Integrating Critical Chain and the PMBOK® Guide

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Purpose and Objectives

The purpose of this paper is to help project management professionals understand how the Critical Chain Approach integrates with and adds value to the current body of project management knowledge, and where it differs from it. Two of the most referenced sources of current knowledge in the project management world include the Project Management Body of Knowledge (PMBOK®) Guide and Dr. Harold Kerzner's Project Management Text.

The paper grew out of a dialogue within the International Institute for Learning (IIL) and with Drs. Kerzner and Goldratt to explore how Critical Chain thinking and practice could be best integrated into the existing body of project management knowledge. Our objectives are to cut through terminology differences, prejudices and unfounded beliefs to see how we can use the Critical Chain Approach, or any aspects of it, to improve project management and the performance of the organizations that rely on projects for success.

Structure

The document begins with a look at the Theory of Constraints/Critical Chain Approach and how Critical Chain Approach enhances the foundation of Critical Path practice. The document also discusses Critical Chain relative to each of the nine knowledge areas of the Project Management Body of Knowledge. A glossary of Critical Chain terms is included.

Introduction

The Critical Chain Approach is a way to manage all of an organization's projects holistically Developed using the Theory of Constraints improvement methodology, Critical Chain puts forward only a few strategic changes in how projects are planned, scheduled and managed. However, these few changes are resulting in claims of tripling the number of projects completed, reducing project cycle times (the project's elapsed time or duration) by 25% or better, and increasing company revenues by tens of millions of dollars. Critical Chain methods focus mostly on improving project cycle time (within quality and scope requirements). Sometimes, conscious tradeoffs are made in resource cost, in order to generate a much higher Throughput from the project.
This magnitude of improvement implies that Critical Chain is impacting the entire process of managing projects, and not just one small part. The reaction to Critical Chain of many experienced project managers has been somewhat negative. First, most people who have managed projects professionally for many years are skeptical that such improvement is possible. Second, there are arguments that some aspects of Critical Chain are in conflict with current best practices, especially relative to the current body of project management

1. Project Management, A Systems Approach to Planning, Scheduling and Controlling, Wiley Press, 1998. After six editions, this is one of the most widely sold texts on Project Management methodology.
2. Dr. Eliyahu Goldratt is the author of Critical Chain, North River Press, 1996, and widely credited with advancing its practice around th world. References to "Goldratt" are about the systems approach put forward by Dr. Eliyahu M. Goldratt, the person most associated with the creation and advancement of the Theory of Constraints methodology.
3. A holistic or systems oriented approach is one that considers all aspects of the system within which a process exists

knowledge known as the PMBOK® Guide. Finally, many experienced project managers already use some of the Critical Chain concepts in their projects, and find it annoying to put a Critical Chain label on it.

The Theory of Constraints and the Critical Chain Approach

The Theory of Constraints (TOC) is a holistic or systems-oriented approach to process improvement. The Critical Chain Approach is an application of TOC principles to project management. The Theory of Constraints assumes that a system is like a chain. A chain is only as strong as its weakest link. The links are interdependent on each other to satisfy a need. A project operates the same way. To achieve the project's goals requires the cooperation of many different people, departments and functions, in a series of interdependent actions. The principle difference between this and the concepts underlying the Critical Path Approach is that the critical chain includes logically and resource related tasks, while the critical path includes only logically related tasks. The belief is that finding and strengthening the weakest link (the system constraint) gives the greatest opportunity for measurable improvement, both within individual projects and across the entire collection of an organization's projects.

This is wonderful news for organizations that have adopted a professional approach to project management. Every TOC improvement effort recognizes that most of what we are doing today is good. We want to find only one or two leverage points to change the system, so that the results are far better than with current approaches. For organizations that already have a well disciplined, mature approach to project management (as embodied in the PMBOK® Guide), the Critical Chain Approach will not disrupt, but rather enhance the organization. For organizations that are not at such a maturity level, the combination of Critical Chain and traditional project management is a powerful one. Successful project managers using traditional techniques have recognized and addressed many of the aspects in the Critical Chain Approach. However, Critical Chain provides a complete systematic way of addressing them.

Often, if you are missing just one important aspect of a system, the entire system fails, or its performance degrades significantly. Critical Chain brings together and educates management on all of the aspects of the system that must exist in order to get the best results.

