# Critical Chain: Assessing the Efficacy and Feasibility

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***Abstract***

The three pillars of project management as every project manager is well aware are schedule, scope and cost. They are necessary conditions and the success of a project's execution will be measured against the planned vis-à-vis actual performance of these three criterions. In a specific project they may be co-equals or one may be more heavily weighted than the others, but make no mistake they are all important and they are all evaluated.

Many companies are successfully managing their projects across every industry sector since 1997 using Critical Chain project management (CCPM) methodology. The results suggest this is a legitimate alternative to the Critical Path (CP) project management methodology. After sixteen years of CCPM acclaim in the market it is time for a critical review of the effectiveness while evaluating completeness of the solution in managing the three pillars.

Some key distinctions between *CP* and CCPM will be highlighted. There are some technical differences and there are some logical precepts separating the two methodologies. The CP approach has been captured and documented in the Project Management Institute's (PMI) Body of Knowledge (BOK) and the CCPM approach in the Theory of Constraints International Certification Organization (TOCICO) Dictionary. When Eliyahu Goldratt published, *Critical Chain* in 1997, different software solutions were developed capturing the essence and logic of the CCPM approach. As a practical matter the complexity of the project management environment, both CP and CCPM approaches require software embedded with their respective logic, assumptions and rules.

The *CP* approach is well documented in the PMI's BOK and many other additional sources. The BOK provides a written roadmap covering all aspects of project management. Although the PMI recognizes CCPM, clearly their emphasis focuses on the traditional CP approach. On the other hand The TOCICO provides a written Dictionary providing the commonly used CCPM definitions while providing a roadmap by testing individual knowledge of CCPM theory leading to a TOCICO certification. Many books and papers have been published augmenting the theoretical and practical CCPM knowledge. The International Supply Chain Educational Affiliation (ISCEA) has developed the IC3PM, (ISCEA CCPM Certification) which provides training in CCPM theory and in Exepron software via an IC3PM workshop.

 

Having worked with companies in different industry sectors over the years I am no longer surprised by the extent of unawareness that much of the work they do are de facto projects. If they are not recognizing the work as projects they will not derive the significant advantages that could be achieved by using project management tools. Or even if the work is recognized as being projects, their project management performance is less than desirable, falling short of what could be achieved. This is the result of many factors such as the company's culture, previous experience and lack of training. In addition there is a general lack of leveraging the advancements in knowledge and technology to challenge some of the long accepted beliefs of what determines whether a series of tasks qualifies as a project.

We will be examining how effectively the CCPM approach provides the tools for planning, scheduling and controlling projects. This can only be fully accomplished by successfully managing the three pillars of the triumvirate.

 

# Critical Chain: Assessing the Efficacy and Feasibility

*By Daniel P. Walsh*

In order to better appreciate the Critical Chain Project Management (CCPM) approach to project management it is important to understand that CCPM is part technical and part methodology. As you will soon see this requires challenging some of the conventional paradigms and thinking.

*Critical Chain* – The *Critical Chain (CC)* is defined as the longest chain of dependencies taking task and resource dependencies into consideration. It is the *constraint* of the project. This is different than the *Critical Path (CP)*, which is defined as the longest chain of task dependencies. This is a significant new approach and technical departure with far reaching implications from the conventional CP paradigm. In the CC there may be a resource dependency and not a physical predecessor and successor dependency between tasks. In execution the CCPM methodology does not permit the planned CC to change whereas in *CP* methodology it is acceptable for the original planned *CP* to change. This is a very significant paradigm change and is the basic building block for the CCPM technical and methodology approach.

Think of the CC being the datum plane that will remain a constant for everyone's focus while managing the inevitable variability and uncertainty impacting the project during execution. One of the obvious advantages of maintaining the same CC from start to finish is that decisions made protecting the CC in most case will remain valid vis-à-vis decisions that are made protecting a continuously moving CP that may actually contribute to an ever changing of task prioritization.

The first step after the team reaches consensus on the objective of the project is agreeing on the scope of the final task. This means a well-defined exit criterion identifying the three necessary elements:

- The scope of work or effort to achieve the exit criterion
- The required principal resources needed to execute
- The best estimation of the time duration to achieve the exit criterion

It is essential to engage the most knowledgeable people, as this is a very important building block and essential for developing a CCPM schedule. The time duration for the task is based on extracting all of the safety, padding, management reserve … in order to get as close as possible, to the 'actual hands on' time duration. This means that all of the anticipated variability and uncertainty that will be encountered in execution are ignored when determining the duration time of a task. Since we don't have a crystal ball to see into the future, in the planning phase all we can do is give our best guess on how long it will take do the task. As a reminder in planning the

task duration time is in reality a non-deterministic number, the team uses their knowledge and experience to determine the time without the burden of anticipating how much safety time will be needed in execution. Using the median time for the task duration is a good rule of thumb Figure 1. However, the team has to recognize that process driven task duration may not have any embedded safety, (If it takes 2 days for paint to dry). As we will see later, the final CCPM solution will provide the protection currently being provided at the task level with CP methodology with a more effective protection for the entire project.

