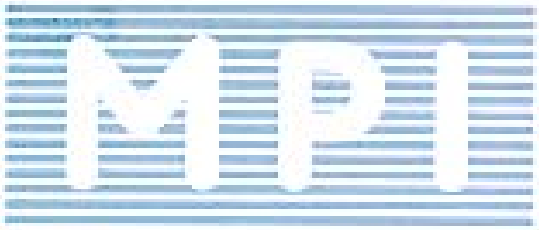

Comparative Resource Scheduling Using Various Software Packages

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Abstract

Resource Allocation is without doubt one of the most important areas of concern to construction management. The two main problems of resource allocation of concern are resource levelling and resource scheduling. The normal convention is for, the resource scheduling problem to be solved using either heuristic methods or optimization techniques. Where heuristic methods are used, resource scheduling is always treated as a subsequent problem for the critical path analysis.

In this paper, the resource scheduling problem is handled using heuristics, where logic dependence and resource availability limits are considered after the time scheduling process. Both Resource Constrained and Time Constrained models are discussed.

Constant resource demand of activities is assumed, and the task once started will continue if the project is constrained by time and so cannot be interrupted. However where resource availability limits are reached and the task has Total Float it can be split in order to avoid overloading the resource.

Splitting however may have other consequences, so control of splitting is demonstrated. Several example projects are solved by different heuristic methods using different software. The results are compared with the latest heuristic models: current float technique and ranked positional weight method.

Keywords: Construction Management; Resource Management; Resource Scheduling; Simulation

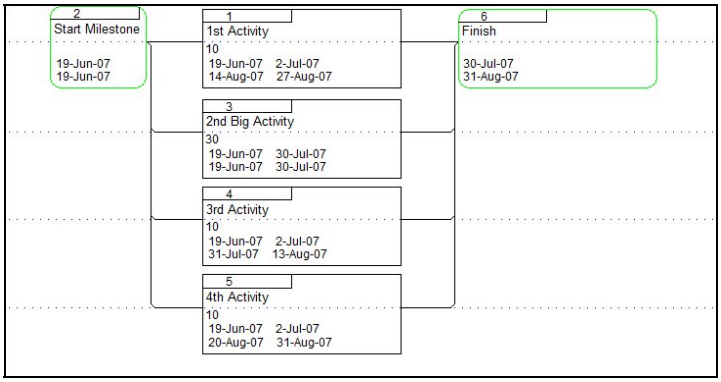
Introduction

The premise of this paper is to illustrate that Resource Scheduling is a most important part of the Project Planner & Scheduler's armory, but is not often used as much as it should be. It appears to be generally accepted that Resource Loaded projects are too hard to operate and that the results are quite often not what would be expected and that there are too many conflicting attributes in particular software to select without understanding how they relate to each other.

It is my contention that there is never an occasion where a project is analyzed without the use of resources otherwise the results which are produced running Time Analysis only assume unlimited resources are available to the project. Which as we all well know is not true but how do different project management Software packages process the same data and what are the variations in the results obtained?

A simple critical path network of four tasks and two milestones was created and a single resourced was allocated to each of the four tasks. The network is shown in Exhibit 1, three of the tasks have ten day duration and the other has duration of 30 days, giving a resource total of 480 hours of effort. The finish milestone has an imposed constraint date of 31st August 2007 (Target, Finish On or before).

Exhibit 1 – Sample Network



The sample network has a start date of 19th Jun 2007; running time analysis gives a completion date of 30th July 2007. Tasks 1, Task 3 and Task 4 each have twenty days Total Float. The total number of man hours of work is 480, i.e. 60 days x 8 hours per day. The dates shown in the task boxes in Exhibit 1 are the Earliest Start and Earliest Finish on the first line and the Resource Start and Resource Finish on the second line

Running resource analysis manually to the earliest end date of 30th July 2007, indicates that there will be an over allocation of 230 hours of work.

The problem to be solved is to determine how many extra people are required to be added to the project to execute the actual amount of work and if extra cannot be obtained what will the delay be after the client's imposed finish date 31st August 2007? Or how much overload will occur in maintaining the imposed date of 31st August 2007?

