

**PERSONAL COMPUTER NETWORK PLANNING TECHNIQUES**  
**AMONGST BUILDING CONTRACTORS**  
**IN THE WESTERN CAPE.**

**A THESIS IN PARTIAL FULFILLMENT OF THE REQUIREMENTS**  
**FOR A MASTERS DEGREE IN INDUSTRIAL ADMINISTRATION**  
**FROM THE UNIVERSITY OF CAPE TOWN.**

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**JULY 1990.**

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## **OBJECTIVE.**

To investigate the way computer planning packages are used in the Building Industry of the Western Cape, and to make recommendations as to ways in which they can be used effectively

## SYNOPSIS.

The construction of a building requires that the sequence of operations to be planned in one way or another.

In the last 100 years a variety of planning techniques have been developed. Common methods amongst builders are "Bar Charts" and various network analysis techniques. The recent advent of powerful personal computers linked to these analysis methods have opened new horizons.

Just how are these techniques being used amongst the members of the Master Builder's Association of the Western Cape?

A survey amongst members showed that the use of planning techniques and attitudes towards them were similar to that reported in literature. Network analysis techniques were used on about 10% of projects. Firms with personal computers used about 7% of computer time on network analysis techniques.

Visits to firms showed that the techniques were used in a different way in each of the firms visited.

The precision of computers was found to be of limited use in an industry where numerous sequences of operations - equally suitable - exist simultaneously in a workplace situated outdoors in uncontrollable climatic conditions.

However computer aided, network techniques do have applications in the building industry. Methods of application are therefore proposed for companies which will enable the maximum benefit to be obtained from these techniques.

## **DECLARATION**

I, Michael John Dreyer, submit this thesis for the Degree of Master of Industrial Administration.

I claim that this is my original work, and that it has not been submitted in this or in similar form for a degree at any University.

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## INTRODUCTION

Since the 1960's CPM, PERT, Precedence Diagrams, and similar network analysis planning techniques aided by the computer have enabled projects with complexity far beyond the limitations of the human brain to be planned and controlled.

Yet in the building construction industry there is much evidence in overseas literature of disquiet with and a swing away from these network planning techniques.

A survey of relevant literature reveals that if network analysis is needed at all, then the higher productivity it is expected to produce depends not only on techniques but on the proper involvement of human beings. The planning and scheduling techniques, the technical characteristics of the computer hardware and the sympathy of the software to the contractor's needs are not enough. The productivity of this approach is effected by the depth of the planner's construction experience, and ultimately the motivation of the doers whose degree of motivation is related to their degree of participation in the planning process.

There is little reported on the effect of the comparatively recent proliferation of Personal Computers and their increasing use by contractors in management. Reports on the effectiveness of Laptop computers, the flood of new ranges of user-friendly software, and the growing trend towards networking are similarly scarce.

The purpose of this paper is to determine the degree of success experienced with computer network planning techniques as perceived overseas, and then, within the confines of the Building Industry in the Western Cape, to establish the use of such techniques and make proposals which might lead to their more effective use.

A Questionnaire was circulated in March 1989 amongst third year Building Surveying and Construction Supervisors at the Cape Technikon to assess their awareness of network analysis techniques in their sponsoring firms.

Their response indicated virtually no awareness that these techniques were used in their companies.

Taking this finding into account, and after further careful consideration of the nature of the local building industry, a questionnaire was prepared.

This questionnaire was posted in June 1989 to all members of the Master Builders' Association in the Western Cape under a covering letter which was sent in the name of ( and was also for the use of) the Cape Technikon as it was judged that there would be a better response in view of these firms frequently being asked to comment on course content.

This mail survey on the way Personal computers were used among the 400 Members of the Master Builders' Association in the Western Cape obtained 104 returns. Half the respondents did not use computers. The other half indicated that they used their computer time as follows:-

- 40% on accounting, wages and salaries
- 32% on the estimating/costing/monthly claim bundle,
- 21% on Wordprocessing and
- 7% for planning the sequence of operations.

The use of computer bureaux slightly distort these figures.

The mail survey also indicated that network analysis techniques are used as the planning method for about 10% of building contracts.

A further questionnaire was circulated to five people in occupations serving many of the respondents to the June survey in order to establish characteristics of the firm that might successfully use network analysis techniques.

This failed to obtain a response as the intended respondents felt it incompatible with their occupation to make any judgement on the firms they served.

While these surveys were being carried out a series of practical experiments was being performed. A few experiments in planning the sequence of operations were carried out on a simulated contract for a multistoried building using both manual and computer assisted techniques.

In view of consensus that top of the range packages required a minimum of six months hands-on experience for worthwhile comment, the practical experiments were

limited to basic packages and the experience gained on the visit to the energy conversion plant must substitute for practical experience on top-of-the-range packages.

Practical experiments with one or two low-range computer packages indicate that different approaches are required for computer and manual techniques, and that when the needs of the building industry are considered, characteristics of available hard and soft -ware limit the productivity of computer aided network techniques. This state of affairs might be corrected with time.

Once these stages had been completed and evaluated, interviews were conducted with a number of firms.

Interviews revealed that each firm used different aspects of a package in a way that suits their management philosophy.

Interviews indicated problems with the application of packages. Many of these problems are due to the inherent characteristics of the building industry:-

Work is done outside in uncontrollable weather conditions.

A network indicates one construction sequence. There may often be a number of equally satisfactory alternative forms of construction.

Sometimes a quick answer is required. A computer approach is inflexible requiring a time consuming and rigid data input and checking routine.

and due to severe limitations in the hardware:-

Visual display screens are too small for live work

Even AT's were found to be slow without additional co-processors.

The writer was indeed fortunate to be able to have a discussion with one source outside the construction industry - a member of an energy conversion plant. This discussion lifted the horizons of how computer aided network planning techniques could be used.

After carefully considering all the information gathered, and with some difficulty owing to the diversity of problems surrounding the application of these techniques, a proposal is made regarding the application of these techniques to building sites.

In essence they are as follows. Once network planning techniques are deemed applicable, a planning meeting of the site management team plans the sequence of macro events by moving chips on a white board. The planner then puts this sequence of macro events into a computer. The computer produces a weekly print out of operations which must be done - but it is the site staff and not the computer which complete the detail as to the day and hour at which the task is actually done. The computer produces the exception reports.

## ACKNOWLEDGEMENTS.

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Finally, but by no means least, the writer wishes to express his warm thanks to Mr Gordon Lister, his supervisor at the University of Cape Town, for his tact, friendliness, and wise guidance during the development of this thesis.



## CONVENTIONS.

Certain conventions have been used in this thesis, and they are outlined below.

1). Italic type face has been used to identify quotations.

2). References to literature are indicated thus in the text

"Rigors and Myers (1981)."

The full reference may then be found in the Chapter 7, the Reference section, where each entry has been arranged alphabetically and in this manner; eg:-

"Rigors and Myers, 1981, Personal Administration, 9th Ed,  
McGraw-Hill Book Co, New York, pp 23 - 24."

3). Some of the chapters are long and have been divided into a number of sections covering a particular aspect. In order that the reader may not lose track of the place in the thesis running heads have been used. The top line gives the chapter number and heading, and the second line the title of the section.



## **CHAPTER ONE**

### **REVIEW OF AVAILABLE LITERATURE.**

## **1.1. OUTLINE OF "REVIEW OF AVAILABLE LITERATURE."**

What has been written about Network Analysis Techniques is grouped and summarised under the following headings:-

### **1.2. The background to the spread of network techniques.**

Owing to its perceived success, the technique spread throughout industry and commerce.

However, there were indications that it was not an unqualified success.

### **1.3. Findings of Surveys into the Success of Network Analysis Techniques in the Construction Industry.**

Investigators probed the construction Industry to find out just how successful the techniques were in practice.

They found limited acceptance and signs of a swing towards other techniques.

### **1.4. Tailoring packages to meet specific company needs.**

In view of these difficulties in applying these potentially powerful network analysis techniques to the construction Industry and in an attempt to overcome the difficulties, firms began to match or adapt computer packages to their specific operating needs.

### **1.5. Possible Reasons for the Success or Failure with Network Analysis Techniques in the Construction Industry.**

Published reasons for the present situation are grouped under three sub-headings.

Under the first, "Problems with the use of Network Analysis Techniques" reasons for the problems are summarised.

The second section under the sub-heading, "Considerations Favouring the use of Network Analysis Techniques", contains reasons as to why members associated with the construction industry believe the techniques must ultimately be successful.

Under the third sub-heading, "Spheres in which network analysis techniques are always regarded as successful", are found reported circumstances under which most writers agree that these techniques always have great value.

### **1.6. The needs of the contractor with regard to scheduling work.**

Contractors in differing situations have differing needs. For some the control of the deliveries of material is important. Others require optimisation of resources in different forms. Others again want it as the basis for future claims.

### **1.7. The cost of planning to the contractor.**

The wants of the contractor are tempered by the cost of meeting those wants.

## **1.2. THE BACKGROUND TO THE SPREAD OF NETWORK TECHNIQUES.**

### **1.2.1. General.**

The development and application of network analysis techniques in the late 1950's enabled Project planning to take off . For the first time there were techniques available capable of planning and controlling vast, complex projects.

These techniques were not limited by the abilities of the human mind: the increasing availability of computers continually lifted the horizons of scope for these techniques. *"The computer has had a major impact on the use of CPM and PERT. Large construction projects may require 1000 or more nodes. In the 1960's it was not unusual to find the network diagram for such a project spread out over three walls of a room that was dedicated to that purpose for the duration of the project. Major changes in the plan were a major pain in their own right and communication among the multiple contractors was cumbersome. The computer has changed all of that.*

*"The analysis is now done on a computer. Multiple runs spanning the life of the project are the order of the day. In the early phases it is important to ensure that orders for major components are placed early enough. ....Regular updating based on supplier reports enables management to see when it is necessary to expedite an order. New information is fed into the model; and the program rerun on a weekly basis. Obviously the information obtained from such runs influences the allocation of resources. It may even affect the design of the project. If a cost control report.....indicates serious cost over runs early enough, later parts of the project may be redesigned."* Eppen et al,1987.

Network analysis techniques were initially developed in the space industry and the factory maintenance field. Because of their perceived success there, the methods soon spread to other spheres of commerce and industry.

This development took place against the background of the mood of the world in the sixties. For instance in the 1930's there was a mood of pessimism. It was the time of the great depression.

However in the 1960s there was the mood of universal well being and optimism. A British Prime Minister was able to offer the slogan "*You have never had it so good*". This then was the era when the techniques of network analysis and computers came into being. It was the age when people expected computers to take over.

However, even at that stage, there were suspicions that planning with Network Analysis Techniques was not as effective as it seemed.

For instance, one of the first well known applications of a modified PERT analysis technique was on the Polaris project in 1959. Sapolsky (1972) described how the Navy Special Projects Office developed the PERT technique on the Polaris project to sustain the myth that they had an integrated, uniquely effective management system. The project was actually managed by more direct, conventional means. But the political use of the network analysis gave project management credibility and independence of action. It built a "fence" to keep the rest of the Navy at bay. During the course of this project - and since - there have been growing doubts about some of the advantages initially attributed to PERT.

A more recent, yet similar situation, occurred in Cape Town. During the construction of the recent extensions to Groote Schuur Hospital in Cape Town, the planner is reputed to have spent three weeks with a major computer company producing the computer generated network analysis required in terms of the contract. From then on he - and it is suspected the professional team - used more direct, conventional means to plan and control the progress of the contract.

### **1.2.2. More of a Fad than an effective aid.**

Some people suspected that network analyses were used at times more for effect than to achieve an actual increase in productivity.

Writing in the "Project Management Handbook", G.Morton (1983) states that "*Though network planning has been sold as an essential element in effective project management, the value of network planning has been challenged in academic literature. Thus Marquis, studying the use of network planning in industry in 1969,*

*found that project managers who use it are most likely to be highly regarded than those who do not. However, he also found no relationship between this judgement on the excellence of project managers and the outcome of their projects, either technically or administratively."*

Harrison (1985), continuing on the same theme, summarized the situation as follows:-

*" Because projects were becoming larger and more complex, and their planning more critical to project management efficiency, there was a trend towards widespread adoption of CPM/PERT in the 1960's and early 1970's. Its end became accepted as typifying good practice in project planning, and those who did not use it were considered to be old fashioned, or even immoral !"*



### **1.3. FINDINGS OF SURVEYS INTO THE SUCCESS OF NETWORK ANALYSIS TECHNIQUES IN THE CONSTRUCTION INDUSTRY.**

#### **1.3.1. General.**

There now exist a whole body of researchers who have investigated the application and tested the success of network analysis techniques in the construction industry. They have highlighted the problems associated with network analyses techniques and the use of computers to perform such network analysis.

They consistently report that as far as the construction industry is concerned these techniques were not as successful as people were led to believe.

For instance Harrison (1985) summarized the situation as follows:-

*" Despite the fact that it was fashionable to use CPM/PERT, bar charts were still widely used, in these years in both small and large projects. CPM/PERT never really got established in the planning of the smaller project, because it was not really required, its increased sophistication discouraged its use and bar charts were, and still are, an adequate and effective way of planning and controlling the smaller project. Even with larger projects, bar charts were often used as the primary planning technique, principally because they were simple, easy to use, project staff were familiar with them and they were often adequate for the state of the art of planning.*

*"However, even in the late 1970's, contrary to all the publicity and literature produced on CPM/PERT, many companies were actually discarding CPM/PERT and returning to the use of bar charts, even on the larger and more complex projects. For example:-*

*" One engineering manager from a large US aerospace/weapons contractor commented that in 1979 that CPM/PERT had fallen out of favour with his*

*company, very few of the company projects use this technique and he had not been associated with PERT for five years.*

*" A Senior project manager from a large UK chemical company went out to tender on a 20M Pound sterling project in 1979, and on a preliminary survey of possible contractors found that most of them were not using CPM/PERT.*

*" Though in the past the US department of Defence enforced the use of PERT on their contractors, they now state they do not require contractors to use any specific scheduling technique. PERT, Line of Balance, Gantt and Milestone charts are all good techniques which are effective when employed.*

*" Thus in the late 1970's there was a trend in some companies away from the use of CPM/PERT, even on the larger project, back to using the Gantt charts for project planning. Even when CPM/PERT was used, it is often used only as a sales factor, or because the home office or the client insisted upon it."*

### **1.3.2. Surveys on the use of Network analysis.**

Morton (1983) states *" Davis (1972), in one of the few studies on the use of network analysis in large construction firms, found that, although 80% of the companies used network planning, only 13% of the users felt that they were very successful in achieving the numerous benefits attributed to it."*

Davis (1974), in a later survey of large construction companies, showed that only 15% of CPM/PERT users deemed them very successful.

These low figures are slightly contradicted in an untraced reference to another study where the use of CPM was reported to enjoy better support. *"BRT (1983) in another study found that 43% of large construction companies used CPM effectively."*

More recently Waddill and Mayes (1986) found that the situation in small construction companies was even less encouraging than that in large companies in that only 10% attempted to use CPM.

Still more recently Allam (1988) reports his investigations as follows:-

*" The other main problem of the available scheduling models is that they are based on CPM. However, despite the fact that CPM has been available to construction companies for more than two decades, in a survey published in 1974 Davis (Davis,1974), 45% of the companies ( the sample contained 400 of the top American construction companies), indicated that they never, or seldom used CPM. This was much higher than expected when CPM was first introduced in the early 1960's. In the authors survey among British construction companies (Allam,1986, pp 80-98) 4.9% of the CPM users applied it to all their projects and 68.3% used it on less than half their projects. The fact is that only 34.5% or less of the current CPM users use it in all the phases of project planning. Some of the planners and schedulers whom the author has met - who are the chief planners in the largest British construction companies - have become totally unconvinced by CPM. They have begun to depend on their own experience and use the bar charts as a method of presenting the developed schedules."*

Further American reports quoted by Allam, (eg Moder et al (1983)), give similar results.

## **1.4. TAILORING PACKAGES TO MEET SPECIFIC COMPANY NEEDS.**

The results of the extensive work of Davis and others must be seen against the background of certain changes in worldwide business attitudes.

### **1.4.1. The mood of the world.**

The 1980's would seem to be the years of pragmatism. The time when people ask the question "Does it work". This is the age when companies decided *"that instead of letting computer technology determine how a company operates, corporate interests would be better served if overall needs dictated the uses of computers."* Rigors and Myers (1981) continue by stating that firms asked themselves the question *"How can computers best serve the interests of the organisation as a whole, while avoiding the waste of human resources which can result from single minded action by a brilliant computer technician who has little understanding of how to work with people."*

The 1980's were the also the age of economic competitiveness when managers were forced to consider if things really contributed to the economic well being of the company. In Britain it was the age of "Thatcherism" when the consequences of economic reality took their course.

Another more subtle change of attitude spreading throughout the developed world is reported by Toffler (1980). Toffler stressed the fact that the world was moving from the world of "mass", (ie everything the same for all people), into the age of the "individual", (ie niches, special requirements for each customer).

It was therefore not surprising that this trend emerged in the search for suitable computer packages. Firms realised that each had a particular way of operating and therefore packages must be sought which were consistent with their approach.

The resolve of some firms to get what they require is illustrated in an interview with Gleeds associate manager, Noel Stephens, in which M.Jarrett (1989) quoted him as saying "We found we had to work hard to get the computers to do what we wanted". Gleeds had used computers from the early 1960's and had much experience in harnessing them for Gleeds' tasks. Gleeds found they had to write a number of programs by themselves in order to get what they wanted.

In a research project into controlling a site by admittedly financial rather than progress charts, R.Z.Abdullah (1989) states

*"There is a gap between what is written in textbooks and articles and what the construction Industry actually uses.*

*A gap also exists between the software packages available and the construction company requirements..*

*These two gaps mean that cost control and monitoring systems (Site control systems) lag behind other construction management techniques in their effectiveness."*

#### **1.4.2. What has been done as a result of these trends?**

Two main approaches exist to get what a firm wants:-

- 1.4.2.(a). selecting - or changing to - a suitable package, or
- 1.4.2.(b). tailoring a package to suit the company's particular needs.

#### **1.4.2.(a). Selecting New Packages**

There is a vast variety of packages to choose from. They consist of a constant supply of upgraded or entirely new computer network analysis packages.

G.Reiss (1989) states *"There are some 150 packages available on a very wide range of hardware configurations. The range starts with free 'Shareware' packages through cassette systems for the Sinclair Spectrum to an enormous range of PC software up to mini and mainframe systems costing many thousands of pounds."*

The same edition of the magazine in which Reiss's article appears lists many companies vying with each other to sell some of these 150 marketable programmes.

#### 1.4.2.(b). Tailoring Existing Packages.

Ways of tailoring an existing package to a firm's specific needs are:-

either to modify an existing package,  
or to link various standard packages together, ie use "add-on" modules.

##### 1.4.2.(b)(i). Modify Existing Packages.

An example of the first approach is described in the Spring 1989 edition of Construction Computing where there is a case study of Wimpey's search for a suitable network package to replace their existing one. *"Four leading packages were tried in what was to be a five-month evaluation programme. After only one month it was found that none covered all the specified requirements, and neither were they able to persuade the vendors to help customise the programmes."* (My underlining.) Eventually Wimpey found a potentially suitable package, "Open Plan", which because it was newly introduced to the market, was tailored by the suppliers to suit Wimpey's specific needs.

To meet the need that each firm has of a slightly different package, Metier now market their "Planning 9000" package in a variety of slightly different configurations. The package is incomplete in the sense that once the purchaser has selected the configuration closest to his needs, provision is made for the purchaser to develop the package further as his needs develop. In this case he uses Metier's "Artemis" Language.

##### 1.4.2.(b)(ii). Linking Packages Together.

D. Judd and N.King (1988) report that the UK company, Taylor Woodrow, have not only been using computer programming packages since the 1960's but have continuously developed their own add-on modules for existing commercial packages.

They not only use these add-on modules in-house, but also sell them to other interested companies.

Examples of Taylor Woodrow's add-on packages are "Preprod", and more recently Judd and King (1988) their latest package, i.e. "Arrow".

[Preprod: An enhancement feature for working alongside network analysis packages such as "Plantrac" and "Pertmaster". It covers pre-production planning and establishes data bases, check lists, and similar.]

[Arrow : An enhancement feature for working alongside network analysis packages such as "Plantrac" and "Pertmaster". Its function is to produce excellent printouts of timescaled networks or linked barcharts.]

Producers of existing complex packages are introducing user-friendly add-on modules for their products. For instance Plantrac has recently introduced their "Easyplan" package.

Further examples of contractors linking packages are given in Rita Robison's (1986) article on successful use of packages by site based computers when she reported that most users had tailored their packages to their needs. In virtually all these cases the contractors had linked different packages to create the management tool most suitable for their needs. One user stated, "*Although we use Primavera on other projects, there were not so many activities to control on this one, and we used Pertmaster that was interfaced with Primavera.*"

### **1.4.3. Matching the package to the culture of the country.**

Another aspect of matching computer packages to the needs of a company is that each country in which the company operates has its own, different culture.

A prominent manager in a local construction company who frequently travels overseas made a relevant observation.

In Europe people move up the career ladder very slowly indeed - promotion normally occurs when dead men's shoes are filled. It is the place of Master Craftsmen in the true sense. The kind of computer package favoured there is the one that is linked to many output areas. For instance, a line drawn by CAD will effect the Schedule of Quantities, the estimate, the buying orders, and the programme for the contract.

In the USA packages will be taken up and discarded rapidly. In a nation of few backup staff it is likely that the person who needs the information will have the product on his desk. He is unlikely to be an expert in the European sense.

In South Africa the average user is likely to "play" with the package. He will dabble in all sorts of packages and "make a plan". His capability may be brilliant or amateurish. It is unlikely that the package will ever reach its full potential. It will probably never have to!



## **1.5. POSSIBLE REASONS FOR THE SUCCESS OR FAILURE WITH NETWORK ANALYSIS TECHNIQUES IN THE CONSTRUCTION INDUSTRY.**

While there has been feverish activity in the market place in attempts to get Network Analysis Techniques with computer support to work productively in the construction industry, much research has been simultaneously carried out in an attempt to determine just what causes these techniques to succeed or fail; to be accepted or rejected; to be needed or not needed.

Summaries of these investigations follow. They are grouped into three sections:-

- 1.5.1. Problems with the use of Network Analysis Techniques.
- 1.5.2. Considerations favouring the use of Network Analysis Techniques.
- 1.5.3. Spheres where network analysis Techniques are always regarded as successful.

### **1.5.1. Problems with the use of Network analyses.**

#### **1.5.1.(a). Does the project really need network analysis?**

Kersner (1984) gives a simple reason for failure of network techniques, and that is that companies should ask themselves whether or not they actually need PERT for a particular project because unnecessary problems and costs are caused by using ill chosen techniques.

Two further practical examples of network analysis being an ill chosen technique are given in a paper by P.F.McEwan (1979) on the planning of a base metals mine at Aggenyuys.

- a). It was necessary to tailor part of their computer package in order to be able to apply it to a housing scheme. In looking back he says, "*This programme operated successfully, but, there are doubts whether the complications thus introduced are really worth the effort.*"
- b). A major subcontractor found that out of 10 months for a contract three months would be taken up if an acceptable programme was produced using network techniques. They believed there were quicker ways of getting the contract going.

In the light of this which project should be then be networked? One simplistic answer is given by L.R.Stuckenbruck (1981). "*Usually any project of \$1m (1981) in cost - or greater - can benefit from applying network methods.*"

#### 1.5.1.(b). Are the present forms of network analysis suitable for the building industry?

Doubts expressed about the general suitability of these techniques, have made investigators aware that the presently available systems are not specifically developed for the construction industry.

D.Arditi (1983) indicated that network analysis as known then would not necessarily be successful in the construction industry. He pointed out that network planning techniques were not developed in the construction industry. PERT was developed for planning the development and manufacture of a military weapon system: CPM for minimizing downtime on the regular maintenance schedule of a chemical company. These techniques were 'lifted' out of these fields and 'dumped' on the construction industry. Various attempts were then made to 'fit' these techniques - sometimes after much investigation and research.

However he states that until such research is widened from mere

- a) methods of resolving uncertainty in construction operation and

b) methods of presenting the data for site use

to include research into *"the organisational, cultural, psychological, sociological, behavioral, and economic aspects of network applications , these techniques are bound to remain underused or used without success."*

[This research is now underway at Technion Haifa and the University of Texas: see Appendices for extracts of the research.]

