White Paper:

Taming Uncertainty

in the

Multi-project Environment:

The Critical Chain Difference

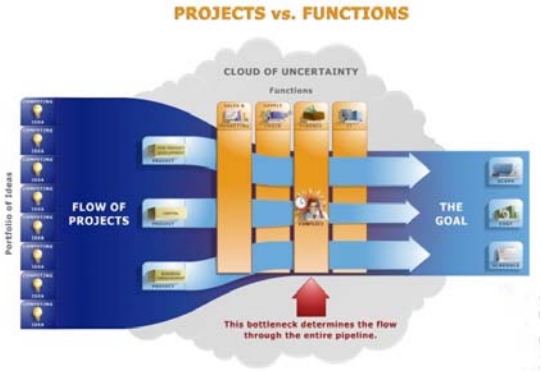

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TABLE OF CONTENTS

SUMMARY

Two major issues surrounding the management of multiple projects are resource planning and management of uncertainty. Traditional methods may be able to deal with the issue of resource planning, but provide no simple answer to the management of uncertainty in execution.

Critical Chain project management, with its buffer management method, gives the multi-project manager a high degree of visibility, focus and control over the specific tasks across a multitude of projects that require his or her attention.

In this talk you will understand the meaning of: the Critical Chain, buffer management, the pacing resource, the Critical Ratio and how they all fit together to provide a simple, elegant and common sense solution to managing complexity.

THE NATURE OF UNCERTAINTY AND COMPLEXITY

It is a fact of life that in all of our endeavours, nothing is more certain than uncertainty itself. In the area of project management this might manifest itself in a variety of forms:

- Vendor performance is unreliable
- The effort required to complete tasks is not fully known
- The time to complete even well known tasks can vary
- The delivery of needed tools, material and equipment is uncertain
- The availability of the appropriately skilled people cannot be guaranteed.

When this uncertainty is combined with the way we run our organisations, usually based on functional responsibility for specific activities such as design, purchasing, operations, distribution, marketing and sales, then the complexity of managing multiple projects becomes overwhelming.

In most instances, this complexity is managed by breaking organisations into parts small enough to control and making each part accountable for its own performance. This is usually based on the unstated assumption that optimising the sum of the effort of the parts results in what is best for the enterprise as a whole.

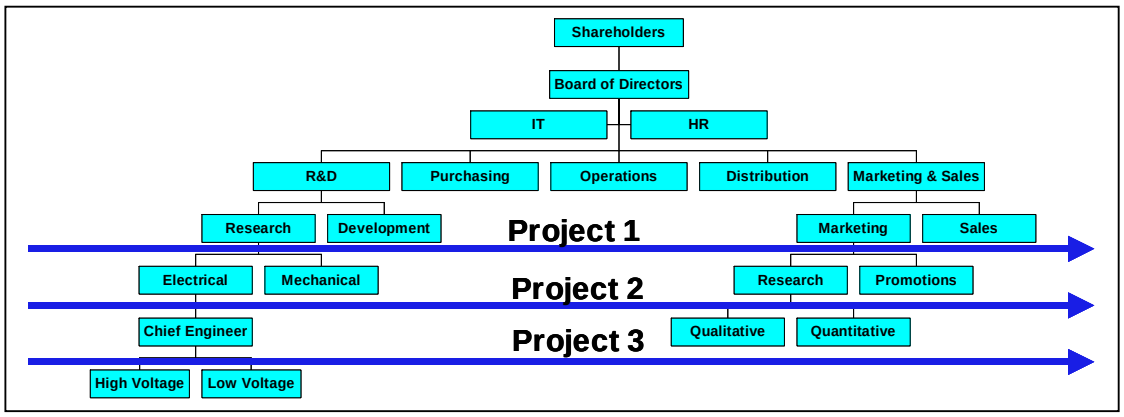

Fig 1: Projects vs. functions

All might agree that value in the eyes of the customer is added ***across*** the functions of the enterprise. If such an enterprise vests organisational command and control (and hence accountability) within functional silos, an inherent conflict arises between functional and project bosses over the use of skilled, finite resources which are in high demand. The functional boss is trying to optimise his or her profit or cost centre while at the same time the project managers are pushing for adherence to their schedules.

How is this conflict resolved? Is the current way sufficient for an increasingly competitive world? Must every conflict be referred to the layer of management above for resolution? How does that "layer above" decide what is in the best interest of the enterprise? What impact do arbitrary decisions have on project performance, customer perception of value and staff morale?