This data was then input into three different Project Management Software Applications, these were

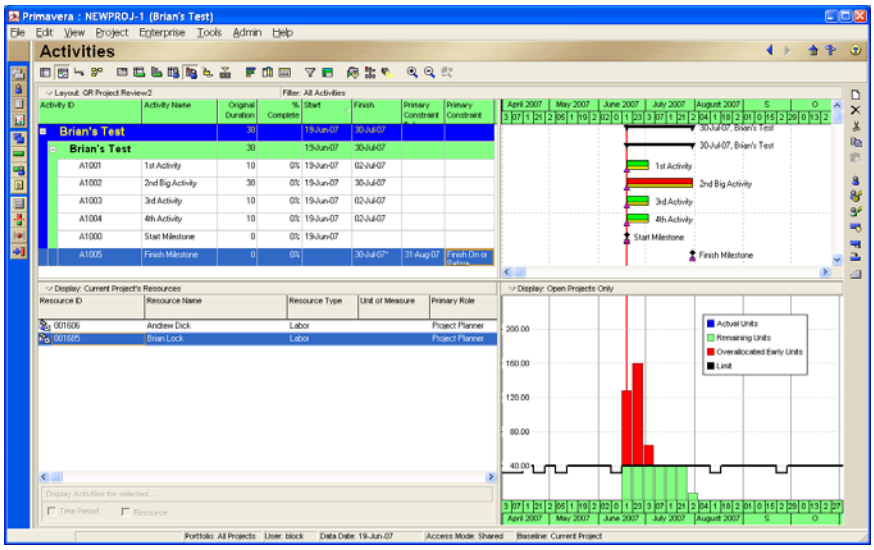
1. Primavera V3 Enterprise
2. Deltek OPP V3
3. Micro Planner X-Pert for Windows V3.12

1. Primavera 3 Enterprise

The same simple project was input into Primavera V3.Enterprise. The Finish milestone has a 31 Aug 07 constraint (Finish on or before). The total calendar duration is 54 days.

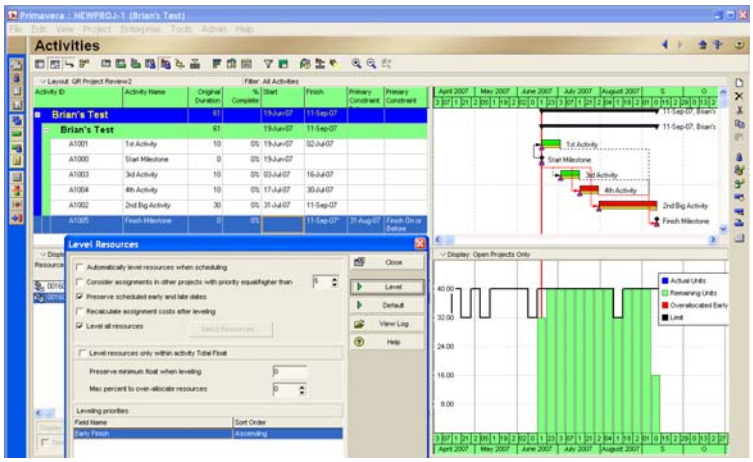
Establishing the basic model by running Time Analysis only, using the early dates, and with no leveling; logic states you would finish on the 30 Jul 07, and the resource scheduling would over allocate 230 hours of work out of the 480 hours. (That is 60 work days of 8 hours each), and no total float used or imposed dates considered. Exhibit 2 shows the resource histogram with the overload as expected and the Gantt chart shows that the tasks are scheduled at their early dates. Note the summary task is 30 days, which indicates that the imposed end date of 31st August 2007 has not been considered in the analysis. The analysis was a "straight out of the box" schedule, which does not provide the optimal answer.