**50% task time estimate** – A task time estimate that has a 50% chance (or .5 probability) of being achieved.

Illustration: In the figure below the probabilities given represent the area under the curve to that point in time.

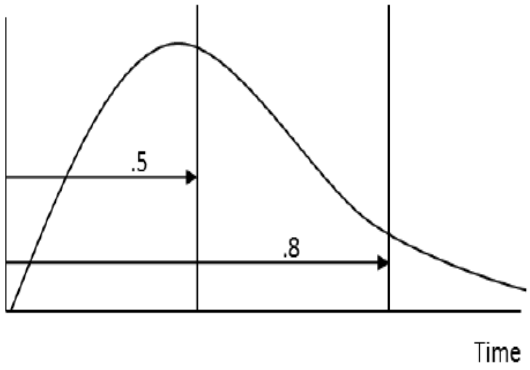


Figure 1.
Source: *TOCICO Dictionary*

Using this disciplined methodology the next step is constructing a logic based project network. Following the advice of Stephen Covey, "Start with end in mind", we place the final task furthermost to the right on the planning screen. We are preparing to build the project network, starting at the right and adding tasks to the left based on cause and effect dependency. So this means the network is being built from starting from right to the left. Many project managers initially may feel more comfortable building the network from left to right, but this akin to the adage, 'If you don't know where you are going any road will get you there.' This is a crucial part of the CCPM methodology; it will result in a logic-based network, providing greater clarity on the true required scope of each task. Much of the 'nice to have' and 'superfluous' content will be more easily identified and flushed out of the task, Figure 2.

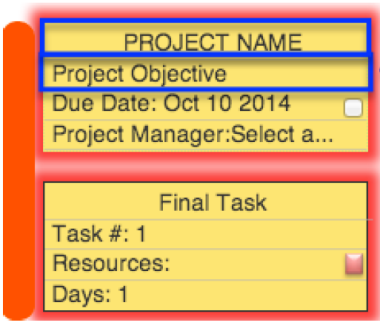


Figure 2.
Source: *www.exepron.com*

When establishing the predecessor-successor dependency between tasks, the CCPM solution limits creating only start to finish relationships. This limits the degrees of freedom, reducing complexity, while sharpening focus on the cause and effect logic of the final schedule. Once the scope of a task is agreed to, the team asks the question, "What must be accomplished in order to start this task", (successor task), the answer to this question will define the scope of the predecessor task(s), Figure 3.

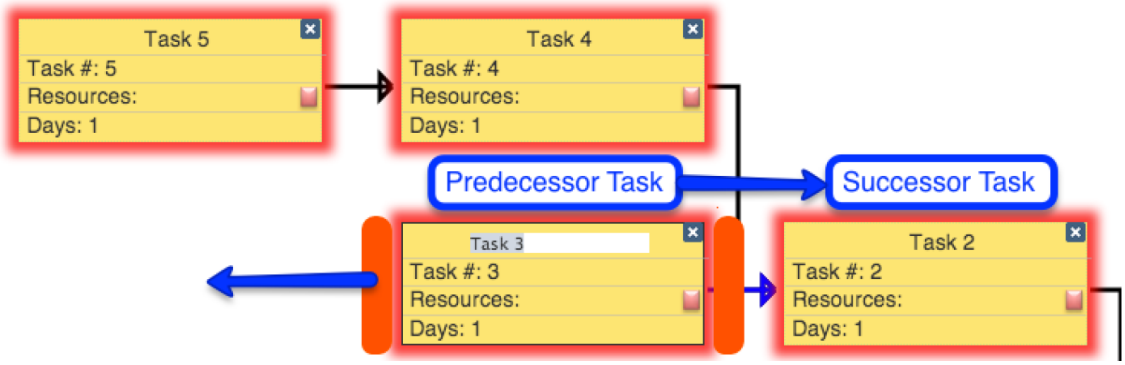


Figure 3.
Source: *www.exepron.com*

This process will be repeated until there are no further predecessor tasks. Once this is reached, the first task on the multiple pathways of predecessor-successor tasks, furthermost to the left is identified and will become the first task in the CCPM schedule. This means that there may be multiple tasks with no predecessor tasks. However every task except for the final task will have a successor task. It is recommended using a PERT type of format for developing the project network since it is provides visibility and is very easy for changing task predecessor-successor relationships. However using an alternative format such as a spreadsheet format for identifying the predecessor-successor relationships is acceptable.