#### 1.5.1.(c). A changing focus?

It may well be that in construction firms there has been a shift in management practices from focusing in on network analysis to other spheres.

There has been research into this change in focus in the USA.

A survey was conducted in 1986 amongst small to medium sized American construction firms by E.Koehn (1988).

This was a follow-up survey to one conducted in 1981 and in turn similar to one conducted amongst the top 400 USA construction companies.

The survey found that the growing problem amongst these contractors (in productivity terms) is "labour relations on site". The ratings for items with a "high-potential" for possible "on-site" productivity improvement were given as :-

	<u>1986</u>	<u>1981</u>
"Site Supervision"	73%	62%
"Labour Relations"	68%	51%
"Wage Agreements"	62%	52%

"Delivery of materials" (59% up from 46%) was also a growing problem.

Results for the top 400 construction firms were similar.

The ratings for "Main-office" functions showed that the growing problems were:-

"Procurement of Materials" ( 32%, up from 21%), and  
"Communication" (55%, up from 49%).

"Planning and Scheduling" remained approximately constant at 53%. Because a few respondents changed the rating of the possible improvement in "Planning and Scheduling" from "high-possibility" to "medium-possibility", observation was made that some companies were beginning to accept the present position in these fields as normal.

This would indicate that improvement in productivity in the area of "Planning and Scheduling" through the use of network analysis techniques or other systems is not a priority amongst many of these companies, and may contribute to the conclusions of previously quoted surveys.

A slightly different view of priorities is mentioned by other researchers.

Some investigators, for instance, feel that managers have concentrated on planning at the expense of other aspects. In a holistic view of network analysis, Laufer and Tucker (1987) *state that "Managements perceived ability to effect the time goal more than the cost or quality goals is reflected in the greater attention given to the planning of the schedule, and to the lesser attention given to construction resources and methods statement."*

In an earlier paper Erskine-Murray (1972), came to the conclusion that it is vital to increase the effort devoted to "methods planning" at the expense of "resources" and the attention given to "scheduling".

#### 1.5.1.(d). Network planning: An end in itself.

When productivity improvements in the wider sense are considered, then one aspect namely that of obtaining optimum productivity from workmen must be constantly kept in mind. In a summary of major motivation surveys carried out mainly America N.R.Mansfield (1989) found that it was consistently reported that workmen like to be kept occupied. They hate waiting for materials, instructions or decisions, and dislike having insufficient work to do. Planning should be a means of meeting this

requirement. It is not an end in itself. Thus should network planning become an art/end in itself, then the planner has lost sight of its real value.

The planner forgets the oft quoted maxim "*Planning and doing are different parts of the same job; they are not separate jobs.*" (Steiner, (19691).)

Or put another way; "*The planner is seduced by computers and forgets that his primary function is to produce plans that work.*" [Mason (1982)]

B.N.Baker et al (1988) reporting the results of a 1972 survey states "*The over use of CPM-PERT systems was found to hamper success. It was the judicious use of CPM-PERT which was associated with success.*"

#### 1.5.1.(e). Difficulties caused by "planning" and "doing" carried out in different places.

Planning which is devised and performed independently in different places is a potential failure.

However there is a problem. To what degree can it be done successfully in other ways?

Laufer and Tucker (1988), quote studies which indicate the amount of time a line manager has for concentrating on a particular aspect of his work. This aspect is important as "*planning must be carried out within the protective shield of large blocks of uninterrupted time.*"

*"Are allowances made for these prerequisites in managers' job assignments? The work they do has been extensively, if inconclusively studied, but there is enough evidence to indicate that their activities are typified at all levels by brevity, variety and fragmentation. Mintzberg found half of the activities by American chief executives lasted less than 9 minutes, and only 10% to exceed one hour. A study of British middle and top managers found them working without interruption for half an hour or more only once every two days. As for low level managers, a study determined that US foreman averaged 583 activities during an 8-hour shift, a change every 48 seconds."*

In order to plan, however, a person requires a stressless working atmosphere with few interruptions. He finds that even when he is consulting with line managers, their meeting is frequently interrupted or brought to an abrupt end by interruptions.

Managers therefore sometimes work over weekends and at night to have uninterrupted time. However, this is only partially successful as they have no one with whom to consult. If their plan is to win the commitment of the doers, then they must be part of the planning process. This approach only resolves the problem partially.

Laufer and Tucker (1988) found the situation to be as follows:-

*"The more progressive construction companies follow a practice of creating separate and independent planning and scheduling units responsible for the preparation of plans which are then submitted to line management for approval. What happens in reality is that planning is based on incomplete information and is carried out without true decision authority and implementary power. Unsurprisingly, planning is treated at best as forecasting. The manager operating without plans, performs in a reactive style which more resembles crisis management than planned management. This breeds a vicious circle of urgent situations that leave no time for planning.*

*"To sum up the situation: we have a planner who produces only forecasts, a manager who makes only short-term decisions, and there is no one to do forward planning. This fits well Ackhoff's conclusion that when planning and doing are separated `planning is given the kiss of death.'"*

#### 1.5.1.(f). Excessive information to assimilate.

One of the great changes brought about by the introduction of the computer is its ability to generate great volumes of data on paper for managers and staff to digest.

*"Managers find it impossible to assimilate over abundant, over elaborate, irrelevant data." [Bennett (1983), and others, etc]*

Harrison (1985) p 75 makes the point that there is a difference between `data' and `information'. *"The distinction between data and information is important. For example, the data in a procurement report may be 150 pages of computer print out, but the information is six lines of computer printout which states that six orders are going to be late."*

1.5.1.(g). Has the programme produced the "optimal" result?

Allam, 1985, states, *"The grounds for their disenchantment with CPM lie in the lack of success with optimisation. Packages regard projects/construction contracts as being either time-constrained or resource-constrained. However surveying 48 UK construction companies Allam found that in 63% of the cases both constraints occurred simultaneously. In Egypt a similar survey with 15 companies gave similar results. Further personal interviews with Egyptian project and site managers - admittedly from the same company - again found that 85% of them agreed with what he had found in the UK."*

An investigation into the methods used within packages to optimise results, revealed that different packages use different heuristic rules to schedule activities. Many of these rules are kept secret by the producers of the packages for proprietary reasons.

1.5.1.(h). People problems.

*"People problems are the most difficult obstacles in applying CPM"* (Laufer and Tucker (1985))

D.Cohenca (1989) quotes a respondent to explain the often indifferent attitude of management to planning :- *" Planning costs - Doing pays"*

Kersner (1984) gives a number of people related problems. They are:-

- 1). Managers feel they are giving up personal power if they commit themselves to a network.
- 2). Younger managers are better educated than the present senior managers who resent or simply remain unconvinced by the alleged effectiveness of new techniques. They tend to put spanners in the works either deliberately or through ignorance.
- 3). Plans are devised in remote locations and then site staff - the doers- are expected to carry them out. The site staff - even if the plan network is sound -

do not "own" the programme, and therefore are not committed to making it work. One researcher mentions numerous projects whose construction schedules were deliberately sabotaged by rebellious site staff.

- 4). Managers believe the network to be the final answer forgetting it is merely a statement of intention at a particular time.
- 5). Many people have simply come to expect too much from PERT-type networks.

Laufer and Tucker (1988) also support 3). above. *"Studies demonstrate in fact that separation between planning and doing causes partial and deficient implementation of plans. Bass and Levitt showed that performance and attitudes were better when subjects were using plans developed by themselves rather than by others. The difficulties of proper understanding of decisions made by others - always a crucial factor in implementation - was found to be a prime obstacle, particularly with regard to planning which creates abstractions that are difficult to communicate."*

D.Arditi (1983) with similar views to 3 above, states *"It is the belief of the writer that novelties introduced without the consent and enthusiasm of those involved are bound to result in spectacular failures."* His comment is consistent with the oft repeated international research into "what workers expect out of their jobs". "Money", surprisingly enough, invariably ranks number five on a list as devised by the worker, but it is "Feeling in on things" which is always top of the list devised by he worker. (Here `worker' means a person being supervised at whatever level). It is the latter finding which is relevant to this paper.

Mansfield (1989) states that job satisfaction is the catalyst which leads to high productivity and job dissatisfaction is the catalyst which leads to poor productivity. "Being in on things" leads to more satisfaction. Mansfield quotes studies which also showed a drop in foreman morale for having a less participative role in larger projects.



### 1.5.1.(i). The effect of Gamesmanship.

Besides the pure task of planning the contract, power play and politics exert their subtle influences on the planning process.

G.H.A.Morton (1983) described how planners typically ( and naturally ) gained power on a contract. A power which they could use for various ends.

In order to perform properly a planner needs to see much information. He must therefore be placed in the path of existing information flows. (Memo's, letters, telexes, faxes, minutes of meetings, drawing transmittal forms, requisitions, orders, expediting reports, goods-received notes, progress reports, etc). He has valid reason for seeing these documents.

This knowledge in itself is frequently gives the planner considerable power.

Morton points out that the planner, in addition to seeing all the information flows, will attend many meetings, particularly the progress review meeting. If the planner wants to take advantage of his position to give him maximum power, the planner should volunteer to take the minutes, and as minute taking is usually an unpopular task, he would get the job.

The planner is then in the position to :-

- \* carefully record commitments to take action
- \* to repeatedly bring them to the committees attention by including items week after week .
- \* to divert the committees attention elsewhere by dropping an item.
- \* record the minutes in such a way that responsibility for success or failure is fairly - or unfairly - distributed or attributed.

In other words the planner through manipulation has the ability to influence, if not actually control, the future outcome of the project.

Morton goes on to say *"We have looked at the planner's source of power and at the dynamics of power in project relationships. In practice, on large projects, a triumvirate may develop: the project manager becomes a statesman, primarily concerned with the management of external stakeholders in the project; the construction manager becomes a chief operating officer, and the planner becomes the manager of the project, an integrator and strategist."*

The author's experience on four large projects in Cape Town would serve to confirm this view by Morton.

#### 1.5.1.(j). The Adverse Effect of network analysis as a control tool.

Network analysis performed by computer is a powerful control tool. Excessive pressure on site personnel to comply with a construction schedule can result in them becoming totally distracted from today or tomorrow's tasks in order to produce an historical record of yesterday's problems. They often find it more advantageous to use their mental energy preparing a justification of what happened yesterday than in trying to improve their plans for tomorrow.

Pressure on the planner can even result in him adjusting his plans to match actual performance.

#### 1.5.1.(k). The problem of realistic input.

In his article on CPM's effectiveness A.Jaafari (1984) attempts to place the blame for the alleged failure of CPM produced networks on the shoulders of the planner on the basis of "Garbage in, Garbage out". If the planner had a lack of understanding of the relationships of the project and was provided with unrealistic assessments of productivity for tasks, there is every likelihood that the plan will not work.

#### 1.5.1.(l). The Lack of Repetition.

One characteristic of the building industry is the lack of repetition. Many projects by their nature are "one off". There is no repetition. In energy conversion plants, by contrast, there is the annual shut down. The previous shutdown's schedule can be

reused and improved upon. In the building industry everything happens just once. There are no cost or experience benefits to be gained by reusing a previous plan.

It is this lack of repetition which makes computer aided network analysis so unattractive for the building industry.

To overcome this problem, and to increase productivity, D.C.Uprichard,(1986) has come up with the proposal that there should be a library of "Standard Network Modules". When preparing the construction schedule for the contract, these blocks could be assembled to give the overall programme for the contract. He believes this strategy would be effective in 50% of tenders for contracts.

This strategy would also reduce the high cost of development of new, unique schedules for each contract. And the familiarity of working with standard modules would also lead to yet higher productivity.

In some ways this is coming closer to the area of artificial intelligence.

### **1.5.2. Considerations favouring the use of Network analysis.**

#### **1.5.2.(a). Reports on Successful applications.**

In one article on the effect of having computers on site, Rita Robison (1986) painted three glowing pictures of contracts managed with the assistance of on-site computers.

- 1). Mike Sanders was a Project Manager of Scotsman Mfg which erected modular buildings. He used to spend at least two days updating handdrawn critical path networks for three to four construction projects. By matching new contracts to standardised plans and production schedules, he could now produce or handle as many as seven projects simultaneously and update them in half an hour. His biggest spin-off was the ability to resource level between projects. Should resources be overextended he could play "what-if" games to reschedule contracts. In addition he could work from any location and leave a hardcopy of a workable programme for the site staff.

- 2). A consortium of contractors rebuilt Philadelphia's Schuylkill Expressway. They all used the same computer package for scheduling work. The contract parameters changed so rapidly with changing conditions that frequent updates were necessary. The programme was updated weekly and the updated information was distributed among the many parties concerned on floppy discs. The package produced short duration bar charts for specific areas of the site. This was found to be most successful because this information could be quickly and easily pulled out of the master updated network plan.
- 3). A fire destroyed a main aircraft repair hanger at Tinker Air Force Base in Oklahoma. Repair work started immediately. Naturally many stoppages occurred as damaged work was uncovered revealing greater than anticipated damage. By quickly referring to a network analysis the contractor was able to minimise delays by moving resources to the next most critical area while plans were made to cope with the area of greater than expected damage.

1.5.2.(b). The need for these systems owing to the complexity of modern contracts.

Emphasising success with the technique when there is a genuine need, D.Arditi (1983) believes that network techniques will only develop properly when there is a need. The need may be internal, external, or simply be forced on the company by economic circumstances. Although limited by today's needs, bar charts are easy to use; they will only be replaced when there is a need to change to another form. "*Construction managers in industrialised countries now realize that bar charts are not adequate any more for large and complex jobs that are built today. Thus, there is a need for an updated, more flexible, more accurate, and more efficient technique. Indeed it has been observed that network analysis can be successfully introduced into a company if, among other factors, there exists a need for such techniques in the firm.*"

Attention to a more specific need is drawn by John Keane (1989) who considers the problem of proving, in court if necessary, the effects of changes to the contract on contract duration. He makes the point that bar charts, although simple to understand, are simply too limited as a technique to show the global effect of individual causes on a contract schedule of work and prove the effect beyond contention. It is only a

logically linked network which will handle this problem. Because of the repetitive nature of the calculations he recommends it be done on a computer.

#### 1.5.2.(c). The prospect of incorporating artificial intelligence into packages.

The future offers the hope of harnessing artificial intelligence to make the production of networks automatic and reduce the amount of input from the planning team.

R.Levitt et al (1988) identify a weakness with present systems and suggest a solution:-

*The "limitations of network-based project management tools result in the need for a repeated input of high-level expertise to adapt and modify plans as project conditions change. Since this expertise is typically scarce or unavailable on an ongoing basis in all but the largest projects; network-based planning tools tend to be used for the initial analysis of project plans, but are not routinely used for ongoing project control, nor for detailed operations planning."*

*"While project managers have been using computerized critical path analysis tools to analyze the project plans that they generate and to archive the impact of disruptions on these plans, AI scientists have been trying to make computers generate simple plans of action for achieving a given set of goals and interpret patterns of project status information in relation to the project plans."*

In a more specific article on the subject D.Navinchandra et al (1988) give an insight into their research work done on harnessing Artificial Intelligence to the task of producing networks for a contract. They describe the state of their programme, "GHOST", and describe the stage at which they are at the moment. They illustrate their article with the example of a building to house a transformer. All that is input is the list of activities of the order of a). "Build foundation", b). "Build col A", c). "Build column B", d). "Build lintel". The package eventually produces a network showing a complete list of activities. Eg for the lintel :- "Erect supportwork", "Make and erect formwork", "Fix reinforcing steel", "Cast concrete", "Cure concrete", "Strip formwork", "Remove supportwork."

The authors refer to work done in 1988 by Chereff on "Automated Generation of Construction Schedules from Architectural Drawings"

### 1.5.2.(d). The Advantages offered by Personal Computers.

Following a measure of agreement by manufacturers on the standardisation of computers in the "Personal Computer" class, economies of scale have brought about price reductions which in turn have made personal computers readily available to firms and individuals.

The existence of a larger market has in turn encouraged the producers of software to develop a whole new range of user friendly packages which are menu driven and require one finger operation.

Simultaneously ongoing hardware developments have produced personal computers yet more powerful and useful. The recent introduction of Laptop computers has meant that managers can take their "assistant" anywhere. Thus at this stage there appear no limits to future possibilities for greater computer use.

Side by side with these developments has been the emergence of a greater pool of computer literate people.

A practical indication of the effect of these developments was heard by the writer at a seminar in London on the 25th October 1989 when the presenter stated that Mettler had sold 1000 Artemis packages for mainframes over a period of ten years, while their Personal computer version had sold 15 000 packages in the three years it had been on the market.

Bigger packages now incorporate so many features that they can be said to comprehensibly manage projects. Network analysis, the focus of this thesis, is but a small component of these packages. Facilities are available through calendars to indicate when resources are available. Other facilities store information about variable and fixed costs for each resource. Skills scheduling, the controversial information store regarding the relative efficiencies of workteams on a set of standard tasks, is already in existence in commercially available packages. And the programmes are powerful enough to answer questions such as who must do what at what minute of what day and using what method to finish the job in so many months and what it will cost to do it this way.

W.Charette and W.S.Halverson (1981) state with much enthusiasm:-

*"Experience indicates that it doesn't take longer to plan a project using network techniques than traditional methods, but the network method yields more accurate and detailed plans. For monitoring, network techniques far exceed traditional methods in speed, accuracy, and reliability. For replanning or evaluating new factors, the network method has no equal among traditional planning tools."*

Having said that they state clearly where they believe computer packages have an advantage. *"The value of computer packages lies in the modern facilities for displaying and printing graphics in formats easily assimilated by the eye. These formats are cheaper and quicker to produce by computer than by draughtsman."*

G.Reiss (1987) believes that in the future interactive video / computer graphics will overcome many of the present shortcomings of planning packages.

Only a small part of the exciting field of opportunity offered by computers has been gathered together in this section of this paper. If but a small section of available ideas is applied to the construction industry it cannot but be a benefit somewhere.

### **1.5.3. Spheres where Network analysis Techniques are always regarded as successful.**

Despite the arguments advanced for using, or for not using, the network analysis techniques, there is a consistent body of opinion which says that the techniques will always be beneficial to the contractor if used in certain ways.

In essence the greatest benefit is obtained by merely going through the exercise of doing a Network Analysis. Some examples of this are given below.

The experience of many practitioners is summed up in the popular management cliché, *"After you completed the planning you could lock up the plans in a desk draw, and still derive 90% of the benefits of the activity"* (Dermer, 1977),

Dr Martin Barnes, when speaking to the author in about 1978, told the story of the UK project manager working in the Middle East who spent two weeks playing around with a sophisticated computer package which did network analysis. While at the end of the two weeks the Project manager did not know whether the predicted outcomes of

certain strategic decisions would in fact be realised, he did know what would most likely happen and what to look for when he implemented certain changes.

The value of foresight in project planning is confirmed in a report by Ahaja and Nandakumar (1985) who reveal that early recognition of future events, such as a potential delay, can be significantly helpful to the contractor and the owner in reducing their adverse effects.

Some students of planning techniques believe that the mere knowledge of "*what will happen if.....*" often outweighs all other advantages of networking analyses.

A. Jaafari (1984) quotes a manager who said "*Its greatest benefit in our firm has been the necessity for the project and site managers to `know' the project in detail before the work is actually done*".

Project Managers should manage jobs with the assistance of network analysis and should not use it as a substitute for their knowledge and experience. B.Paulsen (1976) states that managers are led to expect too much from a Network Analysis. "*The Network is a guide and not a Bible masterplan.*"

Prof Keith Lockyer speaking at a lecture attended by the author held that any programme containing more than 35 activities was too big. No one could comprehend any greater amount of detail. He was stressing the point that at each level networking must be kept simple to be useful.

Bruce N. Baker et al focus on this aspect by referring to a 1974 survey in which the following question was asked :-

*" Is the use of PERT/CPM systems the most important factor contributing to project success ?"*

The answer was :-

*"No. PERT/CPM systems do contribute to project success, especially when initial over optimism and/or a "buy-in" strategy has prevailed in the securing of the contract, but the importance of PERT/CPM is far outweighed by a host of other factors including the use of project tools known as "systems management*



*concepts." These include work breakdown structures, life-cycle planning, systems engineering, configuration management, and status reports. The overuse of PERT/CPM systems was found to hamper success. It was the judicious use of PERT/CPM which was associated with success."*

McEwen (1979), in his assessment of the value of network analysis as applied to the base minerals mine in the Northern Cape, to which previous reference has been made, makes these positive statements:-

*"The question then is, "When is the program correct?" There comes a point when obvious errors and inconsistencies have been attended to and the networks are in an acceptable state to put into use. Again review will enable problems to be attended to as they appear and the user has to have some faith in the planner but must not be blinded, by the computer print out. He has to realise that he has been given an aid but still has to use his judgement."*

*"The need for proper, rational, formal pre-planning is the one point which has emerged most strongly from this work."*

## **1.6. THE NEEDS OF THE CONTRACTOR WITH REGARD TO SCHEDULING WORK.**

### **1.6.1. Section Outline.**

This section contains summaries of literature focussed on the construction industry: literature which attempts to define the `needs' of the contractor with regard to scheduling work.

The literature already gathered under the preceding headings also contains findings implying a `need': a `need' which was not necessarily emphasised as such under those headings.

What literature says about the `needs' of contractors is gathered under the following headings:-

#### **1.6.2. To plan with an emphasis on material delivery dates.**

#### **1.6.3. To plan optimising resources:-**

- a) between sites
- b) on a site
- c) the best way to optimise.

#### **1.6.4. To plan in the short term:**

- a) As a matter of policy.
- b) Due to uncontrollable factors.

#### **1.6.5. To produce work schedules for a section.**

1.6.6. To produce work schedules that are easy to grasp.

1.6.7 To form the basis of future claims.

1.6.8 To control progress on contracts.

[For another review of contractors needs, but through the eyes of another panel of researchers, see the extracts of research being done at Technion Haifa and University of Texas in the appendix.]

### **1.6.2. To Plan with an emphasis on material delivery dates.**

On certain types of contract requiring components with long lead times, or in times of shortages of components, it is the delivery date of the components which frequently determines the schedule of work for the contract. There is thus the need to determine the delivery date of components, and then to continually monitor progress to ensure that they are delivered to the site on due date.

Taylor Woodrow, for instance, have developed and continuously use the add-on module - "Pre-Prod" - which performs this function. (The module was described earlier in this paper.)

Shtub (1988) describes an approach to material management on large, complex, construction projects. It is based on using CPM and linking this to a model of the procurement process. (eg MRP - Materials Requirements Planning ). On certain types of contract he has found material management to be a very real practical problem and too many schedules of work were belatedly found to be impractical because they ignored the long-lead times for key materials.

Shtub adds an inventory control module to a CPM module and inventory data to the systems data base. He describes a logical way in which lead times are integrated into the schedule. His overall aim is to minimize the cost of projects taking account of the costs of delayed activities and the costs of expediting orders.

He reports " *An attempt to integrate CPM and material management on a large construction project resulted in reducing the length of the project by about 20% compared to the original contract. The project contractor supplied a new hospital including all the required furniture, equipment, and 20 modular buildings that were*

*ordered from outside vendors and assembled at the construction site. The original contract called for a duration of 20 months but the project was finished within 16 months."*

Chase and Aquilano (1985) propose in detail a new approach to project scheduling with CPM/MRP. Their method pegs resources to activities and these are controlled as well as the activities.

### 1.6.3. To plan optimising resources :-

#### 1.6.3.(a) between sites

Oxley (1989) claims that contractors are limited by scarce resources, and claims that what contractors actually need is a package that schedules, not a single contract, but all the contractor's contracts simultaneously. This multiproject approach moves scarce resources between contracts.

Examples of such a scarce resource could be a specific tower crane, a specialist subcontractor with limited resources, or a craftsman highly skilled in a specific task.

#### 1.6.3.(b). on a site - "Resource Levelling".

In this approach an attempt is made to avoid peaks and valleys in resource requirements by levelling these *within the boundaries of a site* to obtain a more uniform demand. The demands on resources are levelled by using the various floats to reschedule activities so that the peaks and valleys can be smoothed.

#### 1.6.3.(c). the best way to optimize.

Some comment on this matter has already been reported in section "Has the programme produced the 'optimal' result?"