Critical Chain Focuses on Project Cycle Time

Since projects are undertaken to bring benefits to an organization, the sooner they are completed, the sooner the benefits are realized. Critical Chain focuses on the amount of time it takes to complete any single project. In a collection of projects, Critical Chain focuses on the factor that most effects the cumulative cycle time of all the projects. This factor is known as the organization's strategic or critical resource, also called the "Drum". Critical Chain's focus on the critical factor to improve overall project performance is one of its major contributions.

Accepting cycle time as a significant target of our improvement efforts, we must focus our attention on the causes of long cycle times.

Dedicated Effort

In projects, there is a difference between elapsed time (duration) and effort. Effort can be applied in a dedicated or non-dedicated way. For example, non-dedicated would have a resource assigned to several tasks simultaneously, whereas a dedicated resource would be fully assigned to one task until that task is completed. Non-dedicated effort implies extending the duration.

Critical Chain highlights the importance of dedicating effort to streamline and optimize the cycle time. Critical Chain analysis shows that within single projects, the biggest factor impacting cycle times is the practice of estimating tasks according to non-dedicated elapsed time, and subsequently, managing the execution of those tasks to a due date.

Within the multi-project environment, the biggest factor impacting cycle times is the resource bottleneck. This factor is created by the current system of pushing work (in the form of new projects, etc.) into the organization, irrespective of the capacity of the most critical resource - the one that most impacts the cycle time of all projects.

Critical Chain addresses both the single and multi-project factors in the reduction of duration.

How Critical Chain Enhances Critical Path

Critical Chain assumes a good critical path network that has been effectively resource leveled. Starting from that point, Critical Chain enhances the ability to optimize the schedule and set the stage for improved project monitoring and control. It should be noted that some of the actions needed to implement Critical Chain successfully might be significant changes for an organization. Following are specific ways that the Critical Chain Approach works and adds value.

1. Using the Critical Chain approach, team members are asked to dedicate themselves to a project task, to complete it as quickly as possible and to periodically report how many days are remaining. When planning a project, task times should be estimated much closer to how long the task will take with dedicated resources, rather than elapsed times assuming the organization's current practice of assigning resources to work on several tasks at once. This also significantly reduces behaviors called "student syndrome" and "Parkinson's Law" (see glossary).

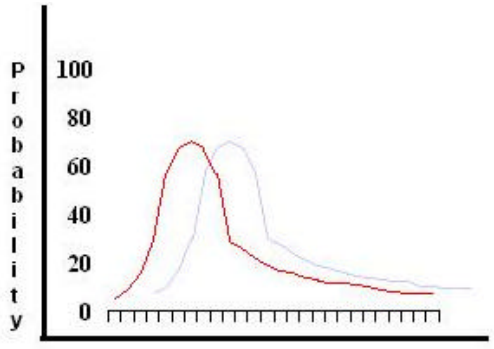

Figure 2 - Effects of "Student Syndrome" and "Parkinson's Law" on task duration

4. Effort is the amount of resource time (e.g., person hours) required for a task.

2. Bad multitasking (see the glossary for a definition) is significantly reduced, permanently. The reduction of bad multitasking goes hand in hand with reducing task estimates to dedicated elapsed times and having people complete tasks before starting new ones, as much as possible.

3. In executing a project, people are not measured and are not held accountable for completing their tasks on time. Managing tasks by due dates is not done. People are asked to pass on their outputs to the next resource as quickly as possible. Use of intermediate due dates is limited. This is sometimes called the "relay runner ethic." It is a controversial issue that will be further addressed in the discussions on Time Management and Human Resource Management, below.

4. By taking resource dependency, as well as logical task dependency into account, the longest sequence of dependent tasks can be seen more clearly. This longest sequence, the Critical Chain, may cross logical paths in the network.

5. Buffers (equivalent to schedule contingency reserves) are a key part of the schedule and how it is managed. The ability to increase the certainty of project completion dates is closely related to the use of buffers. The use of buffers, strategically placed in the plan, allows the planner to clearly accommodate all common cause variations (variations in duration that predictably occur because they are part of the system within which projects are performed). Buffer types include Project buffers, Feeding buffers, Resource buffers, Drum buffers and Strategic Resource buffers. See the glossary for definitions of the different types of buffers.