THE FIVE FOCUSING STEPS OF TOC

The Theory of Constraints (TOC), of which Critical Chain Multi Project Management (CCMPM) is a part, is a method for continuous improvement in organisational productivity. It is an accepted law of TOC that any system has within it a constraint. If that were not so, the system would produce an infinite amount of output.

Put more simply, a constraint is anything that prevents the system from achieving more of its goal. In the language of project management, a constraint is anything that prevents projects from approaching zero lead-times.

In order to improve the performance of a system or project it is useful to adopt the Five Focusing Steps of TOC:

1. ***Identify*** the constraint
2. ***Exploit*** the constraint
3. ***Subordinate*** to the constraint
4. ***Elevate*** the constraint
5. Do not allow ***Inertia*** to become the constraint – return to step 1.

1 *Identify* the constraint

In the Single Project Environment
What prevents the single project coming in within zero lead-time is the longest set of dependent events through the project, taking both task precedence *and* resource availability into account. This is defined as the ***Critical Chain.***

What about the ***Critical Path***? The definition of the ***Critical Path*** deals only with the issue of task precedence. Unless one is operating in an environment of infinite resources, the duration of a project is almost always extended by resource contention - different tasks competing for the same resources. The definition of the ***Critical Chain*** takes resource availability into account.

In the Multi-Project Environment
When projects are added into an enterprise project pipeline, the resource or group of resources which are most utilised relative to the capacity available will govern the rate of the pipeline. CCMPM calls this rate determining resource the ***pacing resource.***

2 Exploit the constraint

The term “exploit” is not intended for use in the pejorative sense, but rather as the means by which the most can be squeezed from the rate determining resources within the project network. In the case of the single project, one would seek to understand how parallel engineering, interrogation of the validity of precedence dependencies and integrity of task duration estimates can be scrutinised, to develop the shortest possible plan for project completion.

When dealing with multiple projects, if the enterprise can only deliver at the rate of its most critically constrained resource, then surely common sense dictates that such a resource should be treated differently to all others? The CCMPM treatment of how this works will be dealt with later in this paper.

3 Subordinate to the constraint

If it is accepted that the throughput of any system is governed by a constraint, then it follows that the non-constraints will not be fully utilised. In project language this is seen in all paths that are not the Critical Chain and is responsible for the creation of slack or float. The implications of having non-constrained resources on a project, however goes to the heart of the mode of operation of most enterprises, whether or not they have formal project disciplines in place.

"Efficient" utilisation of resources is the means by which most managers govern their projects, in a never-ending quest to eliminate waste. But what use is it to optimise "utilisation" of a resource in the name of efficiency when it adds no value to the duration of the project? How can the standard equation linking activity to value be broken? How do all levels within the enterprise become comfortable with the idea that when there is nothing to do, the best thing to do is nothing? What measurement system should be put in place to change behaviour from optimising task completion to optimising project completion? And finally, what signals should all project participants get to ensure that they are aligned in their efforts to continuously do what is right to reduce the lead time of their project?

The behaviour required to gain the best performance on the Critical Chain demands that the resources not on the Critical Chain "subordinate" to the demands of the Critical Chain. Subordinate means ensuring that the Critical Chain is not held up, even if it means their own non-critical chain tasks take longer or are disturbed. So while the non-critical chain resources may appear to be doing what is not best for themselves, they are doing what is best for the project as a whole.

In the multi-project environment, this would mean subordinating to the requirements of the pacing resource.

4 Elevate the constraint

Once all efforts have been made to squeeze an individual project's duration down to as close to zero as prudent planning will allow, it is time to "elevate" the constrained resource. This is usually a strategic step and would require the addition of resources to improve the throughput of either the project or enterprise pipeline.

Do not allow Inertia to become the constraint – return to step 1
Once again, common sense dictates that if there is always a constraint in a system, constraints will not disappear with the elevation step, they will simply appear elsewhere. It is important when considering and implementing the elevation step to determine where the new constraint will appear, and if this is where you want it to be. If all systems have constraints, then there really are only two choices – either you manage the constraints, or they manage you. Understanding this proposition allows the enterprise to select where it wants its constraint (also known as its control point or throttle) to be and thus control its own process of ongoing improvement.

THE CRITICAL CHAIN METHOD

The Critical Chain method is unique in the way in which it treats and measures variability within a project and across projects, so that the effects of that variability are minimised, performance is optimised and reliability is improved.