This can be a simple or complex operation. It can merely be an exercise in rescheduling activities by using certain of the heuristic rules that follow, or it can be a highly complex calculation involving linear programming, skills analysis, etc, in addition to the mere network analysis techniques which are the subject of this thesis.

For instance, some companies have now introduced 'Skills Scheduling' into their computer packages. The efficiencies of different teams relative to each other in similar tasks are fed into the computer. The computer works out the 'best' schedule of work, not only in terms of 'timing' by means of network analysis, but also in terms of the most advantageous allocation of work to teams using linear programming. This is but one simple example of possible complexity in optimising.

However, this paper is confined to network analysis techniques.

A number of writers have investigated just what heuristic rules give the 'best' result when using network analysis techniques.

Allam (1988) reports on his investigation into a variety of heuristic rules. He lists them as follows:-

- The critical indicator - type of weighted ranking for sequence.
- The earliest completion due date.
- The earliest modified completion due date.
- Minimum slack.
- Minimum proportional slack.
- Total Work content.
- The weighted activity indicator.

He comes to the conclusion (as yet untested on an operating contract) that when duration and resources are under pressure, his rule of "minimum slack" will generally give the optimum result when resource levelling.

J.J.Moder (1988) reports that:-

*"Two categories of heuristics that have been found to be most effective are those incorporating some measure of time, such as activity slack or duration, and*

*those incorporating some measure of resource range. Davis has made an extensive comparison of eight heuristics on some 83 network problems for which optimal solutions were obtained using his bounded enumeration procedure."*

The rules tested included :-

- Minimum late start time.
- Minimum late finish time.
- Resource scheduling method.
- Shortest imminent operation.
- Greatest Resource Demand.
- Greatest Resource Utilization.
- Most Jobs possible.
- Select jobs randomly.

Moder cautions that although "Minimum late start time" gave the best result most of the time, "*should the planner want to be sure of the optimum solution, then the planner should actually apply all eight rules in each case.*"

#### **1.6.4. To plan in the short term.**

This is required either on a policy basis or because of uncontrollable factors.

##### **1.6.4.(a). As a matter of policy.**

Some contractors regard their official work schedule as a 'coarse' plan and require, as a matter of policy, that the site staff plan in fine detail on a weekly, or other short term basis. For instance some companies require both a 'five week', running, "look ahead" work schedule in fair detail and a weekly work schedule in fine detail.

#### 1.6.4.(b). Due to uncontrollable factors.

Invariably the programme needs frequent updating (eg daily) due to uncontrollable factors - eg absenteeism, shortages of materials, inclement weather (rain/wind), late changes to the design of the project.

In order to appreciate the complexities of trying to use network planning at this level, consider the effect of (say) rain on the programme. In his original network analysis the planner attempts to solve the problem by including average delays due to inclement weather.

The planner can do no more than allow (say) 15 rain/wind days per annum. However the *duration* and *intensity* ( deluge or continuous drizzle ) and the *actual stage* of the contract during which the inclement weather actually occurs (open trenches or roof already complete) have significant yet different effects on the programme.

However the site staff deal with the problem differently to the planner's average delay approach.

The site manager/foremen attempts to maintain continuity of work for his labour force. This means that during "good" weather (dry) he pushes ahead with outside work (eg- foundation work, pipelines, and the concrete frame) and deliberately allows undercover work to fall behind schedule. The labour force then have something to fall back on when bad weather comes and do not have to be laid off. When the "bad" weather (wet) comes the men work undercover and the undercover work is brought up to, and even ahead of, schedule.

Should the "bad" weather continue too long, the available undercover work may run out and the site manager/foreman may be forced to perform exposed work. Then the workforces' efficiency is reduced due to working in rainsuits, sliding in wet clay, etc. Such conditions obviously alter the parameters by which the planner had determined the duration of activities.

Another type of uncontrollable situation occurs typically on a reconstruction contract. As the work proceeds totally unexpected 'things' are uncovered.

These unforeseen factors can occur at any moment on a reconstruction contract and can cause delays while solutions to the problems caused by the

factors are found. There is therefore a need to be able to consult the network and quickly determine where resources can be effectively re-allocated to minimize the delay.

Both the above uncontrollable factors require either

- (i) that the graphical presentation of the work schedule is such that merely by looking at it the site manager can make the correct decisions, or
- (ii) that the computer and package are readily available - on site if possible - for the rapid input of new information and the speedy recalculation and printing of new work schedules.

#### **1.6.5. To produce work schedules for a section.**

A master programme is adequate for a site office. But each team or gang needs its own short-range, area-bound work schedule.

In order to address this problem the ability of a package to produce a *short range* bar chart for a *particular section* of a contract in sympathy with the requirements of the main network is vital.

This is normally achieved by using the "activity coding" (or the American term "work breakdown down structure") facility in the package. Activity coding includes facilities for encoding gang type, area of work, trade, etc. The required information (for, say, a specific section of the contract) can then be extracted using the relevant part of the activity code.

#### **1.6.6. To produce work schedules that are be easy to grasp.**

The graphical presentation of work schedules must be such that the user can quickly assimilate the information he needs.

Taylor Woodrow have developed the add-on module "Arrow" (previously described) to enhance the graphical presentation of standard commercially available packages.



Other companies claim their packages have superior graphics for the display of charts.

Packages and printers able to display various types of pattern or colours are a distinct advantage.

#### **1.6.7. To form the basis of future claims.**

Some contractors see network programming firstly as a means of establishing the basis for future contract claims, and then as a means of quantifying and proving the extent of these delays (when they occur) for monetary purposes.

H.Berman (1987) states that the most important technical specialist in a litigation team is the schedule analyst. It is recommended that he has a degree in engineering, five or more years of project experience, and five years in CPM or other form of schedule preparation /analysis. He goes on to state that it is impossible to understand the interrelationship of tasks on a large contract without CPM.

#### **1.6.8. To control progress on contracts.**

The nub of this aspect is the need for the package to produce an exception report.

Proper contract control is actually a function of a number of aspects. This is summarized by Harrison (1985) :-

*"The requirements of a good control and information system are as follows:-*

- 1. It must bring to management's attention quickly deviations from planned performance so that action can be taken to correct them, co-ordinate other activities with them, or take decisions to effectively manage the project.*
- 2. It must not only bring these deviations to management's attention, but also highlight them for those responsible for the activities concerned.*

3. *It must be able to be used, when combined with the project implementation plan, to effectively motivate people to higher performance by:-*

*(a) positively - showing people what is required to achieve high performance and keeping them informed of their performance;*

*(b) negatively - making people aware that if they do not meet the planned performance, then it will be brought to senior management's attention.*

*"A good control and information system must therefore meet the following standards :-*

1. *It must make use of three sets of data:*

*(a) a base level of performance, i.e. progress, costs or resources used;*

*(b) the actual performance, i.e. progress, costs or resources used;*

*(c) the earned value obtained by the use of these resources.*

2. *It must use these three sets of data to extract management information for decision and action by both variance and performance analysis. This data must be effectively analyzed to present to the manager information and not just raw data.*

3. *It must not tell you what has happened, but also what is going to happen if present trends continue, i.e. it must be forward looking and not backward looking.*

4. *It must be sensitive enough to pick up the beginning of deviations from plan or budget so that action can be taken early enough to have an effect.*

5. *It should therefore produce information quickly, both for as short as possible a time period and as soon after the end of that time period. Therefore although a four- week period is the convenient measuring period, weekly and two weekly periods should be considered, and the maximum delay in producing information should be two weeks and more preferably one week.*

6. *Although the data should be filtered, consolidated and analyzed for senior management, where problems or deviations are identified it should be able to trace quickly and easily the root causes of them.*
7. *The earned value used should always be objective, that is factual, and it should not be based on subjective estimates of progress, except on very small packages of work.*
8. *The data used must be reliable.*
9. *It should communicate the information produced to all those involved and not just senior management.*
10. *It should promote time and cost consciousness on all those involved.*
11. *It should be an integrated system involving both progress and cost.*
12. *It should include:-*
  - (a) real time control*
  - (b) Control by involvement;*
  - (c) informal as well as formal information , and*
  - (d) gut feel."*

In section 3) above Harrison says a good control chart is forward - not backward - looking. The actual recording of progress on a contract is comparatively meaningless. It is the use of the data to forecast the future possible state of the contract that is vital for effective management. B.Paulson (1976) gives an outstanding example of such an exception report. It is included in the Appendix titled "Exception Report".

A.Kerridge (1988) explains in detail how to assess progress and shows how this assessment can be used to forecast what will happen if the present trends continue.

## **1.7. THE COST OF PLANNING TO THE CONTRACTOR.**

The needs that a contractor might have for planning are tempered by the knowledge that it costs to plan.

In a previous section, "A Changing Focus", attention was drawn to one possible reason for little general interest in network analysis techniques. Essentially a contractor could get a better return on investment by putting effort into "Labour relations on site" than into "Planning and Scheduling".

But what does planning actually cost?

Planning is very time consuming.

P.F. McEwan, (1979), stated that the experience of a major subcontractor on a South African base metals mine showed that a 10 month contract would actually need three months in which to produce an acceptable programme.

In a recent study (Laufer and Cohenca, 1987), 72 managers of planning and scheduling departments of large US construction companies reported the time required for planning and control. It was found for a 20M dollar construction project lasting 18 months, three man-months are invested in planning prior to the onset of construction, with control (including replanning) in the course of construction consuming 15 man-months."

Chase and Aguilano (1985) give an idea of cost:-

*"The cost of applying PERT or CPM rarely exceeds 2 percent of total project cost. PERT can be used with PERT-Cost. Using PERT-Cost is more expensive, but rarely exceeds 5 percent."*

W.Charette and W.S.Halverson (1981) contradict the previous statements.

*"Experience indicates that it doesn't take longer to plan a project using network techniques than traditional methods, but the network method yields more accurate and detailed plans.*

*For monitoring, network techniques far exceed traditional methods in speed, accuracy, and reliability.*

*For replanning or evaluating new factors, the network method has no equal among traditional planning tools.*

*Experience also indicates that the cost of applying network methods is small, perhaps no more than 0.5% of the project cost. Project time and cost savings return this investment several fold when these methods are successfully applied."*

In order to get some idea of comparative costs, it is generally accepted that the mark up on Cape Town building contract is of the order of 6% to cover "Overheads and Profit".

## **CHAPTER TWO**

**NOTES ON HANDS-ON EXPERIMENTS WITH THE PROCESS OF SCHEDULING.**

## **NOTES ON HANDS-ON EXPERIMENTS WITH THE PROCESS OF SCHEDULING.**

### **2.1. Purpose.**

There is no substitute for hands-on experience in order to acquire detailed, practical experience with various methods of doing network analysis.

The writer wished to obtain firsthand experience of various methods of doing network analysis techniques - both manually and by computer.

The choice of manual techniques was simple. The choice of a computer package was more complex.

The manual methods that the writer instinctively went for - because of more than 25 years experience in the building industry - were of the "time scaled activity-on-arrow network" or "linked bar chart" type.

The choice of computer methods was more complex.

A planner is consistently reported to require six months full time practice in order to become conversant with the facilities of major packages - and this is with constant support from the supplier. Even the most basic computer network analysis package takes much practice to master. Therefore, not only was the writer obliged to restrict himself to basic packages, but was also obliged to accept that in the time available he would only gain the most elementary feel for a package. A detailed knowledge of packages would have to be obtained second hand from those whose daily job it was to work with them.

### **2.2. Method.**

A scenario was devised. The complete scenario is described in the appendices.

Network analysis was performed on this scenario in a number of different ways:-

Manually:-

By drawing on graph paper.

By using stick-on-bars on graph paper.

Using a computer:-

Using a basic package operated by the writer.

Using a basic package operated by an experienced person.

(Note. When considering the comments which follow in the 'by computer' section, it is important to bear in mind that these are packages in the lowest category of a classification system consisting of three price-brackets. Also bear in mind that the packages were not devised specifically for the building construction industry. They are general packages for use by any business using network analysis. Do not infer by these statements that the packages are faulty, or inferior in any way. The packages confine themselves to the basics, avoid frills and the advanced - and therefore more complicated - features of more expensive packages.

The results of the practical sessions are given in "*A Diary of Experiences.*"

### **2.3. A Diary of Experiences.**

#### **2.3.1. Manually: By drawing on graph paper.**

No special equipment needed.

Excellent for seeing what has to be done.

Feeling of real control.

Feeling of accomplishment as finished schedule appears.

Can scratch on another piece of paper and rub out.

Ideal for examining a few events.

Can see all the details of the network simultaneously and easily.

Ideal for making little optimising decisions as I went along. ( eg If I use a stronger concrete here, I could strip earlier and consequently obtain a desired benefit.)



However when I made an error, or wished to change anything, I had virtually to begin again. This meant:-

I had to spend as much time on the change as I would if I was doing it for the first time.

The surface of the paper became messy with rubbing out.

I also had to re-scale each item.

Should I wish to pick one event - eg Strip the formwork to a particular section - and use it as the base-line for another series of events - eg Plaster ceiling, paint plaster -, I would have to redraw that activity. A change in the base-line, would also mean redrawing the built-upon part as well.

### 2.3.2. Manually: By using stick-on-bars on graph paper.

This experiment was designed to use present day stationery and facilities available in the normal office.

A3 sheets of graph paper, Scotch "Post-it Note Tape" No 658, and fluorescent highlighters were bought from a large stationery store.

The sheet of A3 graph paper with 1 cm squares was marked up with the contract calender to a scale of 1 cm = 1 day. This clearly showed all the working days and holidays.

The Scotch "Post-it Note Tape" No 658 was:-

colour coded with highlighters to represent each task in the building.

and cut to a length representing the duration of the respective activity.

This strip was then pressed down on the graph paper. The particular advantage of this tape is the ease with which it can be peeled off, leaving no mark, and then stuck down in a new location. This makes it ideal for changes.

One problem was that the materials had to be acquired. Admittedly they were easily available from a large stationery store.

It took time to prepare the strips of "Post-it Note Tape". A lot of time was spent in annotating each strip. A word processing package would have sped up the annotation of each strip - annotation which was largely repetitive in this case.

However, the fact that stick-on strips were pre-cut to predetermined lengths had advantages:-

They could be marked off in a jig / template - hence the chance of marking off errors were reduced - and never again did the duration have to be scaled out as the same strips were reused when repositioned on the chart.

The annotated strips made it extremely easy to visually assemble the progress chart. This turned out to be a real pleasure. When a break in the continuity of a task occurred due to a public holiday or the end of a page, the strip was simply cut at that point and the space represented the holiday. When it came to an alteration and the break no longer occurred in the same place, the two pieces were merely stuck adjacent to each other again. It was quick to reassemble the chart as there was no need to re-scale each activity.

Little problems surfaced:-

The highlighters smeared the ink used to make annotations, and

The strips were initially pressed down too firmly, although tweezers help to lift off these strips.

The scale had to be large to make it workable. This is not really a disadvantage as ample room on the strips is given for annotations.

Although the scale produced a large schedule, modern photostating machines can easily capture the programme in any desired size. In fact reducing the A3 sheet to A4 size made the chart look very good.

Unfortunately the colour coding on the strips did not reproduce on the photostats. With hindsight it would have been better to have "pattern coded" and not "colour coded" the strips representing the tasks.

By using the manual method I had the feeling of being in totally in control of the situation. I was not distracted by having to gauge the length of each activity at the same time as I was working out the sequence of each activity. All I had to do was to stick down the strips.

I could also use judgement as to when following activities should begin. Either they could begin at the end of the previous item or they could run concurrently, but 1 day behind, etc.

I could control the layout of the work schedule. In this case each task gang was plotted on its own row.

I could see the whole programme at any one time.

I could make optimizing decisions as I went along. ie Does the contract work a full day before the Easter break? If I wished to allow for half a day's work before the start of the Easter weekend it was simple - merely place the activity strip to stop half way through the Thursday.

It was particularly tedious to make changes near the beginning of the schedule. This is due to the irregular length of the weeks caused by the series of Public Holidays in South Africa in April, May, June. Later in the year the regular shape of the weeks made changes less tedious and sometimes gave opportunity for short cuts: eg merely slide the date bar backwards and forwards.

While I was investigating "What-if" situations, or if I had to correct a mistake, all I had to do was to lift and replace the stick-on-strips of paper. I could see the whole schedule at a glance and I never had that nagging doubt that I had forgotten to alter something I could not see. I did not have that feeling that something was happening somewhere else - something of which I was completely unaware.

This manual method would be an ideal means of programming when a group of people was discussing ways of optimising/altering the programme.

### 2.3.3. By computer: Using a Low Category Package operated by myself.

The package was extremely user friendly. By means of pull down menus I could use any part of the package at anytime. I was able to teach myself how to use the package by trial and error, and made reasonable progress 8 hours after starting.

I found I still had to do a measure of data preparation before feeding it into the computer.

Keying in the activities was extremely tedious, although how else could descriptions, etc, be fed in? As many repetitive descriptions were used, a "copy" facility would have been helpful.

The next problem was keying in the linkages. At first I tried to do it by linking activity blocks on the screen. It was too awkward using the keyboard - a mouse or light pen would have overcome the problem. I eventually printed the task list and manually prepared a table of linkages which I then had to tediously type in table form.

Then came the checking.

I tried to check by using the information displayed on the screen. Now the problem which faces all computer users, but is presently unavoidable, faced me. The screen is simply not big enough to see any worthwhile segment of the data. This package had a toggle for 64 line mode ( twice as much information as usual on the screen). This feature helped. The package also had a 'reduce' facility (smaller typeface resulting in more data on the screen) - but simultaneously with each reduction a bit more of the visible data was discarded. Eventually the only information on the screen was the activity down code and linkages. I now needed to refer to both a printed task list showing the identity of the task by activity code, and the screen with the linkages on it.

Eventually I resorted to printing the networks and then meticulously checking the printed network for errors - mainly linkages. This I feel nullifies an advantage of the computer - that of being able to change data and immediately see the effect. Using a print out to check means that once the changes have been fed in, another print out

has to be produced and again meticulously rechecked. This was not the case with hand preparation.

The printed work had then to be studied for possible optimisation opportunities - optimisation did not happen naturally in the course of assembly as was the case with the hand assembly of the time scaled Pert diagram / linked bar chart approach in the first two manual experiments.

When it came to printing the networks, the printing was quickly done - while I did something else. The clarity of the diagrams was most impressive.

The possibility of printing charts in different formats at the push of a key is an exceptional advantage of the computer.

Another great benefit was that after revision - and checking - a network could immediately be reprinted in one of many formats. No time was lost waiting for a draughtsperson to redraw the network before copies could be made. (There would be no need for a draughtsperson either!)

When working with networks it is useful to be able to work in different formats. The speed with which one could change the format by toggling from Pert to Gantt to Data bases for each task was impressive. The fact that a change in one changed the others, was most useful.

Revisions to the network requiring the insertion of non-working days - delays caused by material supply delays, or delays due to wet weather - was a pleasure. Simply change a calendar.

Changing data, particularly linkages was risky as I could not see which linkages were being discarded and/or whether the revised ones were being accepted by the computer. A mistake in typing in but one symbol of the information could affect the final network in any place. Only a complete check of the printed result could guarantee that the change had been correctly made.

It was when I came to play "What-if" games that I realised that my approach to the computer methods was that of a person trained to do the whole operation manually ! To take advantage of the computers ability I should enter the data in a far more basic manner and let the computer calculate the durations. eg:- Each task should have been entered with (say) "total manhours required to complete the task " and resources should have been entered with ( say) "manhours available per day". Then the computer would actually devise the duration of the task. It would then be possible to play "what if" games with the work schedule merely by altering the gang make-up, re-calculating the revised "manhours available per day", and then entering this data into the computer.

I then re-entered the data in order to try out this approach. The data input was tedious. The meticulous checking that the input data was correct was a pain.

Then the problems began - somewhere in the programme there was something wrong - probably operator error - the package began to produce erratic results. Hours were spent getting nowhere. At this stage I realised that if a network has to be produced in a specific time it would be better to do it by the second manual method. If the analysis is done manually, at least the planner can see everything at once and has the opportunity of taking short cuts. With a package there is simply no short cut. All the data must be correct to obtain a reliable output. There was also no doubt that I simply had not yet mastered the package.

#### 2.3.4. By computer; Using a basic package operated by an experienced person.

Another package in the basic category was used in this experiment. It was operated by a person with experience in its use. I wanted to see the effect of a different package, operated by a person practised in its use.

His approach was different to mine in that he had no preconceived ideas about what the end result should be. He had no "mental sets" about building construction. He believed in feeding the computer package with basic data and letting the computer devise the network.

Every link was challenged. Any link based on "Well that is how it will turn out" was not considered. Any link caused by a resource constraint was not considered. Only

restraints determined by physical necessity were included. Resource levelling would take care of the rest of the links.

First entry was the activity code.

Then came the entry of the links. By now the absolute tediousness of the keyboard entry of data was very apparent.

The technical limitations of the computer were apparent. ie :-

- \* Even in reduced mode - the screen is simply too small to see enough data.
- \* A light pen or mouse would speed up the linkage of tasks immensely.
- \* A "copy" facility for task descriptions that were repetitive would be an advantage.
- \* The computer - an AT - was far too slow. A maths co-processor was necessary.

Because of the enormous time taken to enter and manipulate the data, there was no time in the operating session to complete the next steps which would have been to complete the calendars and to allocate the resources.

In an operating company there might already be a data bank of resources. This might save time.

A major problem occurred with the resource allocation system. Resources are allocated in hours. Yet in the scenario being done, a key resource was the quantity of formwork. What was needed was a type of stores inventory system. As formwork was removed from the stockpile and placed in the position of use, the quantity of formwork available for other tasks would be reduced. Later on, as the formwork was stripped out, it would be returned to the stockpile and again became available for reuse. This facility was not available on the package being used.

## CHAPTER THREE

### THE THREE SURVEYS.



### **3.1. REPORT ON SURVEY ONE: THE SURVEY AMONGST THIRD YEAR TECHNIKON STUDENTS.**

#### **3.1.1. Selection of target for the questionnaire.**

Technikon students currently attend lectures for six months of the year and do practical work in firms for the balance of the period. They therefore should have worked for at least one year at the time of the survey and should have come into contact with planning techniques.

The third year students questioned were either Construction Supervisors or Building Surveyors.

**3.1.2. The questionnaire.**

April 1989					
(for M.Dreyer)					<u>SURVEY.</u>
Student name	.....				
Course	C2	B2	C3	B3	
Name of Company working for	.....				
Does company use Personal Computers?		Yes	No		
Planning of a contract is done using:-		Bit of paper	.....		
		Barchart	.....		
		Network analysis	.....		
Progress of contracts is recorded on a :-		Bit of paper	.....		
		marked up barchart	.....		
		marked up network	.....		
Do they use	<u>PERT</u>	or	<u>CPM</u>	or	<u>Precedence Diagrams</u>
					or <u>Network analysis</u>
This is done with the aid of a computer		Yes	No		
The name of the computer programme company uses is:-	.....				

Results of the questionnaire:-

SURVEY RESULTS.

Question mark placed against all replies = 4

Does company use  
Personal Computers?                      Yes = 14              No = 3

Planning of a  
contract is done  
using:-

Bit of paper	...5...
Barchart	..10...
Network analysis	...2...

Progress of contracts  
is recorded on a :-

Bit of paper	...4...
marked up barchart	..11...
marked up network	..2...

Do they use              PERT or CPM or Precedence Diagrams  
or Network analysis = 3

This is done with the  
aid of a computer                      Yes = 5              No = 5

The name of the  
computer programme  
company uses is:-                      ....See text below.....

### 3.1.3. General analysis of returned questionnaires.

The questionnaire was completed in class after a brief explanation.

The students gave the impression of being serious about answering the questionnaire, yet being slightly bewildered by being asked about planning in their firms. The atmosphere in the class revealed surprise amongst the students that network analysis - for instance - had any application in the running of their firm's operations.

While the response of some students was identical to their firm's response in the mailed survey posted three months later, many of the students' responses contradicted their employers' response.

For instance, the student of a firm known for good planning stated that much of their site planning was done on the back of a cigarette box. This could of course indicate planning done in different ways at different places.

Students who said their firm planned only "on a bit of paper", also said their firms planned "using a computer programme". This is an unlikely combination of procedures.