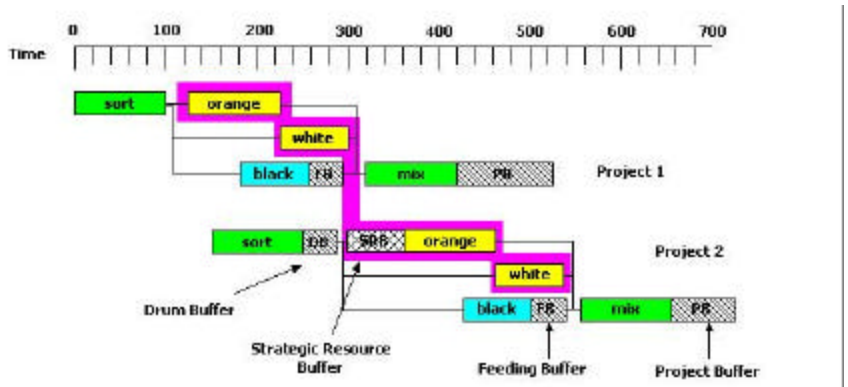

Figure 3 - Buffers are a key part of the schedule

6. Critical Path uses a concept of slack time or float to determine how much flexibility there is in non-critical path tasks. Critical Chain Approach groups tasks on each non-critical (or feeding) path entering into the critical chain and "protects" the critical chain with a Feeding Buffer. The feeding buffer is equivalent to a schedule contingency reserve that is local to a part of the project. The Critical Chain

Approach is explicit and systematic about the use of Feeding buffers throughout the task network.

7. This buffering allows for non-critical tasks to be scheduled at their latest possible start times to discourage costly early investment of work in process. This also significantly reduces behaviors called "student syndrome" and "Parkinson's Law" (see the glossary). Early starts are discouraged unless there is a major strategic reason for doing so.
8. Often, the Critical Path changes during execution because there is no buffer to absorb the variation in task times. If implemented correctly, the Critical Chain plan and the Critical Chain itself do not change throughout the life of the project, because the buffers absorb the uncertainties in task duration.
9. Critical Chain recognizes that there are multi-project environments in which projects have resource-based interdependencies. In other words, projects share a common resource pool, for at least some tasks.
10. The Critical Chain Approach identifies the critical resource (called a Drum Resource) across a collection of projects. When overloaded or not available, this resource is the one most likely to impact the project cycle time of all projects.
11. The staggered introduction of projects into the system is used to improve the flow of projects, to increase the predictability in each project outcome and to increase the effectiveness of critical resources by minimizing the effect of bad multitasking. A shorter project cycle time and an increase of the number of projects that can be pushed through the system without increasing resources result from staggering the release of new projects.
12. Similar to vertical traceability in Critical Path, the Critical Chain plan and detailed schedules are linked entities. Any logic at the detailed levels must be reflected in the summary level(s).
13. The benefits of Critical Chain will be secured permanently for the organization with the implementation of a performance measurement system, policies and education that are in keeping with the Critical Chain Approach.

Critical Chain & the PMBOK® Guide's Nine Knowledge Areas

Project Integration Management

A good plan is one that must have a high probability of being achieved. Good plans are predictable.

Critical Chain and traditional risk management both recognize that the time required to perform any individual task is uncertain. In fact, some individual tasks can easily take twice as long as estimated, and this should be considered normal.

Therefore, to have a good plan, Critical Chain insists that the protection from individual task variances must be accumulated into buffers, and not managed individually. Goldratt suggests that to properly insulate a project from variance, the project must have a Project buffer duration of approximately 50% of the length of the Critical Chain. In practice, the size of the buffer that project managers use today depends a great deal on the environment - how risky it is, and how variable the task durations are. In practice, a range of 30-50% is common.

The Critical Chain Approach attempts to reduce the number of times that management must intervene due to task time variation. We attempt to include a large proportion (say, 97.5%) of the variation in the schedule (using buffers, realistic task estimates, risk mitigation, etc.) leaving only, say, 2.5% of the instances of task time variations that would require higher level management intervention.

