A microcomputer based planning system for construction projects

Geoffrey Alan Reiss

This thesis is submitted as a partial fulfillment of the requirements of a Master of Philosophy Degree to the Council for National Academic Awards.

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An Abstract

The thesis outlines the research project undertaken to examine the effect of microcomputers in the field of project planning on construction projects.

The hypothesis to be tested was that project planning had a poor reputation within the construction industry and that this poor reputation was due to two primary factors. One was that the work of project planning was carried out by personnel inappropriately positioned within the construction management structure and the second was that there were inherent problems with the use of the technique of network analysis that make it unattractive to site management personnel.

A series of structured interviews was conducted which appeared to confirm the general hypotheses and, based on this, an experiment was established to re-locate the role of project planning to an on-site role in a number of longitudinal case studies. To achieve this a microcomputer was necessary and, at that time, a software program had to be created as no suitable programs were available that would enable the experiment to proceed within a realistic budget.

In general site management welcomed the changes brought about in the experiment and reacted favourably to the ability to plan projects on site. As a result some of the inherent problems associated with the technique were overcome.

Project planning was, by those involved with the test program, better regarded and generally rapid on site project planning was seen as being of increased value. The benefits gained by the use of a microcomputer which were speed, ease of use and availability on site seemed to remove many of the objections raised by project planners and managers when discussing project planning by manual or main frame methods.

There were suggestions that the use of a computer could be taken further and that the computer could adopt more of the network planning role, particularly the creation of the network model.

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CHAPTER 1

INTRODUCTION

1.1: The Outline of the nature of the project.

After a number of years as a practitioner in the field of construction project planning it appeared that there were significant problems associated with the use of project planning techniques within the construction industry.

It appeared that the general attitude to the use of project planning that was found in construction management was poor. It was suspected that, on average, construction management personnel did not regard project planning as a useful tool in achieving progress on construction projects.

There appeared to be a number of problems associated with the technique that caused this attitude. Especially frequently mentioned were such problems as:

a: Project planning was frequently remote from the project and not adequately involved in the projects developments.

b: Plans were frequently out of date and therefore of little use.

A research project was therefore embarked upon in an attempt to investigate this attitude and attempt to discover more accurately the reasons for it.

A number of attempts to execute project planning by computer had been noted but, it was considered, that these did not address the problems outline above as generally the work needed in project plan preparation was still lengthy and remote from the project for which it was intended.

The project coincided with the advent of relatively cheap microcomputers and it was considered that a microcomputer might be able to contribute to reducing the problems under investigation.

Microcomputers, it was reasoned, might permit project planning to proceed :

a:on site

b: more rapidly

and might therefore reduce the problems suggested above.

It was therefore considered that a microcomputer based project planning system might help to remove the problems under investigation and therefore might improve the attitude to project planning.

If such an improvement in attitude resulted from the introduction of a microcomputer it would be reasonable to assume that the attitude to project planning was poor, that the reasons had been as least in part identified and that a microcomputer could help to reduce these problems.

1.2 Definitions.

In this section the terminology used is defined to avoid ambiguity.

Construction Management is defined as the role executed by personnel associated with a construction project with the objective of bringing it to completion on time and to budget.

Project Planning is the technique of predicting the flow of work on a construction project and the preparation of reports detailing these predictions.

Network Planning is the technique of using network diagrams as a means to assist in the execution of project planning. Network Planning can utilise such techniques as activity on arrow and precedence network diagrams.

The Structured Interview technique is an Indirect Observation technique where the interviewer prepares a list of questions and discusses these questions with the interviewee in a one to one situation. It is specifically designed to be useful in testing a series of hypotheses.

A Microcomputer is a subset of the computer. Like all computers a microcomputer is a machine capable of receiving, recording, manipulating and displaying data. To define the subset of computers that are referred herein as microcomputers is to define a computer capable of being used on a construction site and by construction personnel and being within the cost parameters set. As these cost parameters are not constant it should be noted that a microcomputer was defined at the outset of the project as a computer costing no more than 5,000 pounds.

A software package is a set of instructions that are written in a language understood by a computer and that instruct the computer to perform one or more functions.

1.3 The Hypothesis.

The following hypothesis were defined in an attempt to define the problem as follows:

Poor reputation

Project planning in general and of network planning techniques in particular were received with caution by site management, who in general terms, did not regard project planning as a useful aid to their site management role.

It was noted that project planning by network analysis was regarded by site management as a process independent from managers in the construction phase.

Inappropriate location

On the basis that of the first hypothesis, it was argued that the reason for the above symptoms might be that:

a: Project planning was executed by individuals frequently inappropriately positioned within the management organisation of the construction company.

b: There were fundamental problems associated with the use of the network analysis technique which contributed to the attitude of site management.

The use of a microcomputer

Again on the basis that these previous elements were substantiated it was an objective that the potential of the microcomputer should be evaluated to examine the potential for reducing some of the aforementioned problems.

If the advantages apparently offered by the microcomputer could help to reduce the amount of management time involved in preparing network plans preparation and if this led to a better view of network planning as perceived by site management then there would be indications that the hypothesis had been confirmed as valid. Additionally it might be possible to indicate a direction which some site management organisations might adopt to improve their network planning techniques.

1.4 Objectives.

The hypothesis was tested by setting the following objectives.This section outlines the objectives of the research which were as follows:

(i) To establish the general attitude to project planning within the construction industry by a series of interviews.

(ii) To develop a flow diagram for the process in an attempt to more clearly define the process in theoretical terms.

(iii) To develop and test a microcomputer based project planning system in a number of longitudinal case studies to examine the effect such a system would have.

This thesis therefore describes how these objectives were achieved, how the data gained was analysed and outlines some conclusions relevant to the hypothesis.

CHAPTER 2.0

METHODOLOGY

2.1 Overview of the methodology

In order to achieve the research objectives a research model was produced. This took the form of a FLOW DIAGRAM of the project planning process and was an attempt to get a clear view of the process.

A Flow Diagram of the construction process would, it was hoped, allow a clearer picture of the process and also provide a framework for the remainder of the research project.

A series of structured interviews were held with a variety of construction management personnel. In an attempt to obtain the most accurate view, interviews were carried out with personnel ranging from those who were project planning professionals (creators of project plans) to personnel who were involved in site management (user of project plans).

These interviews established outline details of the interviewee and obtained his views on project planning. The interviewer was also asked to identify useful features of an on-site network planning tool.

This series of interviews appeared to ratify the first and second elements in the hypothesis suggesting that on-site execution of project planning could be more acceptable to site management if some of the problems associated with its use could be alleviated. There was some suggestion that a microcomputer could alleviate some of these problems.

A test environment was then established where the role of project planning was established as a on-site role executed by the on-site management and which enabled frequent review and remodeling of project plans to be executed by the on-site management personnel.

It was necessary to create a microcomputer project planning software package to achieve this as no suitable package was commercial available at that time. It was expected that project planning techniques would be required to be at a simple level and that advanced techniques would not be possible at site level.

The research project was fortunate enough to establish three longitudinal test sites. On these sites the planning was executed on site for an extended period and the utilisation of the revised roles was periodically monitored. The results of these three tests tended to indicate that the third element in the hypothesis was also correct.

A number of works published during the period spanned by the research project also proposed similar views which again gave credence to the hypothesis. During the duration of the research a number of microcomputer project planning packages have become commercially available.

2.2 The Research Model

It was desired to examine the project planning process in a theoretical manner in the hope that this examination might reveal factors that were relevant to the objectives of the research.

Noting the objective relating to microcomputer it was considered that a theoretical examination of the flow of data would be most relevant to the research project. This would be more likely to be valuable to the research as the flow of data rather than the flow of responsibility was likely to reveal problems that a microcomputer could help to resolve.

Therefore a theoretical method of examining the flow of information or data through the project planning was required. A Data Flow diagram was evaluated as a possible tool. Data flow diagrams are designed to show the flow of data within a system. They are little concerned with who or what processes the data nor the processes involved and therefore appeared to have qualities useful to the research project.

A diagram demonstrating the flow of data within the project planning system was extracted from a larger model so that a clearer picture of the process might emerge. This diagram and the deductions that were derived are discussed in Section 3 of this thesis.

2.3 Structured Interviews

At the onset of the research it was necessary to obtain views about project planning from current practitioners. Similarly their views would be useful in specifying a test program. Two techniques were considered:

a: Questionnaires by Post.

In this technique a questionnaire is prepared and sent out by post usually accompanied by a covering letter. There is a lack of personal contact in this technique and it is necessary to frame the questions prior to the first interview.

Another disadvantage of this technique is that the construction industry is notoriously poor at replying to such questionnaires. Informal research tended to confirm this opinion.

The Postal Questionnaire Technique is of greater value where a large sample can be circulated so that even a low response rate will yield sufficient data. In this case the researcher was interested primarily in interviewing project planners and site managers. There were difficulties in identifying a sufficient supply to yield acceptably accurate data from the structured interviews where the total sample required is noticeably less.

It was decided that the postal questionnaire technique was not suitable for the research.

b: The Structured Interview.

The Structured Interview is a technique classed as INDIRECT OBSERVATION - the researcher does not himself observe but interviews others who have been observing the subject.
In a structured interview the interviewee meets directly with the interviewer and an interview is carried out. Whilst the interviewer has a series of set goals and an overall structure to the interview, it was possible to modify the interviews slightly to suit the background, knowledge and attitude of the interviewee.

A prime function of the Structured Interview was to verify existing theories and hypotheses. A Structured interview is a form of research designed to be of most value where the objective is to evaluate a hypothesis. It is less appropriate in a research project where a discovery is the objective. This nature of structured interviews was very close to the researchers needs.

Using The Structured Interview technique the researcher was able to take advantage of the personal relationships gained over a 12 year period as a practitioner in the field.

There was published evidence that the nature of the structured interview was as described:

"The scientist who utilizes this technique is usually intent upon testing an existing set of hypotheses, he is less concerned with discovery per se" (Sjoberg & Nett, 1968).

It was considered that the Structured Interview was seen as economical and efficient - it attempted to eliminate needless questions and helped to promote a degree of standardisation. In the field of Social Research, The Structured Interview tended to be regarded as having questions that tended to be stylised and formal and had the reputation of oversymplifying or overstructuring reality - whilst this was seen as proof of the economical nature of the technique, this was not seen as a problem as the nature of this research was structured and limited in scope.

Again from published work on the topic of the structured interview it was noted that "The structured interview is more applicable to large scale surveys in the field of social research and to the formal testing of hypotheses" (Sjoberg & Nett, 1968). As these sentiments were in line with the objectives of this part of the research project it was deduced that the Structured Interview was suitable for the research project.

The research project was concerned with the attitudes of project managers and therefore with indirect observation. Direct observation was not feasible in this type of research project When using The Structured Interview the researcher was encouraged to create a predetermined questionnaire with fairly rigid categories, to precode the data and create tables to assist in analysis of the data.

Hence again The Structured Interview was seen as a valuable tool in this research. The questions used were designed to discover factors pertaining to the objectives and to permit the data to be used in an analysis phase that normally follows on from the interviewing phase.

It was recognised that a number of the questions did not have a simple yes/no response. In many cases a degree of preference or desirability was required.

For this reason a concept propounded by Charles E Osgood (1957) and known as methodological orientation was used. The instrument involves the construction of a multidimensional scale around certain concepts.

The respondents reaction to the questions was to indicate a point along a scale that the respondent felt appropriate to his or her view of the topic. A simple example of this technique in a survey of attitudes to incentives schemes might be:

How important, in your opinion, is the publishing of incentive scheme

targets to the labour force?

important:----:----:----:----:----:----:----:Not important

The question was phrased to allow the respondent to respond suitably and the interview commenced with an explanation of the technique such that a response may be made in terms of a selection of range of responses ranging, in this case, from 1 (very important) through 3&4 (neutral response) to 7 (not at all important). The range may be varied although the range of 7 is acknowledged to be a normally useful range. Too small a number gives insufficient scope and too large a range leads to indecision.

It must be stated that this technique relies on: a: The ability of the interviewer to explain the nature of the interview to the interviewee at the beginning of the discussion

b: Questions that avoid confusion.

It was generally agreed amongst experts in the field of interviewing and particularly structured interviewing techniques that the wording of the questions should be carefully considered. The point made frequently (Sjoberg and Nett, 1968) was that the more structured an interview is to be the more precision is required in the wording of the questions as there is little room for clarifying perplexing points for the interviewee.

It was suggested by Sjoberg & Nett that questions are:

a: Phrased in terms of the knowledge level of the interviewee - they argued that the interviewer must be careful to request information within the knowledge base of the interviewee and should provide simple routes to avoid the question without loss of face should the question fall outside the scope of the interviewees knowledge base.

b: Built from simple straightforward vocabulary and style. It is argued that the more complex and ambiguous the style the less reliable will be the response.

c: Void of emotionally tinged words - so as to avoid emotionally tinged responses.

d: Phrased to sustain the interest of the interviewee. Again Charles E Osgood was aware that people lose interest easily in the interviewing environment and unreliable responses follow from this lack of enthusiasm.

e: Occasionally used to check on the respondents memory and veracity. Questions may be repeated under a different guise so as to provide a measure of these values.

2.4 A test program

In an attempt to gain a clearer understanding of the problems associated with project planning it was seen as desirable to test the theory in practice. Specifically it was seen as desirable to evaluate what effect a microcomputer based project planning system might have on the attitude to project planning as found within construction management personnel.

With this in mind a test program was required. Such a program, it was argued, could be mounted on a microcomputer and installed on selected construction projects and its use monitored.

This monitoring would enable an evaluation to be made of the effectiveness of the program.

A search was carried for a suitable program but this search did not result in the location of a suitable program.

As it was necessary to locate the test program on a construction site and so that planning could be carried out very rapidly, the project planning packages available commercially on mini and main frame computers were rejected as being either too expensive, too difficult to control or too slow.

As no suitable available program could be located at that time to use as a test program it was necessary to create one for the purposes of this testing process.

It was resolved to examine the requirements for such a program in the series of the structured interviews and thereby arrive at an outline specification for such a program. During the interviews, it was resolved to investigate the following points in respect of the test program:

a: the nature of the program

b: the capacity of the program

c: The features required in such a program

The model of the construction process also served to indicate some of the features that were desirable in the test program.

Due to the limited resources available during the project the test program was limited in functions but it appeared possible to create a test program that was sufficiently powerful to test the hypothesis adequately.

After the period of time during which the monitoring of the program was carried out, a revised specification was drawn up. This revised specification was the result of the findings of the test program monitoring and was the result of suggestions for improvement made by the users during the testing period.

The possibility of an artificial environment where a rapid on site project planning environment was artificially created was considered but discarded due to the lack of a practical method of achieving this objective.

2.5 The Longitudinal Case Studies

A small number of construction projects were located on which a microcomputer based project planning system could be installed and monitored. It was considered that a variety of projects offering different backgrounds in terms of

a: Type of personnel

b: Current project planning method

c: Type of project

would give the most useful results.Three case studies locations were identified and these did cover a variety of backgrounds.

Clearly the practical limitations of the research project prevented a large number of case studies to be evaluated. However it was felt that sufficient data was gained for a reasonably clear set of deductions to be made.

When making use of Longitudinal Case Studies the researcher executes a series of interviews over an extended period of time on each specific case.

These interviews tend to be, in total, lengthy and time consuming but have the advantage of allowing the researcher to appreciate more deeply the factors affecting the particular subject in its particular environment.

Additionally the researcher can examine developments reasonably closely over a period of time and is therefore able to examine the effects of a change.

The limited resources available to the researcher in this case dictated that should this technique be adopted solely, the total number of results would be inconsistent with accurate result calculation.

It was decided therefore that this technique would be valid for the evaluation of the test program, where a new system was to be installed, but was not appropriate for the testing of the initial hypothesis.

CHAPTER 3

A MODEL OF THE CONSTRUCTION PLANNING PROCESS.

3.1 To obtain a better view of the construction planning process a model of the construction planning process was examined by reference to work done in this field.

The objective of this was to obtain a clearer view of the project planning process and to provide a framework for the research. It was hoped that this examination might reveal the steps involved in project planning more clearly and therefore might reveal significant factors in its under-utilisation.

Also it was hoped that the examination of a model of the planning process would assist in evaluating the effect of on-site and off-site project planning. This related to the objective of establishing if project planning personnel were frequently badly positioned within the management structure of a project.

There was evidence to suggest that one of the problems with network planning was its relatively heavy requirement in terms of management time and expertise.

It was considered that project planning by network analysis, perhaps due its complexity when compared with other management techniques (for example barcharts), was frequently not able to proceed at a pace that suited the direct on-site management.

It was proposed that this led to a situation where plans were regarded as less than useful as they were frequently out of date. In extreme cases plans were found that were out of date at their time of issue. It was possible that this contributed to the poor reputation that network planning had within the field of site management.

It was a hypothesised in the research project that slow planning techniques were contributory to the attitude to project planning within the construction industry.

In Modern Construction Management (Harris and McCaffer ,1977) the functions of a central planning office are discussed and are stated have having two prime functions.

a: To support the estimating department to prepare tender programs etc

and b: To provide planning and co-ordinating services to site

They write that "Such arrangements have created problems for virtually all planners at head office irrespective of the company." And later the authors write that "Such a policy has lead to poor planning and a lack of confidence in the planning function by those who carry greater responsibilities such as estimators and site managers"

An article in the Building Economist (Hinds, September 1981) discussed this theme. In his article the author asked "Why do not builders prepare detailed network construction programmes?". He examined the history and potential of the technique but found to his dissapointment that "very few builders have utilised this programming technique"

This article identified the problem that in general the techniques of project planning and particularly network analysis were techniques rarely found in the British construction industry. In America this view was also expressed.

In a paper submitted to the AACE conference in Washington (M.D.Ryan AIQS and D.M.McCarthy,1980) stated that "The high cost in time and labour of preparing coded input often discourages the use of computerised CPM scheduling systems." The view here was that the technique was potentially useful but that there was a net loss of management time involved in the use of the technique of network planning.

The amount of time invested in creating computerised network plans exceeded, in the view of the writers, the benefits gained. This paper took as a basic assumption the view that computerised network planning techniques were not widely used. This once again was similar to the author's personal experiences.

In Building Economist (Mr.M.Hinds,1981) suggested that builders do not have sufficient time nor incentive to fully investigate work (specifically subcontract work). Also he suggested that costs of production of the network are high and time to produce them is limited. The view recorded is based on the observation that personnel in project management rarely made use of project planning techniques. They gave as one of the reasons for this lack of use the view that the investment exceeds the returns.

In a paper entitled "Integrated Project & Process management" (M.A.A.Dabbas and D.W.Halpin, 1982) the lack of abundance of field decision making and control methodologies and systems was discussed. They proposed that levels of sophistication found in the network planning process varied widely and often fell into the "scientific guesses" classification. The authors searched for a better system of project management that would provide some decision making ability (on site) so that site management could efficiently utilise their physical resources.

This paper assumed a under-utilisation of the network planning technique and attempted to locate a replacement technique that would be more useful. This was similar to proposals included in this thesis.

N.M.L.Barnes and M.Wright:1980 stated that "Experience has shown that, in project management, it is important to use the computer only to do simple things. The computer should add only the ability to do these things on a scale and at a speed which is superhuman. Computation using unfamiliar or sophisticated mathematical relationships although acceptable in design work, prevents a management system becoming widely or confidently used"

The paper went on to suggest that it was possible that the main frame approach to project management attempted to do precisely this - using sophisticated sensitivity and statistical methods to derive project plans.

The use of convenient microcomputers, it was argued, performing relatively simple tasks may remove some of the obstructions to the use of project planning techniques.Again this paper assumed that the techniques were not widely used and suggested reasons for this lack of use.

In Production & Planning applied to Building (R.J.Hollins ,1962) the author stated that short term plans should be utilised "to keep the plan alive.

Nothing can be gained by leaving an out of date and unrealistic plan pinned up in the site office". He recommended that short term plans be produced "at regular intervals" and that an executive at head office should be responsible for seeing that short term plans are prepared at frequent intervals.

Therefore it was decided to produce a model of the construction planning process to evaluate these factors.

The field of Data Flow Diagrams was investigated to locate or prepare a diagram that would fulfill these objectives. A basic diagram was located and the research model deduced from it.

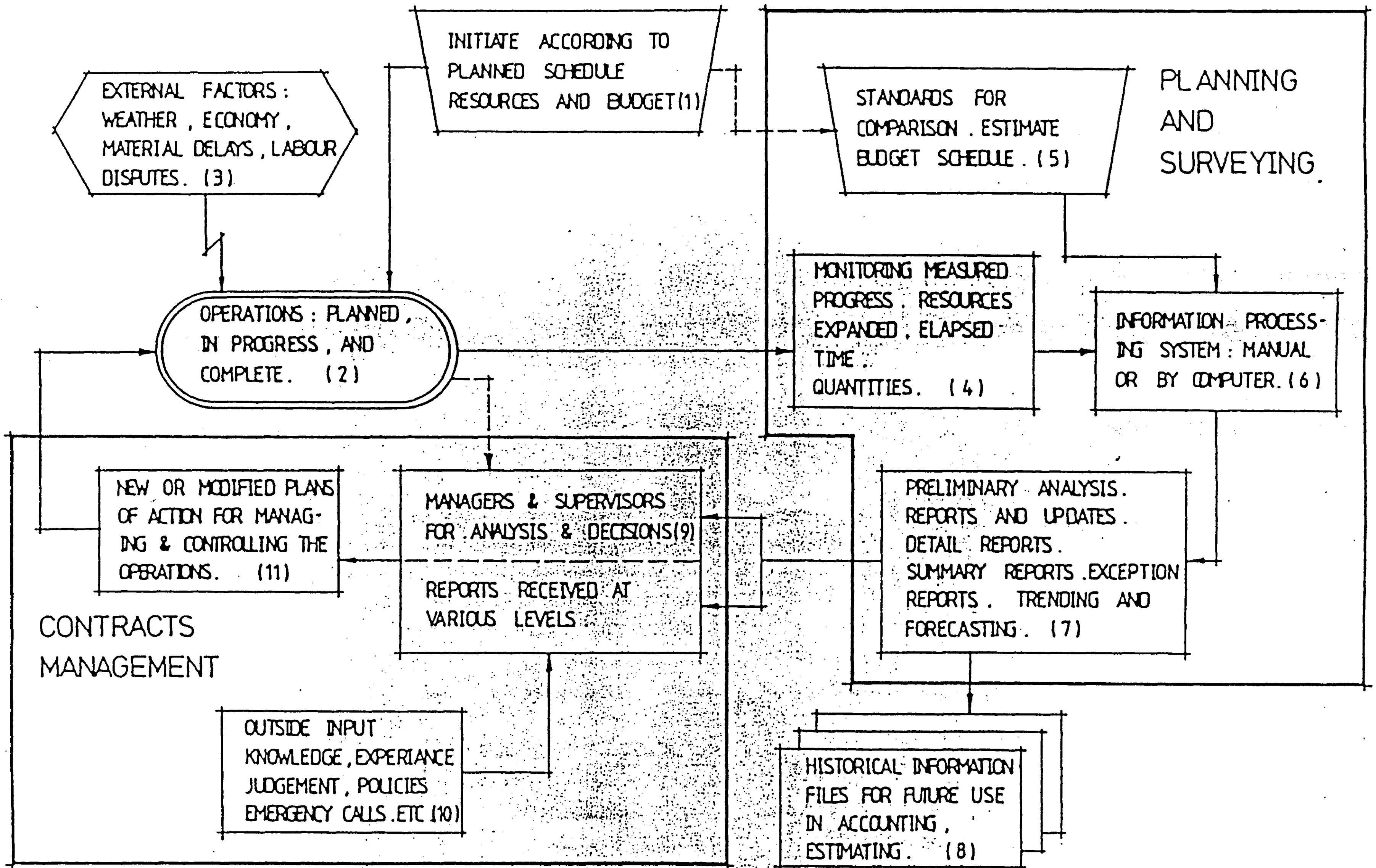
A flow chart taken from "Concepts of project planning and control " (Boyd C Poulson Jr, 1978) was considered to evaluate its suitability for the research project.

This diagram included an examination of the project planning process as a part of an examination of the construction management process.

It was a data flow diagram for the construction management process which had been prepared some 10 years before the date of this research.

To be suitable for the research project, which it should be noted was a pilot research project at that stage, the data flow model would be required to have the following qualities:

a: It should represent the project planning process in terms of data flow rather than in terms of responsibility. This would allow an examination of data movement in a variety of different management structures.



From :- Boyd C. Paulson Jr. "Concepts of Project Planning and Control," Journal of the Construction Division , A.S.C.E. vol. 102

Appendix A.

b: It should be detailed enough to demonstrate the steps involved in the project planning process so that these steps could be considered in light of the research. It should not be too detailed as in a data flow diagram that might be prepared as a part of the latter end of the process involved in the creation of a software package as such a detailed data flow diagram would loose sight of the concepts necessary to a pilot research project.

c: It should not assume any method of data preperation, nor assume any physical arrangement (management structures nad location) of the roles involved as the research covered a wide variety of of methods of data preperation and physical location arrangements.

d: Ideally it would show interaction with other systems in the construction management process so that should questions arise of this nature they could be considered.

The selected model fulfilled these criteria and therefore was considered to be suitable. This diagram had the advantages of suitability and adaptability and it made it possible to view the process in relation to the wider project management process.

The elements of the diagram that related to project planning were extracted from the source diagram.

In this model Box 1 indicated the initiation of the project based on a plan for the project and this was followed by the production of work (box 2). The plan became a frame of reference for control purposes (box 5). As the project proceeded there were external factors that effected the production of work (box 3) and these included such elements as weather, design change and industrial disputes.

The key element in an external factor was that it will affect progress in a way that was dissimilar to that planned. It was noted that this could mean a delay or an opportunity to advance the works.

The actual progress of the works was fed into a system which is an information processing system (box 6) which provided a comparison of information regarding planned targets and actual progress. Such a system may also be involved with making other similar comparisons such as comparing planned budget with actual expenditure.

This was a measuring of progress against the original frame of reference as described at project initiation in box 1.

Box 4 represented a measuring of actual progress . This process was the recording of actual progress in terms of work executed, resources expended and elapsed time.

Information flowed from box 4 to box 6 where a system compared actual progress with planned and provides information to another system (box 7) where reports were prepared to present this comparative information.

The information comparing actual progress with the planned progress was converted into reports summarising this information for management consumption.

Two flow paths resulted from this comparison. One was a feed back to the central company store of information regarding production outputs and formed a part of the historical information used within the company. The second was a more immediate feedback to project management to report problems on the specific project.

Basing their decisions on the information gained from box 7 and from external systems managers and supervisors took decisions about the future work load and thereby create new or modified project plans.

These modified plans fed information back to the operations in progress. It should be noted that this part of the system diagram was a loop and it was suggested that the loop should be followed round on a regular basis.

G.A.Reiss:1982 presented his thoughts on this topic to the Association of Project Managers at a conference (Computers in Project Management). At this conference it was noted that with traditional project planning systems it was not frequently possible for the project planning to keep pace with the Production work. Plans fell increasingly far behind the actually work.

The concept being suggested was that project planning and management teams should on a regular basis:

(1) plan to provide a frame of reference

(2) monitor against that frame of reference and

(3) re-plan to provide a fresh frame of reference

This was a feedback mechanism and associated with it is a feedback time. P.Barton:1985 states that this feedback time should be "As short as possible so that managers and supervisors can receive accurate and up-to-date information in time to make decisions and formulate plans of action, so as to have maximum impact in controlling those operations which are generating the information in the first place".

This feedback process included the following activities:

Create standards for comparison

This item related to the establishing of a frame of reference, usually in the form of a project plan. The project plan, frequently a bar chart, forms a basis on which to evaluate progress.

Measure progress

This item to the measurement of work done against, or in comparison with, the frame of reference described above.

Produce reports comparing actual progress with planned progress

Once a frame of reference has been established and progress measured in comparison with it reports can be produced making this comparison.

Analyse differences

Using the reports created above the manager may analyse the differences to establish what parts of the project are in need of concentration, which tasks are not proceeding in accordance with the plan in either a negative or positive manner. Specifically the manager normally searches for those tasks that deviate by more than a preset margin from the plan.

Decide on action to be taken

To resolve any discovered deviations from plan, the manager may take a wide range of actions. Such actions are designed to make the project proceed in an efficient manner. Actions include the relocation of resources, the acquisition of additional resources and the re-sequencing of tasks.

Produce new or modified plans

To evaluate possible plans of action the manager may produce new or modified plans.

Analyse these new or modified plans

The manager will analyse his new plan either manually or by computer aided methods to discover the implications of his new plan.

Produce reports detailing the new or modified plan

As a result of the actions planned the manager expects that the project will proceed in a certain manner and the various tasks to be related in logic and in time to other tasks in a new way. To communicate these new plans and to evaluate them the manager may produce new plans showing the revised project plan. These new reports will provide a revised frame of reference against which the process may be once again begun.

There was evidence that this process was not frequently followed within the construction industry and also in the rare cases where it was followed, it met with limited success.

3.4 It was considered that the amount of time taken to pass around the 'monitor, compare, decision making,re-plan' feed back loop in normal project planning situations was excessive. An excessive feedback time is one that prevents the plans being sufficiently up to date for the management team to control the project.

This lengthy time period prevented project managers and project planners executing the desirable frequent updating of plans and therefore the plans that were produced quickly became out of date and therefore of little value.

The Flow Chart showed this information flow from box 4 via box 6 and box 7 to box 9 .

It was considered that the fact of the inability of this flow of information to take place with sufficient speed was a major contribution to the poor reputation that project planning had been to found to have within the construction industry.

It was thought that there two problems that prevented the flow from happening sufficiently rapidly, that delayed the feedback loop.

A: Preparing reports showing the comparison and preparing reports showing the new plan.

B: Preparing new or modified plans and processing these new plans.

In Construction Management & Design (Mr.J.F.Woodward , 1975) the writer stressed that one of the major benefits of a computerised network planning system was when "it is required to maintain surveillance over progress on the project. The usual practice was to update the computer data tape by indicating what activities have been completed by a particular stage and perhaps modifying the durations of forthcoming activities in the light of experience of the project to date."

He continued saying that "This regular updating monitoring and re-planning is of very great importance, but is often neglected because of the sheer amount of work involved in undertaking it. It is here perhaps that computers can be of the greatest help where updating is so easily completed.

This discussion led to the following observations :

a: There was a feedback loop that involved the flow of information from the monitoring process to the updating process in project planning.

b: That there was a need for this process to be competed rapidly.

c: It was possible that in many construction situations this process was not executed since it was difficult to achieve at sufficient speed.

This was considered to be a major contribution of the poor reputation of project planning within the construction industry.

Consequently a microcomputer, if able to speed this process might make significant improvements in the execution of the planning role.

The above concepts and views were therefore used as a basis for the design of a questionnaire incorporated in the structured interviews which would additionally test the hypothesis.

THE STRUCTURED INTERVIEWS

4.0 Overview

This chapter examines the requirement for a results gained in a series of structured interviews in broad terms.

The detailed analysis of the results is included as Appendix A of this report and the tabular data gained from the interviews is included as Appendix B of this report.

4.1. Rationale

The structured interviews were held to achieve two of the objectives essential to the research.

These two objectives were:

> To establish the general attitude to project planning within the construction industry by a series of interviews.
>
> To develop and test a microcomputer based project planning system in a number of longitudinal case studies to examine the effect such a system would have.

The questions were selected to extract information in a number of areas aimed at these two objectives.
It should be noted that, as described in section 2.3, the interviewer did not simply repeat the question but used the questions as a basis of a reasonably relaxed conversation between interviewee and interviewer. It was felt that this would result in the best atmosphere to gain the maximum knowledge.

The first few questions were aimed at finding out a little about the company in which the interviewee worked. This was regarded as important as correlations might exist between company type and the use of planning techniques. Additionally this sort of question was, it was hoped, easy for the interviewee to answer so he would be put at ease at the beginning of the interview.

Having established some data about the interviewee's company the interview turned to the particular project or projects that the interviewee was involved in. Again the researcher was attempting to establish correlations between project type and size with the use of the various project planning techniques. These questions (1 to 6) were aimed at establishing the background of the interviewee.

The interviewee's views were obtained on the project planning system in use on his current projects and the reason for his views.

To cater for the situation where one company used a number of different techniques the interviewee was asked about other projects either current or past where other project planning techniques were used.

The next section attempted to obtain information about the location of the project planning role. The location of the project planning role was investigated and the interviewee's view of the success of project planning when executed from that role gained.

The two factors most directly relating to speed of processing plans are the system used and the location of the role. These questions therefore were designed to confirm the model previously described.

As it was possible that some construction companies had run experiments using project planning techniques different to their normal system, the next few questions probed into any such experiments that had been run within the interviewee's company. Again questions were asked that related to the speed of execution and location of the role and the interviewee's view were sought on the value of the techniques tried.

Therefore questions 7 to 19 related to the type and attitude to project planning as experienced by the interviewee. This related very directly to the first objective of the interviews.

Questions 20 to 29 related to the interviewees experience with computers.

The next section concerned the use of computers. Questions were asked about the companies computerisation in a way unrelated to project planning. Still on the topic of computers the users experience with computers was also probed in case there was a correlation between attitude and experience.

Next the topic of network planning was covered, again probing for details of the users experience mostly with a view to deducing the reliability of the responses. If the interviewee had had experiences with network planning he was asked about its success, the positioning of the role and the reasons for the success or failure of the technique.

Questions 30 to 34 related therefore to the experience gained by the interviewee in network planning in any form and then questions 35 and 36 reacting specifically to project planning by network analysis by microcomputer.

interviews - to discover the attitude to project planning within construction personnel.

Then the questions turned to the topic of microcomputerised network planning system. The interviewer outlined such a system and attempted to describe a system in terms of speed and ease of use. The interviewee was then asked to consider that if he was responsible for the installation of such a system how would he implement it. The interviewee was asked questions that examined the location of such a system (and therefore the project planning role) and the features that he would like to see in such a system.

The next stage in the structured interviews was to attempt to define the functional specification of a suitable software package. It was planned that, partly as a result of these interviews, partly as a result of the research model, a software package would be created to test the theories outlined more fully.

It was necessary therefore to define a functional specification of a software package that would enable a package to be created (if possible) so that the testing could proceed. It was though valuable to seek the views of the interviewees on the features they considered should be contained within such a package.

would lead to a project planner being creative with his requests for software programming. Therefore the interviewer asked for a reaction in terms of importance of a number of possible features.

This also permitted averages to be taken so that a reasonable common view could be taken. Hence the interview continued with a number of questions relating to the possible features of a network planning package running on a microcomputer.

The researcher asked "Lets consider that you can have a network planning system on site under your control". This was meant to get the interviewee in a frame of mind where he had a computer and suitable software under his own control. This concept had to be explained to some people but again the description was factual and matter of fact where possible.

Thereafter questions 37 to 58 related to a microcomputer based project planning system and the desired features as seen by the interviewee.

Many of the questions were prompted by the thinking inherent in the model of the project planning process discussed in section 3.0.

4.2 Analysis of the Results of the Questionnaire

The results of the questionnaire are reported in Appendix B of this report and these results are analysed in Appendix A.

The results of this analysis are summarised in the following section.

4.3 Summary of Interview Findings

Analyses of the first part of the interview

This section analyses the responses to the first part of the structured interviews This appendix then goes on to report the second part of the interviews where an attempt was made to define the specification of a microcomputer based project planning software package.

General

The first part of the interviews had tended to confirm the hypothesis in a number of ways.

A reasonably wide range of environments had been tested covering both large and small firms, large and small sites and a variety of people involved in project planning.

By far the most common planning method had been barcharts drawn manually and only in unusual circumstances had network planning been found to be valued.

Most contractors had run experiments with more advanced network planning techniques but these had not been very successful. Most companies had found computers useful in traditional ways and many had some experience of computers in a`least one environment.
It was felt that the interview sample was adequate for the second part of the session which was to attempt to define in outline, the specification of a microcomputer based project planning package.

Experiences and attitudes to project planning.

It can be seen that generally the interviews tended to confirm the hypothesis. Those involved in project management were of the view that project planning did not have a strong reputation within the construction industry. There was a body of opinion that blamed this poor reputation on the slow nature of the tasks involved in project planning. It had been established within the scope of the research that project planning was a topic that construction companies experimented with and that larger projects attracted the more advanced techniques.

In general the view was that project planning was an expensive overhead and was only utilised where the special demands of the project made it necessary.

There was a view given that the fixed nature of plans was unsuitable for the planning process in the construction industry and this tended to confirm the research model view - that a repetitive plan, monitor and re-plan cycle was essential to well respected project planning. This view was expressed most strongly by managers - users of plans rather than creators of plans.

Within the poor reputation of project planning, network planning was especially poorly regarded as it did not solve the problems caused by the slow nature of the planning process.

23 of the interviewees had witnessed project planning in a work environment and most of these felt that:

a: It was used for some purpose not connected with the efficient running of the project

b: It had not been very successful.

Points raised as contributing to the successful implementation of a network planing system included the point referred to previously of unpredictability. Most mentioned that network planning was too sophisticated for the tasks it undertakes to solve.

Again this confirmed that network planning was not in wide use and that the reputation and attitude to planning was poor.

It was noted that taking the group of people who claimed experience with the use of critical path analysis and examining their reaction to the question of the value of critical path gave a higher score - those experienced with network diagrams tended to feel that the approach was better than those who had little experience of the technique.

This tended to indicate that those who devoted time and effort to use network planning saw its benefits.

There was a correlation between remotely executed project planning and a poor attitude to the role. Those interviewees who had experience of on-site planning generally had a better attitude to the role than those who generally worked with a head office planning role.

Those who had planned, rather than those who had used plans, tended to feel that the system was more successful.

It was not possible to establish a relationship between type of planning method and success of the project, only to relate type of project planing to attitude to the technique. It was not surprising that those responsible for project planning, ie planners themselves, generally felt the technique was more useful than those who used the plans ie line managers.

A large number of interviewees had gained some experience with computers and nearly all companies had a computer function somewhere within the company.

In general terms the view was that the computer had a role to play within the construction firm (generally administrative) but few connected this with the role of successful project planning. This confirmed the hypothesis that computer based systems were not commonly used within the construction industry.

Also, as 31 of the interviewees had had some experience of computers, either in a work or home environment, it was reasonable to assume that the sample would be able to answer questions relating to the concepts of a microcomputer based project planning system.

Attitude to a site based network planning system

Generally the thoughts given here were encouraging.

Of course it was noted that it was easier and less controversial for a interviewee to make polite comments about such a concept.

In an attempt to avoid this the interviewer tried not to be enthusiastic making it clear that this was research and that no such system currently existed.

referred to the project manager. This was interpreted as indicating that the interviewees at least felt that such a system could be used by a builder and would not need a specialist.

Also is was recognised if the microcomputer made possible the re-location of the project planning process to the site some of the remoteness problems raised by the interviewees might be lessened.

It was noted that those who had work experience of a computer had a slightly higher expectation of the successful implementation of a microcomputer on site.

A series of questions were put to the interviewee about the features of the proposed package, how it would operate and what it would be expected to do.

Most of the interviewees responded sensibly even though their first hand knowledge was limited and very few impractical ideas were suggested.

This was taken as confirmation that the sample of managers were reliable in these terms.

The design of the model package was based on the desires of the interviewees - activity on arrow network for example being especially frequently requested.

A strong response was noted to question 44 which asked if the system should be fast and to question 54 which asked how long a typical update session should take.

This directly relates to the research model as the prevelant attitude was to confirm that planning had to be rapid so that it could be regularly reviewed. A regularly reviewed planning process should remove the attitude that the forecasting problems made the technique less than valuable.

5 THE DEVELOPMENT OF A FUNCTIONAL SPECIFICATION FOR A PROJECT PLANNING PACKAGE

5.0 Overview

This section served to outline the specification for the test program that was installed on three longitudinal test sites. It is here included so that a clear concept of the operation of the system may be evaluated.

The specification was a result of the interviews so that the views of the interviewees was respected in each stage of the specification wherever this was feasible.

It is important to note that the majority view was that if the network planning system was reasonably quick and convenient, the system would be used more fully.

Generally, it can be seen from the detailed results, the level of interest in precedence technique was low so that the technique of activity or arrow was adopted.

The program had the following outline.

5.1 Basic design

The test project planning package was to use traditional activity on arrow network planning technique as this had been found to be regarded as potentially the better technique for the construction industry. (Questions 37 - 38, Appendix A)

The basic design on the package permitted the user to enter details of the project plan into the computer and have these details recorded on disk. The plan would be entered as a series of activities each defined by a start and end node, a description and a duration in days.

Numbers of activities

A plan, it was desired on average should be able to comprise of up to 1500 activities as this had been defined an adequate number in the previous interviews. (Question 39,Appendix A)

Analysis and reports

The demands in this area were not complex. It was suggested that the operator was able to request an analysis which proceeded rapidly and which resulted in a printed barchart report. (Questions 41-43 & 52 appendix A)

Calendars

The program should allow the operator to create a working holiday calendar that identified working and non-working day and the system was restricted to planning in term of the day as a time unit. (Questions 50,51 appendix A)

Resources

There was no resource management function within the program as although there had been some demand for this ability it was impractical to build such a feature into the system during the project . This was not seen as conflicting with the research model as the nature of resource prediction was not close to the nature of the rapid and repetitive updating of project plans. (Questions 47 & 48 appendix A)

Ease of use

It was regarded as important for the system to create barcharts featuring the work relating to a particular part of the project as this was an identified management request.

It was regarded as a high priority that the program should provide a simple easy means to update the plan to reflect work done to provide up-to-date plans regularly or so that alternate construction techniques to aid rapid and economical construction could be evaluated.

This speedy and easy update mode reflected the desire expressed in the research model for a rapid update ability from a project planning system.

In the view of nearly all interviewees the operation of the program was to be simple so that non-technical people could operate the system and obtain reports. (Questions 54 - 58)

Similarly all interviewees expected that the system would reject obviously erroneous data and would have minimal running costs.

5.2 THE SPECIFICATION FOR THE PROGRAM

As a result of the preceding objectives the specification for the program was prepared to allow the next stage of the research to proceed. The next stage was to create a sample or test program so that longitudinal case studies could be carried out.

Therefore a specification for the program was prepared. The objectives of this specification were

a:to enable a clearer view of the software to be gained and

b:to enable the potential longitudinal test sites and other interviewees to evaluate the program prior to the stage when a commitment to writing the program was taken.

The specification provided a discussion document around which interested parties could contribute to the design of the package.

5.2.1 General

The program should perform the data entry, analysis and report generation of activity on arrow network plans. The program should be written in Applesoft Basic and be suitable for the Apple II 48K microcomputer with black and white monitor and Epson FX80 printer. The Apple II microcomputer was selected as being a cheap, readily available and yet suitably powerful machine. This permitted the system to be easy to use and within the price range established in the interviews.

5.2.2 Data Entry

The user should be able to create project plans each of which would take the following form:

Headings: Each plan would have :-

Plan Title	8 characters
3 additional sub-titles	30 characters each
A calendar identifier	8 characters

This was seen as adequate to define the project.

5.2.3 Calendars

Users would be able to produce calendars each of which would be identified by an 8 character identifier. For each calendar the user should be able to enter a typical working week identifying the project normal working week environment and in addition unlimited numbers of special holidays such as Easter and Christmas. This met the requirements laid out in the interviews.

Typical working weeks should be limited to between 1 and 7 working days per week. Calendars should be capable of being up to 10 years long. Calendars would use the Gregorian calendar as a basis and would show month and day names by means of three character abbreviations.

Calendars would provide a day number chart and the program and the users would use such day number charts when calculating dates.

5.2.4 Projects

A project file would comprise of the headings including the calendar identifier, project titles and up to 1500 activities. These activities would define the network and would take the following form.

Activities would be made up from the following data.

a start node	Numeric from 1 up to 1499
an end node	Numeric from 2 up to 1500
a description	Up to 40 characters
a duration.	In days up to 999

The operator would be able to enter details of project plans as a series of activities. He would able to examine and amend descriptions and durations and would also be able to add and delete activities. These features enabled the rapid update mode objective to be approached.

Node numbers need not be sequential. The logic of the project network would be deduced from the node numbers. Therefore activities finishing at node X would precede any activities beginning at node X. This was seen as the simplest way of defining the logic of the plan and was in line with the wishes of the interviewees for a simple system.

The whole plan would be capable of being recorded on disk for later amendment. It was considered essentially that plans could be re-called for updating as a part of the prime objective of a rapid update facility.

5.2.5 Analysis

At the operator's command the program would execute a forward and backward pass through the network and deduce the critical path through the plan and the total float on each activity. Activities would then be sorted into sequence as defined below and displayed on screen. On the user's command barcharts should be printed. This is a 'batch' approach and met the target set by the interviewees quite adequately.

The analysis and sorting phase should take no longer that 30 minutes based on a 1000 activity plan. It had been recognised that reasonably quick network processing was an important feature and this time scale was acceptable within the terms of the interviews.

5.2.6 Sorting

Activities would be sorted into the following sequence. The activities would be listed in rising sequence of their early start date and where two or more activities had the same earliest start date they would be listed in rising order of duration. Activities with identical earliest start date and identical duration should not be sorted. This sequence most closely approached the manually drawn barcharts normally in use of projects and therefore was adopted.

5.2.7 Report Generation

The program would be capable of producing short term barcharts, project barcharts and date listing information on the printer. The reports should be legible and in a form acceptable to site management personnel. The barchart would show a horizontal time scale and list the activities. For each activity the earliest start and finish would be show by a bar and float to the latest finish would also be shown. The date listing report would list activities and print early and late start and finish as well as total float and durations. Again this was the minimum deviation from manual techniques and therefore most likely to be acceptable.

When requesting a barchart or date listing the user should be able to enter a search or selection key. This selection key would be used to restrict activities to be printed to those that contain the selection key in their descriptions. The user would be expected to specify the location of this selection key. An example of this might be "activities containing the letters XX in position 4 & 5" A number of users had held this ability to be important mentioning the voluminous outputs of the main frame systems.

After printing is completed the user would be asked if he requires another report and additional reports should be possible on different selection criteria.

5.2.9 Method of Operation

The main menu would have the following options:

1: Update an existing plan

2: Create a new plan

3: Create a new calendar

4: End this session

These four options were selected to offer the easiest choice and yet offer the paths through the program that a user would require.

At each stage the user would be presented with a similar simple self explanatory menu which would enable the system to be used by a non-computer technical person. This was as a result of the demand that came from the interviews for a simple easy to use system.

5.2.10 Filing and Data storage

Plans should be recorded automatically without user intervention and each plan would be recorded under its identifier and its version number. Each time a plan is loaded from disk into the memory of the computer for a work session a new version would automatically be produced being 1 greater than the previous plan. This feature would permit a historical record of the project and would allow the researcher to monitor the frequency of updating on the system and to control experimental plans.

CHAPTER 6

Implementation of the Test Package

This chapter discusses the implementation of the test package in three longitudinal case studies.

Three longitudinal case studies were established. They were selected on the basis of providing a wide range of project planning environments. One was a large project with an on-site project planning team who at the time on the commencement of the longitudinal case study were using a main frame project planning system.

The second project was one where normally, that is in accordance with the firms normal practice, no sophisticated techniques would have been used. The project had no on-site planning team and all planning would normally have taken place from the company head office.

The third site was a large project where it was planned to carry out the project planning by manually prepared network analysis. The site resident planning team used manual techniques to prepare project plans for their own site and an adjacent and smaller project.

6.1 The Three Locations

Project A - a large hospital

Site A was a large hospital project in the Greater Manchester area. The project was a traditional competitive tender project and the main contractor had been appointed to co-ordinate a degree of direct works and a range of nominated and other subcontractors.

The project comprised of 8 steel frame tower blocks and the longitudinal test began when the project had progressed to the foundation stage.

Planning on the project had been by main frame processed critical path overall project plan. This was backed up by on-site short term barcharts prepared manually.

The project was large enough to have a substantial main contractor's site set up and a substantial on-site management team. The project director lead a team of some 20 people including three people in project planning and materials progressing.

The microcomputer was not installed in the planner's office but in a spare room where the planners and others could use the machine. One of the planners was appointed to take special responsibility for the machine. This planner had experience of network planning on the main frame computer but had virtually no computing experience. He believed that critical path analysis generally failed to achieve its targets and blamed the speed and inconvenience factors for this failure.

Project B - Council offices

Project B was a new council office project in East Anglia. The main contractor had won the project in competitive tender and established a small on site team backed up by a head office management team. It had been originally planned to execute the project planning by manually prepared barcharts in the head office.

The test program was used on the site. This was achieved by a regular series of visits. Each week the planner and the associated hardware would arrive on site and the team on site would update and review the plans. Actual progress was also measured on a weekly basis. The leader of the site team was the site manager and his was backed up a project manager on a visiting basis and of course the visiting project planner.

The site manager had had little experience of network planing and computers and felt that a barchart was all that was required for a successful project.

He was open minded if dubious about the possibility of a microcomputer based critical path analysis system being of use.

Project C - city centre offices

Project C was a very large city centre office and shop development executed by a major contractor. The project included a large office development on a crowded site. The structure was a reinforced concrete main tower with precast concrete cladding. The large project team included project planners as well as the normal line management.

A senior project manager was resident on site for the larger portion of the project history.

The project planning team also undertook the project planning role of a smaller but adjacent project. Due to the space restrictions on the project there were special planning problems associated with the positioning and periodic re-positionIng of site facilities.

The site huts and storage area were moved to new locations as the work progressed.-

The microcomputer was installed in the main contractor's site offices.

The project manager had some experience of network planning having supervised large projects where network plans had been desirable.

He had no direct experience of computing but again had supervised people using computers for planning and other functions.

The planner on this site had used main frame critical path analysis techniques widely and found that, whilst recognising the limitations, the approach did usually benefit the project.

6.2 Observations made during the longitudinal case studies

The microcomputer installations were monitored by periodic informal interview. In all three cases the operator was a project planner who had had some experience of project planning by network analysis. Despite a total lack of computer experience amongst the three test sites there was a short aclimatisation stage after which the planner claimed to become competent with the technology.

In all three cases there was a problem caused by the lack of typing experience shown by the operators but this served only to slow down data entry. This was short term and not a significant problem.

In all three cases, it must be emphasised, the microcomputer was on site on the temporary site accommodation and in use by site personnel.

In two cases there was an initial period after that of aclimatisation during which the operator developed the project network plan. In these cases there was interest shown by the site management, who were helpful in the creation of the plan although this was mixed with a degree of skepticism with respect to the results expected.

In these two cases (B and C) it was necessary to create the project plans simultaneously with the institution of the system. In case A, a project plan had been prepared using network planning and this was entered into the microcomputer based project planning system. In the other two cases there was no network plan available so that it had to be prepared and entered at the onset of the case study. This created two simultaneous learning curves and aggravated the problems. In these cases the longitudinal case studies began at an early stage in the project life cycle and before much pre-planning had been executed.

In project A the network plan existed and was being analysed by a main frame computer bureau. The senior management, cautious as to the effectiveness of the experiment, planned to run the two systems (the main frame and microcomputer solutions) in parallel for the duration of the experiment. This system was designed so that should the experiment fail the site team could fall back on the main frame system without loss.

The first major effect noticed by the researcher was that the site teams began to frequently and regularly update and re-issue their project plans. The logic behind this development was that as it was not previously possible to keep plans up to date and yet this was a desirable feature of a project planning system. This had been established in the structured interviews and from the literature search on the topic.

On the hospital project the main frame system had prevented the introduction of a regular update/review technique for three reasons:

1: Cost - the main frame project planning system was charged to the project on a runtime basis which made each run of the plan and set of printouts expensive. This did not encourage a regular review.

2: Speed - the actual amount of time taken to update the data entry sheets, send the data to the computer, enter the data and get the results was in the order of one to one and a half weeks. This meant that the plans when received were out of date by 7 to 10 days.

3: Information presentation - The data was not presented by the main frame project planning system in a form acceptable to the site management and, when the data was received, there yet remained a final stage of drawing a traditional barchart for presentation to site management. This total process was too slow.

Using the relatively simple test program and the microcomputer on site it was possible to enter the updated data on site and get barcharts in a form acceptable to the site management in less than one hour.

After a short period a procedure was adopted on the hospital project that entailed the updating and presentation of the short term project barchart on a regular weekly basis to the weekly site team meeting. Indeed on the occasions when the barchart was not, for some reason, available at the meeting, the project planner would be castigated for its absence. This is taken as a strong sign that site management viewed the system with respect and saw it as a useful part of their project management function and role.

All three planners found that they could create useful networks and indeed most became sophisticated in the technique. After the experiment was no more that half way through its 9 month period the planners were beginning to ask for more features to be added to the test software. Where possible these demands were met. Again this is regarded as an indication that the site team were becoming more involved in the field of project planning and felt that they would wish to use the technique more fully. Amongst the features requested was an element of resource management particularly cash flow prediction.

Again at this point in the project some of the interviewees mentioned or alluded to the possibility that the microcomputer program could remove the onerous task of preparing the network diagrams. No solid suggestions were forthcoming on how such a system would be informed of the needs of the project, only a vague concept was expressed. The vague concept was that microcomputer's role could be extended to include network creation.

In one project an industrial dispute caused the steel frame deliveries to cease for a period of months. At the end of the dispute the deliveries began once more but the original delivery sequence was not adhered to. The site team were able to identify a number of possible acceleration measures each of which involved additional craneage and other plant. These alternative acceleration measures were discussed and for each a network plan was created on the microcomputer.

This enable the site team to present to the client a number of alternative plans each with an associated barchart and associated costings. The client/contractor were able to select one of these alternative plans and work began in the chosen direction.

In these two cases as the initial plan was developed and entered into the microcomputer the degree of skepticism grew as no tangible results emanated.

After the initial period (8 weeks in one case and 3 months in the other) the computer began to produce barcharts. This was greeted with some relief by some members of staff who had begun to suspect failure of the experiment. Others saw the experiment as "getting on its feet" at this stage.

CHAPTER 7

7.0 The results of the implementations of the Test Package

This chapter examines the effects and findings of the implementation of the test package in the three longitudinal test sites.

It examines these findings in two ways. Firstly procedural changes that relate back to the research model are examined. This is followed by a report on the perceived change in attitudes amongst the members of the on and off site teams.

7.1 THE REVISED RESEARCH MODEL

The research model was re-examined in the light of the research carried out.

The basic model did not require alteration as the flow of data was unchanged. There were however two significant changes in the model.