Exhibit 2 – Basic Default Resource Leveling



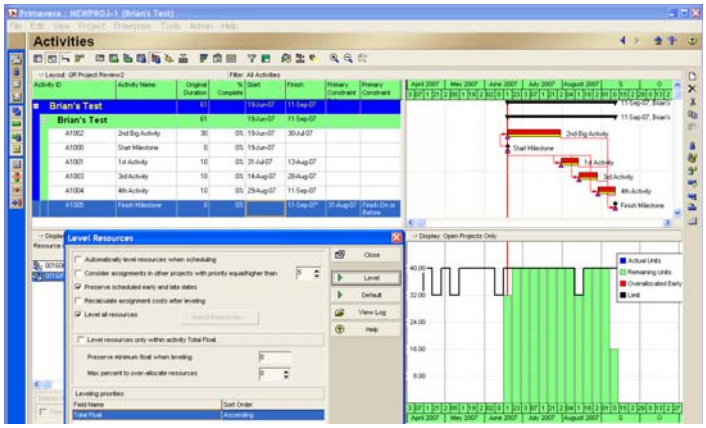
An analysis running Resources and Leveling was initiated, but (Level resources only within Activity Total Float) option was not checked. The Leveling priority was set at Early Finish and Preserve Early and Schedule Dates was checked. Note task 2 finishes on the 11 Sep 07pm, 7 days after the constraint date. See Exhibit 3 for the resource histogram and Gantt chart and schedule. This is in spite of not wanting the schedule to be schedule past 31st August 2007. The summary task is now shown as 61 days.

Exhibit 3 – Resource Leveling – Early Finish



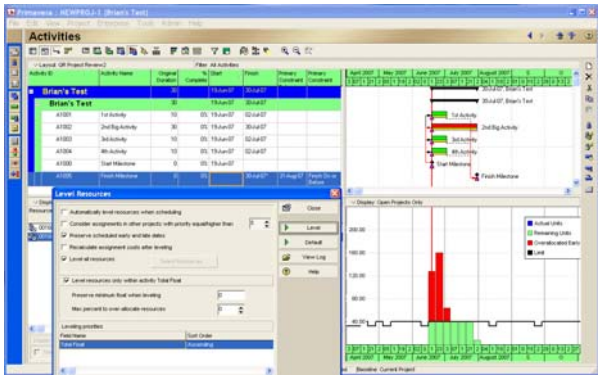
A second analysis was carried out with Resources and Leveling applied, but (Level resources only within Activity Total Float) option was not checked. The Leveling priority was set at Early Finish. Note task 2 finishes on the 11 Sep 07, 6 days after the constraint date. See Exhibit 4 for the resource histogram and Gantt chart and schedule. This is in spite of not wanting the schedule to be scheduled past 31st August 2007. However note that there is no overload in the resource schedule. The summary task is now 61 days.

Exhibit 4 – Resource Leveling – Total Float



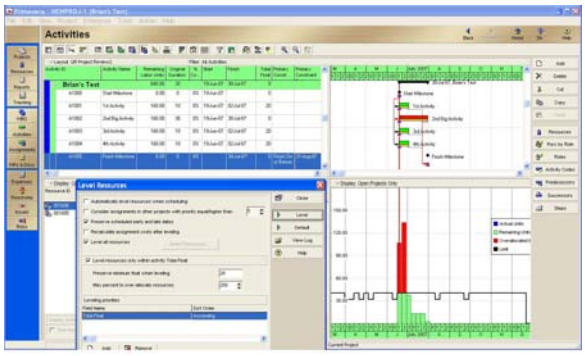
A third analysis was carried with Resources and Leveling applied, This time (Level resources only within activity Total Float) selected, Leveling priorities set at Total Float, and 0% set at Max % to over allocate resources. As can be seen in Exhibit 5 the resource schedule appears to over allocate 230 hrs (29 Man days), to finish a month early on the 30 Jul 07? Note the summary task is now only 30 days.

Exhibit 5 – Resource Leveling – Total Float – Max % Over Allocate



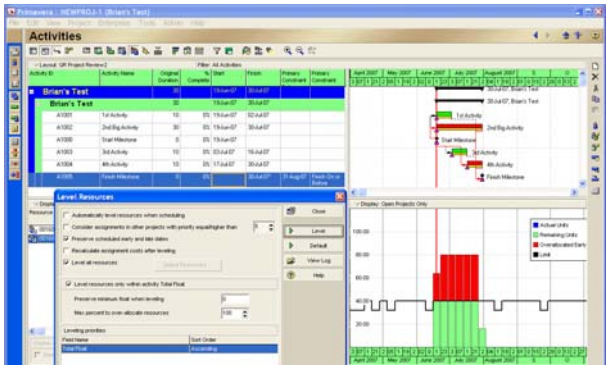
A fourth analysis was carried out (Level resources only within activity Total Float) selected, Total Float Leveling priorities were set, and 200% set at Max % to over allocate resources plus preserve 20 Days of minimum float. The results as observed in Exhibit 6 appears to give same answer as time analysis on early dates and finish a month early on the 30 Jul 07. Note that the summary activity is back to 30 days.

