213, September 1966, pp. 32-5 *and* 46-52.
Broadbent, Geoffrey H., 'Design Method in Architecture', *Architects' Journal*, 14 September 1966, pp. 679-85.
Broadbent, Geoffrey H., 'Portsmouth Symposium on Design Methods in Architecture', *Arena/Interbuild*, February 1968.

2. There are brief descriptions of operational research and related techniques with a good bibliography in Hanika, F. De P., *New Thinking in Management*, London, Hutchinson, 1965.
The most useful techniques are described in greater detail in:
Sargeaunt, M. J., *Operational Research for Management*, London, Heinemann, 1965.
Duckworth, E., *A Guide to Operational Research*, London, Methuen, 1962.

3. Sargeaunt, M. J., *op.cit.*

4. Archer, Bruce, 'Systematic Method for Designers', (reprint from *Design*) London, Council of Industrial Design, 1965.

5. Jones, J. C. 'Review of Design Research', *in* Broadbent and Ward, *op.cit.*

6. Best, Gordon, 'Method and Intention in Architectural Design', *in* Broadbent and Ward, *op.cit.*

7. Murray, Alan, and Middleton, Derek, *in* CEGB *Design Guide for Medical Centres;* quoted in Jones, J. Christopher, 'Design Methods Compared – 2: Tactics', *Design*, 213, September 1966, pp. 46-52.

8. Broadbent, G. H., 'Creativity' *in* Gregory, S. H., *op.cit.*

9. Osborn, Alex F., *Applied Imagination*, New York, Scribner, 1963.

10. Gordon, William J. J., *Synectics*, New York, Harper, 1961.

11. Markus, Thomas A., 'The Role of Building Performance Measurement and Appraisal in Design Method', *Architects' Journal*, 20 December 1967, pp. 1565-73.

12. *See* Hanika, Sargeaunt and Duckworth, *op.cit.*

13. Ackoff, R. L., *Scientific Method: Optimising Applied Research Decisions*, New York, Wiley, 1962.

14. Architects' Journal Briefing Guides: 'Church Buildings', *Architects' Journal*, 9 August 1967, pp. 373-88.

15. Asimow, M., *Introduction to Design*, New Jersey, Prentice-Hall, 1962.

16. *See*, for example, Fletcher, T. J. (editor), *Some Lessons in Mathematics*, Cambridge, Cambridge U.P., 1963.

17. Halmos, Paul R., *Naive Set Theory*, Princeton, van Nostrand 1960.

18. Ore, Oystein, *Graphs and their uses*, New York, Random House 1963.

19. Courant, Richard and Robbins, Herbert, 'Topology' *in* Newman, James R., *The World of Mathematics*, vol. 1, London, Alan & Unwin 1960.

20. Alexander, Christopher, *Notes on the Synthesis of Form*, Cambridge Mass., Harvard U.P., 1964.

21. Alexander, Christopher, *op.cit.*

22. Alexander, Christopher, 'A City is not a Tree', *Design*, February 1966, pp. 46-55.

23. Alexander, Christopher, 'The City as a mechanism for sustaining human contacts', *Transactions of the Bartlett Society Volume 4*, 1965-6, pp. 93-136.

24. Alexander, Christopher, 'The patterns of streets', *Architectural Design*, November 1967, 529-31.

25. Daley, Janet, 'Behaviourism' *in* Broadbent and Ward, *op.cit.*

26. Rapoport, Amos, 'Facts and Models' *in* Broadbent and Ward, *op.cit.*

27. Thornley, D. G. 'Design Method in Architectural Education' *in* Jones and Thornley, *op.cit.*

28. Levin, P. H., 'Decision making in urban design', Building Research Current Papers, Design Series 49, 1966: *also* 'Design Process in Planning', *Town Planning Review*, April 1966, pp. 5-20.

29. Royal Institute of British Architects, *Handbook of Architectural Practice and Management*, London, 1965.

30. Broadbent, G. H., *Design in Architecture*, Chichester & New York, Wiley (in preparation).