Experiences with a new approach to innovative projects

Experiences with a New Approach to Innovative Projects

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Summary

Methods hitherto used throughout the world by designers of production machines are inadequate to meet the growing need for a reduction in running time required for the process of innovation. This, aggravated by the necessity for greater overlap of activities, raises uncertainty as to the desired specification of the design intended.
The design proces has therefore been reconsidered and a new, apparently fairly simple "project strategy" formulated on the basis of the "Oriëntation", "Decision-making" and "Execution" triad. Known methods can be integrated within such a strategy.
Some years of experience have now been acquired,as the method has also been introduced into the mechanical engineering curriculum, particularly at the Eindhoven University of Technology, in the form of lecture courses and practicals in the later years of study, as well as in the research tasks performed for the final examinations and is also beeing introduced in industry in a number of its own pilot projects.
The strategy is basically adjusted to the daily practice of the designer, but also embraces larger projects in a complex situation.
Although project strategy seems very simple, its application can only be succesful when the engineer has had the opportunity of acquiring the necessary experience in an early stage of his design studies.

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1. Introduction

A project is a complex of decisions and activities with the object of realising an already roughly defined target at a predetermined time. The decisions and activities are related to one another, and this has been made evident in the structure of the project. Discrete projects often show a same structure.
These project structures have, in the course of years, crystallised out within enterprises, becoming fixed procedures and suborganisations (departments), each responsibele for a certain part of the decision-making and the activities within the project.
One then speaks of routine work instead of projects. Projects which are largely new are often found to lead to considerable deviations from the result originally intendend, both as to technical specifications as well as date of delivery and project costs.
Competition obliges enterprises to shorten the throughput time of their innovative projects. Likewise, the result of these projects must, as far as possible, meet the upcoming or existing demand from the customers who are to be served. Both the setting of the target of the project as well as finishing it in time are thus essential to the result of the enterprise.
If the throughput time of innovative projects has to be shortened, decisions as to product and means-of-production specification have to be taken in an different sequence than usual and at a higher speed. The shortening of the throughput time also makes it necessary for more people to have to make their contribution simultaneously.
Larger enterprises often have their development departments rather widespread geographically. Cooperation of these departments in a project makes good decision-taking difficult. The new project structure which is required for the short throughput time makes it difficult to fit these projects into existing organisations.
The literature on design methods and project organisation provides a number of valuable techniques for part processes within a project (decision-taking, problem-solving....).
A universal method for approaching a project as such, so that the shortest throughput time can be obtained at the lowest costs was never found, however. The need has therefore arisen to rethink the approach to innovative projects still again. What has to be sought is an approach which can be applied not only for very big, but also for very small projects and one in which the techniques developed up to now for finding solutions to problems, taking decisions, etc. can be integrated. The area of activity of the mechanical engineering designer was taken as the starting point. The development was carried out in consultation with about 20 designers, senior designers and project engineers, and was then tested on a large number of projects, during which time experience was gained through the work of about 30 students in their last year of study at the Eindhoven University of Technology.

2. General project structure

Figure 1 shows the simplest project structure for any project, irrespective of volume. The simplest exploded view of the "project" block leads to the general project structure shown in figure 2.

The result of the "orientation" part project in figure 2 will have to include all the data required for "decision making". The plan will be put into execution in the "execution" phase. A further exploding of the "plan" is given in figure 3.
The plan contains part projects, each of which can be separately approached in the execution phase according to this same "orientation-decision making-execution" triad.
A number of observations can be made at this point.
In order to control a plan properly
- the interfaces between the part projects must be well defined,
  the relationship with completely different projects must be laid down,
- the results of the part projects must be tested as to whether they meet the specifications or not.

How far one has to go with detailing the plan is a matter of the underlying strategy. The more detailed the plan, the longer it needs to make it, but the less has to be done in the part projects. An optimum strategic choice in this matter can be made, for instance, in aiming at shorter throughput time and lower costs.

3. Method and strategy

The general project structure of figure 2 leads to a method and to a strategy.

3.1 Method

The general project structure applies to each project and each part project. For that reason this must also apply to the part projects "orientation", "decision making" and "execution". "Exploding" these part projects bring about new triads and in theory goes on to infinity. In reality it will only go on until the moment the part task aimed at can be approached in the "best" way arising out of experience, training or research. This dilemma, which occurs in fact in every thought process, is overcome by planning in the part results at times laid down in advance, so that the pressure of time is given no oppurtunity for involvement in endlessly long, more and more detailed reflections as to how to make an approach, approaching the approaches to this, etc.... and a decision is taken on the approach which is then planned-in during the time allowed.

Figures 4, 5 and 6 give the first exploded view of orientation, decision making and excecution respectively. This first exploded view is in general adequate and leads to good project results. In fact, these results illustrate the method. In what follows, the three part projects O, D and E are described. Each part activity can be followed by a check. This check can be carried out by the person carrying out the project, but it is advisable to find the person (s) who can make the proper input. See figure 6.

