The Reasoning of Designers

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1. The Universe of Design

It is one of the mysteries of our civilization that the noble and prominent activity of design has found Little scholarly attention until recently. During the last decades this has begun to change (1962 was the first conference on design methods in London[1]). The present conference here in Boston is an indication of a sudden burst of interest across numerous disciplines. Perhaps, the reason is not just intellectual curiosity, but also widespread dissatisfaction with our ability to design the worlds we live in.

Everybody designs sometimes; nobody designs always. Design is not the monopoly of those who call themselves "designers". From a downtown development scheme to an electronic circuit; from a tax law to a marketing strategy, from a plan for one's career to a shopping list for next Sunday's dinner, all of these are products of the activity called design.

The scope of entities designed is vast and the knowledge employed in design is very diverse, ranging through all aspects of human experience. Only if there is some specific commonality between these activities in spite of the great diversity of the objects they deal with, it is justifiable to talk about design in general terms. I contend that there are such characteristic commonalities which demarcate design from other forms of coping with difficulties.

What are these commonalities? All designers intend to intervene into the expected course of events by premeditated action. All of them want to avoid mistakes through ignorance and spontaneity. *They want to think before they act.* Instead of immediately and directly manipulating their surroundings by trial and error until these assume the desired shape, designers want to think up a course of action thoroughly before they commit themselves to its execution. Designing is plan-making. Planners, engineers, architects, corporate managers, legislators, educators are (sometimes) designers. They are guided by the ambition to imagine a desirable state of the world, playing through alternative ways in which it might be accomplished, carefully tracing the consequences of contemplated actions. Design takes place in the world of imagination, where one invents and manipulates ideas and concepts instead of the real thing - in order to prepare the real intervention. They work with *models* as means of vicarious perception and manipulation. Sketches, cardboard models, diagrams and mathematical models, and the most flexible of them all, speech, serve as media to support the imagination.

Design terminates with a commitment to a plan which is meant to be carried out.

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The act of designing could be fun: what would be a more rewarding pastime than to think up some future and to speculate how to bring it about? However, what is troublesome is the recognition that the plan may be actually carried out If so, the designer faces two possible kinds of failure. A *type-1* failure has occurred if the plan does not accomplish what was intended. A *type-2 failure* has occurred when the execution of the plan causes side and after effects that were unforeseen and unintended, and prove to be undesirable. Normally, mainly the fear of the latter type of failure spoils the fun of design: have I forgotten something essential? Designers worry.

Many forms of mental activity take place in the course of design. Designers think more or less coherently; they figure, they guess, they have sudden ideas "out of the blue", they imagine, speculate, dream, let their fantasy wheel freely, scrutinize, reckon, they 'syllogize'. Much of the mental activity (some would say 'most') resides and occurs in the subconscious. We certainly do not understand, and we may never know, everything about all the intricate workings of our mind. But a very significant part of design happens under conscious intellectual control. Since design is; intentional, purposive, goal-seeking, it decisively relies on reasoning.

Studying the reasoning of designers becomes a way of attempting to understand how design happens - possibly the only way. We may not know much about reasoning either, but at least it is not nothing.

2. Design as Argumentation

Are there any discernable recurring patterns in the reasoning of designers? Is there a *logic of design?* Here, 'logic' is not meant in the sense of a formal logic, but as a certain way of reasoning, a 'philosophy' guiding a mode of conduct (as in 'the logic of driving a car', or 'The logic of your argument is odd').

'Reasoning' pertains to all those mental operations we are aware of, can even communicate to others. It consists of more or less orderly trains of thought, which include deliberating, pondering, arguing, occasional logical inferences. Imagine a designer thinking aloud, arguing and negotiating with himself (or with others), trying to explain or justify what he is proposing, speculating about future consequences of his plan, deciding the appropriate course of action.

The picture obtained by analyzing this mental activity is not that of the 'classic' problem solver, who first defines his problem in clear terms, obtains the information deemed necessary, and subsequently searches for a solution in the then well-defined 'solution space'.