The computer planning packages named were "DOS 3.1", "Lotus", and one reply was "Marsbar". The first two are consistent with the students' lack of knowledge on the matter.

Four students from reputable firms simply put "?" against all the questions.

One student offered to find out if his firm used network techniques and, if so, the name of the computer package they used to assist them.

The forgoing results seem to indicate that although a firm might use formal planning techniques, amongst which network analysis might be one, this fact had not penetrated to the lower levels of management/supervision where the students were employed.

Other conclusions which can be drawn are:-

1). that the :-

- (i). "bar chart" method is the most commonly known if not used (about ten responses),
- (ii). a "bit of paper" eg cigarette box next (about five responses) and
- (iii). "network analysis" last (about two responses.)

Comment.

This indication by these students of the greater use of bar charts is consistent with the results of the mailed survey.

2). that whereas top management might be using sophisticated techniques in their planning, just what is happening at the coal face?

Comment.

A further issue that has then to be faced is "What happens when the men at the coal face get promotion?"

As a result of this survey, the mailed survey was kept at a relatively basic level.

## **3.2. REPORT ON SURVEY TWO: THE MAILED QUESTIONNAIRE.**

### **3.2.1. Selection of the target for the mailed questionnaire.**

#### **3.2.1.(a). The Members of the Master Builders' Association.**

When the mailed questionnaire was prepared it was known that amongst the "builders" in the Western Cape there was a wide range of effectiveness. There were firms using excellent management techniques as well as those getting by on "brute force and ignorance" aided by good luck rather than good judgement. In order to preselect the respondents, the survey was confined to members of the Cape Master Builders Association whose members, by virtue of the requirements to belong to such an organisation, would tend to be the more organised builders.

#### **3.2.1.(b). The Nature of the Cape Master Builders' Association.**

This Association comprises General Building Contractors, House Builders, Suppliers of building materials, and Subcontractors employed in a variety of building industry trades. The Association's members trade in the geographical area of the Western Cape - generally the area bounded by Saldanha , Worcester, Hermanus and the sea.

**3.2.1.(c). Awareness of the Great Variety of Members.**

In spite of preselecting the firms to whom the mailed questionnaire was sent, it was still apparent at the time of compiling the questionnaire that there was much diversity in the members of the Master Builders' Association..

Consequently such a questionnaire could only seek to determine general practices and opinions. Follow up interviews would also be necessary to get detailed information.

**3.2.2. The Questionnaire.**

The following two pages contain the questionnaire which was mailed to Members of the Cape Master Builders' Association.

Job / Company Title of person completing form .....

Question One.

In this question you are requested to estimate the number of personal computers in your company.

Personal Computers (IBM compatible types) .....  
 ( other types) .....  
 Laptop Computers. ....

Question Two.

In this question you are requested to estimate the time for which your computer/s are used on certain applications. This should be estimated on a percentage basis and total 100%.

	<u>Example</u>	
Estimating	...0%...	.....
Planning	...0%...	.....
Costing	...20%..	.....
Preparing monthly claim	...20%..	.....
Accounting	...0%..	.....
Word processing	...60%..	.....
Other - please specify:-		
.....		.....

Question Three.

In this question you are requested to indicate the areas where you believe there should be a change in the amount of time computers are used in a particular application in your company. Tick either "more" or "less" should if you believe there should be a change.

Estimating                      more / less  
 Planning                        more / less  
 Costing                         more / less  
 Preparing monthly claim    more / less  
 Accounting                    more / less  
 Word processing              more / less  
 Other - please specify:.....more / less



Question Four.

In this question you are requested to indicate the method/s your company uses to plan the sequence of work on a contract. Should your company use a variety of methods, please estimate the percentage of your contracts on which a particular method is used.

Experience / Rule of thumb. ....

Bar Chart .....

Network analysis ( eg CPM / PERT / Precedence Diagram)  
.....

Other - please specify:-

.....

Question Five.

In this question you are requested to indicate with a tick whether you would like any of the techniques of question four to be done manually or by using a computer package. If there is a particular computer planning package that you wish us to consider teaching, kindly mention it in the space at the end of this question.

Experience / Rule of thumb.                      Not applicable

Bar Chart.    Manually / Computer

Network analysis.                                      Manually / computer

Other - please specify:-

.....    Manually / computer.

Name of the computer package, if any, you recommend:-

.....

Question Six.

Are there any particular computer packages, apart from any mentioned in question five, that you would wish us to teach ?

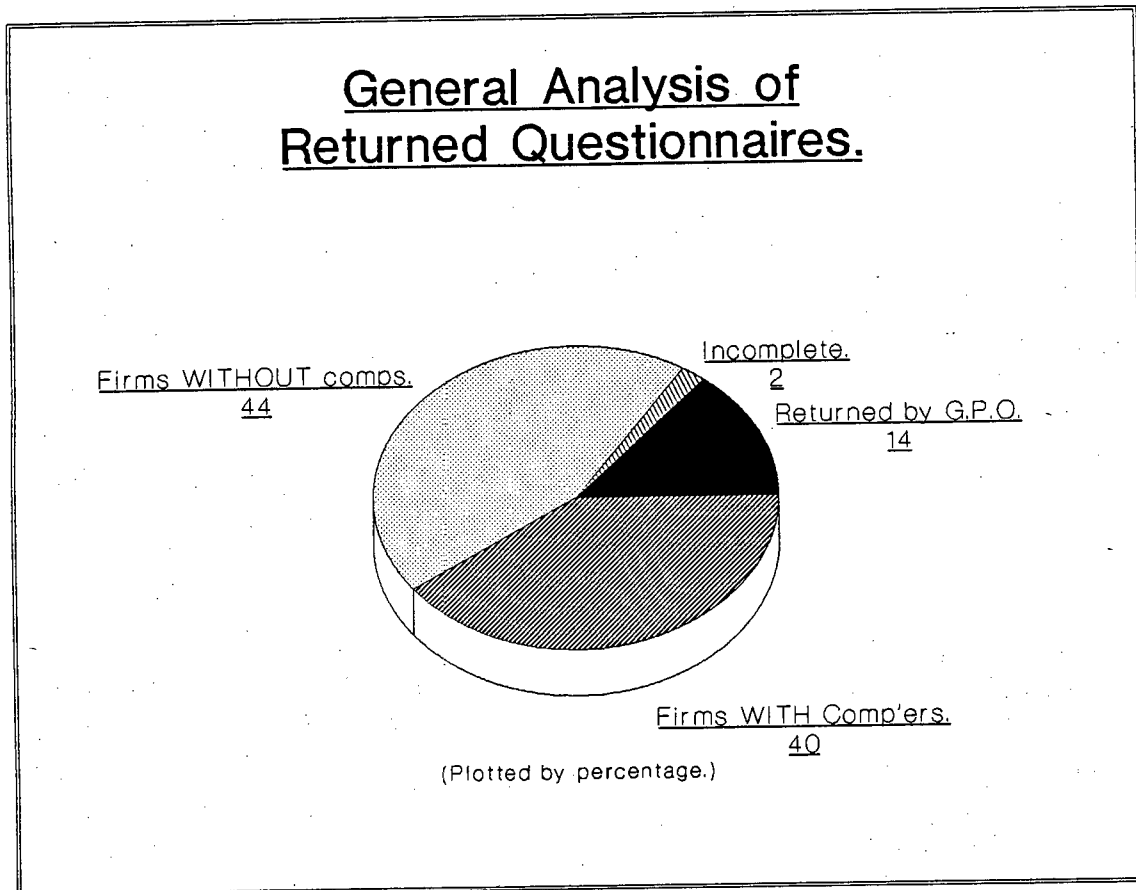
.....

.....

### 3.2.3. Numerical Returns.

[For numeric data see Table 1 in "Numeric Data from Mail Survey" in Appendix.]

#### 3.2.3.(a). Results in graphical form.



#### 3.2.3.(b). Comment.

The 402 Questionnaires were posted on the 6th July 1989.

The response rate of mailed questionnaires in the building industry is traditionally exceptionally low - in the order of 10% to 18%. The 28% response obtained in this survey can therefore be regarded as most satisfactory.

### **3.2.4. Factors to be borne in mind before analysing returns.**

Before beginning to analyse the results of the survey it is necessary to stress the variety of both the type of building firms and the background of the managers who took part in the survey. Each one had a different approach and each thought his was best. This is simply due to the diversity of the nature of business on the one hand and the variety of attitudes of the senior staff of the firms involved on the other.

There are therefore grounds for exercising caution when analysing the results.

The following are factors to be borne in mind:-

3.2.4.1. Responses were obtained from the wide range of Master Builders' Association Members. i.e. from small house builders to major building contractors; from builders' merchants to subcontractors.

Each type of firm needs a different planning and control style when it comes to the type of planning and control which is effective in their business.

For instance:-

- \* A builders' merchant - or for that matter a mass housing scheme - is in essence a stock control exercise.
- \* Houses can be built using re-usable standard bar charts with variations for season.
- \* A one-off, fast track hospital will require intricate network planning. In addition a planning team will invariably be needed on site.

Each firm reported on its general needs in relation to its type of business and this must be taken into account if one is not to compare apples with oranges.

3.2.4.2. Many firms operate in any one segment of the market for an indefinite period. They have little control over the particular segment in which they have to work

For instance in times of recession there is a predominance of Civil Engineering work and in times of boom an abundance of Building work.

Planning needs vary according to the type of contract the firm has been able to obtain and the responses reflect the needs of the firm at the time of the survey.

3.2.4.3. Some of the firms are one man operations. Others are but a small part - the construction wing - of major South African financial houses.

They therefore have different management requirements with regard to planning, reporting, etc.

For instance, subsidiaries of financial houses are more likely to have a style of planning imposed upon them. Sometimes this imposed style may not be appropriate for the type of work the firm is doing.

3.2.4.4. The managers of firms influence the planning techniques used in a firm.

(i). In some cases the type of influence they exert on the method of planning comes about because of their past planning experience.

For example:-

- \* The managers of some of the firms have risen through the ranks. Because of their considerable experience they "plan" using seat-of-pants approach.
- \* Other managers have only a strong academic background and therefore they plan using formal techniques.
- \* Some managers have a healthy mix of both.

(ii). The type of influence they exert on the use of computers in planning comes about because of their past contact with computers.

For example:-

- \* Some managers are computer addicts and believe that the computer can assist them in any task.
- \* Others have had their distrust of computers confirmed by bitter experiences.

(iii). All types of management are represented in the responses.

3.2.4.5. Some firms contract out certain computer functions. This is usually to head office or outside computer bureaux and, incidentally, occurs mainly in the "accounting" or "wage" applications.

This practice therefore restricts the range of applications to which the time of personal computers can be booked in that firm.

3.2.4.6. When completing the questionnaire the allocation of time spent on tasks in the different categories was done arbitrarily and subjectively by one person. No formal "Time and Motion" type studies were done.

The person allocating the time spent on various tasks was also faced with the problem that certain tasks overlap.

For example:-

- (i). To estimate the cost of a contract involves planning. Planning involves estimating. How much time is fairly allocated to each task?
- (ii). Once a computer has been set up for purposes of preparing the monthly claim, it has also been set up to produce much costing information. This is a "free" spin off.

3.2.4.7. In 1984 there were virtually no Personal Computers in construction firms. In 1989 50% of the respondents report owning them.

In this rapidly changing situation it is therefore unlikely that business systems have settled down to the new environment.

To what extent therefore can their sudden spread be reasonably described as acceptance of computer techniques due to productivity improvement or merely novelty ?

3.2.4.8. Companies frequently change computer packages. For example, an interview with one company revealed that it were now onto its fifth planning package, while the package reported on in the questionnaire was no longer favoured.

Reasons for changing to other packages vary from outgrowing an existing system to the previous system not living up to expectations.

The questionnaire gives a limited picture of the this kind of situation. i.e Just how successful is a particular package for a particular project and firm ?

3.2.4.9. Another example of a distortion is the way a firm organises its planning function in relation to other activities.

- (i). For instance a major firm might report one computer dedicated to planning in a centralised planning department, and their remaining computers placed on site and used for other purposes.
- (ii). In contrast some firms regard planning as a site function and the computers on site will be used for this function as well as other duties.
- (iii). A small house building firm might report working to standard work schedules with variations on the schedule for summer or winter working conditions. Their sole computer was therefore used for all the remaining functions.
- (iv). To further complicate this aspect, certain firms use central planning for small contracts and on-site planning for major contracts.

3.2.4.10. When it comes to the carrying out of planned work schedules there are differences in the way the centrally prepared plans are used.

In some firms the site staff are merely expected to carry out the plan.

Other firms expect the site staff to re-plan the contract within the tender parameters.

NOTE:-

- (i) When the mailed survey was compiled many of these aspects were anticipated. Hence the mailed survey was designed to give a general picture of computers and network planning.
- (ii) Follow up interviews would be needed to provide in-depth views.

### 3.2.5. General analysis of returned questionnaires.

#### Outline of Contents:-

A. The computer population in Firms.

How many firms have computers ?

How many computers in a firm?

B. On what tasks are the computers used?

Tasks on which the "average" firm uses computers.

Tasks on which computers are used when there are a number of computers in the firm.

C. The use of different techniques.

How often are the various planning techniques used?

How many firms use only one technique?

When firms use different techniques for different contracts, what is the average use of these techniques?

D. Should computers be used to a greater or lesser extent for listed tasks?

E. Should planning should be done manually or by computer?

F. What packages are reported to be in use?



3.2.5.:- A. THE COMPUTER POPULATION IN FIRMS.

Questionnaire:-

Question One.

In this question you are requested to estimate the number of personal computers in your company.

Personal Computers (IBM compatible types) .....

( other types) .....

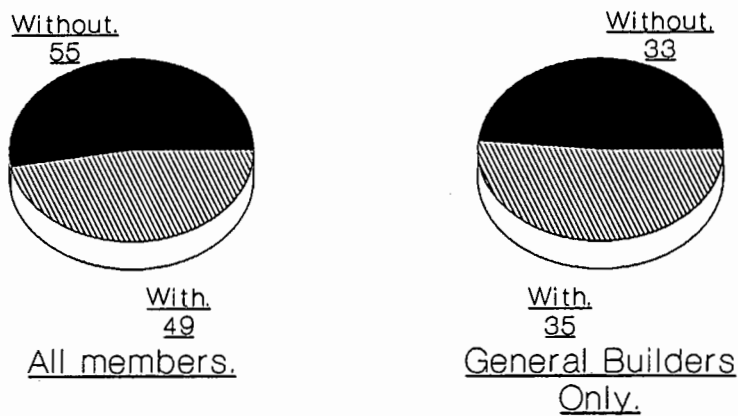
Laptop Computers. ....

[ For numeric data on "How many firms have Computers" see Table 2 in "Numeric Data from Mail Survey" in Appendix.]

[ For numeric data on "The number of Computers in a firm" see Table 3 in "Numeric Data from Mail Survey" in Appendix.]

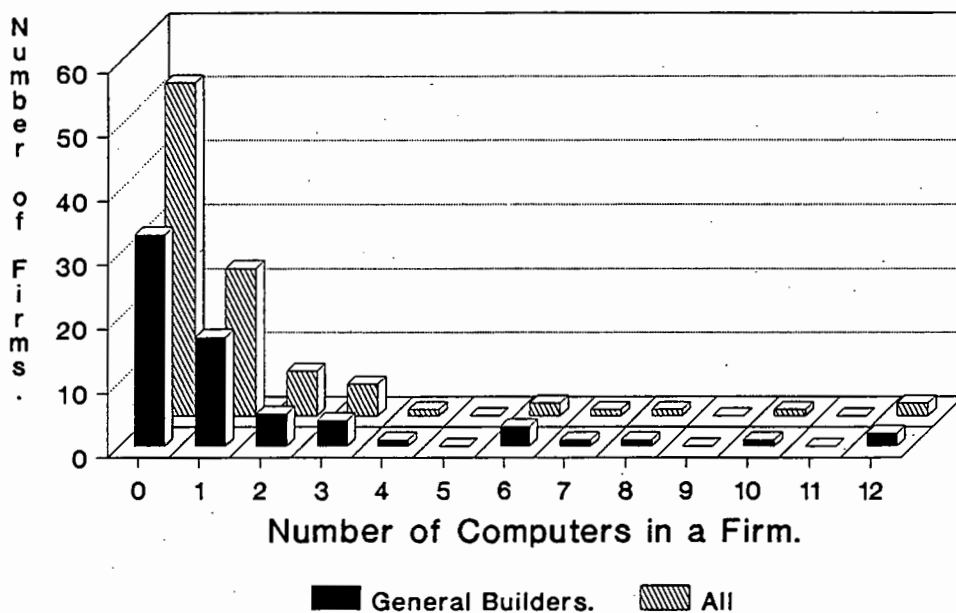
Results in graphical form.

How many firms have computers ?



(Plotted by number.)

How many computers in a firm?



Comment.

(i). How many firms have computers ?

One aim of the questionnaire was to ascertain how many General Builders were in fact using personal computers.

Half the respondents had at least one computer in the firm. When the fact that proliferation of personal computers started in about 1984 - 6 years ago - is taken into account, this indicates a swift acceptance of new approaches to doing certain tasks.

(ii). How many computers in a firm?

The majority of firms report having one or maybe two computers.

This would indicate small firms needing only one computer, or larger firms with computers only in head office.

Firms interviewed anticipated growing use of computers, and therefore greater numbers of computers in firms.

No comment can be made on the effectiveness of the use of these computers.

3.2.5.- B. ON WHAT TASKS ARE THE COMPUTERS USED?

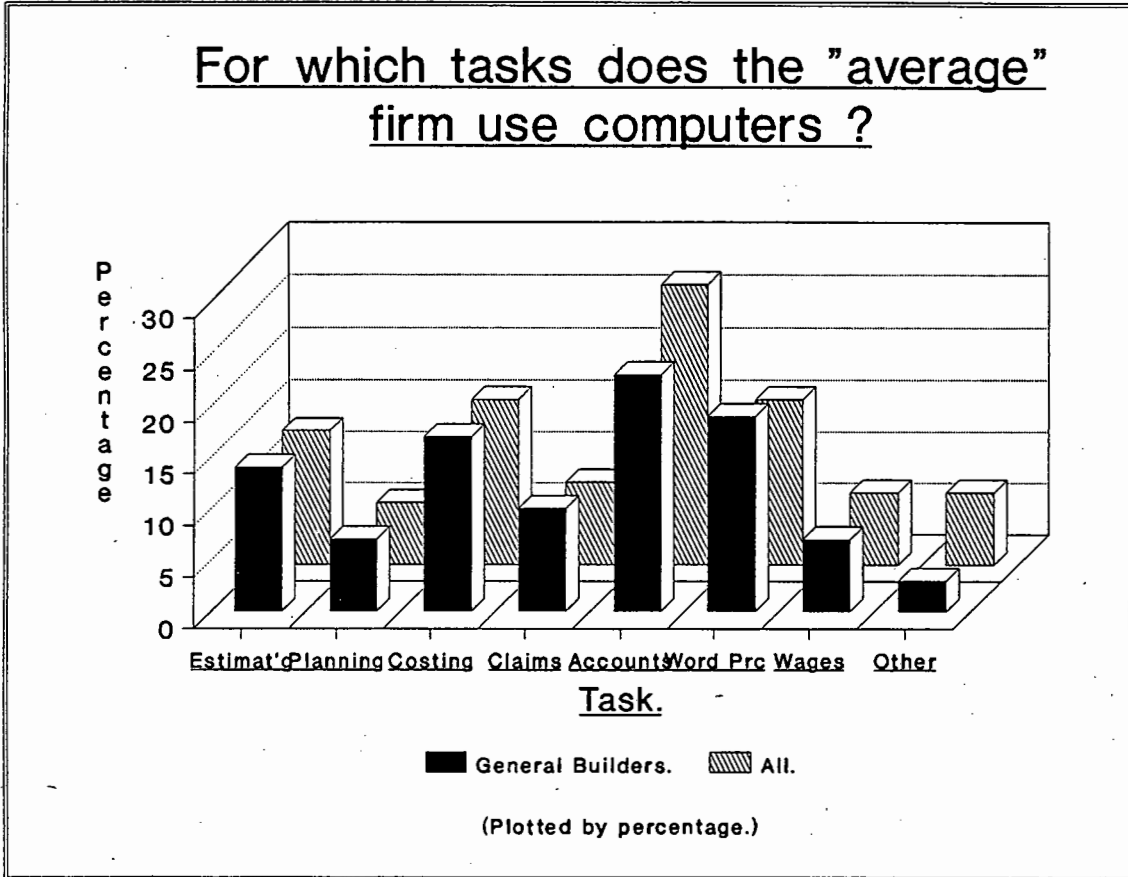
Questionnaire:-

<u>Question Two.</u>		
In this question you are requested to estimate the time for which your computer/s are used on certain applications. This should be estimated on a percentage basis and total 100%.		
	<u>Example</u>	
Estimating	...0%...	.....
Planning	...0%...	.....
Costing	...20%..	.....
Preparing monthly claim	...20%..	.....
Accounting	...0%..	.....
Word processing	...60%..	.....
Other - please specify:-	.....	.....

[For numeric data on "For which tasks does the average firm use a computer?" see Table 4 in "Numeric Data from Mail Survey" in Appendix.]

[For numeric data on "For which tasks are computers used when there are a number of computers in a firm" see Table 5 in "Numeric Data from Mail Survey" in Appendix.]

Results in graphical form.



Comment.

(i) For which Tasks does the "average" firm use a computer ?

The survey revealed that computers are used predominantly in areas where there are strict rules governing the calculation and output of data. For instance:-

"Wages" are calculated by rules established in law.

"Accounts" are controlled by established accounting practice.

One area where computers are the least used is that of "planning".

Perhaps this should come as no surprise as computers and their precision are of little use in an application with the following requirements:-

Planning packages are a complex mixture of spread sheets, data-bases, word processors, graphics, and "logic" to calculate whatever is needed. However "Judgement" is lacking and that is perhaps the most important requirement of all. In addition the definition of "good judgement" varies from person to person.

In the hard world of 15 firms tendering for the same job, it is either the firm that makes the biggest mistake, or the firm that comes up with a better scheme than its competitors (ie is different) that will win the tender. The uniformity of solution as devised by a computer package would be of little benefit.

(ii) For which tasks are computers used when there are a number of computers in a firm ?

General trends are hard to find.

- (a). Firms with one computer tend to use them for wages. Firms with more than three computers don't do wages on them at all. [Many firms take advantage of the excellent wage service provided by the Industrial Council for the Building Industry].

- (b). Firms with one computer report 35% of their time spent on accounts. As the firm acquires more computers - gets larger (?) - usage for accounts purposes drops to 20% as the additional computers are applied to other tasks.
- (c). As a firm acquires more than one computer, the percentage of time spent using the computer to assist with estimating increases. Perhaps the estimator keeps one on his desk?
- (d). The more computers in a firm the more they are used for planning - up to about 15%. Firms with one computer hardly spend any time using them for planning.

3.2.5.:- C. THE USE OF DIFFERENT TECHNIQUES.

Questionnaire:-

Question Four.

In this question you are requested to indicate the method/s your company uses to plan the sequence of work on a contract. Should your company use a variety of methods, please estimate the percentage of your contracts on which a particular method is used.

Experience / Rule of thumb. ....

Bar Chart .....

Network analysis ( eg CPM / PERT / Precedence Diagram)  
.....

Other - please specify.:-  
.....

[For numeric data on "How often are the various planning techniques used?" see table 7 in "Numeric Data from Mail Survey" in Appendix.]

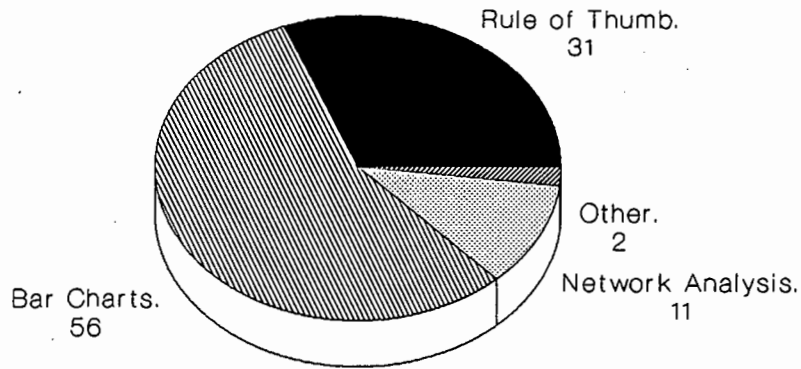
[For numeric data on "How many firms use only one technique?", see Table 8 in "Numeric Data from Mail Survey" in Appendix.]