3.1.1 Checking

The contents of the check is as follows (fig. 7):

a. Checking
- whether the part process has functioned properly
- whether the result of the part process falls within the standards laid down.

If the test is failed (F) the part process must be gone through again. If necessary, the emergency brake (EB) has to be pulled: the result of the part process is such that carrying on is not justifiable.
Redefinition of the project is then required. This can be understood in the negative as well as in the positive sense (unexpected chances!).

Participants in this part of the test are
CUSTOMERS ! - from the previous part processes
and
- from the following part processes

b. Feedback
The results from the part process can lead to adjustment of the used capacity or provision of better means, so as to achieve better results in later projects.

c. Feed forward
Check whether the correct capacity has been set up for the subsequent part process and that it is provided with the correct means.

The executors of the finished part process and the leaders of the executing department(s) of the subsequent part process have to supply the input for b and c of the test.

N.B. The effect of a test can be that the work that has just been finished has to be repeated in part! This means that the planning of the project must take this into account, and ensure that the time at which the result under test is first made available, is long enough before the start of the part process following it.

3.1.2 Orientation

The results of the orientation process serves as input of the subsequent planning process (fig.4). This means that the more precise definition of the task and the further data becoming available will have to be sufficiently detailed for the decision making process it is intended to carry out. If this is not realised adequately, then impulses will come in to replace the data still required, and this will cause an unintended loop in the scheme.
The degree of detail in the project structure which the plan will present thus helps to decide the required degree of detail of the orientation process. The strategy for this is a matter for research, but the problem has to be brought up at the beginning of the orientation process. Paragraph 3.2 deals with this in detail.

3.1.2.1 Asking questions

The questions which have to be generated during orientation could be taken from an extensive checklist. Experience with these check-lists is not very favourable; mostly they contain questions which are not too relevant, so that relevant questions are often overlooked and not put; the length of such a checklist makes one assume that this list is complete. This is never quite certain. Experience with the following random questions which stimulate creativity is favourable, on the other hand.

Random questions

- What precisely is the objective of this task?
- What is the result aimed at?
- What problem must actually be solved by this task?
- What are the possible causes of this problem?
- What are the limits of the system?
  . with regard to the task,
  . with reference to the result.
- Who are the customers in the framework of the present task?
- Are there any links with other projects or organisations?
- What are the criteria for the execution of this task? (requirements; wishes; weighting factors)
  . with reference to the task
  . with reference to the result.

- Is the quality of the data obtained good? (Always check information given willingly. Perhaps your question has not been properly understood!).

3.1.2.2 Decision making and Execution.

The activity speaks for itself. However, it is of importance to study in advance how decision making and execution will be described later, so that these activities can be tackled the same way again .

3.1.3 Decision making.

The result of decision making is the input for its execution (fig.5). That means that, during decision making, the original singular task has been split up into u number of small coherent tasks. The result, for example, can take the form of a more detailed project structure, but also of a design of a machine or building, in which the modules are the parts to be worked out after the decision making has been done. The number of steps and the degree of detail of the new part tasks defined after the decision making, form part of a strategy-question: how big must a step in a plan be?

3.1.3.1 Searching for possiblities

Techniques which are pre-eminently intended for the process of finding technical solutions to problems, but can also be used for generating project structures are:
- Brainstorming
- Written brainstorming (write down in five minutes everything that comes into your mind relating to this part problem)
- Setting up tree structures
- Tapping information systems
- Making a morphological scheme
- Literature research.

Training in applying these methods is part of the training of the executor of an innovative process, so that sufficient insight is available for choosing the correct method of dealing with the problem in hand. Examples can be found in literature (1, 2).

3.1.3.2 Making a choice; the risk analysis

From the possibilities that have been discovered one choice must now be made. Choice techniques are well known literature (1, 2, 3). What is important is following the correct strategy: by making use of the choice criteria derived from the orientation you can first make your choice. This is followed by the risk analysis, by means of which external causes which can frustrate the project are sought out. Adequate techniques for this are also known literature (3). After this analysis the chosen solution to the problem can be adapted by taking the proper measures.

3.1.3.3 Making a specification, analysis of the chance of failure

This includes specification of the new part projects in the case of a project structure; taking the subsequent design step in the case of a design. The aim should be to obtain a precise interphase consensus between the new part projects (in fact an important part of specification) so that, if need be, the parts projects can be executed independently of one another. After this we come to the analysis of the chance of failure. in the case of every part project occurring in the plan, or module specified in a design, we must work out what the unfavourable effects will be in the case of failure of the different functions. The chance of failing is estimated and included. Depending on the product of that chance and of failing, as well as the seriousness of the consequences, the part projects or modules are adapted if necessary.

3.1.3.4 Execution

The part steps of the execution process shown in figure 6 are so self-evident that they require no further explanation.