Insulating any process from those variable things that normally happen in projects attains predictability. For example, if software developers were usually late in a particular company, then planning a project as though they would be on time would be less than clever. However, it is quite possible to address the reasons for these people being late or the extent to which they are late. Many times in order to do that, a systemic change must be made above and beyond the project. In other words, changing the way the organization operates may remove or reduce the cause of lateness. Then, adding a buffer at the end of the path handles the amount of variation that remains in the activity or path. Critical Chain with risk management and quality management can be used to address such issues.

The buffers, dedicated task times, reduction of bad multitasking, the staggering of the release of new projects according to a strategic resource and various risk mitigation techniques all come together to increase the predictability of successful project completion. Risk management and quality management can be applied to reduce the size of buffers and the overall duration of the project (the length of the Critical Chain).

Shrink Task Time

At the same time that Critical Chain is protecting a project at the overall level, it demands a dramatic change in the way that Critical Chain project tasks are done. Somehow, to get an overall favorable effect on total project duration, task times must be reduced drastically way. Critical Chain assumes that "management pressure" is no longer a valid way to shrink the actual time it will take to complete a task.

Critical Chain looks to shrink actual task times in two ways. One way is to eliminate padding for individual tasks (if it exists) that everyone (the team member, the resource manager, the project manager and senior management) agrees are highly uncertain. What we mean by padding is time built into the task time for protection. Instead of using padding, protection is accumulated in a buffer, and not allocated to any individual task. The task duration that remains may have a high probability for variance, and this is the reason that the task performer cannot be held to hitting the task completion deadline.

The biggest opportunity lies in addressing the second way to shrink task times. This is addressing the difference between the dedicated elapsed task time and the non-dedicated elapsed task time.

Consider two typical examples. First, there is a project that requires a senior management committee approval at a certain point. The committee will hear a 60-minute presentation and decide on certain key issues. These decisions drive the rest of the project. How long does the project allow for this one task to occur? This 60-minute task is scheduled over 45 days. Why? Because the committee only meets once per month. The next meeting is scheduled in 15 days. We will assume that the committee won't decide at the first meeting, so two committee meetings, with 30 days in between, are allowed. This is an example of non-dedicated elapsed time. If the cycle time of the project is critical, why not have the committee meet on much shorter notice or agree to resolve the issue at the first meeting? It is not the efficiency of the committee that is critical, rather it is cycle time. Challenging the assumptions underlying when and how the committee meets and even whether it meets can affect project cycle time and overall Throughput.

A second example is also typical. This is where a person, cannot devote 100% of his or her time to the task at hand. The task has, for example, 10 days of dedicated time estimated. The person doing the task is involved in several critical projects. She also has some regular job duties. And there are several legitimate points, during the 10-day task, at which the person will be waiting for input from other sources for at least several hours.

If the person were able to dedicate herself to this task, pushing herself, she could complete it in 10 days. But with the other considerations, she gave an estimate of elapsed time of 25 days.

This 25-day elapsed time is considered legitimate - it is not padding because the person, legitimately, has 15 days of other work and waiting that typically occurs during this time in this organization.

In today's world, it has become acceptable - a way of life - that managers allow and even encourage their resources to do tasks in a non-dedicated way. Managers think that this is the most efficient way to manage resources. From the point of view of keeping everyone as busy as possible, it is efficient. From the point of view of generating the biggest increase in company profits through successful project completion, it is terrible.

As we have said, Critical Chain promotes a systemic change that would enable the performer to dedicate time to the task, thereby reducing the project duration and increasing the number of projects that can be done by the organization, assuming that the task is on the Critical Chain.