There is a plan, monitor and re-plan loop which is typical of a feedback control system and which runs through the following components: 4,6,7,9,11 and 2. It was noted that when the microcomputer was installed on a site the speed at which information flows around this feed back loop increased.

The average time taken to execute the complete loop was in the order of 1 week, meaning that the update process could be executed weekly. Moreover the actual process of re-planning and issuing of new reports (elements 6 and 7) in this model took less than half a day. This meant that when reports were issued they were sufficiently up to date to be respected. In fact due to the weekly updating approach adopted on the longitudinal test sites, the barcharts where never more that one week old, therefore never more than one week out of date.

The sub-system boundaries were revised to respect the removal of the project planning to the site. In the original model the information processing system (6) and monitoring process (4) and report generation (7) were geographically removed to the site and managerially removed to within the scope of the contracts management sub-system.

Because of the restructuring of the boundaries of the subsystems the attitude to planning was improved.

The microcomputer based project management system therefore had contributed in two ways. The feedback loop was followed more rapidly and also the planning role was re-positioned onto the site. The effect of these two changes was contributory to the better attitude to project planning as found within the site management personnel.

Data passing into the feedback loop from the monitoring progress (4) was generally more up to date as the actual length of the path was much shorter, therefore it was deduced that the data was more accurate. Additionally the site management were responsible for the monitoring process after the installation of the microcomputer whereas prior to the installation of the microcomputer the monitoring role was frequently carried out by head office based planning staff. Due to these two combined effects the accuracy of data used in project planning updates was generally more accurate. This improved accuracy also contributed to more accurate programs being issued (barcharts etc) and therefore this also contributed to an improved attitude to project planning.

This generally more accurate data was actually less important with a microcomputer than without. If an inaccurate plan was created in an environment where updates were infrequent, the mistake would exist for a considerable period of time. Where a microcomputer was in use the update would be no more than one week away so that errors were less significant.
This was seen as an advantage of the microcomputer based system.

The shorter feedback loop also reduced the need for skill in identifying activities. Although there was no evidence to suggest that less skill was available it was deduced that as the feedback loop was so much shorter there was a much smaller commitment made by the selection of an activity. If an inappropriate selection was made there would be little problem associated with revising the activity at the date of the next update.

As a system it was noted that whilst the input data had not changed, the output data had changed considerably and the attitude found amongst those receiving the data also changed.

The output from the system to line project management was seen to be a wide range of barcharts and other items of planning information. The microcomputer reduced the amount of man time needed to produce report and it was economical to produce reports detailing parts of the project when requested by line management.

7.2 Observed Changes in Attitude

Due to the changes brought about by the implementation of a microcomputer based project planning system there did seem to be an improvement in the attitude found amongst the line management on the test sites towards project management. They seemed to be more receptive to the idea and concepts found in project planning and took a much more positive view of the technique.

The view was proposed that project planning had become like a "NEWSPAPER. It informed the reader of recent and of forthcoming events.

Increased power in report generation was a feature requested by line management during the case studies.

This again was a positive sign on management involvement - that the site team began to request reports from the system that more closely met with their personal requirements. It was also proposed that this demonstrated a good conceptual grasp of the nature of a computerised project planning system.

It was noted that the senior management, after an initial cautious period, began to feel the presence of a microcomputer on a project was a sign of advanced management. The effect of this was that each of the construction companies organised visits to the project so that other could gain an understanding of the methods in use on the project. Visits included members of the construction company from other projects and from head office.

Also the microcomputer installation was seen as a marketing aid by the senior construction company management. This lead to visits by architects, Quantity Surveyors and potential clients. The objective was to show influential individuals that the construction company was forward thinking and used the most modern aids to achieve its projects.

This was taken as a measure of success as if the site teams had been reporting a lack of success of the microcomputer based project planning system, the senior management would not have thought it appropriate to 'show off' the planning system.

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

8.0 Overview

On the basis of the preceding analysis it is possible to draw the conclusions outlined below.

8.1 Conclusions

It was generally found that the hypotheses appeared to have a strong element of validity. The general attitude of site management personnel to project planning within the construction industry was found to be one of doubt. There was doubt that the techniques had significant value to the site management process.

8.1.2 Generally project planning was executed by the simplest of methods except where complexity or project scale or external factors demanded the use of network planning. In situations where network planning was utilised this was usually found to be executed remotely from the site by specialists and the work produced by such specialists was regarded with some doubt by site management.

8.1.3 In situations where the role of project planning was relocated to site and within the role of the site management the attitude was generally found to be one of enthusiasm. Project planning became a focal point around which the site management team planned the work load, and the results of the project planning were regarded as realistic and useful even by those who were not directly involved in their preparation.

8.1.4 The model program that was created to permit these tests to proceed was seen as oversimplyfying the task (although this was based on site management's preliminary ideas of such a package) and the site management on the test sites clearly felt able to utilise the microcomputer and the test program and indeed stated a desire for more sophistication in terms of their ability to plan.

8.1.5 It was noted by the some of the construction personnel interviewed that the microcomputer with a suitable software package could remove some of the problems experienced with the execution of the technique of project planning by network analysis to an extent that it need not be executed by remote specialists.

Those site teams who had been able to execute project planning themselves, that is by personnel regarded as being a part of the site team, reported a higher level of satisfaction with the the techniques employed. This tended to indicate that where project planning was executed close to the project and not in a remote location, the attitude to project planning was relatively improved.

8.2 Recommendations

8.2.1 There was some disappointment that it was still necessary to create a network diagram for the project. In all cases the desire was stated that the preparation of a network was a means to an end and perhaps the microcomputer could remove this part of the task.

This finding was completely unexpected. The view was expressed frequently that it should be possible for the microcomputer to make the task of project planning even easier. It was mentioned that production of the network plans was not, in itself, an objective. It was the rapid and economical progress of the project that was the overall objective.

An examination of the research model showed that the repetitive process involved in producing, monitoring and updating plans was key to the process of project planning. Once up to date plans have been prepared the model shows that these plans were used to disseminate information to the management team.

This communicative element of project planning was seen by many as being closer to the objective of project planning so that any technological improvements that made the steps leading up to the production of project plans for dissemination would be useful.

The view was given that the technique used to arrive at the plans was almost irrelevant to the management team as long as they could have confidence in those plans.

Hence the challenge was not only to improve of the current techniques by making those techniques more convenient and more rapid but to use the technology to create a new approach to the fundamental problem.

This was a strong confirmation of the original hypothesis. By requesting a faster technique that reached to the true management objective, the hypothesis that project planning was badly thought of partly due to its slowness and partly due its inappropriate positioning tended to be confirmed.

When site manager saw the possibility of rapid, on-site project planning they warmly greeted this technique and very rapidly began to examine the technique for further improvements.

The basis concept from management personnel was that the computer should be able to produce the network plans thus speeding and making even more convenient the process.

8.2.2 To achieve this a software package must have the following areas of knowledge:

Knowledge of the nature of project management

Knowledge of the general nature of the project in hand

Knowledge of the specific project in hand

The ability to absorb this knowledge and produce project plans as a result.

This consideration led to a brief examination of Artificial Intelligence techniques and it was here that some possible links began to emerge.

Artificially Intelligent system are not based on a range of data but on a base of knowledge. Such system concentrate on rules rather than data.

It was considered that a knowledge base of project management, and of general types of project might have been feasible. To this would be added a knowledge base about the specific project which would therefore be able to create project plans for dissemination. It was observed that all the data about a project was available on most projects at an early stage through the tender documents, Bills of Quantities and other pre-construction documents.

As a project proceeds information to the amount of work done, and therefore the amount of work outstanding could be regarded as a re-definition of the project. Such information, it was noted, was available from bonus payments, progress reports and materials reports.

An EXPERT SYSTEM it was found was a form of Artificial Intelligence that deals with the learning of and utilisation of rules.

It was considered that an EXPERT SYSTEM might be created that was aware of the fundamental rules of project management.

It was considered that a company might be able to use an EXPERT SYSTEM to create a knowledge base of the sort of project it has worked on. To this could be added the data relating to the specific project extracted from the wide range of information available at project commencement. The result, it was considered, might be communicative project planning documents.

Many question arose from these thoughts:

Could such a system be created at a cost within the reach of construction companies?
Would project managers utilise such a technique?
Are such techniques in use in other environments and could any such implementations be adapted to the construction industry?
Would site management staff be able to instruct such a system and how would they re-act to such a system?
What, if any, new expertise would such a system demand from site management personnel?

8.2.4 It was considered that this would form the basis of a suitable research project. Such a project would evaluate the possible form of an artificially intelligent project management and attempt to evaluate the features such a system should as seen from the project management viewpoint.

Then a test program would be created which would be installed on a variety of projects and in a variety of companies to test the value of such a system.

Appendix A - Analysis of Responses to the Structured Interviews

Appendix A: The Responses

This section analyses in detail the responses gained during the structured interviews.

It should be noted that the questions repeated herein for clarity were not read and taken literally during these structured interviews but were used as a guide to a continuing discussion between interviewee and interviewer.

A.1 General.

A total of 35 project planners and project managers were interviewed. The following examines their responses. A summary of the responses is included in Chapter 4 of this thesis.

A.2 The Company

The first few questions related to the background of the interviewee's company and its area of work.

Q1:What is the size of the company in turnover?

The average turnover of all companies interviewed was approximately £4.9 million and the range was from £20M to £3,000,000. An adequate range of companies was therefore examined.

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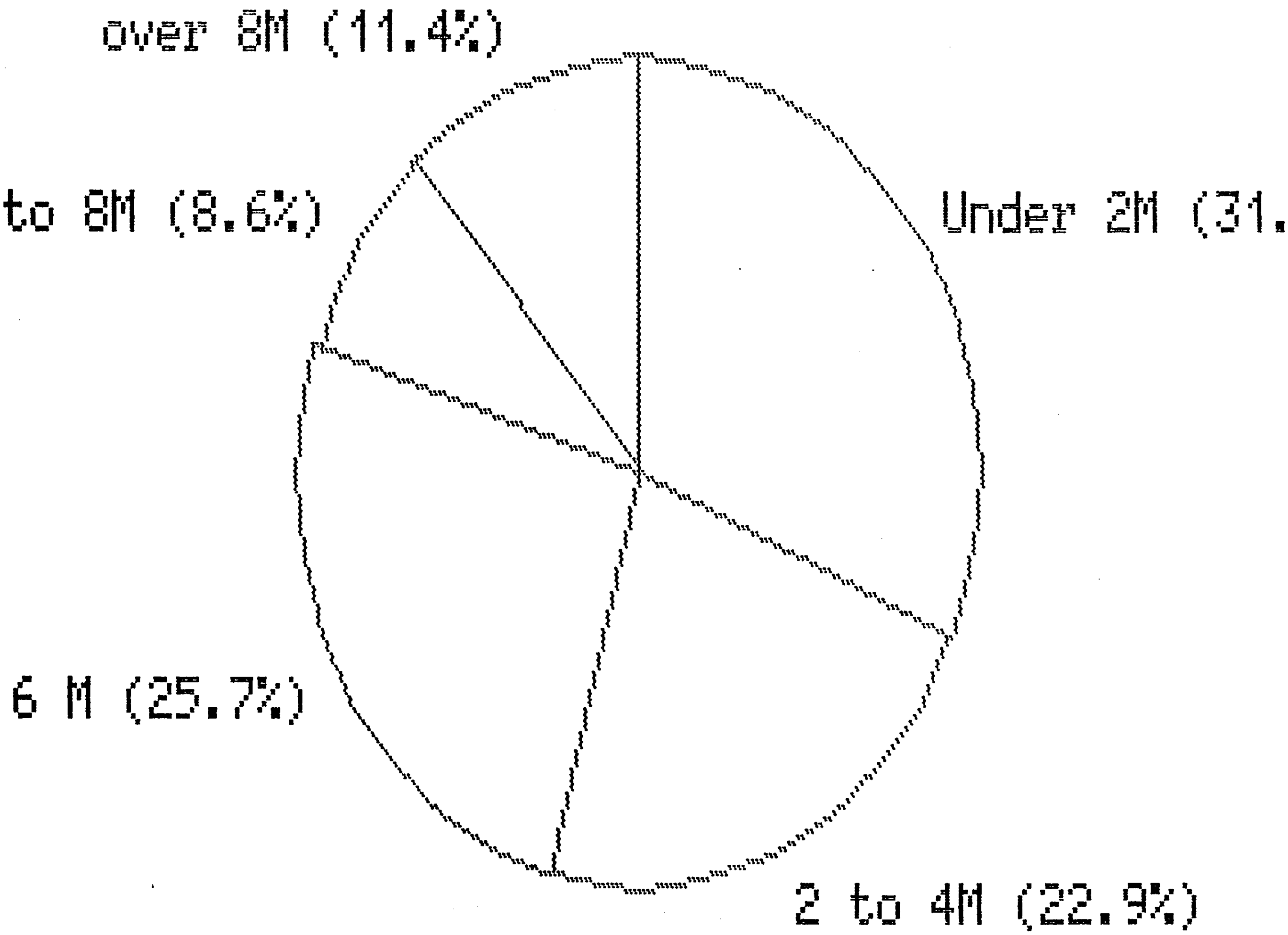
Diagram A1: Responses to Question 1



Q2:What is the size of the company in numbers of employees?

The range was from 2,000 to 25 with an average of 287. The pie chart above shows that most firms were small (under 200 employees) and that a good range of companies were investigated.

Q3:What type of work is the company involved in?

Nearly all the interviewed companies were construction companies involved in normal competitive tendering work for both public and private clients. The type of work ranged from housing to an international airport. Some of the larger organisations included international contracting experience and management fee and other cost recovery types of contract relationships. There were 3 companies who were classed as civil engineers.

A.3. The interviewee

Next the interviewee's personal role and experience were investigated.

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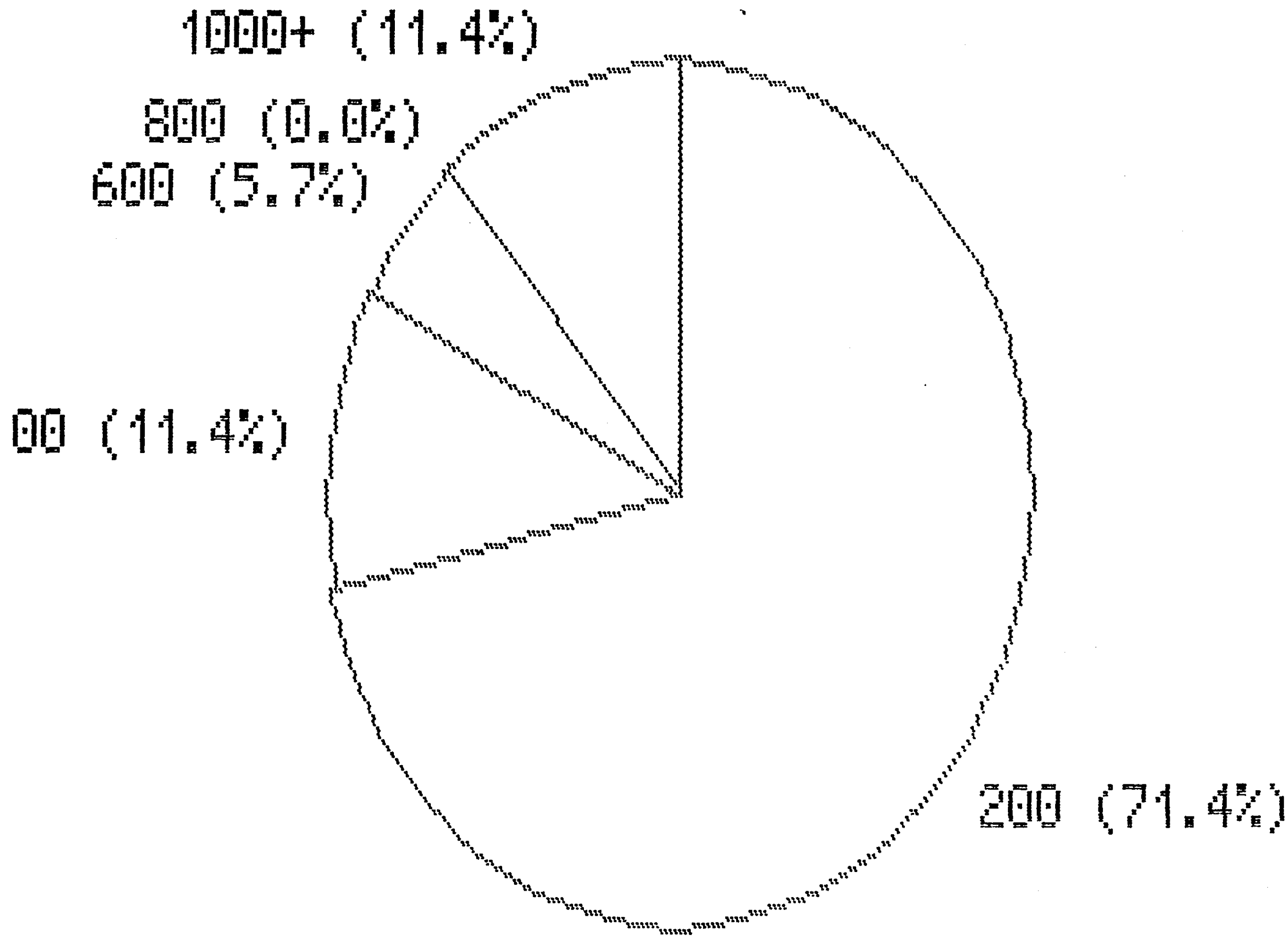
Diagram A2: Responses to Question 2



Q4:What is your job title ?

12 of the interviewees gave their title as Project Planner and a further 7 stated their role as Planning Engineer. These in general seemed to be different job titles for the same role. Together these two catagories totalled 54% of the sample. 2 of the interviewees were Engineers (on-site specialists found predominantly in Civil engineering) and 7 stated their title as Project Manager. This term normally indicated responsibility for a project.

2 managers described their role as Construction Manager (being responsible for the site work on a project). There were 5 others in various site and head office management. The diagram (A4) shows the distribution of job titles.

Q5:What is you role ?

Almost 50% of the interviewees could be classed as project planners (those who perform the task of project planning by some means). 20 were effectively full time and the remainder perfomed some other function in addition to that of project planner for example materials chaser.

The remainder (15) were full time project management staff involved in direct line management either on or off site. Some of these had a responsibility for project planning on some projects. It was noted that the division of responsibility, allocation of titles and role varied for an individual as he moved from project to project and from firm to firm. It was not uncommon for a project planner to become a project manager, nor for a construction manager (who executed his own project planning) to move to a larger project, be elevated to project manager and to delegate project planning to an assistant. 2 were project planning consultants contracting to construction firms and providing a project planning service .

Q6:What type of project are you currently involved in?

All interviewees were involved in some form of construction management. This ranged from housing to major, multi-million hospital projects. A wide range fo projects was therefore examined.

At this point the interviewee was asked about the project or projects in which he was currently involved and the project planning techniques in use on those projects. His opinion was sought on the success of these techniques.

This directly relates to the research model as the prevelant attitude was to confirm that planning had to be rapid so that it could be regularly reviewed. A regularly reviewed planning process should remove the attitude that the forecasting problems made the technique less than valuable.

Also if the microcomputer made possible the re-location of the project planning process to the site some of the remoteness problems raised by the interviewees might be lessened.

Q7 What system (of project planning) is used?

The following statistics emerged and can be seen from diagram A7. In 71% of the projects examined Barcharts were prepared manually (neither using critical path analysis techniques nor using computes). In 10 cases (14%) Barcharts were prepared from network (with or without computers). In 5 cases manual network planning techniques were employed (ie without computers).

5 interviewees used computersied network planning techniques and 1 planner was using the line of balance technique.

It was concluded from this sample that Barcharts are a very common form of communication. There was correlation between the occurance of network planning and the larger, more complex projects.

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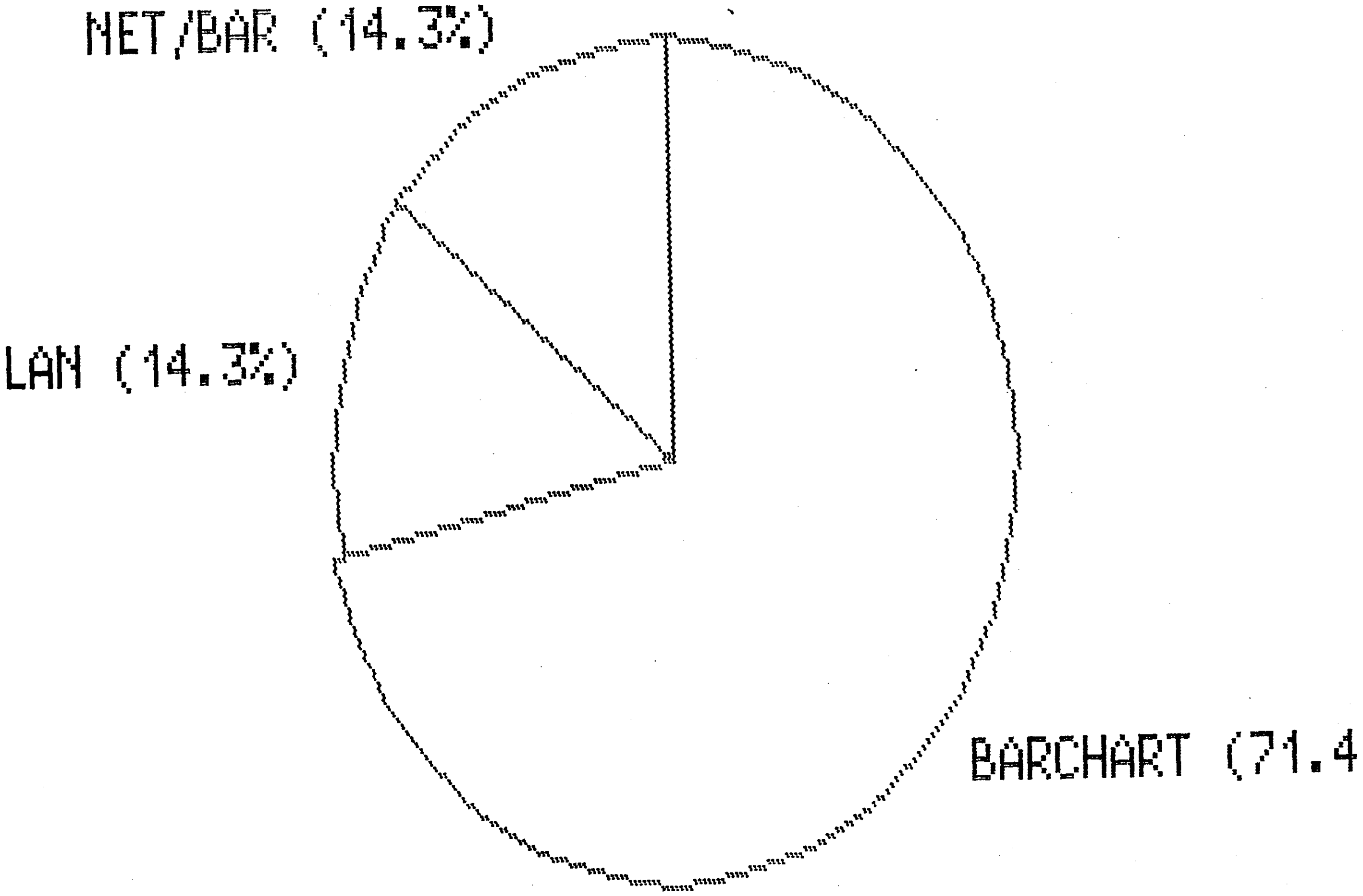
Diagram A7: Responses to Question 7



Who performs the planning role

The answer to this question, shown in diagram A8, frequently contained some reference ot dependant factors. For example many contractors plan large projects on-site and smaller project from head office. Some smaller projects are planned using facilities on a local larger projects.

The interviews did not reveal an accurate measure of project size that would dictate the decision as it was a complex decision relating to a number of factors for example - availability of staff, location of the project, political importance and complexity.

Diagram A8 shows the distribution of the planning work at the time of the interviews.

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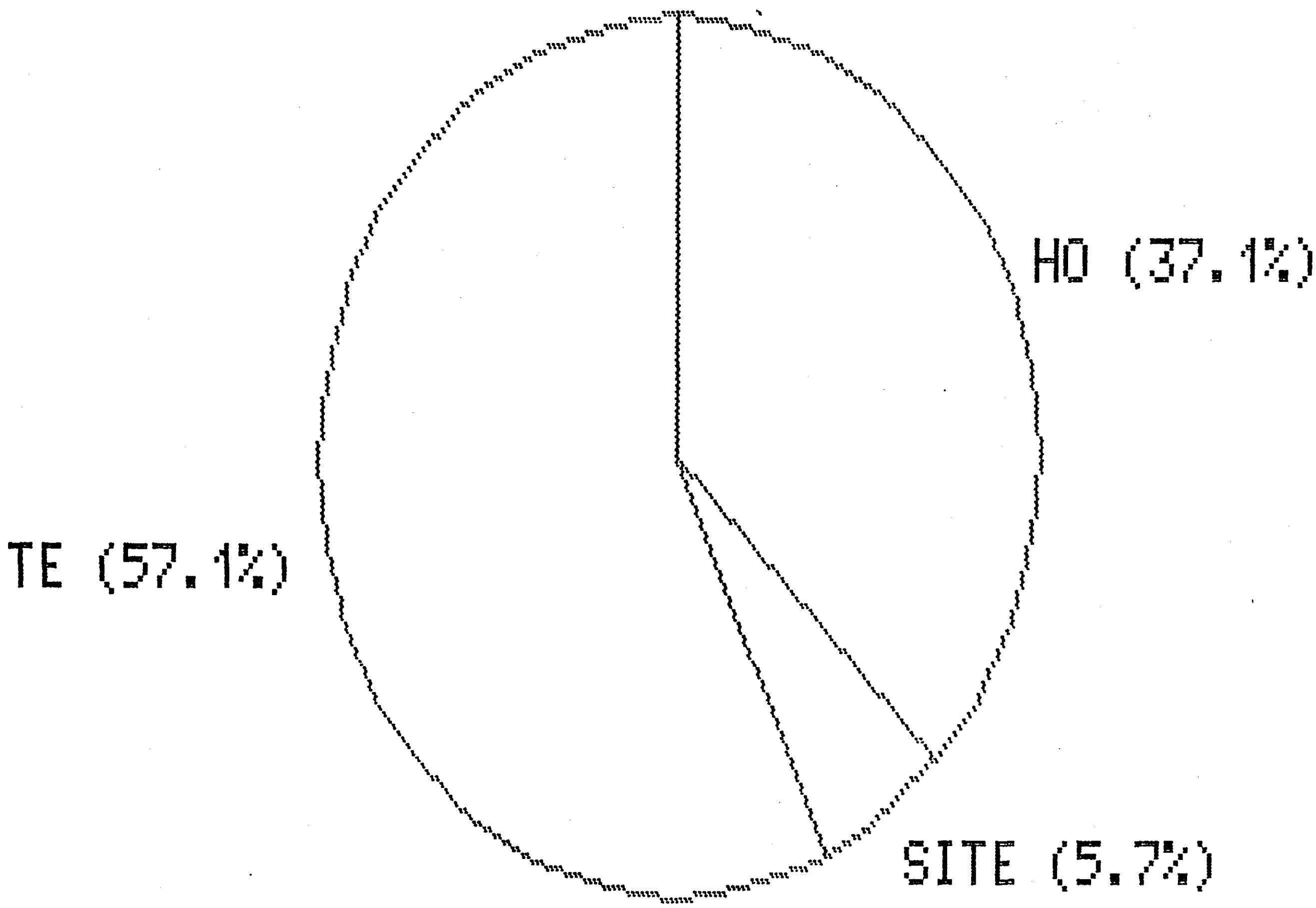
Diagram A8: Responses to Question 8



Q9:Do you feel that this use of planning techniques is successful? (1 = very successful, 7 = not successful at all)

The average response was 4.6. The shape of the graph indicated the general view which was that project planning was not a contributor to successful project management. When the views of those not directly involved with project planning the average were analysed the result was much higher (5.75). This seemed to indicate that whilst those involved with project planning of all kinds doubted the value of project planning, there was a higher degree of doubt amongst those using the plans, the project and construction managers.

Q10:Why do you feel this is the case?

In some cases the view was that it was very difficult (in some views impossible) to predict the flow of a construction project as there were too many external factors (weather, delivery delays etc). This accounted for 20% of the sample and is referred to as "PREDICT" on the pie chart shown in diagram A10.

Also the view was given that as project planning attempted to look into the future its usefulness was limited. On the pie chart this is referred to as "FUTURE" and makes up 56% of the sample.

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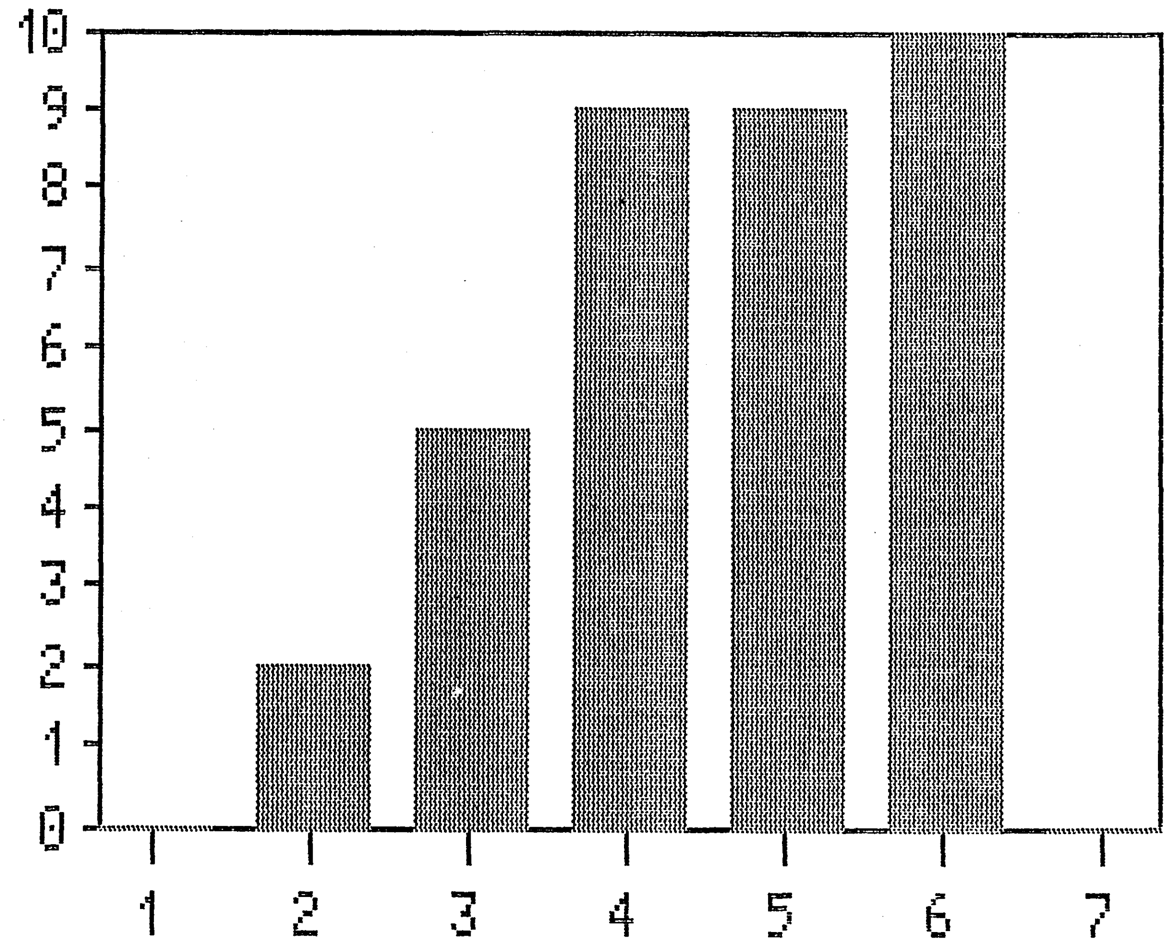
Diagram A9: Responses to Question 9



1 = very, 7 = not sucessful at all

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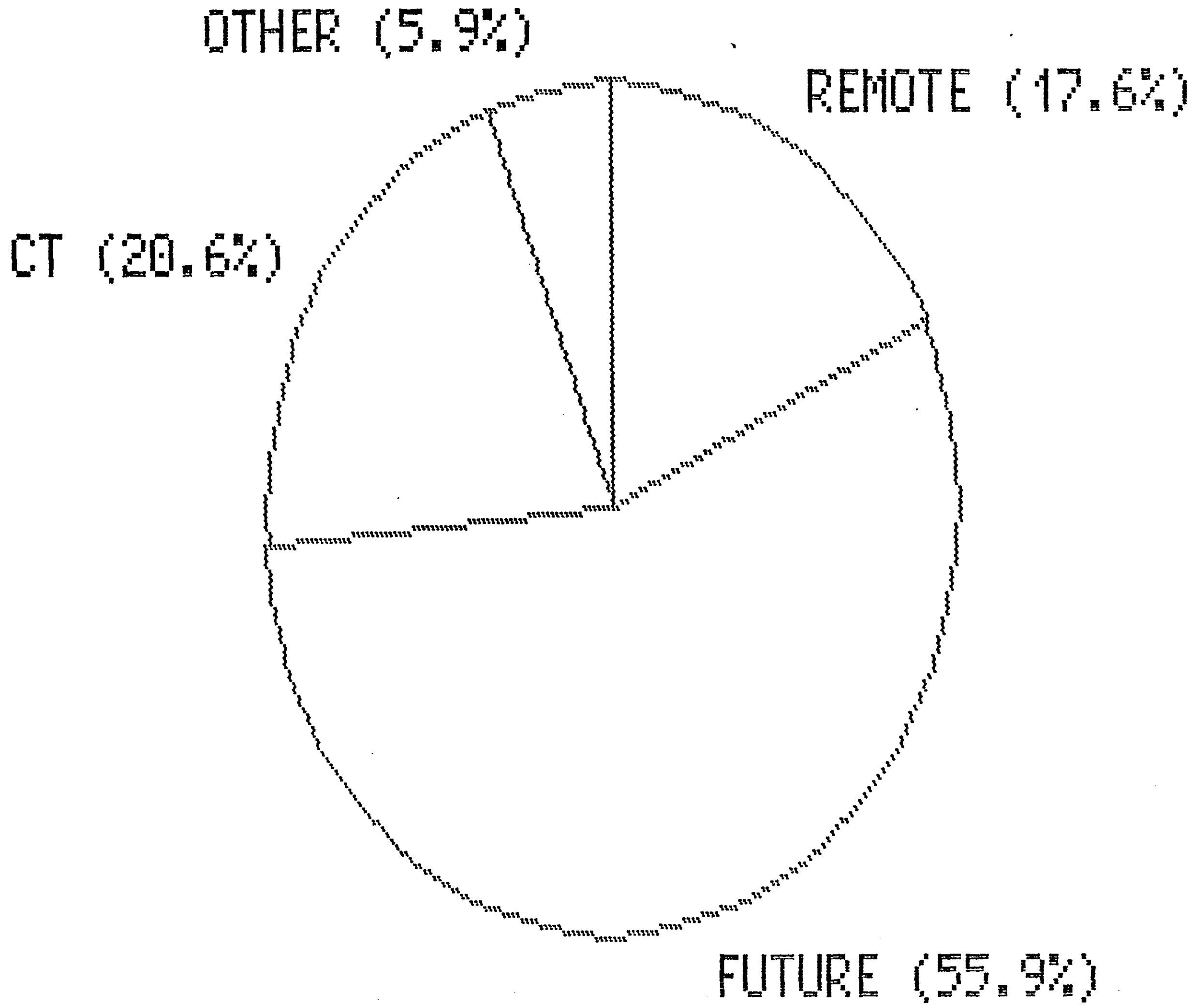
Diagram A10: Responses to Question 10



In addition of those who were involved in projects planned remotely (either from head office or another project site office) many (17% of all interviewed) felt that this an additional factor in the lack of success of the technique. This percentage would be much higher (52%) if taken as a percentage of remotely planned sites.

A.5 Other planning techniques.

The interviewer then asked about other, more sophisticated project planning techniques - other than those discussed in questions 7 to 10. The interviewee was asked about these alternatives, such as network planning and network planning by microcomputer and his opinions of them and in what circumstances these techniques were used.

This tended to indicate a relationship between certain types of project and an increased need for sophisticiation in project planning. In all 33 projects were referred to as being special, complex or large and on which had some more advanced technique had been used. This seemed to confirm the hypothesis that generally, advanced project planning techniques are used only where the project demanded.

Q11:In what kinds of projects are other, more spohisticated systems of planning used and what system is used?

As can be seen from diagram A11, 55% of the interviewees had been aware of the use of project planning techniques on projects that they classed as special. By this they indicated projects that were unusual for the firm in some way. 23% mentioned large projects and 14% mentioned complex projects. 1 mentioned an experiment that had been run within the company and 2 were not aware of any use of techniques that deviated from the norm.

Q12: In these cases mentioned above, who performed the planning role (Head office role/on site role/other)?

26 of the interviewees reported that these special techniques referred to above had been executed from head office, only 7 reported the use of such techniques from site.

This seemed to indicate that such special techniques were head office based generally and that in only a few cases were such techniques used on site.

Q13:Do you feel that these alternative techniques were successful? (1 : very successful, 7 = not successful at all)

The response to this question, on average, was neutral. The average was 3.2

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Diagram A11: Responses to Question 11

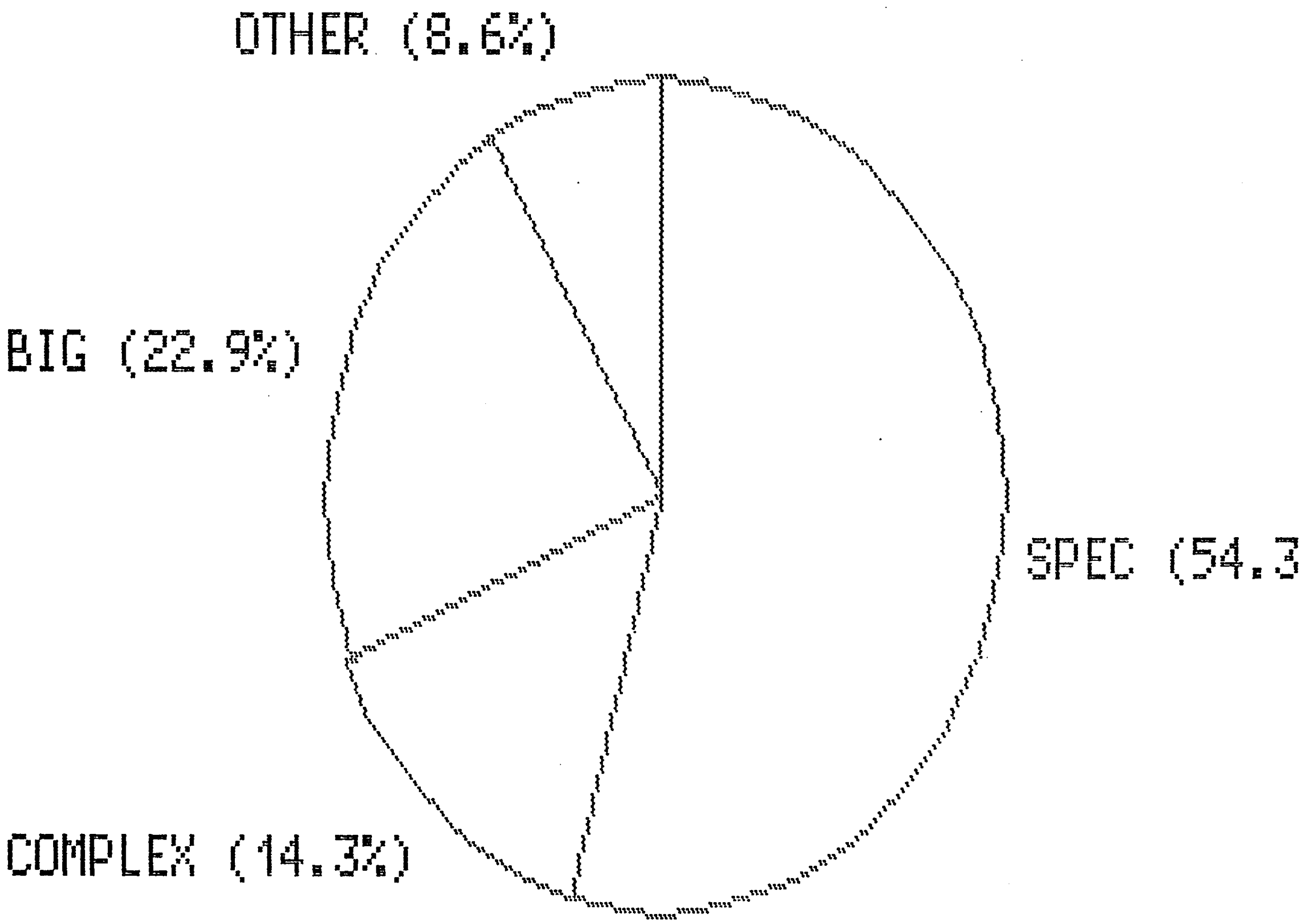

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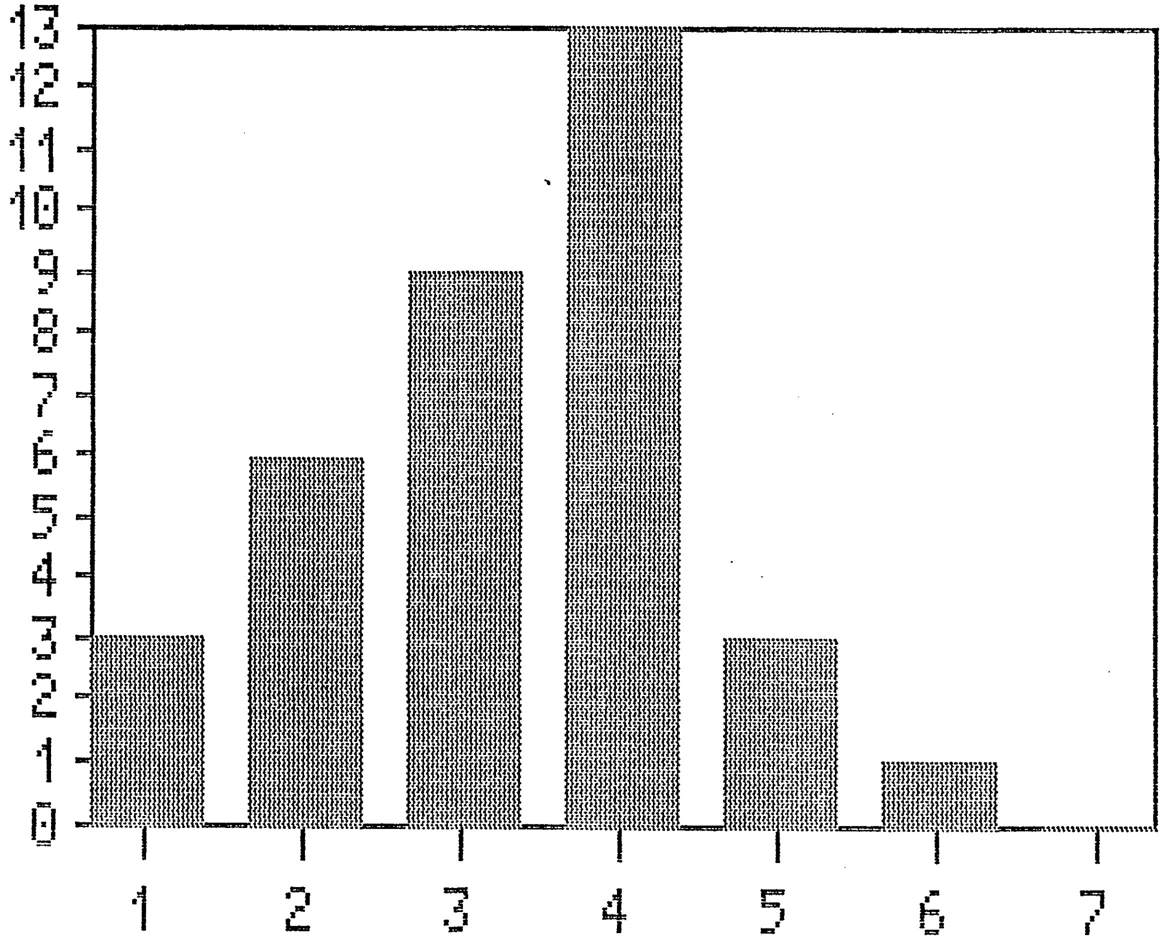
Diagram A13: Responses to Question 13



1 = very, 7 = not sucessful at all

There were a few strong views made in response to this question (see below) but the majority response was neutrality. The shape of the graph in diagram A13 tends to confirm this.

Q14:Why do you feel this is the case?

Of those involved in computerised project planning techniques the general view was that on certain projects this was a useful tool as it enabled the team to keep control of the large number of tasks involved in complex and large projects.

4 interviewees expressed quite strongly that these approaches were very unsuccessful because of the remote, over complex nature of the techniques.

The majority view (60%) was that the special projects that had used more advanced techniques needed to make use of such techniques and therefore the question of success was not relevant.

It was deduced that there was doubt about these more advanced techniques generally but it was thought there were situations where the problems caused by the difficulties of the techniques were outweighed by the special needs of large or complex projects. In no case was a resounding success reported.

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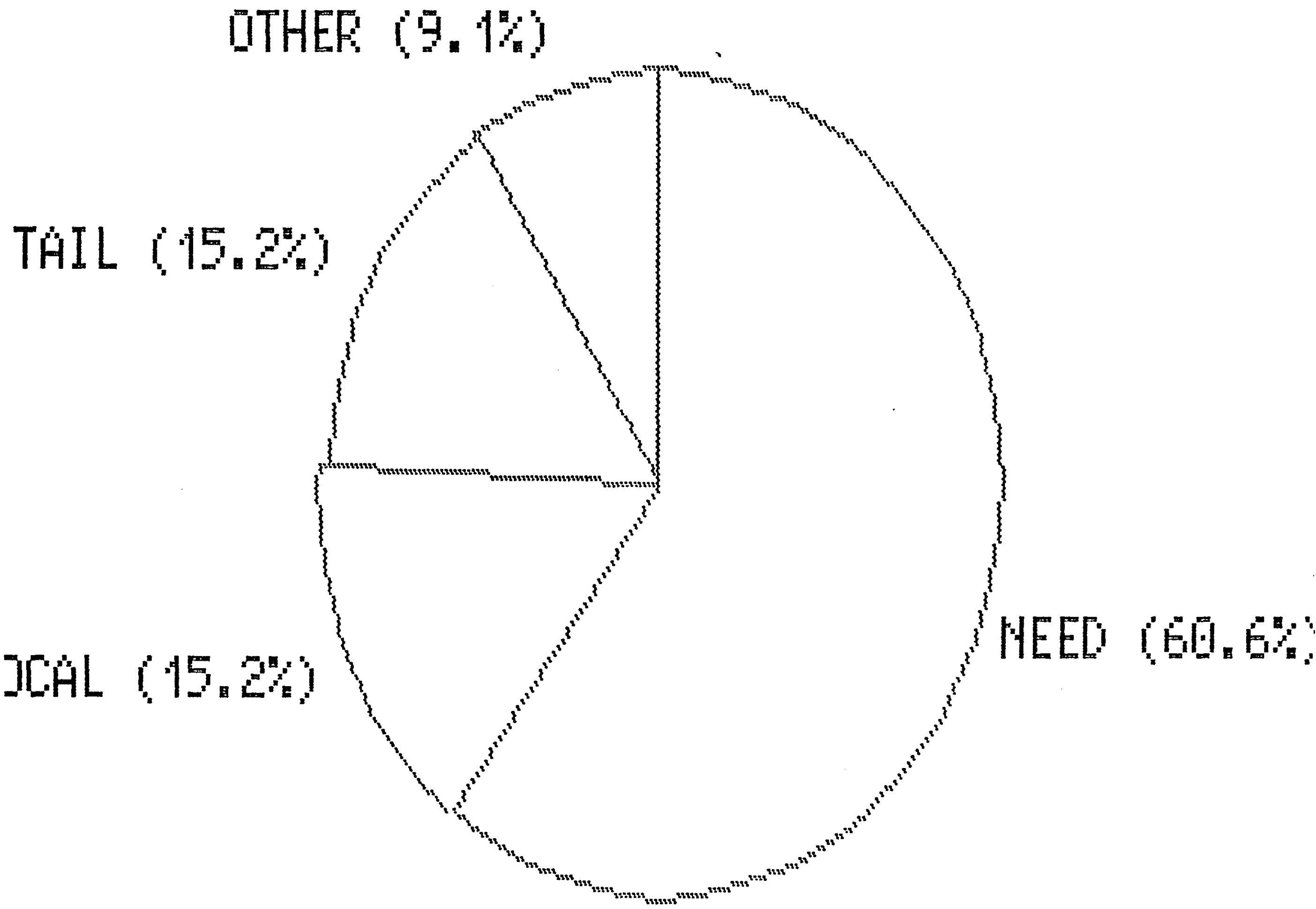
Diagram A14: Responses to Question 14



This tended to confirm the poor view held by managers of project planning techniques in general and of network planning in particular and there was evidence that remoteness and slowness were factors that aggrevated this attitude.

A.6 Project planning experiments

It was possible that a number of construction companies had experimented with some project planning techniques and the interviewer turned to discuss this topic. The questions attempted to discover what experiments had been run and how successful these had been.

Once again questions related to the location of the project planning role and the success of the technique.

Q15:Have there been experiments with computerised methods of project planning within the company?

Nearly all those interviewed had either been involved in or visited a project were computerised network analysis system had been tested. There were only 6 exceptions to this.

Q16:For what kinds of project were these experiments carried out?

Generally these experiments had been carried out on prestigious projects ie, those that were very large, for important clients or for some other reason under the scrutiny of the public or the construction industry. Prestige was seen as a reason not relating to a true desire, but a reason forced on the project team by outside influence.

In all cases a factor such as the prestigous nature of the project, the project's size or complexity had led the team to run some form of experiment with project planning.

Q17:Who performed the planning role?

With only 6 exceptions the role of planning by computerised network planning techniques had been executed as a head office function. In the two of the exceptions a remote terminal had been installed on site and utilised by a project planner based on the project. One of these exceptions was a very large project. In the other 4 exceptions the site had used a remote computer but entered data by data forms posted to the computer bureau. One had been carried out by a consultant project planner.

Q18:Do you feel that it was successful?

(1 = very successful, 7 = not successful at all)

Average = 5.5

Generally the technique was regarded as a failure and the technique had not been adopted for extended use within the company. In only two cases where computerised project planning techniques had been sufficiently successful, had the technique been later adopted for use on large scale projects.

The shape of the graph above shows clearly a weighting towards the "not successful" end of the scale.

Q19:Why do you feel this is the case?

The general view was that a computerised system offered no solutions to the problems associated with project planning. The general view was that the time taken to produce a plan was not noticably reduced and the management time involved was increased ("SLOW" 64%). The argument was proferred by the researcher that the plan could have been examined in greater detail but this was not seen as a advantage.

This tended again to confirm the view that project planning had a poor reputation and that newtork planning and main frame computers merley served to worsen this reutation.

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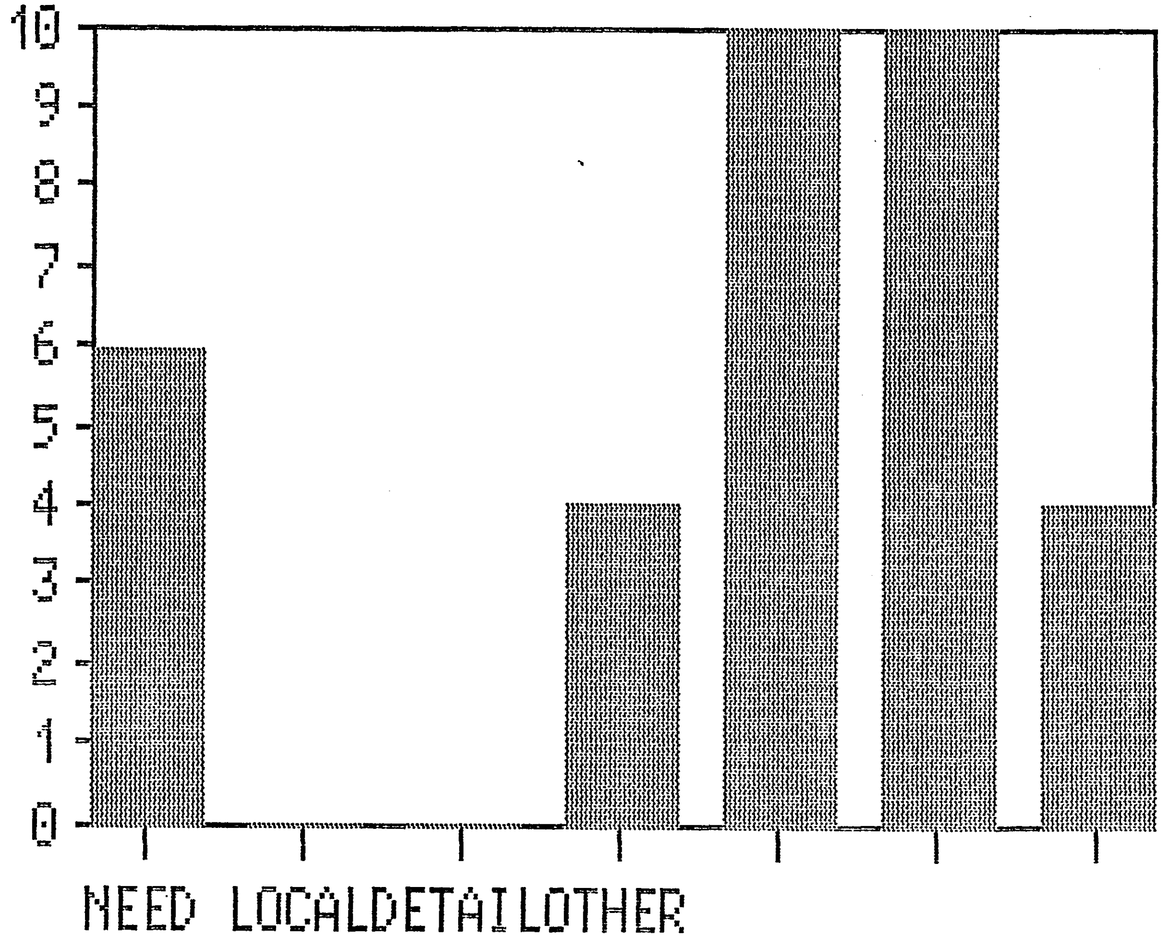
Diagram A18: Responses to Question 18



1 = very, 7 = not sucessful at all

The mere fact that network planning and computers were held in reserve by most firms and only used on the most difficult projects tended to confirm this view.