3.2 Strategy

The method as discussed up to the present can be compared with other known methods, such as project phasing (project structure). That is done in figure 8. In this way the method can also be applied. In the design of a machine, the "decision making" can be regarded as making a design, and "excecution" as carrying out all the tasks that lay between design and delivery of the machine. Fruitful use of the method can indeed be made in this way. Just as in other project-phasings, one struggles with the problem of definition. For example: why does one regard the design as "decision making"? Is detailing the design actually not "execution" of the design? How does preparation of the machine fit into the picture? Such definition problems keep cropping up in ever faster innovation, so that communication between the persons concerned deteriorates.

But there is still a different application of the method. This is sketched out in figure 9. Orientation and decision making processes lead to a plan that is put into execution. The preparation of this plan is the first step in the whole project. All subsequent steps belong to the process of execution, in which the structure of the project is planned with time. These steps are new part projects, the interphases of which are precisely stated in the plan.

An interesting question arising now concerns the number of parts into which the part project "Execution" must be divided.
For each subsequent part project the same question applies again. In order to get any kind of grip on the matter, a project is put forward as a big undefined mass which lies before us. The outside of this mass must still be defined (orientation) and a first division into part projects must take place. Between each of these part projects the mutual relationship (interfaces) must be laid down.
Criteria for the best step-sizes are the following
- short throughput time for the whole project
- low capacity requirement

The following are taken as relevant decision magnitudes in time which are required for taking one decisionforming step (fig. 10):
- the number of potential final decisions to be taken in the project under consideration (the volume or complexity of the project); by "final decision" we can, for example, understand the following:
  - a measurement
  - a tolerance
  - a choice of material
  - a statement (software)
- the factor by which the project is split up into part projects.

In a division according to the ODE approach one step can be divided into the following three parts with the given step times. See fig. 11.
The total time for one step is
$T_s = T_{s_1} + T_{s_2} + T_{s_3}$.
If work had been done on projects for some considerable time consciously using this manner of treatment, then $T_{s_{1,2,3}}$ could have been measured

and perhaps an algorithm developed for the time span required per step of the project. This could have led to the most favourable part-factor d and a precise plan for the project based upon the number of estimated potential final decisions N. If, in the case of the first steps, considerably more or less time were found to be required than was calculated by means of the algorithm, this could have led to the estimate of the numeral N and then to adjustment of the plan. These measurements are however not available and the algorithm isn't either. We now suggest continuing the investigation as follows.
The following approach is taken for the form of the algorithm searched for:

$T_{s_1} = a(n)^p$

- The length of time needed for the orientation is seen as proportional to the surface of a more-dimensional sphere with contents n. Here n is a measure for the size of the project. The proportionality constant is a.

$T_{s_2} = b(d.n)^q$

- The degree of difficulty for this step will increase the size of this partproject and the number of divisions (d) that have to be carried out simultaneously.

$T_{s_3} = c.d.(\frac{n}{d})^r$

- The main activity is the specification of the part projects. The formula is therefore analogous to that for T_{s_1}.

The investigation now aims at finding the values of the parameters a, b, c, p, q, r for different project environments. The first indications we have found give us hope of good results. If a good approach to these parameters is found, the algorithm can be examined, for instance for lowest costs of carrying out the project, or as to the shortest throughput time for the project. Both these aspects of projects have attained great importance at the present time.

4. Experiences obtained in training engineers with the aid of project strategy

4.1 Why?

Experience with young engineers after their traning is that they require years to learn a good project approach.
During their training they have generally obtained knowledge of project strategy and design methods but these are either not used or badly used. The result is again, however, that they have to learn by trial and error how to tackle projects. It takes most of them at least five years to realise that a methodical approach is a sensible thing. After that, however, they no longer have the time to consider this carefully and they take up whatever method happens to come to hand. Usually, after that period, these engineers carry out management functions, so that the work on a smaller scale that they have done for the first five years has nothing more to do with them. They discover that younger engineers to whom they have to give instruction don't work systematically either, although they should have learned to do so. In that way history repeats itself. The problem is therefore that young engineers are certainly taught methods but don't apply them as if it were second nature. A possible solution to the problem is to teach the method of working as outlined here under the heading of "project strategy" at an earlier stage in their training and bring up the young engineers in such a way that, at the end of their studies, its use has become a sort of second nature. There is a great chance that everthing that they will then take up will be dealt with systematically and that the methods they apply in their work will be sound and mature. This good start will be a contribution to making their early years of practice more significant and go far to make their subsequent work still more valuable, so that engineering careers will develop at a considerably higher level.

4.2 Method of work

In the 4th year course on "Special Subjects in Production Automation" a start was made in the university year 1986/87 with two hours of lectures on project strategy, after which every thematic cluster within this course was dealt with as a project.
The main purpose of each of these projects is to obtain the required knowledge, the subsidiary aim being practical work with project strategy.
A mentor is allocated for each cluster by the University of Technology. This mentor has to state in advance what periods of time are probably the best for the orientation, decision making and execution. The student orients himself on the cluster, makes a plan, discusses this with the mentor who, if necessary, puts forward suggestions in order to adjust the plan, and after which the student carries the plan out. If the student finds that he can handle the cluster sufficiently well, the mentor tests him and rewards his efforts with the appropriate numerical mark.
In the instructions given to the student as for orientation, apart from the foregoing random questions they are told in addition to ask themselves the following:
- what is the relationship of this subject to my previous studies?
- what is its relation to my future profession?
- what must I know about it?
- what must I be able to do with it?

