**Best Practice**

**Manpower-Based Turnaround Scheduling and Critical Path Optimisation**

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Most turnaround and project schedules today are compiled using software that uses time as its basic unit. However, in practice the time that work takes depends on the manpower resource available and its productivity, not vice versa. This article aims to explain how adopting manpower productivity as the basic unit for scheduling can deliver more accurate and cost effective schedules. David Fontenot has been active in planning and scheduling manpower-based turnarounds for almost two decades, principally for oil and petrochemical firms in the Americas, and runs Four Point Planning LLC.

**Manpower-based scheduling: Principles and benefits**

Time is undisputably one of the most significant factors to be considered in planning a turnaround because of its cost impacts on the company. The duration of a task is, however, a function of two variables; the amount of effort and the effectiveness of effort put into completing it. The duration is, therefore, also a variable. Where two of these variables are known values it becomes possible to calculate the third accurately. In a turnaround situation, the basic units for these variables are hours, manpower and productivity.

A traditional time-based schedule starts out with the duration as one known value. This may be based on the demands of company strategy to limit the overall shutdown duration and/or on past experience of how long particular tasks take to complete. Estimates of manpower are added based upon assumptions about productivity, and these estimates are refined through various means such as discussions with lead contractors. Often companies will attempt to cover the risk of delays due to low productivity by hiring extra people who can step in where necessary.

By contrast, a manpower-based scheduler will attempt to find the best combination of manpower to accomplish a task. Different combinations will, of course, have different effects upon the time taken to perform the task and also on the logistical support, costs and risks involved. The schedule can be optimised according to which consideration is uppermost.

While a unit of manpower – a man – is a fairly straightforward and unchangeable one, scheduling in this way brings a fresh focus onto productivity and how it can be forecast, measured and managed. A basic measure of productivity can also be calculated fairly accurately by looking at previous turnarounds and quantifying the amount of work done in the time taken. This provides a very straightforward way to find

**Best Practice Highlights**

- Schedule forecasts become closer to reality
- Adds focus on productivity of manpower
- Tends to eliminate unnecessary manpower costs
- Reduces overall project times by better manpower utilisation

**Benefits**

- Decreased headcount from 700 to 320
- Shortened schedule by 2 days and completed on schedule
- Reduced costs in line with manpower reduction

**Location:** Lanxess Orange, Texas

**Size:** 320 ktpa synthetic rubber

**Turnaround Date:** 2004

**Turnaround Size:**

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the time taken for particular scheduled items. Done well, the results can be striking.

For example, manpower-based software is considerably more accurate at forecasting how a turnaround will proceed in practice. During the 1980s the creator of TASC, a manpower-based scheduling software, was already delivering schedules that were echoed by actual events to 98% accuracy.

The upshot of this increased accuracy is that plant owners and contractors have a better grasp of their actual manpower requirements to do the jobs they need. As a result they need a significantly smaller manpower reserve. Because a manpower-based system focuses on the productivity of the people employed, it also seeks to maximise the hands-on time of the people hired; in turn, if people are more engaged and productive, you need fewer of them to complete the work.

For example at Lanxess’ Orange, Texas site David Fontenot adapted an existing time-based turnaround schedule to a manpower basis. He was able to strip out over half of the manpower Lanxess had expected to need, saving significant associated costs for their pay and logistical support, while cutting the overall time by two days. This was done through schedule optimisation based on the available manpower resources, as explained below.

**Manpower-based schedule optimisation**

A time-based schedule can allocate manpower according to the priority of work and assist a focus on the critical path. However, most systems available today do not optimise manpower resources for two reasons. Firstly, they rely on flat estimates of time and manpower: two men for six hours, for example, rather than valuing work at twelve man-hours. This limits the scheduler’s flexibility to use the manpower resources currently available. Secondly, prioritising the critical path can be useful but not always the best use of the manpower reserves available – which, in turn, slows the overall turnaround.

For example, let us say that two tasks are being scheduled. Task A needs 6 men for 12 hours, then 5 men for 20 hours. Task B, on the critical path, needs 5 men for 25 hours then 3 men for 10 hours. The scheduler has 10 men available each hour to conduct the two tasks. If he is prioritising the critical path then typically he will set up the tasks as follows:

![Time-Driven scheduling example](image)

**Time-Driven scheduling example, courtesy of David Fontenot**

While this aims to complete the critical path work in the fastest time, it suffers from two weaknesses. Firstly, it is not the most efficient way to complete both tasks together. By starting Task A first, Task B could be started 12 hours afterwards and both tasks be completed in 47 hours – 10 hours less overall, saving 100 man-hours of pay. Secondly, the manpower resources available to the scheduler are not fully
The maximum utilisation is 90%, and for 47 of the 57 hours it is hovering around the 50% to 60% mark – highly inefficient.