Exhibit 6 – Resource Leveling – Total Float – 200% Max % Over Allocate



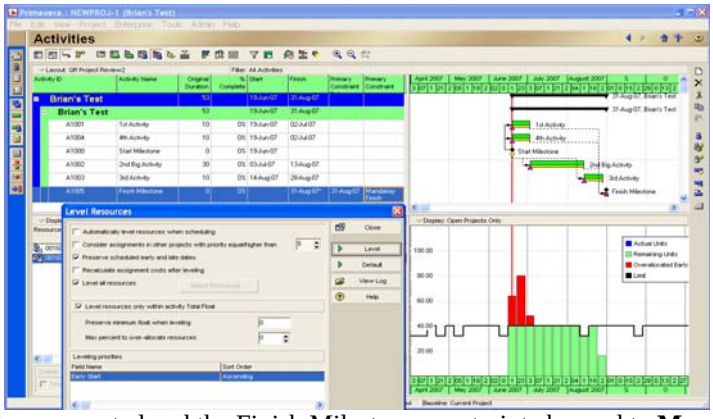
A fifth analysis was carried out (Level resources only within activity Total Float) selected, Total Float Leveling priorities set, and 100% set at Max % to over allocate resources plus preserve 0 days of minimum float. The resource schedule appears to over allocate 47% or 225 hrs of work and finish a month early on the 30 Jul 07 as shown in Exhibit 7. The summary task is still 30 days.

Exhibit 7 – Resource Leveling – Total Float – 100% Max % Over Allocate



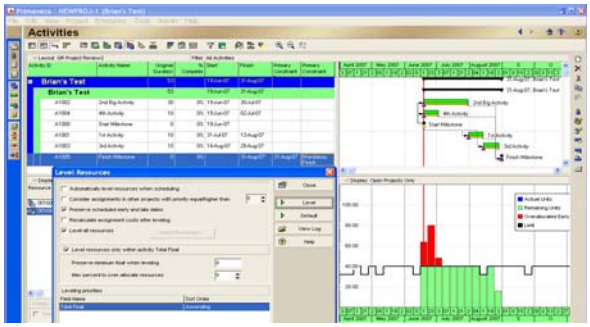
A sixth analysis was detailed where the Finish Milestone constraint was changed to Mandatory Finish (Level resources only within activity Total Float) selected, Early Start Leveling priorities set, and 0% to over allocate plus preserve 0 hours of minimum float. The resource schedule now appears to over allocate early then finish last activity on the 28 Aug 07, wait 3 days then schedule finish milestone as can be seen in Exhibit 8. The summary task is now 53 days.

Exhibit 8 – Resource Leveling – Mandatory Finish – 0% Max % Over Allocate



A seventh analysis was created and the Finish Milestone constraint changed to **Mandatory Finish** (Level resources only within activity Total Float) selected, Total Float Leveling priorities set, and 0% to over allocate plus preserve 0 hours of minimum float. As can be seen from Exhibit 9, the resource scheduling appears to over allocate early for approx 2 weeks then finish last activity on the 28 Aug 07, wait for 3 days then schedule finish milestone. Note the summary task is 53 days

Exhibit 9 – Resource Leveling – Mandatory Finish – Total Float Leveling Priorities



In observing how Primavera resource schedules it would appear that no matter how the user wants to utilize the Total Float, the tasks are always scheduled too early and where the tasks are delayed by the resource limit, the schedule over runs by seven days past the imposed finish date of 31st August 2007.

2. Deltek Open Plan V 3

The same data was input into Open Plan Professional, the first analysis carried out was the default, i.e. straight out of the box schedule. No parameters were set. As can be seen in Exhibit 10, in the Resource Histogram, the schedule overload occurs at the earliest dates immediately in the first ten days (cyan colour), when the schedule is delayed to the latest start dates, the schedule overload is pushed to the right (red colour). The Resource limited schedule extends the schedule to 10th Sep 2007 (green colour). Note where activities 1, 3 and 4 now are scheduled to occur on the timescale.