The student must then, after this orientation, in principle be able to roughly formulate good test questions and process them in his plan.
The plan for instance lays down how parts of the clusters are to be studied,
- what part is only studied in its main points,
- what is learned by way of test practicals so that the necessary knowledge is in fact obtained,

together with further activities, such as
- the setting up of tables, preparation of graphs which illustrate the essential part of the subject,
- the decision to study this cluster completely on one's own, or with two or three other candidates at the same time, with the appropriate division of tasks.

It is thus characteristic that the student first of all looks at the subject matter from outside, makes a plan and then gets down to work. Of the total time taken, about five per cent went on the orientation and ten per cent on making the plan. Even the test questions that they set up themselves had to be dealt with in the end by way of the project strategy!
In the fourth year follows a research task requiring 400 hours of work and a final-study requiring 1100 hours. The final-study task is often carried out in industry. In general, it deals with a task in the field of mechanisation, in which the economic, ergonomic and process-technological aspects must be taken into account

as well. The task in general ends up with a constructional design of a part of a machine. The research task has the same character but is of lesser volume and in general is more constructionally oriented. The students are set the task of preparing their final study with the aid of the project strategy that has been described and must have their first plan ready within three or four weeks after they start. They carry out the task strictly according their plan. Before the plan is put into execution it is thoroughly discussed with the industrial mentor and the tutor at the university. Information is given as to when what tests will take place and who will be present. The same method applies to the research task, but now the student has to have a plan ready two to three weeks after the start.

4.3 Experiences gained

General impressions
Meantime more than 30 students have rounded off their final studies using the described project strategy. The first were confronted at the end of 1985 with project strategy when they started their final study task and others when they started their research task. At that time there wasn't anything more available than a stencil in which the method was described. These students hadn't followed any lectures courses in the subject. The"strategy" part hadn't been developed yet. The students faithfully made out this plan as they were told and then worked according to plan. The method they worked by was often used as a project phasing, with the specific definition problems that went with it. Ideas on "strategy" hadn't been developed yet! Nevertheless most of them are witness to the support which working to plan gave them.
The scepticism in enterprises was generally pretty great, but in most cases this changed, thanks to the good results obtained by the students. Not one of the students was found to be "floating" during the first part of the finishing period, as is so often the case in final-study tasks. They all worked objectively from the beginning.
In order to evaluate the approach, all students and all mentors have been asked about their opinion of project strategy. The mentors are in a position to state what the differences are compared to earlier times. But even the students have a well-founded opinion, because this project strategy could well have been thoroughly relevant a turning point in their student life.

5. Conclusion

The proposed manner of working clearly provides better study results even in the present running-in phase and while still looking for a final form. It costs the mentors to begin with much more time but this is partly made good by the more efficient support in research tasks and final-study tasks. It is also found that the student who has already worked with project strategy at the lecture on "Special Subjects" tackles his research task in a more professional manner.
Finally:
- the method of project strategy makes for better results in study;
- the need to start with project strategy earlier on in the curriculum is becoming increasingly apparent;
- students are more "adult" when they, as young graduates, are about to embark on their profession.

Literature

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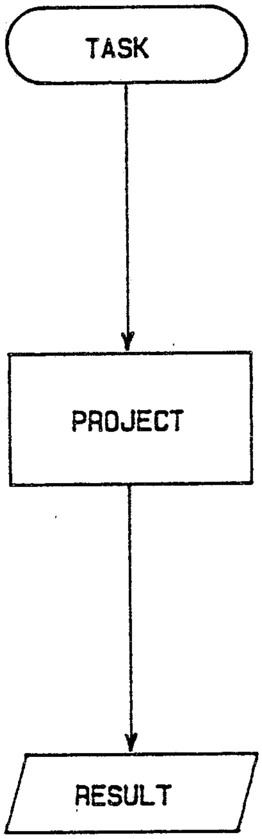