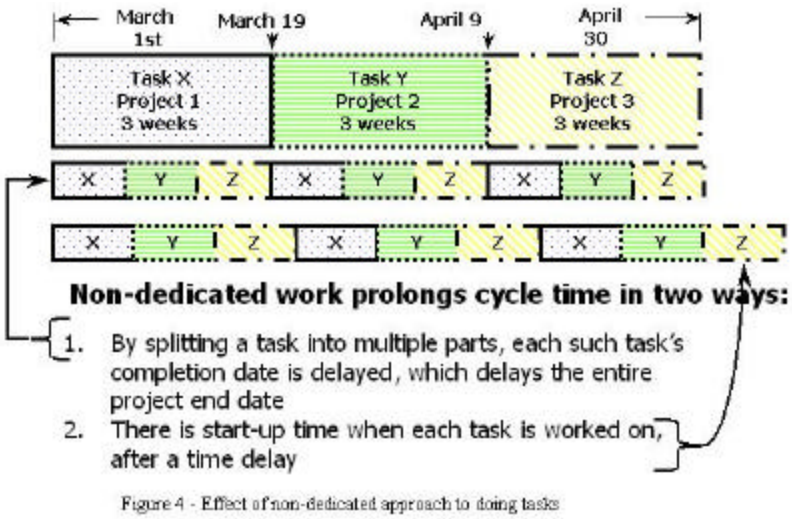

Figure 4 - Effect of non-dedicated approach to doing tasks

Performance Measurement and the Relay Runner Ethic

Further, Critical Chain recognizes that measuring people by whether they finishing their tasks according to a due date, and including milestones in project plans, causes people to NOT pass on their task completions early. Any protection that could be accumulated within a task execution is wasted (as per Parkinson's Law). The Critical Chain Approach promotes and relies on the relay runner work ethic by which each task is completed in the least amount of dedicated time and successor (resource or logic) activities are alerted when an activity might be finished in less time than originally estimated. As part of a Critical Chain implementation, resource managers decide how, and to what extent, resources on the Critical Chain are flexible enough to start work within a range of dates, rather than only on a specific date. With significantly fewer projects in process in the system at any point in time, resource managers are able to accommodate this flexibility in assigning their people to tasks.

There is a tendency in organizations to "whack" people when they do not comply with their task estimates. If they finish early, they are always expected to finish early and if they finish late they are bad guys. This leads people to not deliver tasks early and to pad their task estimates to protect themselves from being penalized for being late.

The relay runner ethic says that people should go as fast as they can (in keeping with good quality) and deliver their results as early as they can. If the per-

former accepts this and is not penalized for late delivery or early delivery she will be motivated to perform and to estimate accurately. The important thing is to get the project done on time, not necessarily to get tasks done on time. Therefore, Critical Chain emphasizes the following points of Project Integration Management:

Project Plan Development

- When creating a plan, list obstacles and intermediate objectives as developed by key team members and anyone who will be impacted by the project. These must include obstacles to implementing the relay runner work ethic and the staggering of projects.

- The project planning methodology includes the Critical Chain (single and multi-project) Approach.

- One subset of the project plan output includes the Critical Chain plan (see the glossary).
- Intermediate date constraints are discouraged, except when there is a strategic reason (e.g., customer payment hinges on it, legal requirement, inspection).

- Scheduled task start dates may be later than traditionally practiced, and are based upon the placement of Feeding buffers, Project buffer, Strategic Resource Buffer and Drum buffer.

Project Plan Execution

- The Critical Chain plan is one of the inputs.

- Buffer management and Critical Chain knowledge should be considered key management skills.

- An essential output of project execution is buffer reporting. Buffer reports include the key ratios comparing the percentage of Critical Chain that is complete with the percentage of the project buffer consumed at any particular time. Another key ratio is the Percentage Feeding Chain complete compared to percentage Feeding Chain buffer consumed. The pace by which buffers are used is also a key indicator of the project's performance over time.

It is well known that finishing certain projects earlier has value to the organization well out of proportion to their cost. For example, in the computer industry, a new generation computer chip that is introduced first into the market generates profits that are several hundred percentage points better than its followers. A new hospital wing being constructed will provide value to the community the sooner the project is completed.