Exhibit 10 – Resource Schedule - No Constraints

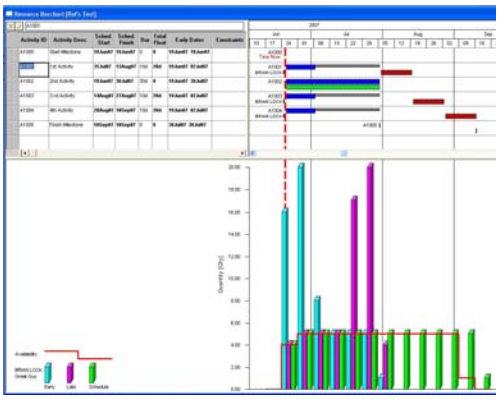
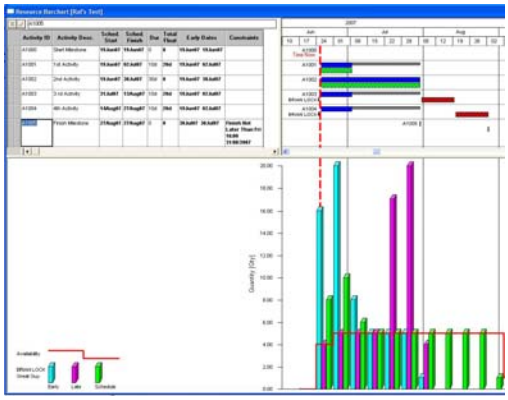


Exhibit 11 - Resource Schedule



Another analysis was run specifying that the schedule should take cognizance of the imposed end date utilizing the earliest start dates for the forward schedule. Activity 2 and Activity 4 were resourced as at the early dates which cause a resource overload, Activity 1 and Activity 3 are delayed until their late dates. The model completes at 31st August 2007 as intended. Exhibit 12 shows the Resource Histogram and where the activities have been scheduled and the Bar Chart shows where on the timescale the activities have been scheduled

Exhibit 12– Resource Schedule – Imposed End Date (Earliest)

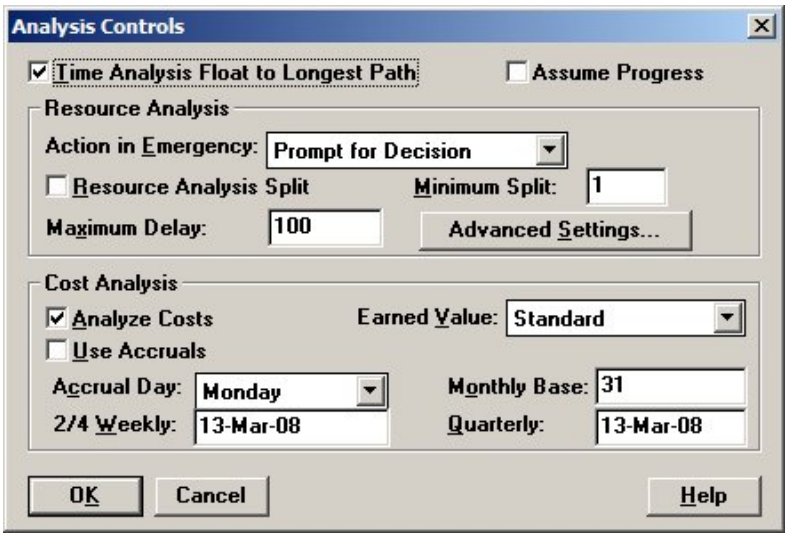
Another analysis was run specifying that the schedule should take cognizance of the imposed end date utilizing the latest start dates for the forward schedule. Activity 2 and Activity 4 were resourced as at the latest dates which cause a resource overload, Activity 1 and Activity 3 are delayed until their late dates. The model completes at 31st August 2007 as intended. Exhibit 13 shows the Resource Histogram and where the activities have been scheduled and the Bar Chart shows where on the timescale the activities have been scheduled

Exhibit 13 – Resource Schedule – Imposed End Date (Latest)

3. Micro Planner X-Pert for Windows V3.12

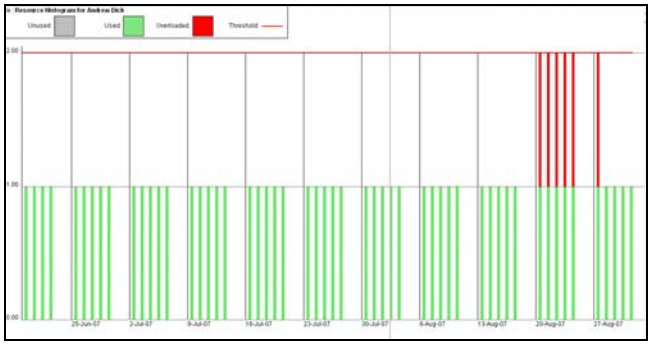
Having input the data into Micro Planner X-Pert for Windows, a Deadline Critical Resource Analysis was carried out, using the Analysis Controls facility; the default of allowing the resource analysis to split tasks was turned off and the minimum split duration was set to 1 day as shown in Exhibit 14 below:-