Before simply accepting such a claim, it is necessary to understand how variation drives behaviours under current modes of operation and how introducing the concept of buffers and buffer management can modify these behaviours.

Figure 2 shows a typical project network with the green solid bars representing a 50% confidence level estimate of task duration and the associated empty bars representing the padding required to take each estimate up to a 90% confidence level. Most project participants, used to the idea of being measured on task completion (local optimisation), and not knowing where trouble will strike, tend to provide as much "protection" for their tasks as they can reasonably get away with, so they pad their estimates. In this way, they can be seen *not* to be the cause of delays to the progress of the entire project.

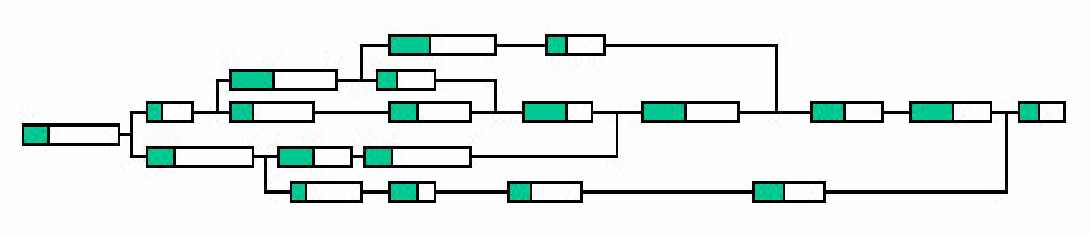

Fig 2: Tasks with added safety

Padding of estimates causes the following problems:

- Projects appear to be longer than necessary
- Work will expand to fill the time available (Parkinson's Law)
- Work will be postponed to the last minute (Student's syndrome) as the time allocated to complete the task exceeds the actual effort required to complete it

Furthermore, with padding in every task, by definition there will be time available to do other things, or to multitask within the project, across projects or in day-to-day activities. This significantly increases the risk of not being available to work on what is in the best interest of the project/s when it is really required. An added negative effect of multitasking is that many more tasks are opened than is necessary, resulting in high levels of work in process. This creates a difficult environment for the project manager to control.

The Critical Chain method addresses the issue of task duration estimating by calling for all tasks to be estimated to only their 50% confidence level. In practical terms this means asking the question: “If all the resources you required to do your task were available to you, and you were not interrupted by any other work, what is your best guess as to how long your task would take?” The balance of the contingency that would take the estimate to 90% confidence is not lost. Instead it is rolled up and put at the disposal of the project manager, out of the hands of the task manager. This aggregate contingency is referred to as a ***buffer***.

Figures 3-5 show the transition from a Critical Path schedule, through to a Critical Chain schedule (resource levelling), and finally on to a Critical Chain schedule with buffers. There is only one of each resource type A, B, C and D. Whilst the overall project duration remains the same, by using the rules of buffer management, the likelihood that the project will be delivered within the quoted time frame is significantly enhanced. How is this possible?

In the first instance, by reducing all tasks down to their 50% confidence level, there is little time to indulge in Parkinson Law or Student’s Syndrome behaviour. The requirement to protect the accuracy of initial estimates is eliminated as task managers are expected to complete on time in only half of all cases and the focus can move from task conformance to project performance. Emphasis is placed on what needs to be done to keep the flow of the project moving.