The designer's reasoning is much more disorderly, disorderly not due to intellectual sloppiness, but rather to the nature of design problems. There is no clear separation of the activities of problem definition, synthesis, and evaluation. All of these occur all the time. A design problem keeps changing while it is treated, because the understanding of what ought to be accomplished, and how it might be accomplished is continually shifting. Learning what the problem is IS the problem Whatever he learns about the problem, becomes a feature of its resolution. From the beginning, the designer has an idea of the 'whole' resolution of his problem which changes with increasing understanding of the problem, and the image of its resolution develops from blurry to sharp and back again, frequently being revised, altered, detailed and modified. His focus

alternates continually from small component pans, back to the whole problem, and back to other details.

This picture defies description in terms of discernable grand phases of task organization. Only at the microlevel we can identify patterns of reasoning corresponding to recurring difficulties of the process. Over the course of the project, the scope of the difficulties may change, but their nature remains the same throughout

The designer's reasoning appears as a *process of argumentation.* He debates with himself or with others; issues come up, competing positions are developed in response to them, and a search is made for their respective pros and cons; ultimately he makes up his mind in favor of some position, frequently after thorough modification of the positions. In this model of design as argumentation, the various issues are interconnected in intricate ways; usually several of them are 'open' simultaneously, others are postponed or reopened. He finds himself in a field of positions with competing arguments which he must assess in order to assume his own position.

The most frequent typical issues are:

- What is or will become the case?

- What is the reason that something is the case?

- What should be accomplished?

- Which ways are there to accomplish what ought to be accomplished?

At the same time, a whole family of "meta - issues" lures in the background, such as:

Am I dealing with the appropriate problem, or is this problem only a symptom of some other, higher level problem which I should attack instead?

Is this problem too comprehensive to cope with? Should I reduce its scope?

This leads nowhere. Should I start all over again?

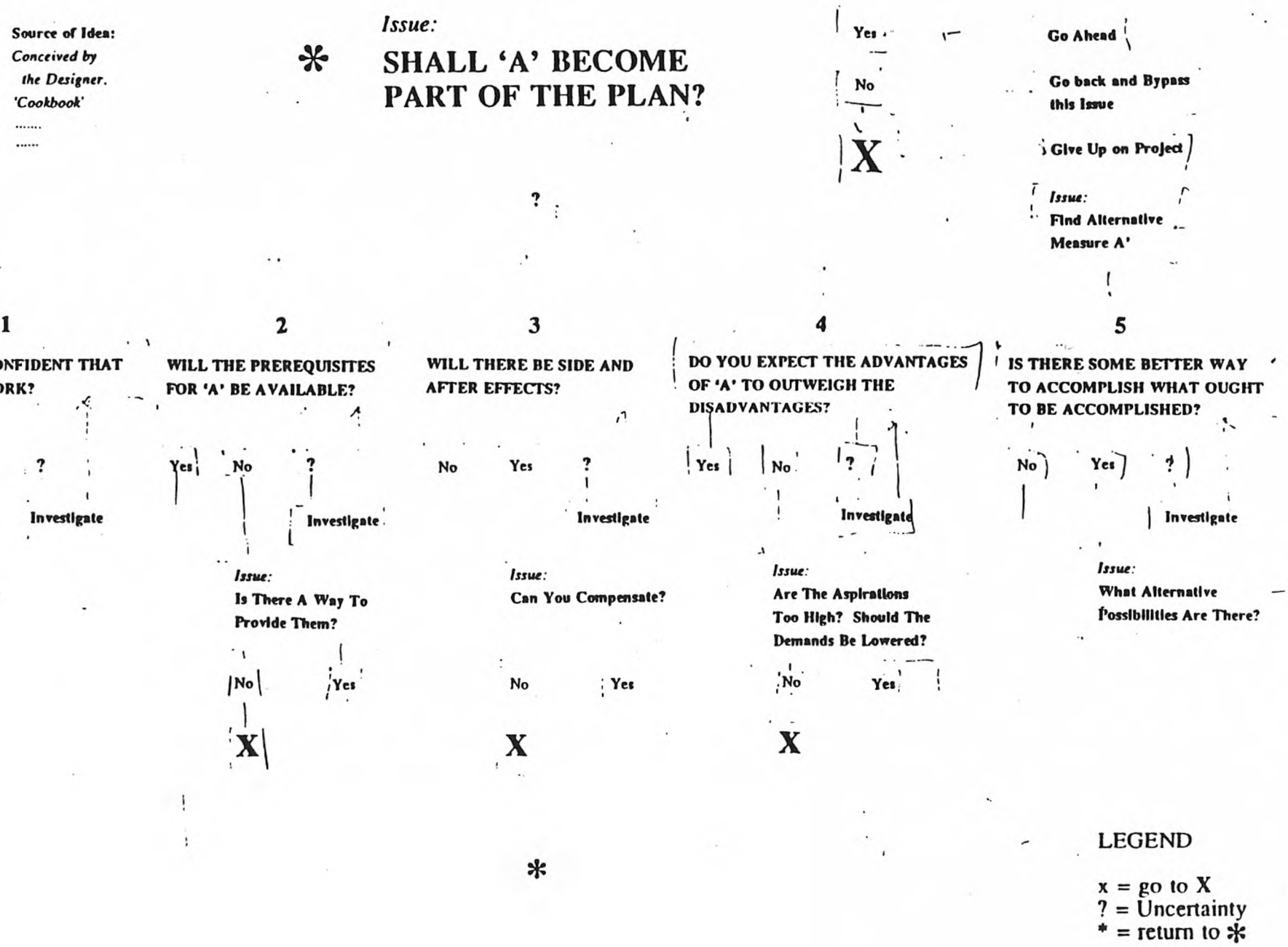
Is it advisable to cut off deliberation now, or should the search and analysis for more solutions be continued?

