

# **ASSESSMENT OF THE USE OF RESOURCE SCHEDULING FACILITIES IN PROJECT MANAGEMENT SOFTWARE PACKAGES FOR LARGE CONTRACTORS**

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In the construction industry today, the execution of project requires the management of scarce resources. Construction planners need to schedule and select appropriate resources, including crew sizes, materials, equipment and plant to execute a construction project. These resources are essential for the successful completion of the project. Making optimal decision by construction planners in the use of these resources is difficult and time consuming, and it usually involves the use of Critical Path Method (CPM) software packages. These software packages are mainly Project Management (PM) software. Surveys were conducted to assess the use of resource scheduling facilities in CPM software packages over a ten-year period. The questionnaire surveys were carried out in 1997 and 2007. The study is concentrated on large construction firms, the top sixty-five contractors as published in the NCE 1995 and 2006 contractors' files. A questionnaire was designed and sent to the contractors: Questions were asked about the following: factors used by contractors regarding the selection of CPM as a planning technique, types of users and types of projects planned and scheduled by CPM. Also questions were asked on the distribution of scarce resources with emphasis on resource optimization methods, and CPM impact on key resource areas. The results confirm that construction professionals are frequent users of PM software. However, the degree of usage differs among respondents in their usage patterns. Most CPM capabilities within the software are not fully utilized by most respondents.

Keywords: resource allocation, resource scheduling, critical path method, project management, construction planners

## **INTRODUCTION**

Construction companies cannot remain competitive in today's business environment without effectively managing their resources. Resources include labour, materials, time and cost. In this paper the project resources referred to are labour, materials, equipment, time and cost. In dealing with project resources, two main types of techniques have been frequently used: resource allocation and resource levelling. Resource allocation and levelling are among the top methods used in project management within the construction industry. Depending on the complexity of projects, resource allocation and levelling have been dealt with as two distinct sub-problems. Two known techniques used in handling resource allocation and scheduling are PERT and CPM methods. These methods, however, do not guarantee optimum solutions.

Generally speaking basic PERT and CPM scheduling techniques have proven to be helpful only when the project deadline is not fixed and the resources are not constrained by either availability or time. In practice however this is not the case. Resource allocation attempts to reschedule the project tasks so that limited number of resources can be efficiently utilized while keeping the unavoidable extension of the project to a minimum. Resource levelling on the other hand, attempts to reduce the sharp variation among peaks and valleys in the resource demand histogram while maintaining the original project duration (Galbreath, 1956; Aras, 1960; Fondahl, 1961; Bennett, 1968). These techniques deal with two distinct sub-problems that can only be applied to a project one after the other than simultaneously.

Usually construction planners use critical path method (CPM) techniques, to effectively and efficiently schedule the project. Planners usually need to adjust the selection of resources in order to shorten or lengthen the project duration. Finding optimal solution is difficult and time consuming, and it usually involves the use of CPM software packages. However the advances in ICT and the software industry, this have an immense impact on the way projects are now planned and managed.

There are several scheduling software packages available (e.g. Microsoft Project; Primavera), so there are plenty to choose from. The first thing you need to do is identify which features would be needed by your organization. Once you have determined this, you need to shop around the software's industry for which scheduling features are available. Many software companies offer trial versions. This is an excellent method of researching which scheduling software package is right for you. They are mostly presented as Project Management (PM) software.

Most large construction firms that work on projects or decide to implement project management have questions about software suitability. Many companies may have gone through several iterations of software packages depending on the time the business was established. Many companies select its project management software based on the recommendations of its principal project manager. This method was most effective in the 1980 when there were only a limited number of products in the market. By the end of the 20<sup>th</sup> century, one has a variety of products to choose from and also the project management profession has become more structured and is covering not only capital projects but also smaller multi-projects. However, with a plethora of PM software market, it may be expedient to source an expert second opinion before deciding on which one to buy.

For anyone who has used more than one project management software products, it must be clear as to what one can expect from the products. The products fall into various different knowledge areas, only very few embrace all aspects of project management (Fondahl, 1991; Hegazy, 1998; Liberatore, 2001, Kim 2005). Some of the main areas covered are as follows:

- Scheduling software that analyses time and resources mathematically using CPM/PERT or other networking principles. Users generally know this type of software as project management software.
- ERP software, which is more, used by the business world and nowadays have better project modules.
- Software packages which cover individual areas such as Risk Management, Time Tracking, Estimation, Simulation and communications.