Fig.1 : SIMPLEST PROJECT STRUCTURE

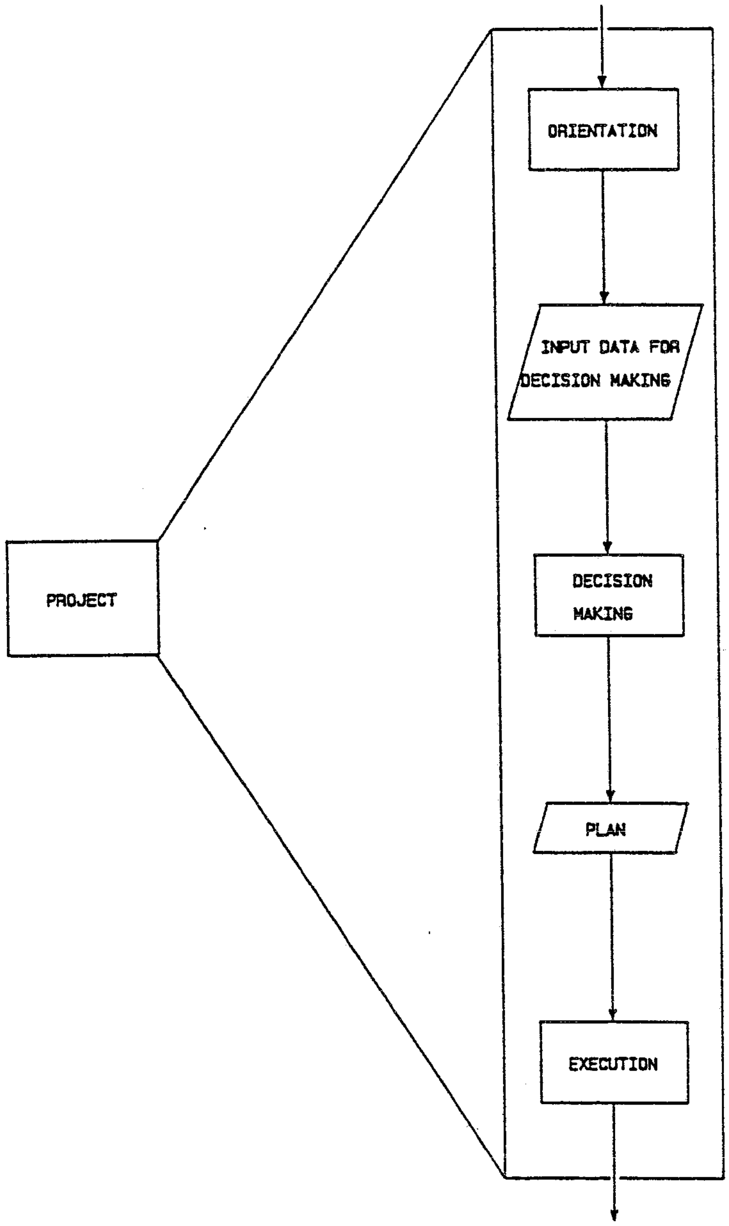

Fig.2 : GENERAL PROJECT STRUCTURE

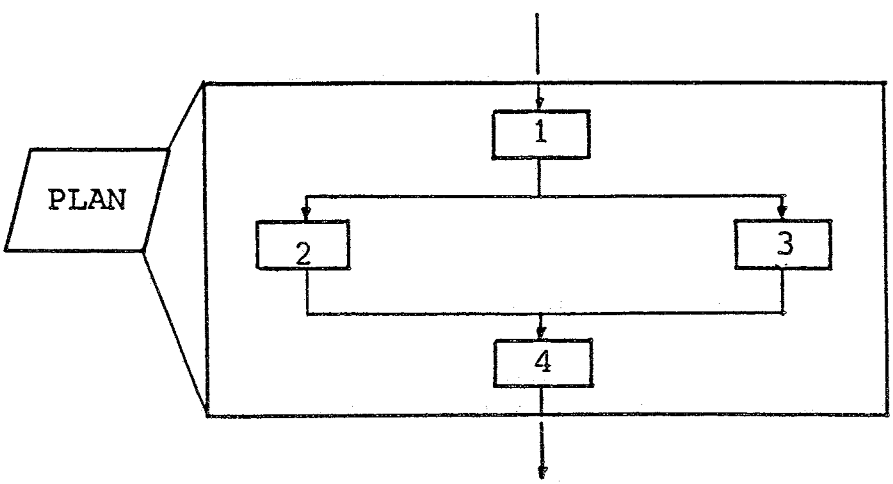

Fig.3 : AN EXAMPLE OF A PLAN WITH PART PROJECTS 1,2,3,4

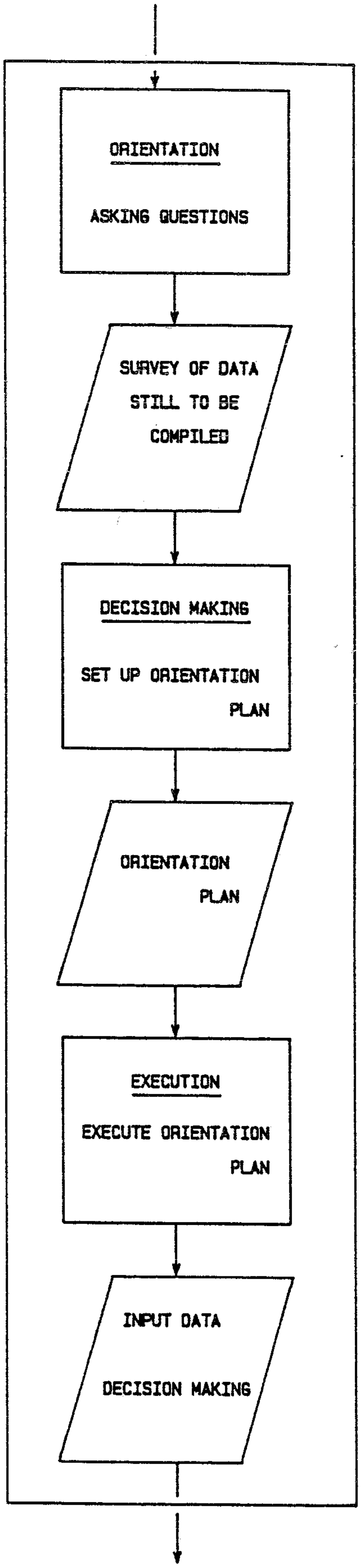

Fig.4 : ORIENTATION

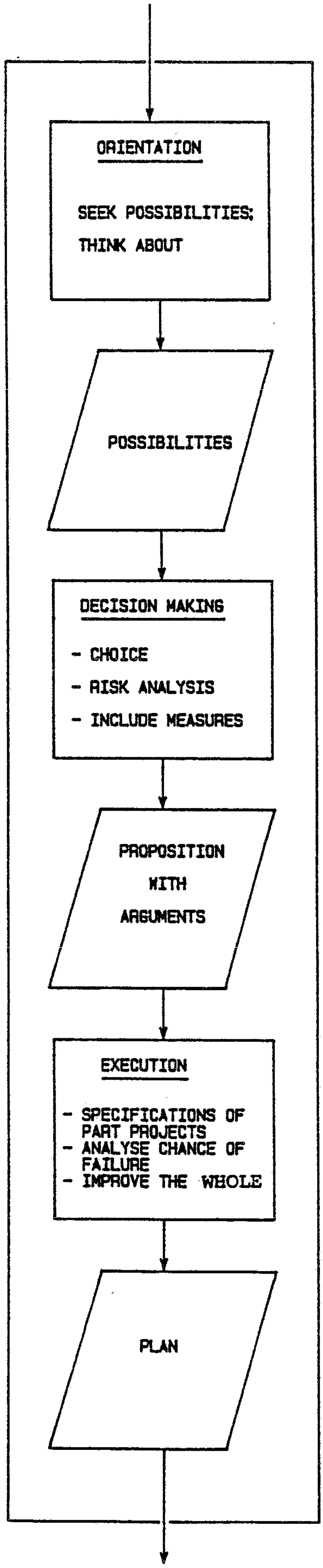

Fig.5 : DECISION MAKING