The views given for this poor reputation had been repeatedly the remoteness and slowness of the technique. This tended to confirm the hypothesis that the technique might be perceived as more useful if it were faster and more convenient.

A.7 The company's experience with computerisation

At this point the interviewer asked a few points about the company's experience with a computer in no specific area of management and about the experience of the interviewee with computing.

Q20:Does the company own a computer?

30 of the companies interviewed had some form of computing facility in the organisation. This represented over 75% ofthe firms interviewed.

Q21:What is it used for?

All companies utilised their computer facility in company adminstrative matters (wages, accounts) or for general administrative matter. It was noted that the references to the computer by the site and management personnel were rather vague as if they had been aware of the computer within the organisation but were unaware of any direct dealings with it or its operation.

4 organisations had additional computing facilities involved in other areas such as estimating, only one had an 'in-house' project planning system.

Q22:Who uses it?

In the adminstration situations the users were given as the administration staff. In the other cases there were specialist computer operators within the company payroll.

Q23:Do you feel that the use of a computer in this environment was successful? (1 = very successful, 7 = not successfull at all)

Average response 2.1. The general view was that computers seemed to provide a useful facility in these areas. The shape of the graph in diagram A23 shows a satisfied response to this question.

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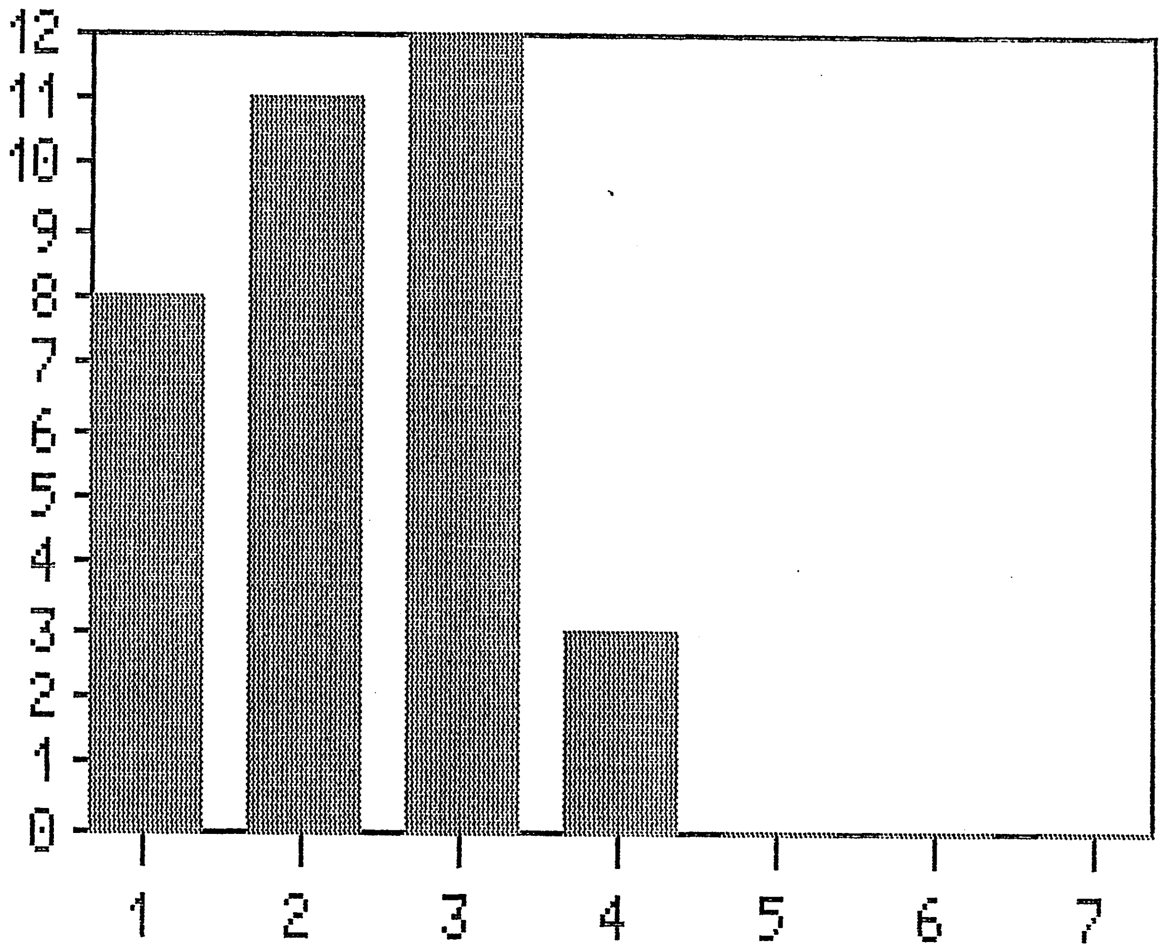
Diagram A23: Responses to Question 23



1 = very, 7 = not sucessful at all

Q24:Why do you feel this is the case?

It was stated that there seemed to be a 'fit' or 'suitability' in these data processing areas for computers. In these roles the interviewees expressed the view that the computer 'works'.

This tended to remove the possibility that the prime reason for the poor reputation for computerised project planning was due to the presence of a computer as the interviewees reported a computer performing a useful function in another role. It was therefore deduced that it was the use of the computer in project planning that was seen as inappropriate, not the computer itself.

Q25:Have you experience of a computer?

Of the 36 persons interviewed 31 had had some experience with a computer.

It was seen as valuable to deduce in what area this experience had been gained.

Q26:In what environment have you gained experience of a computer?

Of the 31 'experienced' computer users the breakdown was as follows:

26 had gained experience of a home computer. 8 had used a business computer at work. Some of the interviewees had gained more than one of these types of experience causing the total of these catagories to exceed the number of interviewees reporting experience with a computer. It was deduced that the sample of construction staff were, due to having some knowledge of computers, reasonable to form the basis of the remainder of the structured interview.

Q27:For what purpose did you use the computer?

The group of 31 answered as follows:

The 26 who had used a home computer had used it either for games or in an effort to gain a general appreciation of the computer. 11 managers had attended a computer appreciation course. 3 of the interviewees were, or had, made use of a computer in the role of project planning.

Q28:Do you feel that this use of a computer was successful? (1 = very successful , 7 = not successful at all)

The average response was 3.2 - slightly less useful than the median. The chart shows a slightly dissapointed response, but the response is very slightly less than neutral.

Q29:Why do you feel this is the case?

The games/appreciation group in general gave the view that the time they had spent experimenting with and playing games at home had been a useful experience. Some felt that some basic understanding had been gained.

2 felt that they had gained very little from the experience.

Those who had attended a computer appreciation course in general stated the view that a basic understanding of the capability of the microcomputer had been gained. Nearly all those who had worked on a regular basis on computers felt that there was a role to be played by computers in certain circumstances.

A.8 Experience with network planning techniques.

At this point the researcher opened the topic of network analysis by acertaining the interviewees experience with the technique. This was to establish the reliability of the interviewees reaction to later questions. Questions were also asked to discover the interviewees attitude to project planning by network analysis.

Q30:Are you familiar with the technique of network planning?

The interviewees were divided as follows:

Those who claimed at least some experience numbered 17. 16 stated that they had had some experience. 2 admitted to having very little experience of the techniques.

It was deduced that the sample was a reasonable sample in that there was an adequate knowledge of the technique within the the sample of managers to give reasonably reliable results.

Q31:In what environment have you seen network planning used?

Site planning = 23 - This group had witnessed planning for projects whilst being on a site even though the planning process had not been executed from the site.

A group of 11 had experienced head office planning (head office resident planning staff) and 1 had experience of tendering/precontract planning (use by head office/estimating department staff)

Q32:Who performed the network planning role ?

The majority had witnessed project planning as an head office role. There were 24 such interviewees. An on-site role had been experienced by 6 and 5 had seen network planing in use on another project.

Whilst the interviewees had been located in a variety of ways (on site, in head office) when they encountered network planning they were working or at least visiting a company head office environment.

This was further evidence that this group were likely to be capable of answering intelligently and with sufficient experience questions on the topics to be discussed.

Q33:Do you feel that network planning was successful? (1 = very successful, 7 = not successful at all)

The average was 3.6 - not very successful.

This tended to confirm the hypothesis that the general attitude to network planning within the construction industry was poor. Again the graph in diagram A33 shows this tendancy more clearly.

Q34:Why do you feel this is the case?

The general feeling was that there were some distinct problems with the successful application of project planning by network analysis. In the construction industry, it was stated, the project was too unpredictable due to the weather and the 'one - off' nature of the work undertaken. It was not sensible to use a sophisticated technique to make detailed predictions about a construction project. Additionally the technique was seen as being too slow to be of use. In these terms the interviewees refered to the amount of actual time and management time involved in network planning techniques.

Finally the view was that it was a technique executed by remote specialists who were not involved in the project. Some saw the technique as being too complex a solution to the problem of planning projects.

In those cases where the technique of network planning had been relatively sucessful the reasons given included a reference to the quick and local benefits of network planning being executed on site or close to the management of the project. One interviewee attributed the relative success of network planning to the individual planner responsible for executing the role.

This tended to indicate that there were situations where network planning was successful but that these situations were few and far between.

A.9 Project planning by microcomputer

At this point the interviewer outlined the possibility of project planning by network analysis on a microcomputer.

The technique was described in outline with the degree of detail varying according to the interviewees knowledge of computers and project planning by network analysis. The possible benefits were not described but a factual account of such a system was given. The questions that follow ask the interviewee to consider the positioning of such a machine and therefore the project planning role.

Q35:Who would use a project planning system on a microcomputer?

The views given were classified as shown:

Of the interviewees the most popular view was that the planner would use a project planning system by microcomputer with 26 giving this view. A group of 6 felt that a project manager would use the system.

Generally, it was deduced, the interviewed sample felt that if a microcomputer was utilised it would be necessary to have a planner on the project. The majority that felt that this was the case outnumbered the number who were planners.

A10 The need for a functional specification for a software package

It had been seen as a part of the research project to evaluate the need and form of a suitable microcomputer based network planning system.

Therfore this part of the structured interviews was designed to gain views on a functional specification of a microcomputer based project planning package.

Features, in terms of inputs and outputs, were described to the interviewee and his views on the relative importance gained.

The interviewer raised and explained where neccessary a particluar feature and asked the interviewee to rate the feature in importance.

The interviewer described briefly the microcomputer based system and then the interviewer asked "What features would it have - Can you rank the degree of importance of each of these elements on a scale where 1= very useful, and 7 = not useful at all ? "

A11 A functional specification for a project planning package

The questions were firstly concerned with the network planning basis of the system:

Q36:Would a project planning system on a microcomputer be useful? (1 =very useful, 7 = not useful at all)

The average response was 3.5 - this average is exactly mid point on the scale. The view felt by the interviewer can be summarised as cautious interest. The graph in diagram A36 above shows a neutral response.

Q37:Precedence networks (1 = useful, 7 = not useful at all)

The graph above and responses show that the majority view did not feel precedence networks were useful. For this reason precedence network capabilities were not included in the model programme.

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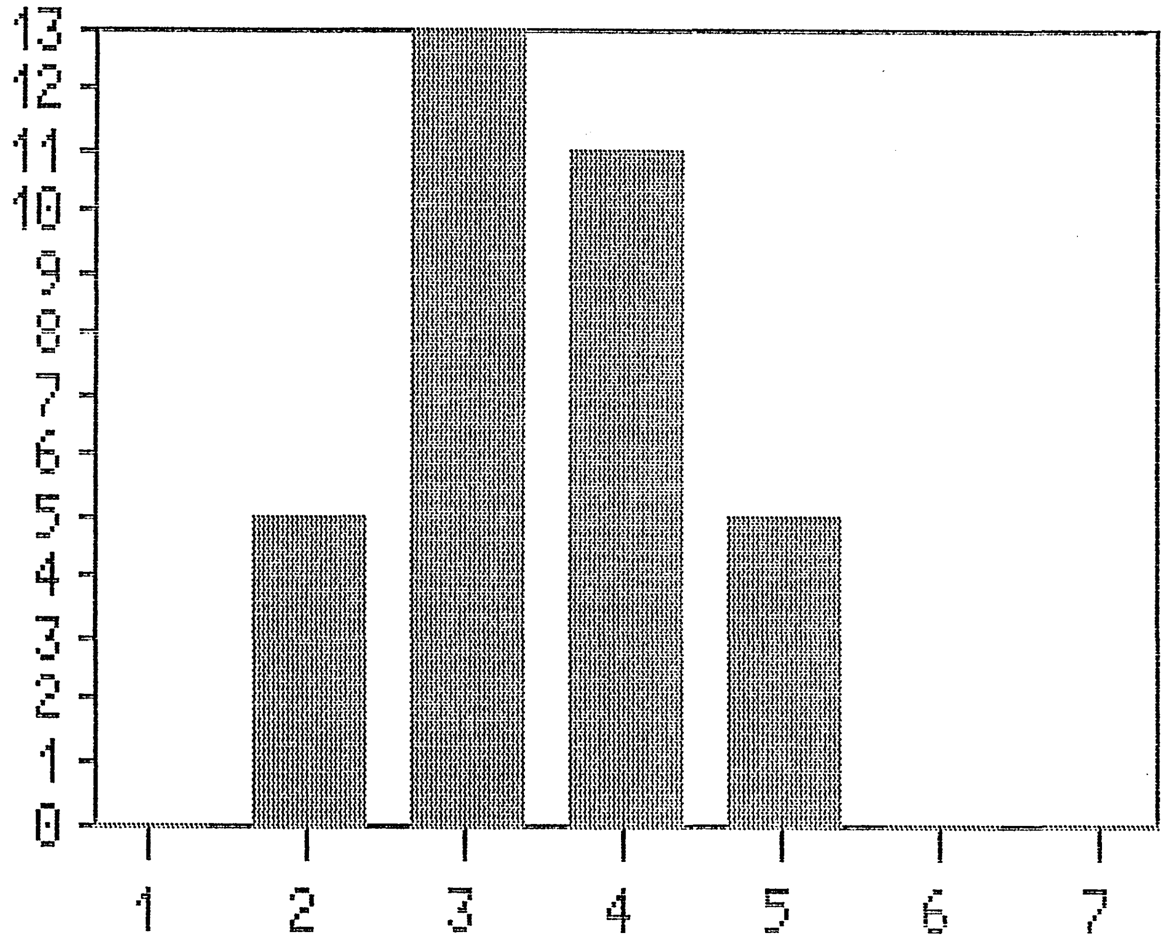
Diagram A36: Responses to Question 36



1 = very, 7 = not sucessful at all

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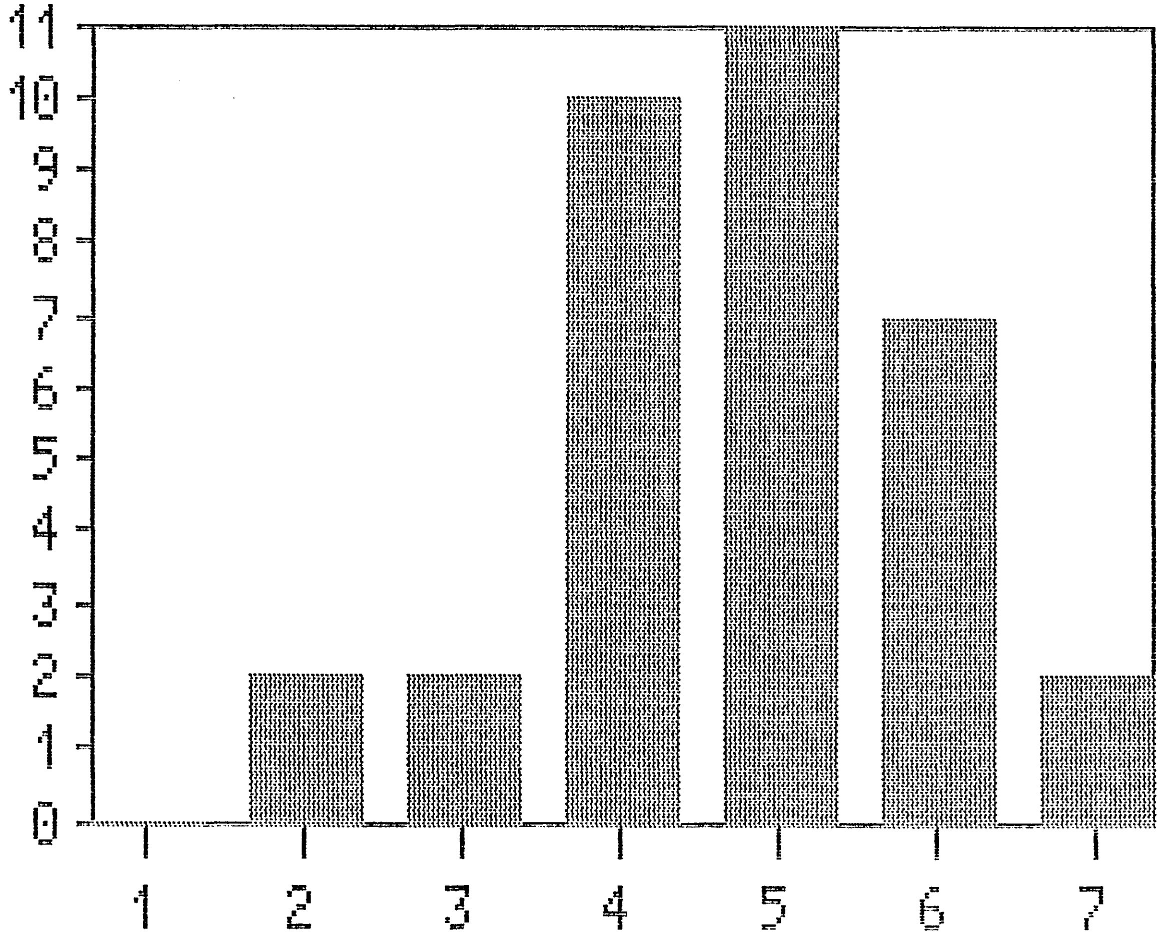
Diagram A37: Responses to Question 37



1 = very, 7 = not sucessful at all

Q38:Activity on arrows (1 = useful, 7 = not useful at all)

A strong majority wished for activity on arrow networks and therefore the model programme was built around this technique. The graph shows a heavy preference for activity on arrow plans.

Q39:How many activities per network would you need? (numeric)

Nearly half (47%) of the interviewees felt that 500 activities would be adequate for an on site microcomputer based project planning system. Some 30% wished to have the ability to plan up to 1000 activities and 22% wished for 1500. The target was set generously at 1500 activities thereby exceeded the majority wish comfortably.

Q40:How long would you like the activity descriptions to be? (number of characters)

The wishes stated varied from 20 characters to 100 with an average of 46. The specification called for 40 characters satisfying over half of the interviewees. Practical problems prevented a larger display at the time. In an attempt to overcome this deficiency an activity coding system was designed.

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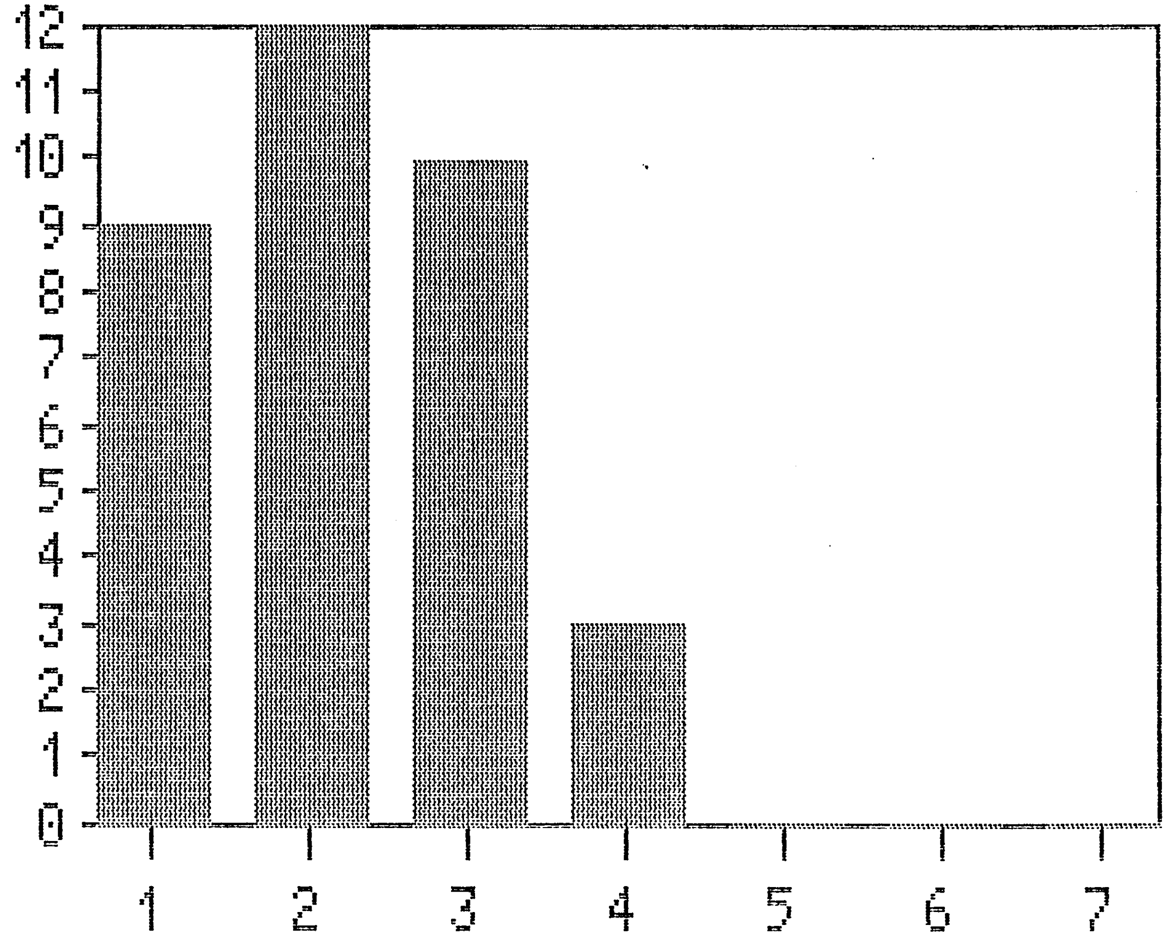
Diagram A38: Responses to Question 38



1 = very, 7 = not sucessful at all

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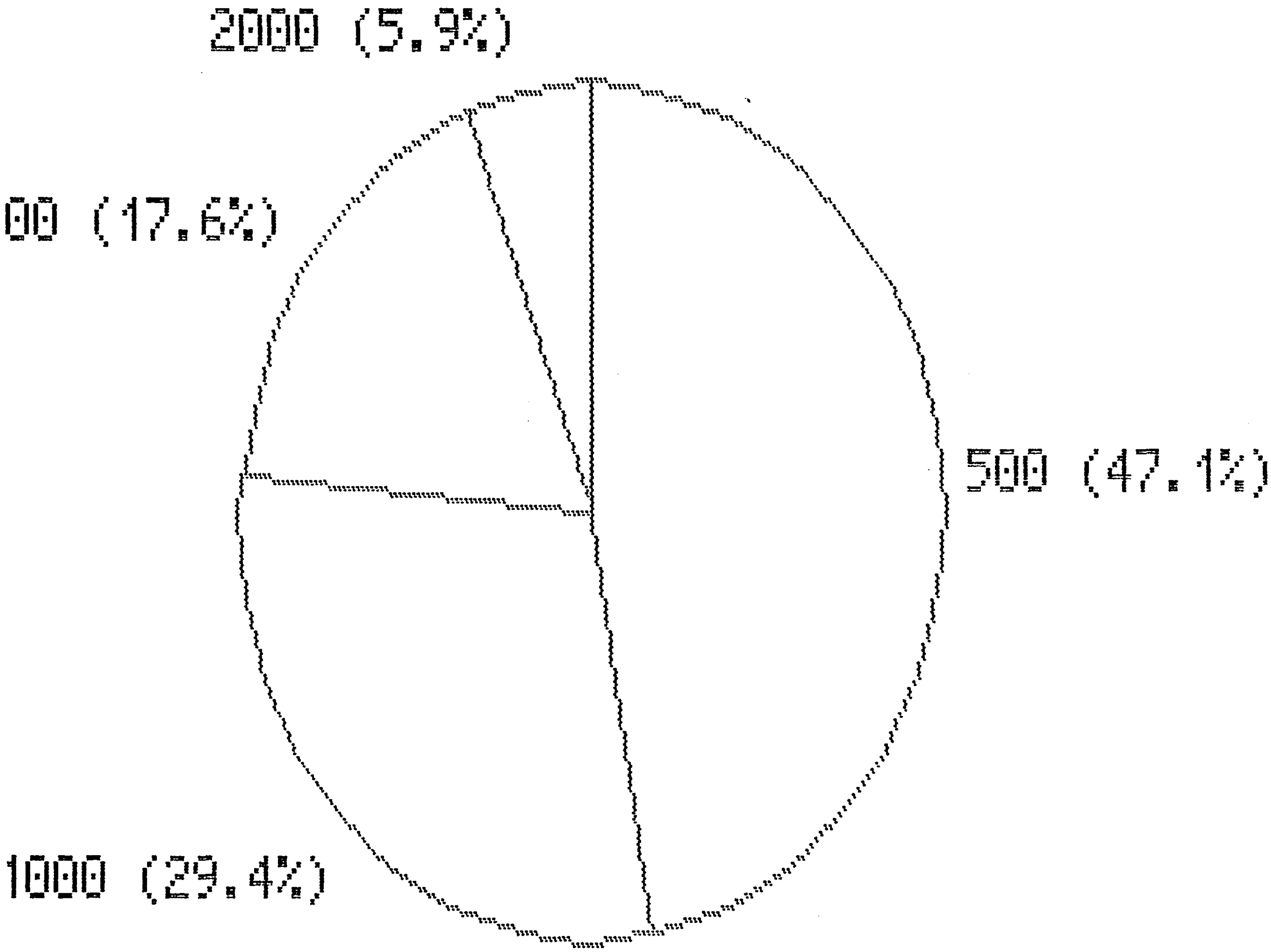
Diagram A39: Responses to Question 39



Next, questions relating to report generation were put.

As a result of the view that one of the failings of project planning was in its inability to keep pace with the needs of the site management team the interviewer asked a few questions about the speed of updating and the interviewees attitude to updating a project plan on a microcomputer:

Q41:The ability to produce small short term barcharts?

(1 = useful, 7 = not useful at all)

The strongest response in the interviews here showed a very strong desire for short term barcharts. This need became a key element in the model program.

Q42:The ability to produce large project barcharts?

(1 = useful, 7 = not useful at all)

The need for a project barchart was not so strong as that for short term bacharts. Hence in the model program this was not treated as a such a high priority. Nevertheless the slighlty better that neutral response made this a desirable feature of such a system.

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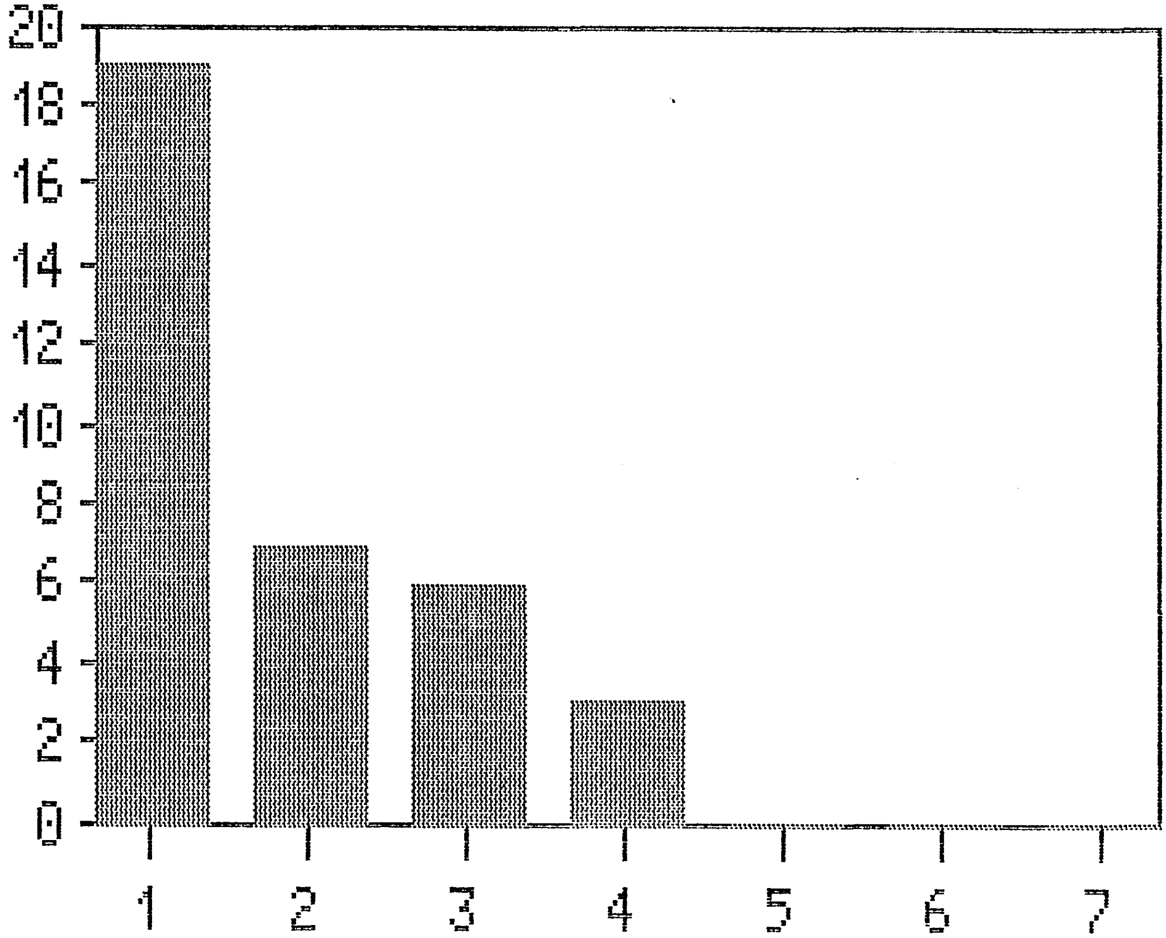
Diagram A41: Responses to Question 41



1 = very, 7 = not sucessful at all

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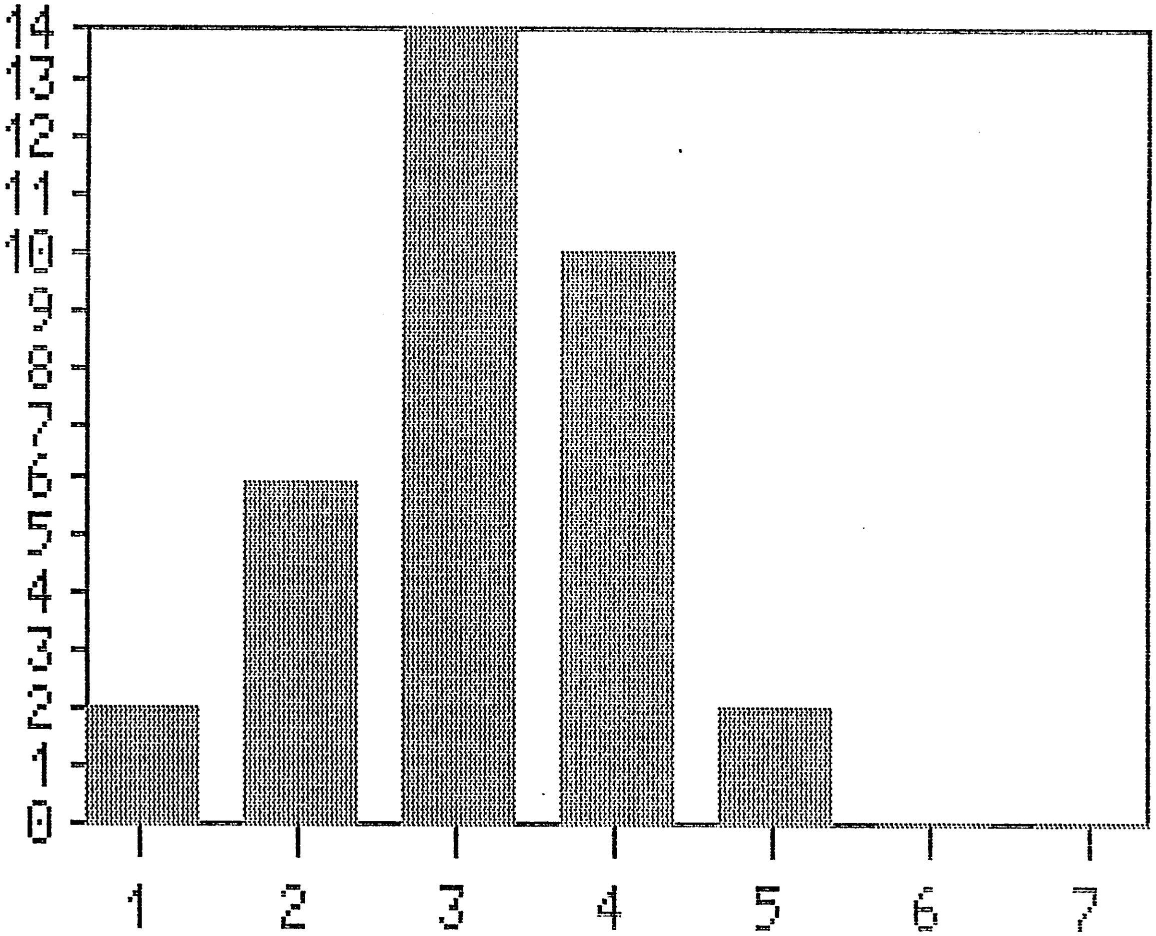
Diagram A42: Responses to Question 42



1 = very, 7 = not sucessful at all

Q43:The ability to produce network drawings?

(1 = useful, 7 = not useful at all)

Generally this was considered as desirable although only a weak preference was seen. The average response was 3.5 - neutral. Due to the addition of the practical problems of creating a network diagram by computer this feature was not included in the specification for a model package.

Then questions relating to convenience were asked:

Q44:Should the system be fast ?

(1 = useful, 7 = not useful at all)

A quite strong response demanding speed was noted. The average reponse (2.5) and the shape of the graph in diagram A44 showed that speed was important. Therefore speed was emphasised in the specification for the model program.

Q45:Should the system be easy to use?

(1 = useful, 7 = not useful at all)

Again a very strong response that the system should be simple was noted. All though it was very difficult to define this the specification called for a simple package in operation and much effort was deveoted to achieving this. Ease of use was seen as a subjective measure and therefore difficult to quantify.

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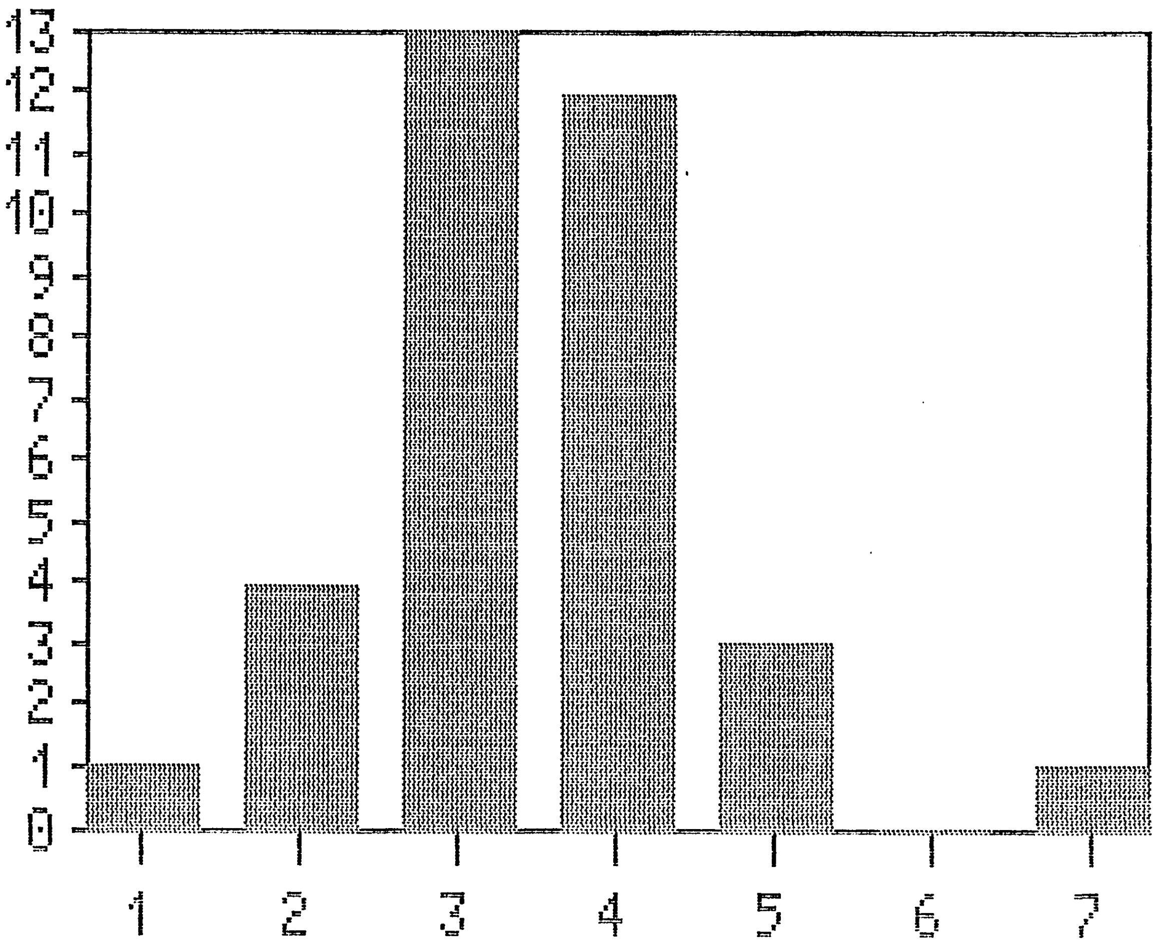
Diagram A43: Responses to Question 43



1 = very, 7 = not useful at all

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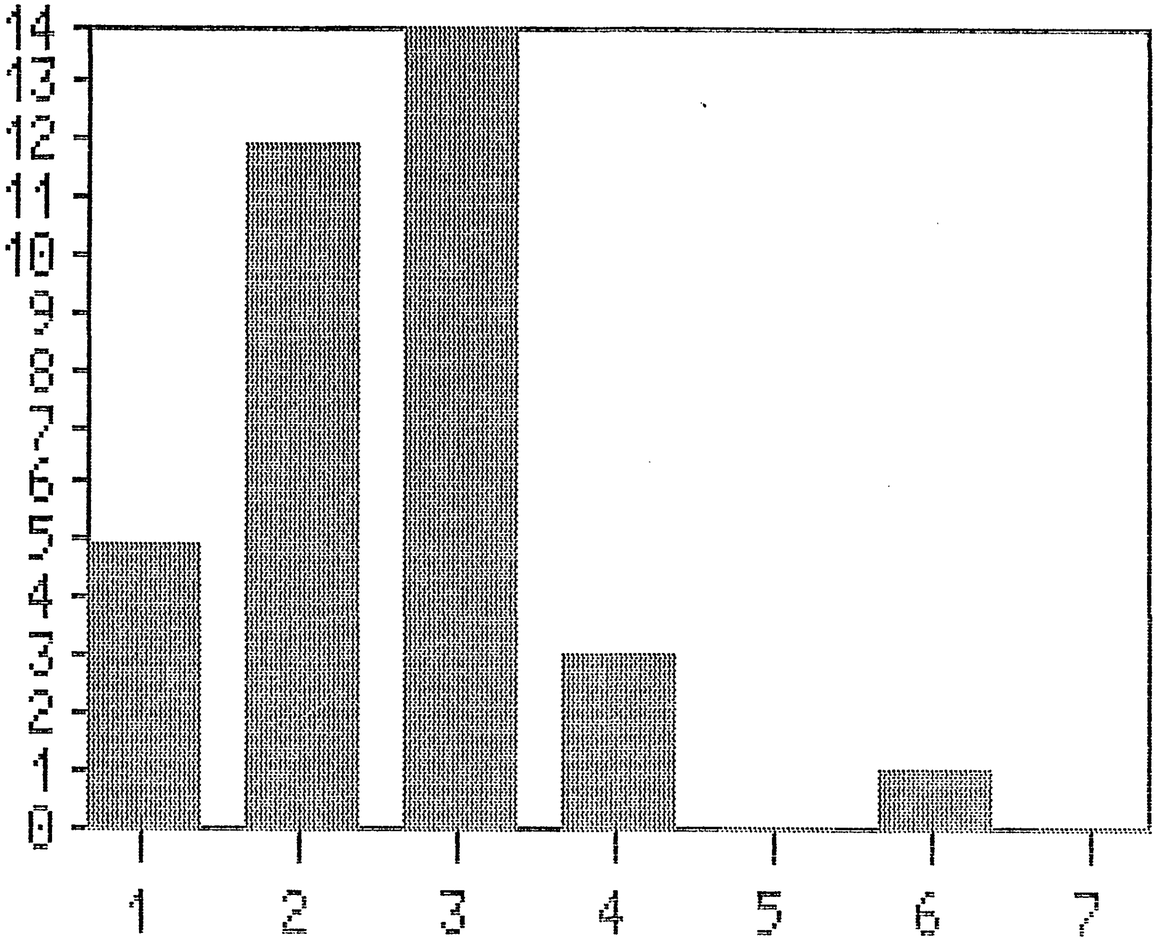
Diagram A44: Responses to Question 44



1 = very, 7 = not useful at all

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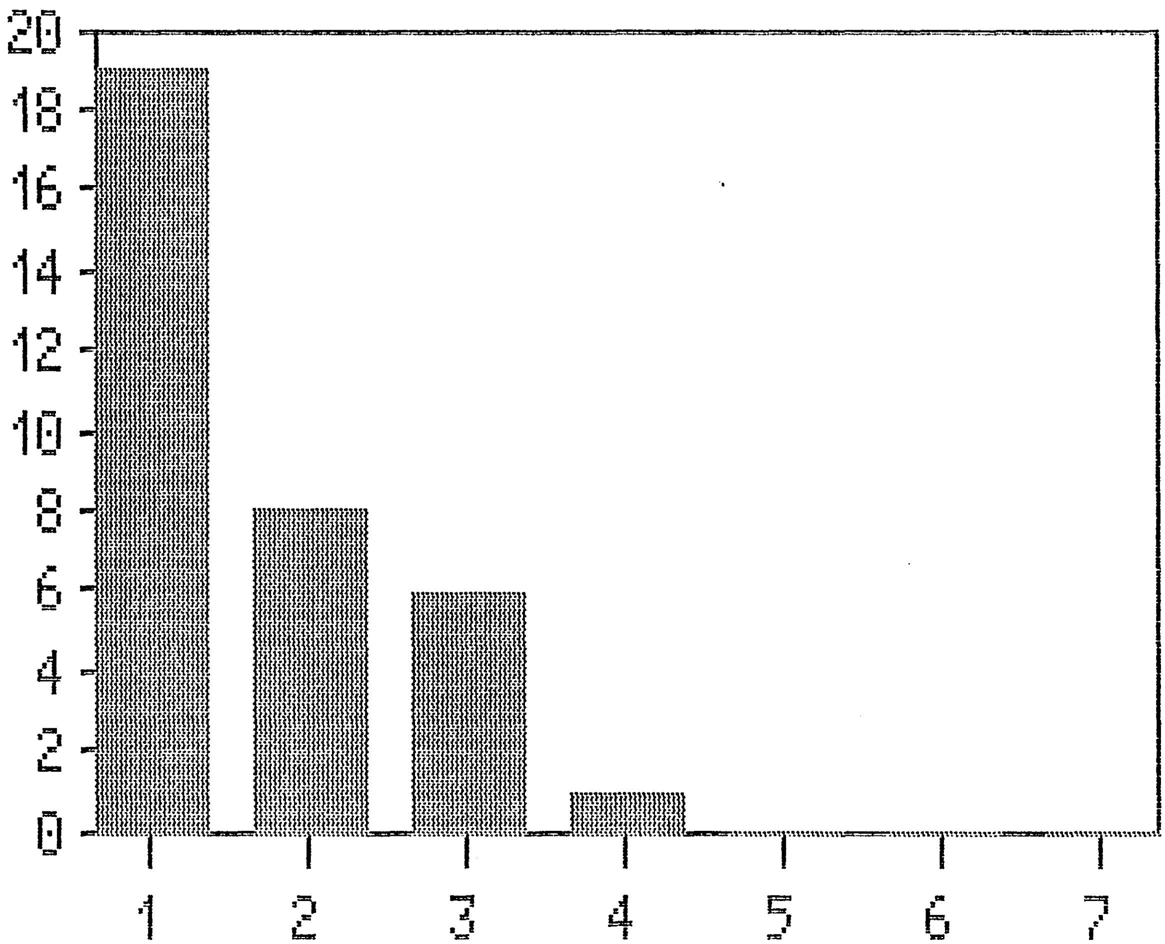
Diagram A45: Responses to Question 45



1 = very, 7 = not useful at all

Q46:Would you go on a two day training course to learn to use the system? (1 = definitely, 7 = not likely at all)

A fairly neutral response to this question was noted. The avergae (3.7) and the shape of the graph in diagram A46 show this neutrality. The question was asked to gauge the potential users expectations from such a system. It was deduced that such a system should not need a great deal of training.

Resource tracking was investigated by the following questions;

Q47:Would you require resource tracking ? (ability to allocate resources, get histograms ? (1 = useful, 7 = not useful at all)

The responses here indicated a preference for resource tracking so that an at least elementary resource tracking facility was seen as useful. At the time practical problems made this objective unrealistic and resource traking was not tested during the project.

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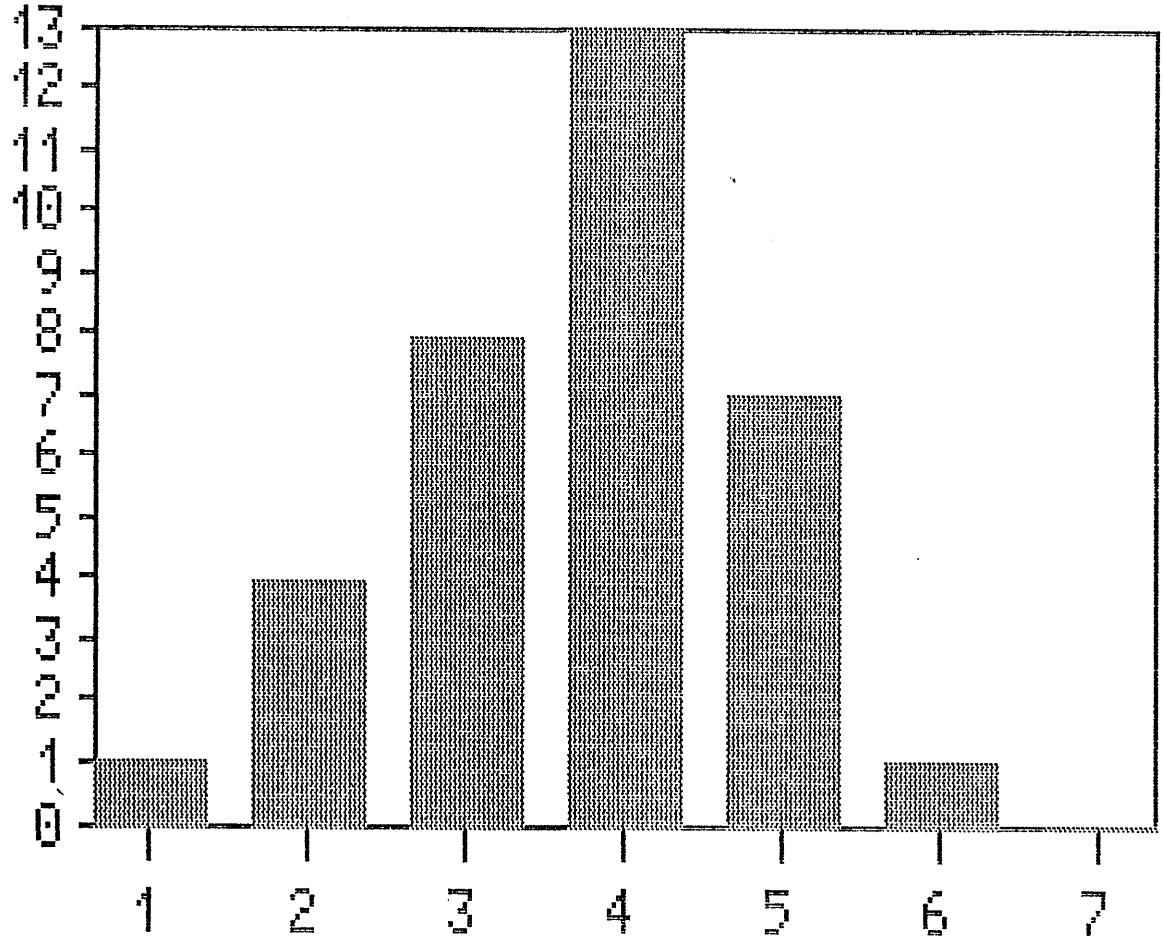
Diagram A46: Responses to Question 46



1 = very, 7 = not useful at all

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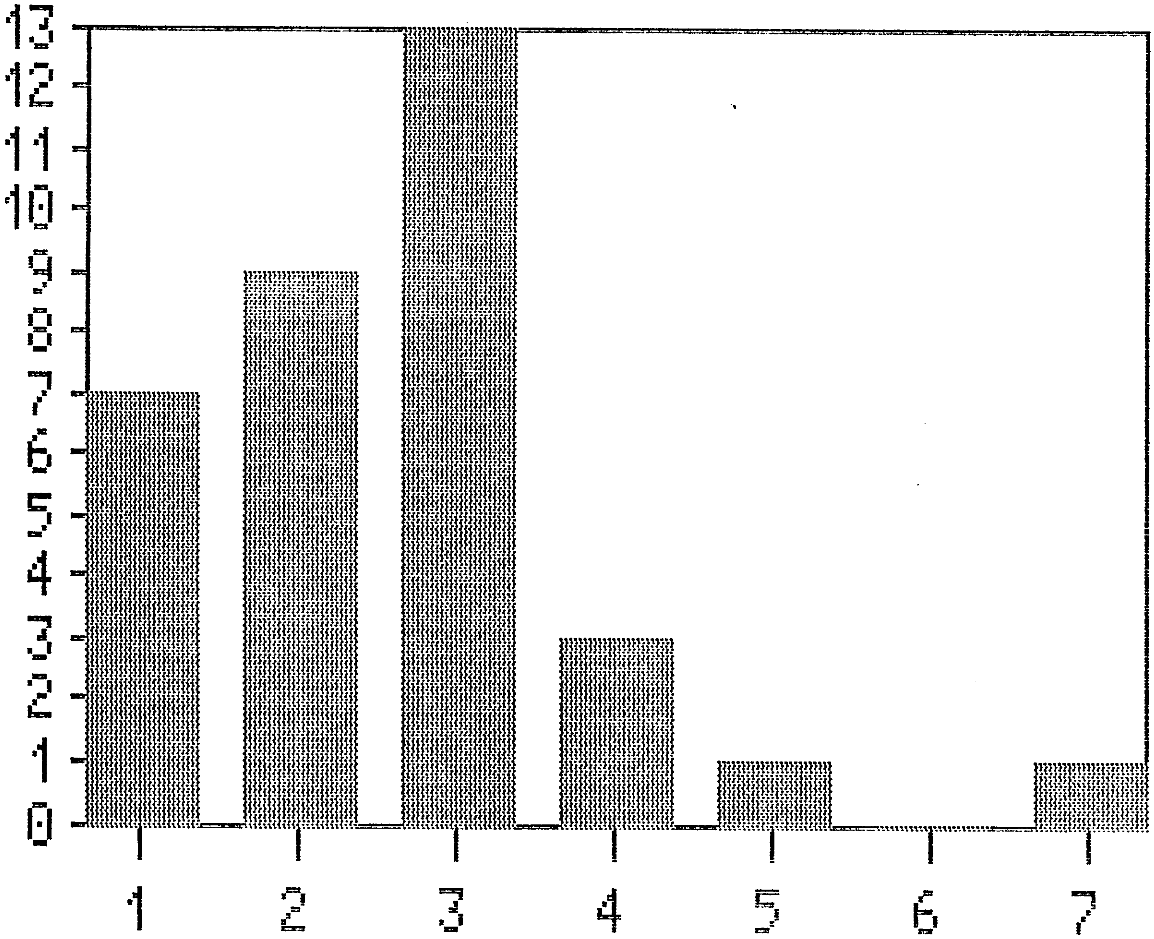
Diagram A47: Responses to Question 47



1 = very, 7 = not useful at all

Q48:Would you require resource smoothing ? (the ability to rationalise or level the resource demand (1 = useful, 7 = not useful at all)

A neutral response to this question was noted, The average of 3.7 and the shape of the graph in diagram A48 confirmed this. Again to to practical restraints it was not possible to test resource levelling facilities within the project.

Q49 - Cost

This question related to the likely cost that a project management team would expect to pay for a microcomputer based project planning package.

During the period of the research and post research analysis and writing stages, the costs of microcomputers and software have fallen so much so that this question ceased to have any useful relevance. Its outcome therefore forms no part of the research project.