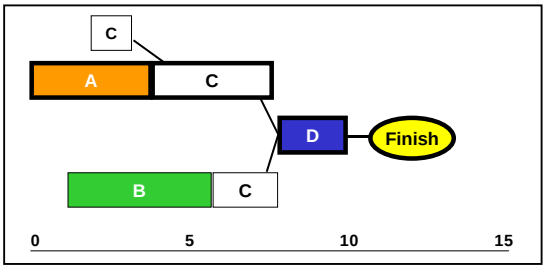

Fig 3: The Critical path

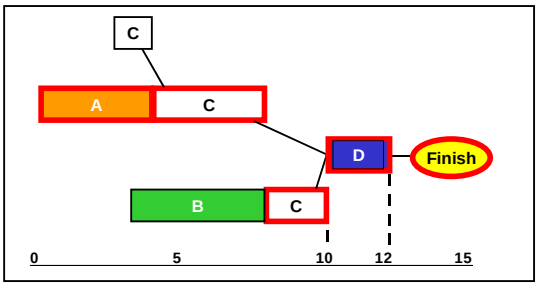

Fig 4: The Critical Chain

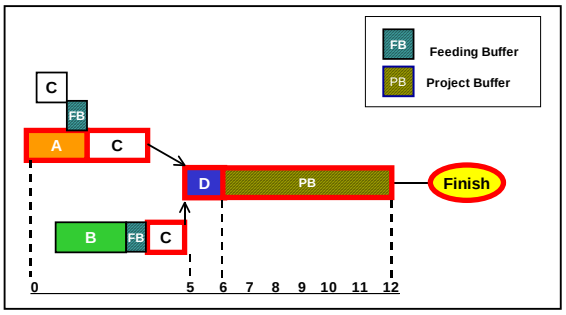

Fig 5: The Critical Chain with buffers

As it is the Critical Chain that determines the overall duration of the project, any increase in the length of this chain will, by definition, cause a delay in the project. What we must endeavour to do is protect the customer of the project from negative variation along the critical chain, and protect the critical chain from negative variation along the non-critical chains, or feeding chains. Any task might be delayed, but it would be very unusual for all tasks to be delayed. Some tasks might even finish early. We thus require a "shock absorber" mechanism to signal when chains are in danger and use this signal as a means of prioritising the allocation of resources. The buffers fulfil this function.

The consumption of buffers can be seen graphically in figure 6, below.

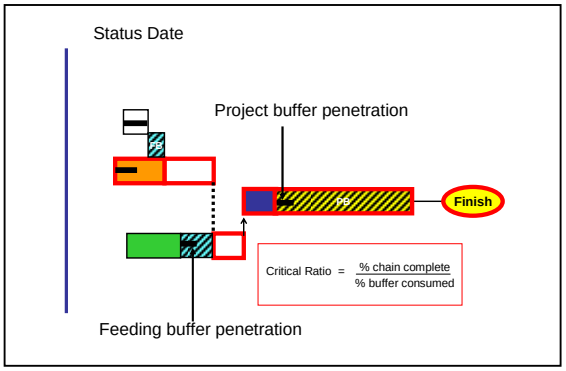

Fig 6: The Critical Chain showing buffer penetration

In this instance, the status date is represented by a blue line. The Critical Chain is represented by the red outline. The Project Buffer (Pb) has been penetrated and the feeding buffer (Fb) has also been penetrated. The orange task is the most critical to work on, as a delay here causes immediate Pb penetration. The role of the resource on the green task is to subordinate to the requirements of the orange task, even though its own feeding buffer has been penetrated due to late start of work. A further delay on the green task will not cause any delay to the duration of the project until the entire feeding buffer is consumed.

CRITICAL RATIO

What happens when the schedule networks are significantly more complex than the one shown above and many chains have buffers penetrated? How do we determine what the prioritisation mechanism is for allocation of resources?

The way that this is done is to introduce the concept of the ***Critical Ratio***. This number identifies for the project manager which task is the single most important task to be worked on at any particular point in time. It is calculated by dividing the percentage of completed chain by the percentage of buffer consumed by that chain.

Thus, if a particular chain is 50% completed and its buffer is 50% consumed, there is no reason for alarm or management attention. However, if 90% of the buffer is consumed but only 10% of the chain it supports is complete then it should be the focus of significant attention as it is acting to block the flow of work through the whole project and will jeopardise due date completion.

This Critical Ratio, or buffer burn rate, forms the foundation stone of managing uncertainty. Within the multi project environment it is the means by which the project or program manager and functional boss gain visibility and control over the multitude of tasks coursing through the organisation's pipeline. The Critical Ratio provides a clear and objective measurement system to determine which resources subordinate to what on any given day.