3. Figures of Reasoning in Design

The fine-structure of reasoning is best demonstrated in terms of a typical recurrent issue.

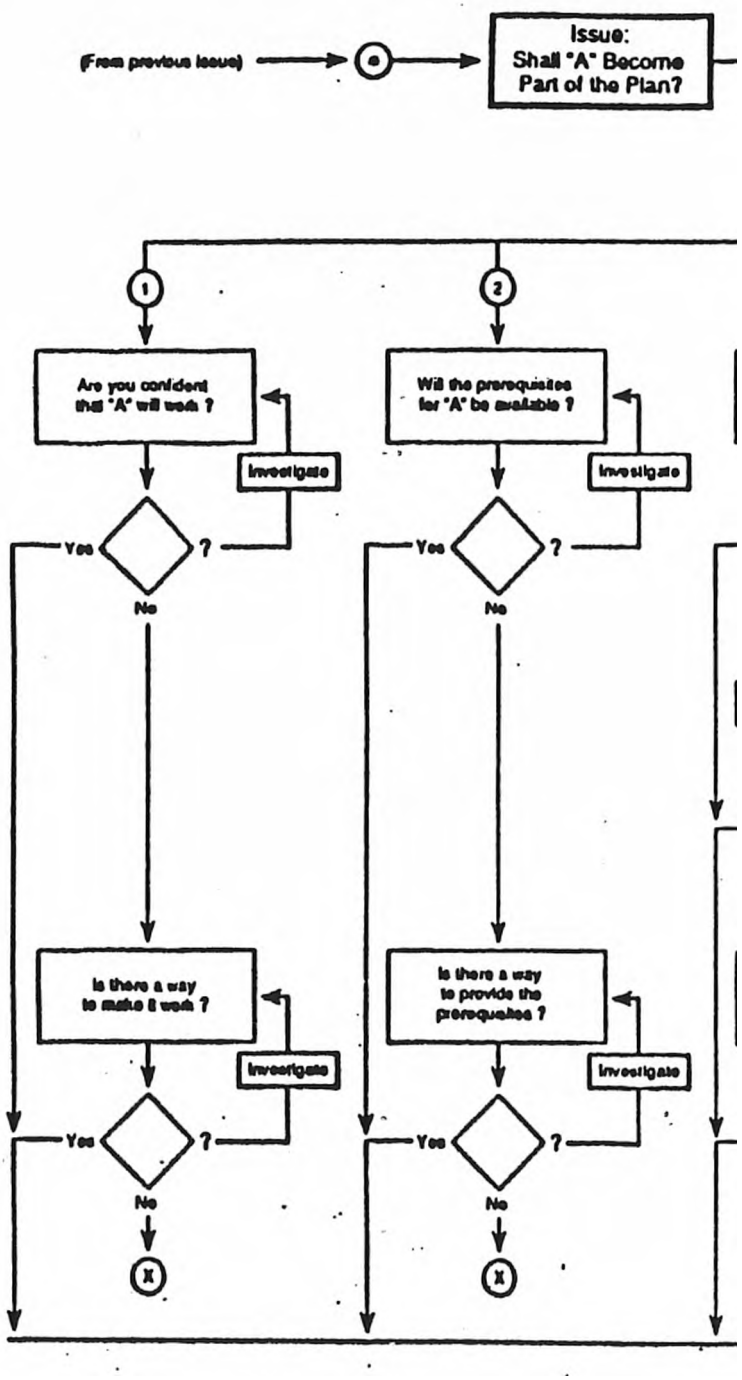
Consider a designer who is contemplating whether a certain measure A (a component, a procedure, a trait) should become pan of the plan. He faces the issue "Should I incorporate A into my plan? ". Fig. 1 shows the (somewhat simplified[5]) web of alternative courses of reasoning in this situation.