Exhibit 14 - Analysis Controls (Non Split)



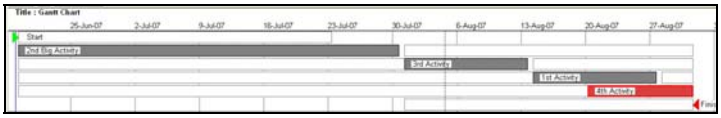
The resource histogram showing the results of the analysis are illustrated in Exhibit 15 below. The allocation of the resource is maintained at the rate of one per day for the first

Exhibit 15 – Deadline Critical Resource Analysis - Resource Histogram Non-Split



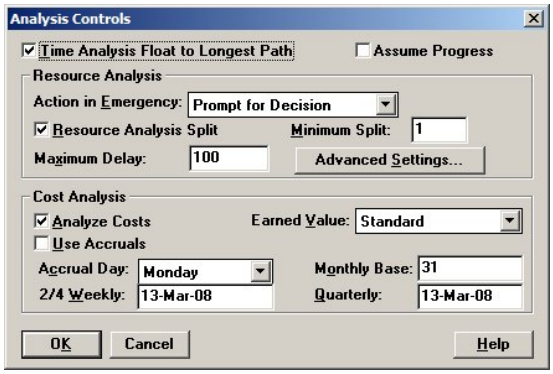
nine weeks until 20th August 2007. Only one additional person for six days is required to complete the tasks by the imposed end date of 31st August 2007; that is 48 hours overload. A Gantt chart showing the analysis of where each task has been allocated in time is shown in Exhibit 16.

Exhibit 16 – Deadline Critical Resource Analysis Gantt Chart – Non Split



The resource analysis has scheduled Task 2 first as it has the longest duration, then Task 3 is scheduled and then Task 1, but Task 1 was delayed due to the limit of one resource being available. However Task 4 has also been delayed due to the limit of one, but because the analysis type is Deadline, which means the Resource Analysis cannot allow any Task to be delayed past the imposed end date of 31st August 2007, so even though the resource limit is one, Task 4 must be scheduled even though it causes an overload in the resource. This is indicated by the red bar in the histogram. (Exhibit 15)

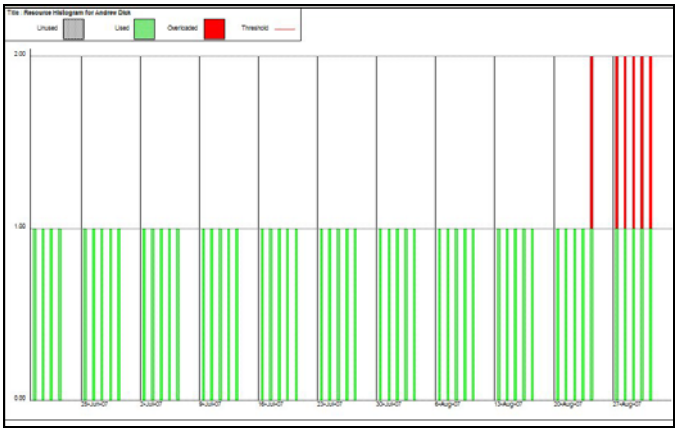
Exhibit 17 – Analysis Controls (1 Day Split)



A second analysis was carried out which allowed tasks to be split by a minimum of one day (as shown in Exhibit 17) at a time to avoid the resource being overloaded. The results of the Deadline Critical Resource Analysis are shown in Exhibit 18 – Deadline Critical Resource Analysis - Resource Histogram – (1 Day Split)