[For numeric data on "When firms use different techniques for different contracts, what is the average use of these techniques?" see table 9 in "Numeric Data from Mail Survey" in Appendix.]



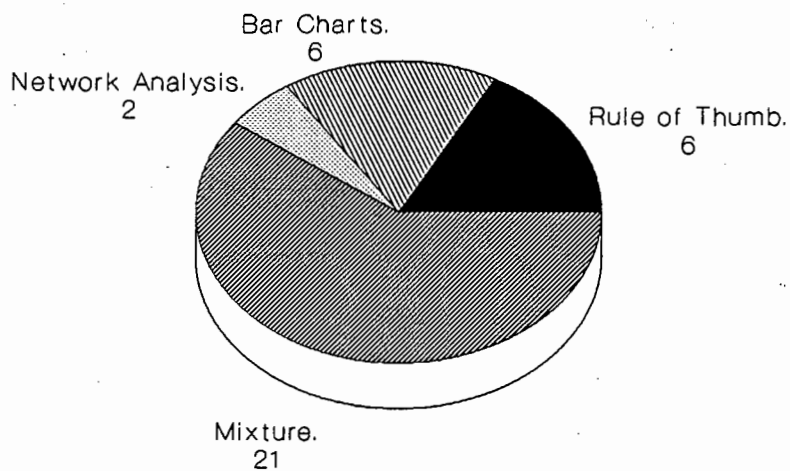
Results in graphical form.

How often are the various planning techniques used ?



(Plotted by percentage.)

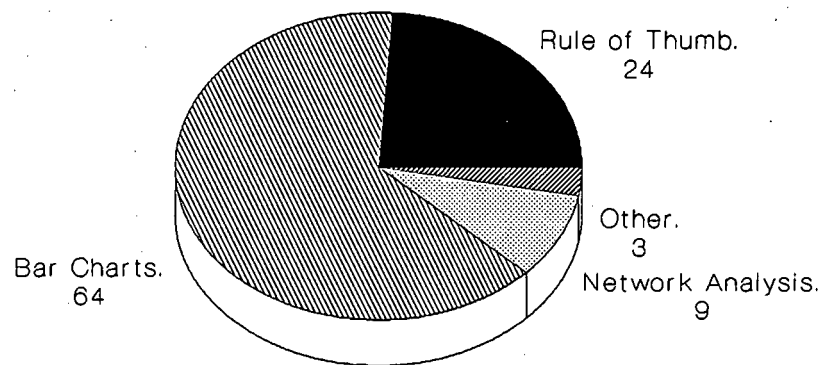
How many firms use only one planning technique ?



(Plotted by number.)

Results in graphical form.

When firms use different techniques,  
what is the average use of each ?



(Plotted by percentage.)

Comment.

(i) How often are the various planning techniques used?

The pie chart shows the average use to which the various network techniques are put.

The relatively low usage of network techniques is apparent.

This can explain the low allocation of computer time to planning as, computer assistance is not really needed for the other techniques.

(ii). How many firms use only one technique?

The exclusive use of a low level technique - eg Bar Chart - can be explained by the user being a small company involved in small structures.

The exclusive use of network planning for all contracts by two respondents is worth greater investigation as low cost contracts are not usually worthy of such complexity. However only two of 124 respondents reported this.

Most firms reported using a mix of planning methods. Interviews later provided more detail. For instance one firm used a mixture of network analysis/bar charts for jobs between R1 and R10 million with the aid of a low priced computer package for presentation purposes where necessary. For contracts over R10 million they used network analysis on a high priced computer package with its many features.

(ii) When firms use different techniques for different contracts, what is the average use of these techniques?

If the percentage use of techniques is recalculated for those 21 firms using a mixture of techniques, (ie excluding those that use only one technique), the average use of the techniques is as shown on the graph.

It is obvious therefore that firms use methods other than network analysis most of the time when planning contracts and this in itself could go some distance in explaining the low usage of computers in network analysis as mentioned before.

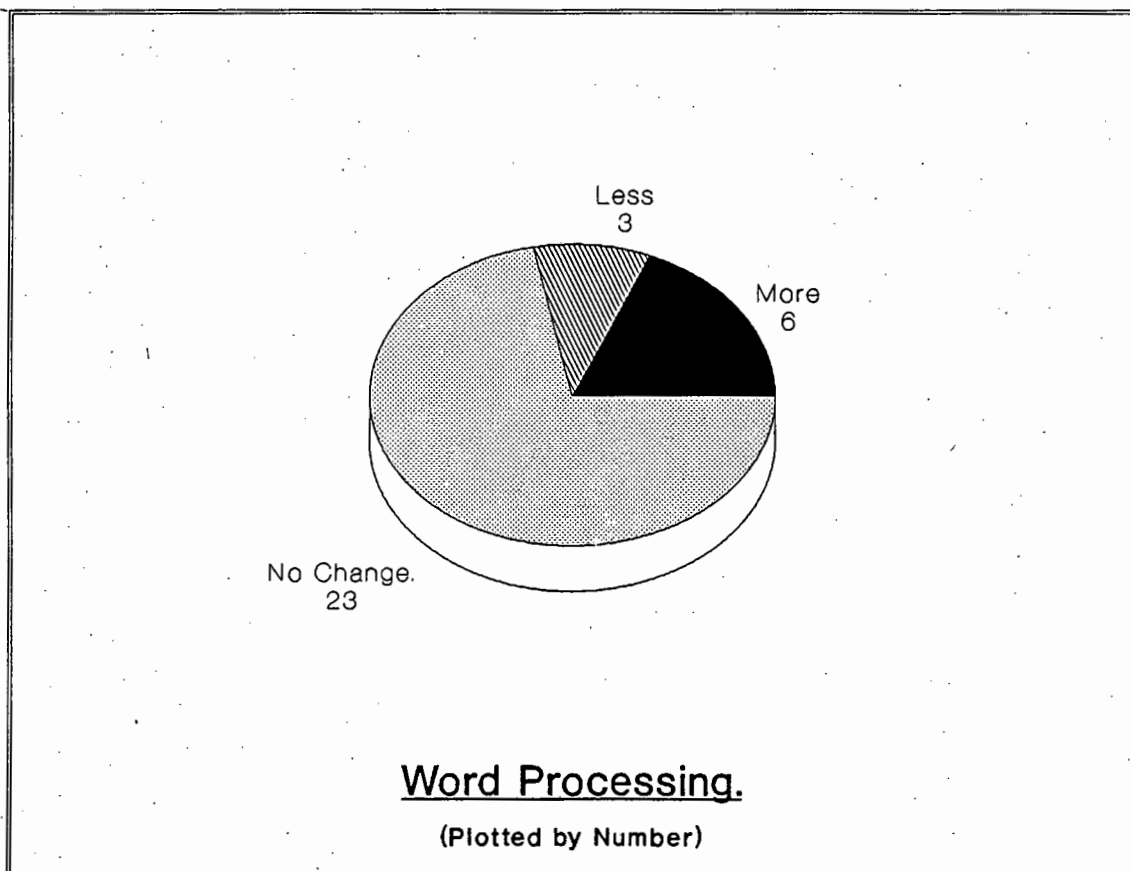
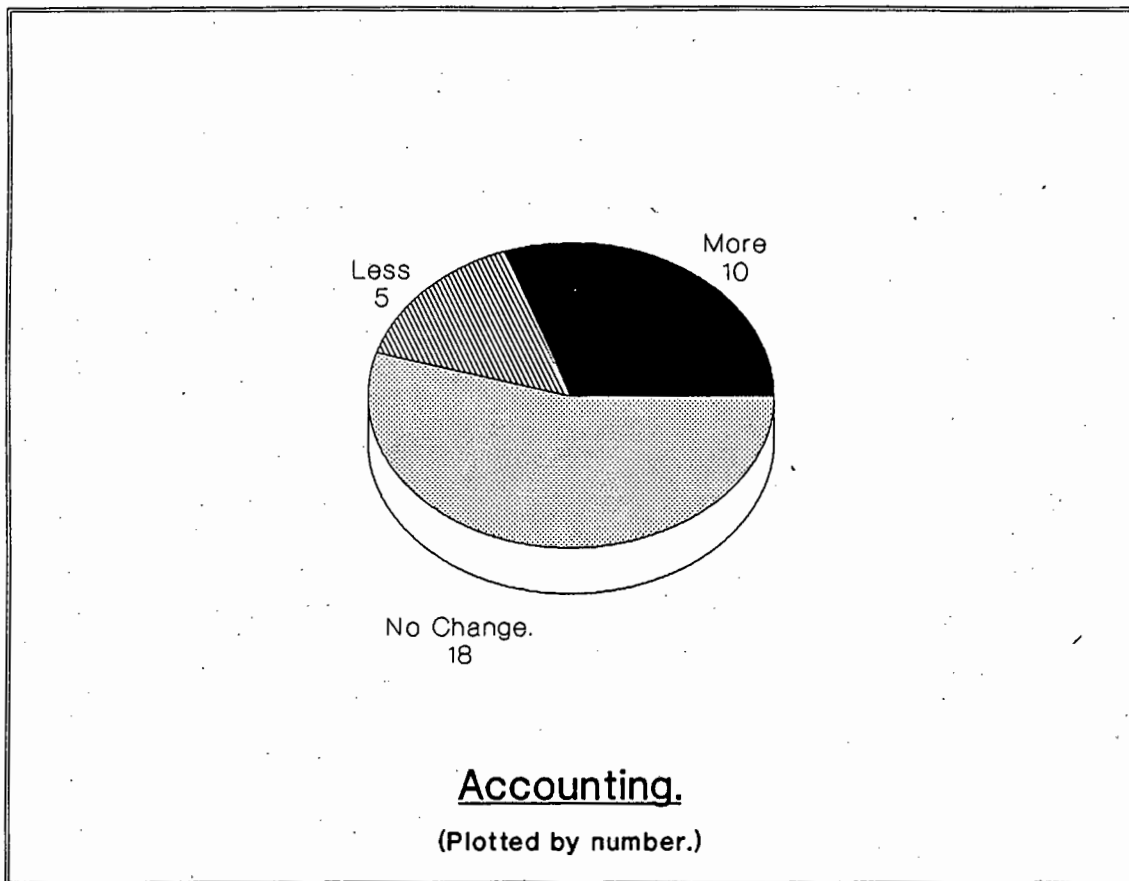
3.2.5.:- D. SHOULD COMPUTERS BE USED TO A GREATER OR LESSER EXTENT FOR LISTED TASKS?

Questionnaire:-

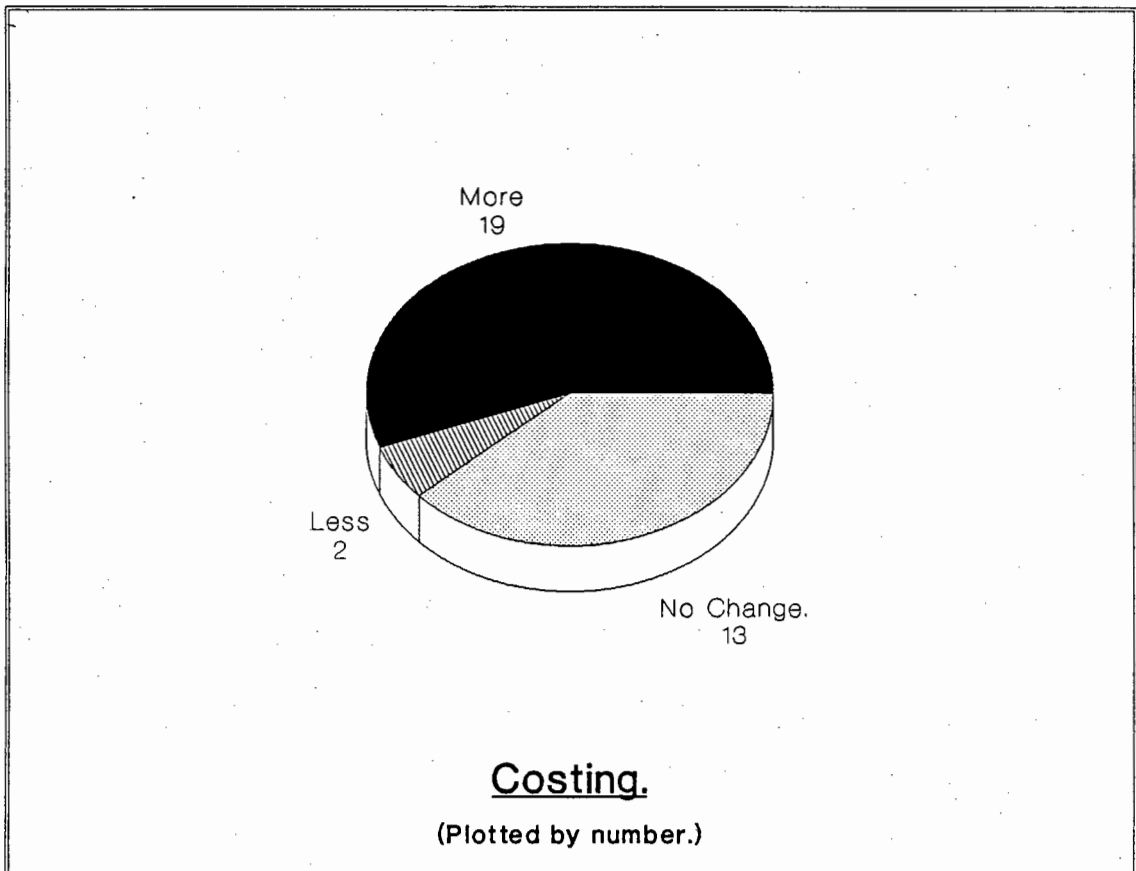
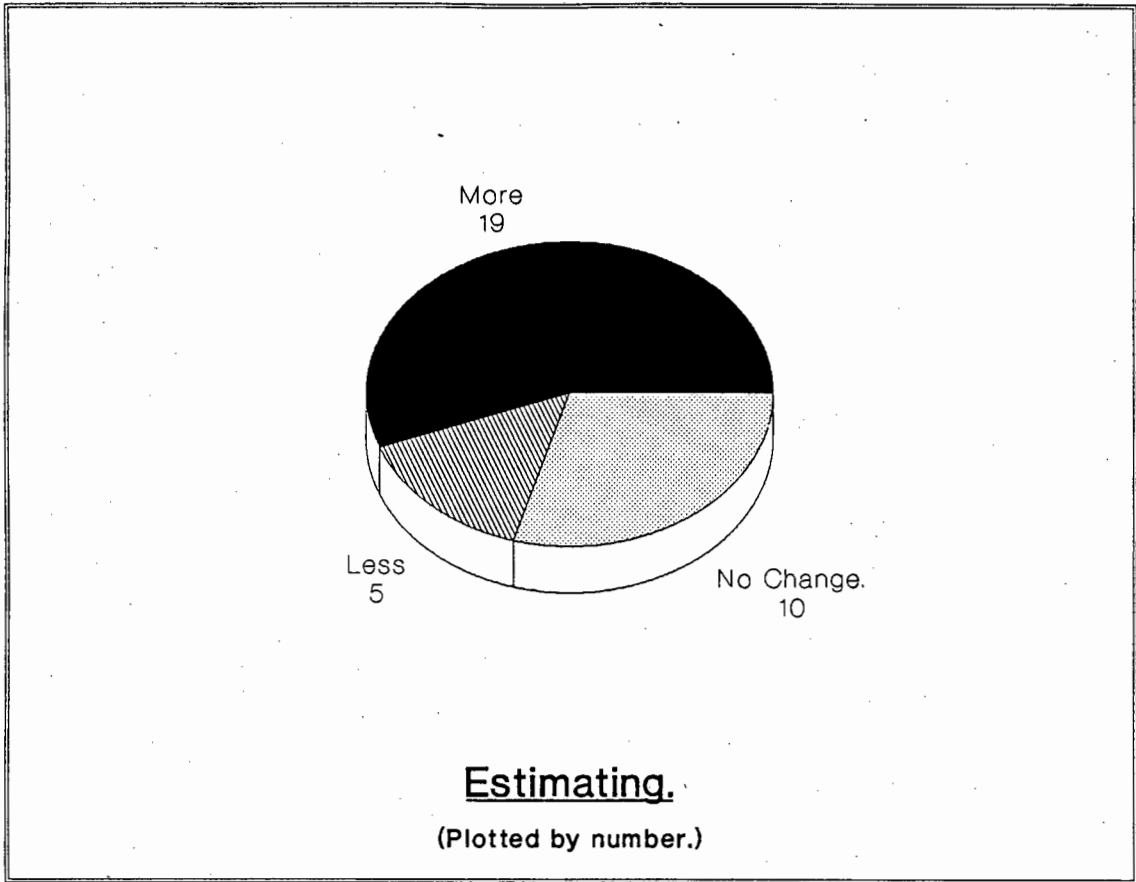
<u>Question Three.</u>	
<p>In this question you are requested to indicate the areas where you believe there should be a <i>change</i> in the amount of time computers are used in a particular application in your company. Tick either "more" or "less" should if you believe there should be a change.</p>	
Estimating	more / less
Planning	more / less
Costing	more / less
Preparing monthly claim	more / less
Accounting	more / less
Word processing	more / less
Other - please specify.:-	
.....	more / less

[For numeric data see Table 10 in "Numeric Data from Mail Survey" in Appendix.]

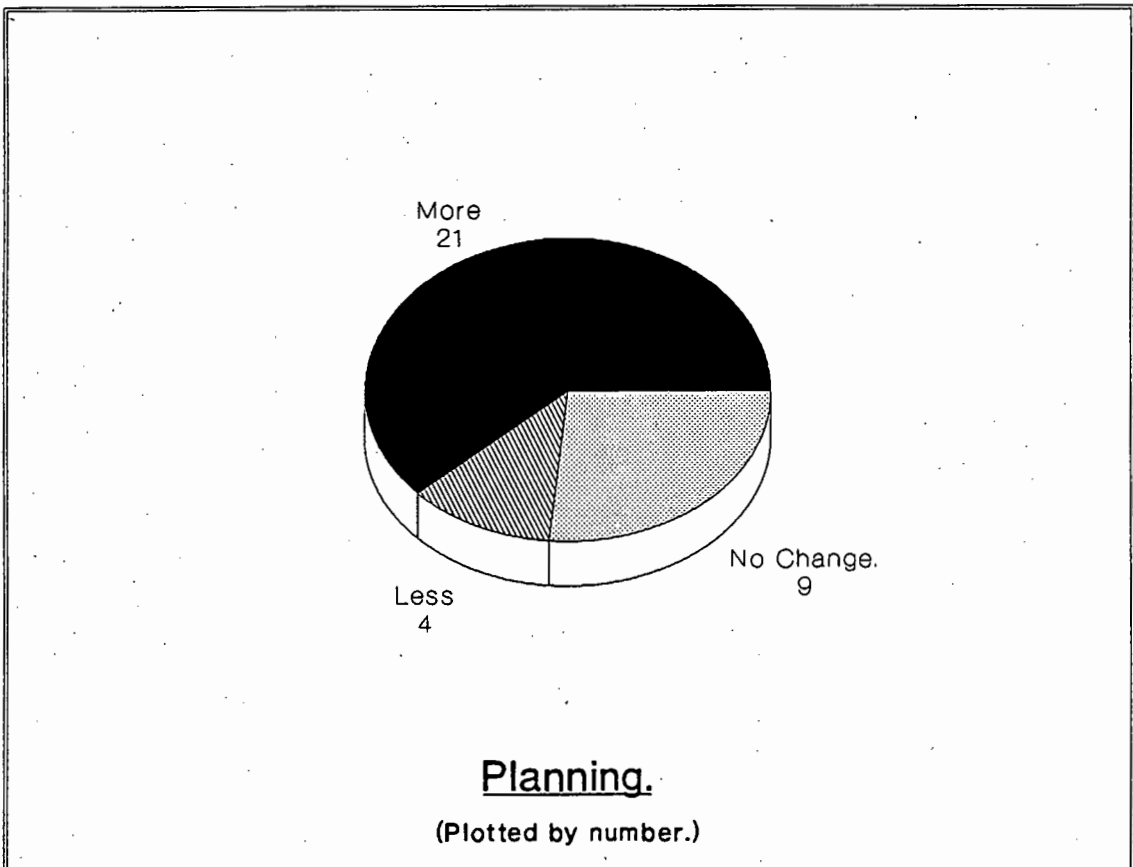
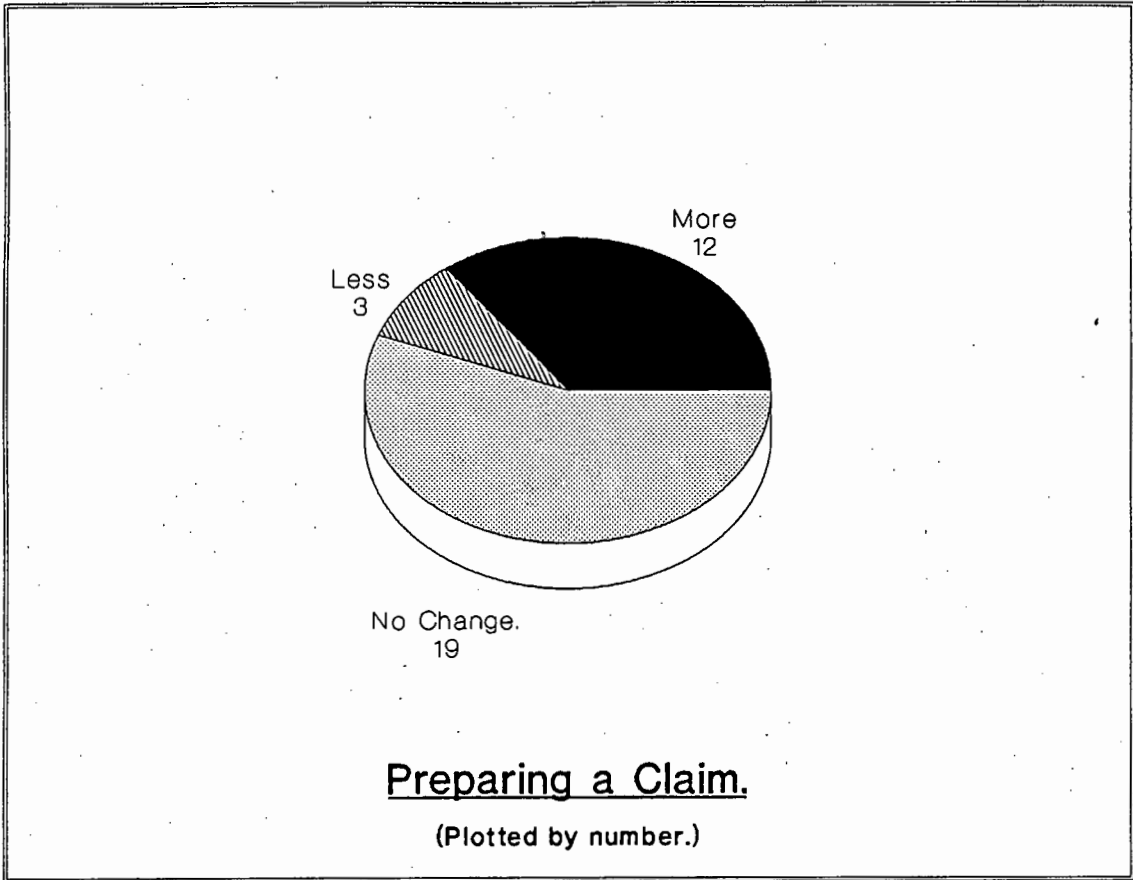
Results in graphical form.



Results in graphical form.



Results in graphical form.



Comment.

The areas of precision "Accounting" and "Word Processing" are reported as being reasonably served by computer techniques. This is by virtue of the large "No Change" response. "Preparing a Claim" also falls into this category.

It is the tasks requiring a healthy mixture of assessment and judgement that are considered to be worthy of more use. eg "Estimating" and "Planning".

"Costing" is worthy of comment. The low "less" response would indicate that firms find the system useful when it is working. The "No change" response - 2, the lowest in all the options - would seem to indicate that those who have it working are well pleased, and the "More" response would seem to indicate that there are firms still finding out how useful computers are for this function. The fact that few computers are on site where "costing" is normally done may also be a factor in this response.