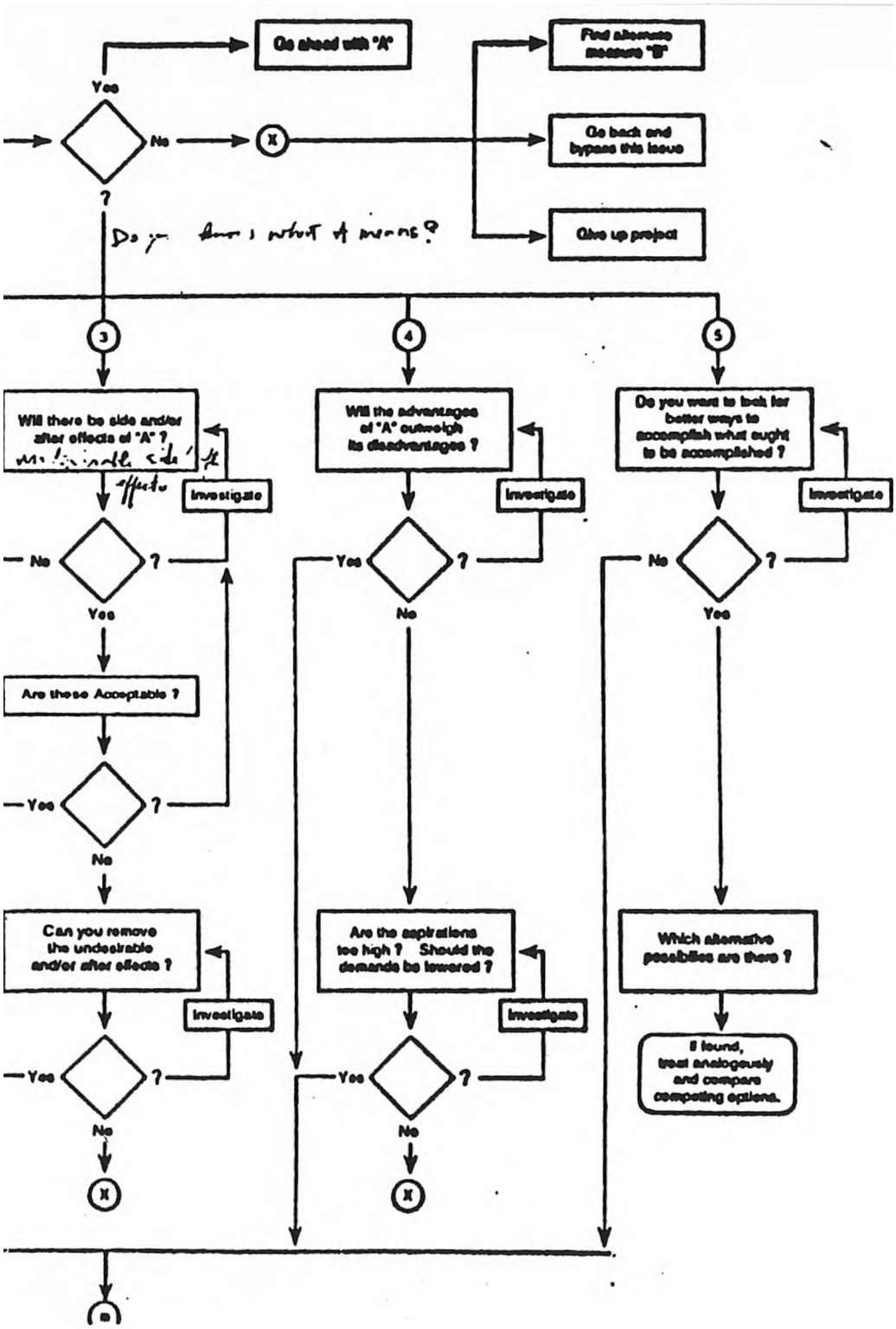
Shall Measure 'A' Become a Part of the Plan?