5. Capers Jones, Assessment and Control of Software Risks, Yourdon Press, 1994, p. 56.

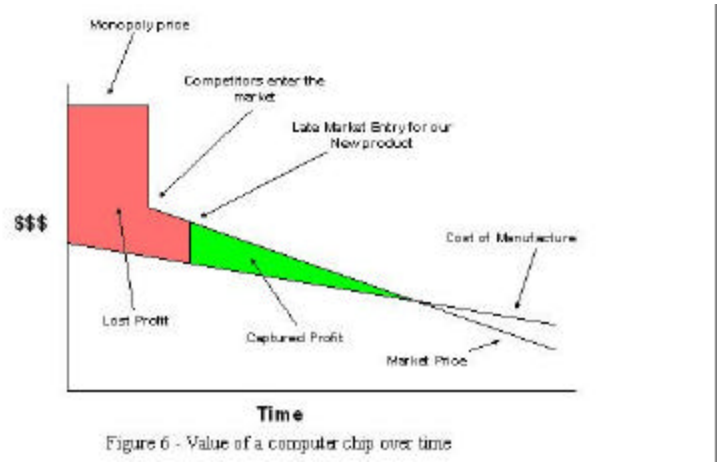

Figure 6 - Value of a computer chip over time

Further, the longer the project takes, the greater the risk that some portion of the originally defined specifications will become obsolete. By one estimate, changes in an IT development project might be about 1% per month. Therefore, Critical Chain plans recognize that doing things that use resources inefficiently, for the sake of shorter total cycle time of the project, has value well beyond the additional cost of the resources. For example, putting four people on a task, when three could do it most efficiently (as measured by some productivity factor per person), may still be warranted in Critical Chain, if the overall project duration shortens by a significant amount. Significant means that the additional cost incurred is less than the measurable benefit.

Initiation

- One of the outputs from project initiation must be the organization's expected benefit from the project. This means the expected Net Present Value (NPV) to be generated from this project. Identification of NPV positive changes if the project is delivered earlier, and NPV negative changes, if the project is delivered later, should also be included. This input allows the team to make better decisions regarding the best ways to plan and execute the project. Planners can evaluate different ways of breaking down the work and different ways of doing the work based on a solid business case. The difference in Critical Chain projects is the emphasis placed on analyzing the value of reduced cycle time. Managers are more focused on this analysis, because senior management has been educated, as part of the Critical Chain implementation, on the strategic importance of cycle time.

Work Breakdown Structure and Work Assignment

- One of the inputs is the NPV analysis described above.
- The Work Breakdown Structure (WBS) analysis output identifies which tasks are reliant on a strategic resource (the Drum resource for the entire organization). This requires a conscious effort to determine whether some of this work could be allocated to other resources to increase the

number of projects that can be done by the organization. For example, some work that might naturally or efficiently be organized under this Drum resource might be organized and separated as a subcontractor package.

- Effective decision-making requires that the planner look at the NPV of throughput and project cost not just the cost alone, in deciding on the most appropriate approach. Work Breakdown Structure analysis recognizes that some items that are most cost efficiently done by one organization unit might be better done by others. Further breakdown of activities and having the sub-activities done in parallel by others or by assigning them to less efficient resources are ways of hastening the project's completion.

  For example, if a change to a Web site is required for a project it is usually most efficient to have it made by the in-house Web specialist. It is a task she could do in say, half a day. However, if that specialist couldn't get to the task for say, three weeks, it might be worth the extra cost to have the task performed by an outside group that would cost more but would reduce the elapsed time.

Project Time Management

The Critical Chain plan must represent every activity but may not schedule every activity in detail in a large project. In other words, the Critical Chain plan schedules summary-level activities. For example, in a large project involving several thousand activities, a few hundred high-level activities are typically sufficient to capture the major dependencies for Critical Chain. In such cases, it is important that a detailed plan for controlling the work at the detail level is linked properly to the Critical Chain plan. This is called "vertical traceability" in Critical Path Method (CPM) scheduling.

Activity Sequencing

- The Critical Chain method includes any resource dependencies in activity sequencing. (As noted above, a resource-loaded and-leveled schedule is an input to the Critical Chain method.)

- The Project Network Diagram output shows both task and resource dependencies.

Activity Duration Estimating

- In general, Critical Chain activity durations are estimated assuming no bad multitasking and resources dedicated to tasks. The duration is the actual time dedicated to perform the task, or something very close to this time. These assumptions are possible if the organization makes the changes required (see the Human Resource Management section, below).

Project Cost Management

Schedule Development

- Schedules are developed using the Critical Chain method as the primary tool.
- Schedules include a Project buffer, Feeding buffers, Resource buffers, Strategic Resource buffers and Drum buffers.
- Tasks normally start as late as possible. The objective is to minimize any work in process and to eliminate "student syndrome" and "Parkinson's Law". In Critical Chain, early starts would represent investment that was made too early to provide a return. Early starts also significantly increase the risk of bad multitasking. Safety is provided by the buffers and helps to avoid the need for, and hence the practice of padding at the task level. Padding may occur unless the organization squeezes time from the schedule to achieve a schedule that shows an earlier completion date.
- Resource leveling is greatly simplified due to the multi-project Critical Chain practice of staggering the introduction of projects into the system according to the availability of the strategic resources of the organization. This typically results in the reduction of bad multitasking and of the number of active projects in the entire organization at a given point in time. Experience shows that, because of these practices, more projects can be delivered in the same time period with the same resources. Also, the ability to use more resources on critical tasks, even though inefficient in terms of the individual productivity of that resource, makes it easier to compress schedules.