3.2.5.:- E. SHOULD PLANNING SHOULD BE DONE MANUALLY OR BY COMPUTER?

Questionnaire:-

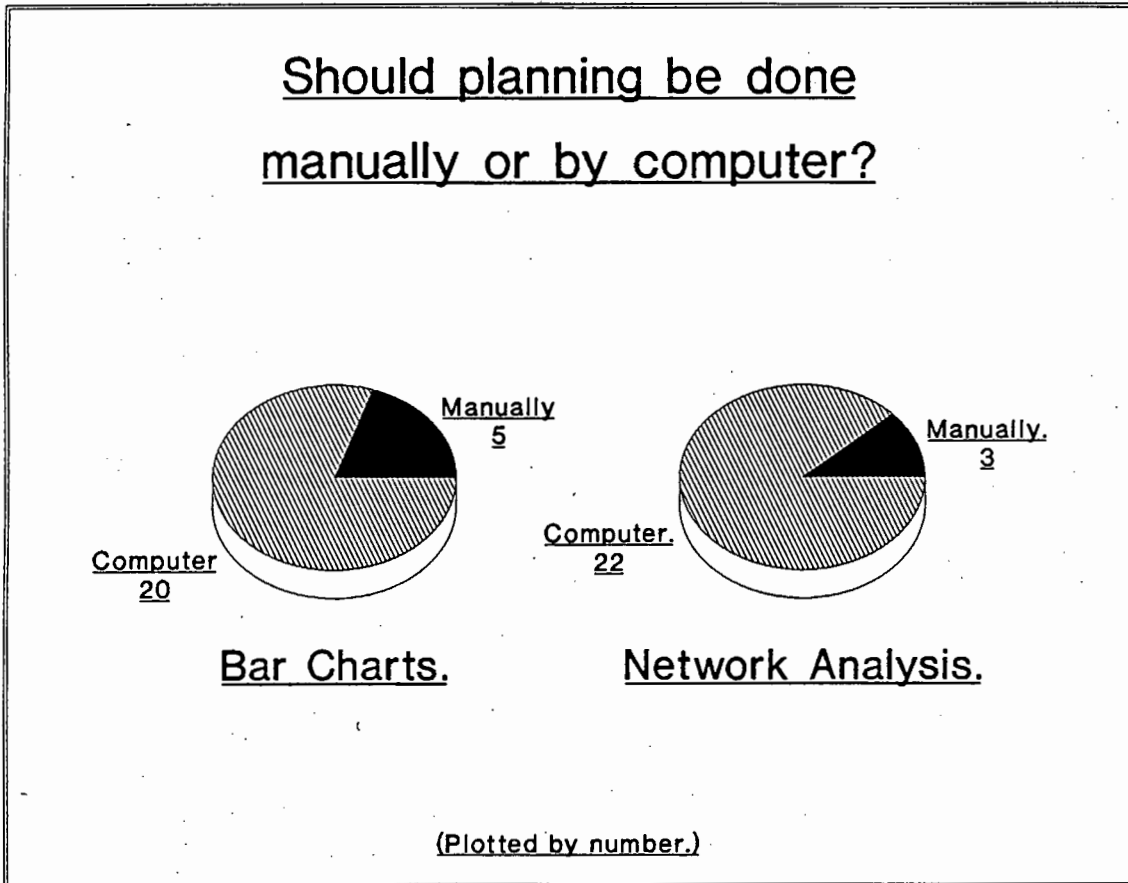
Question Five.

In this question you are requested to indicate with a tick whether you would like any of the techniques of question four to be done manually or by using a computer package. If there is a particular computer planning package that you wish us to consider teaching, kindly mention it in the space at the end of this question.

Experience / Rule of thumb.	Not applicable
Bar Chart.	Manually / Computer
Network analysis.	Manually / computer
Other - please specify:-	
.....	Manually / computer.

[For numeric data see table 11 in "Numeric Data from Mail Survey" in Appendix.]

Results on graphical form.



Comment.

The desire to use computers in these spheres is consistent with the general wish that computer packages be developed and used in the more intangible/less precise areas of estimating and planning,

3.2.5.:- F. WHAT PACKAGES ARE REPORTED TO BE IN USE?

Questionnaire:-

Question Six.

Name of the computer package, if any, you recommend:-

.....

Are there any particular computer packages, apart from any mentioned above that you would wish us to teach ?

.....

.....

### 3.2.6. GENERAL OBSERVATIONS.

Bearing in mind the need to exercise care when producing the foregoing analysis, it is possible to make a few comments on the results.

- (i). There is a trend towards the greater use of computers in building firms.
- (ii). Computers are used mainly in areas where the rules of the task are inflexible - accounting and wages - and less in the areas where they are flexible - eg estimating and planning.
- (iii). "Network Planning" is only used about 10% of the time as a method for preparing work schedules.
- (iv). Judging by the great variety of packages reported to be in use for "Planning" there is no industry standard yet.

An Industry Standard similar to those in other fields such as "Dbase", "Lotus", "Wordperfect" do not exist. This in turn indicates that planning by computer is still in its early stages.

- (v). Some respondents wrote on their completed questionnaires that they saw little need for the complications of network analysis programmes. They believed they were not even realising the potential of (say) Lotus, and felt that existing industry standard packages should be fully exploited first. They felt that greater productivity improvement lay more in the fuller utilisation of existing packages than in trying to divert their management drive with yet another complex package.

Following receipt and analysis of the questionnaires in depth discussions were held with firms using Network Analysis techniques.

### **3.3. REPORT ON THE THIRD SURVEY: TO DETERMINE MANAGEMENT CHARACTERISTICS OF FIRMS.**

#### **3.3.1. SELECTION OF TARGET FOR THE MAILED QUESTIONNAIRE.**

In order to see if there was some correlation between methods of doing things and some very general characteristics of management, a questionnaire was prepared.

A small group of organisations were selected which served most of the firms in the Master Builders' Association in one way or another.

The people/organisations to whom the questionnaires were sent were thus ideally placed through the nature of their business to compare the management characteristics of many of the firms taking part in the mailed survey.

#### **3.3.2. THE QUESTIONNAIRE.**

##### **Request to complete questionnaire.**

A covering letter was sent out with the questionnaire. It contained some of the findings.

Dear Sir,

In June a questionnaire was posted to all members of the local Master Builders' Association to find out firstly the degree to which they used computers and secondly on what tasks they used computer packages to aid them.

In order to establish whether there is a relationship between the degree of use of these techniques and certain characteristics of the firms, would you please assist by completing the attached form.

For interest we include some of the basic findings so far:-

Analysis of returned questionnaires.

Posted	402
Returned undeliverable.	17
Returned but incomplete	3
Returned marked 'not applicable' (ie We don't have a computer.)	52
Returned correctly filled in (ie We have one or more computers.)	47

Analysis of firms with computers.

	<u>All members.</u>	<u>Just</u> <u>"General</u> <u>Builders</u>
Firms using Personal Computers	48	34
Firms NOT using Personal computers	54	33
<hr/> Total	<hr/> 102	<hr/> 67

How is computer time used ?

	<u>"All"</u>	<u>"General Builders"</u>
Accounting	30%	25%
Costing	20%	18%
Word Processing	14%	17%
Estimating	13%	15%
Wages	7%	6%
Claims	6%	8%
Planning	6%	7%
Other	4%	4%

( However take note of the use of computer bureaux for some tasks. )

**SCORING SHEET.**

Please insert the appropriate number in each space on the questionnaire.

Size of firm.

Large	1
Medium	2
Small	3

Control:-

National	1
Mixed	2
Local	3

Management Style:-

Autocratic	1
Mixed	2
Democratic	3

Management Type:-

Conservative / Traditional	1
Mixed	2
Modern / Try new methods	3

Management Background:-

Through the trade	1
Mixed	2
University/Technikon	3

The rest of the questionnaire consisted of a list of all the firms who had responded to the mailed survey. Alongside the names were columns in which the respondent could enter the appropriate number from the scoring sheet and thus answer the question.



### **3.3.3. GENERAL ANALYSIS OF RETURNED QUESTIONNAIRES.**

Of the five questionnaires sent out only one was returned.

It was because of this type of connection - ie that they had inner knowledge of the workings of the firms - that the people/organisations to whom the survey was sent contacted the author to say they regretted that they could in no way be associated with such a survey. They feared that it might jeopardise their relationship with a firm if it was known that they - or their employees - had used their relationship to complete such a survey.

There was thus no alternative but to abandon this section of the survey.

In view of the smaller than expected use of computers in network techniques as revealed in the mailed survey, this survey would have been of limited use.

## **CHAPTER FOUR**

### **INTERVIEWS WITH FIRMS.**

#### **4.1. VISIT TO A LARGE INDUSTRIAL UNDERTAKING.**

The author had the opportunity to spend an afternoon with the senior planner of a vast industrial undertaking. This undertaking is not in the building trade, but the application of network analysis techniques was similar

The planner had more than 30 years international experience in his work and planning in particular.

His terse notes on planning appears at the end of this section.

During discussions with him and associated staff virtually all the comments recorded previously in the section on literature search were voiced.

In this organisation

- a) there was no better way to handle the large scale maintenance other than by network analysis.
- b) there was the advantage of the regular repetition of maintenance operations.

It is difficult to summarise a visit in which everything was relevant to this thesis. However, below are a few notes on the planning process used. Their planning process involves both people and computers.

The way in which this organisation use the computer is of the utmost importance. ie:-

- a) At the start of the process first line supervisors have to work with the planner in developing a list of activities, tasks, and resources.

- b). Activities are scheduled - but their minor component tasks are not. The work to be done is kept in large components for network planning. This is done specifically in order to keep the number of activities below 2000. The planner has found that 2000 is a good target figure and that the most suitable range for the number of activities is between 1200 and 2000 activities.
- c). The network is produced on large white magnetic blackboards on which magnetic chips are moved about as the key people in the maintenance operation stand round and discuss sequence, methods, etc. Lines are then drawn on the white surface to link the chips into a network.
- d). An operator in the planning department meticulously adds Activity Codes - so that later bar charts can be produced for any combination of tasks. eg for a workman, a room, a piece of equipment.
- e). This is then fed into a computer which sorts, resource levels, etc.
- f). The output is then checked for input errors and improved through human intervention.
- g). When the job runs, the computer prints a daily short term look-ahead programme - typically three days - for a section. However, although the bar chart lists the activities to be performed in that period, the bar chart lacks the bars. These are filled in by a person with intimate, up to date knowledge of the work.
- h). This information is fed back into the computer which produces exception reports for control purposes, and then carries on to produce new lists of work to be tackled in the next day's three day look-ahead programme.

The author of this paper stresses the interaction between people and computer, and the role that each has to play in this organisations approach to planning. The interaction between people and computer is the foundation on which this company bases its use of network analysis techniques.

In this situation there are a number of advantages over building construction:-

- a). Repetition for each overhaul.
- b). Learning curve through repetition.
- c). Economies of cost through repetition.
- d). A relatively stable management team and workforce.

Mr John Flood notes's on :-

COMPUTER PROGRAMMES FOR PLANNING AND MANAGING  
OUTAGES/PROJECTS

(Used with permission and grateful thanks).

MAJOR CONCLUSIONS.

1. *Ease of use - ie. user friendly.*
2. *Implementation for the initial programme will take from six months to a year.*
3. *The experience, number and quality of personnel assigned to the computer programme outage/project management team is extremely important to the success of the programme,*
4. *Involve first line supervision to determine how the program could provide them with better management information.*
5. *Programs in use at present predominantly use mainframe computers. The modern trend is towards the use of on-site minicomputers.*

*In recent years, projects/outages have become longer and more complex.*

*It is widely recognised that computerized project control has improved management's ability to control and schedule the increasingly complex projects/outages.*

*The personnel selected for the outage, management should have experience as follows:-*

**EITHER**

*a). Planning scheduling , data processing or computer applications,*

**OR**

*b). Excellent knowledge of the Project/Plant.*

**BUT**

*c). A mixture of both is the best.*

*Program vendors suggest in their literature that their one week training course and a few weeks of field experience will enable the user to plan, schedule and manage a project/outage. It will more likely require six months to a year to implement the program and it will probably also require assistance from the vendor consultant. New projects which include many first time activities invariably need between six months and a-year to complete.*

*Success in implementing the programme also depends a great deal on how well people outside the planning department are indoctrinated and involved in the use of the program.*

#### MAINFRAME OR MINICOMPUTER.?

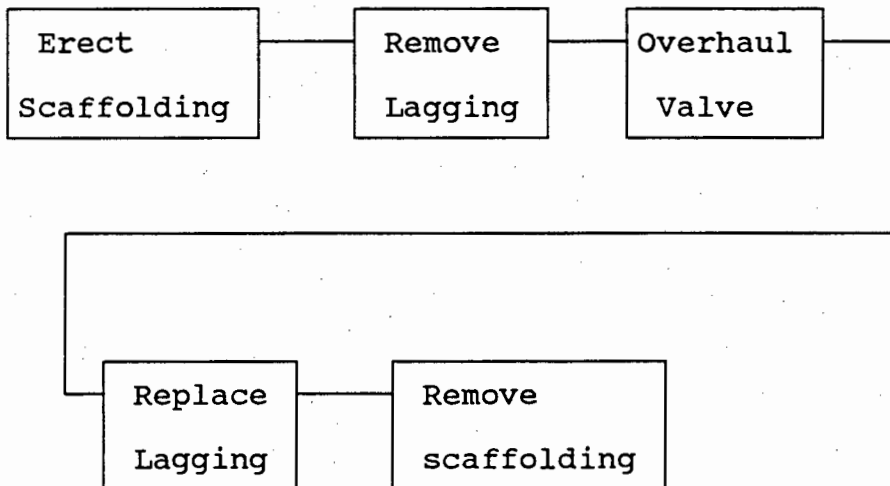
- a). The minicomputer provides easier access and greater programme availability than a mainframe.*
- b). Timely project/outage management with a main frame computer requires reliable communications and a good user priority. Even minor interruptions can be traumatic at the wrong time.*
- c). The minicomputer enables the user to interact directly with the program. Data input errors are validated immediately and inputs can be prompted by the*

program itself as it progresses. This avoids the delay that occurs when errors that may be present in batch input data are reported at a later date.

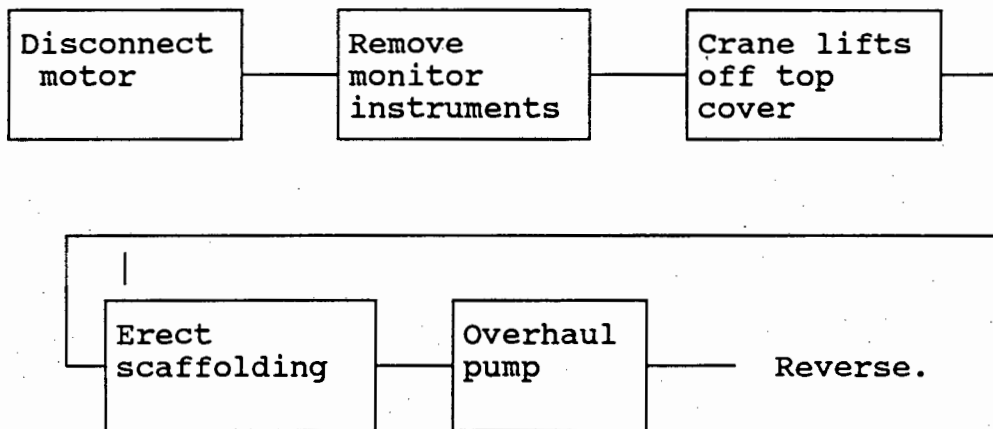
**REMEMBER:-**

- a). With increased programme flexibility comes the requirement for greater experience in Data Processing and scheduling for setting up the programme.
- b). If you have scheduled large number of activities, (say more than 2000), the ability to update the networks, to do critical path analysis, and to investigate alternative courses of action diminishes. This is a limitation of the dynamic project/outage environment and of the personnel resources to manage the project/outage. It is not a limitation of the computer program.
- c). A common mistake is attempting to schedule the activities in too much detail. Leave the detail of an activity to the first line supervisors. Updating the program daily when the project has too many activities becomes a burden to the site personnel, and the programs' usefulness as a management tool is seriously downgraded.

For example:- The activity "Overhaul Valve" consists of :-



*Another Example:- The Activity is "Overhaul Pump" consists of:-*



*A project/outage requires daily updating of the program therefore we must strive to keep down the number of activities whenever practical. (Target range between 1200 and 2000).*

*One method is to have a detailed work list associated to an activity but assign the management of the details to the first line supervisors. This approach is very successful and is therefore recommended.*

### ACTIVITY CODING.

*Activity coding is important in planning a proper project/outage. This is the key to selecting and sorting criteria at the proper level, or within a discrete window, so that reports are precise and useful to the individuals at their levels of responsibility. Coding allows reports to be sorted by system, area, plant condition requirements, Quality Assurance requirements, craft disciplines etc. Coding also describes logical relationships between activities in a network.*

*Erroneous or nonexistent coding creates problems in scheduling a project/outage.*

*An example of such a system is shown below.*



Activity Numbering.

*The activity number is a four character number consisting of one alpha character and three numeric characters.*

*The alpha character will signify:-*

- A: Unit in service.*
- B: Unit shut down.*
- P: Pump.*
- S: Sludge removal.*
- Z: Restart unit.*

*The three digit numeric character will signify:-*

- 001 - 049                      Research and development section.*
- 050 - 099                      Engineering Dept.*
- 100 - 149                      Outside contractors.*
- 150 - 199                      Quality Assurance Department.*

COMMUNICATION AND RELATIONSHIP BETWEEN SECTIONS.

*A most important priority item is to ensure at all times good communications and respectful relationships between all sections ie. Project coordinators, project planners and first line supervisors, etc.*

*This results in swift and rapid updating of a project.*

*Keys to the achievement of these objectives are:-*

- a). Assignment of the responsibility for tasks to the proper level.*
- b). Good management backing for the program.*

*Basically this should result in :-*

- 1). First line supervisors updating reports and forwarding to project/outage planning timeously.*
- 2). Planners and schedulers analyzing progress and where necessary, recommending solutions.*
- 3). Data being quickly fed in, to update information in the program.*

**SELECTION CRITERIA.**

*Cost and the basic way in which the program is to operate, Mainframe vs Minicomputer - interactive vs batch input are the deciding factors in the selection of a programme.*

**SUCCESS CRITERIA.**

*The success of a program is critically dependent on the experience and quality of the personnel, and on the support, training of the personnel, and the emphasis placed on the program by the upper management.*

#### **4.2. VISIT TO CONSTRUCTION COMPANY NO 1.**

The writer was privileged to have the opportunity to discuss network planning analysis and the application of computers for this purpose with the planner of a large Cape Town firm.

In the mailed questionnaire this firm reported having 8 mini computers and using Computer packages to do Network Analysis. They had only listed the computer package they were currently using. They did not mention the four packages that they had evaluated in various ways.

The planner of this firm is a man of great experience. Over his twenty five years in the building industry he has risen steadily through the ranks from tradesman to "the planner". For the past 10 years he has been involved in the planning of numerous different civil and building contracts. Of particular importance to the writer was that much of this time had been spent planning on sites and the planner was therefore well aware of what happened on a site.

In recent years he has worked through 5 different computer packages and found them not entirely suitable for his needs. He is about to start evaluating a new computer package programme - one with a mouse.

One of the main reasons for his preference for doing network analysis manually is that he can do them faster that way.

One minor reason for abandoning one package was the fact that the space for the description in an activity box was too small - the terse abbreviations necessitated frequent reference to a code list. When it came to use the work schedule the site staff got confused by the terse abbreviations.

His biggest problem with computer packages is the need to check the accuracy of input. One small typing error can lead to the most serious consequences. Meticulous checking takes much time. Once the error list has been compiled, the errors have to be corrected by typing them in. Then the whole checking cycle starts all over again. Little confidence can be placed in a computer generated work schedule unless the input data is 100% correct.

This checking cycle is involved every time there is input and is really most time consuming.

Inexperienced staff tend to throw information into the computer in the optimistic view that it would come out correct. They invariably lacked the bitter experience which showed that each tender had to be meticulously examined in all aspects, data prepared, and only then could the network be drawn. There was no escape from the sweat of the planning process.

Clients occasionally use their own computer packages to check the contractors' progress. They put the contractor's network on their package. This then has to be checked by the contractor. The planner has learnt not to trust computer printouts. It takes between one and two weeks to check this data. Sometimes agreement can never be reached as the other package does something inside which gives a different result to that of the contractor.

The discussion then centered around the two different types of planning: the one required for tendering purposes; the other for a contract that has been awarded.

Although different in practice, both have equal weight when it comes to their importance. They both invariably end up as legal documents and therefore have to be right.

The planner confirmed the writer's experience that a company only wins between one in fifteen and one in twenty tenders. Therefore costs at tender stage have to be kept low. Also tendering under these conditions to obtain sufficient contracts for a company means a great volume of work. Overtime has frequently to be put in to meet deadlines. Consequently every part of the planning process for tendering purposes has to be most effective.

He can do the whole exercise more effectively by manual than by computer methods.

The main reason is that the network is but a part of a bigger process. The bigger process involving constant human intervention, juggling, ingenuity and assessment as construction methods are chosen and a tender is put together which may be cheaper than their competitors and within the constraints of the contract. In view of the economic consequences of an incorrect tender can a computer be trusted to get the best result?

When a contract is awarded, the tendered work schedule is given to the site team to explore, check and comment on. They must accept it as their own. They are free to make changes. Obviously changes must be within the parameters of the contract. The planner and his staff will assist - but not dictate - in this process. The site team must believe in the programme and 'own' it.

He has tried to run a few contracts with various computer packages. But found problems.

The one is the checking problem which has already been mentioned.

Changes to the contract did not prove as easy to make on the computer network as first thought. The change would be entered, print out checked for correct data entry, any errors corrected and the printout rechecked for errors. Then the printout would be examined for the result of the change. Invariably the contract would now over run its allowed time. Or there would be problems with resource levelling. The network would then have to be reworked manually and different linkages used or different methods used. Frequently different linkages or methods made little difference to the cost - there are invariably many acceptable different ways of going about a task - frequently with equal ease or risk. As the planner ended up reworking the work schedule anyway, he now did it manually the first time.

Certain packages had required that he "cook" the resources to fit into the units in which the package would calculate resources. This later created problems with interpretation.

He had also found problems when recording progress on the computer package. If work was done out of the planned sequence, then the computer package sometimes had difficulty in reporting this because the linkages would not permit it.

The information from a computer run was produced in large piles of unfriendly print out. Site staff were instantly put off by it. [ The writer found himself having to study the sample printout he was shown, whereas the writer knew that there were other methods of presentation of the same data which could be assimilated at a glance.]

Parts of the reports could be selectively printed. But the planner frequently had to wade through the whole print out in order to know what was worth printing selectively.

The writer questioned the planner about the marking up of the progress. The writer was particularly interested in this aspect since a student had recalled to the writer how in his firm the weekly internal progress meeting, and the preparation for it, had ended up as a session for proving why they could not do what they should have done and why they were not to blame for not doing what they should have done. The student added that the following week was also a shambles as no-one had had time to plan ahead. The planner of this company believed that the progress should be marked up by the site agent and contract manager weekly. It should be done in a constructive manner with an eye to the future. It was essential to maintain the spirit of the site team and the right attitude to marking up progress was essential.

Moving on to presentation of the results of network analysis the planner said that what site staff wanted planning wise was one picture with as much detail as they needed on it.

With regard to short term planning , his personal view was that a monthly rolling schedule was needed for senior staff purposes - eg to enable the monthly claim to be premeasured - and a two weekly programme for the site staff. A one week programme tended to be fine for the week but there was always a problem with the overlapping period between it and the programme for the following week. There was better continuity in a two week programme.

Foremen he found were frequently distracted by site needs when it came to sitting down to heavy planning sessions. After all the foreman needed to be on site. [Here the problem of the doer planning and having the uninterrupted time to do it surfaced.] In the planner's view however much the foreman might be distracted by site problems it was still part of his job to plan for work in the short term. If he had an assistant to plan, he must supervise the assistant closely.