 

Following this disciplined process will produce a project network that will be used as the basis for creating a CCPM schedule. It will be a tight, cause and effect based, with a well defined individual task scope, project plan.

Now the project plan is ready to be turned into a CCPM schedule. The project's Critical Chain (CC) is identified within the project network plan, which is the longest chain of dependencies, taking both task and resource dependencies into account. This is simply recognizing that you have to schedule the tasks that must be performed and the required resources to do the work. CCPM gives both the tasks and resources equal footing when developing a schedule, so it follows that sometimes the resource dependency may be the limiting factor. This is crucial since resource overloading is the primary cause of multi-tasking in execution.

### *Managing Variability and Uncertainty*

After the CC has been created the areas of highest risk in the project are identified and Time Buffers are placed where they can provide the greatest protection for the project. Let's spend some time describing the concept of Time Buffers.

*Buffers* – A buffer of aggregated safety is placed at the end of the final task of the Critical Chain. This final task is by definition also the final task in the project. When building the Critical Chain schedule all of the embedded safety within the individual tasks are extracted and a portion of the removed safety is placed in various buffers throughout the schedule. A portion of the removed safety is placed after the final task of the project and is called the *Project Buffer* in order to protect the delivery date. In addition a portion of the removed safety is placed at the convergence points, where a non- critical chain task feeds into a critical chain task. These are called *Feeding Buffers.* These convergence points are referred to as integration points and are areas of inherently higher risk. They provide extra safety to immunize the *Critical Chain* from the impact of a non-critical chain task finishing late. Once the project starts and delays are encountered, the individual tasks will 'borrow' time from the *Buffers,* and 'replenish time' if the time is not required, protecting the individual tasks, Critical Chain and the project due date.

Now the project network plan is ready to be converted into a CC schedule. As you can see the Buffers are inserted and the CC schedule is created, Figure 4. The dark blue tasks are the *critical chain* tasks. The *project buffer* is placed at the end of the final project task to provide protection against the inevitable variability during execution. The light blue tasks are the *feeding chain* tasks. A *feeding buffer* is inserted at the convergence point of the final task in the chain into the *critical chain* task. This provides additional protection to the *critical chain* and protection to the project's due date. The due date corresponds to the calendar date at the end of the *project buffer.* The buffers will push all of the chains scheduled starts earlier in time

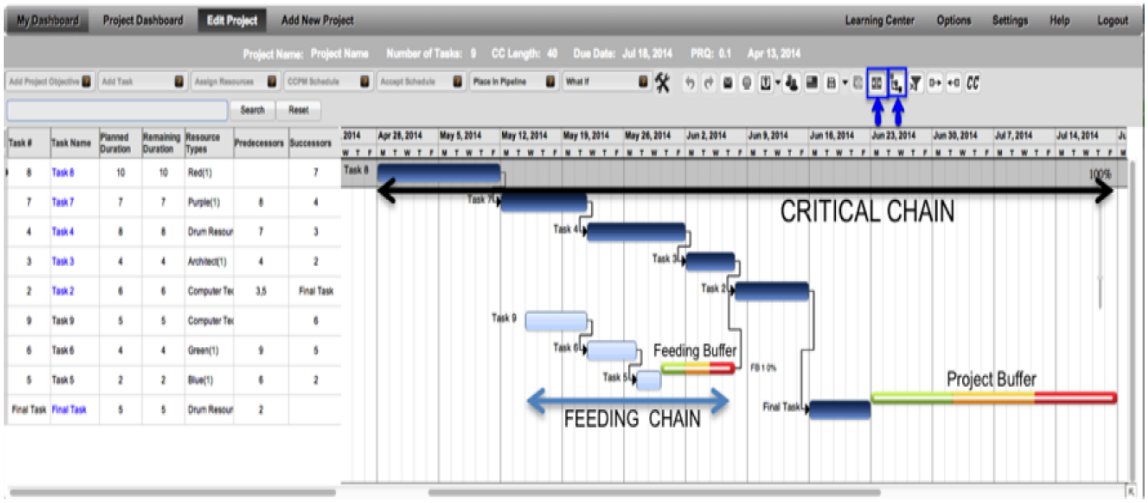


Figure 4.
Source: *www.exepron.com*

Since the CCPM approach strives to plan and schedule the task 'touch time' with all of the safety removed, the cycle time of the project will be less than a CP schedule. The CCPM solution leverages aggregation theory, taking a portion of the safety time removed at the task level and placing in the' time buffers'. Typically, the amount of safety time inserted into the buffers is half of what was previously embedded in the tasks. So, with half the safety the project has much greater protection. This is a major paradigm shift, providing protection at the project level vis-à-vis providing protection at the task level. The variability at the task level is greater than at the project, or system, level. Therefore a fundamental change in project management focus is required.