As frequent users of PM software, professionals in the construction industry have a strong interest in improving the tools and techniques available for better project planning and control. The aim of this paper therefore is to assess the use of PM software packages in the UK construction industry, in particular the use of resource scheduling capabilities in the PM software. This is achieved by:

- Reviewing the literature related to CPM development and resource scheduling
- Conducting a survey to assess the usage of PM software packages resource scheduling facilities by large contracting firms
- Analyzing the data collected, and discussing any trends or findings from such analysis
- Making recommendations in relation to the study conducted.

## **REVIEW OF RESOURCE SCHEDULING AND CPM**

The unique nature of the construction industry, which involves capital ventures, therefore requires planning of its resources. In dealing with project resources, two main types of techniques have been frequently used: resource allocation and resource scheduling. Scheduling determines when the work is to be accomplished, considering scarce resources and the given completion date. Scheduling of a project for the contracting firm is usually accomplished through the use of certain tools and techniques. Some of these tools and techniques in the construction industry are:

1. The bar chart/Gantt chart
2. PERT
3. CPM network

These three are considered the most commonly used tools. The bar chart is acclaimed the most widely used in the industry, while the CPM is acclaimed for its logic and sequential presentation of information. The PERT method is not very common, although similar to CPM, except for the indication of the CPM on the network. CPM is a planning technique that utilizes the contractor's knowledge, experience and instinct in a common sense manner to plan and schedule the construction process, with CPM one can readily determine with certainty the best completion date for the project (East, 1989; Chan 1996).

The objective in the resource-levelling problem is to level the peaks of resources and smooth out the periodic assignments within the required project duration. On the other hand the resource allocation problem assumes resource availability is constrained or limited to some maximum value. The objective is therefore to allocate the available resources to project activities for the shortest project duration. In other cases it may be necessary to extend the overall duration to meet the limits of the available resources. The CPM software packages have facilities in them, for the scheduling of these resources.

What has not been said or investigated is how well these CPM software facilities help the practitioners with the limited resources in the industry to be efficiently scheduled? How has the CPM software been used to assist the contractor in optimizing the limited available resources? How effective and practical are the CPM software facilities in resource scheduling?

*CPM Development and Use*

In 1961, the mathematical algorithm of the CPM was established by Kelly (1961), and stated in his paper that this new tool for planning, scheduling and coordinating complex engineering projects would be the basis for future success in any engineering production/manufacturing and construction industry. Between 1961 and the end of the decade several modification to the algorithm were developed and new algorithms claiming more accurate approaches to the problem (Galbreath, 1956; Fondahl, 1961, Bennett, 1968; Cooper, 1976; Easa, 1989; Echeverry, 1991). In 1965 the first survey was conducted in the US to ascertain whether it would support the views. Several surveys have been conducted over the years (Gleason, 1964; Davis, 1974; Tavakoli, 1990; John, 1997). The surveys reported the use of CPM, and its degree of success had increased among the construction industry when compared to the previous survey.

The developers of modern projects scheduling software came from a variety of background, and as such they have incorporated the functions they believe to be the most important. Computer based projects management system capabilities can include any one or a combination of the following capabilities (Bennett, 1985); *resource loading, resource aggregation, resource availability, resource levelling and resource constrained levelling.*

Assessment of the CPM capabilities in modern project management much survey has not been done in the construction industry in recent times. Considering the changing face of the construction industry in the UK, such as sustainable construction, high employee churn rate, fewer skilled workers, new ways of arranging the parties there is a need to assess the utilization of these packages in assessing these scarce resources. The need to efficiently use the resources that are required to accomplish the work confronts every manager of construction. One way of assessing the utilization of these resources is to throw more light onto this narrow but important area of resource usage facilities in the software packages within construction firms of which this study is about.

## **THE STUDY**

A random survey of large construction firms in the UK was done. The survey served to gather information on work environment and demographic factors, Project Management software usage, and CPM techniques and usage. The survey was evaluated and pre-tested by several peer review practitioners within the construction sector. The survey was conducted over a ten-year period. In dealing with project resources, two main types of techniques have been used: resource allocation and resource levelling. The first survey was carried out as a MSc. dissertation and the latter as an independent study to gauge the similarities, extent and variation of what was observed in the previous study.

The questionnaire survey is intended to assess the way in which Project Management software resources facilities are used when contractors produce their project plans. In particular, it aims to investigate the use of resource scheduling capabilities in CPM software packages. The study is directed to large contractors published by the NCE in the contractors' files - New Engineering Journal of which the top seventy were selected. The new engineering contractors file is one of the most comprehensive up to date listing of major building and civil engineering contractors in the United Kingdom. It provides information on British registered companies that responded to a detailed questionnaire issued in June 1995 and 2006 and which have a turnover of at least £20 million for building and civil engineering works.