In general the planner gave the impression that he felt that the reported successes attributed to using computers in planning always eluded him. He found manual methods quicker and he definitely had more confidence in the result when he had finished. He would keep on trying computer packages to see if ultimately he could find one which was better than his manual approach.

Part of the difficulty is that future users of the "plan" need to see his reasoning as they go along. Manually there is the possibility of margin notes in the natural-to-look place i.e. alongside.

The following comments were also made:-

He did not bother about activity coding/ work breakdown structure.

He found no need to level resources between sites - if the firm did not have sufficient resources available it did not tender.

He found little need for linked bar charts. If drawn with a little thought then the activities followed beneath each other and there was no need to clutter the work schedule with links.

### **4.3. VISIT TO CONSTRUCTION COMPANY NO 2.**

The firm was a major Cape Town firm. Most of its contracts were in Cape Town, but it had a limited number of contracts in other centres as well.

The senior manager granting the interview was personally very interested in computers. He frequently offered his firm as a test centre for new computer packages and had evaluated quite a few. During evaluation of test packages he would investigate aspects such as:-

- amount of memory used,
- speed,
- number of key strokes to enter data,
- and whether it met the operating characteristics he had chosen for his firm.

Seven years ago the firm had purchased its first computers. Now they had 5 in head office and one each on contracts more than 500kms away. He foresaw the day when each contract would have a computer on site. However, present operating systems did not require one on each site.

His company attempted to standardise on equipment so that staff could, if necessary, move to any site and work efficiently. With the improved hard and soft ware that was always coming on to the market, "standardize" had effectively come to mean limiting the variations as much as possible.

They had found that each department needed a slightly different package to do the "same" work. This was due to the different emphasis in each department of the firm.

They rarely found a package that ideally suited their needs. However, suppliers could frequently introduce slight amendments and thereby tailor the package to their needs.



They found it necessary to assemble different packages to meet their full requirements, and the ability of one package to read data into another was an incredible advantage.

Before testing any package - let alone buying it - they would list all their requirements and then check the package against that framework.

The company was onto its third set of network planning packages. This was over a period of five or so years.

The latest planning package they had bought was extremely user friendly and their planner - admittedly experienced in the previous packages they had used - needed only two weeks to master it.

Different techniques were used to plan each job. Manual methods were sufficient for small contracts. Larger ones were put on their previous package - a low priced networking package. Contracts over R10 million, or particularly complicated in some way, were assigned to their latest high priced package. (As a measure of this packages success in the firm they now owned four copies.)

Before anything was put on the computer a manual analysis of the contract was done. The method and manual network analysis outline were produced by one person at the same time. Method and scheduling were treated as one operation - not separate disciplines - in their firm.

Tasks were defined at a relatively high level ("composite tasks") - as they did not believe that there was any advantage in reducing tasks to the smallest element. (Eg "columns" as opposed to the elements of "Reinforcing steel", "formwork", "concrete", "strip", "cure", etc.)

Only when the manual analysis was complete was the data loaded into a computer. They avoided loading data into the computer "live".

Only the planner was allowed to input data. Because he knew:-

what the data he was inputting meant,

what to expect by way of the shape of the output, and because alphanumeric codes used for each task or activity meant more likelihood of errors being picked up,

they did not find a checking routine for input data necessary.

All tasks were coded alphanumerically for "Zone" and "responsibility".

The computer was basically used to calculate the network and produce impressive print outs.

The firm tried to keep one man to each computer lest another user inadvertently change something which could cause a package to operate differently to the way it had operated in the past. This could, for instance, cause an error in the way a package calculated a network.

No one was ever allowed to use a non-company package on any company computer. The reason for this move was that sometimes it was necessary to work on a computer at another place to where the work was normally done. This rule reduced the chance of viruses infecting their machines.

In their firm the success rate for tenders was about 1 in 12. There was never enough time to put networks on computer at tender stage. They were almost always left in manual form.

Contract staff were not involved in tendering procedures. In the event of being awarded a contract the programme, method study, and budget were given to the site staff. The site staff could suggest alternatives if they wished. Invariably they simply accepted the plan of action. If there was an error in plan of action the site staff "made a plan" to overcome it.

He had found that site staff tended to drift away from the laid down programme.

Computer package produced nice presentation documents - and very quickly indeed. Clients were overawed by both facilities!

Many clients tended to accept computer generated data more easily than hand produced data. This was possibly due to the effort required to analyse and investigate the vast amount of detail in a computer generated report.

Because of the availability of computers and modern packages his firm were now able to achieve things that could never previously have been attempted by manual means.

Computer generated material was used on site by the better educated person. They could profitably use the variety of reports generated by the computer. They tried to attract staff to their firm who preferred the computer way of doing things. They found that from foremen level down there was generally a reluctance to know anything about computer generated material.

Returning to a point discussed earlier, he mentioned that there were draw backs in the use of "composite tasks. Although the use "composite tasks" greatly reduced the complexity of networks and simultaneously the time consuming need to check data input by virtue of mistakes being obvious in a more straight forward network programme, they could not easily resource level, or obtain costs from, or play a large variety of "what if" games on a network thus produced. But the present approach was the best balance for the current needs of his firm.

**CHAPTER FIVE.**

**CONCLUSION.**

## **5.0 CONCLUSION.**

The aim of this thesis was to investigate the way computer planning packages are used in the Building Industry of the Western Cape, and to make recommendations as to the future use of such packages.

This chapter comprises conclusions arising out of investigations into the use of computer packages. The next chapter contains the recommendations.

### **5.1. Conclusion One: Many people have reached similar conclusions.**

Whether reviewing literature, performing hands-on-experiments, analysing the mail survey, speaking to people in the construction industry, or working with students as they tried out the procedure proposed in "Recommendation Five" in the next chapter, the writer found the same sort of things being said, or experienced, again and again. These "things" were the aspects brought out in the literature survey. These same aspects - favourable and unfavourable - kept occurring.

This indicates that Cape Town Builders as well as people in other parts of the world have similar situations to contend with.

### **5.2. Conclusion Two: The background of any undertaking plays a significant part in the effective use of any computer package..**

The background, that diverse mix of:-

- management styles,
- types of building contract,
- and even the type of employee,

affects any recommendation that might be made regarding "how" and "when" to use a computer planning package.

This means that no one method of planning will be universally appropriate for any type of job, or for any particular firm, or for all employees in that firm. In other words management will have to select the most effective way of planning each contract.

### **5.3. Conclusion Three. Network analysis is generally used 10% of the time.**

A visitor to the respondents of the mail survey could expect to find network planning techniques being used about 10% of the time.

This seems low. Why might this be?

Firstly, consider the main characteristic of network analysis.

- a). The chief characteristic of network analysis is that it is a logical, step-by-step technique which enables a sequence of performing the various component parts of a contract to be determined.
- b). This sequence - or network - then forms the basis for further valuable exercises; for example:-

" resource levelling",

" crashing",

" determining the probability of meeting the contract time",

" optimizing", etc.

Secondly, consider the environment to which network analysis is applied.

- 1). In most types of building contract there a many, equally acceptable ways of arranging the component tasks in order to achieve an acceptable network.
- 2). Frequent changes to this network are likely to be required because building construction takes place in an environment of flexibility and uncertainty.

Examples of frequently occurring uncontrollable events which may affect a carefully prepared network:-

- i). Building work is invariably done outdoors in totally uncontrollable and unpredictable climatic conditions. ( ie rain, wind, heat, humidity.)
- ii). The attendance of workmen is unpredictable. The writer once dealt with a construction site where, because the infighting amongst site management spilled over to the labour force, absenteeism rose from about 8% on a "normal" contract to about 33%. Planning became a farce in the face of such high absenteeism.

This means that there is little advantage in using a time consuming network analysis if there are:-

many equally acceptable networks,  
the strong likelihood of many time consuming revisions.

It has been suggested that the way to reduce the initial cost of preparing the network and reduce the cost of anticipated revisions is to use macro tasks and leave the details to the site staff.

But if macro tasks are used, then the tasks are linked not with clear "finish-to-start" links but with "leads" and "lags". This is very close in appearance to a linked bar chart!

So why not use the linked bar chart in the first place?. The barchart planning technique is much quicker and easier to use mainly because it contains less detail with regard to linkages and tasks.

It seems therefore that the nature of many of the building contracts is such that a simple linked barchart will be more effective than network analysis simply because the extra effort required for network analysis outweighs the extra advantages gained by using network analysis.

The frequent use of network techniques compared to the use of barcharts by the building industry as shown by the results of the mailed survey, would appear to confirm this.

However, whenever a contract is exceptionally large, or has a severe "bottleneck", then that contract might benefit from the time consuming Network Analysis Technique as there may indeed be one critical path. Examples of contracts with bottlenecks are contracts in a city center with limited access, renovation jobs with only one lift to serve the work areas, a building with many services (eg hospital), a multistory building with a climbing tower crane, a large project with limited resources.

#### **5.4. Conclusion Four. In the average firm only 7% of computer time is used for planning.**

The survey showed that in relation to other uses such as "wages" or "accounting" the time spent by computers on planning was minimal. It was also shown that firms only began to use computers for planning when they had a number of computers in the firm; ie "planning" did not motivate the purchase of the initial computers

Why is the computer time spent on planning so low?

In a nutshell the problem is that the time to set up network analysis on a computer is enormous. There are no short cuts. Either the data is entered properly or the results are suspect. In the hands-on-experiments the one lasting impression was the time taken to feed in data, check it, correct, recheck, etc.

The already severe drawback regarding the time needed to enter data is made worse by the knowledge that network analysis may not be needed and that time consuming frequent revisions are likely to be required.

Therefore it should be no small wonder that the mail survey showed that the average time spent using a computer to plan is of the order of 7%.

Therefore when deciding whether to use a computer to aid network analysis, consideration must be given to the time needed to set up the package for the contract. There are no short cuts. What this means is that it is only large, or complicated jobs with bottlenecks that are likely to benefit from the time and cost needed to get a network onto a computer and keep the network up to date when revisions occur.



**5.5. Conclusion Five. The most appropriate way of using computer packages in the building construction industry has yet to be established.**

The many conflicting views, frequent changes in computer package used, and the different ways in which a package is used, indicate that the most appropriate way of using computer packages in the building industry has not yet been established.

**5.6. Conclusion Six. Computer technology is limited.**

Great advances have been made in the way the human interacts with the computer.

User friendly, pulldown menus, speedkeys, help facilities, the opportunity to enter data in a number of ways and in a number of convenient places, have made it easy to work with packages.

However there are still two aspects demanding attention. The first is the screen display and the second the way the human interacts with the screen display.

Firstly consider the screen. The screen is simply too small to see at one time a meaningful amount of data. The operator resorts to frequent printouts to check the state of the plan.

This is expensive since after a few more keystrokes that print out has little value. Also, information is fed in as if the operator was blind folded. Fewer errors would be made if the operator could see the effects of each entry.

Secondly consider the operator's interaction with the screen.

- 1). If the operator could see a useful amount of data on the screen then a mouse or light pen would enable him to link tasks with the same ease as if he were drawing on a piece of paper.
- 2). If the operator could work in this way he could also adjust the presentation of data on the screen in a similar way to the manner in which cut-and-paste layouts are used to prepare a master sheet for photocopying.

**5.7. Conclusion Seven. It is necessary for computer packages to be compatible.**

The diversity of the building industry makes it likely that no single package will meet the specific needs of a particular company.

A suitable package may well be assembled from a number of commercially available packages.

Examples of linking packages.

- i). Writing Basic Language programmes on a word processor with its "seek", "replace", "copy" facilities is often easier than writing in the basic programme itself.
- ii). One management consultant assembled three packages for his client's needs.
  - \* The clerk input data using the user friendly "Dataease" database package.
  - \* The consultant did the analysis on Lotus 123.
  - \* The results of the analysis were presented to the client using a Desk Top Publishing package.

If the company grew, or its needs changed, the consultant could link more appropriate packages without the need to start from scratch with a new package.

- iii). A firm with which the writer has maintained contact throughout the time taken to prepare this thesis has decided to test another planning package. They will attempt to link the planner's package to the same data base that the estimator's package uses and thus reduce the need of the two men to continually liaise on basic input data.

This trend towards compatibility of different packages was first detected in literature. The writer has since noticed that each update in the very limited range of packages that the writer uses contains more facilities to communicate with other packages than the previous one.

Very expensive packages are reputed to have built in facilities for tailoring the package to the firm's developing needs. However not many building firms are capable of benefiting from such a package. Therefore the ability to link commonly used packages together to fulfil the firms requirements is a great advantage - an advantage made greater by the diversity of the needs of each organisation.

#### **5.8. Conclusion Eight. Planning is but part of the management process.**

Planning is not an end in itself.

A plan is a statement of how the contract will be carried out. Therefore implicit in the plan is the assumption that due consideration has been given to the method statement and specification and that if this plan is followed the contract will be completed not only within time but to specification and within budget as well.

Management must ensure that this is indeed the case if maximum benefit is to be obtained from the time spent on planning.

#### **5.9. Conclusion Nine. Knowledge of how to use computer packages in their own situation is necessary for any business.**

Like a bell tent that only stands upright when guy ropes pull equally in opposite directions so there are two "guy ropes" present when using computer packages.

Therefore management will need to set up the way things are done in their firm to maintain equal and opposite pulls.

On the one side, computer work is best done in an environment free of interruptions by people who are familiar with what is going on within the package.

On the other side, site staff are plagued by frequent interruptions and never have too long for any one particular task.

Therefore, it becomes easy to separate these two aspects.

Should this happen then the experience of the site staff, their ability to react quickly and effectively to sudden changes by virtue of their knowledge of the reason for planning tasks in a particular sequence, and their commitment to "their own" work schedule is lost. The planner also loses heart because the site never uses his labours. Worse still it can happen that a "we" verses "they" situation occurs with valuable resources tied up in conflict.

Recommendation five in the next chapter offers a method of keeping the bell tent standing upright.

**5.10 Conclusion Ten. It might well be asked if the present generation of techniques, computers and computer packages really the answer to the general needs of the building industry?**

While the writer has worked on this thesis the realisation has grown that the present generation of network analysis techniques, computer hardware and software are actually rather odd bed fellows.

Mindless computers do a magnificent job where their tireless ability to calculate, sort, file, retrieve, and compare is utilised in areas where the rules are fixed and apply to all transactions.

This was shown in the mail survey by the initial application of computers to "wages" and "accounts". Outside the building industry there is perhaps no better example of this than the successful use of computers in the electronic banking system.

However in many instances the building industry is an art. The art of making the right things happen by using a flexible approach to turn the daily dose of bad fortune to advantage and to multiply the effects of good fortune and so make possible the impossible.

The industry despite many factors which are rigid, also has a large number of variables. Perhaps there are too many variables to make the present generation of computer systems generally effective in the building industry.

Perhaps there is some new system still to be discovered which will enable "computers" to be used with greater success by more firms in the building industry.

**CHAPTER SIX.**

**RECOMMENDATIONS REGARDING THE USE OF COMPUTER AIDED  
PLANNING TECHNIQUES IN THE BUILDING INDUSTRY.**

## **6.0. RECOMMENDATIONS REGARDING THE USE OF COMPUTER AIDED PLANNING TECHNIQUES IN THE BUILDING INDUSTRY.**

Before making any recommendations careful consideration was again given to the enormous diversity in the nature of each building firm.

This diversity was considered at the time the mailed survey questionnaire was being prepared and is recorded in the section on the mailed survey.

This diversity means that any recommendation that is made must be incompatible with the culture and management style of many of the spectrum of firms forming part of the Master Builders' Association of the Western Cape.

However, in the light of the insights gained during the work on this thesis there are never the less certain recommendations which can be made even though they may only serve as point of reference when adopting a particular strategy in practice.

### **6.1. Recommendation One:- Use a bar chart for the smaller contract.**

No matter what the size of the contract, some sort of planning will always be necessary.

However, in many of the smaller contracts only the most elementary methods of planning will be required. A simple bar chart will be adequate in most cases.

The resources spared by not using network analysis techniques will, if redirected to other spheres of management, bring a greater return.

This situation is believed to apply to 50% of the work done by Master Builders.

## **6.2. Recommendation Two:- Consider using computer aided network analysis techniques when negotiating.**

When negotiating a large project the computer has advantages because of the speed (overnight) with which an attractive looking programme for a possible contract can be presented. [The considerations of speed normally compelled the client to consider negotiation as opposed to tendering in the first place].

The quality of the presentation of the work schedule has inestimable selling power - particularly if there is a lot of it and it is in colour !

As negotiations proceed the network can be rapidly updated because of the computer package's speed.

A further consideration is that secrecy during negotiations requires a small team of people. A computer is one way of increasing the ability of the team without increasing its size.

It is possible that contractors - when preparing such a rapid presentation - use parts of their library of past projects suitably patched and doctored to fit present requirements.

When a computer is used in such a situation both it, its programme, and its library of information, must be totally committed to the care and use of one person. A second user, no matter how acceptable, might inadvertently make a small alteration to something which will produce a result in a way the normal user was not expecting. The possible financial disaster this might cause is not worth the risk.

## **6.3. Recommendation Three:- Use manual techniques when preparing a tender.**

In the majority of tenders, where the success rate is perhaps one in fifteen, there is generally little need to spend any more time on the programme than was spent when preparing the tender.

The estimator/planner's tender notes on the method statement and handdrawn barchart or network are sufficient for the tender. If the contract is won, these

documents will form the basis of a work schedule more appropriate for construction purposes

Preparing a tender is a curious process of blending different construction methods and sequences of work in order to achieve the lowest possible estimate of cost. Frequent adjustments are therefore made - sometimes up to the last minute.

The use of a computer has been shown to be time consuming and a possible risk if the checking of input data is incomplete.

In view of the likelihood of frequent and last minute changes - and therefore little time to check input data - manual methods have the edge on computer methods.

As the two theories of Douglas McGregor will be referred to in the next two recommendations, the two theories are outlined below.

Douglas McGregor's Theories.

Theory X.

- 1). People dislike work and avoid it if they can.
- 2). People must be forced, controlled, directed and threatened with punishment to get them to work.
- 3). The average person wants direction, does not want responsibility, has little ambition, and wants security above all.

Theory Y.

- 1). Work is as natural as play or rest. People do not inherently like or dislike work, but rather develop an attitude towards work based on their own experiences.
- 2). Man will use self direction and self control if he is committed to a project.
- 3). Man has a strong desire to achieve.
- 4). Man wants to accept and seeks responsibility.
- 5). Man wants to use his creativity.



**6.4. Recommendation Four:- Consider using computer aided network analysis techniques for large contracts - in a Theory-X company.**

When a building contract is very large there is invariably some bottleneck or expensive resource which makes network analysis techniques necessary, and the contract's sheer size gives computer methods the edge on manual methods.

Where possible macro-tasks should be used and details left to the site staff.

In a Theory-X company planning would be done in a central place and the site would be expected to make the plan of action happen.

The central planning department would firm out the plans prepared at tender stage. They would use company production standards and methods, and would invariably use network analysis of sorts for planning. This might be well be done on a computer as the staff in a head office department would be continually planning and therefore have the opportunity to build up effective techniques on a computer.

The programme would be presented to the team allocated to the contract. Management would expect the site team to adhere to the programme. Deviations from performance standards would be reflected in exception reports and would be corrected by management pressure, training programmes, movement of personnel, performance bonus' (in widest form), and similar techniques.

In the Theory-X company the computer would be an ideal way to produce the many exception reports which would be required.

**6.5. Recommendation Five:- Consider using computer aided network analysis techniques for large contracts - in a Theory-Y company.**

The same reasons as given in 6.4 above are applicable. ie:-

When a building contract is very large there is invariably some bottleneck or expensive resource which makes network analysis techniques advantageous, and the sheer size of the contract gives computer methods the edge on manual methods.

Where possible macro-tasks should be used and details left to the site staff.

The method of applying the techniques in the democratic Theory -Y company would be different to the method of applying the techniques in the autocratic Theory-X company.

The writer urges that the approach recommended for the Theory-Y firm be adopted wherever circumstances permit since a plan of action developed by those who will carry it out not only gains from their contribution but is also more effective because they are more likely to regard it as their own. Most important of all, however, is the fact that they will know *how and why* it has been planned in that way. The knowledge gained from the *how and why* is one of the few aspects of planning that is universally agreed to be a consistent advantage.

The recommended method is now described in some detail.

In the Theory-X firm the programme, method statement and estimate might have been prepared manually at tender stage and would probably have been agreed to by the prospective contract manager.

In such a firm, once the contract had been won, the senior members of the site team would be summoned to a one day meeting at which the appropriate head office personnel would also be present.

They would be allowed to replan the contract - provided the end result was an improvement on the tendered programme.

This would be done in the following way :-

- \* Having done their homework before such a meeting, key activities would immediately be written on magnetic labels and these would be placed on a series of magnetic white boards.
- \* With everybody present the sequence of these activities would be determined simply by moving them about on the blackboard. Everybody could see and participate.
- \* These activities would be macro activities. Otherwise the process and the computer become bogged down in fine detail which will ceaselessly change

because that is the nature of doing one-off work outside where the weather is both uncontrollable and unpredictable.

- \* Methods would obviously be taken into account when determining this sequence.
- \* Links would then be drawn in khaki pen.
- \* Durations would be agreed upon.
- \* Activity codes - especially who did what - would be decided.
- \* The meeting would end when there was agreement that the proposed programme would be equal to or better than the one prepared at tender stage.

The planning department would then take over the task of preparing the actual plan of action whether it was prepared manually or by computer. They have the expertise and equipment.

If the contract work schedule warranted computer assistance, the data on the white board would be captured on forms. There would be one form for each activity. This data would then be entered into a computer programme and the accuracy of entry could be checked by comparing the data on the form to the data in the computer.

The programme would then be run on the computer and the output checked.

Problems would be expected. But these should be sorted out by the planning department - and if necessary a representative of the site team.

This would then become the contract programme.

Each week progress would be fed into the computer.

Each week the computer would print an exception report of items well ahead or well behind schedule.

It would be a great advantage if the computer package could report progress in the graphical way devised by Mr O. Knauss. [The method is explained in the appendices.]

Each week the computer would print :-

- 1). A two-weekly programme for the areas where it was deemed necessary and for activities for which it was necessary. But this programme would only indicate the work to be done during that period. It would be similar to a bar chart but the actual bars would be missing. It would be for the site person responsible for that work to draw in the actual bar as to when that work should be done on site. Only a site person would have the detailed knowledge to complete the barchart, and this would avoid the computer network being filled with excessive detail - much of it which will never be achieved simply because of (say) the unpredictable effects of inclement weather.
- 2). A four-week "look ahead" programme would be printed for site management only.

Other reports could be printed if and when necessary.

If this approach was followed, then every body would be contributing in the way they were most productively able to do so. Each person who had a responsibility to plan would plan. The planning dept would be interested in both management reporting and feedback for their library of data, site management would have both progress and up to date four weekly look ahead reports, and the site foreman and or section charge hand would be able to make his contribution but in the area he knew best and in the area where he could make the plan he had devised come about.

Not only would the company benefit from the contribution of a great many people but the contributors would have thought through their section of the work (in itself of great value ) and would most likely "own" the programme.

And last but not least, the data in the computer would be kept to manageable and useful levels.

Obviously this is as extreme as the Theory-X case presented earlier. But these scenarios are the only way to attempt to consolidate the knowledge that has been

accumulated during this investigation against the background of the wide diversity of builders in the Western Cape.

**6.6. Recommendation Six:- The hardware should be improved by means of a larger screen and light pen/mouse.**

The biggest practical problem with the application of computers to network analysis is the difficulty of manipulating data on the screen.

Two advances would make a significant improvement:-

- 1). A larger screen is needed so that the operator can see sufficient information on the screen without having to resort to frequent print outs to provide it. This process takes much time and the hard copy is out of date a few keystrokes later.
- 2). A light pen or mouse would enable the operator to link, move items, change the appearance of graphic output without having to use the keyboard all the time.

A larger screen was seen during one of the author's visits to a firm, but it was linked to a CAD system. Although this would be an improvement it did not appear large enough to obviate the problems experienced with present screens. It might even be necessary to have a video projector able to show computer data on a digitizer board.

**6.7. Recommendation Six:- Check for these attributes when selecting software.**

The writer had limited opportunity to test the intricacies of software. However when buying software he considers the following features worthwhile.