CCPM provides a tool called *Buffer Management* for managing the project in execution. This provides a mechanism for measuring the acceptable 'burn rate' of buffer usage and monitoring the potential impact it will have on meeting the required due date to the customer. Think of this as keeping the project within the established control limits. This reduces the needless intervention, changing of priorities and resource multi- tasking to a minimum. During project execution whenever an unacceptable buffer burn rate trend develops, the task or tasks causing the disturbance are quickly identified, focusing the team on devising and implementing a specific recovery plan to keep the system in control, Figure 5.


Figure 5.
Source: *www.exepron.com*

This will transform project managers from being de facto task managers to truly managing the project. Obviously managing the performance of the tasks are important, however far more important is understanding which tasks are jeopardizing the delivery date while there is still enough time remaining for corrective action. Regrettably in your current environment, in many instances, corrective action is too late. The transformation to CCPM will allow the team to:

- Focus on the few and not the many
- Know when and where to intervene
- Prioritize attention on the tasks causing the greatest risk to the project
- Maintain the original planned CC for the life of the project
- Identify and correct disturbances while there is enough time remaining

There are several acceptations to the claim that the original CC will be maintained for the life of the project.

1. CCPM protects a project from the impact caused by *common cause variability.* In fact in many environments it provides a 95% probability of finishing the project on or before the *original* promised completion date. It is not possible to provide a solution that will protect against *special cause variability,* however CCPM provides an earlier and more accurate impact on achieving the committed to completion date.
2. If there is a significant growth in scope. CCPM provides sufficient protection against a moderate increase to the scope by *Buffer Management.* However at some point the management team must assess the feasibility of continuing with the current schedule or decide that a new plan and schedule must be developed.

The team must now recognize that the original project scope and therefore the original schedule are no longer valid. In essence from a scheduling perspective this

is now a *new project*, requiring a new schedule. It cannot be *overstated* that this is the acceptation and not the norm when CCPM methodology is being used.

## *Cost: The Third Pillar*

There is abundant empirical data suggesting that CCPM methodology and software provide a very effective methodology and tools for managing both the scope and schedule in a project. The results reported by companies that are using CCPM supports the belief they will have a congruent positive impact on controlling *budget cost*s. In addition similar results have shown a similar positive impact on *earned value* creation. So the obvious question that begets an answer is if CCPM methodology is so effective in addressing *scope* and *schedule* then why has the third pillar, *cost* not been incorporated?

The answer may not be readily apparent, so we must better understand why *cost* was not incorporated into the CCPM solution. The CCPM solution incorporates *buffers* that are really *time buffers* inserting them at the high-risk areas of the schedule. This has the effect of scheduling many of the tasks earlier in time in order to accommodate the insertion of the *buffers* into the schedule. This is possible because the safety time is removed from the tasks and by leveraging aggregation theory the CCPM schedule provides greater protection for the project with less safety time or *time buffers.* With minimum education it is quite easy for individuals and companies to understand and accept this concept.

As we know every solution, no matter how powerful and innovative have potentially negative aspects. Such is the case with CCPM and experience teaches us that it can limit or in some cases keep companies from incorporating the solution. The negative aspect is that CCPM is not directly compatible and thus not synchronized with the company's cost planning and execution legacy tools. Even if a company overcomes the negative aspect and successfully deploys CCPM, over time may lead to abandonment.

This is symptomatic of a conflict of thinking between what we will refer to as the *cost world* and the *throughput world*. This conflict does not exist when using conventional CP methodology since it resides in the *cost world.* The basis for developing a CP schedule starts with taking a specification turning into a WBS and identifying the work that must be accomplished which is the basis for estimating the project cost. So far there is no conflict with the CCPM solution that resides in the *throughput world.* The process from taking a specification and or WBS, converting into an execution plan and then an execution schedule is where the conflict starts. Using CP methodology the identified cost within a task is based on the level of effort or earned value added. So it follows that the cost and the scheduled time to complete the task are completely compatible.