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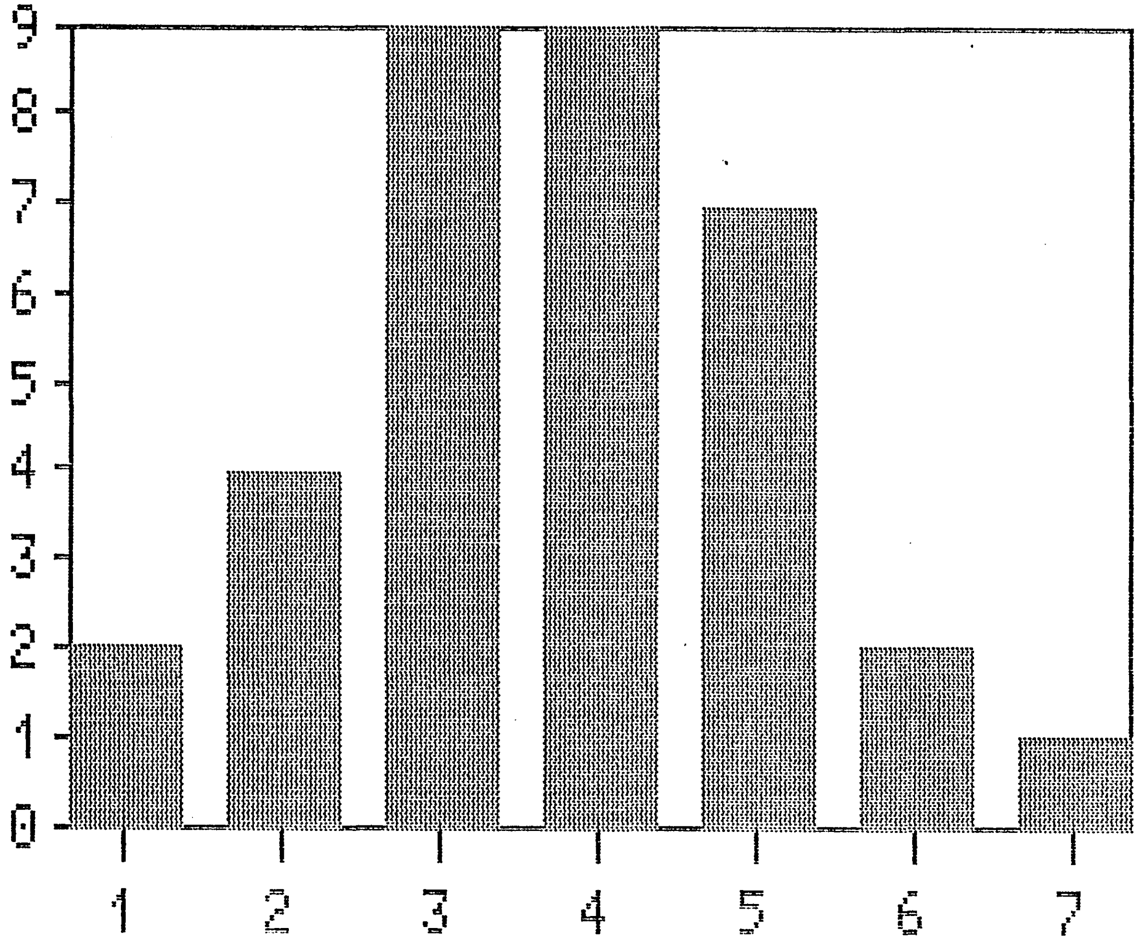
Diagram A48: Responses to Question 48



1 = very, 7 = not useful at all

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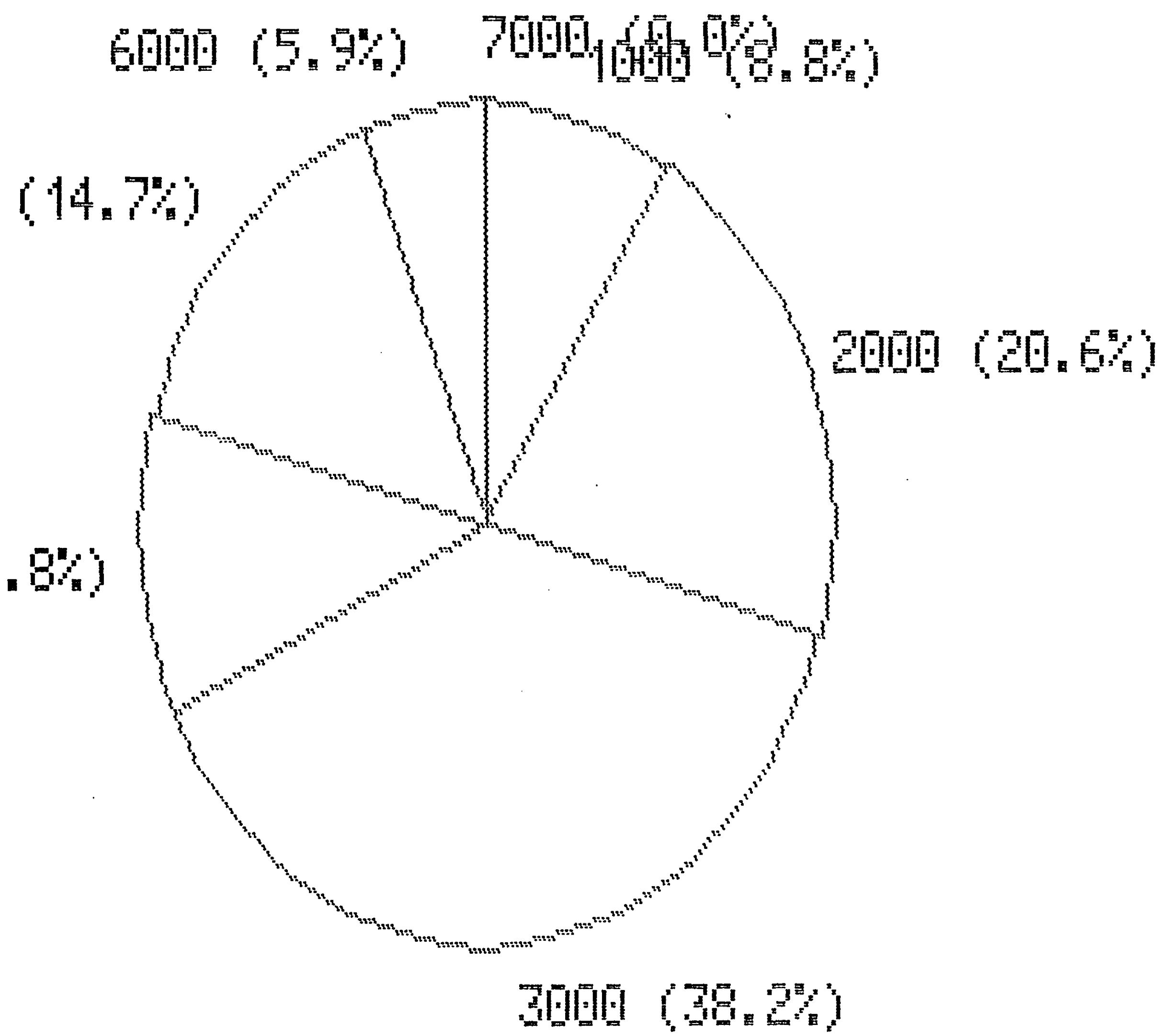
'iagram A49: Responses to Question 49



Q50 Would the use of days as the time unit be adequate or would you wish to use another unit ? (shifts/weeks/hours) (1 = useful, 7 = not useful at all)

The general view here was that sub day time units were not essential and this feature was therefore excluded from the specification of the test program. The average response (4.6) and the shape of the graph in diagram A49 above confirmed this view.

Q51: Would you need to be able to plan different projects against different working weeks and different holidays? (1 = useful, 7 = not useful at all)

As with the previous question and for the same reasons this feature was not included in the model program. The average response (4.5) and the shape of the graph In Diagram A50 seemed to indicate that this was not required.

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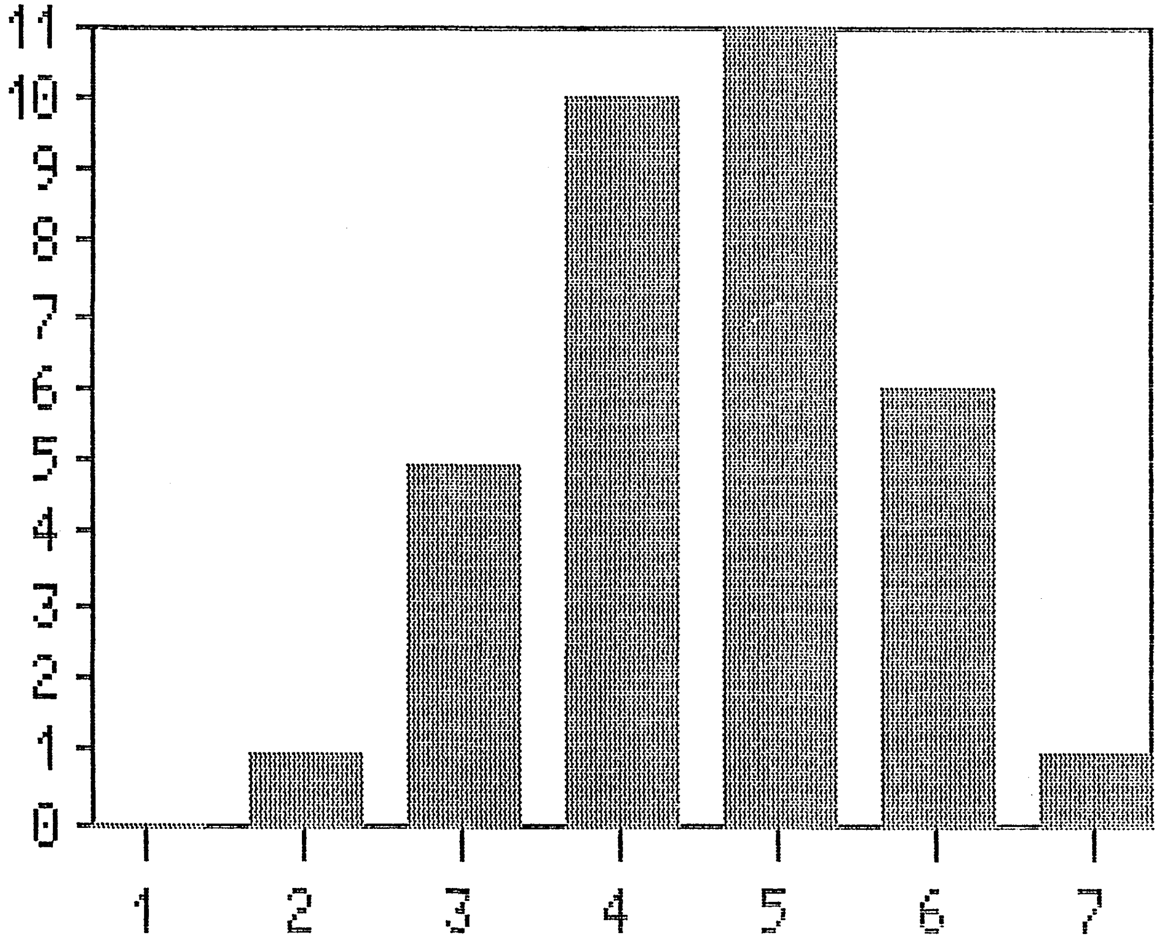
iagram A50: Responses to Question 50



1 = very, 7 = not useful at all

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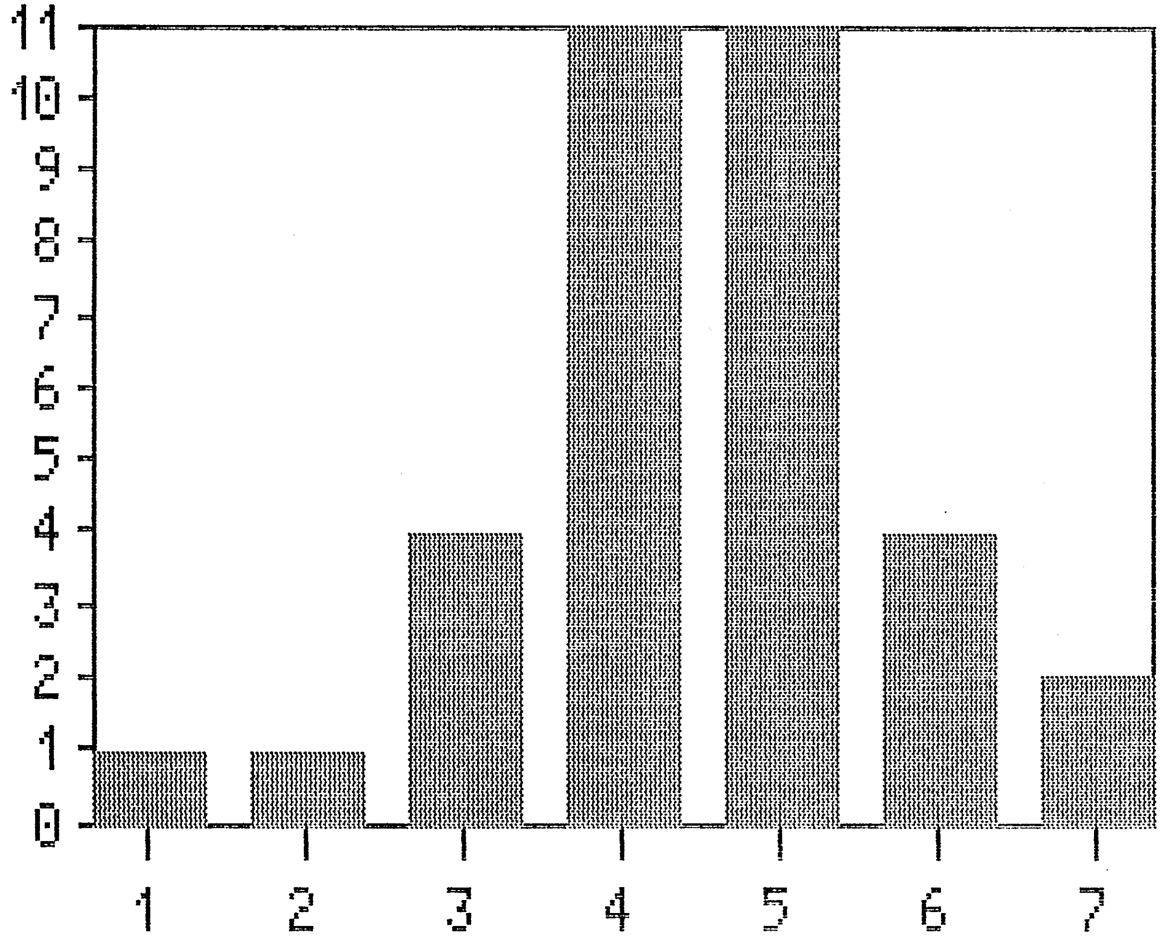
iagram A51: Responses to Question 51



1 = very, 7 = not useful at all

Q52: Would you want to be able to get report ? (barcharts) for specific parts of the project or including the work under specific responsibilities ? (selective reports) (1 = useful, 7 = not useful at all)

A reasonably strong response showing a desire to be able to seperate parts of the project when reporting was noted. A simple task selection system was designed for the sample package as the average response (2.9) and the shape of the graph In Diagram A51 showed a demand for this.

Q53: Should such a system reject stupid data ? (1 = useful, 7 = not useful at all)

A good degree of error checking was incorporated into the design of the package to achieve the desired rejection of stupid data. The average response (3) and the shape of the graph In Diagram A52 made this a desirable feature and the technology existed to achieve some error checking within the resources available to the project.

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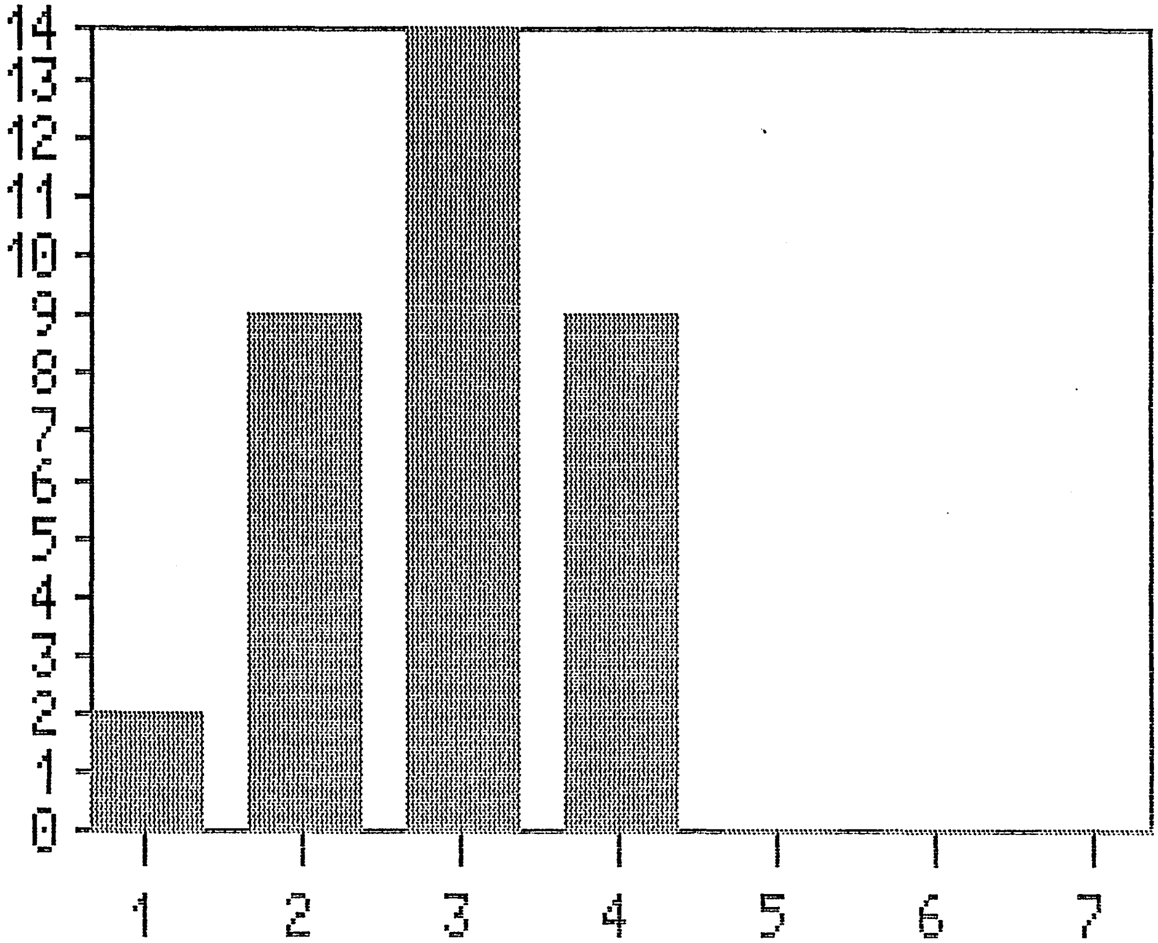
iagram A52: Responses to Question 52



1 = very, 7 = not useful at all

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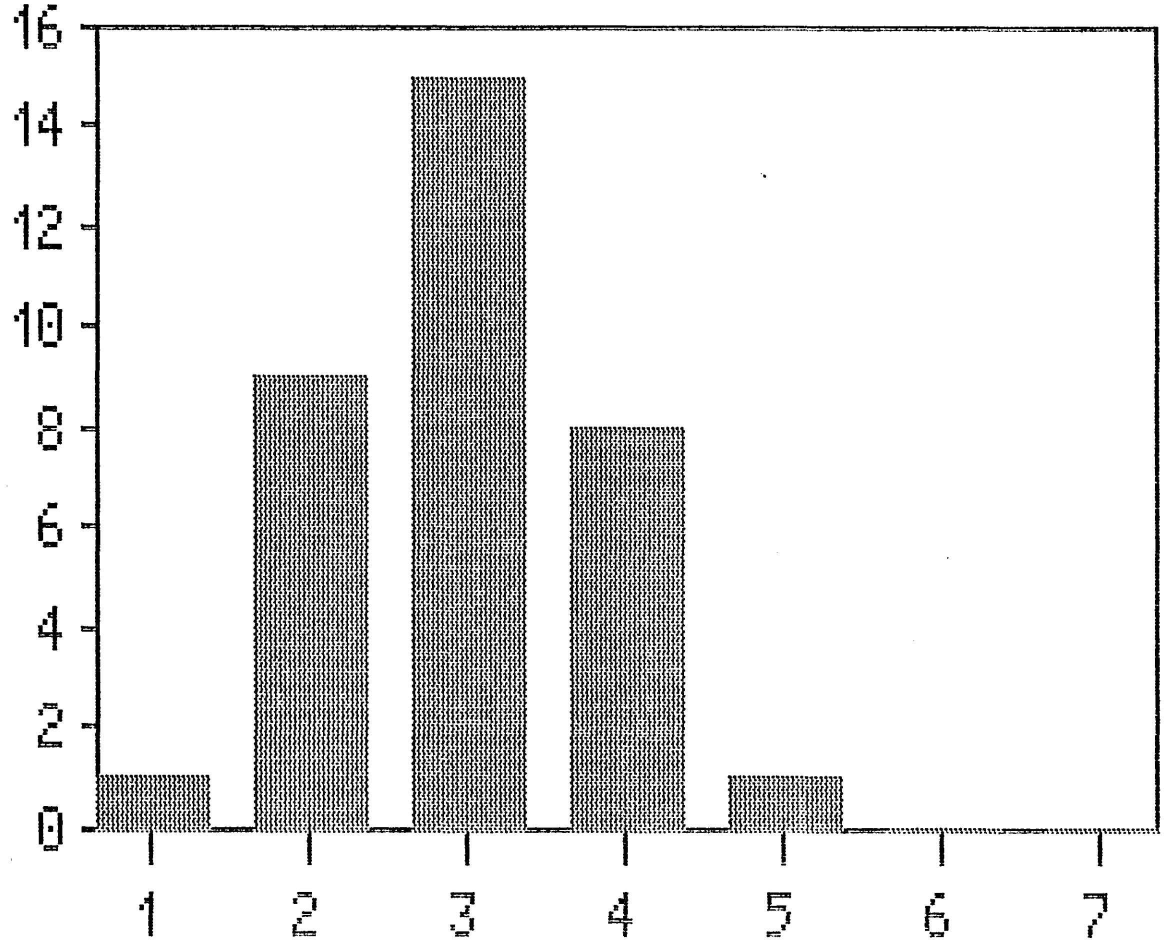
iagram A53: Responses to Question 53



1 = very, 7 = not useful at all

Q54:How important is the speed of update - how long would you expect to spend carrying out a normal weekly update of the project plan? (numeric in minutes)

The average response to this question was 32 minutes and this confirmed the general view that such a system would have to be convenient and easy touse to be accepted by project planners.

It can be seen from the graph In Diagram A53 that speed of update was consodered to be important.

It was set as an objective to achieve this rapid update time for reasonable plans in the specification for the model programme.

Q55: How important is the speed of analysis ? (1 = very useful, 7 = not useful at all)

The average response was 3.1 - slighly more important that neutral. The impression gained by the interviewer was that the overall time for an updating process was more important than analysis speed. As analysis speed played a part in update times the desire for speed was mentioned in the specification for the model programme.

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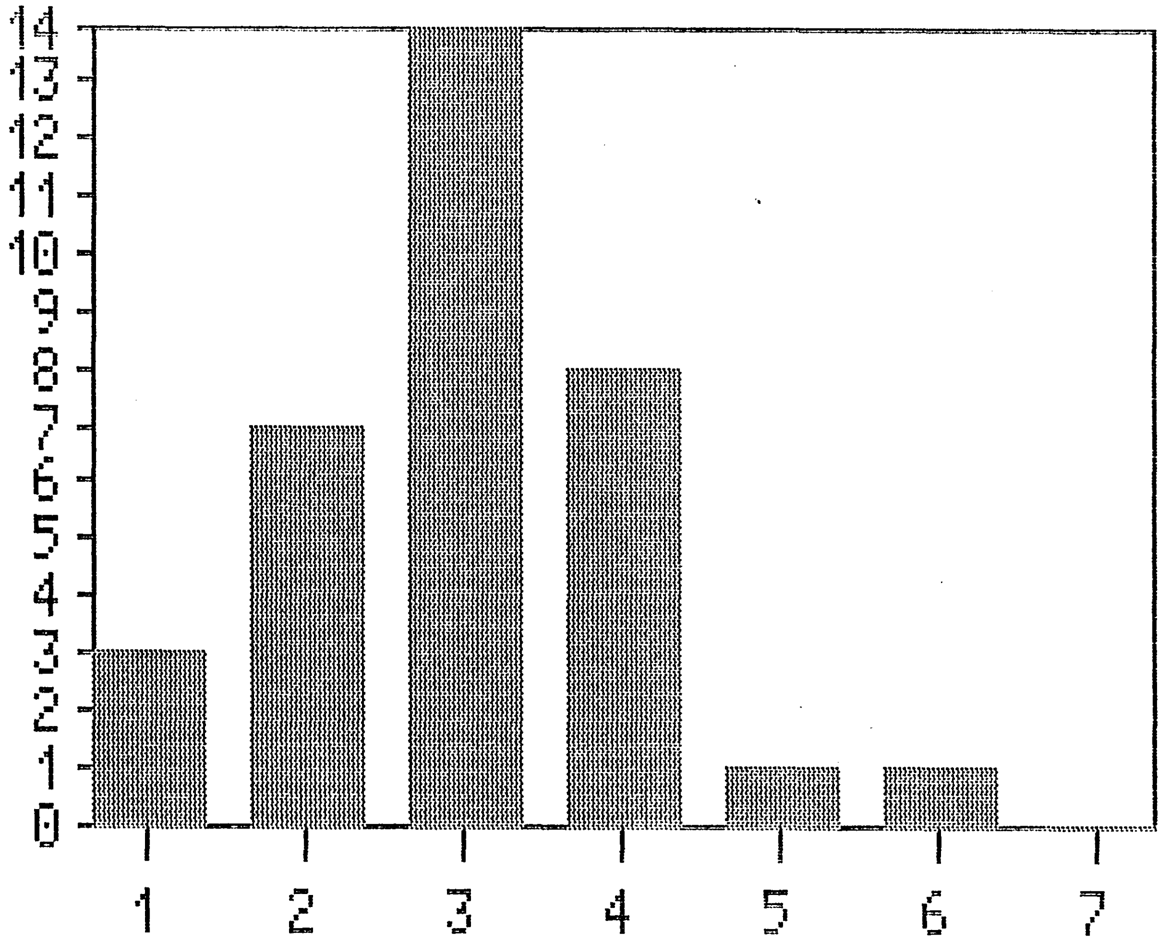
Diagram A55: Responses to Question 55



1 = very, 7 = not useful at all

Q56: Would you use the system to evaluate alternative methods of construction ? (1= very likely, 7 = not likely at all)

A slightly less than neutral response showed some interest in more frequent updating. No strong interest was noted. The average response of 4 and the shape of the graph In Diagram A55 both show this tendancy.

A version number system was designed in the specification to assist in evaluating alternative methods. The version number system would allow the user to differentiate each version of a plan.

Q57: Are there other features that you would like to see in such a system?

It was in response to this question that a number of interviewees expressed the view that the microcomputer should be able to prepare the network diagrams. The view was that the function of the microcomputer could spread to include the preperation of the network plan. This view was expressed in a vague manner and indeed on some ocassions in a half-joking way but nevertheless the point was made that the task of designing the plan in the first case might be a job executed electronically.

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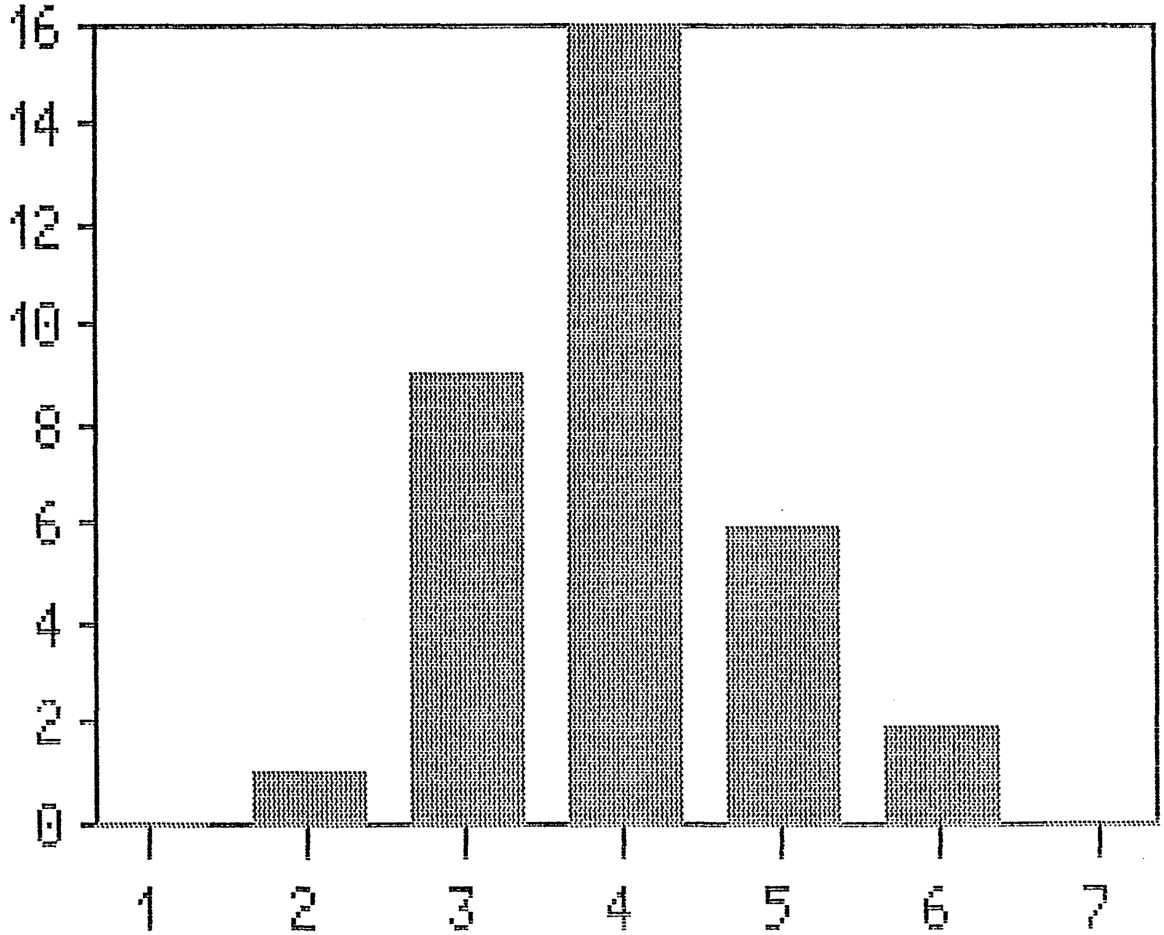
Diagram A56: Responses to Question 56



1 = very, 7 = not useful at all

		Q #1	Q #2	Q #3	Q #4	Q #5	Q #6	Q#7	Q#8	Q#9	Q#10
company #	1	20	2000		PLANNER	FULL	HOSPIT	NETPLAN	SITE/HO	3	FUTURE
company #	2	1.5	50		PROJMAN	PART	FACTORY	BARCHART	HO	4	PREDICT
company #	3	3	60		PLAN ENG	FULL	FACTORY	BARCHART	HO	2	GOOD MAN
company #	4	5	56		ENG	PART	INDUST	NET/BAR	HO	5	FUTURE
company #	5	4	40		PLANNER	FULL	HOUSING	BARCHART	HO	6	FUTURE
company #	6	12	1200		PLAN ENG	FULL	DOCK	NETPLAN	SITE	5	FUTURE
company #	7	0.9	34		PLAN ENG	FULL	INDUST	BARCHART	HO	4	FUTURE
company #	8	8	120		PROJMAN	PART	SCHOOL	NET/BAR	SITE/HO	5	PREDICT
company #	9	3	67		PLANNER	PART	HOUSING	BARCHART	HO	6	PREDICT
company #	10	12	1000		PROJMAN	FULL	ROAD	NETPLAN	SITE/HO	5	FUTURE
company #	11	6	590		PLAN ENG	FULL	HOSPIT	BARCHART	SITE/HO	4	FUTURE
company #	12	7.5	600		PROJMAN	FULL	INDUST	NETPLAN	SITE/HO	5	PREDICT
company #	13	3	100		OTHER	FULL	INDUST	BARCHART	SITE/HO	6	FUTURE
company #	14	2	45		CONSTRMAN	PART	HOUSE	BARCHART	HO	6	REMOTE
company #	15	5	120		OTHER	FULL	VARIOUS	BARCHART	SITE/HO	5	FUTURE
company #	16	5.5	240		PLANNER	PART	INDUST	NET/BAR	SITE/HO	4	FUTURE
company #	17	3.4	134		PLAN ENG	PART	HOUSE	BARCHART	HO	4	REMOTE
company #	18	6	120		PLANNER	PART	VARIOUS	BARCHART	SITE/HO	3	FUTURE
company #	19	0.9	34		PLANNER	FULL	INDUST	BARCHART	HO	4	FUTURE
company #	20	5	180		PROJMAN	PART	HOUSE	BARCHART	SITE/HO	5	FUTURE
company #	21	4	180		PLANNER	PART	INDUST	BARCHART	SITE/HO	6	REMOTE
company #	22	0.8	50		PLAN ENG	FULL	VARIOUS	BARCHART	SITE/HO	3	PREDICT
company #	23	0.3	25		ENG	FULL	PUBLIC	BARCHART	SITE/HO	4	FUTURE
company #	24	2	50		PLANNER	PART	INDUST	BARCHART	HO	3	REMOTE
company #	25	15	1500		PLAN ENG	FULL	CITY	NETPLAN	SITE	2	QUICK
company #	26	7	300		PROJMAN	FULL	VARIOUS	BARCHART	SITE/HO	3	FUTURE
company #	27	5.5	240		OTHER	FULL	INDUS	BARCHART	SITE/HO	4	PREDICT
company #	28	3.4	134		PROJMAN	FULL	HOUSE	BARCHART	SITE/HO	5	FUTURE
company #	29	6	120		PLANNER	PART	ROADS	BARCHART	SITE/HO	6	FUTURE
company #	30	0.9	34		PLANNER	PART	HOUSE	BARCHART	HO	5	REMOTE
company #	31	5	280		CONSTRMAN	PART	VARIOUS	NET/BAR	SITE/HO	6	FUTURE
company #	32	4	180		PLANNER	FULL	INDUST	BARCHART	SITE/HO	4	FUTURE
company #	33	0.8	50		OTHER	FULL	HOUSE	BARCHART	HO	6	SLOW
company #	34	0.3	25		OTHER	FULL	SMALL WKS	BARCHART	HO	6	REMOTE
company #	35	2	100		PLANNER	PART	VARIOUS	NET/BAR	SITE/HO	6	PREDICT
=========		====	=====							====	
AVERAGE		4.9	287							4.6	
========		====	=====							====	

Q#11	Q#12	Q#13	Q#14	Q#15	Q#16	Q#17	Q#18	Q#19	Q#20	Q#21
SPECIALS	SITE	2	LOCAL	YES	COMPLEX	CONSULT	5	REMOTE	YES	GENERAL
COMPLEX	HO	3	DETAIL	YES	BIG	SITE	6	COMPLEX	YES	ADMIN
SPECIALS	HO	4	NEED	YES	PRESTIGE	HO	7	SLOW	YES	ADMIN
BIG	HO	4	NEED	YES	PRESTIGE	HO	6	SLOW	YES	ADMIN
SPECIALS	HO	4	NEED	NO					YES	ADMIN
VERY BIG	SITE	3	LOCAL	YES	BIG	SITE	6	COMPLEX	YES	GENERAL
SPECIALS	HO	2	NEED	YES	PRESTIGE	HO	6	SLOW	YES	ADMIN
COMPLEX	HO	2	DETAIL	YES	PRESTIGE	HO	5	SLOW	YES	GENERAL
SPECIALS	HO	1	NEED	NO					YES	ADMIN
COMPLEX	SITE	2	LOCAL	YES	PRESTIGE	HO	4	SLOW	YES	GENERAL
SPECIALS	HO	2	NEED	YES	PRESTIGE	HO	4	REMOTE	YES	GENERAL
SPECIALS	SITE	3	DETAIL	YES	PRESTIGE	HO	5	SLOW	YES	ADMIN
BIG	HO	4	NEED	YES	PRESTIGE	HO	5	SLOW	YES	ADMIN
SPECIALS	HO	5	COMPLEX	NO					NO	
SPECIALS	HO	5	DETAIL	YES	COMPLEX	SITE	6	COMPLEX	YES	GENERAL
LARGE	HO	6	REMOTE	YES	PRESTIGE	HO	7	SLOW	YES	ADMIN
SPECIALS	HO	4	NEED	YES	PRESTIGE	HO	6	SLOW	YES	ADMIN
COMPLEX	SITE	4	LOCAL	YES	PRESTIGE	HO	5	COMPLEX	YES	ADMIN
SPECIALS	HO	3	NEED	YES	PRESTIGE	HO	6	SLOW	NO	
EXPERMT	HO	4	NEED	YES	PRESTIGE	HO	5	SLOW	YES	ADMIN
SPECIALS	HO	4	NEED	YES	COMPLEX	SITE	4	OK	YES	GENERAL
COMPLEX	HO	5	REMOTE	YES	PRESTIGE	HO	5	REMOTE	YES	ADMIN
NOT				NO					NO	
BIG	HO	4	NEED	YES	PRESTIGE	HO	7	SLOW	NO	
VERY BIG	SITE	4	DETAIL	YES	PRESTIGE	HO	6	SLOW	YES	ADMIN
SPECIALS	HO	4	NEED	YES	COMPLEX	HO	4	COMPLEX	YES	ADMIN
SPECIALS	HO	3	NEED	YES	PRESTIGE	HO	5	SLOW	YES	ADMIN
SPECIALS	HO	3	NEED	YES	PRESTIGE	HO	7	SLOW	YES	ADMIN
BIG	HO	3	NEED	YES	PRESTIGE	HO	5	REMOTE	YES	ADMIN
NOT				NO					YES	GENERAL
SPECIALS	HO	3	NEED	YES	PRESTIGE	HO	6	SLOW	YES	ADMIN
SPECIALS	SITE	4	LOCAL	YES	PRESTIGE	SITE	5	SLOW	YES	ADMIN
BIG	HO	4	NEED	YES	COMPLEX	HO	6	REMOTE	YES	ADMIN
SPECIALS	HO	2	NEED	NO					NO	
SPECIALS	HO	3	NEED	YES	PRESTIGE	HO	6	SLOW	YES	ADMIN
		====					====			
		3.2					4.6			
		====					====			

Q#22	Q #23	Q#24	Q#25	Q#26	Q#27	Q #28	Q#29	Q#30	Q#31	Q#32	Q#33	Q#34	Q#35	Q#36	Q#37
GENERAL	3	EFFICIENT	YES	HOME/WORK	PLANNING	2	TOOL	YES	SITE PLAN	HO	2	FAST	PLANNER	3	4
ADMIN	3	WORKS	YES	HOME	APPRCT	3		SOME	SITE PLAN	SITE	4	SLOW	PLANNER	2	5
ADMIN	2	WORKS	YES	HOME	APPRCT	4		LITTLE	HO PLAN	HO	3	FUTURE/SLOW	PLANNER	3	4
ADMIN	1	NEED	YES	WORK	APPRCT	3		LITTLE	SITE PLAN	SITE/HO	2	FUTURE/SLOW	PLANNER	4	5
ADMIN	2	WORKS	YES	HOME	APPRCT	4		LITTLE	HO PLAN	HO	2	FUTURE/SLOW	PLANNER	3	6
VARIOUS	3	WORKS	YES	HOME	APPRCT	5		YES	SITE PLAN	SITE	2	FAST	ENG	2	5
ADMIN	2	WORKS	YES	HOME/WORK	PLANNING	4	TOOL	LITTLE	SITE PLAN	HO	4	FUTURE/SLOW	PLANNER	3	4
GENERAL	3	WORKS	YES	HOME	APPRCT	4		YES	HO PLAN	HO	3	FUTURE/SLOW	PLANNER	4	6
ADMIN	4	NEED	YES	HOME	APPRCT	3		LITTLE	SITE PLAN	SITE	5	FUTURE/SLOW	PLANNER	4	5
VARIOUS	3	WORKS	NO					YES	SITE PLAN	SITE	5	COMPLEX	ENG	3	4
GENERAL	2	WORKS	YES	HOME	APPRCT	5		SOME	HO PLAN	HO	4	FUTURE/SLOW	PLANNER	2	3
ADMIN	2	WORKS	YES	HOME	APPRCT	4		YES	SITE PLAN	SITE/HO	4	SLOW	PLANNER	4	4
ADMIN	3	WORKS	YES	WORK	APPRCT	3		YES	SITE PLAN	HO	5	FUTURE/SLOW	PLANNER	3	5
			YES	HOME	GAMES	2	FUN	YES	SITE PLAN	SITE	5	SLOW	PROJMAN	4	2
GENERAL	3	WORKS	YES	HOME	APPRCT	3		LOT	SITE PLAN	SITE	3	FUTURE/SLOW	PLANNER	5	4
ADMIN	2	WORKS	YES	HOME	APPRCT	5		LOT	SITE PLAN	SITE	4	FUTURE/SLOW	PLANNER	5	6
ADMIN	1	WORKS	YES	WORK/HOME	PLANNING	4	TOOL	LITTLE	HO PLAN	HO	4	COMPLEX	PROJMAN	5	5
ADMIN	2	WORKS	YES	HOME	APPRCT	4		YES	SITE PLAN	SITE	5	COMPLEX	PLANNER	5	4
			YES	HOME	APPRCT	4		LITTLE	ESTIMATES	HO	3	FUTURE/SLOW	PROJMAN	4	5
ADMIN	3	WORKS	NO					LITTLE	HO	HO	3	FUTURE/SLOW	PLANNER	3	6
GENERAL	2	WORKS	YES	HOME	APPRCT	4		YES	SITE PLAN	SITE/HO	5	FUTURE/SLOW	PLANNER	2	7
ADMIN	3	WORKS	YES	HOME	APPRCT	4		LITTLE	SITE PLAN	SITE	5	FUTURE/SLOW	PLANNER	3	6
			YES	WORK	APPRCT	2		LITTLE	SITE PLAN	SITE	4	FUTURE/SLOW	PROJMAN	4	3
			YES	WORK	APPRCT	3		SOME	HO PLAN	HO	3	FUTURE/SLOW	PROJMAN	4	4
ADMIN	4	WORKS	YES	HOME	APPRCT	5		YES	SITE PLAN	SITE	4	SLOW	ENG	3	5
ADMIN	3	WORKS	YES	HOME	GAMES	2	FUN	LITTLE	HO PLAN	HO	5	FUTURE	PLANNER	3	2
ADMIN	3	WORKS	YES	HOME	APPRCT	4		LITTLE	SITE PLAN	SITE/HO	2	FAST	PLANNER	3	6
ADMIN	2	WORKS	NO					V LITTLE	HO PLAN	HO	5	SLOW	PLANNER	4	5
ADMIN	1	WORKS	YES	HOME	GAMES	2		LITTLE	SITE PLAN	SITE	2	GOOD MAN	PLANNER	5	4
GENERAL	2	WORKS	YES	HOME	APPRCT	4		LITTLE	SITE PLAN	SITE	3	SLOW	PLANNER	4	7
ADMIN	2	WORKS	YES	WORK	APPRCT	5		YES	SITE PLAN	SITE	1	LOCAL	PLANNER	3	6
ADMIN	4	WORKS	YES	HOME	APPRCT	3		LITTLE	HO PLAN	HO	4	SLOW	PLANNER	2	5
ADMIN	3	WORKS	YES	HOME	APPRCT	4		LITTLE	HO PLAN	HO	3	FUTURE/SLOW	PLANNER	3	4
			NO					V LITTLE	SITE PLAN	SITE	4	LOCAL	PROJMAN	4	5
ADMIN	2	WORKS	YES	HOME	APPRCT	4		LOT	SITE PLAN	SITE	3	LOCAL	PLANNER	3	6
	====					====					====			====	====
	2.1					3.2					3.6			3.5	4.8
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Q#38	Q#39	Q#40	Q#41	Q#42	Q#43	Q#44	Q#45	Q#46	Q#47
2	3000	40	1	2	3	1	1	3	1
4	1000	40	1	3	3	3	1	5	1
3	500	30	1	4	3	2	1	4	1
4	500	40	2	3	3	1	1	3	1
2	750	40	1	3	4	2	2	5	1
3	1500	25	1	3	2	3	2	4	3
1	300	100	3	3	4	3	2	4	2
3	400	40	1	4	4	3	2	4	3
2	1000	30	1	2	3	3	1	5	3
1	1000	50	1	4	4	2	1	5	3
2	500	50	1	3	3	2	1	5	3
1	750	30	1	2	5	2	1	4	2
3	400	70	1	1	4	3	3	4	2
2	200	40	1	3	3	3	1	4	3
3	300	50	2	4	4	4	1	6	3
4	1500	30	1	2	4	2	1	3	5
2	300	25	1	3	3	2	1	2	7
3	500	50	1	2	3	3	4	4	3
2	750	60	4	1	2	3	3	3	2
1	200	80	1	3	1	2	1	5	1
1	2000	100	1	4	5	1	1	4	2
1	1500	30	3	3	4	1	1	3	3
3	500	20	2	4	7	3	2	5	4
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1	750	40	3	3	3	2	2	2	2
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2	1500	20	1	4	4	3	1	4	4
1	350	25	3	3	3	6	2	2	3
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Q#48	Q#49	Q#50	Q#51	Q#52	Q#53	Q#54	Q#55	Q#56
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4	2000	5	5	2	3	30	3	4
6	3000	4	4	2	3	60	3	4
5	3000	5	5	2	2	20	2	4
2	5000	5	5	2	2	20	4	5
4	4500	5	5	3	2	20	5	3
3	4000	4	4	1	4	30	4	3
1	1000	4	4	3	4	15	6	4
4	2500	6	6	3	3	10	2	4
6	4500	5	6	3	2	40	2	3
5	6000	5	5	1	1	60	1	5
7	5000	5	4	4	5	20	2	4
5	2000	7	4	3	4	40	3	6
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5	3500	4	4	4	4	30	4	5
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3	3000	3	4	3	4	45	3	4
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4	1000	4	5	4	3	15	4	4
3	3000	4	7	3	3	30	4	2
4	3000	4	5	2	2	45	3	5
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2	1500	6	5	2	4	20	4	6
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3.7	3006	4.6	4.5	2.9	3	32	3.1	4
====	====	====	====	====	====	====	====	====

Appendix C - The Revised Functional Specification for a Project Planning Package

Appendix c: REVISED FUNCTIONAL SPECIFICATION

This section describes in more detail the software package that might be used in a future research project or might form the basis of a suitable package for use of construction sites..

1 A FUNCTIONAL SPECIFICATION FOR A SOFTWARE PACKAGE.

1.1 General: The program should perform the data entry, analysis and report generation of activity on arrow and precedence network plans.

The program should be written so as to be suitable for the popular microcomputer configurations.

Data Entry: The user should be able to create project plans each of which would take the following form:

Headings: Each plan would have a

Plan Title	8 characters
3 additional sub-titles	30 characters each
A calendar identifier	8 characters

Activities would be made up from the following data.

a start node	Alphanumeric
an end node	Alphanumeric
a description	Up to 40 characters
a duration.	In time units up to 999
Responsibility code	
(Maybe combined with description or resources)	
Resource requirements	See below

The operator would be able to enter details of project plans as a series of activities. He would able to examine and amend descriptions and duration and would also be able to add and delete activities.

Node number need not be sequential as the logic of the project network would be deduced from the node numbers.

The whole plan would be capable of being recorded on disk for later amendment.

Analysis

At the operator's command the program would execute a forward and backward pass through the network and deduce the critical path through the plan and the total float on each activity. Activities would then be sorted into sequence defined by the user and displayed on screen. On the user's command barcharts and other reports may be printed.

The analysis and sorting phase should take no longer that 30 seconds based on a 1000 activity plan.

Sorting: Activities would be sorted into the sequence established by the user but should include at a minimum - early start sequence, critical sequence and responsibility sequence.

When requesting any report the user should be able to enter a search or selection key. This selection key would be used to restrict activities to be printed to those that contain the selection key in their descriptions, their resources or their responsibility code. The user would be expected to specify the location of this selection key. An example of this might be "activities containing the letters XX in position 4 & 5"

After printing is completed the user would be asked if he requires other reports and additional reports should be possible on different selection criteria. The ability to pre-order a set of print outs that are frequently required together is desirable.

The system should be controlled by a menu structure or command line technique and there should be adequate on-line help.

At each stage the user would be presented with a similar simple self explanatory menu which would enable the system to be used by a non-computer technical person.

Calendar: Users would be able to produce calendars each of which would be identified by an 8 character identifier. For each calendar the user should be able to enter a typical working week identifying the project normal working week environment and in addition unlimited numbers special holidays.

Typical working weeks should be limited to between 1 and 7 working days per week. Calendars should be capable of being up to 10 years long. Calendars would use the Gregorian calendar as a basis and would show month and day names by means of three character abbreviations.

The ability for certain resources and certain tasks to operate in different working/non-working day environments when compared with the main project environment is desirable. It is also desirable to permit the user to work in non single day time units such as shifts, weeks or other unit.

Projects:

The project file would comprise of the headings including the calendar identifier and a up to 2500 activities. These activities would define the network and would take the following form.

Plans should be recorded automatically without user intervention and each plan would be recorded under its identifier and its version number. Each time a plan is loaded from disk into the memory of the computer for a work session a new version would automatically be produced being 1 greater than the previous plan.

The user should be able to allocate resource demands to each activity and be able to produce resource histograms and cash flow curves. An ability to level resource either automatically or interactively is desirable. An ability to draw the network diagram is desirable.

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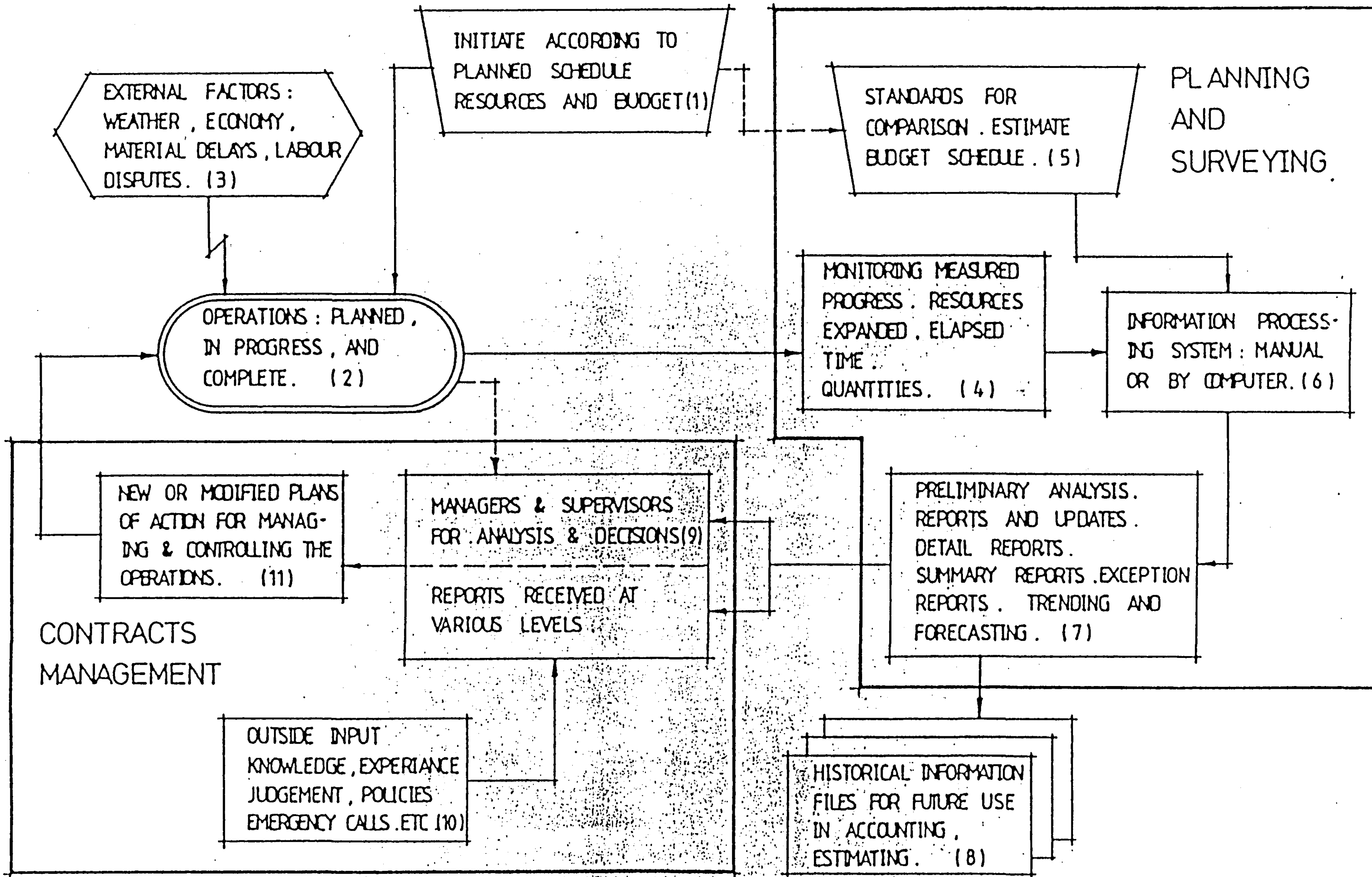

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Appendix A.

A microcomputer based planning system for construction projects

Geoffrey Alan Reiss

This thesis is submitted as a partial fulfillment of the requirements of a Master of Philosophy Degree to the Council for National Academic Awards.

This thesis is sponsored by the Sheffield City Polytechnic, Pond Street, Sheffield.

Submitted: March 1988

A microcomputer based planning system for construction projects

Geoffrey Alan Reiss

An Abstract

The thesis outlines the research project undertaken to examine the effect of microcomputers in the field of project planning on construction projects.

The hypothesis to be tested was that project planning had a poor reputation within the construction industry and that this poor reputation was due to two primary factors. One was that the work of project planning was carried out by personnel inappropriately positioned within the construction management structure and the second was that there were inherent problems with the use of the technique of network analysis that make it unattractive to site management personnel.

A series of structured interviews was conducted which appeared to confirm the general hypotheses and, based on this, an experiment was established to re-locate the role of project planning to an on-site role in a number of longitudinal case studies. To achieve this a microcomputer was necessary and, at that time, a software program had to be created as no suitable programs were available that would enable the experiment to proceed within a realistic budget.