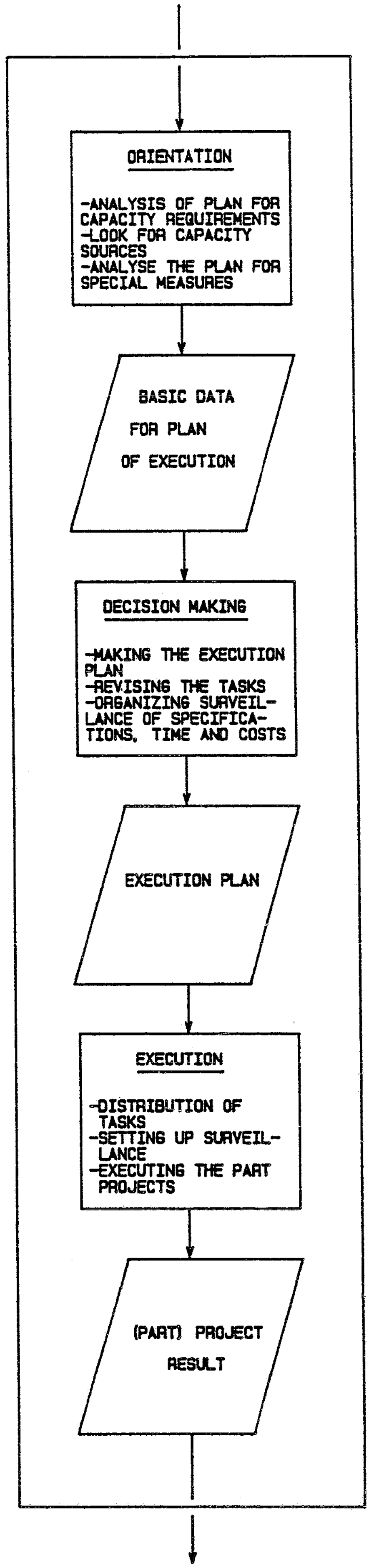

Fig.6: EXECUTION

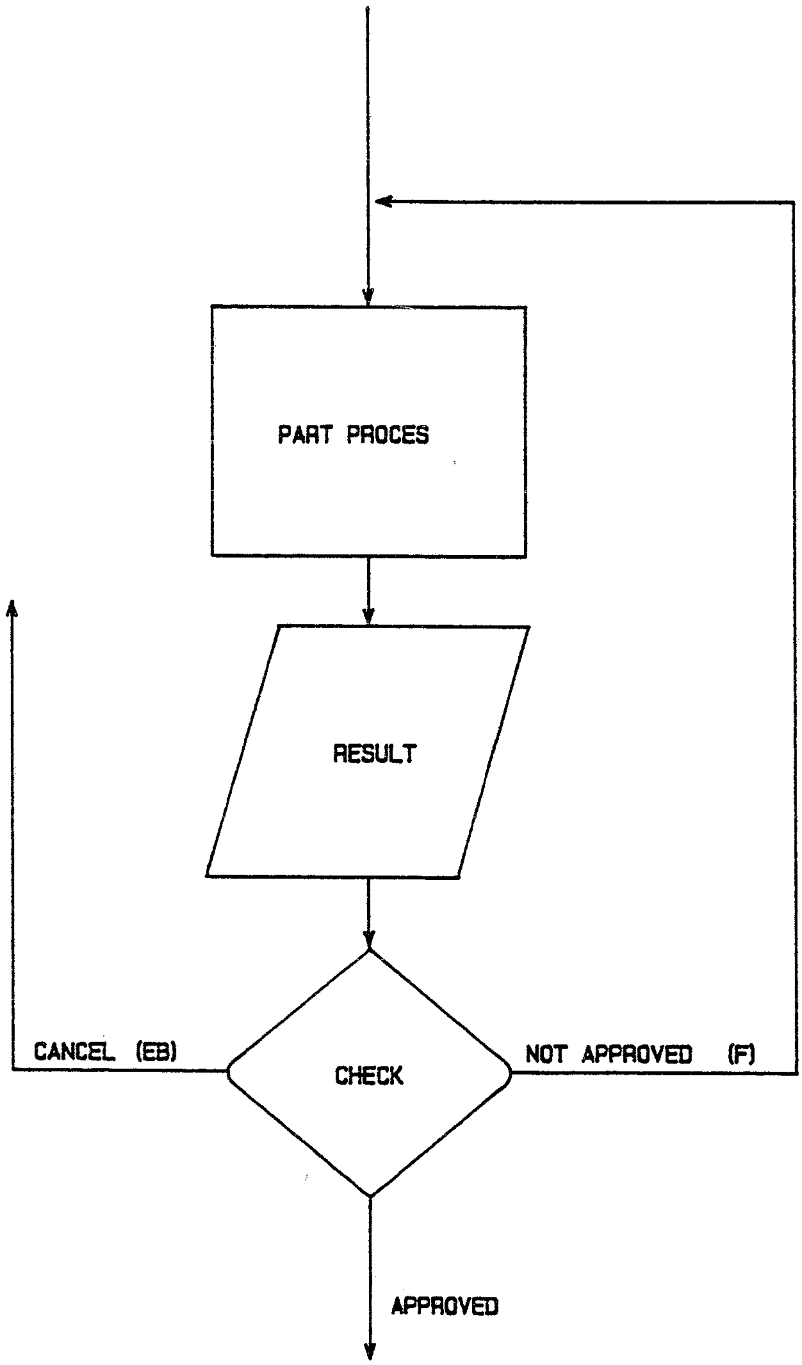

Fig.7: CHECK

Kepner, Tregoe

Situation Appraisal	Problem Analysis	Decision Analysis	Potential Probl. Analysis	

F.Hansen

Vorüberlegung	Kombin. von Lösungselement.	Fehler Kritik	Wertigkeits Vergl.	

K.Roth

Aufgaben Formulierungs Phase	Funktionelle Phase	Gestaltende Phase	

Systemtechnik

System Studie	Ziel Programm	Syst. Synt.	Syst. Anal.	Syst. Bewertung	Syst. Entschei dung		Systemsausführungsplanung	

R.Koller

Funktionssynthese	Qualitaets Synthese	Quant. Synth.	

Value Analysis

Information Phase	Analyt. Phase	Creat. Phase	Evaluation	Presentation-	Implementation