This is the origin of the major conflict with CCPM methodology. The building of a CCPM schedule starts with identifying the effort required at the task level, which is compatible with the specification and WBS. However the task level of effort and the time to complete is based on extracting safety out of the task. This is the median time discussed earlier, which in many cases requires reducing the time to complete the task in half. The CCPM methodology schedule is developed on the assumption there is a 50% chance the task will finish within the scheduled time. This does not mean the level of effort, or cost is 50% less. In fact this means a task will take longer than the scheduled time 50% of the time and will require additional level of effort. This is consistent with CCPM methodology; you plan for the known, albeit it may be your best guess while planning for the unknown variability. The protection against variability is provided with the *time buffers, which* immunize the project schedule. However there is a cost associated by maintaining enough resources as protective capacity and this protection and must be accounted for in the budget.

This is a crucial requirement that CCPM ignores; reconciling the actual costs in planning and then managing in execution. A similar dilemma is encountered reconciling *earned value* with CCPM methodology. The problem is caused by the same conflict and therefore follows that the solution must address both requirements.

There have been attempts at solving the dilemma, regrettably with a noticeable lack of acceptance. One of the solutions identified in the TOCICO Dictionary is the concept of *cost buffers.* This attempts to budget for the associated cost of the required protective capacity to offset the additional effort of supporting tasks when they exceed the planned cost. This is recognition that additional effort will be required in execution, however it is not possible to forecast when and where and how much will be needed. With *cost buffers* the additional costs are accounted for by aggregating anticipated cost increases. The formulae for deriving the *cost buffers* appeared to be somewhat arbitrary and the calculus difficult to defend. Even though individuals and companies accept the concept of *time buffers* they resist accepting the concept of *cost buffers.*

CCPM drives companies to complete projects significantly faster with a much higher probability of meeting the committed delivery date. This will de facto drive down the actual costs by making the resources more productive. So the solution must not penalize the company from generating additional throughput for their efforts. The solution to the dilemma is surprisingly simple yet the ramifications are profound.

The CCPM solution focuses on throughput, hence it is referred to as being in the *throughput world*. However it must address the *cost world* needs of being able to plan, schedule and manage *budgets* and *earned value.* Frank Whitley the inventor of the jet engine was asked how he developed this game-changing solution. To paraphrase his response, "I didn't hire any propeller engineers." Accepting and

recognizing that the *budget* and *earned value* are and must remain in the *cost world* is the key to adding the third pillar of project management to the CCPM solution.

"Render unto Caesar the things that are Caesar … ", instead of perpetuating and challenging the universally accepted precepts of cost accounting, rather embrace them and incorporate into CCPM thinking. Then the CCPM tools must develop this capability, reconciling and mapping all of the costs and earned value directly to a specific task in the project's CCPM schedule. This becomes an integral part of the planning phase – scheduling phase – execution phase.

## Summary

In order for CCPM to become a legitimate alternative to CP project management it must address all three of the pillars cost, schedule and scope. The key is being able to budget while in planning and track costs and earned value in execution just like we do today, in what we will call the cost world. This will allow for the oversight and scrutiny for meeting regulatory and fiduciary requirements. Since this is the method currently used it will not require any paradigm changes.

The CCPM approach to planning the project's tasks and turning into a schedule requires a change in thinking. Using a WBS is an effective way for identifying the scope and capturing the cost and earned value. However the limitation to the WBS structure is that it does not address the interactive work dependencies across the vertical multiple silos at the different levels. In other words, the WBS is a top to bottom hierarchical structure identifying the required work within different competencies and functional areas in the WBS.

The CCPM project schedule is built horizontally, starting at the end, establishing the work dependencies across the competencies and functional areas. This is a very effective way for establishing the logic driven predecessors and successors relationships. This will produce a significantly different schedule than just rotating the WBS ninety degrees to the right. CCPM methodology requires identifying the predecessor and successor relationships for the work (tasks), identifying the required resources for each of the tasks then this is converted into the project schedule. As a reminder all of the safety is removed from the tasks and *time buffers* are strategically placed in the schedule.

The cost and earned value are calculated in the *cost world* and the schedule is calculated in the *throughput world*. We now can now mange the three pillars. Now the cost data can be directly mapped back to the CCPM task. It might be helpful to visualize two parallel universes that will have to be updated in execution. We will update the cost and earned value and update the time remaining in the project schedule. The additional effort is very minimal and the benefits enormous.

So, what shall we call this addition to the CCPM approach? Let's call it CCPM Pro.

*Daniel P. Walsh is a noted critical chain expert. He along with John Thompson founded Exepron, an innovative and advanced critical chain SaaS business solution that in addition to CCPM have developed the CCPM Pro capability. The solution can be viewed at [http://www.exepron.com](http://www.exepron.com) .*