In general site management welcomed the changes brought about in the experiment and reacted favourably to the ability to plan projects on site. As a result some of the inherent problems associated with the technique were overcome.

Project planning was, by those involved with the test program, better regarded and generally rapid on site project planning was seen as being of increased value. The benefits gained by the use of a microcomputer which were speed, ease of use and availability on site seemed to remove many of the objections raised by project planners and managers when discussing project planning by manual or main frame methods.

There were suggestions that the use of a computer could be taken further and that the computer could adopt more of the network planning role, particularly the creation of the network model.

A microcomputer based planning system for construction projects

Geoffrey Alan Reiss

This thesis is submitted as a partial fulfillment of the requirements of a Master of Philosophy Degree to the Council for National Academic Awards.

This thesis is sponsored by the Sheffield City Polytechnic, Pond Street, Sheffield.

The author has not been registered as a candidate for another award with the CNAA or any other academic or professional institution.

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J.& A Elliot Construction, Bishop's Stortford.

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Lilley Construction, Glasgow

Abtex Software Limited, Bradford

Bovis Construction Limited, Harrow, Middlesex

Shepherd Construction Limited, York

Laing Management Construction Limited, Luton

May Gurney Limited. Trowse, Norwich

CHAPTER 1

INTRODUCTION

1.1: The Outline of the nature of the project.

After a number of years as a practitioner in the field of construction project planning it appeared that there were significant problems associated with the use of project planning techniques within the construction industry.

It appeared that the general attitude to the use of project planning that was found in construction management was poor. It was suspected that, on average, construction management personnel did not regard project planning as a useful tool in achieving progress on construction projects.

There appeared to be a number of problems associated with the technique that caused this attitude. Especially frequently mentioned were such problems as:

a: Project planning was frequently remote from the project and not adequately involved in the projects developments.

b: Plans were frequently out of date and therefore of little use.

A research project was therefore embarked upon in an attempt to investigate this attitude and attempt to discover more accurately the reasons for it.

A number of attempts to execute project planning by computer had been noted but, it was considered, that these did not address the problems outline above as generally the work needed in project plan preparation was still lengthy and remote from the project for which it was intended.

The project coincided with the advent of relatively cheap microcomputers and it was considered that a microcomputer might be able to contribute to reducing the problems under investigation.

Microcomputers, it was reasoned, might permit project planning to proceed :

a:on site

b: more rapidly

and might therefore reduce the problems suggested above.

It was therefore considered that a microcomputer based project planning system might help to remove the problems under investigation and therefore might improve the attitude to project planning.

If such an improvement in attitude resulted from the introduction of a microcomputer it would be reasonable to assume that the attitude to project planning was poor, that the reasons had been as least in part identified and that a microcomputer could help to reduce these problems.

1.2 Definitions.

In this section the terminology used is defined to avoid ambiguity.

Construction Management is defined as the role executed by personnel associated with a construction project with the objective of bringing it to completion on time and to budget.

Project Planning is the technique of predicting the flow of work on a construction project and the preparation of reports detailing these predictions.

Network Planning is the technique of using network diagrams as a means to assist in the execution of project planning. Network Planning can utilise such techniques as activity on arrow and precedence network diagrams.

The Structured Interview technique is an Indirect Observation technique where the interviewer prepares a list of questions and discusses these questions with the interviewee in a one to one situation. It is specifically designed to be useful in testing a series of hypotheses.

A Microcomputer is a subset of the computer. Like all computers a microcomputer is a machine capable of receiving, recording, manipulating and displaying data. To define the subset of computers that are referred herein as microcomputers is to define a computer capable of being used on a construction site and by construction personnel and being within the cost parameters set. As these cost parameters are not constant it should be noted that a microcomputer was defined at the outset of the project as a computer costing no more than 5,000 pounds.

A software package is a set of instructions that are written in a language understood by a computer and that instruct the computer to perform one or more functions.

1.3 The Hypothesis.

The following hypothesis were defined in an attempt to define the problem as follows:

Poor reputation

Project planning in general and of network planning techniques in particular were received with caution by site management, who in general terms, did not regard project planning as a useful aid to their site management role.

It was noted that project planning by network analysis was regarded by site management as a process independent from managers in the construction phase.

Inappropriate location

On the basis that of the first hypothesis, it was argued that the reason for the above symptoms might be that:

a: Project planning was executed by individuals frequently inappropriately positioned within the management organisation of the construction company.

b: There were fundamental problems associated with the use of the network analysis technique which contributed to the attitude of site management.

The use of a microcomputer

Again on the basis that these previous elements were substantiated it was an objective that the potential of the microcomputer should be evaluated to examine the potential for reducing some of the aforementioned problems.

If the advantages apparently offered by the microcomputer could help to reduce the amount of management time involved in preparing network plans preparation and if this led to a better view of network planning as perceived by site management then there would be indications that the hypothesis had been confirmed as valid. Additionally it might be possible to indicate a direction which some site management organisations might adopt to improve their network planning techniques.

1.4 Objectives.

The hypothesis was tested by setting the following objectives.This section outlines the objectives of the research which were as follows:

(i) To establish the general attitude to project planning within the construction industry by a series of interviews.

(ii) To develop a flow diagram for the process in an attempt to more clearly define the process in theoretical terms.

(iii) To develop and test a microcomputer based project planning system in a number of longitudinal case studies to examine the effect such a system would have.

This thesis therefore describes how these objectives were achieved, how the data gained was analysed and outlines some conclusions relevant to the hypothesis.

CHAPTER 2.0

METHODOLOGY

2.1 Overview of the methodology

In order to achieve the research objectives a research model was produced. This took the form of a FLOW DIAGRAM of the project planning process and was an attempt to get a clear view of the process.

A Flow Diagram of the construction process would, it was hoped, allow a clearer picture of the process and also provide a framework for the remainder of the research project.

A series of structured interviews were held with a variety of construction management personnel. In an attempt to obtain the most accurate view, interviews were carried out with personnel ranging from those who were project planning professionals (creators of project plans) to personnel who were involved in site management (user of project plans).

These interviews established outline details of the interviewee and obtained his views on project planning. The interviewer was also asked to identify useful features of an on-site network planning tool.

This series of interviews appeared to ratify the first and second elements in the hypothesis suggesting that on-site execution of project planning could be more acceptable to site management if some of the problems associated with its use could be alleviated. There was some suggestion that a microcomputer could alleviate some of these problems.

A test environment was then established where the role of project planning was established as a on-site role executed by the on-site management and which enabled frequent review and remodeling of project plans to be executed by the on-site management personnel.

It was necessary to create a microcomputer project planning software package to achieve this as no suitable package was commercial available at that time. It was expected that project planning techniques would be required to be at a simple level and that advanced techniques would not be possible at site level.

The research project was fortunate enough to establish three longitudinal test sites. On these sites the planning was executed on site for an extended period and the utilisation of the revised roles was periodically monitored. The results of these three tests tended to indicate that the third element in the hypothesis was also correct.

A number of works published during the period spanned by the research project also proposed similar views which again gave credence to the hypothesis. During the duration of the research a number of microcomputer project planning packages have become commercially available.

2.2 The Research Model

It was desired to examine the project planning process in a theoretical manner in the hope that this examination might reveal factors that were relevant to the objectives of the research.

Noting the objective relating to microcomputer it was considered that a theoretical examination of the flow of data would be most relevant to the research project. This would be more likely to be valuable to the research as the flow of data rather than the flow of responsibility was likely to reveal problems that a microcomputer could help to resolve.

Therefore a theoretical method of examining the flow of information or data through the project planning was required. A Data Flow diagram was evaluated as a possible tool. Data flow diagrams are designed to show the flow of data within a system. They are little concerned with who or what processes the data nor the processes involved and therefore appeared to have qualities useful to the research project.

A diagram demonstrating the flow of data within the project planning system was extracted from a larger model so that a clearer picture of the process might emerge. This diagram and the deductions that were derived are discussed in Section 3 of this thesis.

2.3 Structured Interviews

At the onset of the research it was necessary to obtain views about project planning from current practitioners. Similarly their views would be useful in specifying a test program. Two techniques were considered:

a: Questionnaires by Post.

In this technique a questionnaire is prepared and sent out by post usually accompanied by a covering letter. There is a lack of personal contact in this technique and it is necessary to frame the questions prior to the first interview.

Another disadvantage of this technique is that the construction industry is notoriously poor at replying to such questionnaires. Informal research tended to confirm this opinion.

The Postal Questionnaire Technique is of greater value where a large sample can be circulated so that even a low response rate will yield sufficient data. In this case the researcher was interested primarily in interviewing project planners and site managers. There were difficulties in identifying a sufficient supply to yield acceptably accurate data from the structured interviews where the total sample required is noticeably less.

It was decided that the postal questionnaire technique was not suitable for the research.

b: The Structured Interview.

The Structured Interview is a technique classed as INDIRECT OBSERVATION - the researcher does not himself observe but interviews others who have been observing the subject.
In a structured interview the interviewee meets directly with the interviewer and an interview is carried out. Whilst the interviewer has a series of set goals and an overall structure to the interview, it was possible to modify the interviews slightly to suit the background, knowledge and attitude of the interviewee.

A prime function of the Structured Interview was to verify existing theories and hypotheses. A Structured interview is a form of research designed to be of most value where the objective is to evaluate a hypothesis. It is less appropriate in a research project where a discovery is the objective. This nature of structured interviews was very close to the researchers needs.

Using The Structured Interview technique the researcher was able to take advantage of the personal relationships gained over a 12 year period as a practitioner in the field.

There was published evidence that the nature of the structured interview was as described:

"The scientist who utilizes this technique is usually intent upon testing an existing set of hypotheses, he is less concerned with discovery per se" (Sjoberg & Nett, 1968).

It was considered that the Structured Interview was seen as economical and efficient - it attempted to eliminate needless questions and helped to promote a degree of standardisation. In the field of Social Research, The Structured Interview tended to be regarded as having questions that tended to be stylised and formal and had the reputation of oversymplifying or overstructuring reality - whilst this was seen as proof of the economical nature of the technique, this was not seen as a problem as the nature of this research was structured and limited in scope.

Again from published work on the topic of the structured interview it was noted that "The structured interview is more applicable to large scale surveys in the field of social research and to the formal testing of hypotheses" (Sjoberg & Nett, 1968). As these sentiments were in line with the objectives of this part of the research project it was deduced that the Structured Interview was suitable for the research project.

The research project was concerned with the attitudes of project managers and therefore with indirect observation. Direct observation was not feasible in this type of research project When using The Structured Interview the researcher was encouraged to create a predetermined questionnaire with fairly rigid categories, to precode the data and create tables to assist in analysis of the data.

Hence again The Structured Interview was seen as a valuable tool in this research. The questions used were designed to discover factors pertaining to the objectives and to permit the data to be used in an analysis phase that normally follows on from the interviewing phase.

It was recognised that a number of the questions did not have a simple yes/no response. In many cases a degree of preference or desirability was required.

For this reason a concept propounded by Charles E Osgood (1957) and known as methodological orientation was used. The instrument involves the construction of a multidimensional scale around certain concepts.

The respondents reaction to the questions was to indicate a point along a scale that the respondent felt appropriate to his or her view of the topic. A simple example of this technique in a survey of attitudes to incentives schemes might be:

How important, in your opinion, is the publishing of incentive scheme

targets to the labour force?

important:----:----:----:----:----:----:----:Not important

The question was phrased to allow the respondent to respond suitably and the interview commenced with an explanation of the technique such that a response may be made in terms of a selection of range of responses ranging, in this case, from 1 (very important) through 3&4 (neutral response) to 7 (not at all important). The range may be varied although the range of 7 is acknowledged to be a normally useful range. Too small a number gives insufficient scope and too large a range leads to indecision.

It must be stated that this technique relies on: a: The ability of the interviewer to explain the nature of the interview to the interviewee at the beginning of the discussion

b: Questions that avoid confusion.

It was generally agreed amongst experts in the field of interviewing and particularly structured interviewing techniques that the wording of the questions should be carefully considered. The point made frequently (Sjoberg and Nett, 1968) was that the more structured an interview is to be the more precision is required in the wording of the questions as there is little room for clarifying perplexing points for the interviewee.

It was suggested by Sjoberg & Nett that questions are:

> a: Phrased in terms of the knowledge level of the interviewee - they argued that the interviewer must be careful to request information within the knowledge base of the interviewee and should provide simple routes to avoid the question without loss of face should the question fall outside the scope of the interviewees knowledge base.
>
> b: Built from simple straightforward vocabulary and style. It is argued that the more complex and ambiguous the style the less reliable will be the response.

c: Void of emotionally tinged words - so as to avoid emotionally tinged responses.

d: Phrased to sustain the interest of the interviewee. Again Charles E Osgood was aware that people lose interest easily in the interviewing environment and unreliable responses follow from this lack of enthusiasm.

e: Occasionally used to check on the respondents memory and veracity. Questions may be repeated under a different guise so as to provide a measure of these values.

2.4 A test program

In an attempt to gain a clearer understanding of the problems associated with project planning it was seen as desirable to test the theory in practice. Specifically it was seen as desirable to evaluate what effect a microcomputer based project planning system might have on the attitude to project planning as found within construction management personnel.

With this in mind a test program was required. Such a program, it was argued, could be mounted on a microcomputer and installed on selected construction projects and its use monitored.

This monitoring would enable an evaluation to be made of the effectiveness of the program.

A search was carried for a suitable program but this search did not result in the location of a suitable program.

As it was necessary to locate the test program on a construction site and so that planning could be carried out very rapidly, the project planning packages available commercially on mini and main frame computers were rejected as being either too expensive, too difficult to control or too slow.

As no suitable available program could be located at that time to use as a test program it was necessary to create one for the purposes of this testing process.

It was resolved to examine the requirements for such a program in the series of the structured interviews and thereby arrive at an outline specification for such a program. During the interviews, it was resolved to investigate the following points in respect of the test program:

---

a: the nature of the program

b: the capacity of the program

c: The features required in such a program

The model of the construction process also served to indicate some of the features that were desirable in the test program.

Due to the limited resources available during the project the test program was limited in functions but it appeared possible to create a test program that was sufficiently powerful to test the hypothesis adequately.

After the period of time during which the monitoring of the program was carried out, a revised specification was drawn up. This revised specification was the result of the findings of the test program monitoring and was the result of suggestions for improvement made by the users during the testing period.

The possibility of an artificial environment where a rapid on site project planning environment was artificially created was considered but discarded due to the lack of a practical method of achieving this objective.

2.5 The Longitudinal Case Studies

A small number of construction projects were located on which a microcomputer based project planning system could be installed and monitored. It was considered that a variety of projects offering different backgrounds in terms of

a: Type of personnel

b: Current project planning method

c: Type of project

would give the most useful results.Three case studies locations were identified and these did cover a variety of backgrounds.

Clearly the practical limitations of the research project prevented a large number of case studies to be evaluated. However it was felt that sufficient data was gained for a reasonably clear set of deductions to be made.

When making use of Longitudinal Case Studies the researcher executes a series of interviews over an extended period of time on each specific case.

These interviews tend to be, in total, lengthy and time consuming but have the advantage of allowing the researcher to appreciate more deeply the factors affecting the particular subject in its particular environment.

Additionally the researcher can examine developments reasonably closely over a period of time and is therefore able to examine the effects of a change.

The limited resources available to the researcher in this case dictated that should this technique be adopted solely, the total number of results would be inconsistent with accurate result calculation.

It was decided therefore that this technique would be valid for the evaluation of the test program, where a new system was to be installed, but was not appropriate for the testing of the initial hypothesis.

A MODEL OF THE CONSTRUCTION PLANNING PROCESS.

~~3.1 To obtain a better view of the construction planning process~~ a model of the construction planning process was examined by reference to work done in this field.

The objective of this was to obtain a clearer view of the project planning process and to provide a framework for the research. It was hoped that this examination might reveal the steps involved in project planning more clearly and therefore might reveal significant factors in its under-utilisation.

Also it was hoped that the examination of a model of the planning process would assist in evaluating the effect of on-site and off-site project planning. This related to the objective of establishing if project planning personnel were frequently badly positioned within the management structure of a project.

There was evidence to suggest that one of the problems with network planning was its relatively heavy requirement in terms of management time and expertise.

It was considered that project planning by network analysis, perhaps due its complexity when compared with other management techniques (for example barcharts), was frequently not able to proceed at a pace that suited the direct on-site management.

It was proposed that this led to a situation where plans were regarded as less than useful as they were frequently out of date. In extreme cases plans were found that were out of date at their time of issue. It was possible that this contributed to the poor reputation that network planning had within the field of site management.

It was a hypothesised in the research project that slow planning techniques were contributory to the attitude to project planning within the construction industry.

In Modern Construction Management (Harris and McCaffer ,1977) the functions of a central planning office are discussed and are stated have having two prime functions.

a: To support the estimating department to prepare tender programs etc

and b: To provide planning and co-ordinating services to site

They write that "Such arrangements have created problems for virtually all planners at head office irrespective of the company." And later the authors write that "Such a policy has lead to poor planning and a lack of confidence in the planning function by those who carry greater responsibilities such as estimators and site managers"

An article in the Building Economist (Hinds, September 1981) discussed this theme. In his article the author asked "Why do not builders prepare detailed network construction programmes?". He examined the history and potential of the technique but found to his dissapointment that "very few builders have utilised this programming technique"

This article identified the problem that in general the techniques of project planning and particularly network analysis were techniques rarely found in the British construction industry. In America this view was also expressed.

In a paper submitted to the AACE conference in Washington (M.D.Ryan AIQS and D.M.McCarthy,1980) stated that "The high cost in time and labour of preparing coded input often discourages the use of computerised CPM scheduling systems." The view here was that the technique was potentially useful but that there was a net loss of management time involved in the use of the technique of network planning.

The amount of time invested in creating computerised network plans exceeded, in the view of the writers, the benefits gained. This paper took as a basic assumption the view that computerised network planning techniques were not widely used. This once again was similar to the author's personal experiences.

In Building Economist (Mr.M.Hinds,1981) suggested that builders do not have sufficient time nor incentive to fully investigate work (specifically subcontract work). Also he suggested that costs of production of the network are high and time to produce them is limited. The view recorded is based on the observation that personnel in project management rarely made use of project planning techniques. They gave as one of the reasons for this lack of use the view that the investment exceeds the returns.

In a paper entitled "Integrated Project & Process management" (M.A.A.Dabbas and D.W.Halpin, 1982) the lack of abundance of field decision making and control methodologies and systems was discussed. They proposed that levels of sophistication found in the network planning process varied widely and often fell into the "scientific guesses" classification. The authors searched for a better system of project management that would provide some decision making ability (on site) so that site management could efficiently utilise their physical resources.

This paper assumed a under-utilisation of the network planning technique and attempted to locate a replacement technique that would be more useful. This was similar to proposals included in this thesis.

N.M.L.Barnes and M.Wright:1980 stated that "Experience has shown that, in project management, it is important to use the computer only to do simple things. The computer should add only the ability to do these things on a scale and at a speed which is superhuman. Computation using unfamiliar or sophisticated mathematical relationships although acceptable in design work, prevents a management system becoming widely or confidently used"

The paper went on to suggest that it was possible that the main frame approach to project management attempted to do precisely this - using sophisticated sensitivity and statistical methods to derive project plans.

The use of convenient microcomputers, it was argued, performing relatively simple tasks may remove some of the obstructions to the use of project planning techniques.Again this paper assumed that the techniques were not widely used and suggested reasons for this lack of use.

In Production & Planning applied to Building (R.J.Hollins ,1962) the author stated that short term plans should be utilised "to keep the plan alive.

Nothing can be gained by leaving an out of date and unrealistic plan pinned up in the site office". He recommended that short term plans be produced "at regular intervals" and that an executive at head office should be responsible for seeing that short term plans are prepared at frequent intervals.

Therefore it was decided to produce a model of the construction planning process to evaluate these factors.

The field of Data Flow Diagrams was investigated to locate or prepare a diagram that would fulfill these objectives. A basic diagram was located and the research model deduced from it.

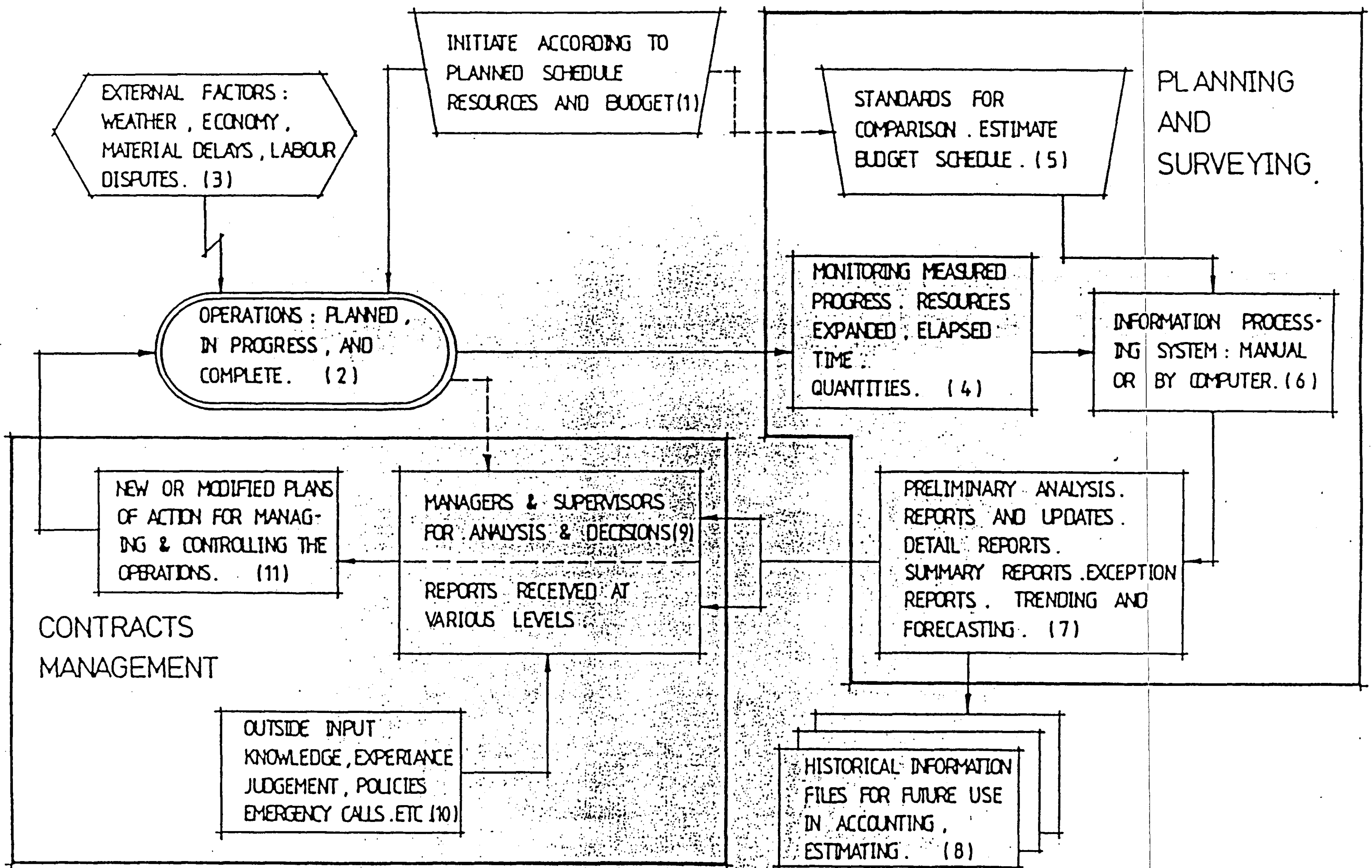
A flow chart taken from "Concepts of project planning and control " (Boyd C Poulson Jr, 1978) was considered to evaluate its suitability for the research project.

This diagram included an examination of the project planning process as a part of an examination of the construction management process.

It was a data flow diagram for the construction management process which had been prepared some 10 years before the date of this research.

To be suitable for the research project, which it should be noted was a pilot research project at that stage, the data flow model would be required to have the following qualities:

a: It should represent the project planning process in terms of data flow rather than in terms of responsibility. This would allow an examination of data movement in a variety of different management structures.



From :- Boyd C. Paulson Jr. "Concepts of Project Planning and Control," Journal of the Construction Division., A.S.C.E. vol. 102

Appendix A.

b: It should be detailed enough to demonstrate the steps involved in the project planning process so that these steps could be considered in light of the research. It should not be too detailed as in a data flow diagram that might be prepared as a part of the latter end of the process involved in the creation of a software package as such a detailed data flow diagram would loose sight of the concepts necessary to a pilot research project.

c: It should not assume any method of data preperation, nor assume any physical arrangement (management structures nad location) of the roles involved as the research covered a wide variety of of methods of data preperation and physical location arrangements.

d: Ideally it would show interaction with other systems in the construction management process so that should questions arise of this nature they could be considered.

The selected model fulfilled these criteria and therefore was considered to be suitable. This diagram had the advantages of suitability and adaptability and it made it possible to view the process in relation to the wider project management process.

The elements of the diagram that related to project planning were extracted from the source diagram.

In this model Box 1 indicated the initiation of the project based on a plan for the project and this was followed by the production of work (box 2). The plan became a frame of reference for control purposes (box 5). As the project proceeded there were external factors that effected the production of work (box 3) and these included such elements as weather, design change and industrial disputes.

The key element in an external factor was that it will affect progress in a way that was dissimilar to that planned. It was noted that this could mean a delay or an opportunity to advance the works.

The actual progress of the works was fed into a system which is an information processing system (box 6) which provided a comparison of information regarding planned targets and actual progress. Such a system may also be involved with making other similar comparisons such as comparing planned budget with actual expenditure.

This was a measuring of progress against the original frame of reference as described at project initiation in box 1.

Box 4 represented a measuring of actual progress . This process was the recording of actual progress in terms of work executed, resources expended and elapsed time.

Information flowed from box 4 to box 6 where a system compared actual progress with planned and provides information to another system (box 7) where reports were prepared to present this comparative information.

The information comparing actual progress with the planned progress was converted into reports summarising this information for management consumption.

Two flow paths resulted from this comparison. One was a feed back to the central company store of information regarding production outputs and formed a part of the historical information used within the company. The second was a more immediate feedback to project management to report problems on the specific project.

Basing their decisions on the information gained from box 7 and from external systems managers and supervisors took decisions about the future work load and thereby create new or modified project plans.

These modified plans fed information back to the operations in progress. It should be noted that this part of the system diagram was a loop and it was suggested that the loop should be followed round on a regular basis.

G.A.Reiss:1982 presented his thoughts on this topic to the Association of Project Managers at a conference (Computers in Project Management). At this conference it was noted that with traditional project planning systems it was not frequently possible for the project planning to keep pace with the Production work. Plans fell increasingly far behind the actually work.

The concept being suggested was that project planning and management teams should on a regular basis:

(1) plan to provide a frame of reference
(2) monitor against that frame of reference and
(3) re-plan to provide a fresh frame of reference

This was a feedback mechanism and associated with it is a feedback time. P.Barton:1985 states that this feedback time should be "As short as possible so that managers and supervisors can receive accurate and up-to-date information in time to make decisions and formulate plans of action, so as to have maximum impact in controlling those operations which are generating the information in the first place".

This feedback process included the following activities:

Create standards for comparison

This item related to the establishing of a frame of reference, usually in the form of a project plan. The project plan, frequently a bar chart, forms a basis on which to evaluate progress.

Measure progress

This item to the measurement of work done against, or in comparison with, the frame of reference described above.

Produce reports comparing actual progress with planned progress

Once a frame of reference has been established and progress measured in comparison with it reports can be produced making this comparison.

Analyse differences

Using the reports created above the manager may analyse the differences to establish what parts of the project are in need of concentration, which tasks are not proceeding in accordance with the plan in either a negative or positive manner. Specifically the manager normally searches for those tasks that deviate by more than a preset margin from the plan.

Decide on action to be taken

To resolve any discovered deviations from plan, the manager may take a wide range of actions. Such actions are designed to make the project proceed in an efficient manner. Actions include the relocation of resources, the acquisition of additional resources and the re-sequencing of tasks.

Produce new or modified plans

To evaluate possible plans of action the manager may produce new or modified plans.

Analyse these new or modified plans

The manager will analyse his new plan either manually or by computer aided methods to discover the implications of his new plan.

Produce reports detailing the new or modified plan

As a result of the actions planned the manager expects that the project will proceed in a certain manner and the various tasks to be related in logic and in time to other tasks in a new way. To communicate these new plans and to evaluate them the manager may produce new plans showing the revised project plan. These new reports will provide a revised frame of reference against which the process may be once again begun.

There was evidence that this process was not frequently followed within the construction industry and also in the rare cases where it was followed, it met with limited success.

3.4 It was considered that the amount of time taken to pass around the 'monitor, compare, decision making,re-plan' feed back loop in normal project planning situations was excessive. An excessive feedback time is one that prevents the plans being sufficiently up to date for the management team to control the project.

This lengthy time period prevented project managers and project planners executing the desirable frequent updating of plans and therefore the plans that were produced quickly became out of date and therefore of little value.

The Flow Chart showed this information flow from box 4 via box 6 and box 7 to box 9 .

It was considered that the fact of the inability of this flow of information to take place with sufficient speed was a major contribution to the poor reputation that project planning had been to found to have within the construction industry.

flow from happening sufficiently rapidly, that delayed the feedback loop.

A: Preparing reports showing the comparison and
   preparing reports showing the new plan.

B: Preparing new or modified plans and
   processing these new plans.

In Construction Management & Design (Mr.J.F.Woodward , 1975) the writer stressed that one of the major benefits of a computerised network planning system was when "it is required to maintain surveillance over progress on the project. The usual practice was to update the computer data tape by indicating what activities have been completed by a particular stage and perhaps modifying the durations of forthcoming activities in the light of experience of the project to date."

He continued saying that "This regular updating monitoring and re-planning is of very great importance, but is often neglected because of the sheer amount of work involved in undertaking it. It is here perhaps that computers can be of the greatest help where updating is so easily completed.

This discussion led to the following observations :

a: There was a feedback loop that involved the flow of information from the monitoring process to the updating process in project planning.

b: That there was a need for this process to be competed rapidly.

c: It was possible that in many construction situations this process was not executed since it was difficult to achieve at sufficient speed.

This was considered to be a major contribution of the poor reputation of project planning within the construction industry.

Consequently a microcomputer, if able to speed this process might make significant improvements in the execution of the planning role.

The above concepts and views were therefore used as a basis for the design of a questionnaire incorporated in the structured interviews which would additionally test the hypothesis.

THE STRUCTURED INTERVIEWS

4.0 Overview

This chapter examines the requirement for a results gained in a series of structured interviews in broad terms.

The detailed analysis of the results is included as Appendix A of this report and the tabular data gained from the interviews is included as Appendix B of this report.

4.1. Rationale

The structured interviews were held to achieve two of the objectives essential to the research.

These two objectives were:

> To establish the general attitude to project planning within the construction industry by a series of interviews.
>
> To develop and test a microcomputer based project planning system in a number of longitudinal case studies to examine the effect such a system would have.

The questions were selected to extract information in a number of areas aimed at these two objectives.
It should be noted that, as described in section 2.3, the interviewer did not simply repeat the question but used the questions as a basis of a reasonably relaxed conversation between interviewee and interviewer. It was felt that this would result in the best atmosphere to gain the maximum knowledge.

The first few questions were aimed at finding out a little about the company in which the interviewee worked. This was regarded as important as correlations might exist between company type and the use of planning techniques. Additionally this sort of question was, it was hoped, easy for the interviewee to answer so he would be put at ease at the beginning of the interview.

Having established some data about the interviewee's company the interview turned to the particular project or projects that the interviewee was involved in. Again the researcher was attempting to establish correlations between project type and size with the use of the various project planning techniques. These questions (1 to 6) were aimed at establishing the background of the interviewee.

The interviewee's views were obtained on the project planning system in use on his current projects and the reason for his views.

To cater for the situation where one company used a number of different techniques the interviewee was asked about other projects either current or past where other project planning techniques were used.

The next section attempted to obtain information about the location of the project planning role. The location of the project planning role was investigated and the interviewee's view of the success of project planning when executed from that role gained.

The two factors most directly relating to speed of processing plans are the system used and the location of the role. These questions therefore were designed to confirm the model previously described.

As it was possible that some construction companies had run experiments using project planning techniques different to their normal system, the next few questions probed into any such experiments that had been run within the interviewee's company. Again questions were asked that related to the speed of execution and location of the role and the interviewee's view were sought on the value of the techniques tried.

Therefore questions 7 to 19 related to the type and attitude to project planning as experienced by the interviewee. This related very directly to the first objective of the interviews.

Questions 20 to 29 related to the interviewees experience with computers.

The next section concerned the use of computers. Questions were asked about the companies computerisation in a way unrelated to project planning. Still on the topic of computers the users experience with computers was also probed in case there was a correlation between attitude and experience.

Next the topic of network planning was covered, again probing for details of the users experience mostly with a view to deducing the reliability of the responses. If the interviewee had had experiences with network planning he was asked about its success, the positioning of the role and the reasons for the success or failure of the technique.

Questions 30 to 34 related therefore to the experience gained by the interviewee in network planning in any form and then questions 35 and 36 reacting specifically to project planning by network analysis by microcomputer.

interviews - to discover the attitude to project planning within construction personnel.

Then the questions turned to the topic of microcomputerised network planning system. The interviewer outlined such a system and attempted to describe a system in terms of speed and ease of use. The interviewee was then asked to consider that if he was responsible for the installation of such a system how would he implement it. The interviewee was asked questions that examined the location of such a system (and therefore the project planning role) and the features that he would like to see in such a system.

The next stage in the structured interviews was to attempt to define the functional specification of a suitable software package. It was planned that, partly as a result of these interviews, partly as a result of the research model, a software package would be created to test the theories outlined more fully.

It was necessary therefore to define a functional specification of a software package that would enable a package to be created (if possible) so that the testing could proceed. It was though valuable to seek the views of the interviewees on the features they considered should be contained within such a package.

would lead to a project planner being creative with his requests for software programming. Therefore the interviewer asked for a reaction in terms of importance of a number of possible features.

This also permitted averages to be taken so that a reasonable common view could be taken. Hence the interview continued with a number of questions relating to the possible features of a network planning package running on a microcomputer.

The researcher asked "Lets consider that you can have a network planning system on site under your control". This was meant to get the interviewee in a frame of mind where he had a computer and suitable software under his own control. This concept had to be explained to some people but again the description was factual and matter of fact where possible.

Thereafter questions 37 to 58 related to a microcomputer based project planning system and the desired features as seen by the interviewee.

Many of the questions were prompted by the thinking inherent in the model of the project planning process discussed in section 3.0.

4.2 Analysis of the Results of the Questionnaire

The results of the questionnaire are reported in Appendix B of this report and these results are analysed in Appendix A.

~~The results of this analysis are summarised in the following~~ section.

4.3 Summary of Interview Findings

Analyses of the first part of the interview

This section analyses the responses to the first part of the structured interviews This appendix then goes on to report the second part of the interviews where an attempt was made to define the specification of a microcomputer based project planning software package.

General

The first part of the interviews had tended to confirm the hypothesis in a number of ways.

A reasonably wide range of environments had been tested covering both large and small firms, large and small sites and a variety of people involved in project planning.

By far the most common planning method had been barcharts drawn manually and only in unusual circumstances had network planning been found to be valued.

Most contractors had run experiments with more advanced network planning techniques but these had not been very successful. Most companies had found computers useful in traditional ways and many had some experience of computers in a`least one environment. It was felt that the interview sample was adequate for the second part of the session which was to attempt to define in outline, the specification of a microcomputer based project planning package.

Experiences and attitudes to project planning.

It can be seen that generally the interviews tended to confirm the hypothesis. Those involved in project management were of the view that project planning did not have a strong reputation within the construction industry. There was a body of opinion that blamed this poor reputation on the slow nature of the tasks involved in project planning. It had been established within the scope of the research that project planning was a topic that construction companies experimented with and that larger projects attracted the more advanced techniques.

In general the view was that project planning was an expensive overhead and was only utilised where the special demands of the project made it necessary.

There was a view given that the fixed nature of plans was unsuitable for the planning process in the construction industry and this tended to confirm the research model view - that a repetitive plan, monitor and re-plan cycle was essential to well respected project planning. This view was expressed most strongly by managers - users of plans rather than creators of plans.

Within the poor reputation of project planning, network planning was especially poorly regarded as it did not solve the problems caused by the slow nature of the planning process.

23 of the interviewees had witnessed project planning in a work environment and most of these felt that:

a: It was used for some purpose not connected with the efficient running of the project

b: It had not been very successful.

Points raised as contributing to the successful implementation of a network planing system included the point referred to previously of unpredictability. Most mentioned that network planning was too sophisticated for the tasks it undertakes to solve.

Again this confirmed that network planning was not in wide use and that the reputation and attitude to planning was poor.

It was noted that taking the group of people who claimed experience with the use of critical path analysis and examining their reaction to the question of the value of critical path gave a higher score - those experienced with network diagrams tended to feel that the approach was better than those who had little experience of the technique.

This tended to indicate that those who devoted time and effort to use network planning saw its benefits.

There was a correlation between remotely executed project planning and a poor attitude to the role. Those interviewees who had experience of on-site planning generally had a better attitude to the role than those who generally worked with a head office planning role.

Those who had planned, rather than those who had used plans, tended to feel that the system was more successful.

It was not possible to establish a relationship between type of planning method and success of the project, only to relate type of project planing to attitude to the technique. It was not surprising that those responsible for project planning, ie planners themselves, generally felt the technique was more useful than those who used the plans ie line managers.

A large number of interviewees had gained some experience with computers and nearly all companies had a computer function somewhere within the company.

In general terms the view was that the computer had a role to play within the construction firm (generally administrative) but few connected this with the role of successful project planning. This confirmed the hypothesis that computer based systems were not commonly used within the construction industry.

Also, as 31 of the interviewees had had some experience of computers, either in a work or home environment, it was reasonable to assume that the sample would be able to answer questions relating to the concepts of a microcomputer based project planning system.

Attitude to a site based network planning system

Generally the thoughts given here were encouraging.

Of course it was noted that it was easier and less controversial for a interviewee to make polite comments about such a concept.

In an attempt to avoid this the interviewer tried not to be enthusiastic making it clear that this was research and that no such system currently existed.

referred to the project manager. This was interpreted as indicating that the interviewees at least felt that such a system could be used by a builder and would not need a specialist.

Also is was recognised if the microcomputer made possible the re-location of the project planning process to the site some of the remoteness problems raised by the interviewees might be lessened.

It was noted that those who had work experience of a computer had a slightly higher expectation of the successful implementation of a microcomputer on site.

A series of questions were put to the interviewee about the features of the proposed package, how it would operate and what it would be expected to do.

Most of the interviewees responded sensibly even though their first hand knowledge was limited and very few impractical ideas were suggested.

This was taken as confirmation that the sample of managers were reliable in these terms.

The design of the model package was based on the desires of the interviewees - activity on arrow network for example being especially frequently requested.

A strong response was noted to question 44 which asked if the system should be fast and to question 54 which asked how long a typical update session should take.

This directly relates to the research model as the prevelant attitude was to confirm that planning had to be rapid so that it could be regularly reviewed. A regularly reviewed planning process should remove the attitude that the forecasting problems made the technique less than valuable.

5 THE DEVELOPMENT OF A FUNCTIONAL SPECIFICATION FOR A PROJECT PLANNING PACKAGE

5.0 Overview

This section served to outline the specification for the test program that was installed on three longitudinal test sites. It is here included so that a clear concept of the operation of the system may be evaluated.

The specification was a result of the interviews so that the views of the interviewees was respected in each stage of the specification wherever this was feasible.

It is important to note that the majority view was that if the network planning system was reasonably quick and convenient, the system would be used more fully.

Generally, it can be seen from the detailed results, the level of interest in precedence technique was low so that the technique of activity or arrow was adopted.

The program had the following outline.

5.1 Basic design

The test project planning package was to use traditional activity on arrow network planning technique as this had been found to be regarded as potentially the better technique for the construction industry. (Questions 37 - 38, Appendix A)

The basic design on the package permitted the user to enter details of the project plan into the computer and have these details recorded on disk. The plan would be entered as a series of activities each defined by a start and end node, a description and a duration in days.

Numbers of activities

A plan, it was desired on average should be able to comprise of up to 1500 activities as this had been defined an adequate number in the previous interviews. (Question 39,Appendix A)

Analysis and reports

The demands in this area were not complex. It was suggested that the operator was able to request an analysis which proceeded rapidly and which resulted in a printed barchart report. (Questions 41-43 & 52 appendix A)

Calendars

The program should allow the operator to create a working holiday calendar that identified working and non-working day and the system was restricted to planning in term of the day as a time unit. (Questions 50,51 appendix A)

Resources

There was no resource management function within the program as although there had been some demand for this ability it was impractical to build such a feature into the system during the project . This was not seen as conflicting with the research model as the nature of resource prediction was not close to the nature of the rapid and repetitive updating of project plans. (Questions 47 & 48 appendix A)

Ease of use

It was regarded as important for the system to create barcharts featuring the work relating to a particular part of the project as this was an identified management request.

It was regarded as a high priority that the program should provide a simple easy means to update the plan to reflect work done to provide up-to-date plans regularly or so that alternate construction techniques to aid rapid and economical construction could be evaluated.

This speedy and easy update mode reflected the desire expressed in the research model for a rapid update ability from a project planning system.

In the view of nearly all interviewees the operation of the program was to be simple so that non-technical people could operate the system and obtain reports. (Questions 54 - 58)

Similarly all interviewees expected that the system would reject obviously erroneous data and would have minimal running costs.

5.2 THE SPECIFICATION FOR THE PROGRAM

As a result of the preceding objectives the specification for the program was prepared to allow the next stage of the research to proceed. The next stage was to create a sample or test program so that longitudinal case studies could be carried out.

Therefore a specification for the program was prepared. The objectives of this specification were

a:to enable a clearer view of the software to be gained and

b:to enable the potential longitudinal test sites and other interviewees to evaluate the program prior to the stage when a commitment to writing the program was taken.

The specification provided a discussion document around which interested parties could contribute to the design of the package.

5.2.1 General

The program should perform the data entry, analysis and report generation of activity on arrow network plans. The program should be written in Applesoft Basic and be suitable for the Apple II 48K microcomputer with black and white monitor and Epson FX80 printer. The Apple II microcomputer was selected as being a cheap, readily available and yet suitably powerful machine. This permitted the system to be easy to use and within the price range established in the interviews.

5.2.2 Data Entry

The user should be able to create project plans each of which would take the following form:

Headings: Each plan would have :-

Plan Title	8 characters
3 additional sub-titles	30 characters each
A calendar identifier	8 characters

This was seen as adequate to define the project.

5.2.3 Calendars

Users would be able to produce calendars each of which would be identified by an 8 character identifier. For each calendar the user should be able to enter a typical working week identifying the project normal working week environment and in addition unlimited numbers of special holidays such as Easter and Christmas. This met the requirements laid out in the interviews.

Typical working weeks should be limited to between 1 and 7 working days per week. Calendars should be capable of being up to 10 years long. Calendars would use the Gregorian calendar as a basis and would show month and day names by means of three character abbreviations.

Calendars would provide a day number chart and the program and the users would use such day number charts when calculating dates.

5.2.4 Projects

A project file would comprise of the headings including the calendar identifier, project titles and up to 1500 activities. These activities would define the network and would take the following form.

Activities would be made up from the following data.

a start node	Numeric from 1 up to 1499
an end node	Numeric from 2 up to 1500
a description	Up to 40 characters
a duration.	In days up to 999

The operator would be able to enter details of project plans as a series of activities. He would able to examine and amend descriptions and durations and would also be able to add and delete activities. These features enabled the rapid update mode objective to be approached.

Node numbers need not be sequential. The logic of the project network would be deduced from the node numbers. Therefore activities finishing at node X would precede any activities beginning at node X. This was seen as the simplest way of defining the logic of the plan and was in line with the wishes of the interviewees for a simple system.

The whole plan would be capable of being recorded on disk for later amendment. It was considered essentially that plans could be re-called for updating as a part of the prime objective of a rapid update facility.

5.2.5 Analysis

At the operator's command the program would execute a forward and backward pass through the network and deduce the critical path ~~through the plan and the total float on each activity. Activities~~ would then be sorted into sequence as defined below and displayed on screen. On the user's command barcharts should be printed. This is a 'batch' approach and met the target set by the interviewees quite adequately.

The analysis and sorting phase should take no longer that 30 minutes based on a 1000 activity plan. It had been recognised that reasonably quick network processing was an important feature and this time scale was acceptable within the terms of the interviews.

5.2.6 Sorting

Activities would be sorted into the following sequence. The activities would be listed in rising sequence of their early start date and where two or more activities had the same earliest start date they would be listed in rising order of duration. Activities with identical earliest start date and identical duration should not be sorted. This sequence most closely approached the manually drawn barcharts normally in use of projects and therefore was adopted.

5.2.7 Report Generation

The program would be capable of producing short term barcharts, project barcharts and date listing information on the printer. The reports should be legible and in a form acceptable to site management personnel. The barchart would show a horizontal time scale and list the activities. For each activity the earliest start and finish would be show by a bar and float to the latest finish would also be shown. The date listing report would list activities and print early and late start and finish as well as total float and durations. Again this was the minimum deviation from manual techniques and therefore most likely to be acceptable.

When requesting a barchart or date listing the user should be able to enter a search or selection key. This selection key would be used to restrict activities to be printed to those that contain the selection key in their descriptions. The user would be expected to specify the location of this selection key. An example of this might be "activities containing the letters XX in position 4 & 5" A number of users had held this ability to be important mentioning the voluminous outputs of the main frame systems.

After printing is completed the user would be asked if he requires another report and additional reports should be possible on different selection criteria.

5.2.9 Method of Operation

The main menu would have the following options:

1: Update an existing plan

2: Create a new plan

3: Create a new calendar

4: End this session

These four options were selected to offer the easiest choice and yet offer the paths through the program that a user would require.

At each stage the user would be presented with a similar simple self explanatory menu which would enable the system to be used by a non-computer technical person. This was as a result of the demand that came from the interviews for a simple easy to use system.

5.2.10 Filing and Data storage

Plans should be recorded automatically without user intervention and each plan would be recorded under its identifier and its version number. Each time a plan is loaded from disk into the memory of the computer for a work session a new version would automatically be produced being 1 greater than the previous plan. This feature would permit a historical record of the project and would allow the researcher to monitor the frequency of updating on the system and to control experimental plans.

CHAPTER 6

Implementation of the Test Package

This chapter discusses the implementation of the test package in three longitudinal case studies.

Three longitudinal case studies were established. They were selected on the basis of providing a wide range of project planning environments. One was a large project with an on-site project planning team who at the time on the commencement of the longitudinal case study were using a main frame project planning system.

The second project was one where normally, that is in accordance with the firms normal practice, no sophisticated techniques would have been used. The project had no on-site planning team and all planning would normally have taken place from the company head office.

The third site was a large project where it was planned to carry out the project planning by manually prepared network analysis. The site resident planning team used manual techniques to prepare project plans for their own site and an adjacent and smaller project.

6.1 The Three Locations

Project A - a large hospital

Site A was a large hospital project in the Greater Manchester area. The project was a traditional competitive tender project and the main contractor had been appointed to co-ordinate a degree of direct works and a range of nominated and other subcontractors.

The project comprised of 8 steel frame tower blocks and the longitudinal test began when the project had progressed to the foundation stage.

Planning on the project had been by main frame processed critical path overall project plan. This was backed up by on-site short term barcharts prepared manually.

The project was large enough to have a substantial main contractor's site set up and a substantial on-site management team. The project director lead a team of some 20 people including three people in project planning and materials progressing.

The microcomputer was not installed in the planner's office but in a spare room where the planners and others could use the machine. One of the planners was appointed to take special responsibility for the machine. This planner had experience of network planning on the main frame computer but had virtually no computing experience. He believed that critical path analysis generally failed to achieve its targets and blamed the speed and inconvenience factors for this failure.

Project B - Council offices

Project B was a new council office project in East Anglia. The main contractor had won the project in competitive tender and established a small on site team backed up by a head office management team. It had been originally planned to execute the project planning by manually prepared barcharts in the head office.

The test program was used on the site. This was achieved by a regular series of visits. Each week the planner and the associated hardware would arrive on site and the team on site would update and review the plans. Actual progress was also measured on a weekly basis. The leader of the site team was the site manager and his was backed up a project manager on a visiting basis and of course the visiting project planner.

The site manager had had little experience of network planing and computers and felt that a barchart was all that was required for a successful project.

He was open minded if dubious about the possibility of a microcomputer based critical path analysis system being of use.

Project C - city centre offices

Project C was a very large city centre office and shop development executed by a major contractor. The project included a large office development on a crowded site. The structure was a reinforced concrete main tower with precast concrete cladding. The large project team included project planners as well as the normal line management.

A senior project manager was resident on site for the larger portion of the project history.

The project planning team also undertook the project planning role of a smaller but adjacent project. Due to the space restrictions on the project there were special planning problems associated with the positioning and periodic re-positionIng of site facilities.

The site huts and storage area were moved to new locations as the work progressed.-

The microcomputer was installed in the main contractor's site offices.

The project manager had some experience of network planning having supervised large projects where network plans had been desirable.

He had no direct experience of computing but again had supervised people using computers for planning and other functions.

The planner on this site had used main frame critical path analysis techniques widely and found that, whilst recognising the limitations, the approach did usually benefit the project.

6.2 Observations made during the longitudinal case studies

The microcomputer installations were monitored by periodic informal interview. In all three cases the operator was a project planner who had had some experience of project planning by network analysis. Despite a total lack of computer experience amongst the three test sites there was a short aclimatisation stage after which the planner claimed to become competent with the technology.

In all three cases there was a problem caused by the lack of typing experience shown by the operators but this served only to slow down data entry. This was short term and not a significant problem.

In all three cases, it must be emphasised, the microcomputer was on site on the temporary site accommodation and in use by site personnel.

In two cases there was an initial period after that of aclimatisation during which the operator developed the project network plan. In these cases there was interest shown by the site management, who were helpful in the creation of the plan although this was mixed with a degree of skepticism with respect to the results expected.

In these two cases (B and C) it was necessary to create the project plans simultaneously with the institution of the system. In case A, a project plan had been prepared using network planning and this was entered into the microcomputer based project planning system. In the other two cases there was no network plan available so that it had to be prepared and entered at the onset of the case study. This created two simultaneous learning curves and aggravated the problems. In these cases the longitudinal case studies began at an early stage in the project life cycle and before much pre-planning had been executed.

In project A the network plan existed and was being analysed by a main frame computer bureau. The senior management, cautious as to the effectiveness of the experiment, planned to run the two systems (the main frame and microcomputer solutions) in parallel for the duration of the experiment. This system was designed so that should the experiment fail the site team could fall back on the main frame system without loss.

The first major effect noticed by the researcher was that the site teams began to frequently and regularly update and re-issue their project plans. The logic behind this development was that as it was not previously possible to keep plans up to date and yet this was a desirable feature of a project planning system. This had been established in the structured interviews and from the literature search on the topic.

On the hospital project the main frame system had prevented the introduction of a regular update/review technique for three reasons:

1: Cost - the main frame project planning system was charged to the project on a runtime basis which made each run of the plan and set of printouts expensive. This did not encourage a regular review.

2: Speed - the actual amount of time taken to update the data entry sheets, send the data to the computer, enter the data and get the results was in the order of one to one and a half weeks. This meant that the plans when received were out of date by 7 to 10 days.

3: Information presentation - The data was not presented by the main frame project planning system in a form acceptable to the site management and, when the data was received, there yet remained a final stage of drawing a traditional barchart for presentation to site management. This total process was too slow.

Using the relatively simple test program and the microcomputer on site it was possible to enter the updated data on site and get barcharts in a form acceptable to the site management in less than one hour.

After a short period a procedure was adopted on the hospital project that entailed the updating and presentation of the short term project barchart on a regular weekly basis to the weekly site team meeting. Indeed on the occasions when the barchart was not, for some reason, available at the meeting, the project planner would be castigated for its absence. This is taken as a strong sign that site management viewed the system with respect and saw it as a useful part of their project management function and role.

All three planners found that they could create useful networks and indeed most became sophisticated in the technique. After the experiment was no more that half way through its 9 month period the planners were beginning to ask for more features to be added to the test software. Where possible these demands were met. Again this is regarded as an indication that the site team were becoming more involved in the field of project planning and felt that they would wish to use the technique more fully. Amongst the features requested was an element of resource management particularly cash flow prediction.

Again at this point in the project some of the interviewees mentioned or alluded to the possibility that the microcomputer program could remove the onerous task of preparing the network diagrams. No solid suggestions were forthcoming on how such a system would be informed of the needs of the project, only a vague concept was expressed. The vague concept was that microcomputer's role could be extended to include network creation.

In one project an industrial dispute caused the steel frame deliveries to cease for a period of months. At the end of the dispute the deliveries began once more but the original delivery sequence was not adhered to. The site team were able to identify a number of possible acceleration measures each of which involved additional craneage and other plant. These alternative acceleration measures were discussed and for each a network plan was created on the microcomputer.

This enable the site team to present to the client a number of alternative plans each with an associated barchart and associated costings. The client/contractor were able to select one of these alternative plans and work began in the chosen direction.

In these two cases as the initial plan was developed and entered into the microcomputer the degree of skepticism grew as no tangible results emanated.

After the initial period (8 weeks in one case and 3 months in the other) the computer began to produce barcharts. This was greeted with some relief by some members of staff who had begun to suspect failure of the experiment. Others saw the experiment as "getting on its feet" at this stage.

CHAPTER 7

7.0 The results of the implementations of the Test Package

This chapter examines the effects and findings of the implementation of the test package in the three longitudinal test sites.

It examines these findings in two ways. Firstly procedural changes that relate back to the research model are examined. This is followed by a report on the perceived change in attitudes amongst the members of the on and off site teams.

7.1 THE REVISED RESEARCH MODEL

The research model was re-examined in the light of the research carried out.

The basic model did not require alteration as the flow of data was unchanged. There were however two significant changes in the model.

There is a plan, monitor and re-plan loop which is typical of a feedback control system and which runs through the following components: 4,6,7,9,11 and 2. It was noted that when the microcomputer was installed on a site the speed at which information flows around this feed back loop increased.