Schedule Control

- Buffer management is the primary schedule control mechanism, for the overall project. In large projects, traditional methods still apply at the most detailed level.
- Team members are not given due dates. Rather, they are asked to report the days remaining on each task.

As a general principal, the Critical Chain Approach looks for the best impact on the organization, taking into account throughput, operating expense and investment as summarized in the NPV. Many organizations have resource managers who are measured by the "efficient" use of their resources. Critical Chain strategy, using other measures, promotes decisions that support what is best for the project or organization as a whole. If it reduces the total project duration significantly (i.e., benefits exceed added costs), this might imply individual resource inefficiency.

6. See TOC Review Magazine, February 2001 Issue

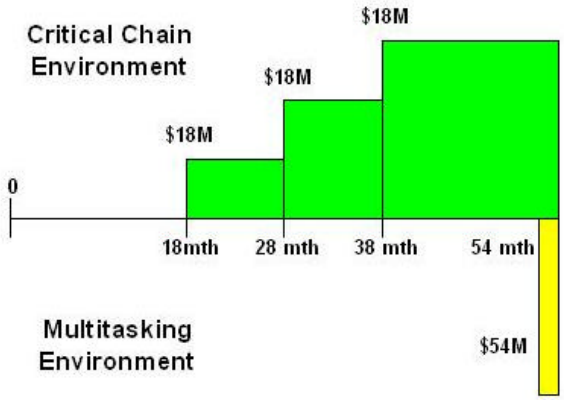

Figure 7 - Cash flow (NPV) from three projects

Resource Planning

- Resource requirement quantities are considered in terms of the three global parameters of the TOC - throughput, investment and operating expense.

- The amount of labor resource in a Critical Chain plan is typically significantly smaller than for a traditional plan to accomplish the same work. This is because the labor consumed with bad multitasking and non-dedicated task times is removed.

Cost Budgeting

- The cost baseline should include some calculated worth of the project and Feeding buffers. These buffers allow for uncertainty in task estimates. Generally, a project's promised delivery date is at the end of the Project buffer. Therefore, the value of these buffers, perhaps computed at some average running rate of the activities the buffer is intended to protect, should be translated to allow a Cost buffer as well. This is equivalent to the traditional project cost reserves.

Cost Control

- The TOC suggests that a systems approach is vital, with respect to cost control and measuring performance to budget. Some cost tradeoffs during a project are good, provided that the impact on the organization's and/or customer's goals is significant. The key is to get project managers to better understand the real cost of a late delivery, to make project cost decisions with those figures in mind, and to keep key decision makers informed so that there are no surprises.

  Some organizations use cost as their number one criteria for decisions. In Critical Chain, throughput is the number one priority, not cost control. It does not mean that costs are ignored. Rather, any costs accrued that do not contribute to throughput are considered a waste.

Project Quality Management

TOC and the Critical Chain Approach are quality improvement oriented strategies. Critical Chain improves the quality of project planning and execution. The project plan becomes increasingly stable as the common, recurring causes of slippage are built into it. Resources are focused on one task, rather than many tasks, reducing the quality problems that are typical of environments full of bad multitasking.

Quality Assurance

Quality Assurance assesses and works to improve the process by which projects are performed. Critical Chain highlights the need to address the project management process at the multi-project level as well as the individual project level. By identifying common causes of project slippage, not only can their results be included in Project buffers and task estimates, but they can be addressed as improvements in the way the organization as a whole addresses projects.

One of the quality tools in the multi-project environment, suggested by Gerald Kendall, is a measurement called Project Dollar Days. By measuring the number of dollars generated by the collection of projects (at Net Present Value) divided by the number of resource days consumed by projects, a productivity ratio is developed. With this measurement, if a project develops a quality problem, two things typically occur. First, there is rework necessary to correct the problem, adding to the number of resource days consumed. Second, the project may be delivered late, reducing the benefit and therefore reducing the (NPV). Therefore, this measurement becomes a natural quality indicator that can be used by the Project Management Office, senior management and project teams.