- 1). Pulldown menus while learning the package.
- 2). Speedkeys - normally two keystrokes - which enable data to be entered quickly. This is for the operator once familiar with the package.
- 3). The possibility of the network analysis package being linked to other packages.

- 4). Good graphics presentation of the end results. "A picture is worth a thousand words."
- 5). It should be possible to enter activity codes in Alphanumeric format.
- 6). The software should be loaded onto a computer which is fast. The writer wished his AT had a maths co-processor. At the time of writing ATs are being superseded by new technology
- 7). The software should be purchased from a supplier who is both competent and prepared to support the package over at least six months.
- 8). The package should have "Help" facilities and "Tutorials".
- 9). The package should support a mouse or light pen.
- 10). There should be enough space in cells to enter meaningful descriptions.

#### **6.8. In Conclusion - The manager must remain master of both the technique and the computer.**

The draft of these recommendations was discussed on a random and informal basis with colleagues in the construction industry.

One point of interest that emerged from the discussions was the move in at least four national building companies to place computers on large sites and have the time clerks and / or site clerks/storemen enter data directly into the computers. No longer was the personal computer only to be found on the desk of the Managing Director. Apparently these site staff were handling their computer duties competently and the data was immediately available in the variety of formats required by different senior staff. The writer noted that the use of the computers was in the field of "wages" and "accounts".

Another point that emerged from the discussions was one which had been anticipated in view of the diversity of managers and firms. Few people agreed with the recommendations as set out. However, of more significance to the writer was the extent to which the views of different people within the same firm differed when they commented on the recommendations. There is obviously as yet little agreement over just what is the best way to apply these techniques in the building industry.

One manager said that he believed that the best way to apply these techniques was to know all about useful techniques, and then to select those techniques, or

combinations of techniques, which were of advantage to a particular contract. If the full benefit of these techniques was to be enjoyed then it was not good enough merely to select a technique. The manager must be able to select and apply those parts of the technique which were appropriate and he must have the strength of mind to avoid those parts of a technique which, no matter how fascinating they might be, had no benefit to that particular contract.

The user must not be overawed by techniques or computers. Significant productivity will only be achieved by these methods if the users can select the appropriate part of a technique and apply it to a particular contract.

The manager must remain master of both the technique and the computer.

**CHAPTER SEVEN.**

**REFERENCES.**



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**CHAPTER EIGHT.**

**APPENDICES.**

### **8.1. REVIEW AND EXTRACT OF RESEARCH CURRENTLY BEING DONE ON NETWORK APPLICATIONS IN THE BUILDING INDUSTRY BY TEAMS IN HAIFA AND TEXAS.**

#### **Another review of contractors problems, but through the eyes of another panel of researchers.**

In a review of the contractors' problems with regard to planning and scheduling of contracts Laufer and Tucker (1987) *"argue that the CPM concept was created for national projects and cannot satisfy the contractors needs for whom an efficient utilization of resources and their cost control is more important than construction time. Specifically the following weaknesses are exposed*

- 1) *The CPM model refers mainly to technological constraints while the limitations of resources are barely considered. It does not ensure full continuity for the construction crew which is the backbone of operational planning in construction.*
- 2) *Even for technological relationships the model does not always provide satisfactory solutions. CPM is suitable for "sequential" operations which characterize an erection-type of work. It is not suitable for "bulk" operations which is typical of an installation-type of work, where detailed sequencing of activities is often irrelevant or unimportant.*
- 3) *When technological relationships are well defined and the model may be theoretically satisfactory we find that in many instances CPM is difficult to apply in practice. The majority of activities on a construction site are overlapping , not only with the immediate preceding and succeeding items, but possibly with a score of preceding and following activities. This fact has always been obvious on a bar chart but is difficult and tedious to express accurately in an activity network.*

- 4) *The model only processes planning data that has been fed into it. Other input data - duration of activities, relationships, and resources - have to be prepared by the planner using mainly heuristic decision making concepts which entail giving attention to each activity and making many activities critical. This contrasts with the model algorithm which determines an incidental critical path related to activity duration.*
  
- 5) *The network model usually presupposes that interferences and variability occur rarely. In fact, uncertainty is not a brief intrusion into a predictable sequence of operations. The opposite is true. Randomness and uncertainty exist in construction everywhere."*

In a later article Laufer and Tucker ,1988 continue their overview of construction planning practices and make the following comments about the degree of detail involved :-

*"The degree of detail to which plans are worked out is a major determinant of construction planning effectiveness ( Harrison,1981; Lichtenberg, 1986; Mason,1984). This aspect holds the key to the solution of the timing dilemma. Based on two studies in construction companies Arditi (1981) concluded that there is much confusion about what should be regarded as an adequate degree of detail. Morton(1983) summarized it by stating that 'too much detail is probably the most common problem in project planning'.*

*Ramifications to overly detailed planning are :*

- 1.) *Costliness*
  
- 2.) *Cluttering, obscuring a clear overview of the project.*
  
- 3.) *Heavy updating requirements, which are time consuming in the monitoring and replanning phases, with long response time and concomitant loss of opportunities for corrective action.*
  
- 4.) *High obsolescence, as detail plans decay much faster because some of the information is not based on reliable data but on the best intelligent guesses. The decay accelerates towards the far end of the planning horizon ( Galbraith,*



1977). Also, the chances of a detailed rote plan to materialize are quite slim particularly in uncertain environments (Ewing, 1969).

It is therefore recommended that :-

- 1). plans be prepared at the lowest possible degree of detail, and
- 2) the degree of detail should vary inversely with the planning horizon.

Stated differently, the closer the moment of implementation the greater the detail. The pace at which the level of detail varies across time is not uniform. It is contingent upon various factors, mostly that of uncertainty. For high uncertainty the guidelines are :

- (1) to lower the degree of detail for the near term, and
- (2) to accelerate the decrease in degree of detail across the planning horizon.

Thus, instead of maintaining a constant degree of detail across time one should aim for a uniform degree of planning accuracy thereby achieving early as well as more effective planning.

The suggested approach advocates a reorientated attitude to near- and far- term planning. As the planning horizon stretches longer, changes in the following aspects of planning can be observed :-

- 1). Degree of completeness of plan. The longer the planning horizon the smaller the list of activities and the more compact the specification for each activity.
- 2) Focus of Planning. As planning horizon increases, more attention is paid to the examination of ideas rather than to the analysis of precise facts and numbers.
- 3) Role of planning. As planning horizon increases more emphasis is placed on assessing the futurity of current decisions. Thus, near term planning becomes predominantly action planning (affirmative planning), while far-term planning becomes primarily preventing planning."

## **8.2. THE PROCESS OF 'MARKING UP' BAR CHARTS TO RECORD PROGRESS.**

### **8.2.3. How computer facilities might simplify this process.**

The writer's 20 years of experience in the building industry indicate that there is a great need for reducing elaborate networks to bar chart form for the purposes of 'marking up' progress.

In the writer's experience the marking up of the bar chart is crucial to the success of the contract, is seen and hopefully used by everybody, and forms the basis of progress reports at site meetings. It is not surprising therefore that considerable staff time is always spent on this sphere of scheduling a contract.

The bar chart is normally marked up weekly using a different colour to represent each week and to show the progress in that week. This is normally done on the original bar chart on the construction site. Later bar charts at other locations where progress must be reported are marked up in accordance with the site bar chart.

Two problems always occur:-

Firstly, the drawing that is marked up on site becomes tatty after a few months. Yet it cannot be replaced because of the wealth of information it contains.

Secondly, similar bar charts have to be marked up regularly at other locations (eg Head office) as well. It is a problem to transfer the information correctly and a further problem for another person at these locations to get the marking up correct. Alternatively if marked up drawings are sent from the site to the other location/s, there is the cost of constantly replacing and marking up such drawings from scratch .

Here the facilities offered by a computer system would be invaluable. The information could be stored/transported on floppy disc. The information could then either be called up onto a screen for a quick check, or printed out for a permanent record. The ability to print a hardcopy in patterns or colour would be a distinct advantage. The most satisfactory way of marking up bar charts.

The method of marking up a bar chart must be one in which the observer can immediately assimilate a wealth of information from the chart.

The best method, in the writer's experience, is the marking up method which was introduced to the author by a Mr O.Knauss. It has proved its worth many times over as a management tool, and because of its great usefulness is described now.

### **8.2.2. Mr O.Knauss' method of marking up bar charts.**

The first step in marking up the bar chart is to select a different colour-marking for each time period on the time bar of the chart.

Whenever work is done during a particular period, then the colour of that period is used to colour up the progress on the bar of any task.

The length of the coloured-in section represents the proportion of the work shown by the bar that was done during that time period.

By inspecting the marked up bar chart it is possible to see:-

- a). Whether all parts of the contract are on time.
- b). When the work in any part was done.
- c). Whether tasks are being carried out faster or slower than planned. (ie will that task finish ahead or behind the planned schedule?)
- d). Whether a crew, unable to work in a particular area, still maintained their output, but in a different place and no necessarily in the right sequence.

See the example on the next page.

Example of marked progress schedule.

MONTH.	MAY	JUNE	JULY	AUG	SEPT
Progress code:	mmmmmmmm	jnjnjnjnj	j1j1j1j1j	aaaaaaa	sssssss
Task One.	mmmmmmmm	jnjnjnjnj	j1j1j1j1j	aaaaaaa	sssssss
Task two.	mmmmmm j	njnj j1j1	j1j1 aaaa	aaaaa s	ssssss
Task three.	mmmmmmmm	jnjnjn j1	j1 aa s		
Task four.	jnjnjnjn	j1j1j1j1j	aaaaaaaaa	sssssss	
Task Five.	mmmmmmmm	j1j1j1j1j	aaaaaaaaa	sssssss	
Task six.	aaaaaaa	sssssssss			
Task seven.	mmmmmmmm	mm njnjn	jnjn j1j1	j1j1j1j1j	aaaaaa

Assume all tasks are scheduled during the whole time period shown.

- Task one :- Runs to schedule.  
 Task two :- Falls behind, then catches up.  
 Task three:- Falls further and further behind.  
 Task four :- Has started early and keeps ahead.  
 Task five :- No progress in June. Remains one month behind.  
 Task six :- Is, and remains, two months late.  
 Task seven:- Gains time each month and is eventually ahead of schedule.

- \* By following a colour down the page one can see the progress of any job at any time period.
- \* By the length of the coloured bar one can see if a month's work was done in that month. This also shows if an task is gaining or falling bewhind schedule, and by how much.
- \* By looking at the colour one can also see when the month's work was done.
- \* By looking at the colours it is also possible to project items into the future an d guage the effect on the contract.

If a computer package is going to be useful to a contractor in the building industry, then the writer strongly recommends that the package be able to handle this technique. In fact on a contract that runs according to the original schedule of work, in the writer's opinion there will be no more useful a task that the computer and package can do.

### **8.2.3. How can the amount of work done be determined?**

Marking up is important. Yet how is how is the amount of work done in a specific time period determined?

There are a number of different ways in which the amount of progress to be marked up can be determined:-

- i) By estimated percentage of work done.
- ii) By calculated amount of work done (eg 10,000 bricks laid)
- iii) By amount of money spent. (eg Cost)
- iv) By amount of money claimed (eg Monthly claim)
- v) By revenue earned. (eg Payment by client)
- vi) By milestone/section/system of work complete (eg 3rd floor plumbing complete).

There are problems in selecting the appropriate methods. Frequently a number of methods are used simultaneously as a check on each other. It is also appropriate to use different methods (eg i to vi) to report on different tasks on the same chart.

If a computer package is used, the package should make provision for the amount of progress to be fed in using whatever method or methods of determining progress is or are most suitable.

### **8.3. THE PLANNING SCENARIO USED TO TEST TECHNIQUES**

#### **8.3.1. Aim.**

The purpose of this scenario is to establish a fairly typical construction project sequence which can be used to test methods of computer aided network analysis.

#### **8.3.2. Data.**

Number of typical floors	10
Size of Floor [Flat slab]	51 m x 15.630 m
Thickness of concrete slab	250 mm.
Amount of steel reinforcement	80 kg/per m <sup>3</sup> of concrete.
Rate of fixing reinforcement	1000 kg / 4 hours.
Steel Fixing Gang Size	1 fixer. 4 labourers.

[The fixer requires 6m width of slab before he can start to fix.]

[Can only start fixing at beginning of a day.]

Cost of stop ends	50 R/m <sup>2</sup>
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Site batching - delivering concrete at the rate of 12m<sup>3</sup> /hour for maximum of 8 hours per day.

No work allowed on Saturday, Sunday, or Public Holidays .

Commencement date	13th Feb 1989.
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The Formwork gangs can only be used on formwork.

A tower crane is available to move formwork from one floor to another.

Ignore effects of columns, lift wells, staircases, slab edges.

Learning curve effects apply to the formwork only.

### **8.3.3. Specification for propping :-**

Slabs must be propped for 7 days after casting. [However panels may be removed after three days provided props are not disturbed]

The floor below the cast must be repped with 50% propping, and the floor below that with 25% of the propping, until 7 days after the slab is cast .

### **8.3.4. Rules.**

Tasks can only start at the beginning of a day.

However when erecting or stripping kwickstage, bearers, decking plates the gang can go from one casting panel to the next without waiting for the next day to start. This is, however, subject to the availability of material.

**8.3.5. Key to layout of structure.**

Each floor is divided into three sections. This is the minimum number of sections and is determined by the limited daily concrete output.

(NB:- A section is specified as follows:- "2A")

Area of each section is 266m<sup>2</sup> )

	<u>Cast A</u>	<u>Cast B</u>	<u>Cast C</u>
	(A)	(B)	(C)
7th floor (7)	xxxxxxxx	xxxxxxxx	xxxxxxxx
6th floor (6)	xxxxxxxx	xxxxxxxx	xxxxxxxx
5th floor (5)	xxxxxxxx	xxxxxxxx	xxxxxxxx
4th floor (4)	xxxxxxxx	xxxxxxxx	xxxxxxxx
3rd floor (3)	xxxxxxxx	xxxxxxxx	xxxxxxxx
2nd floor (2)	xxxxxxxx	xxxxxxxx	xxxxxxxx
1st floor (1)	xxxxxxxx	xxxxxxxx	xxxxxxxx
Ground Floor	-----All ready constructed-----		



**8.3.6. Nature of the task and dependancies.**

<u>Task</u>	<u>Description of Task.</u>
Erect kwikstage supportwork	Supportwork erected by one gang. Depends on sufficient qantity of material being available.
Erect timber bearers.	Bearers erected by one gang. Depends on completed kwikstage and sufficient quantity of material being available.
Erect decking.	Deck plates placed by one gang. Depends on bearers having been placed and sufficient quantity of material being available.
Fix Steel Reinforcing.	By a subcontractor once there is sufficient space to work.
Cast Concrete.	Once steel is placed, concrete can be cast.
Strip decking.	One gang starts once curing is complete.
Strip bearers	One gang starts once deckplates are stripped
Strip kwikstage.	One gang starts once bearers are removed.
Reprop 50%	-
Remove 25% of props.	-

### **8.3.7. The size and output of formwork gangs:-**

Area of each cast/section is 266 m<sup>2</sup>

<u>Task.</u>	<u>Gang Size</u>	<u>Output.</u>
Erect kwikstage supportwork	4 men	115m <sup>2</sup> /wk or 23m <sup>2</sup> /day
Erect timber bearers.	2 men	115m <sup>2</sup> /wk or 23m <sup>2</sup> /day
Erect decking.	3 men	230m <sup>2</sup> /wk or 46m <sup>2</sup> /day
Strip decking.	3 men	115m <sup>2</sup> /wk or 26m <sup>2</sup> /day
Strip timber bearers.	2 men	460m <sup>2</sup> /wk or 92m <sup>2</sup> /day
Strip kwikstage.	4 men	115m <sup>2</sup> /wk or 23m <sup>2</sup> /day
Reprop 50%		
Remove 25% of props.		

### **8.3.8. Additional Data for purposes of the network computer package.**

For purposes of more efficient utilisation of the "what if" function on the package used, the following equivalent data was devised. It was "Equivalent" as the package could not accept the data directly.

<u>Task.</u>	<u>Gang-hours required.</u>	<u>Original Gang</u>		<u>Optimised Gang.</u>	
		<u>Size</u>	<u>Output</u>	<u>Size</u>	<u>Output</u>
Erect kwikstage supportwork	78	4 men	8	6 men	12
Erect timber bearers.	78	2 men	8	4 men	12
Erect decking.	46	3 men	8	4 men	10
Strip decking.	78	3 men	8	6 men	12
Strip timber bearers.		Fixed	2 men	Cannot alter.	
Strip kwikstage.	78	4 men	8	6 men	14
Reprop 50%					
Remove 25% of props.-					

### **8.3.9. Notes on the make up of the scenario.**

The nature of building construction provides two extremes of activity for which to plan.

The one type is where progress can be controlled simply by the controlling the quantity produced. ( eg Thousands of bricks laid per week).It does not really matter where the bricks are laid as long as the quantity of the bricks that have to be laid each week are in fact be laid each week.

The other type of activity is the one chosen for the test which follows. It is one in which a sequence of operations is necessary.

The scenario was created to have the following features:-

There are two calendars. The workmen only work on normal working days.  
The concrete sets every day.

The working week is irregular. Public holidays interfere in different combinations.

The start/stopping of operations is different.

Erecting support work is limited only by sufficient material and a place to erect it.

Concreting can only take place in one day bursts.

Should the sequence of Steelfixing be interrupted, it can only re-start at the beginning of a new day.

As the network develops it should indicate how many sets of equipment are needed.

Various "What if" games can be played (eg by varying the quantities of equipment.)

The effects of a steel strike, or the effects of the inability to work due to various sequences of wet weather can be determined.

#### 8.4. NUMERIC DATA FROM THE MAIL SURVEY.

##### General Analysis of Returned Questionnaires.

Table 1 : General analysis of returned questionnaires.

Item	Number	%
Posted	402	100
Returned - un-delivered.	17	14
Returned - but incomplete	3	2
Returned marked 'not applicable' (ie No computers in use.)	55	44
Returned correctly filled in (ie Firms using Personal Computers.	49	40

Total Returned	124	100
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**A: The Computer Population in Firms.**

Table 2.

A (i). How many firms have computers?

	All members	"General Builders"
Firms NOT having Personal computers	55	33
Firms HAVING Personal Computers	49	35
Total	104	68

Table 3.

A (ii). How many computers in a firm?

Number of computers in a firm.	All	General Builders
0	52	33
1	23	17
2	7	5
3	5	4
4	1	1
5	-	-
6	2	3
7	1	1
8	1	1
9	-	-
10	1	1
11	-	-
12	2	2

**B: On what tasks are the computers used?**

Table 4.

B (i) For which tasks does the "average" firm use computers?

Application.	All Respondents %	General Builders %
Estimating	13	14
Planning	6	7
Costing	16	17
Claiming	8	10
Accounting	27	23
Word Processing	16	19
Production Analysis	3	1
CAD	0	0
Wages	7	7
Project development.	3	1
Other	1	1



Table 5.

For which tasks are computers used by "General Builders" when there are a number of computers in the firm ?

Notes:-

- i). No firms reported having 5, 9, or 11 computers. These columns are therefore missing from the table below.
- ii). The "Av" (= Average) shown is the average of all the results. It is not the average of the averages in the adjacent columns.

Number of computers in the firm.	1	2	3	4	6	7	8	10	12	Av
Number of firms with this number of comps.	17	5	4	1	3	1	1	1	2	-
Wages	12	5	2	0	0	0	0	0	0	7
Accounting	28	23	24	0	13	25	20	20	3	23
Word Processing	17	22	27	0	17	15	20	30	13	19
Estimating	11	17	14	0	20	45	10	20	18	14
Costing	17	18	11	20	18	0	15	5	39	17
Monthly claims	9	5	6	20	23	0	15	5	11	10
Planning	2	8	4	40	8	15	20	10	15	7
Production planning	4	0	4	0	0	0	0	0	0	2
CAD	0	0	0	0	0	0	0	10	0	0
Project development	0	2	10	0	0	0	0	0	0	2
Other	0	0	0	20	0	0	0	0	3	2

**C: The use of different techniques.**

Table 7.

C (i): How often are the various planning techniques used?

Method	%
Experience/Rule of thumb	31
Bar Charts	56
Network Analysis	11
Other	2

Table 8.

C (ii) How many firms use only one technique?

Method.	Number
Experience/Rule of thumb	6 firms
Bar Charts	6 firms
Network Analysis	2 firms
Mixture	21 firms
Total	35 firms

Table 9.

C (iii) When firms use different techniques for different contracts, what is the average use of these techniques?

Method.	%
Experience/Rule of thumb	24%
Bar Charts	64%
Network Analysis	9%
Other	3%

**D: Should computers be used to a greater or lesser extent for listed tasks?**

Table 10.

Activity.	More	Less	No Change.
Estimating	19	5	10
Planning	21	4	9
Costing	19	2	13
Prepare Claim	12	3	19
Accounting	10	5	18
Word Processing	6	3	23

**E: Should planning should be done manually or by computer?**

Table 11.

Method	Manually	Computer
Bar Charts	5	20
Network Analysis	3	22

## 8.5. EXAMPLE OF CONTROL REPORT

(From " Concepts of project planning and control" by B.C.Paulson on page 77 of "The Journal of the Construction Division" (1976).)

### EXAMPLE CONTROL REPORT

#### E X C E P T I O N R E P O R T B A S E D O N C O S T V A R I A N C E S

ACTIVITIES SHOWN HAVE VARIANCES GREATER THAN 10%

PROJECT NUMBER: 197501      PROJECT TITLE: EXAMPLE CONCRETE BRIDGE      START DATE: 06/21/75  
 PROJECT LOCATION: STANFORD, CALIFORNIA      DUR SECONDARY SORT      DATA DATE: 07/11/75  
 ACTIVITIES ARE SORTED AS FOLLOWS: ES PRIMARY SORT      REPORT DATE: 07/14/75

ACTIVITY		ESTIMATED		ACTUAL		EST TO		EST TTL		PERCENT		FORECAST		TREND	
LAB. CODE	DESCRIPTION	UNIT	QUANTITY	DATE	DATE	COMPL	COMPL	Q. COMPL	Q. COMPL	COMPL	COMPL	VARIANCE	VARIANCE	PERCENT	PERCENT
<b>CFF.0310 CONCRETE FORMWORK FOR FOUNDATION SF</b>															
	DURATION:		34	2	9	38	76%	4	11.8%	HIGH					
	EST. START:		\$24900	\$23800	\$7450	\$31250	76%	\$6350	25.5%	HIGH					
	ACT. START:		15860	13600	4150	17750	77%	1890	11.9%	HIGH					
	EST. FINISH:		\$1.57	\$1.75	\$1.80	\$1.76		\$0.19	12.1%	HIGH					
	ACT. FINISH:														
<b>CRF.0320 CONCRETE RE-STEEL FOR FOUNDATION LB</b>															
	DURATION:		29	21	9	30	70%	1	3.5%	HIGH					
	EST. START:		\$19700	\$15850	\$6805	\$22655	70%	\$2955	15.0%	HIGH					
	ACT. START:		82400	74410	31890	106300	70%	\$23900	29.0%	HIGH					
	EST. FINISH:		\$0.24	\$0.21	\$0.21	\$0.21		-\$0.03	-10.9%	LOW					
	ACT. FINISH:														
<b>CPF.0330 CONCRETE PLACING FOR FOUNDATION CY</b>															
	DURATION:		34	16	21	37	43%	3	8.8%	HIGH					
	EST. START:		\$36700	\$17770	\$23330	\$41100	43%	\$4400	12.0%	HIGH					
	ACT. START:		1200	690	850	1540	45%	340	28.0%	HIGH					
	EST. FINISH:		\$30.58	\$25.75	\$27.45	\$26.69		-\$3.89	-12.7%	LOW					
	ACT. FINISH:														
<b>CRW.0320 CONCRETE RE-STEEL FOR WALLS LB</b>															
	DURATION:		34	9	26	35	26%	1	2.9%	LOW					
	EST. START:		\$18900	\$4160	\$12470	\$16630	25%	-\$2270	-12.0%	LOW					
	ACT. START:		78750	19730	59170	78900	25%	150	0.2%	LOW					
	EST. FINISH:		\$0.24	\$0.21	\$0.21	\$0.21		-\$0.03	-12.2%	LOW					
	ACT. FINISH:														

-\*\*\*- E N D O F R E P O R T -\*\*\*-