Orientation			Decision making			Execution		
O	D	E	O	D	E	O	D	E

Fig.8: PROJECT PHASING

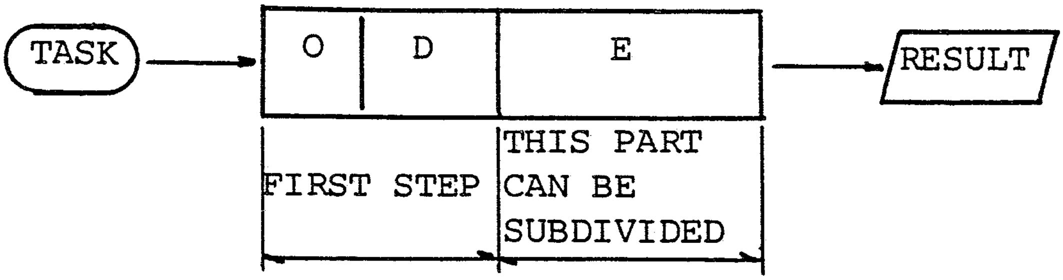

Fig.9: PROJECT ANALYSIS SUBDIVIDING IN THE EXECUTION PHASE

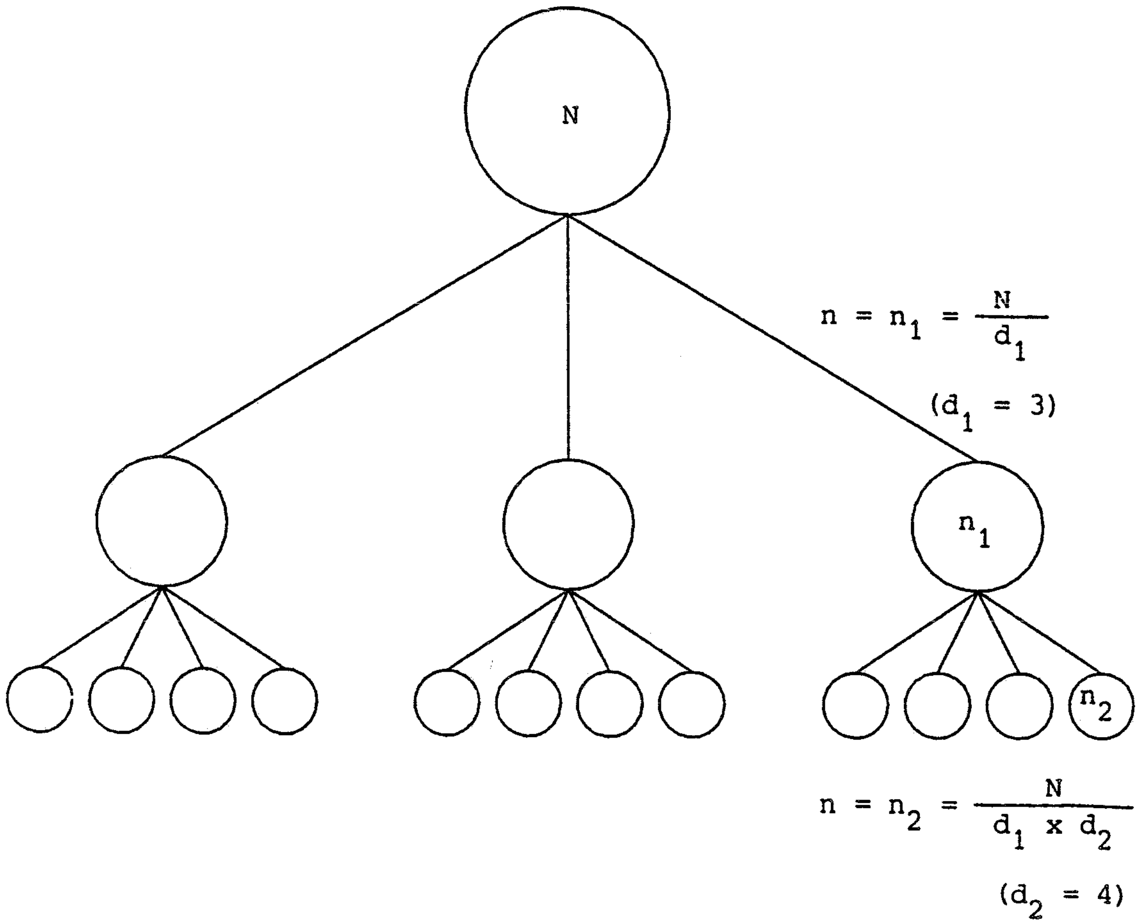

Fig.10: SUBDIVISIONS

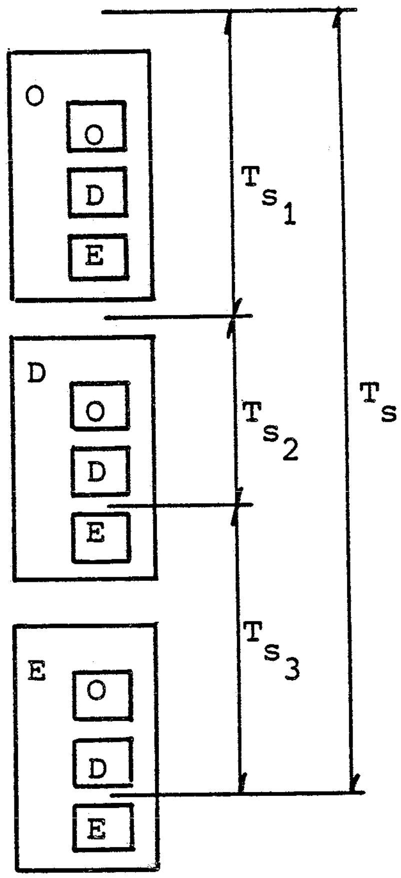

Fig.11: ALLOCATING TIMES TO THE STRUCTURAL PHASE