The average time taken to execute the complete loop was in the order of 1 week, meaning that the update process could be executed weekly. Moreover the actual process of re-planning and issuing of new reports (elements 6 and 7) in this model took less than half a day. This meant that when reports were issued they were sufficiently up to date to be respected. In fact due to the weekly updating approach adopted on the longitudinal test sites, the barcharts where never more that one week old, therefore never more than one week out of date.

The sub-system boundaries were revised to respect the removal of the project planning to the site. In the original model the information processing system (6) and monitoring process (4) and report generation (7) were geographically removed to the site and managerially removed to within the scope of the contracts management sub-system.

Because of the restructuring of the boundaries of the subsystems the attitude to planning was improved.

The microcomputer based project management system therefore had contributed in two ways. The feedback loop was followed more rapidly and also the planning role was re-positioned onto the site. The effect of these two changes was contributory to the better attitude to project planning as found within the site management personnel.

Data passing into the feedback loop from the monitoring progress (4) was generally more up to date as the actual length of the path was much shorter, therefore it was deduced that the data was more accurate. Additionally the site management were responsible for the monitoring process after the installation of the microcomputer whereas prior to the installation of the microcomputer the monitoring role was frequently carried out by head office based planning staff. Due to these two combined effects the accuracy of data used in project planning updates was generally more accurate. This improved accuracy also contributed to more accurate programs being issued (barcharts etc) and therefore this also contributed to an improved attitude to project planning.

This generally more accurate data was actually less important with a microcomputer than without. If an inaccurate plan was created in an environment where updates were infrequent, the mistake would exist for a considerable period of time. Where a microcomputer was in use the update would be no more than one week away so that errors were less significant.
This was seen as an advantage of the microcomputer based system.

The shorter feedback loop also reduced the need for skill in identifying activities. Although there was no evidence to suggest that less skill was available it was deduced that as the feedback loop was so much shorter there was a much smaller commitment made by the selection of an activity. If an inappropriate selection was made there would be little problem associated with revising the activity at the date of the next update.

As a system it was noted that whilst the input data had not changed, the output data had changed considerably and the attitude found amongst those receiving the data also changed.

The output from the system to line project management was seen to be a wide range of barcharts and other items of planning information. The microcomputer reduced the amount of man time needed to produce report and it was economical to produce reports detailing parts of the project when requested by line management.

7.2 Observed Changes in Attitude

Due to the changes brought about by the implementation of a microcomputer based project planning system there did seem to be an improvement in the attitude found amongst the line management on the test sites towards project management. They seemed to be more receptive to the idea and concepts found in project planning and took a much more positive view of the technique.

The view was proposed that project planning had become like a "NEWSPAPER. It informed the reader of recent and of forthcoming events.

Increased power in report generation was a feature requested by line management during the case studies.

This again was a positive sign on management involvement - that the site team began to request reports from the system that more closely met with their personal requirements. It was also proposed that this demonstrated a good conceptual grasp of the nature of a computerised project planning system.

It was noted that the senior management, after an initial cautious period, began to feel the presence of a microcomputer on a project was a sign of advanced management. The effect of this was that each of the construction companies organised visits to the project so that other could gain an understanding of the methods in use on the project. Visits included members of the construction company from other projects and from head office.

Also the microcomputer installation was seen as a marketing aid by the senior construction company management. This lead to visits by architects, Quantity Surveyors and potential clients. The objective was to show influential individuals that the construction company was forward thinking and used the most modern aids to achieve its projects.

This was taken as a measure of success as if the site teams had been reporting a lack of success of the microcomputer based project planning system, the senior management would not have thought it appropriate to 'show off' the planning system.

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

8.0 Overview

On the basis of the preceding analysis it is possible to draw the conclusions outlined below.

8.1 Conclusions

It was generally found that the hypotheses appeared to have a strong element of validity. The general attitude of site management personnel to project planning within the construction industry was found to be one of doubt. There was doubt that the techniques had significant value to the site management process.

8.1.2 Generally project planning was executed by the simplest of methods except where complexity or project scale or external factors demanded the use of network planning. In situations where network planning was utilised this was usually found to be executed remotely from the site by specialists and the work produced by such specialists was regarded with some doubt by site management.

8.1.3 In situations where the role of project planning was relocated to site and within the role of the site management the attitude was generally found to be one of enthusiasm. Project planning became a focal point around which the site management team planned the work load, and the results of the project planning were regarded as realistic and useful even by those who were not directly involved in their preparation.

8.1.4 The model program that was created to permit these tests to proceed was seen as oversimplyfying the task (although this was based on site management's preliminary ideas of such a package) and the site management on the test sites clearly felt able to utilise the microcomputer and the test program and indeed stated a desire for more sophistication in terms of their ability to plan.

8.1.5 It was noted by the some of the construction personnel interviewed that the microcomputer with a suitable software package could remove some of the problems experienced with the execution of the technique of project planning by network analysis to an extent that it need not be executed by remote specialists.

Those site teams who had been able to execute project planning themselves, that is by personnel regarded as being a part of the site team, reported a higher level of satisfaction with the the techniques employed. This tended to indicate that where project planning was executed close to the project and not in a remote location, the attitude to project planning was relatively improved.

8.2 Recommendations

8.2.1 There was some disappointment that it was still necessary to create a network diagram for the project. In all cases the desire was stated that the preparation of a network was a means to an end and perhaps the microcomputer could remove this part of the task.

This finding was completely unexpected. The view was expressed frequently that it should be possible for the microcomputer to make the task of project planning even easier. It was mentioned that production of the network plans was not, in itself, an objective. It was the rapid and economical progress of the project that was the overall objective.

An examination of the research model showed that the repetitive process involved in producing, monitoring and updating plans was key to the process of project planning. Once up to date plans have been prepared the model shows that these plans were used to disseminate information to the management team.

This communicative element of project planning was seen by many as being closer to the objective of project planning so that any technological improvements that made the steps leading up to the production of project plans for dissemination would be useful.

The view was given that the technique used to arrive at the plans was almost irrelevant to the management team as long as they could have confidence in those plans.

Hence the challenge was not only to improve of the current techniques by making those techniques more convenient and more rapid but to use the technology to create a new approach to the fundamental problem.

This was a strong confirmation of the original hypothesis. By requesting a faster technique that reached to the true management objective, the hypothesis that project planning was badly thought of partly due to its slowness and partly due its inappropriate positioning tended to be confirmed.

When site manager saw the possibility of rapid, on-site project planning they warmly greeted this technique and very rapidly began to examine the technique for further improvements.

The basis concept from management personnel was that the computer should be able to produce the network plans thus speeding and making even more convenient the process.

8.2.2 To achieve this a software package must have the following areas of knowledge:

Knowledge of the nature of project management

Knowledge of the general nature of the project in hand

Knowledge of the specific project in hand

The ability to absorb this knowledge and produce project plans as a result.

This consideration led to a brief examination of Artificial Intelligence techniques and it was here that some possible links began to emerge.

Artificially Intelligent system are not based on a range of data but on a base of knowledge. Such system concentrate on rules rather than data.

It was considered that a knowledge base of project management, and of general types of project might have been feasible. To this would be added a knowledge base about the specific project which would therefore be able to create project plans for dissemination. It was observed that all the data about a project was available on most projects at an early stage through the tender documents, Bills of Quantities and other pre-construction documents.

As a project proceeds information to the amount of work done, and therefore the amount of work outstanding could be regarded as a re-definition of the project. Such information, it was noted, was available from bonus payments, progress reports and materials reports.

An EXPERT SYSTEM it was found was a form of Artificial Intelligence that deals with the learning of and utilisation of rules.

It was considered that an EXPERT SYSTEM might be created that was aware of the fundamental rules of project management.

It was considered that a company might be able to use an EXPERT SYSTEM to create a knowledge base of the sort of project it has worked on. To this could be added the data relating to the specific project extracted from the wide range of information available at project commencement. The result, it was considered, might be communicative project planning documents.

Many question arose from these thoughts:

> Could such a system be created at a cost within the reach of construction companies?
> Would project managers utilise such a technique?
> Are such techniques in use in other environments and could any such implementations be adapted to the construction industry?
> Would site management staff be able to instruct such a system and how would they re-act to such a system?
> What, if any, new expertise would such a system demand from site management personnel?

8.2.4 It was considered that this would form the basis of a suitable research project. Such a project would evaluate the possible form of an artificially intelligent project management and attempt to evaluate the features such a system should as seen from the project management viewpoint.

Then a test program would be created which would be installed on a variety of projects and in a variety of companies to test the value of such a system.

Appendix A - Analysis of Responses to the Structured Interviews

Appendix A: The Responses

This section analyses in detail the responses gained during the structured interviews.

It should be noted that the questions repeated herein for clarity were not read and taken literally during these structured interviews but were used as a guide to a continuing discussion between interviewee and interviewer.

A.1 General.

A total of 35 project planners and project managers were interviewed. The following examines their responses. A summary of the responses is included in Chapter 4 of this thesis.

A.2 The Company

The first few questions related to the background of the interviewee's company and its area of work.

Q1:What is the size of the company in turnover?

The average turnover of all companies interviewed was approximately £4.9 million and the range was from £20M to £3,000,000. An adequate range of companies was therefore examined.

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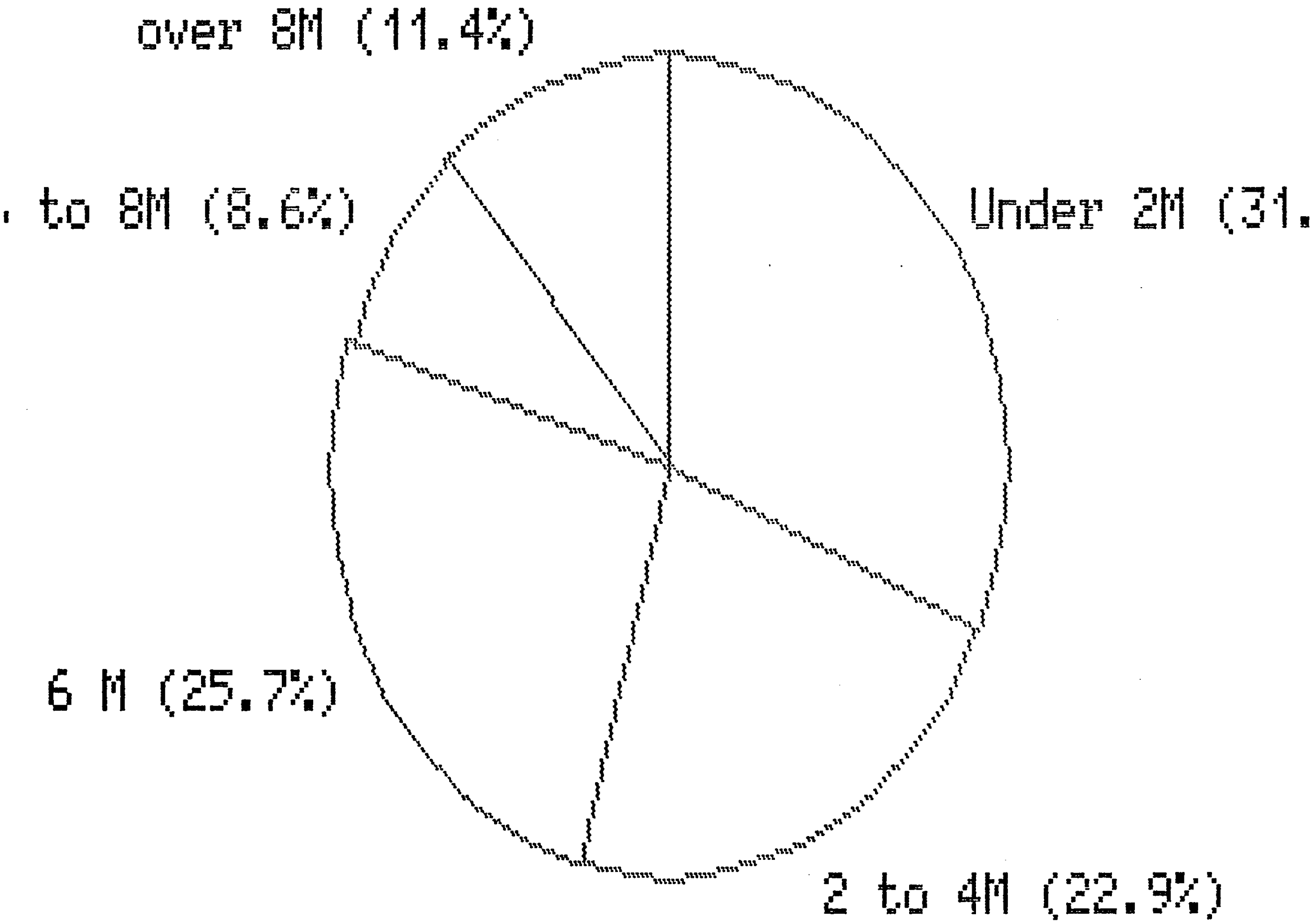
Diagram A1: Responses to Question 1



Q2:What is the size of the company in numbers of employees?

The range was from 2,000 to 25 with an average of 287. The pie chart above shows that most firms were small (under 200 employees) and that a good range of companies were investigated.

Q3:What type of work is the company involved in?

Nearly all the interviewed companies were construction companies involved in normal competitive tendering work for both public and private clients. The type of work ranged from housing to an international airport. Some of the larger organisations included international contracting experience and management fee and other cost recovery types of contract relationships. There were 3 companies who were classed as civil engineers.

A.3. The interviewee

Next the interviewee's personal role and experience were investigated.

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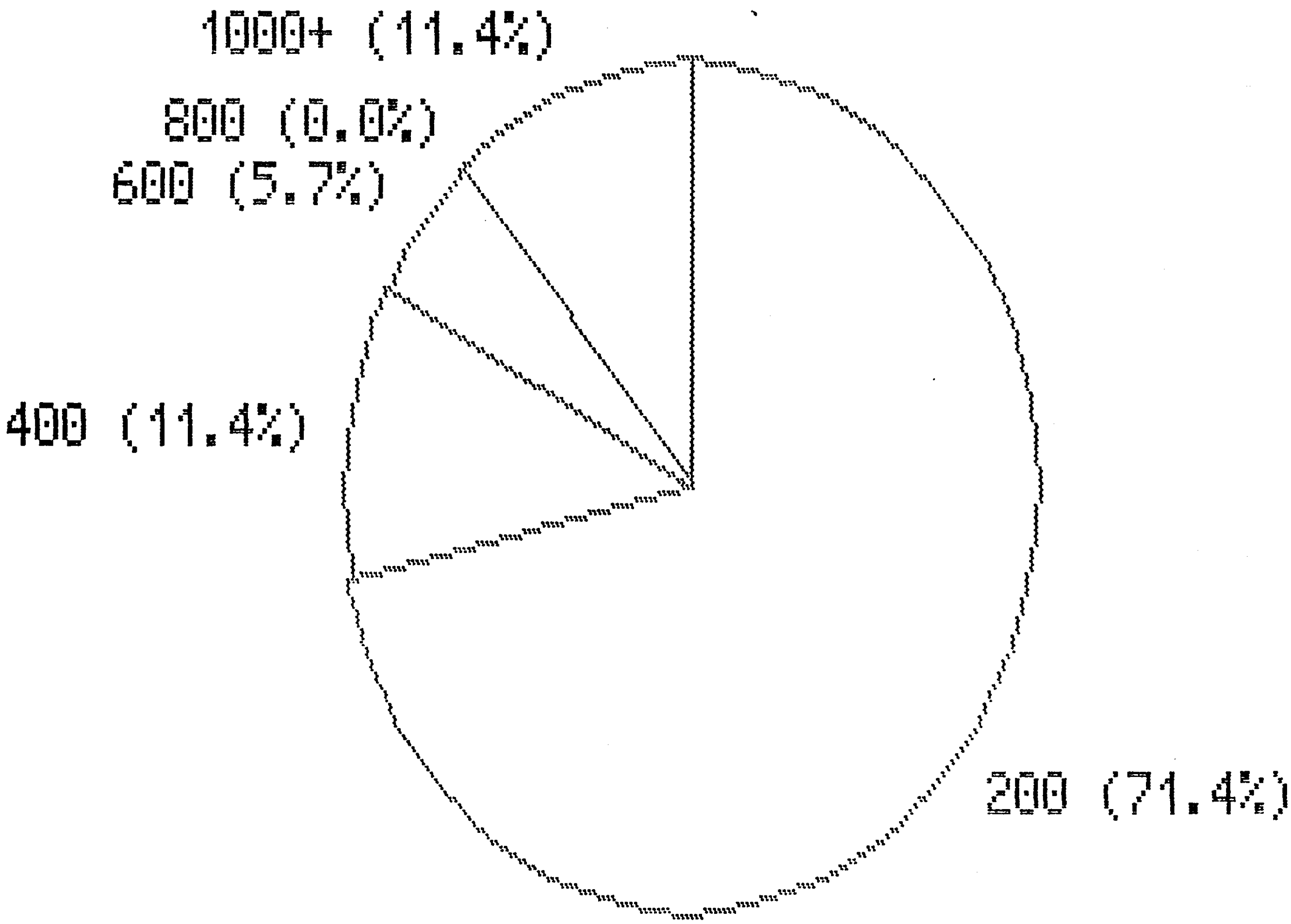
Diagram A2: Responses to Question 2



Q4:What is your job title ?

12 of the interviewees gave their title as Project Planner and a further 7 stated their role as Planning Engineer. These in general seemed to be different job titles for the same role. Together these two catagories totalled 54% of the sample. 2 of the interviewees were Engineers (on-site specialists found predominantly in Civil engineering) and 7 stated their title as Project Manager. This term normally indicated responsibility for a project.

2 managers described their role as Construction Manager (being responsible for the site work on a project). There were 5 others in various site and head office management. The diagram (A4) shows the distribution of job titles.

Q5:What is you role ?

Almost 50% of the interviewees could be classed as project planners (those who perform the task of project planning by some means). 20 were effectively full time and the remainder perfomed some other function in addition to that of project planner for example materials chaser.

The remainder (15) were full time project management staff involved in direct line management either on or off site. Some of these had a responsibility for project planning on some projects. It was noted that the division of responsibility, allocation of titles and role varied for an individual as he moved from project to project and from firm to firm. It was not uncommon for a project planner to become a project manager, nor for a construction manager (who executed his own project planning) to move to a larger project, be elevated to project manager and to delegate project planning to an assistant. 2 were project planning consultants contracting to construction firms and providing a project planning service .

Q6:What type of project are you currently involved in?

All interviewees were involved in some form of construction management. This ranged from housing to major, multi-million hospital projects. A wide range fo projects was therefore examined.

At this point the interviewee was asked about the project or projects in which he was currently involved and the project planning techniques in use on those projects. His opinion was sought on the success of these techniques.

This directly relates to the research model as the prevelant attitude was to confirm that planning had to be rapid so that it could be regularly reviewed. A regularly reviewed planning process should remove the attitude that the forecasting problems made the technique less than valuable.

Also if the microcomputer made possible the re-location of the project planning process to the site some of the remoteness problems raised by the interviewees might be lessened.

Q7 What system (of project planning) is used?

The following statistics emerged and can be seen from diagram A7. In 71% of the projects examined Barcharts were prepared manually (neither using critical path analysis techniques nor using computes). In 10 cases (14%) Barcharts were prepared from network (with or without computers). In 5 cases manual network planning techniques were employed (ie without computers).

5 interviewees used computersied network planning techniques and 1 planner was using the line of balance technique.

It was concluded from this sample that Barcharts are a very common form of communication. There was correlation between the occurance of network planning and the larger, more complex projects.

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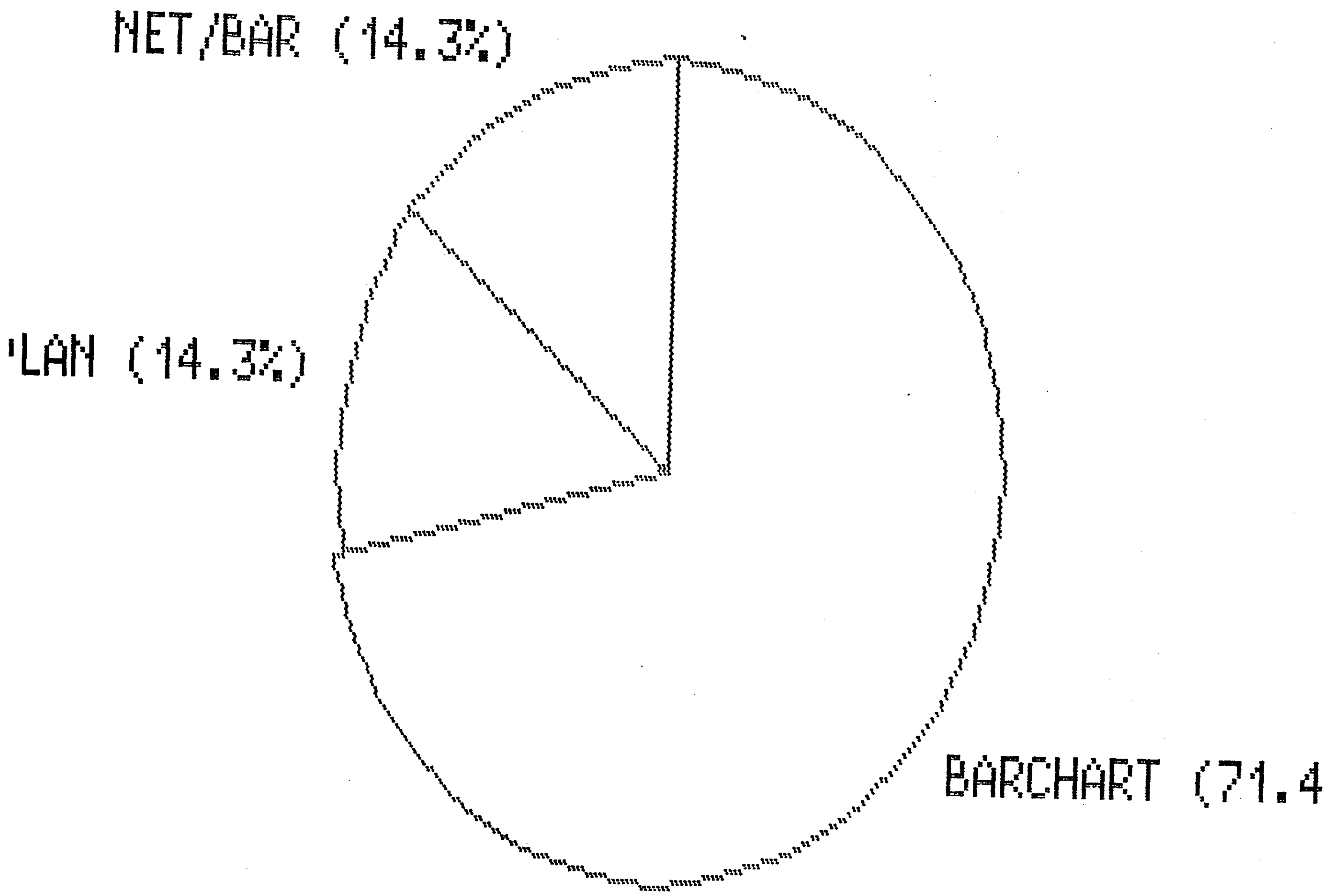
Diagram A7: Responses to Question 7



Who performs the planning role

The answer to this question, shown in diagram A8, frequently contained some reference ot dependant factors. For example many contractors plan large projects on site and smaller project from head office. Some smaller projects are planned using facilities on a local larger projects.

The interviews did not reveal an accurate measure of project size that would dictate the decision as it was a complex decision relating to a number of factors for example - availability of staff, location of the project, political importance and complexity.

Diagram A8 shows the distribution of the planning work at the time of the interviews.

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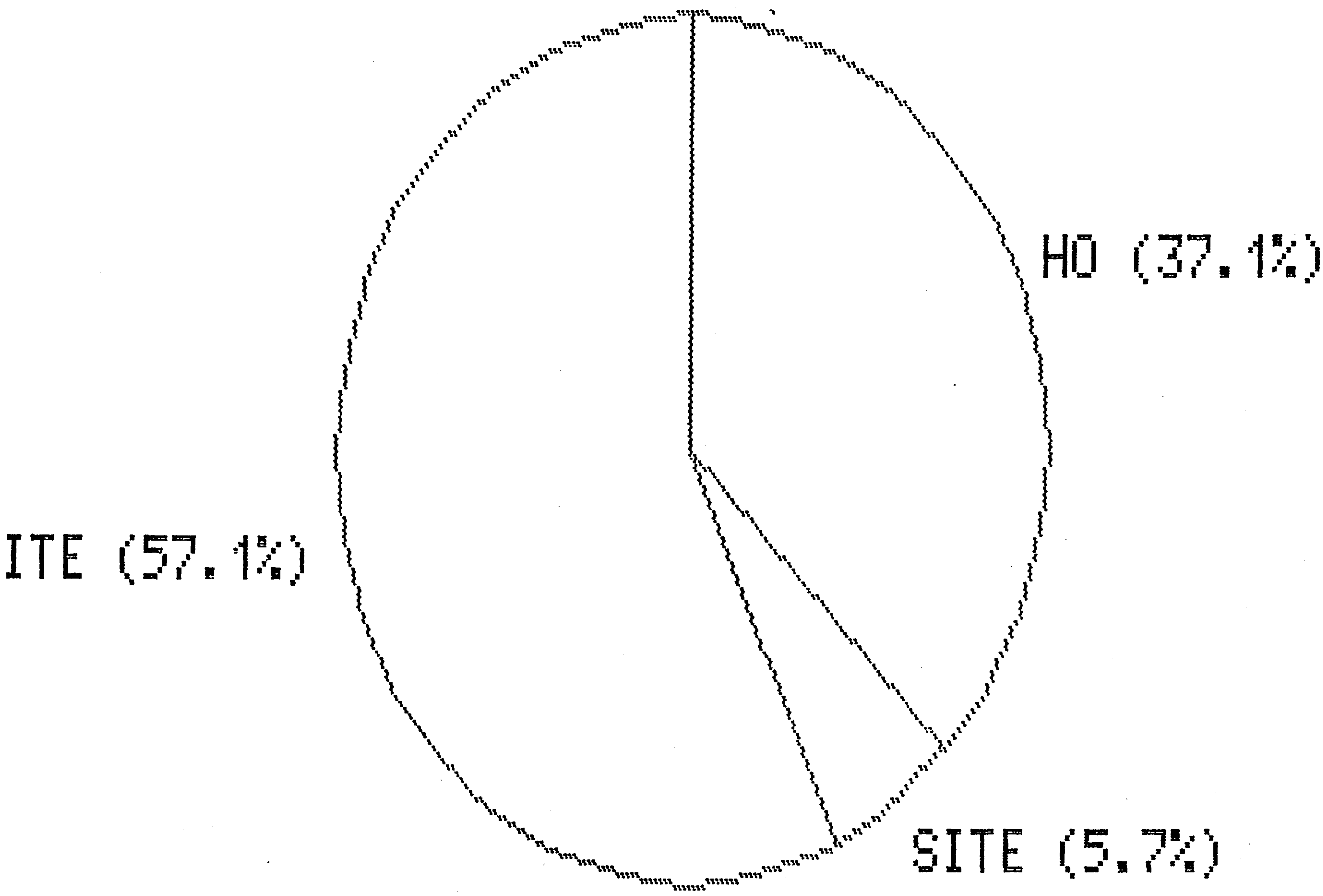
Diagram A8: Responses to Question 8



Q9:Do you feel that this use of planning techniques is successful? (1 = very successful, 7 = not successful at all)

The average response was 4.6. The shape of the graph indicated the general view which was that project planning was not a ~~contributor to successful project~~ management. When the views of those not directly involved with project planning the average were analysed the result was much higher (5.75). This seemed to indicate that whilst those involved with project planning of all kinds doubted the value of project planning, there was a higher degree of doubt amongst those using the plans, the project and construction managers.

Q10:Why do you feel this is the case?

In some cases the view was that it was very difficult (in some views impossible) to predict the flow of a construction project as there were too many external factors (weather, delivery delays etc). This accounted for 20% of the sample and is referred to as "PREDICT" on the pie chart shown in diagram A10.

Also the view was given that as project planning attempted to look into the future its usefulness was limited. On the pie chart this is referred to as "FUTURE" and makes up 56% of the sample.

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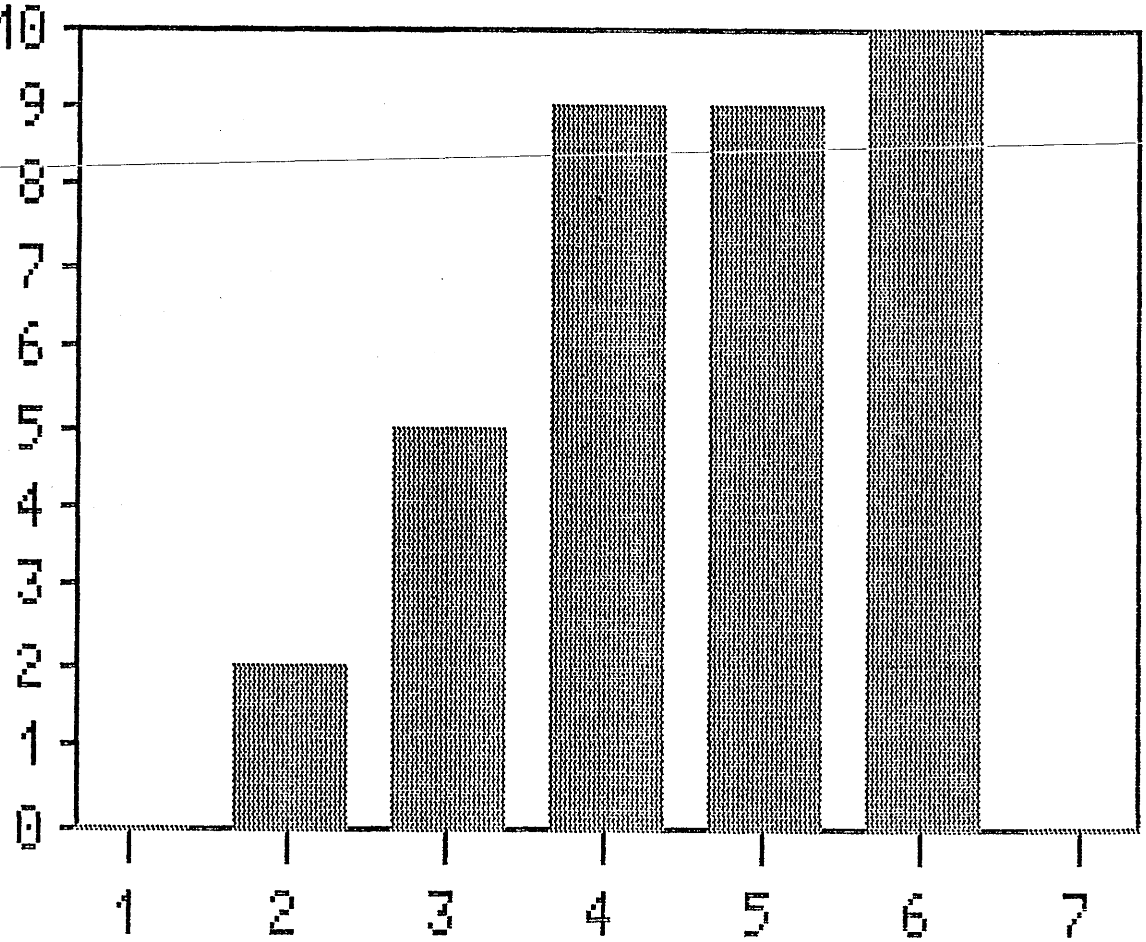
Diagram A9: Responses to Question 9



1 = very, 7 = not sucessful at all

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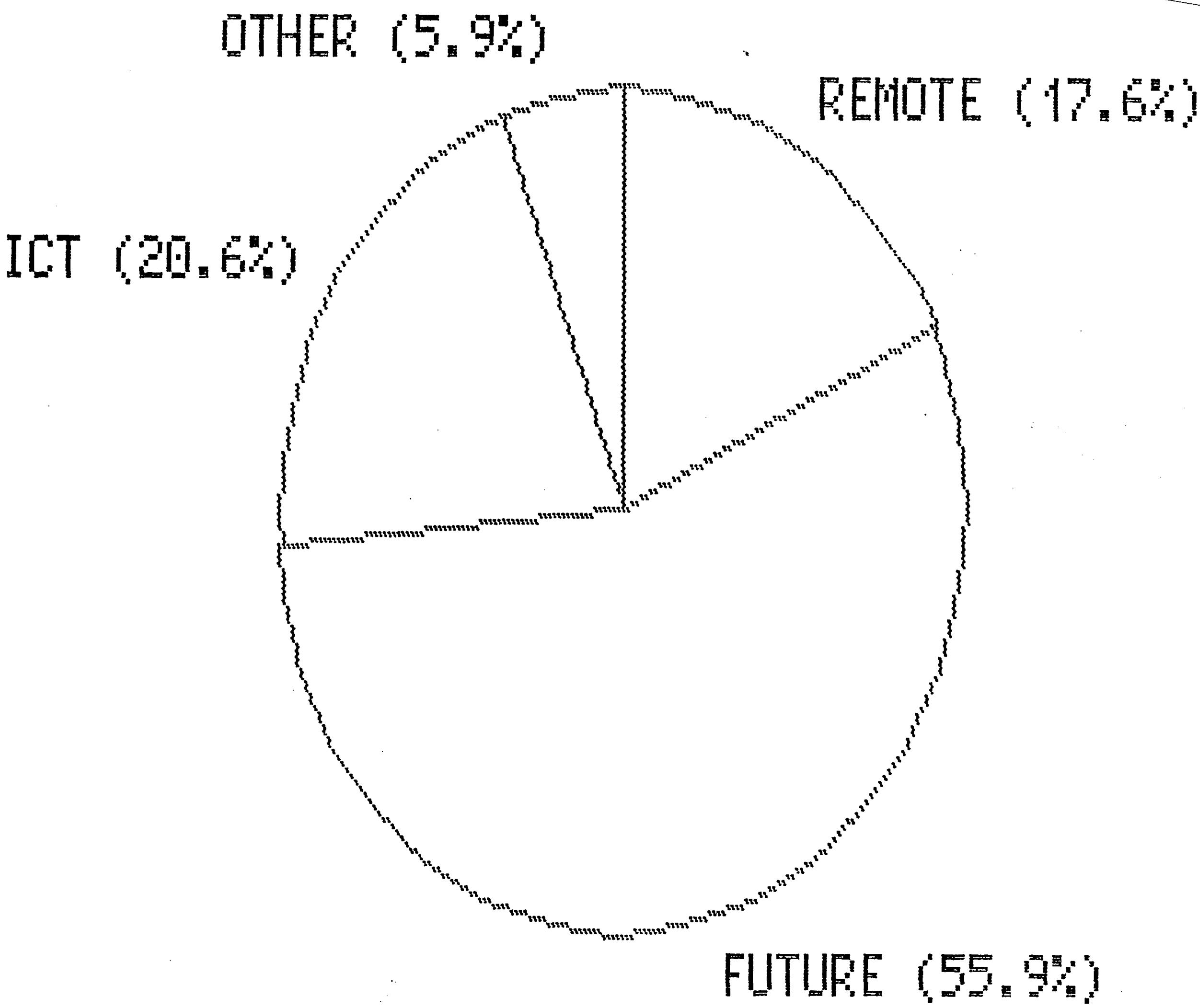
Diagram A10: Responses to Question 10



In addition of those who were involved in projects planned remotely (either from head office or another project site office) many (17% of all interviewed) felt that this an additional factor in the lack of success of the technique. This percentage ~~would be much higher (52%) if taken as a percentage of remotely~~ planned sites.

A.5 Other planning techniques.

The interviewer then asked about other, more sophisticated project planning techniques - other than those discussed in questions 7 to 10. The interviewee was asked about these alternatives, such as network planning and network planning by microcomputer and his opinions of them and in what circumstances these techniques were used.

This tended to indicate a relationship between certain types of project and an increased need for sophisticiation in project planning. In all 33 projects were referred to as being special, complex or large and on which had some more advanced technique had been used. This seemed to confirm the hypothesis that generally, advanced project planning techniques are used only where the project demanded.

Q11:In what kinds of projects are other, more spohisticated systems of planning used and what system is used?

As can be seen from diagram A11, 55% of the interviewees had been aware of the use of project planning techniques on projects that they classed as special. By this they indicated projects that were unusual for the firm in some way. 23% mentioned large projects and 14% mentioned complex projects. 1 mentioned an experiment that had been run within the company and 2 were not aware of any use of techniques that deviated from the norm.

Q12: In these cases mentioned above, who performed the planning role (Head office role/on site role/other)?

26 of the interviewees reported that these special techniques referred to above had been executed from head office, only 7 reported the use of such techniques from site.

This seemed to indicate that such special techniques were head office based generally and that in only a few cases were such techniques used on site.

Q13:Do you feel that these alternative techniques were successful? (1 : very successful, 7 = not successful at all)

The response to this question, on average, was neutral. The average was 3.2

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Diagram A11: Responses to Question 11

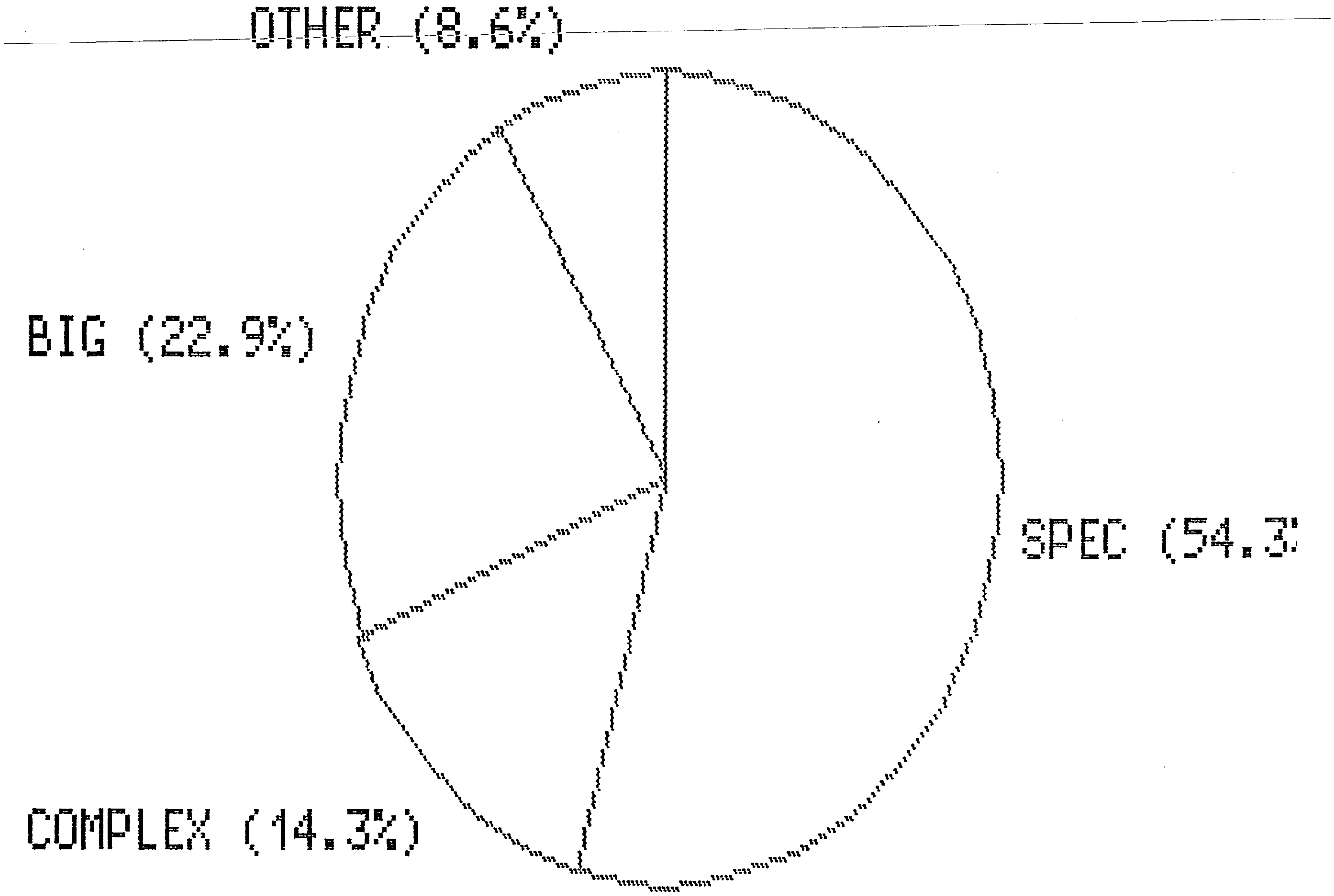

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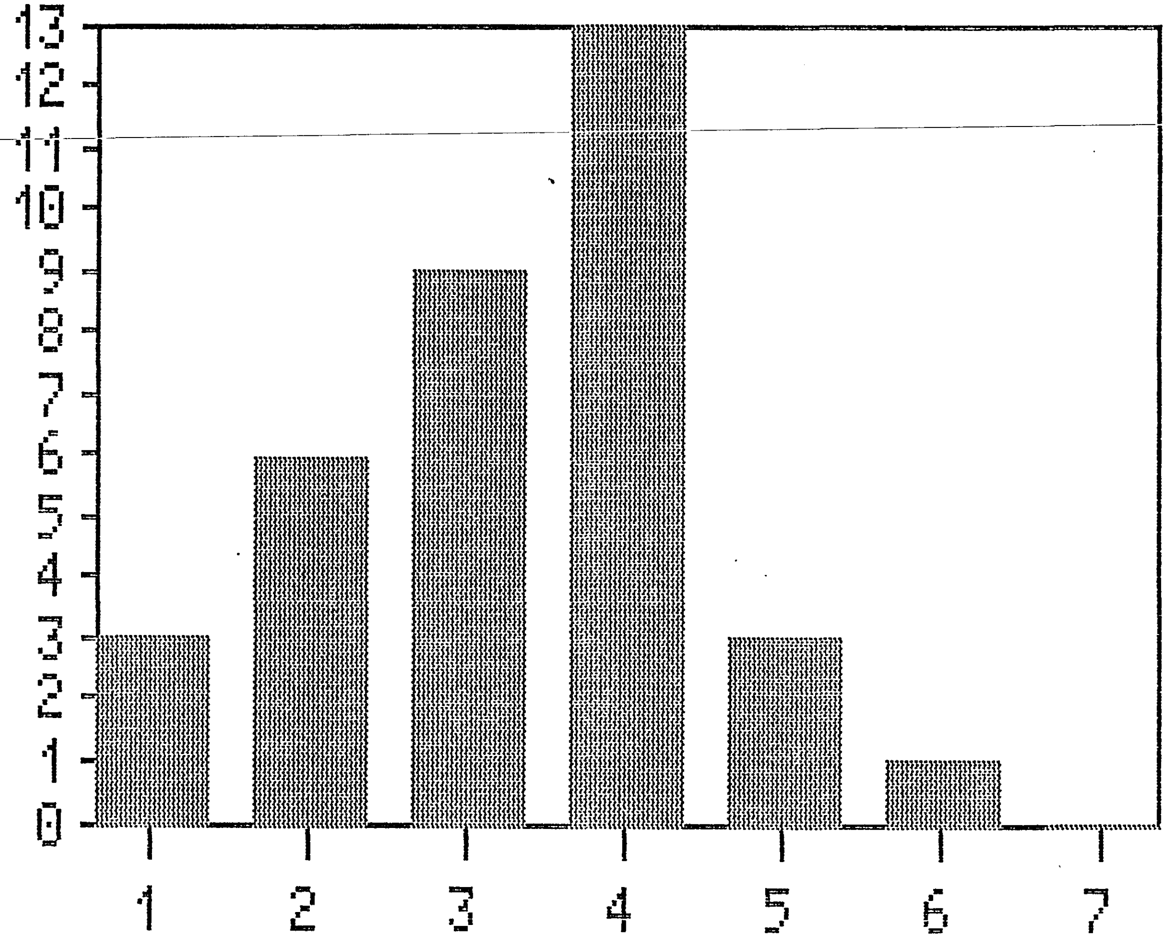
Diagram A13: Responses to Question 13



1 = very, 7 = not sucessful at all

There were a few strong views made in response to this question (see below) but the majority response was neutrality. The shape of the graph in diagram A13 tends to confirm this.

Q14:Why do you feel this is the case?

Of those involved in computerised project planning techniques the general view was that on certain projects this was a useful tool as it enabled the team to keep control of the large number of tasks involved in complex and large projects.

4 interviewees expressed quite strongly that these approaches were very unsuccessful because of the remote, over complex nature of the techniques.

The majority view (60%) was that the special projects that had used more advanced techniques needed to make use of such techniques and therefore the question of success was not relevant.

It was deduced that there was doubt about these more advanced techniques generally but it was thought there were situations where the problems caused by the difficulties of the techniques were outweighed by the special needs of large or complex projects. In no case was a resounding success reported.

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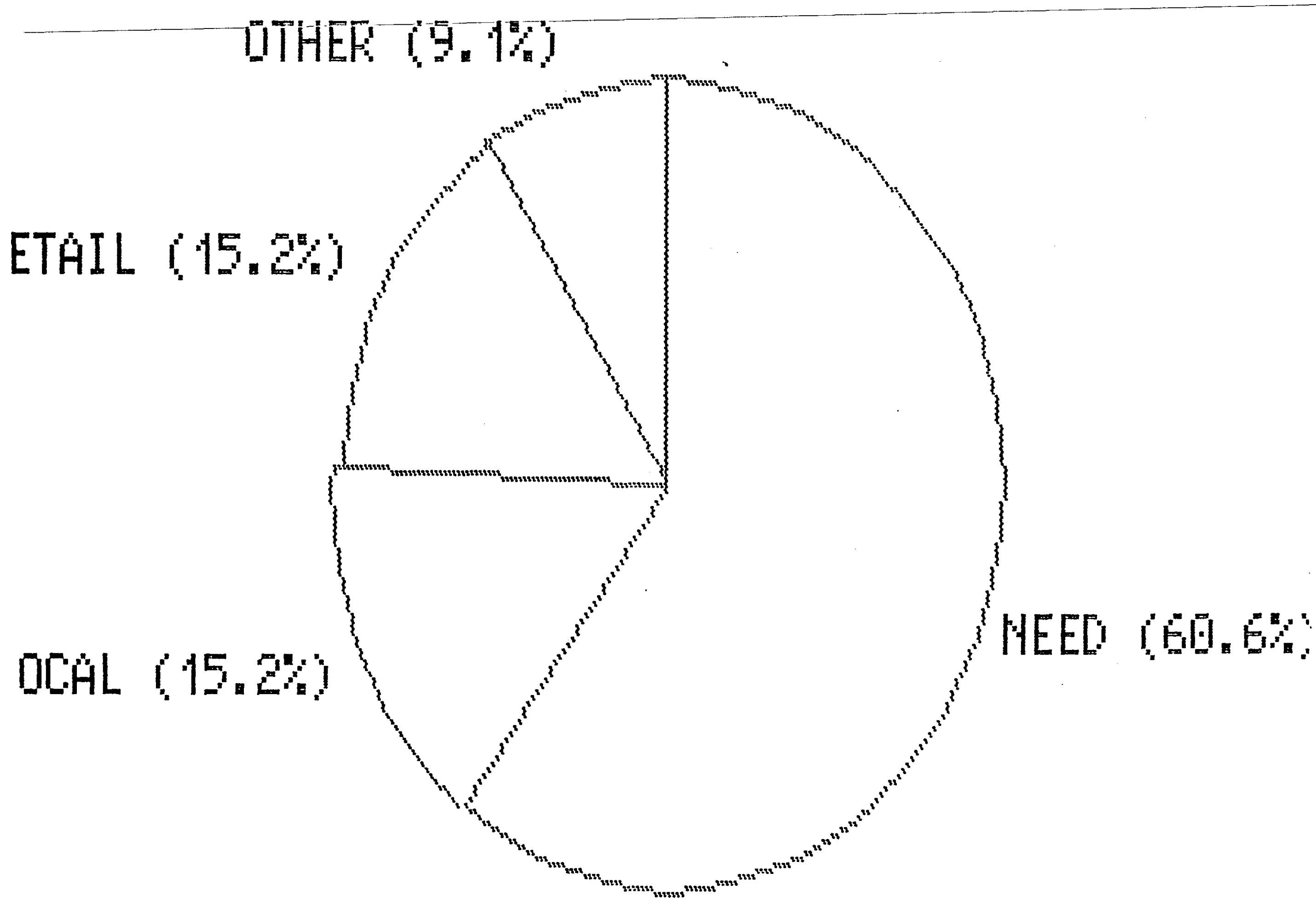
Diagram A14: Responses to Question 14



This tended to confirm the poor view held by managers of project planning techniques in general and of network planning in particular and there was evidence that remoteness and slowness were factors that aggrevated this attitude.

A.6 Project planning experiments

It was possible that a number of construction companies had experimented with some project planning techniques and the interviewer turned to discuss this topic. The questions attempted to discover what experiments had been run and how successful these had been.

Once again questions related to the location of the project planning role and the success of the technique.

Q15:Have there been experiments with computerised methods of project planning within the company?

Nearly all those interviewed had either been involved in or visited a project were computerised network analysis system had been tested. There were only 6 exceptions to this.

Q16:For what kinds of project were these experiments carried out?

Generally these experiments had been carried out on prestigious projects ie, those that were very large, for important clients or for some other reason under the scrutiny of the public or the construction industry. Prestige was seen as a reason not relating to a true desire, but a reason forced on the project team by outside influence.

In all cases a factor such as the prestigous nature of the project, the project's size or complexity had led the team to run some form of experiment with project planning.

Q17:Who performed the planning role?

With only 6 exceptions the role of planning by computerised network planning techniques had been executed as a head office function. In the two of the exceptions a remote terminal had been installed on site and utilised by a project planner based on the project. One of these exceptions was a very large project. In the other 4 exceptions the site had used a remote computer but entered data by data forms posted to the computer bureau. One had been carried out by a consultant project planner.

Q18:Do you feel that it was successful?

(1 = very successful, 7 = not successful at all)

Average = 5.5

Generally the technique was regarded as a failure and the technique had not been adopted for extended use within the company. In only two cases where computerised project planning techniques had been sufficiently successful, had the technique been later adopted for use on large scale projects.

The shape of the graph above shows clearly a weighting towards the "not successful" end of the scale.

Q19:Why do you feel this is the case?

The general view was that a computerised system offered no solutions to the problems associated with project planning. The general view was that the time taken to produce a plan was not noticably reduced and the management time involved was increased ("SLOW" 64%). The argument was proferred by the researcher that the plan could have been examined in greater detail but this was not seen as a advantage.

This tended again to confirm the view that project planning had a poor reputation and that newtork planning and main frame computers merley served to worsen this reutation.

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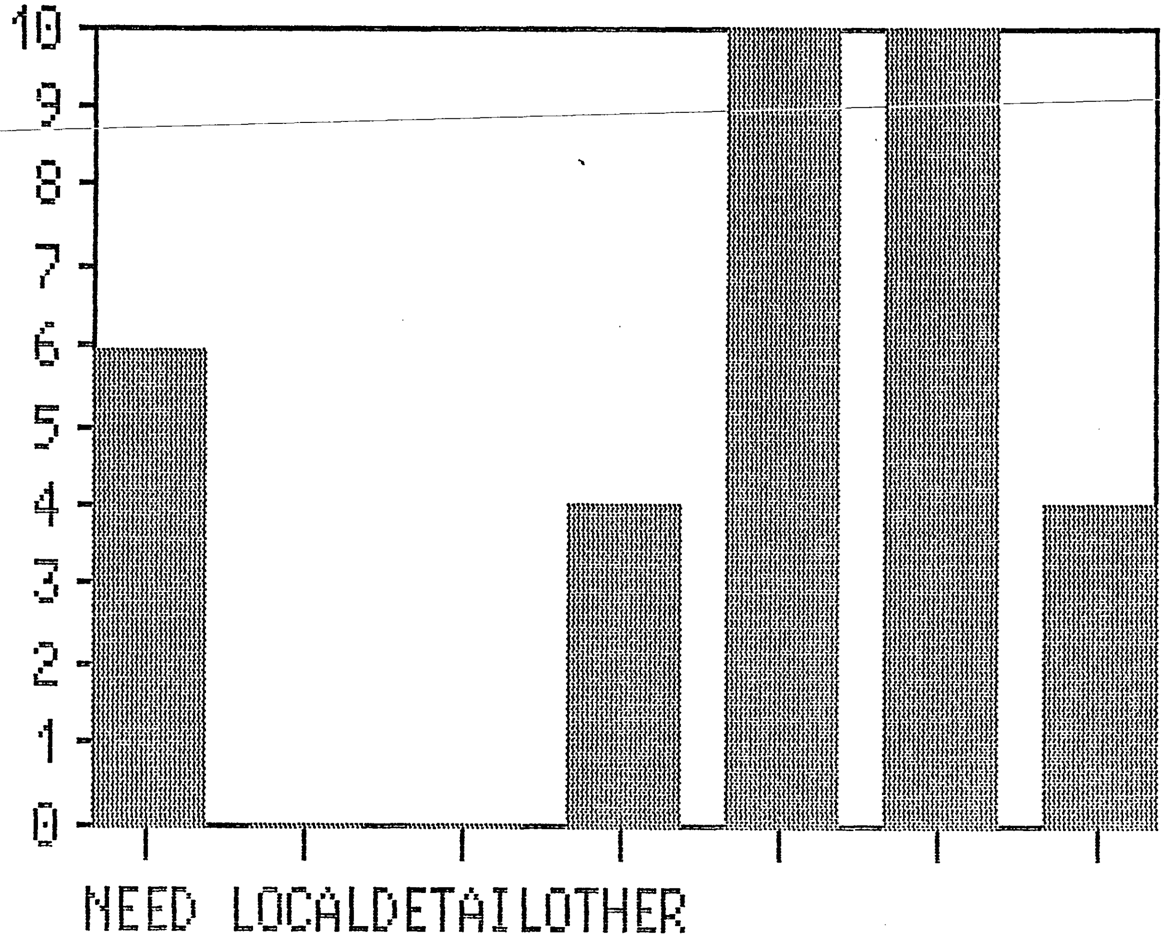
Diagram A18: Responses to Question 18



1 = very, 7 = not sucessful at all

The mere fact that network planning and computers were held in reserve by most firms and only used on the most difficult projects tended to confirm this view.