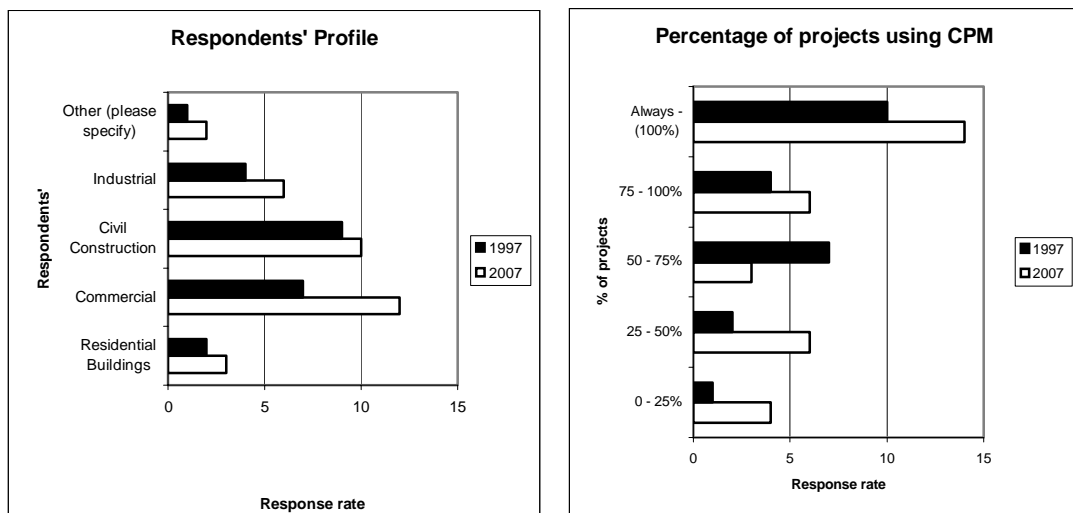
## ANALYSES AND RESULTS

In the 1997 survey, of the sixty-five questionnaires sent, thirty-three were returned completed (55% positive results). In the 2007 survey seventy questionnaires were sent of which twenty-three responded (34% positive results). The main process used in analyses of data was to draw inferences from information and comments provided by respondents, and by observing any trends and commonalities. A descriptive method of analysis was used in evaluating respondent's comments, with minimal statistical judgment applied to explain inferences from the study. Further telephone conversations were made to those practitioners who offered exposition and insight into the usage pattern of the software.

The most important findings of the survey are summarized in the sub-sections below. The respondents' profile and work environment findings are shown first, followed by the results pertaining to software resource scheduling issues.

### Respondent Profile

Respondents' interests are widespread, although buildings predominate. Respondents are employed across a broad range of organization sizes but are mainly from employing those 500 staff or more. The following figures show the profile of the respondents.



### Project management software usage patterns

All respondents have commercially manufactured software with the exception of one in the 1997 survey who had their software developed by a group of university scientists. The most frequently used commercial softwares have changed over the years as shown in the Table below. Some firms do use more than one type of software. The age range is from 10 years old to the most recent in 2007 that is *Asta Power Project*.

**Table 1:** Software usage types over the years

Year	Name of Software
Up to 1990	Artemis, Hornet, Plantrac
Between 1990 and 1997	Power Project Professional, Pertmaster, Microsoft Project, Primavera
From 1997 to 2007	Asta Power Project, Microsoft Project, Primavera, Suretrak, Pertmaster

The factors that contractors consider when deciding to use PM software packages especially with CPM capabilities are:

- The complexity of the project in question
- The nature and size of the project
- The client/contract requirements
- Individual preferences

The cost of the project is not an important factor for making decision on the use of CPM. Most of the respondent went on to state that they also use CPM on the tender stage of their projects.

### **Research findings about usage techniques in resource scheduling**

The response rate to this question was lower than for most other questions on the questionnaire, especially in the 2007 survey. From the answers given and the way the question was avoided by some respondents, it is probable that some are not actually making adequate use of such a tool. Most of the respondents, rely heavily on the resource levelling capabilities of the software without given due thought to its credence. Those that are using the “what-if-scenario” are only relying on the speed of the computer to produce different alternatives of networks, and then using their experience to try and make the most feasible choice. From the look of things, there is a need for guided logic with some amount of soft link incorporated into the initial network, taking into cognisance critical activities, before any resource levelling can be done. Most comments from planners stated, “*the devil is in the computer and software*”. Therefore it would appear that some planners do heavily rely on the software without carefully evaluating what lies before them, in which an uneconomic schedule may be prepared. Another noticeable difference between the 1997 and the 2007 surveys is that the reliance by planners on the machine has increased, as friendly GUI nature of the computer improves.