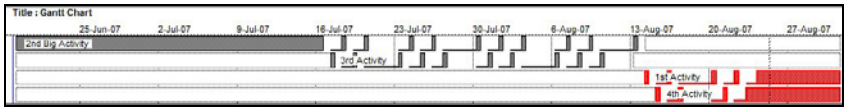
The resource analysis has scheduled Task 2 for twenty days and then it schedules Task 3 which is split between Task 2 which allows the limit to be maintained at one, then Task 1 is scheduled but is also split to allow Task 4 to be scheduled, by which time total float is now running out

Exhibit 18- Deadline Critical Resource Analysis - Resource Histogram –(1 Day Split)



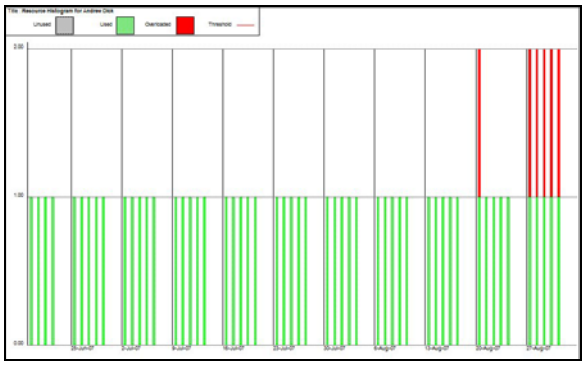
thus the tasks start to become critical, but splitting between the two tasks occurs for five days and because of criticality the two tasks must now be scheduled together into overload, This is indicated by the red bar in the histogram. (Exhibit 18) and can be easily observed in Exhibit 19 – Deadline Critical Resource Analysis Gantt Chart – (1 Day Split). You can see that the resource overload has now been pushed to the imposed end date of 31st August 2007

Exhibit 19 – Deadline Critical Resource Analysis Gantt Chart – (1 Day Split)



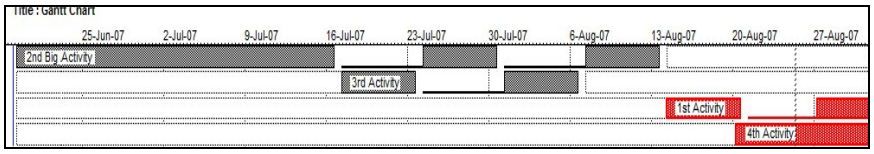
A third analysis was carried out which limited tasks to be split by a minimum of five days at a time to avoid the resource being overloaded. Task 3 is scheduled to occur after twenty days of the start of Task 2, maintaining the limit of one resource, Task 2 is scheduled for a further five days (as this is the minimum split). Task 3 is then scheduled and is completed. The last five days of Task 2 are then scheduled, all the time the limit of one is being maintained. Task 1 is now scheduled for 6 days and stops for four whilst Task 4 is scheduled. This causes one day where both tasks have to be scheduled together to avoid delaying the project, even though it causes an overload. The four days having elapsed Task 1 no longer has any float and thus has to be scheduled with Task 4 thus causing another overload for five days. The results of the Deadline Critical Resource Analysis are shown in Exhibit 20 – Deadline Critical Resource Analysis - Resource

Exhibit 20 – Deadline Critical Resource Analysis - Resource Histogram – (5 Day Split)



Histogram – (5 Day Split). The Gantt chart in Exhibit 21 clearly illustrates the schedule of each activity by the resource analysis.

Exhibit 21 – Deadline Critical Resource Analysis Gantt Chart – (5 Day Split)



Conclusion

Resource Over-Allocation occurs when activities/tasks are competing for the same resource at the same time. Several techniques can be used together or independently to eliminate or reduce the over-allocation of a resource. A common technique is to change non-critical activities to critical activities.

The three project management software packages tested in this study provide various resource schedule solutions as described below:

- Considerable knowledge of how to specify the large number of variables and parameters in Primavera was required before producing a reasonable schedule.
  Eight analyses were carried out using the variable parameters without once producing the same result as produced from Micro Planner X-Pert.
- Good knowledge of Open Plan Professional was also required to produce a result that was close to results obtained from Micro Planner X-Pert.

- Neither Primavera nor Open Plan was able to schedule using Resource Analysis (Deadline Critical), which is a standard resource analysis technique found in Micro planner X-Pert

- Micro Planner X-Pert for Windows was the only application that provided an optimal solution “straight from the box”

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Acknowledgements

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AUS www.microplanning.com.au

A sample fully operational copy of the X-Pert software can be downloaded from our US and UK sites