LEGEND

x = go to X
? = Uncertainty
* = return to *


(From previous issue)
a
Issue:
Shall "A" Become
Part of the Plan?
1
2
Are you confident
that "A" will work ?
Will the prerequisites
for "A" be available ?
Investigate
Investigate
Yes
?
No
Yes
?
No
Is there a way
to make it work ?
Is there a way
to provide the
prerequisites ?
Investigate
Investigate
Yes
?
No
Yes
?
No
X
X


Go ahead with "A"
Yes
No
Find alternate measure "B"
Go back and bypass this issue
Give up project
Do you know what it means?
3
4
5
Will there be side and/or after effects of "A" ?
Investigate
No
Yes
Are these Acceptable ?
Yes
No
Can you remove the undesirable and/or after effects ?
Investigate
Yes
No
Will the advantages of "A" outweigh its disadvantages ?
Investigate
Yes
No
Are the aspirations too high ? Should the demands be lowered ?
Investigate
Yes
No
Do you want to look for better ways to accomplish what ought to be accomplished ?
Investigate
No
Yes
Which alternative possibilities are there ?
If found, treat analogously and compare competing options.

His response to this issue *(*)* may be clearly and spontaneously affirmative and he goes ahead with A. If his judgment is negative, there are three options to proceed (x):

- to abandon A and seek alternative means A' to the same end (which leads to another issue of similar structure).

- to trace back the reasoning that led to the present issue and take another path with bypasses the present issue.

- to conclude - due to frustration - that if there is no resolution to present issue then the whole project should be given up.

Frequently, however, he will be unsure of the appropriateness of A. Then he can ask himself any one of five subsequent questions:

1. "Are you confident that A will work? ", i. e whether A will actually accomplish what it is intended to accomplish.

2. "Will the prerequisites (ingredients, conditions, input states) for A be available? ", i. e. whether A will be actually executable in the context of the present project.

3. "Will there be undesirable side and after effects of A? "

4. "Do you expect the advantages of A to outweigh its disadvantages? "

5. "Is there some better way A' to accomplish what is to be accomplished by A? "

The deliberation of any of these will lead either to abandonment (x) of A or back to (*). If still undecided the same or another one of the questions is to be dealt with. This process proceeds until the designer has made up his mind about the original issue **(*).**

A little journey through this web may help to clarify its significance.

Assume our undecided designer asks himself, whether the prerequisites for employing A will be available (2). If he detects that it is not so, he may either give up the pursuit of A, or he might raise a new issue "Is there an acceptable way B to provide the missing prerequisite? ". This issue is treated in a similar way while (*) is dormant. Let us assume that perhaps after extended deliberation (possible diverting through several other subordinate issues) he has found an acceptable measure B. He returns to (*) and might find himself still uncertain about the appropriateness of A.

This time his uncertainty might pertain to A's side and after effects (3). Assume that he detects some consequence of A which he judges very undesirable. His pondering of pros and cons will lead to make up his mind whether.

- to "live with this consequence", perhaps unhappily (back to (*));

- to search for some measure C which alleviates the ill effect (thus raising the side issue of finding such a remedy);

- to reject A because of this effect (go to (x)).