THE MULTI-PROJECT SOLUTION

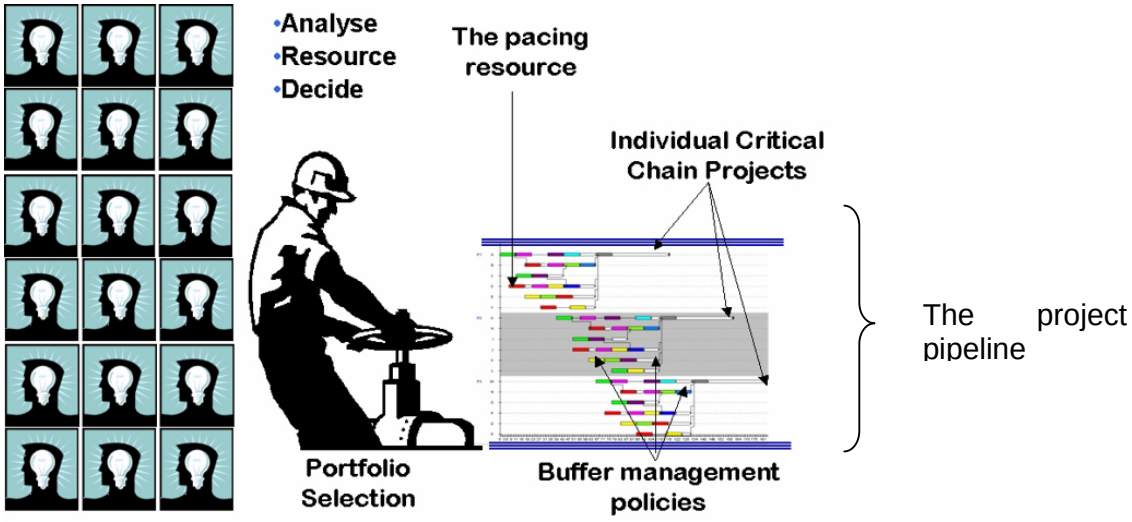

Fig 7: The multi project solution

In most enterprises there is a bank of ideas or projects waiting to kick off, but it is beyond the enterprise's capacity to have all of them active concurrently. If the organisation wishes to execute more of these ideas, the projects will either have to be done faster – a greater velocity across the pipeline – or a bigger pipeline will have to be built – that is, add more resource capacity.

It is the job of the senior executives to analyse the demands of the business, resource it according to organisational constraints and then decide what is going to be done and the priorities.

The TOC multi-project approach to managing the enterprise once these decisions have been made is as follows:

First, the Critical Chain is identified in each individual project – the shortest path through the project network, taking both task and resource dependency into account. This ensures that each project has the best possible chance of finishing in the shortest possible lead-time. However the critical chain is not enough – what of the interdependencies across projects that share the same resource base?

To manage these interdependencies, it is best to take a strategic view and identify the resource that governs the pace of the entire pipeline. Clearly, this must be the resource that is most loaded relative to all others – the constraint of the pipeline. Software can help to identify this, but in most enterprises people already know who the "pacing" resource is by virtue of his/her specialist knowledge, strategic insight and heavy demand on his/her time.

Once the "pacing" resource has been identified (or selected), resources are "gated" or released into the pipeline according to the prioritisation of the portfolio *and* the capacity of the pacing resource. In other words, the load is leveled across the projects in accordance with the availability of the pacing resource.

Why do we not level all tasks for all resources within the pipeline?
The level of "noise" or inherent variability in the processes would make such an exercise futile when it comes to project execution.

A much better mechanism to determine when and where a resource should be deployed on any given day is to observe the buffers and their associated Critical Ratios as the projects proceed within the pipeline. This mechanism allows both the project manager and the resource manager (functional boss) to have the same view of prioritisation. Clearly the project with the highest priority gets the resource if the Critical Ratio is the same. The demon of uncertainty is tamed by the power of common sense.

SOME CRITICAL CHAIN RESULTS

Shea Homes
- Home construction cycle time reduced from 91 days to 56 days
- On time delivery over 90%

Israel Defence Forces
- On time completion of projects rose by over 40%
- Average cycle time reduction of around 60%

FMC Energy Systems
- On time delivery improved from 40% to over 90%

Lucent Technology
- 400+ projects – 4 000 resources
- On time project completion increased from 55% to over 90%

Harris Semi Conductor
- The industry standard to get the plant up and running to 90% capacity is about 46 months. The plant was recently completed and is up to 90% production in 13 months

Israel Aircraft Industries
- We succeeded in dropping our average turnaround time per aircraft visit from three months to two weeks…

Honeywell DAS
- We originally scheduled to take 13 months to deliver; the team did it in 6 months

Matador Refrigeration
- The first time out, we took 26 days out of a 71-day hypermarket re-fit, a 37% increase in capacity

The Financial Times states in its new "The Definitive Guide to Project Management: The Fast-Track to Getting the Job Done on Time and On Budget" focuses solely on the critical chain method of project management. To quote them:
"Much of project management is common sense but in some areas it involves special tools or methods that must be learned," the authors assert. "Rather than risk confusion, this book has been written to reflect just one: the critical chain method. Projects managed using the critical chain method has been shown to have a far greater chance of delivering the required outputs on time and on budget than those managed any other way."

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Further reading:

Critical Chain – Eli Goldratt

Project Management in The Fast Lane – Rob Newbold

Critical Chain Project Management – Lawrence P Leach