### **Research findings about resource optimization**

This section of the resource levelling capabilities of the CPM software is intended to address the various factors which contractors use when there is a need to optimize scarce resources. Here, the emphasis is on the priority of allocation of the resources, if there were more than one type of resources competing on how to schedule them efficiently, what are the factors that one would consider as most important would be uppermost in the optimization of these resources. In answer to this part of the questionnaire we have six schools of thought. They are as follows:

1. “What-if-see” scenario is tried after the first run of the prepared network.
2. Concentrating on the most and major important resource on the project, then establish a hierarchy of importance.
3. Concentrate on the scarcest resources on the project, and then add soft links after to allow the software program to do the levelling.
4. Give priority to critical activities that needs such scarce resource and try to use up the float time for other activities.
5. Never consider it that way, allow the software package to do the levelling and that is it.
6. Alternative logic is used.

However, the above answers sounded more rhetoric than factual, if they do rely on the 'devil' in the computer.

### CPM impact on key resources

It appears that those who fully understand the Project Management software, the impact of CPM usage for effective utilization of key resources would improve progressively. As such it would be expected that the impact study on these key resources would show to certain extent a significant impact on some resources in the past ten years. From the figures in Table 2 (i.e. regular fonts represents 1997 and italic fonts the year 2007), it appears that there is a significant awareness of the usage capabilities of CPM impact between the two (i.e. 1997 and 2007) surveys.

**Table 2:** CPM impact on key resources

Resource Type / Impact	Highly significant 1997 (2007)	Significant 1997 (2007)	Some significance 1997 (2007)	Little significance 1997 (2007)	No significance 1997 (2007)
Material Procurement	1, <i>1</i>	8, <i>9</i>	15, <i>7</i>	4, <i>3</i>	1, <i>0</i>
Crew assignment	2, <i>3</i>	3, <i>10</i>	14, <i>2</i>	10, <i>1</i>	0, <i>0</i>
Plant use	3, <i>2</i>	6, <i>7</i>	16, <i>3</i>	10, <i>1</i>	2, <i>0</i>
Resource levelling	1, <i>6</i>	7, <i>6</i>	18, <i>3</i>	4, <i>0</i>	3, <i>0</i>

## DISCUSSION AND CONCLUSIONS

The study reported is an attempt to assess the use of resource scheduling facilities in software packages, of which the target group are large contracting firms. Considering the usually low rate of response to mailed questionnaire in the construction industry, a response of 33 (55 %) and 23 (33%) managers of planning and scheduling department is an indication of the relevance and importance of the subject. Because of the response rate conclusions should be drawn with great care. However the data do indicate the following.

Majority of the large firms do use CPM software packages when preparing their project plans. Resource scheduling facilities in these software packages are not yet fully utilized by large contracting firms. A small numbers of contractor (30 %) are versatile in using these resource facilities and tapping the full benefit of the software programs from the comments and exposition from telephone interviews. Majority of the firms who are versatile are those that have regular form of training for their staff members. Those that are within the threshold of realizing the benefits of the resource scheduling facilities within these software packages have occasional form of training. There is a dire need for training of the users of CPM software packages, in other that the full potential of both the user and the packages will help the contracting firm to realize its maximum benefits in its resource investment. There needs to be some improvement in two areas in the construction industry, concerning CPM and the realization of the full use of the resource scheduling facilities in the packages.

- There should be a shift or improvement in the method of communication between contractors, clients and / or client representative. By the gradual introduction of the CPM method along side bar chart and / or linear change method.
- So much can be done in optimizing the use of resource scheduling facilities in these software packages. Most project management systems are adaptable,

flexible and responsive to changing markets or operational circumstances, if they are well understood. In order to do it, there needs to be a change in many contracting firms as regards training, educational and development in the use of CPM software packages.

Critical path analysis is the analytical techniques use most frequently by the construction respondents during the planning and control stages of managing a project. Results indicate that; majority of large contracting firms are using CPM in planning their project, while the frequently employed communication method is the bar chart. About 30% of the respondents actually incorporate soft links when they plan their projects. All contracting firms utilize resource levelling, but resource optimization is not fully appreciated by most of the respondents. CPM use has some impact on key resource areas although it is yet to be significantly realized. Contractors are investing on software packages but are not utilizing all the capabilities of the software to their full potential for resource scheduling. The result of this study confirms that construction professionals are frequent users of PM software. Project management functions such as resource allocation, resource levelling, time-cost trade-off analysis have been the least improved among practitioners in the past ten years.

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