In reality, tasks are more flexible than that. Tasks will tend to have a sensible maximum and minimum number of people involved: below a certain number they cannot be done, but more than a given number cannot effectively help. Obviously, fewer people cannot accomplish a task as quickly as more people. So, instead of relying on a fixed time and manpower allocation, the manpower-based scheduler looks at the man-hours it takes to perform a task and what sizes of work crew would be practical minima and maxima.

To carry on from the example above, let us say that Task A will need 72 man-hours for 6 to 8 people, then 100 man-hours for 4 to 5 people. Task B requires 125 man-hours for 4 to 6 people, then 30 man-hours for 2 to 4 people. Already we can see that there is a considerable degree of flexibility now in how the schedule is arranged. For example:

With this formulation, the time taken to perform the two tasks drops radically. What is more, throughout the 32 hours Task A now takes manpower utilisation is at worst 90%. No more manpower is needed, but the people available are being used much more efficiently. This both reduces time and saves on manpower costs.

This formulation takes the critical path task, Task B, up from 35 hours to 40 hours. Clearly other formulations are possible which will maximise the manpower on task B and reduce its duration. This will pull manpower from Task A and potentially extend the total time elapsed: whether this is a benefit or not depends on the scheduling priorities, but now the scheduler has that extra level of control to decide where to allocate resources.

In fact, if the scheduler wants to then there are further refinements of the process available. In the example above, after Task A has changed to only needing 5 people, an extra person can be allocated to complete Task B. This reduces Task B’s time to complete by 4 hours and increases manpower utilisation to 100% for 32 of the 36 hours it takes to complete both tasks.

Clearly, the savings involved in this are not only in time, but also in the cost; in this case, 10 men have to be paid irrespective of what they are working on. This new, manpower-based schedule has saved the plant owner 21 hours x 10 men = 210 man-hours of manpower costs.
Of course there will inevitably be emergent work which needs manpower to cover. However, using this kind of methodology the scheduler knows exactly who is available; indeed, they will typically hire extra people specifically to cope with emergent work. At Lanxess Orange, 30 people were hired specifically to cope with emergent work, raising overall headcount from 290 to 320; still less than half the 700 originally planned using time-based methodology.

**Productivity forecasting, measurements and management**

Productivity is, of course, the key to ensuring that any schedule remains on track. Productivity is affected by a wide variety of influences such as local regulations, work culture, site familiarity, contract type and more. Because of these variations, for any given site it is advisable to assess productivity – the number of tasks done in how many man-hours – individually. This will provide a useful benchmark to base calculations of productivity upon.

It is also a useful benchmark to check against during the process of selecting contractors. While contractors can offer estimates for work, there is a temptation for them to assume the greatest possible productivity per man, either working on a best-case scenario or else overlooking elements such as a fire watch supervisor. In some cases they may also underestimate the preparation needed to fulfil work on a deadline-driven turnaround rather than routine maintenance. Issues such as this will affect their productivity in practice, causing the schedule to slip behind what was expected. Using a typical scheduling system, they may try to compensate by making use of unallocated manpower. In a system where there is a much greater resource allocation, which manpower-based scheduling makes possible, this kind of spare manpower has been removed. Consequently, the scheduler needs to be able to work closely with the contractors to understand the assumptions they have used in building their estimates and make sure they are realistic.

During the turnaround it is possible to monitor productivity by tracking how long it takes a contractor team to complete a given task: you know the time and the manpower in the team, so a productivity calculation is relatively easy. By comparing this against the planned estimates it is possible to forecast what change this will make to scheduled completions and allow the turnaround management team to react quickly: if there is some logistical element which is decreasing productivity a solution can be found, for example. On the other hand, if a contractor is more productive than planned, again the effect of this on the schedule can be quantified and the schedule can be moved up to account for this productivity.

As a result of all this, the productivity of individuals and teams becomes a much more significant factor in the approach to the turnaround as a whole. In practice this can translate into different approaches being taken to the choice of contractor, how their performance is measured and how any bonus/malus system in their contract operates. Because the system allows the measurement of productivity, it is possible to quantify concepts such a value for money much more accurately. This can be a useful argument in favour of using a more expensive (by man-hour) but more productive contractor, for example, as the overall costs to employ them may turn out to be similar or less than the cheaper option; another argument may be that the more productive contractors lower the risk of project overruns. Being able to identify those contractors and also justify their selection can be a useful tool for the Turnaround Manager.

Clearly, using a manpower-based system for scheduling is significantly different from time-based operations and may require elements of re-training and probably new software to use effectively on something as complex as a turnaround. However, it offers a great deal of flexibility and value for those companies that adopt it.