Etc., etc. In any round of deliberation, he may ask himself whether there is not a better way than A to accomplish the same ends (5) and proceed accordingly.

This description has been deliberately abstract in order to underscore the claim that there are universally recurring difficulties and ways to cope with them. Any number of examples can be easily found in any realm of design.

4. Epistemic Freedom.

This exemplary analysis shows the argumentative nature of the designer's reasoning. The process appears as one of formation of judgement, alternating with the search for ideas. The understanding of the situation changes with the alternatives seen in pursuit of the plan. Different facts and different ought-to-be questions come up depending on the means to accomplish these ends.

It also shows that all deliberations terminate with judgments ("Good enough! ", e. g.) which may be 'based' on the deliberations, but are not derived from them. Looking at the various pros and cons, the designer has 'made up is mind'. How this happens is beyond reasoning.

The analysis reveals the awesome *epistemic freedom* in designing: there are no logical or epistemological constraints or rules which would prescribe which of the various meaningful steps to take next. There are no 'algorithms' to guide the process. It is left up to the designer's judgement how to proceed. There is no - logical or other - necessity to want or to do something particular in response to an issue. *Nothing has to be or to remain as it is or as it appears to be;* there are no limits to the conceivable. There is a lack of 'sufficient reason' which would dictate to take a particular course of action and no other.

It is not easy to live with epistemic freedom, therefore many designers are grateful for what the Germans call 'sachzwang'. It is a device to 'derive ought from fact'. [6] For example 'Because 58% of the population say they want a freeway, I shall seek to provide it". Or "Since the demand for electricity is increasing by 7% per year, by 1995 we must build new 8 nuclear power plants by then". Obviously, these are fallacies. If demand threatens to exceed supply, you might also try to reduce the demand. The hidden deontic premise in the first example is "Thou shalt give all the people what the majority say they want" - a debatable principle which certainly does not *follow* from the facts. Nevertheless, 'sachzwang' is very popular among politicians and planners, because it reduces the epistemic freedom and releases the designer from responsibility. He has no choice.

5. The Varieties of Reasoning in Design.

How does one explain the huge variety of styles of designing? Why are design products for seemingly very similar situations so vastly different?

The preceding considerations should have demonstrated that the course of designing depends decisively and at every step of reasoning on the *world view* of the designer. There is no neutral, objective design. *Design is subjective.* Of course. Why shouldn't it be?

What the designer knows, believes, fears, desires enters his reasoning at every step of the process, affects his use of epistemic freedom. He will - of course - commit himself to those positions which matches his beliefs, convictions, preferences, and values, unless he is persuaded or convinced by someone else or his own insight Design is associated with power. Designers plan to commit resources and thereby affect the lives of many. Designers are actors in the application of power.

Take a few examples. An important aspect is the division of phenomena into *changeables and invariants.* Whether somebody regards The Building Code as an immutable given, as a source of rigid constraints to abide by, or whether he considers its regulations as negotiable claims (you can always seek an exception!) makes a great difference for the range of resolutions that might be considered. Some people see gravity as an inescapable fate, while others try to invent anti-gravity devices or put their production lines into outer space.

Constraints are decided, selected, and self-imposed, and not implied, derived or logical necessities. Every constraint what the designer does not want to change.

Another source of variety in design are the *guarantors* used by designers as unquestioned, sources of reliable knowledge. It can be tradition ('We have always done it this way'), the state of the art ('Nowadays, we do it this way'). It can be science, common sense or the spirit of progress. Sometimes it is conscience, gut feelings, or revelation.

Obviously the designers outlook on life, and his personality traits, play a significant role. Thus an optimist will often assume that "It will work! ", and proceed accordingly, while the pessimist is constantly nagged by the suspicion that "Nothing works as intended". The role of hope, self-confidence, and courage on the designers reasoning is apparent

It is no wonder that every designer wants to sell what he knows best Thus an architect will hardly ever discourage a client from new construction, and a real estate agent would suggest looking at the buildings. This is a problem of the predominant aspects. An economist sees only problems, an engineer sees only engineering problems, and a manager only managerial problems, while all the other aspects remain in the background to be dealt with later (if at all). [7] But design problems are usually all-encompassing and don't fit neatly into pigeon-holes of the professions.