~~The views given for this~~ poor reputation had been repeatedly the remoteness and slowness of the technique. This tended to confirm the hypothesis that the technique might be perceived as more useful if it were faster and more convenient.

A.7 The company's experience with computerisation

At this point the interviewer asked a few points about the company's experience with a computer in no specific area of management and about the experience of the interviewee with computing.

Q20:Does the company own a computer?

30 of the companies interviewed had some form of computing facility in the organisation. This represented over 75% ofthe firms interviewed.

Q21:What is it used for?

All companies utilised their computer facility in company adminstrative matters (wages, accounts) or for general administrative matter. It was noted that the references to the computer by the site and management personnel were rather vague as if they had been aware of the computer within the organisation but were unaware of any direct dealings with it or its operation.

4 organisations had additional computing facilities involved in other areas such as estimating, only one had an 'in-house' project planning system.

Q22:Who uses it?

In the adminstration situations the users were given as the administration staff. In the other cases there were specialist computer operators within the company payroll.

Q23:Do you feel that the use of a computer in this environment was successful? (1 = very successful, 7 = not successfull at all)

Average response 2.1. The general view was that computers seemed to provide a useful facility in these areas. The shape of the graph in diagram A23 shows a satisfied response to this question.

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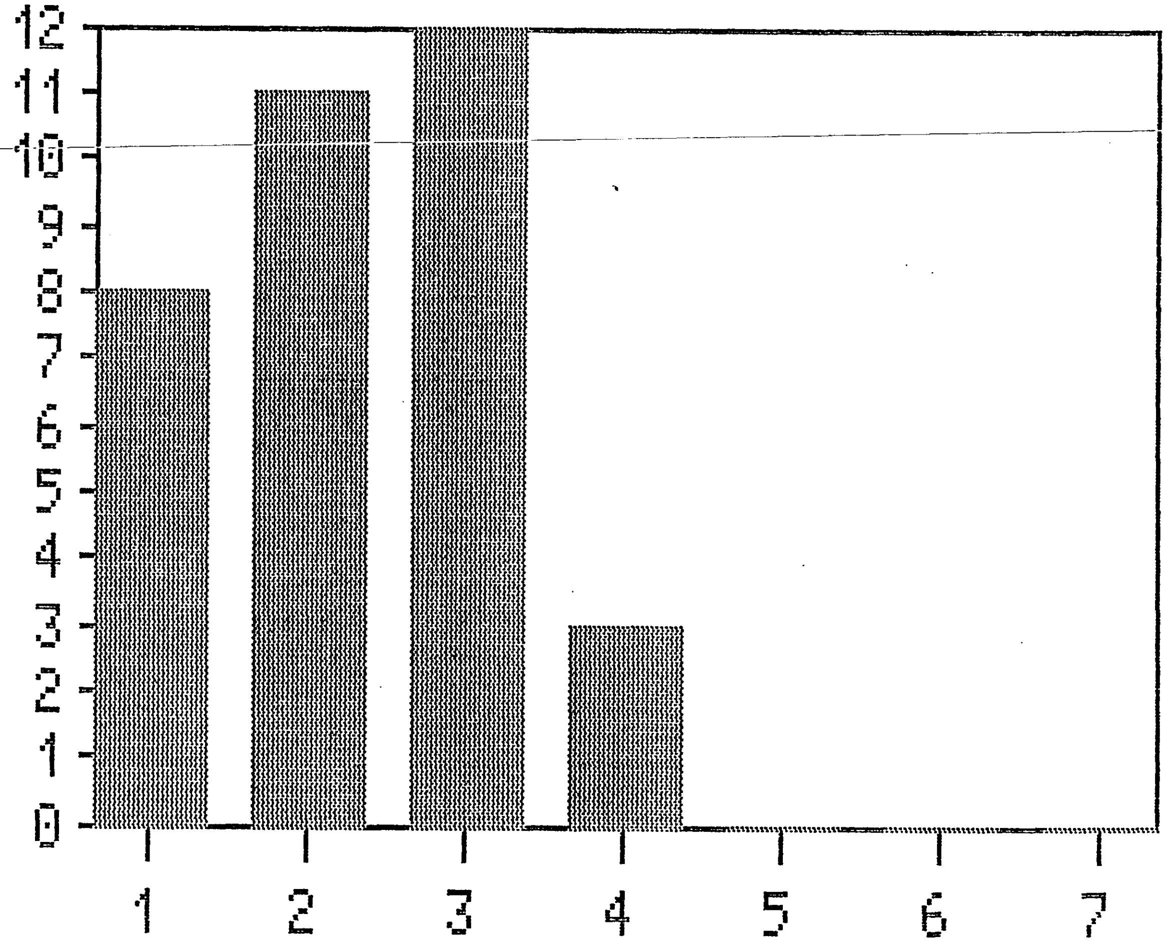
Diagram A23: Responses to Question 23



1 = very, 7 = not sucessful at all

Q24:Why do you feel this is the case?

It was stated that there seemed to be a 'fit' or 'suitability' in these data processing areas for computers. In these roles the interviewees expressed the view that the computer 'works'.

This tended to remove the possibility that the prime reason for the poor reputation for computerised project planning was due to the presence of a computer as the interviewees reported a computer performing a useful function in another role. It was therefore deduced that it was the use of the computer in project planning that was seen as inappropriate, not the computer itself.

Q25:Have you experience of a computer?

Of the 36 persons interviewed 31 had had some experience with a computer.

It was seen as valuable to deduce in what area this experience had been gained.

Q26:In what environment have you gained experience of a computer?

Of the 31 'experienced' computer users the breakdown was as follows:

26 had gained experience of a home computer. 8 had used a business computer at work. Some of the interviewees had gained more than one of these types of experience causing the total of these catagories to exceed the number of interviewees reporting experience with a computer. It was deduced that the sample of construction staff were, due to having some knowledge of computers, reasonable to form the basis of the remainder of the structured interview.

Q27:For what purpose did you use the computer?

The group of 31 answered as follows:

The 26 who had used a home computer had used it either for games or in an effort to gain a general appreciation of the computer. 11 managers had attended a computer appreciation course. 3 of the interviewees were, or had, made use of a computer in the role of project planning.

Q28:Do you feel that this use of a computer was successful? (1 = very successful , 7 = not successful at all)

The average response was 3.2 - slightly less useful than the median. The chart shows a slightly dissapointed response, but the response is very slightly less than neutral.

Q29:Why do you feel this is the case?

The games/appreciation group in general gave the view that the time they had spent experimenting with and playing games at home had been a useful experience. Some felt that some basic understanding had been gained.

2 felt that they had gained very little from the experience.

Those who had attended a computer appreciation course in general stated the view that a basic understanding of the capability of the microcomputer had been gained. Nearly all those who had worked on a regular basis on computers felt that there was a role to be played by computers in certain circumstances.

A.8 Experience with network planning techniques.

At this point the researcher opened the topic of network analysis by acertaining the interviewees experience with the technique. This was to establish the reliability of the interviewees reaction to later questions. Questions were also asked to discover the interviewees attitude to project planning by network analysis.

Q30:Are you familiar with the technique of network planning?

The interviewees were divided as follows:

Those who claimed at least some experience numbered 17. 16 stated that they had had some experience. 2 admitted to having very little experience of the techniques.

It was deduced that the sample was a reasonable sample in that there was an adequate knowledge of the technique within the the sample of managers to give reasonably reliable results.

Q31:In what environment have you seen network planning used?

Site planning = 23 - This group had witnessed planning for projects whilst being on a site even though the planning process had not been executed from the site.

A group of 11 had experienced head office planning (head office resident planning staff) and 1 had experience of tendering/precontract planning (use by head office/estimating department staff)

Q32:Who performed the network planning role ?

The majority had witnessed project planning as an head office role. There were 24 such interviewees. An on-site role had been experienced by 6 and 5 had seen network planing in use on another project.

Whilst the interviewees had been located in a variety of ways (on site, in head office) when they encountered network planning they were working or at least visiting a company head office environment.

This was further evidence that this group were likely to be capable of answering intelligently and with sufficient experience questions on the topics to be discussed.

Q33:Do you feel that network planning was successful? (1 = very successful, 7 = not successful at all)

The average was 3.6 - not very successful.

This tended to confirm the hypothesis that the general attitude to network planning within the construction industry was poor. Again the graph in diagram A33 shows this tendancy more clearly.

Q34:Why do you feel this is the case?

The general feeling was that there were some distinct problems with the successful application of project planning by network analysis. In the construction industry, it was stated, the project was too unpredictable due to the weather and the 'one - off' nature of the work undertaken. It was not sensible to use a sophisticated technique to make detailed predictions about a construction project. Additionally the technique was seen as being too slow to be of use. In these terms the interviewees refered to the amount of actual time and management time involved in network planning techniques.

Finally the view was that it was a technique executed by remote specialists who were not involved in the project. Some saw the technique as being too complex a solution to the problem of planning projects.

In those cases where the technique of network planning had been relatively sucessful the reasons given included a reference to the quick and local benefits of network planning being executed on site or close to the management of the project. One interviewee attributed the relative success of network planning to the individual planner responsible for executing the role.

This tended to indicate that there were situations where network planning was successful but that these situations were few and far between.

A.9 Project planning by microcomputer

At this point the interviewer outlined the possibility of project planning by network analysis on a microcomputer.

The technique was described in outline with the degree of detail varying according to the interviewees knowledge of computers and project planning by network analysis. The possible benefits were not described but a factual account of such a system was given. The questions that follow ask the interviewee to consider the positioning of such a machine and therefore the project planning role.

Q35:Who would use a project planning system on a microcomputer?

The views given were classified as shown:

Of the interviewees the most popular view was that the planner would use a project planning system by microcomputer with 26 giving this view. A group of 6 felt that a project manager would use the system.

Generally, it was deduced, the interviewed sample felt that if a microcomputer was utilised it would be necessary to have a planner on the project. The majority that felt that this was the case outnumbered the number who were planners.

A10 The need for a functional specification for a software package

It had been seen as a part of the research project to evaluate the need and form of a suitable microcomputer based network planning system.

Therfore this part of the structured interviews was designed to gain views on a functional specification of a microcomputer based project planning package.

Features, in terms of inputs and outputs, were described to the interviewee and his views on the relative importance gained.

The interviewer raised and explained where neccessary a particluar feature and asked the interviewee to rate the feature in importance.

The interviewer described briefly the microcomputer based system and then the interviewer asked "What features would it have - Can you rank the degree of importance of each of these elements on a scale where 1= very useful, and 7 = not useful at all ? "

A11 A functional specification for a project planning package

The questions were firstly concerned with the network planning basis of the system:

Q36:Would a project planning system on a microcomputer be useful? (1 =very useful, 7 = not useful at all)

The average response was 3.5 - this average is exactly mid point on the scale. The view felt by the interviewer can be summarised as cautious interest. The graph in diagram A36 above shows a neutral response.

Q37:Precedence networks (1 = useful, 7 = not useful at all)

The graph above and responses show that the majority view did not feel precedence networks were useful. For this reason precedence network capabilities were not included in the model programme.

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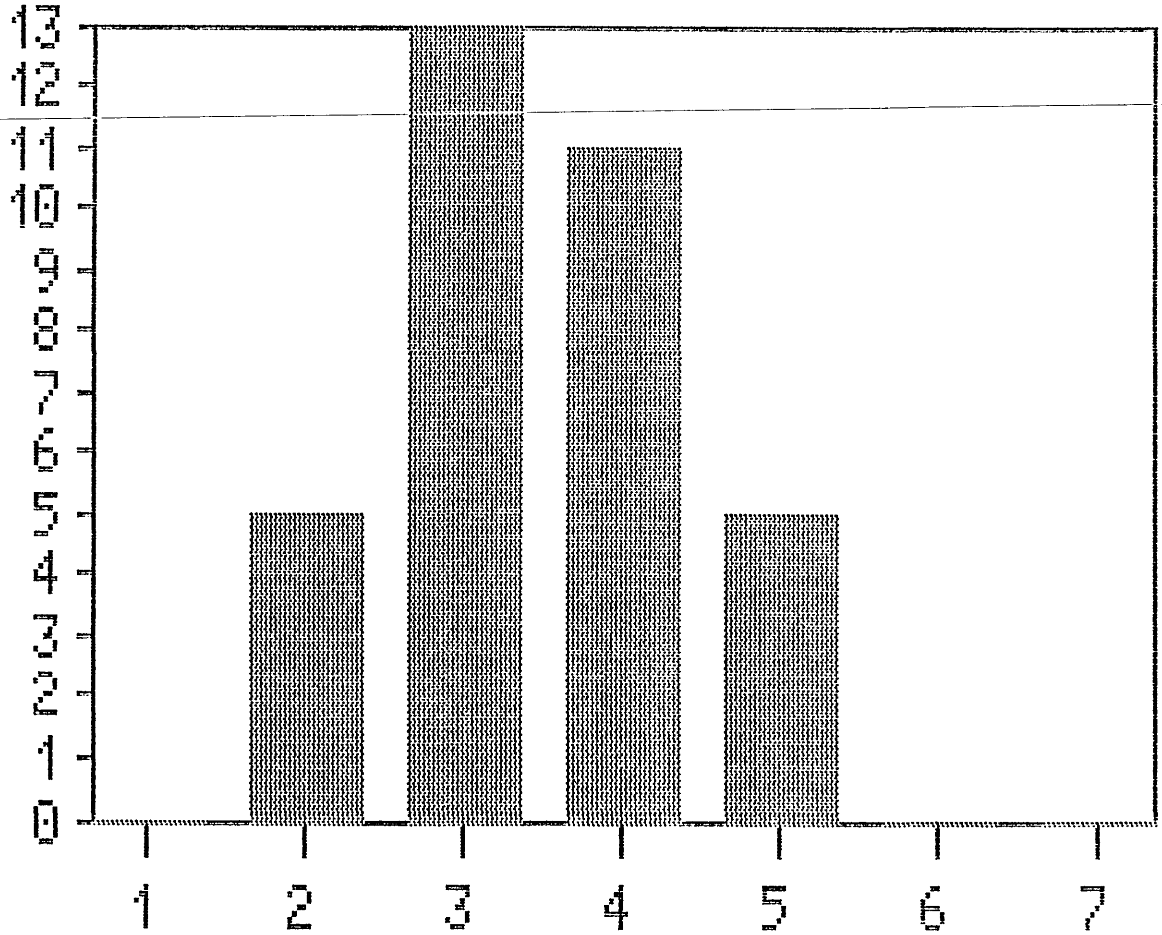
Diagram A36: Responses to Question 36



1 = very, 7 = not sucessful at all

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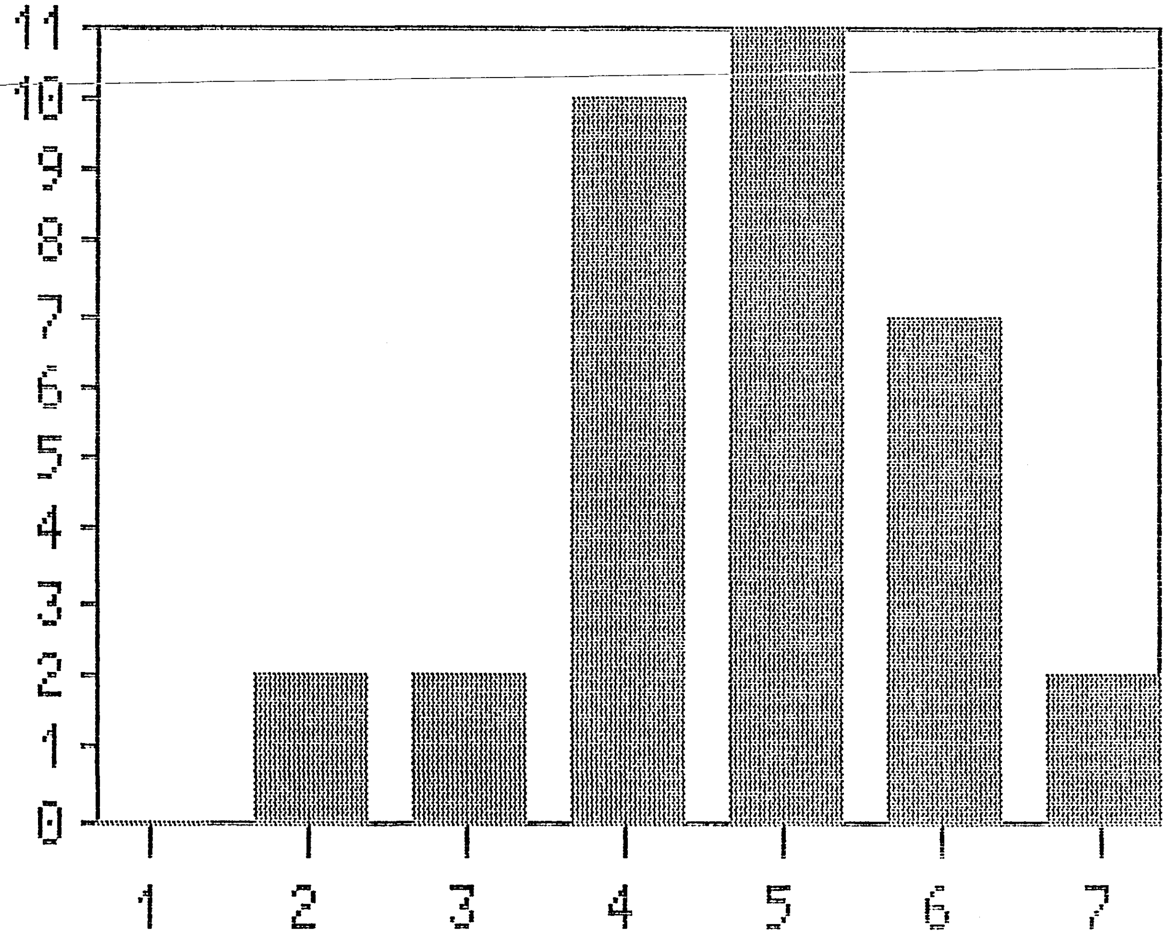
Diagram A37: Responses to Question 37



1 = very, 7 = not sucessful at all

Q38:Activity on arrows (1 = useful, 7 = not useful at all)

A strong majority wished for activity on arrow networks and therefore the model programme was built around this technique. The graph shows a heavy preference for activity on arrow plans.

Q39:How many activities per network would you need? (numeric)

Nearly half (47%) of the interviewees felt that 500 activities would be adequate for an on site microcomputer based project planning system. Some 30% wished to have the ability to plan up to 1000 activities and 22% wished for 1500. The target was set generously at 1500 activities thereby exceeded the majority wish comfortably.

Q40:How long would you like the activity descriptions to be? (number of characters)

The wishes stated varied from 20 characters to 100 with an average of 46. The specification called for 40 characters satisfying over half of the interviewees. Practical problems prevented a larger display at the time. In an attempt to overcome this deficiency an activity coding system was designed.

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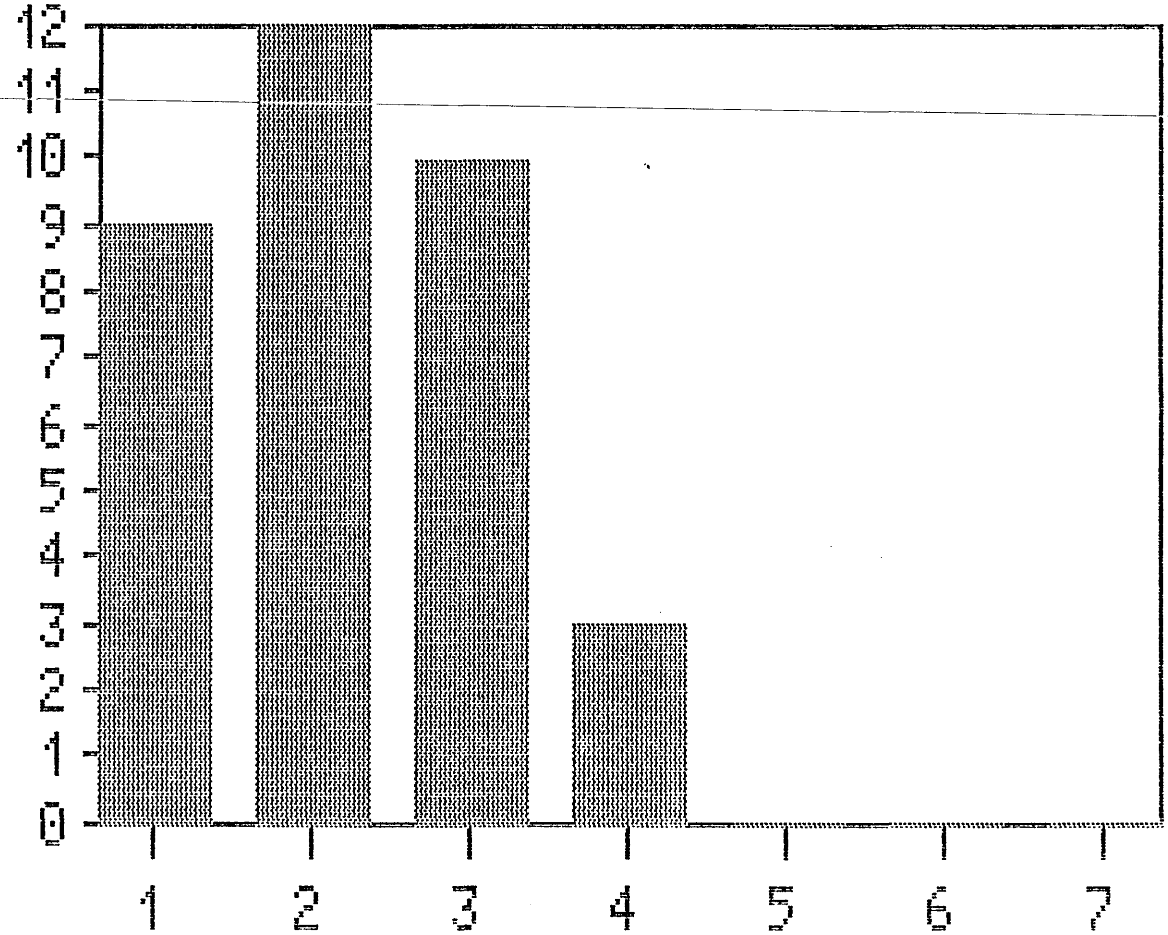
Diagram A38: Responses to Question 38



1 = very, 7 = not sucessful at all

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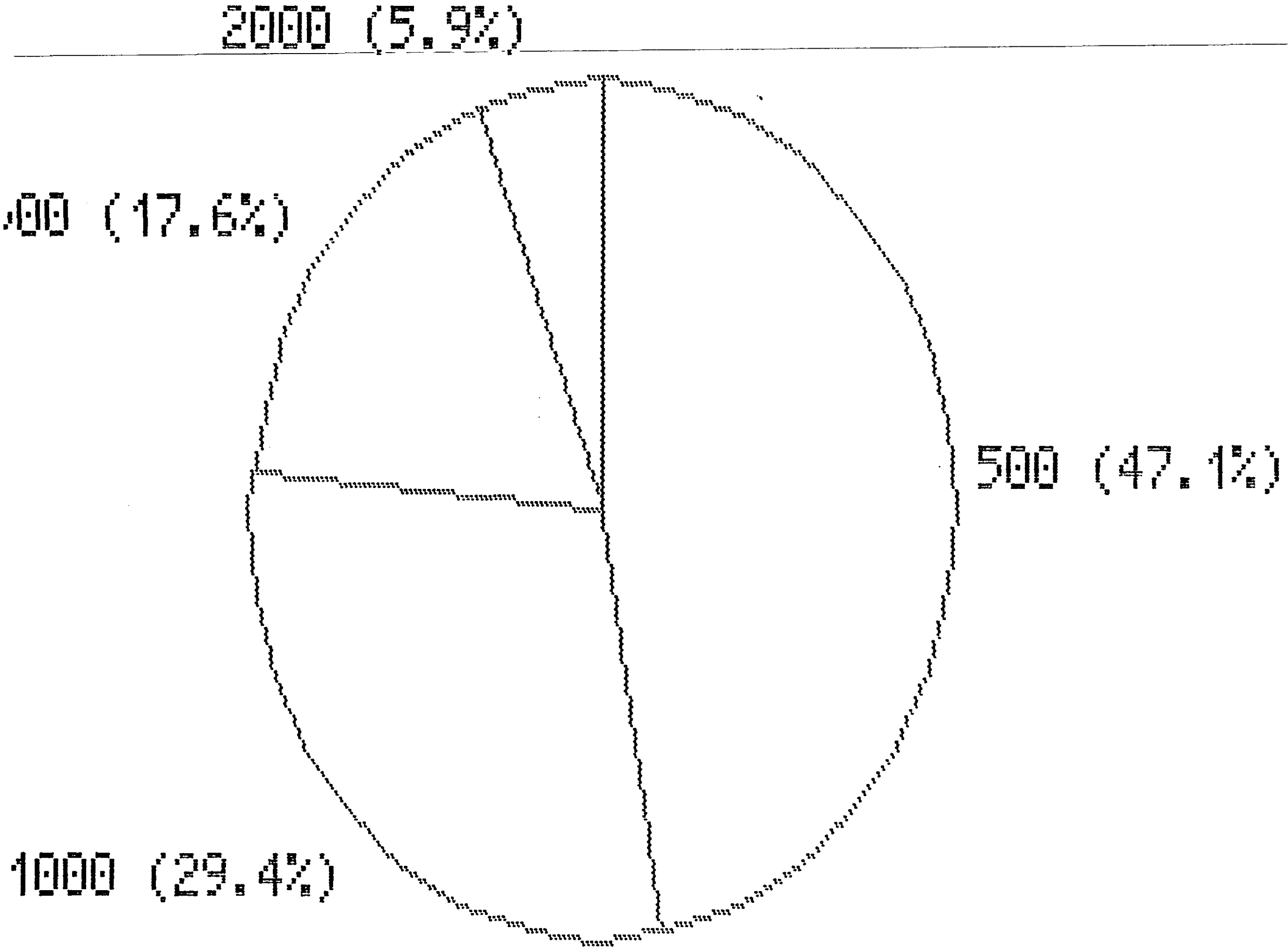
Diagram A39: Responses to Question 39



Next, questions relating to report generation were put.

As a result of the view that one of the failings of project planning was in its inability to keep pace with the needs of the site management team the interviewer asked a few questions about the speed of updating and the interviewees attitude to updating a project plan on a microcomputer:

Q41:The ability to produce small short term barcharts?

(1 = useful, 7 = not useful at all)

The strongest response in the interviews here showed a very strong desire for short term barcharts. This need became a key element in the model program.

Q42:The ability to produce large project barcharts?

(1 = useful, 7 = not useful at all)

The need for a project barchart was not so strong as that for short term bacharts. Hence in the model program this was not treated as a such a high priority. Nevertheless the slighlty better that neutral response made this a desirable feature of such a system.

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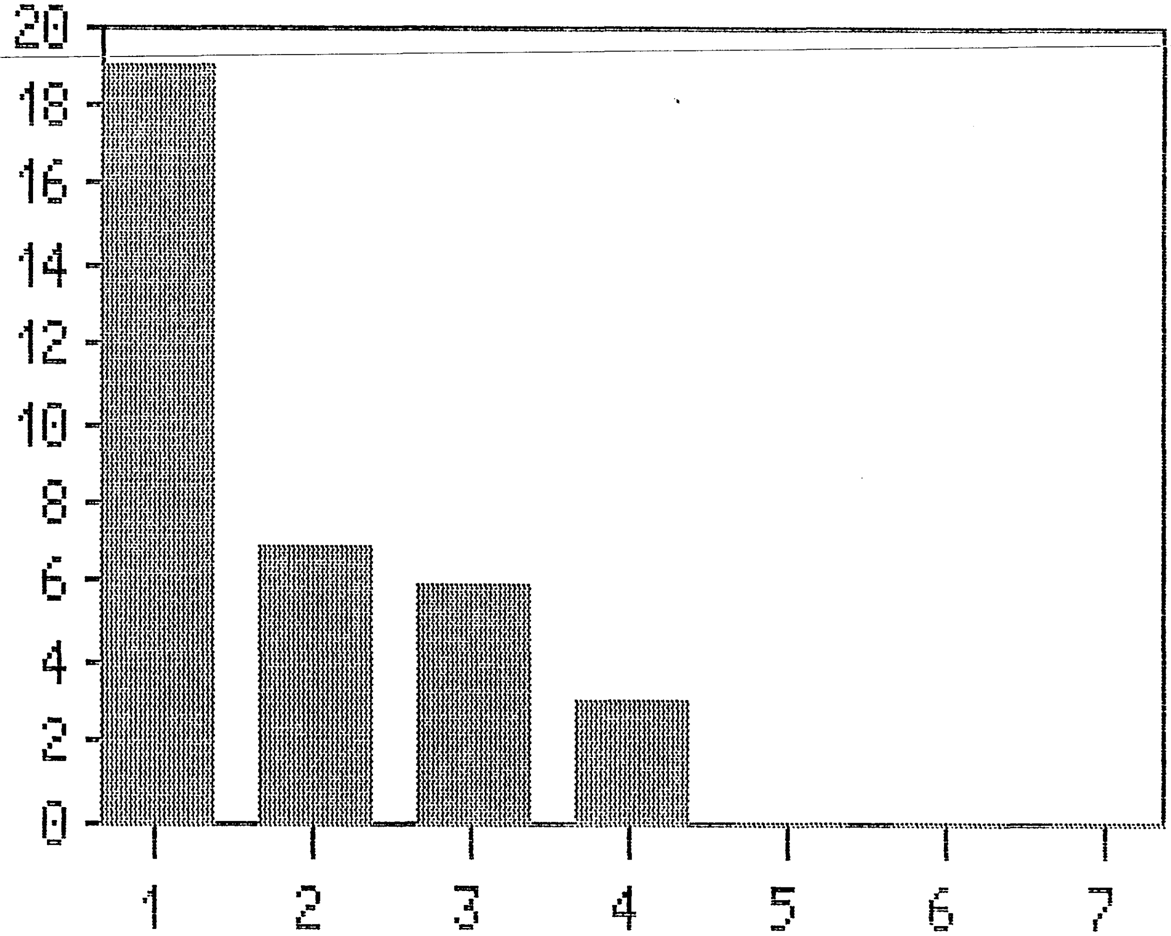
Diagram A41: Responses to Question 41



1 = very, 7 = not sucessful at all

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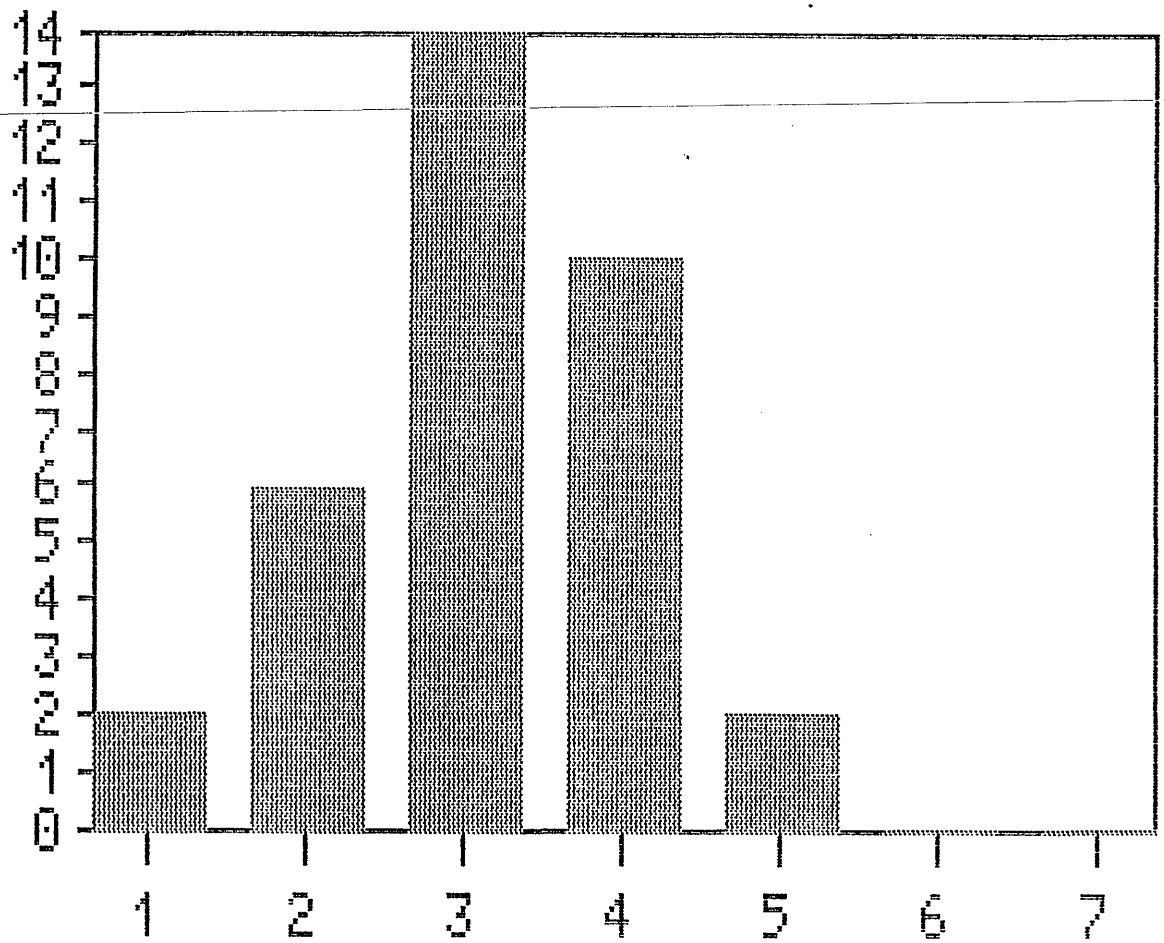
Diagram A42: Responses to Question 42



1 = very, 7 = not sucessful at all

Q43:The ability to produce network drawings?

(1 = useful, 7 = not useful at all)

Generally this was considered as desirable although only a weak preference was seen. The average response was 3.5 - neutral. Due to the addition of the practical problems of creating a network diagram by computer this feature was not included in the specification for a model package.

Then questions relating to convenience were asked:

Q44:Should the system be fast ?

(1 = useful, 7 = not useful at all)

A quite strong response demanding speed was noted. The average reponse (2.5) and the shape of the graph in diagram A44 showed that speed was important. Therefore speed was emphasised in the specification for the model program.

Q45:Should the system be easy to use?

(1 = useful, 7 = not useful at all)

Again a very strong response that the system should be simple was noted. All though it was very difficult to define this the specification called for a simple package in operation and much effort was deveoted to achieving this. Ease of use was seen as a subjective measure and therefore difficult to quantify.

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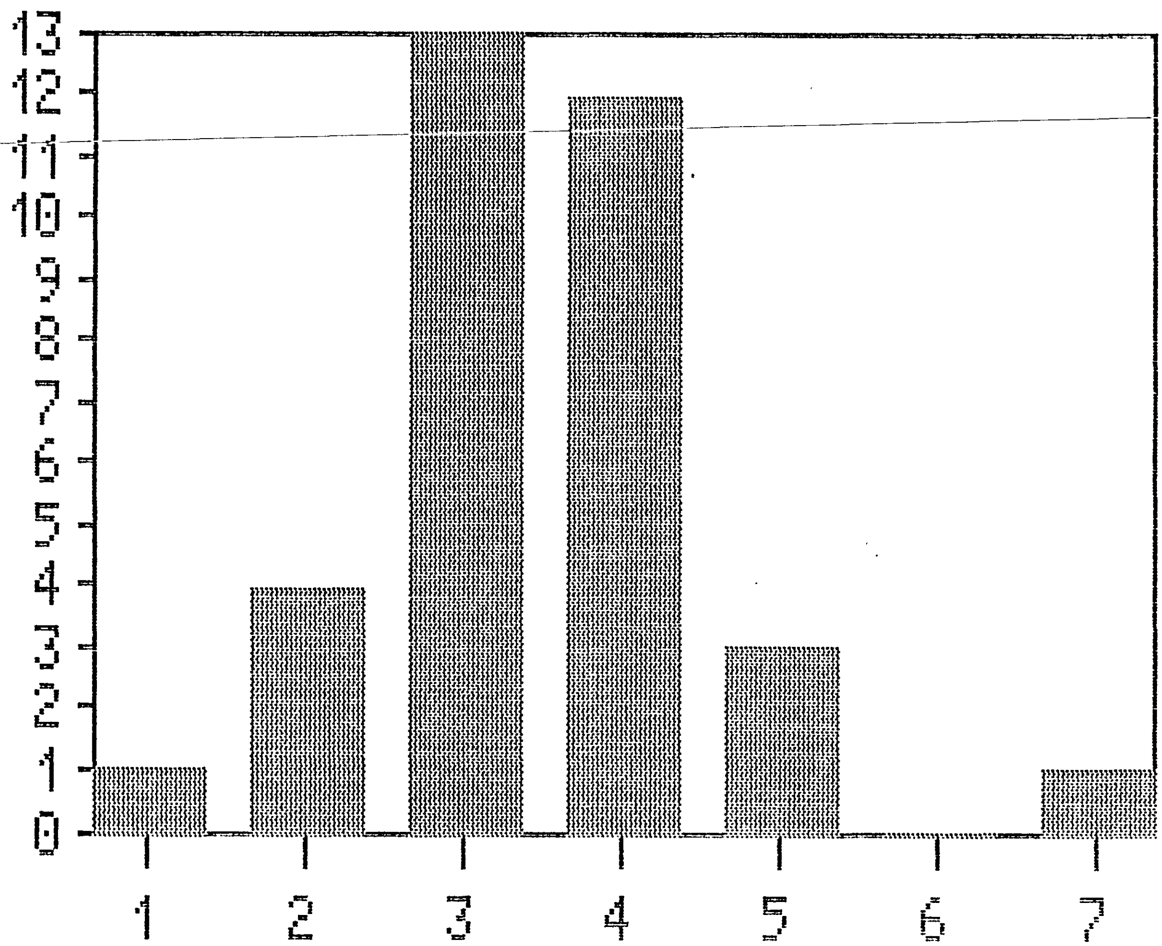
Diagram A43: Responses to Question 43



1 = very, 7 = not useful at all

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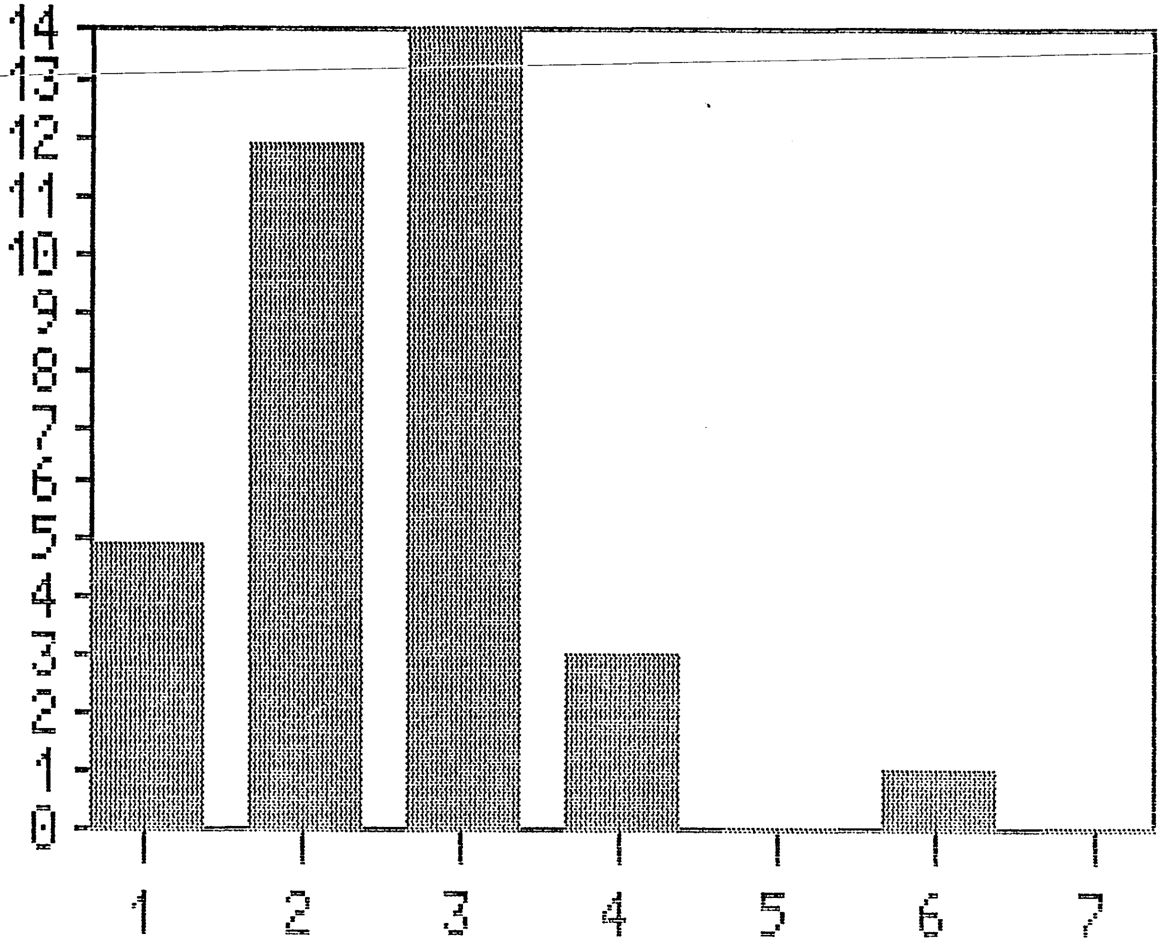
Diagram A44: Responses to Question 44



1 = very, 7 = not useful at all

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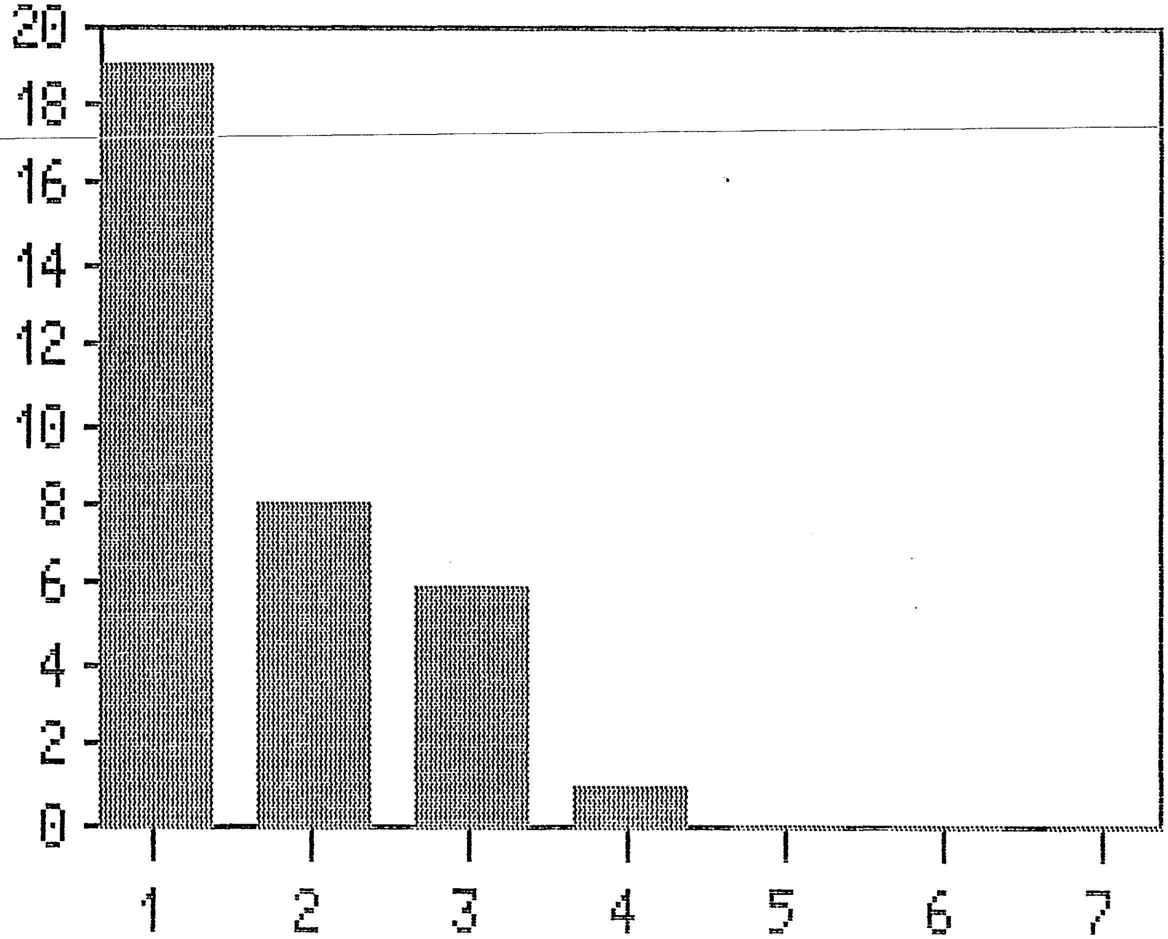
Diagram A45: Responses to Question 45



1 = very, 7 = not useful at all

Q46:Would you go on a two day training course to learn to use the system? (1 = definitely, 7 = not likely at all)

A fairly neutral response to this question was noted. The avergae (3.7) and the shape of the graph in diagram A46 show this neutrality. The question was asked to gauge the potential users expectations from such a system. It was deduced that such a system should not need a great deal of training.

Resource tracking was investigated by the following questions;

Q47:Would you require resource tracking ? (ability to allocate resources, get histograms ? (1 = useful, 7 = not useful at all)

The responses here indicated a preference for resource tracking so that an at least elementary resource tracking facility was seen as useful. At the time practical problems made this objective unrealistic and resource traking was not tested during the project.

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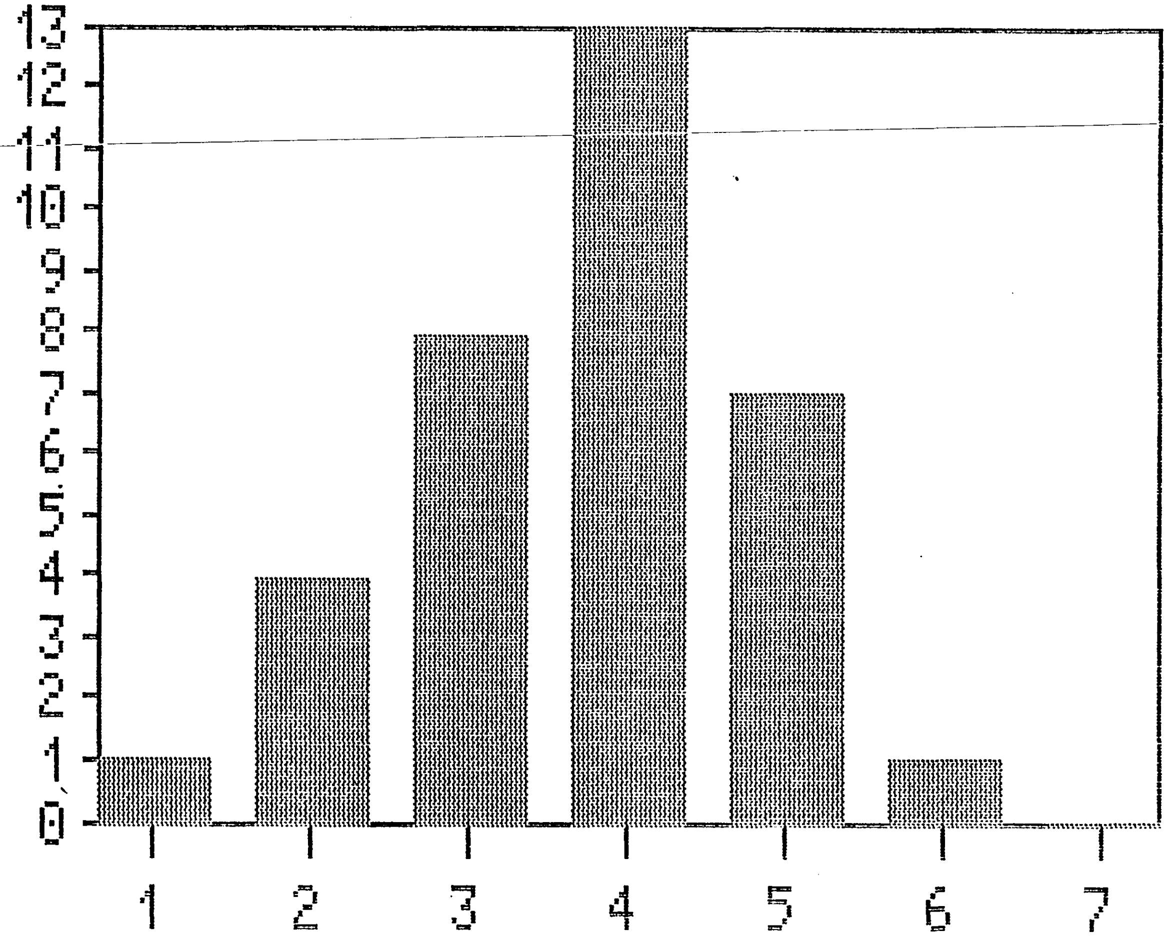
Diagram A46: Responses to Question 46



1 = very, 7 = not useful at all

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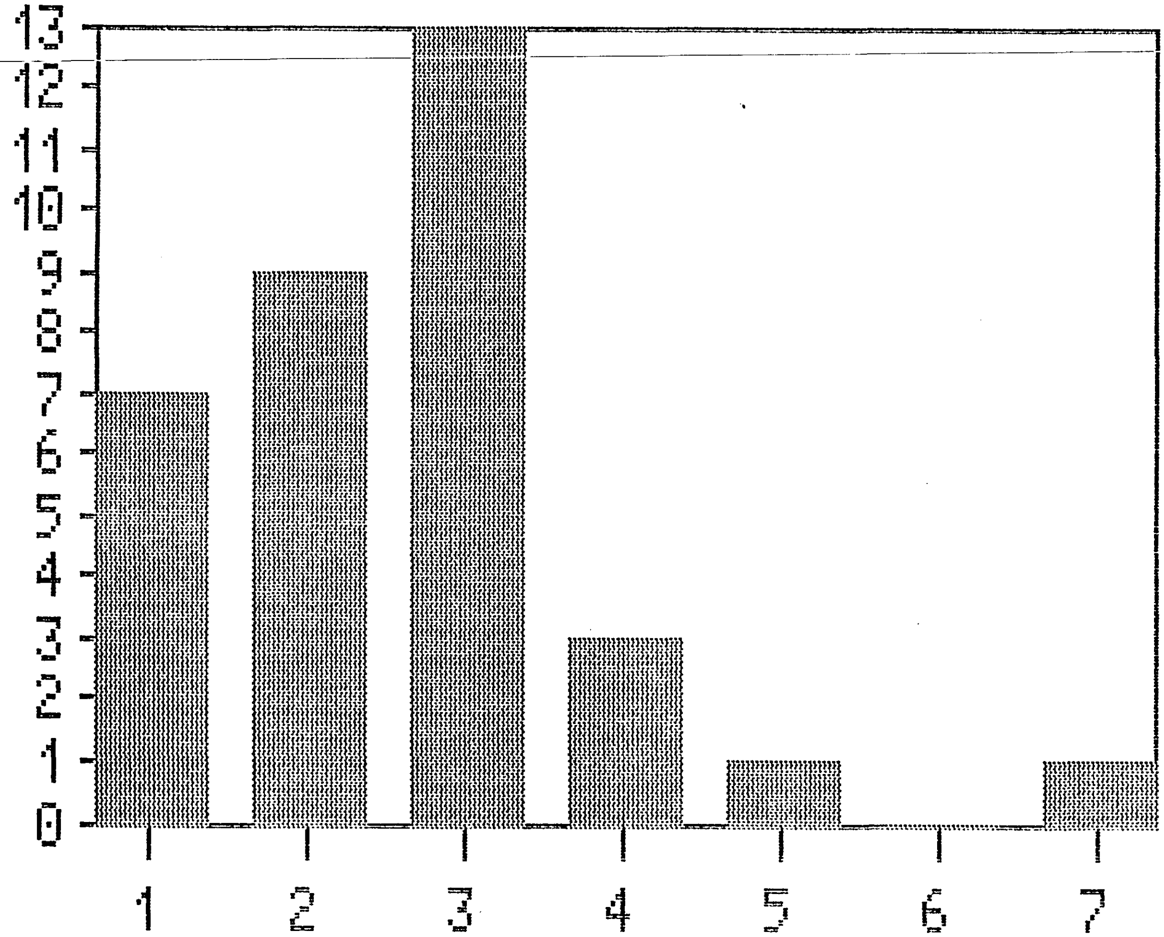
Diagram A47: Responses to Question 47



1 = very, 7 = not useful at all

Q48:Would you require resource smoothing ? (the ability to rationalise or level the resource demand (1 = useful, 7 = not useful at all)

A neutral response to this question was noted, The average of 3.7 and the shape of the graph in diagram A48 confirmed this. Again to to practical restraints it was not possible to test resource levelling facilities within the project.

Q49 - Cost

This question related to the likely cost that a project management team would expect to pay for a microcomputer based project planning package.

During the period of the research and post research analysis and writing stages, the costs of microcomputers and software have fallen so much so that this question ceased to have any useful relevance. Its outcome therefore forms no part of the research project.

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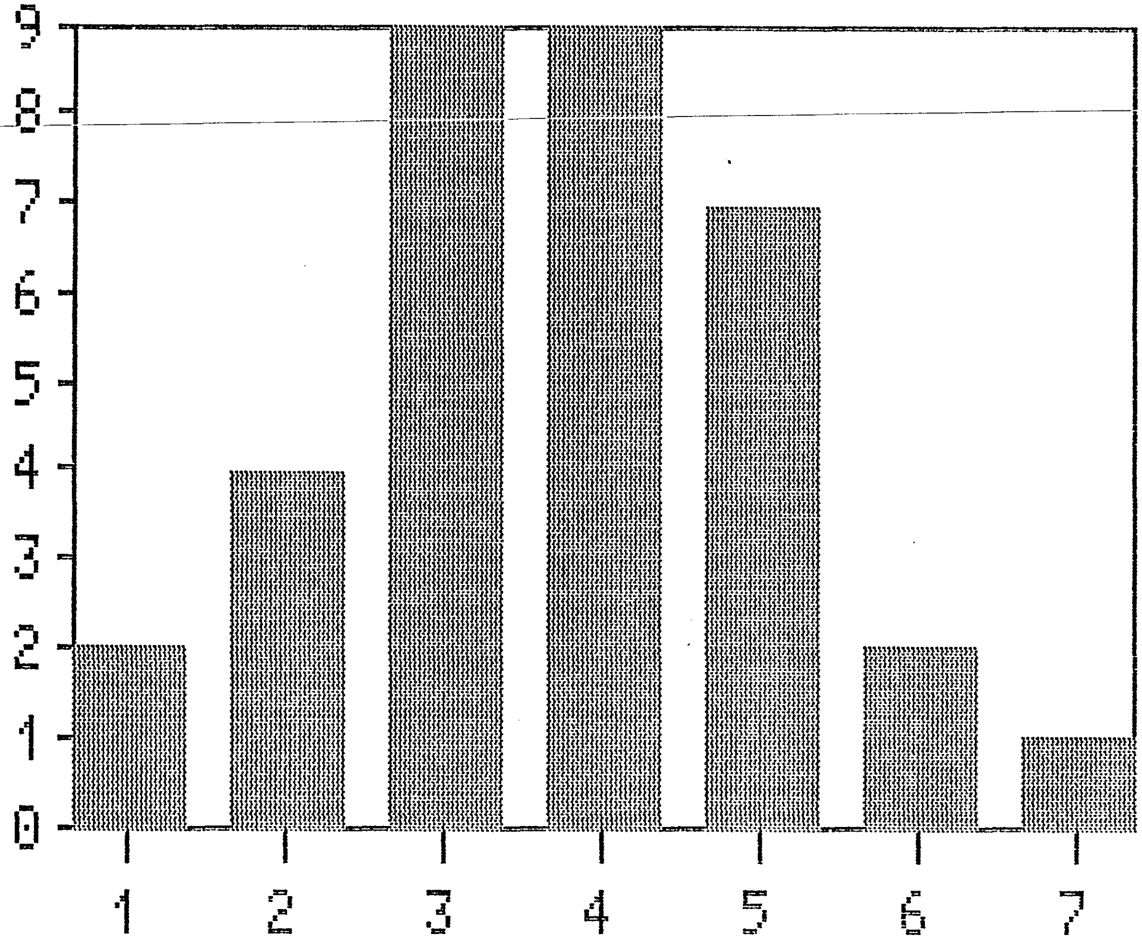
Diagram A48: Responses to Question 48



1 = very, 7 = not useful at all

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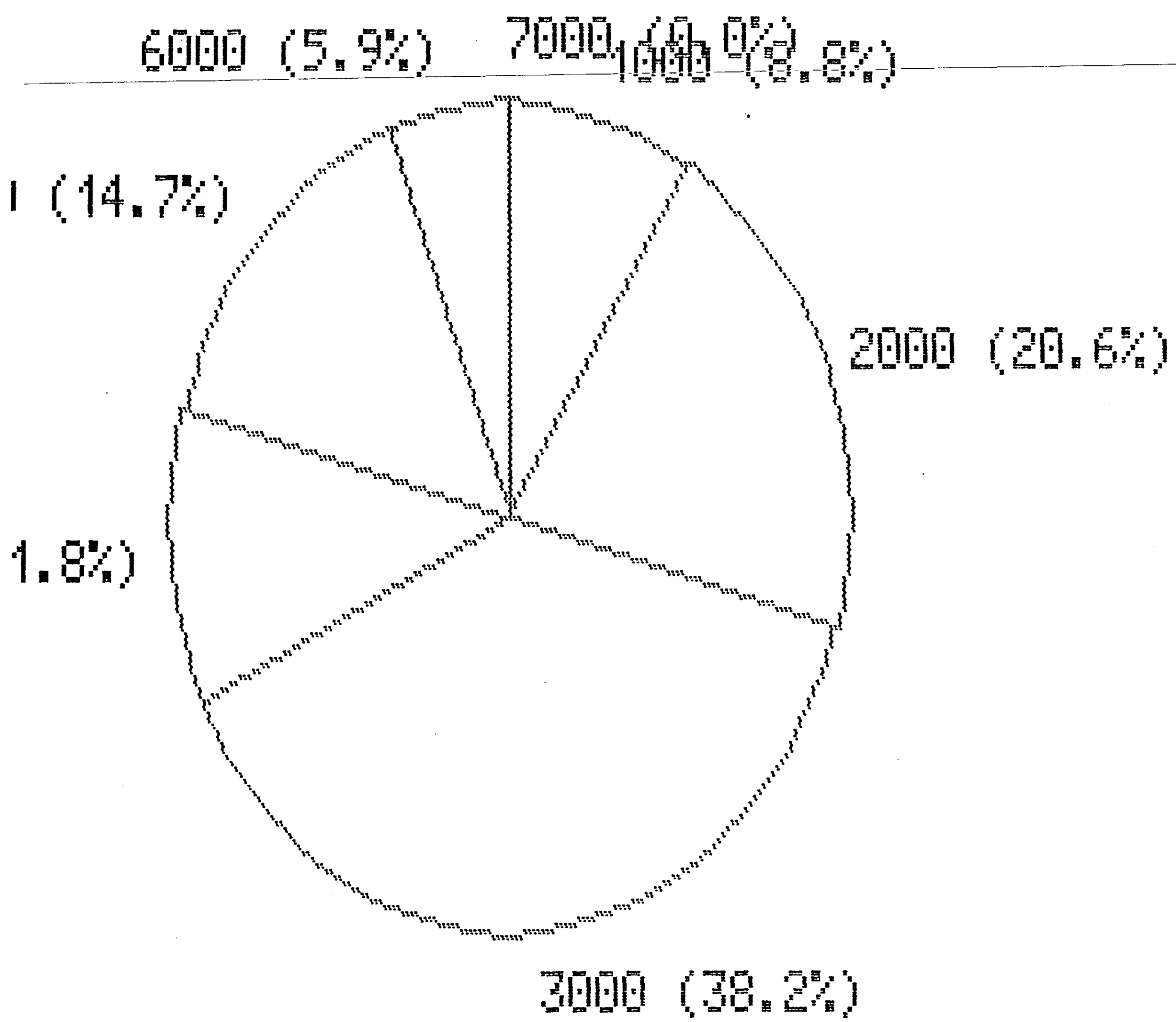
Diagram A49: Responses to Question 49



Q50 Would the use of days as the time unit be adequate or would you wish to use another unit ? (shifts/weeks/hours) (1 = useful, 7 = not useful at all)

The general view here was that sub day time units were not essential and this feature was therefore excluded from the specification of the test program. The average response (4.6) and the shape of the graph in diagram A49 above confirmed this view.

Q51: Would you need to be able to plan different projects against different working weeks and different holidays? (1 = useful, 7 = not useful at all)

As with the previous question and for the same reasons this feature was not included in the model program. The average response (4.5) and the shape of the graph In Diagram A50 seemed to indicate that this was not required.

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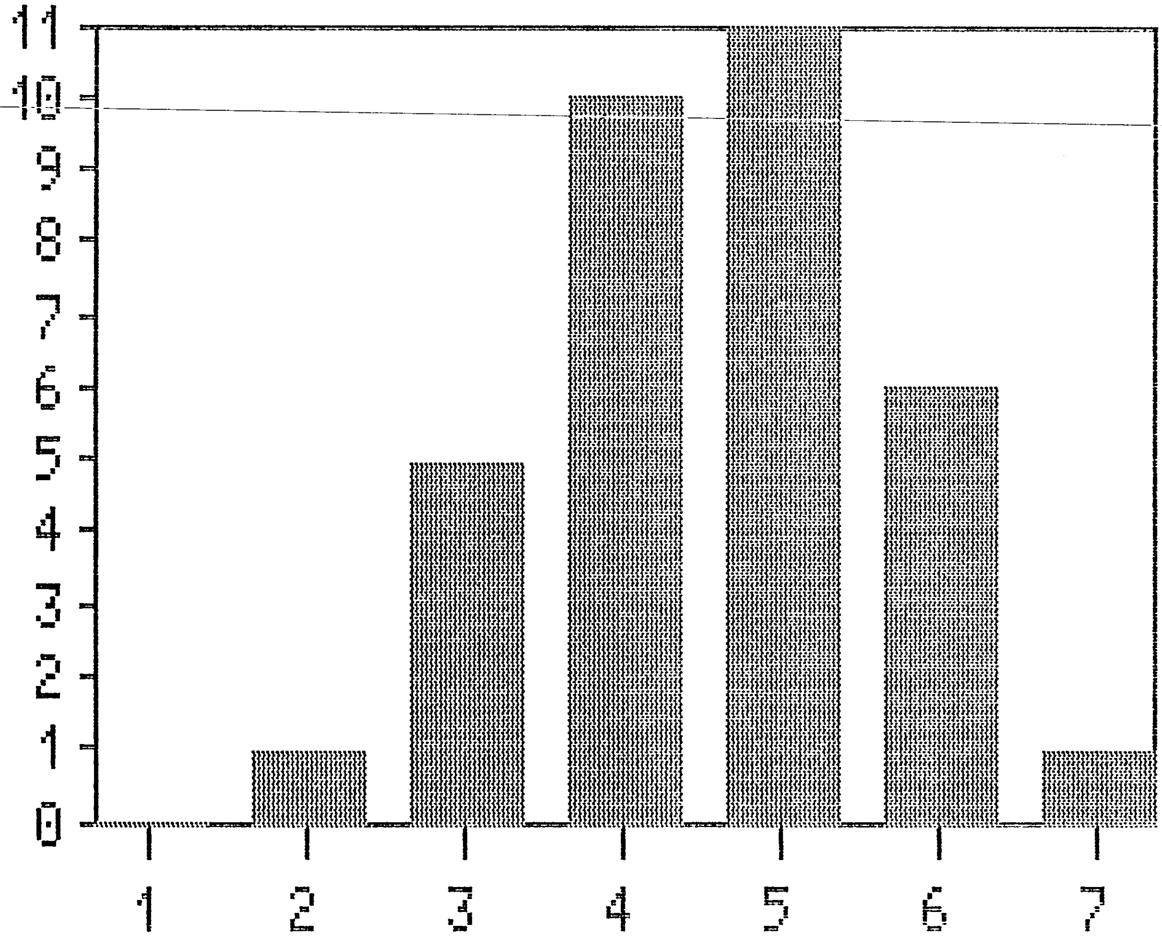
Diagram A50: Responses to Question 50



1 = very, 7 = not useful at all

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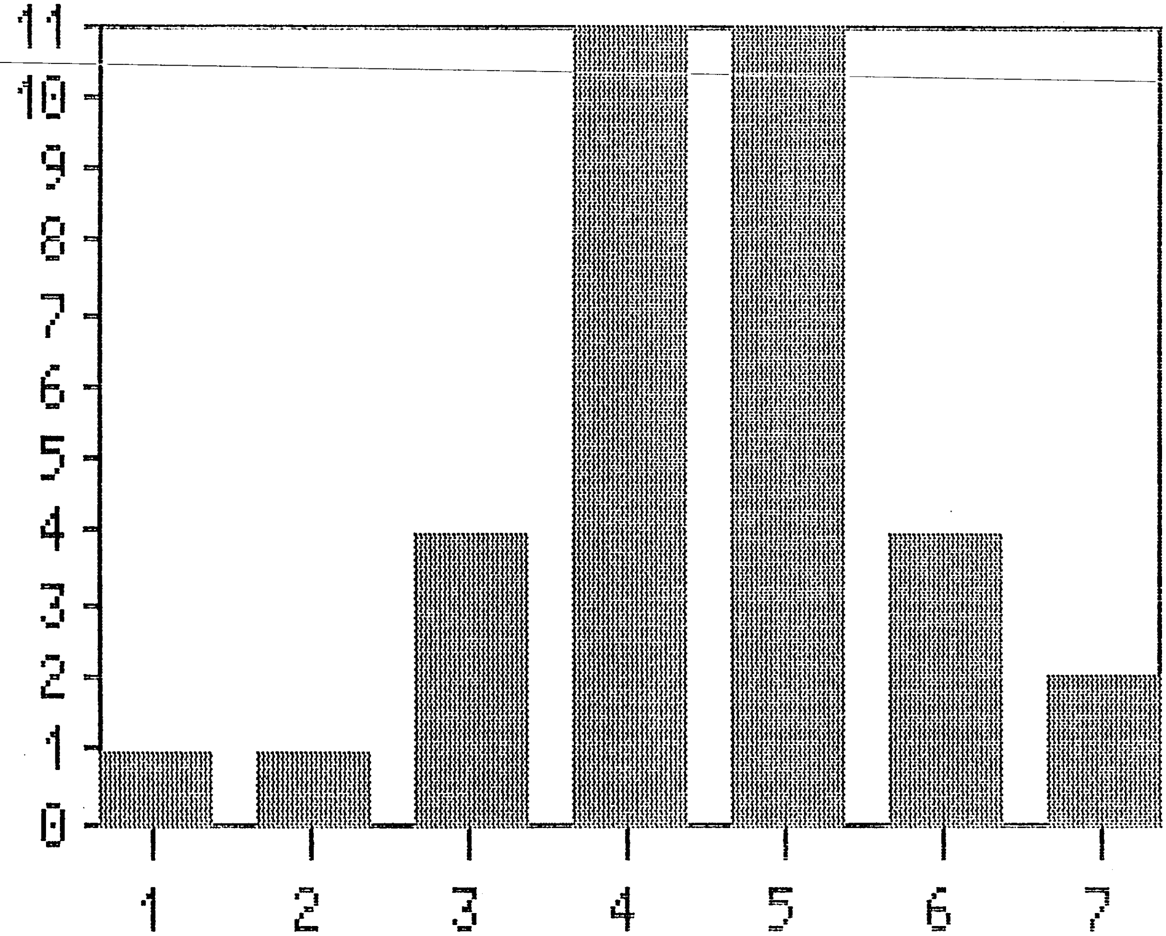
Diagram A51: Responses to Question 51



1 = very, 7 = not useful at all

Q52: Would you want to be able to get report ? (barcharts) for specific parts of the project or including the work under specific responsibilities ? (selective reports) (1 = useful, 7 = not useful at all)

A reasonably strong response showing a desire to be able to seperate parts of the project when reporting was noted. A simple task selection system was designed for the sample package as the average response (2.9) and the shape of the graph In Diagram A51 showed a demand for this.

Q53: Should such a system reject stupid data ? (1 = useful, 7 = not useful at all)

A good degree of error checking was incorporated into the design of the package to achieve the desired rejection of stupid data. The average response (3) and the shape of the graph In Diagram A52 made this a desirable feature and the technology existed to achieve some error checking within the resources available to the project.

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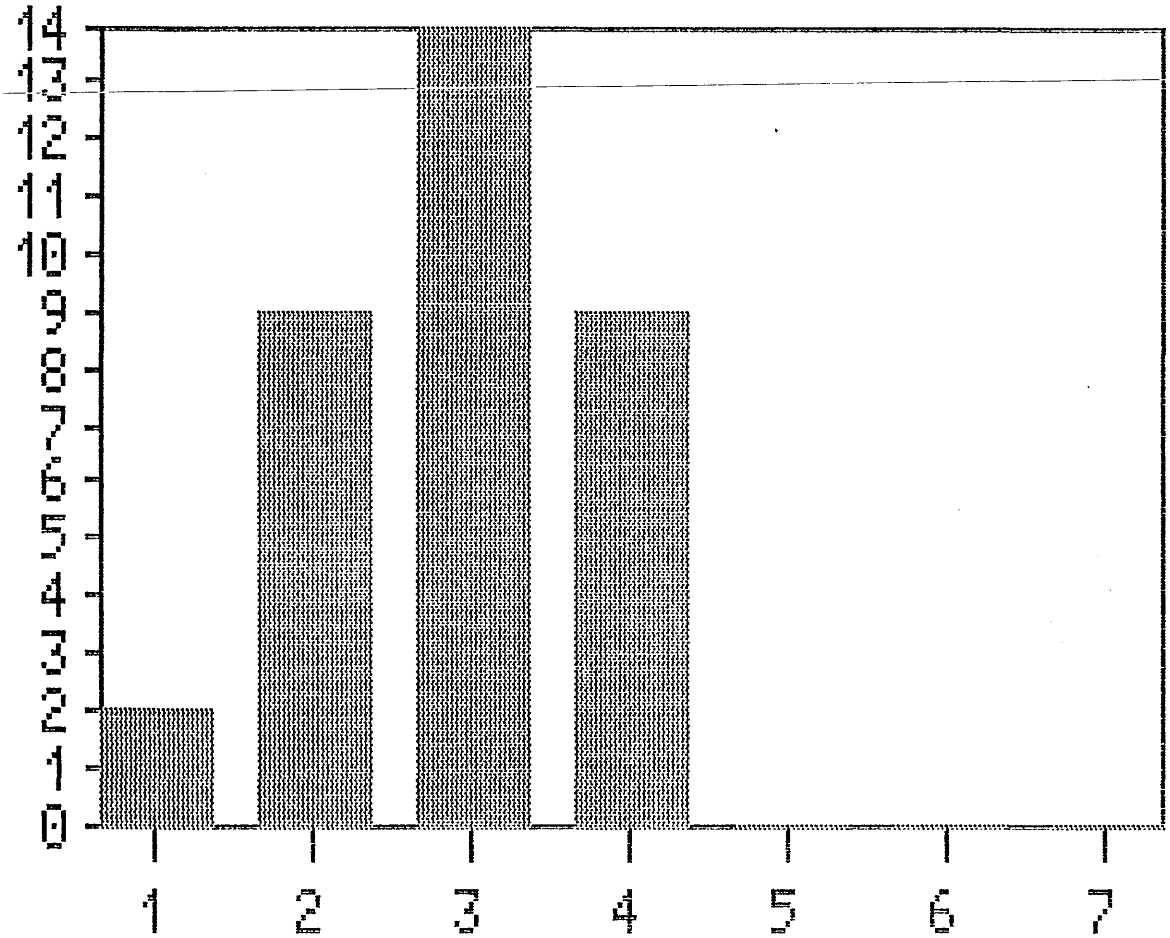
Diagram A52: Responses to Question 52



1 = very, 7 = not useful at all

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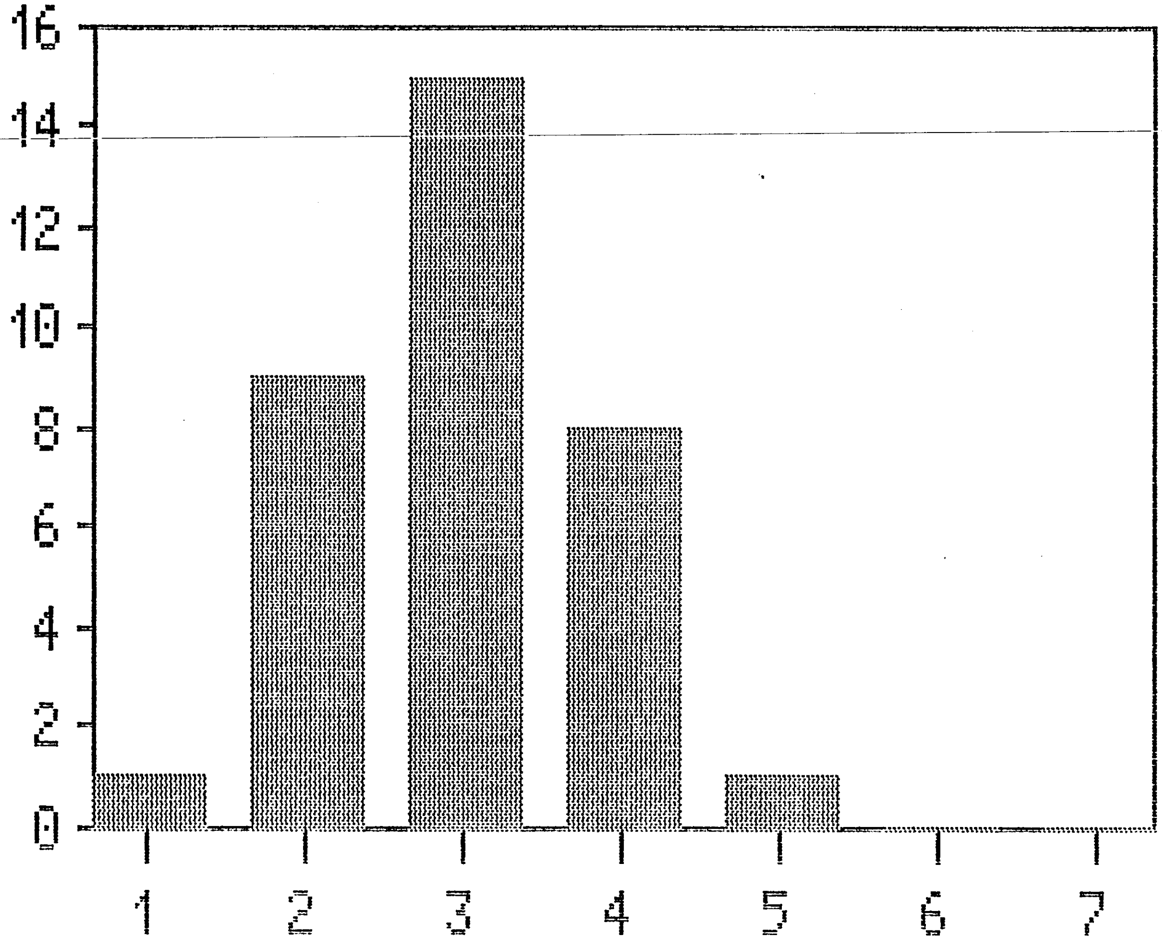
Diagram A53: Responses to Question 53



1 = very, 7 = not useful at all

Q54:How important is the speed of update - how long would you expect to spend carrying out a normal weekly update of the project plan? (numeric in minutes)

The average response to this question was 32 minutes and this confirmed the general view that such a system would have to be convenient and easy touse to be accepted by project planners.

It can be seen from the graph In Diagram A53 that speed of update was consodered to be important.

It was set as an objective to achieve this rapid update time for reasonable plans in the specification for the model programme.

Q55: How important is the speed of analysis ? (1 = very useful, 7 = not useful at all)

The average response was 3.1 - slighly more important that neutral. The impression gained by the interviewer was that the overall time for an updating process was more important than analysis speed. As analysis speed played a part in update times the desire for speed was mentioned in the specification for the model programme.

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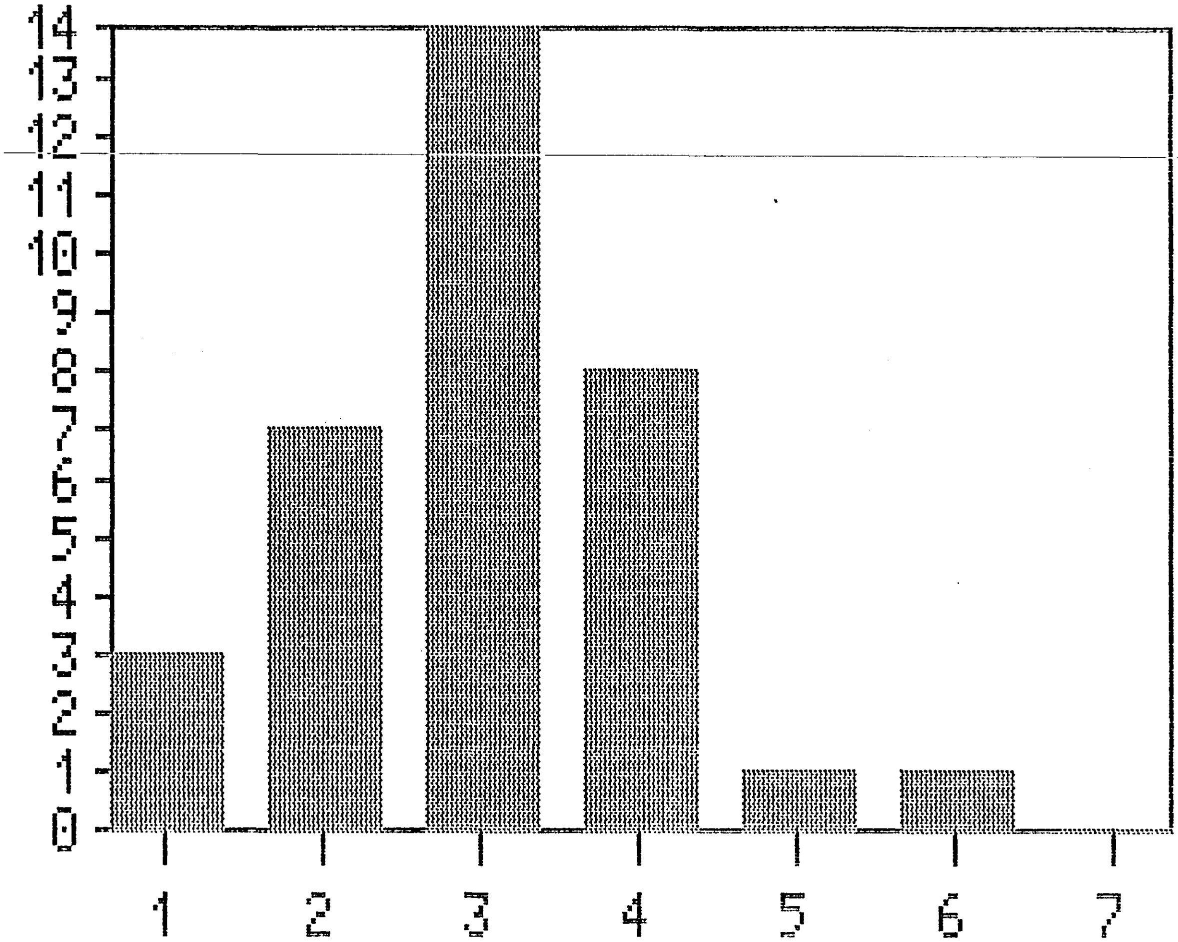
Diagram A55: Responses to Question 55



1 = very, 7 = not useful at all

Q56: Would you use the system to evaluate alternative methods of construction ? (1= very likely, 7 = not likely at all)

A slightly less than neutral response showed some interest in more frequent updating. No strong interest was noted. The average response of 4 and the shape of the graph In Diagram A55 both show this tendancy.

A version number system was designed in the specification to assist in evaluating alternative methods. The version number system would allow the user to differentiate each version of a plan.

Q57: Are there other features that you would like to see in such a system?

It was in response to this question that a number of interviewees expressed the view that the microcomputer should be able to prepare the network diagrams. The view was that the function of the microcomputer could spread to include the preperation of the network plan. This view was expressed in a vague manner and indeed on some ocassions in a half-joking way but nevertheless the point was made that the task of designing the plan in the first case might be a job executed electronically.

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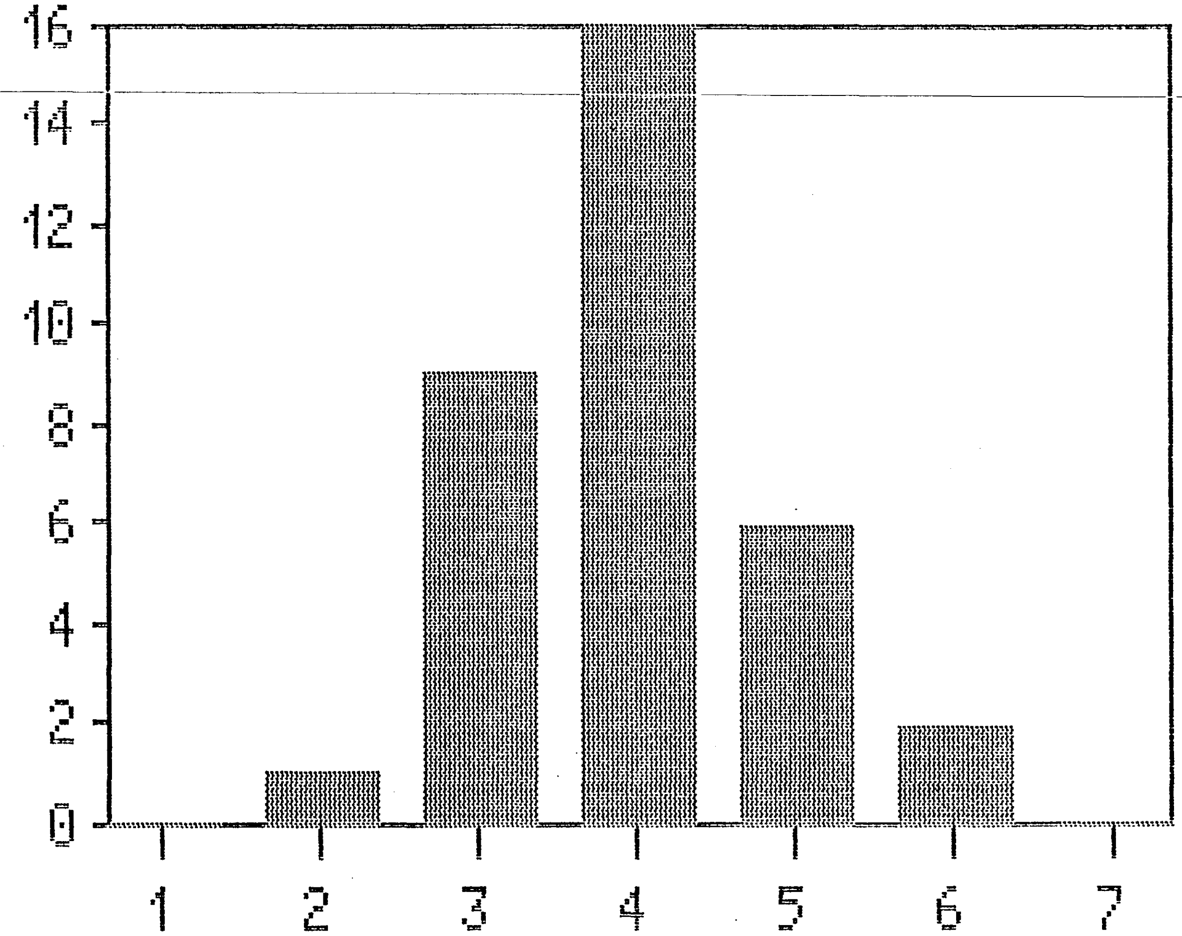
Diagram A56: Responses to Question 56



1 = very, 7 = not useful at all

		Q #1	Q #2	Q #3	Q #4	Q #5	Q #6	Q#7	Q#8	Q#9	Q#10
company #	1	20	2000		PLANNER	FULL	HOSPIT	NETPLAN	SITE/HO	3	FUTURE
company #	2	1.5	50		PROJMAN	PART	FACTORY	BARCHART	HO	4	PREDICT
company #	3	3	60		PLAN ENG	FULL	FACTORY	BARCHART	HO	2	GOOD MAN
company #	4	5	56		ENG	PART	INDUST	NET/BAR	HO	5	FUTURE
company #	5	4	40		PLANNER	FULL	HOUSING	BARCHART	HO	6	FUTURE
company #	6	12	1200		PLAN ENG	FULL	DOCK	NETPLAN	SITE	5	FUTURE
company #	7	0.9	34		PLAN ENG	FULL	INDUST	BARCHART	HO	4	FUTURE
company #	8	8	120		PROJMAN	PART	SCHOOL	NET/BAR	SITE/HO	5	PREDICT
company #	9	3	67		PLANNER	PART	HOUSING	BARCHART	HO	6	PREDICT
company #	10	12	1000		PROJMAN	FULL	ROAD	NETPLAN	SITE/HO	5	FUTURE
company #	11	6	590		PLAN ENG	FULL	HOSPIT	BARCHART	SITE/HO	4	FUTURE
company #	12	7.5	600		PROJMAN	FULL	INDUST	NETPLAN	SITE/HO	5	PREDICT
company #	13	3	100		OTHER	FULL	INDUST	BARCHART	SITE/HO	6	FUTURE
company #	14	2	45		CONSTRMAN	PART	HOUSE	BARCHART	HO	6	REMOTE
company #	15	5	120		OTHER	FULL	VARIOUS	BARCHART	SITE/HO	5	FUTURE
company #	16	5.5	240		PLANNER	PART	INDUST	NET/BAR	SITE/HO	4	FUTURE
company #	17	3.4	134		PLAN ENG	PART	HOUSE	BARCHART	HO	4	REMOTE
company #	18	6	120		PLANNER	PART	VARIOUS	BARCHART	SITE/HO	3	FUTURE
company #	19	0.9	34		PLANNER	FULL	INDUST	BARCHART	HO	4	FUTURE
company #	20	5	180		PROJMAN	PART	HOUSE	BARCHART	SITE/HO	5	FUTURE
company #	21	4	180		PLANNER	PART	INDUST	BARCHART	SITE/HO	6	REMOTE
company #	22	0.8	50		PLAN ENG	FULL	VARIOUS	BARCHART	SITE/HO	3	PREDICT
company #	23	0.3	25		ENG	FULL	PUBLIC	BARCHART	SITE/HO	4	FUTURE
company #	24	2	50		PLANNER	PART	INDUST	BARCHART	HO	3	REMOTE
company #	25	15	1500		PLAN ENG	FULL	CITY	NETPLAN	SITE	2	QUICK
company #	26	7	300		PROJMAN	FULL	VARIOUS	BARCHART	SITE/HO	3	FUTURE
company #	27	5.5	240		OTHER	FULL	INDUS	BARCHART	SITE/HO	4	PREDICT
company #	28	3.4	134		PROJMAN	FULL	HOUSE	BARCHART	SITE/HO	5	FUTURE
company #	29	6	120		PLANNER	PART	ROADS	BARCHART	SITE/HO	6	FUTURE
company #	30	0.9	34		PLANNER	PART	HOUSE	BARCHART	HO	5	REMOTE
company #	31	5	280		CONSTRMAN	PART	VARIOUS	NET/BAR	SITE/HO	6	FUTURE
company #	32	4	180		PLANNER	FULL	INDUST	BARCHART	SITE/HO	4	FUTURE
company #	33	0.8	50		OTHER	FULL	HOUSE	BARCHART	HO	6	SLOW
company #	34	0.3	25		OTHER	FULL	SMALL WKS	BARCHART	HO	6	REMOTE
company #	35	2	100		PLANNER	PART	VARIOUS	NET/BAR	SITE/HO	6	PREDICT
=========		====	=====							====	
AVERAGE		4.9	287							4.6	
========		====	=====							====	

Q#11	Q#12	Q#13	Q#14	Q#15	Q#16	Q#17	Q#18	Q#19	Q#20	Q#21
SPECIALS	SITE	2	LOCAL	YES	COMPLEX	CONSULT	5	REMOTE	YES	GENERAL
COMPLEX	HO	3	DETAIL	YES	BIG	SITE	6	COMPLEX	YES	ADMIN
SPECIALS	HO	4	NEED	YES	PRESTIGE	HO	7	SLOW	YES	ADMIN
BIG	HO	4	NEED	YES	PRESTIGE	HO	6	SLOW	YES	ADMIN
SPECIALS	HO	4	NEED	NO					YES	ADMIN
VERY BIG	SITE	3	LOCAL	YES	BIG	SITE	6	COMPLEX	YES	GENERAL
SPECIALS	HO	2	NEED	YES	PRESTIGE	HO	6	SLOW	YES	ADMIN
COMPLEX	HO	2	DETAIL	YES	PRESTIGE	HO	5	SLOW	YES	GENERAL
SPECIALS	HO	1	NEED	NO					YES	ADMIN
COMPLEX	SITE	2	LOCAL	YES	PRESTIGE	HO	4	SLOW	YES	GENERAL
SPECIALS	HO	2	NEED	YES	PRESTIGE	HO	4	REMOTE	YES	GENERAL
SPECIALS	SITE	3	DETAIL	YES	PRESTIGE	HO	5	SLOW	YES	ADMIN
BIG	HO	4	NEED	YES	PRESTIGE	HO	5	SLOW	YES	ADMIN
SPECIALS	HO	5	COMPLEX	NO					NO	
SPECIALS	HO	5	DETAIL	YES	COMPLEX	SITE	6	COMPLEX	YES	GENERAL
LARGE	HO	6	REMOTE	YES	PRESTIGE	HO	7	SLOW	YES	ADMIN
SPECIALS	HO	4	NEED	YES	PRESTIGE	HO	6	SLOW	YES	ADMIN
COMPLEX	SITE	4	LOCAL	YES	PRESTIGE	HO	5	COMPLEX	YES	ADMIN
SPECIALS	HO	3	NEED	YES	PRESTIGE	HO	6	SLOW	NO	
EXPERMT	HO	4	NEED	YES	PRESTIGE	HO	5	SLOW	YES	ADMIN
SPECIALS	HO	4	NEED	YES	COMPLEX	SITE	4	OK	YES	GENERAL
COMPLEX	HO	5	REMOTE	YES	PRESTIGE	HO	5	REMOTE	YES	ADMIN
NOT				NO					NO	
BIG	HO	4	NEED	YES	PRESTIGE	HO	7	SLOW	NO	
VERY BIG	SITE	4	DETAIL	YES	PRESTIGE	HO	6	SLOW	YES	ADMIN
SPECIALS	HO	4	NEED	YES	COMPLEX	HO	4	COMPLEX	YES	ADMIN
SPECIALS	HO	3	NEED	YES	PRESTIGE	HO	5	SLOW	YES	ADMIN
SPECIALS	HO	3	NEED	YES	PRESTIGE	HO	7	SLOW	YES	ADMIN
BIG	HO	3	NEED	YES	PRESTIGE	HO	5	REMOTE	YES	ADMIN
NOT				NO					YES	GENERAL
SPECIALS	HO	3	NEED	YES	PRESTIGE	HO	6	SLOW	YES	ADMIN
SPECIALS	SITE	4	LOCAL	YES	PRESTIGE	SITE	5	SLOW	YES	ADMIN
BIG	HO	4	NEED	YES	COMPLEX	HO	6	REMOTE	YES	ADMIN
SPECIALS	HO	2	NEED	NO					NO	
SPECIALS	HO	3	NEED	YES	PRESTIGE	HO	6	SLOW	YES	ADMIN
		====					====			
		3.2					4.6			
		====					====			

Q#22	Q #23	Q#24	Q#25	Q#26	Q#27	Q #28	Q#29	Q#30	Q#31	Q#32	Q#33	Q#34	Q#35	Q#36	Q#37
GENERAL	3	EFFICIENT	YES	HOME/WORK	PLANNING	2	TOOL	YES	SITE PLAN	HO	2	FAST	PLANNER	3	4
ADMIN	3	WORKS	YES	HOME	APPRCT	3		SOME	SITE PLAN	SITE	4	SLOW	PLANNER	2	5
ADMIN	2	WORKS	YES	HOME	APPRCT	4		LITTLE	HO PLAN	HO	3	FUTURE/SLOW	PLANNER	3	4
ADMIN	1	NEED	YES	WORK	APPRCT	3		LITTLE	SITE PLAN	SITE/HO	2	FUTURE/SLOW	PLANNER	4	5
ADMIN	2	WORKS	YES	HOME	APPRCT	4		LITTLE	HO PLAN	HO	2	FUTURE/SLOW	PLANNER	3	6
VARIOUS	3	WORKS	YES	HOME	APPRCT	5		YES	SITE PLAN	SITE	2	FAST	ENG	2	5
ADMIN	2	WORKS	YES	HOME/WORK	PLANNING	4	TOOL	LITTLE	SITE PLAN	HO	4	FUTURE/SLOW	PLANNER	3	4
GENERAL	3	WORKS	YES	HOME	APPRCT	4		YES	HO PLAN	HO	3	FUTURE/SLOW	PLANNER	4	6
ADMIN	4	NEED	YES	HOME	APPRCT	3		LITTLE	SITE PLAN	SITE	5	FUTURE/SLOW	PLANNER	4	5
VARIOUS	3	WORKS	NO					YES	SITE PLAN	SITE	5	COMPLEX	ENG	3	4
GENERAL	2	WORKS	YES	HOME	APPRCT	5		SOME	HO PLAN	HO	4	FUTURE/SLOW	PLANNER	2	3
ADMIN	2	WORKS	YES	HOME	APPRCT	4		YES	SITE PLAN	SITE/HO	4	SLOW	PLANNER	4	4
ADMIN	3	WORKS	YES	WORK	APPRCT	3		YES	SITE PLAN	HO	5	FUTURE/SLOW	PLANNER	3	5
			YES	HOME	GAMES	2	FUN	YES	SITE PLAN	SITE	5	SLOW	PROJMAN	4	2
GENERAL	3	WORKS	YES	HOME	APPRCT	3		LOT	SITE PLAN	SITE	3	FUTURE/SLOW	PLANNER	5	4
ADMIN	2	WORKS	YES	HOME	APPRCT	5		LOT	SITE PLAN	SITE	4	FUTURE/SLOW	PLANNER	5	6
ADMIN	1	WORKS	YES	WORK/HOME	PLANNING	4	TOOL	LITTLE	HO PLAN	HO	4	COMPLEX	PROJMAN	5	5
ADMIN	2	WORKS	YES	HOME	APPRCT	4		YES	SITE PLAN	SITE	5	COMPLEX	PLANNER	5	4
			YES	HOME	APPRCT	4		LITTLE	ESTIMATES	HO	3	FUTURE/SLOW	PROJMAN	4	5
ADMIN	3	WORKS	NO					LITTLE	HO	HO	3	FUTURE/SLOW	PLANNER	3	6
GENERAL	2	WORKS	YES	HOME	APPRCT	4		YES	SITE PLAN	SITE/HO	5	FUTURE/SLOW	PLANNER	2	7
ADMIN	3	WORKS	YES	HOME	APPRCT	4		LITTLE	SITE PLAN	SITE	5	FUTURE/SLOW	PLANNER	3	6
			YES	WORK	APPRCT	2		LITTLE	SITE PLAN	SITE	4	FUTURE/SLOW	PROJMAN	4	3
			YES	WORK	APPRCT	3		SOME	HO PLAN	HO	3	FUTURE/SLOW	PROJMAN	4	4
ADMIN	4	WORKS	YES	HOME	APPRCT	5		YES	SITE PLAN	SITE	4	SLOW	ENG	3	5
ADMIN	3	WORKS	YES	HOME	GAMES	2	FUN	LITTLE	HO PLAN	HO	5	FUTURE	PLANNER	3	2
ADMIN	3	WORKS	YES	HOME	APPRCT	4		LITTLE	SITE PLAN	SITE/HO	2	FAST	PLANNER	3	6
ADMIN	2	WORKS	NO					V LITTLE	HO PLAN	HO	5	SLOW	PLANNER	4	5
ADMIN	1	WORKS	YES	HOME	GAMES	2		LITTLE	SITE PLAN	SITE	2	GOOD MAN	PLANNER	5	4
GENERAL	2	WORKS	YES	HOME	APPRCT	4		LITTLE	SITE PLAN	SITE	3	SLOW	PLANNER	4	7
ADMIN	2	WORKS	YES	WORK	APPRCT	5		YES	SITE PLAN	SITE	1	LOCAL	PLANNER	3	6
ADMIN	4	WORKS	YES	HOME	APPRCT	3		LITTLE	HO PLAN	HO	4	SLOW	PLANNER	2	5
ADMIN	3	WORKS	YES	HOME	APPRCT	4		LITTLE	HO PLAN	HO	3	FUTURE/SLOW	PLANNER	3	4
			NO					V LITTLE	SITE PLAN	SITE	4	LOCAL	PROJMAN	4	5
ADMIN	2	WORKS	YES	HOME	APPRCT	4		LOT	SITE PLAN	SITE	3	LOCAL	PLANNER	3	6
	====					====					====			====	====
	2.1					3.2					3.6			3.5	4.8
	====					====					====			====	====

Q#38	Q#39	Q#40	Q#41	Q#42	Q#43	Q#44	Q#45	Q#46	Q#47
2	3000	40	1	2	3	1	1	3	1
4	1000	40	1	3	3	3	1	5	1
3	500	30	1	4	3	2	1	4	1
4	500	40	2	3	3	1	1	3	1
2	750	40	1	3	4	2	2	5	1
3	1500	25	1	3	2	3	2	4	3
1	300	100	3	3	4	3	2	4	2
3	400	40	1	4	4	3	2	4	3
2	1000	30	1	2	3	3	1	5	3
1	1000	50	1	4	4	2	1	5	3
2	500	50	1	3	3	2	1	5	3
1	750	30	1	2	5	2	1	4	2
3	400	70	1	1	4	3	3	4	2
2	200	40	1	3	3	3	1	4	3
3	300	50	2	4	4	4	1	6	3
4	1500	30	1	2	4	2	1	3	5
2	300	25	1	3	3	2	1	2	7
3	500	50	1	2	3	3	4	4	3
2	750	60	4	1	2	3	3	3	2
1	200	80	1	3	1	2	1	5	1
1	2000	100	1	4	5	1	1	4	2
1	1500	30	3	3	4	1	1	3	3
3	500	20	2	4	7	3	2	5	4
1	1000	30	3	3	5	2	1	4	3
2	500	50	4	4	4	1	3	3	4
1	750	40	3	3	3	2	2	2	2
2	1000	40	2	2	4	3	3	4	3
3	1250	70	1	5	3	4	1	3	2
2	1500	20	1	4	4	3	1	4	4
1	350	25	3	3	3	6	2	2	3
2	500	100	2	5	4	4	3	3	2
3	1500	30	3	4	2	2	2	2	1
2	500	40	2	3	3	3	3	1	2
3	1000	40	4	4	2	2	1	4	3
2	4000	50	2	5	3	3	1	3	2
====	=====	====	====	====	====	====	====	====	====
2.2	949	46	1.8	3.2	3.5	2.5	1.7	3.7	2.6
====	=====	====	====	====	====	====	====	====	====

Q#48	Q#49	Q#50	Q#51	Q#52	Q#53	Q#54	Q#55	Q#56
5	6000	6	4	2	3	15	3	3
4	2000	5	5	2	3	30	3	4
6	3000	4	4	2	3	60	3	4
5	3000	5	5	2	2	20	2	4
2	5000	5	5	2	2	20	4	5
4	4500	5	5	3	2	20	5	3
3	4000	4	4	1	4	30	4	3
1	1000	4	4	3	4	15	6	4
4	2500	6	6	3	3	10	2	4
6	4500	5	6	3	2	40	2	3
5	6000	5	5	1	1	60	1	5
7	5000	5	4	4	5	20	2	4
5	2000	7	4	3	4	40	3	6
3	1200	2	3	3	3	45	4	4
4	4000	3	3	4	2	30	3	3
4	3000	5	5	4	3	20	4	4
5	3500	4	4	4	4	30	4	5
5	2500	3	1	3	3	30	3	4
3	4000	5	5	2	4	30	3	3
4	1000	4	6	3	3	60	3	4
3	2000	3	7	4	2	45	2	5
3	3000	4	6	3	3	15	3	3
2	2000	5	5	2	2	20	2	4
3	3000	3	4	3	4	45	3	4
2	5000	6	2	4	3	60	2	3
4	3000	3	4	3	3	30	1	4
1	2000	4	3	4	4	30	1	5
3	3000	6	4	3	3	45	3	4
5	3000	5	3	4	2	10	3	3
4	1000	4	5	4	3	15	4	4
3	3000	4	7	3	3	30	4	2
4	3000	4	5	2	2	45	3	5
3	3000	6	4	3	3	30	3	4
2	1500	6	5	2	4	20	4	6
3	3000	5	4	4	3	25	5	5
====	====	====	====	====	====	====	====	====
3.7	3006	4.6	4.5	2.9	3	32	3.1	4
====	====	====	====	====	====	====	====	====

Appendix C - The Revised Functional Specification for a Project Planning Package

Appendix c: REVISED FUNCTIONAL SPECIFICATION

This section describes in more detail the software package that might be used in a future research project or might form the basis of a suitable package for use of construction sites..

1 A FUNCTIONAL SPECIFICATION FOR A SOFTWARE PACKAGE.

1.1 General: The program should perform the data entry, analysis and report generation of activity on arrow and precedence network plans.

The program should be written so as to be suitable for the popular microcomputer configurations.

Data Entry: The user should be able to create project plans each of which would take the following form:

Headings: Each plan would have a

Plan Title	8 characters
3 additional sub-titles	30 characters each
A calendar identifier	8 characters

Activities would be made up from the following data.

a start node	Alphanumeric
an end node	Alphanumeric
a description	Up to 40 characters
a duration.	In time units up to 999
Responsibility code	
(Maybe combined with description or resources)	
Resource requirements	See below

The operator would be able to enter details of project plans as a series of activities. He would able to examine and amend descriptions and duration and would also be able to add and delete activities.

Node number need not be sequential as the logic of the project network would be deduced from the node numbers.

The whole plan would be capable of being recorded on disk for later amendment.

Analysis

At the operator's command the program would execute a forward and backward pass through the network and deduce the critical path through the plan and the total float on each activity. Activities would then be sorted into sequence defined by the user and displayed on screen. On the user's command barcharts and other reports may be printed.

The analysis and sorting phase should take no longer that 30 seconds based on a 1000 activity plan.

Sorting: Activities would be sorted into the sequence established by the user but should include at a minimum - early start sequence, critical sequence and responsibility sequence.

When requesting any report the user should be able to enter a search or selection key. This selection key would be used to restrict activities to be printed to those that contain the selection key in their descriptions, their resources or their responsibility code. The user would be expected to specify the location of this selection key. An example of this might be "activities containing the letters XX in position 4 & 5"

After printing is completed the user would be asked if he requires other reports and additional reports should be possible on different selection criteria. The ability to pre-order a set of print outs that are frequently required together is desirable.

The system should be controlled by a menu structure or command line technique and there should be adequate on-line help.

At each stage the user would be presented with a similar simple self explanatory menu which would enable the system to be used by a non-computer technical person.

Calendar: Users would be able to produce calendars each of which would be identified by an 8 character identifier. For each calendar the user should be able to enter a typical working week identifying the project normal working week environment and in addition unlimited numbers special holidays.

Typical working weeks should be limited to between 1 and 7 working days per week. Calendars should be capable of being up to 10 years long. Calendars would use the Gregorian calendar as a basis and would show month and day names by means of three character abbreviations.

The ability for certain resources and certain tasks to operate in different working/non-working day environments when compared with the main project environment is desirable. It is also desirable to permit the user to work in non single day time units such as shifts, weeks or other unit.

Projects:

The project file would comprise of the headings including the calendar identifier and a up to 2500 activities. These activities would define the network and would take the following form.

Plans should be recorded automatically without user intervention and each plan would be recorded under its identifier and its version number. Each time a plan is loaded from disk into the memory of the computer for a work session a new version would automatically be produced being 1 greater than the previous plan.

The user should be able to allocate resource demands to each activity and be able to produce resource histograms and cash flow curves. An ability to level resource either automatically or interactively is desirable. An ability to draw the network diagram is desirable.

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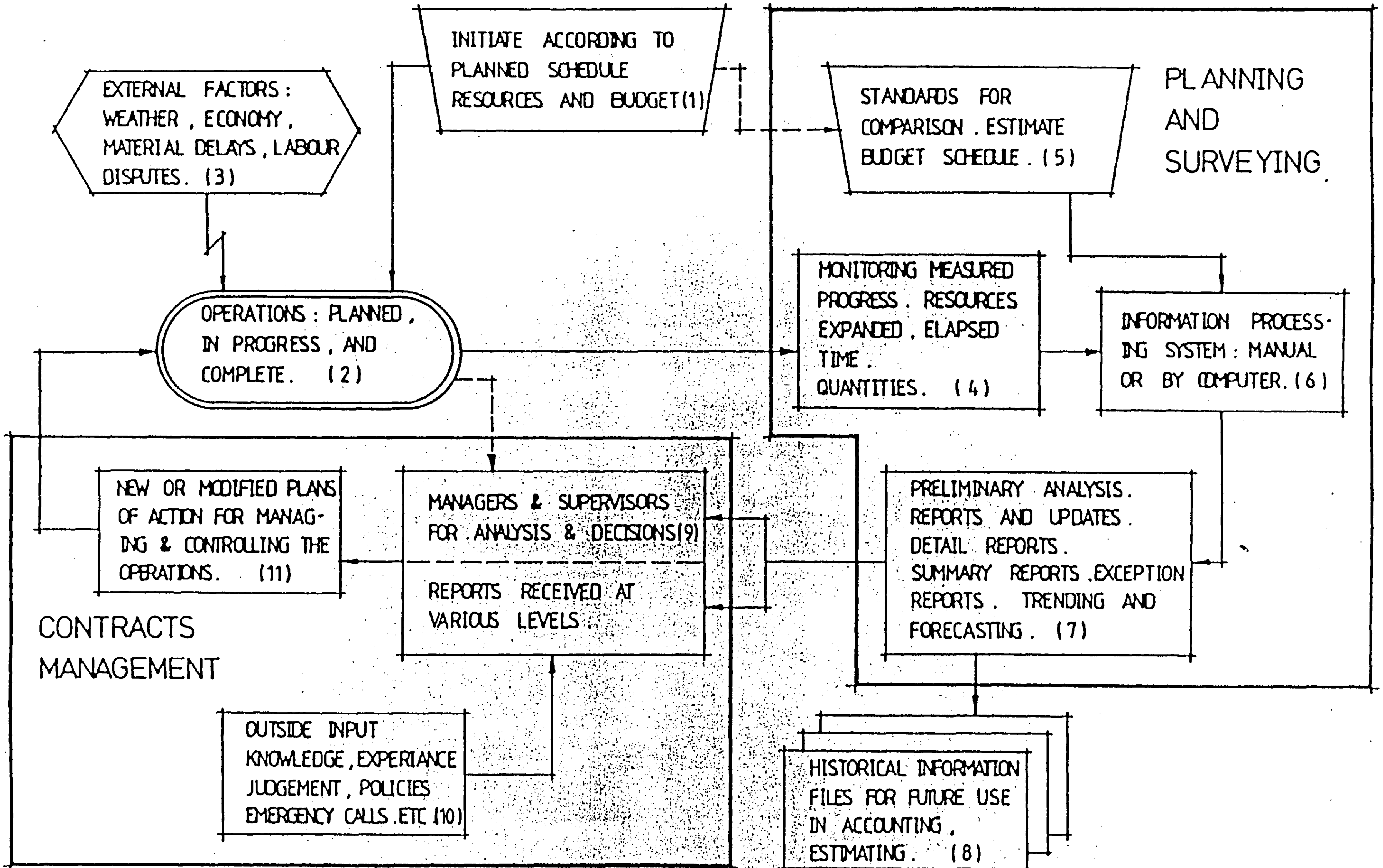

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Appendix A.