The question 'What ought-to-be accomplished? ' is easy for some. They *know* what is good for mankind, and for you and me specifically, while for others this is a most tortuous question. Some see their peers as their predominant audience, others put themselves before the judgment of history, others are satisfied with pleasing their client, and still others want to be loved by everybody.

What has been called 'cognitive style' [8] in design can be analyzed in similar ways. Some start with the issue "What shall the whole thing be like? ", while others work from the bottom up, starting with "What shall the parts and components of the thing be like? " Some like to dash into depth pursuing a particular aspect, while others work

'breadth first'. [9]

It is easy to compose the worldviews which guide the common caricatures of designer types, such as the 'MASTERMINDER', the 'TECHNOCRAT', the 'BUREAUCRAT', the 'VISIONARY', and so on.

Fortunately for all of us, most designers don't succeed in shaping the world their way. Design takes place in a *social context.* Virtually all plans affect many people in different ways. Plan-making aims at the distribution of advantages and disadvantages.

No plan has ever been beneficial to everybody. Therefore, many persons with varying, often contradictory interests and ideas are or want to be involved in plan-making. The resulting plans are usually compromises resulting from negotiation and the application of power. The designer is party in these processes; he takes sides. Designing entails political commitment - although many designers would rather see themselves as neutral, impartial, benevolent expens who serve the abstraction of 'the common good'.

6. Science of Design?

Do these consideration about the nature of reasoning in design render the attempts to develop a science of design futile? Not at all. On the contrary, our abilities to design or to shape the human condition are not so perfected that we can live comfortably with the usual ways of muddling through, and ignore the difficulties of the activity of design. The economy, environment, international affairs, our institutions, and the world of artifacts surrounding us all suggest that the art of design leaves much to be desired. Besides its intellectual appeal (what could be more fascinating than studying peoples ways of shaping their futures?), the science of design might even prove to be useful. Even if it helps us to find out only how NOT to design.

The science of design has three tasks. First, to further develop the theories of design, to learn more about the reasoning of designers. Secondly, it should pursue empirical inquiries into how plans come about, and what the effects of plans are in comparison with what they intended. Finally, on this basis, it should look for tools to support designers in their work. The human mind is fallible. Methods should be sought to amplify its abilities, even if its only to keep us from falling prone to our idiosyncracies. -

Even if such remedies cannot be found easily, can we afford not to keep searching?

Footnotes

[1] The proceedings of this conference are documented in Jones (1963). It is interesting to compare the issues of that conference with those at the present conference.

[2] This is only a thought experiment, assuming that the designer is telling the truth, does not attempt to construct ‘post facto rationalizations’ for his decisions, etc. If used as a practical research method, many obstacles have to be taken into account: ‘mental reservations’ of the talking subject, the effects of ‘talking about what you think making you think about what you talk’, etc.

[3] Design problems (which can be called ‘wicked problems’) have specific difficulties which make them different from ‘tame problems’. For a discussion of wicked problems and their characteristics, see Rittel (1973), or Rittel (19??).

[4] A information system to guide and to monitor the process of argumentation and to administer the evolving network of issues has been developed called IBIS, for Issue Based Information System. Computer controlled versions of this system have also been realized. Further readings about the structures and uses of IBIS can be found in Dehlinger and Protzen (1972), Kunz and Rittel (1970), Kunz and Rittel (1973), McCall (1978) and Reuter and Werner (1983).

[5] For the sake of legibility some less frequent though realistic options have been omitted, such as "Giving up ‘A’ because one cannot sufficiently remove the uncertainties associated with it", "Accepting ‘A’ in spite of doubts in its workability (Let us hope that it works!)", etc.

[6] Rittel, Der Sachzwang - Ausreden fuer Entscheidungsmuede, Institut fuer Grundlagen der Planung, Universitaet Stuttgart.

[7] Darke, The Primary Generator and the Design Process, 1979

[8] Cross, The Relevence of Cognitive Styles in Design Education.

[9] McCall, On the Structure and Use of Issue Systems in Design, 1978.

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