Quality Control

As defined in the PMBOK® Guide 2000, Quality Control is "the process of monitoring specific project results to determine if they comply with relevant quality standards and identifying ways to eliminate causes of unsatisfactory performance." Critical Chain is focused on the identification and elimination of the causes of performance problems. It promotes the recognition of performance problems that have systemic causes and highlights the need for addressing these above the individual project level. If performance problems cannot be addressed at that level, then Critical Chain recommends being realistic enough to include their impact in project plans.

Project Human Resource Management

"Tell me how you measure me, and I will tell you how I'll behave. If my measurements are unclear, no one can predict how I will behave, not even me". Dr. Eli Goldratt

To achieve major improvement in project delivery times, an essential ingredient is a drastic change in how team members' performances are measured on

projects. A second major change happens at the executive level, to eliminate the constant release of new projects even when key resources are not, available (which encourages bad multitasking as shown below). The third major change is complete Critical Chain education for team members, project and resource managers and executives.

Organizational Planning

- As discussed above, there are some major changes to organizational practices, specifically with regard to executives. Functional executives with budgetary authority often work independently of each other, releasing projects into the system to meet their quarterly or annual targets. When resource conflicts occur, different executives and managers make conflicting demands on resource managers. The resulting compromise in most organizations is multitasking of resources - people working on multiple projects simultaneously. In Critical Chain, this practice is stopped, and the "push" system is replaced by a "pull" system. A new project can only be released into the system when the critical resource - the Drum resource - can be dedicated to the project. The project start date is based upon the availability of the Drum resource.

- Team members are asked to eliminate padding, from their task estimates and are no longer expected to finish their tasks according to a due date. All project resources are taught that it doesn't necessarily matter whether or not a task finishes on time. What is important is that the project finishes on time or early. Resource managers manage project resources to complete their tasks as quickly as possible. There is no such thing as late delivery. However, finishing a task early adds further protection to the project.

  The Relay Runner Work Ethic motivates effective performance to get the project done on time. Instead of insisting that performers finish their tasks on due dates that are often based on wishful thinking, performers are asked to get their tasks done as quickly as possible. This helps to eliminate the student syndrome (waiting for the last minute to get started) and helps to promote shorter cycle times.

Team Development

- To obtain benefits, Critical Chain training is essential for all team members, project managers, resource managers, project office personnel and executives. Team members will not respond to requests to provide estimates that accurately reflect the amount of time it will take assuming dedicated resources, unless they are convinced that management and executives are 100% behind the new measurements.

  As long as people are evaluated based on their ability to hit a due date, they will do their best to create due dates that give them a strong possibility of succeeding. This generally translates into padding. Often organ-

izations reduce the durations proposed by teams, whether padded or not, in order to publish an acceptable completion date or get a competitive bid. When task estimates are required that accurately reflect the dedicated-resource time of the task without adopting the other Critical Chain practices, performer motivation is reduced and their respect for their management is often undermined. Some common thinking goes like this - "Who in their right mind would expect that to get done in so short a time in this environment?"

While Critical Chain is not on the surface a team building approach, it has the effect of improving morale and performance efficiency by highlighting project completion as the common focus of all members of the team, at all levels.

Project Communications Management

In a large organization with many active projects, resource managers must have access to current information about all relevant projects. In this environment, experience has proven that multi-user, multi-project Critical Chain software is an essential ingredient to make communications work properly.

Communications Planning

- Under communications requirements, resource managers must know the status of the Critical Chain plan in order to make correct decisions on the priority of resource assignments. One way to achieve this is through having online access to all projects for the resource managers. Another way is through reporting. Such a system requires various levels of software training for resource managers, project managers and resources (if they will be entering their own progress reports). This must be planned in advance, along with the collaboration of the Information Technology people and relevant software companies.

Information Distribution

- Critical Chain project information must be accessible, and Critical Chain reports must be scheduled for distribution on a timely basis. Decisions must be made on how project information will be updated, and by whom. Also, the right of access to information by various individuals and authority levels must be decided. This will not necessarily be the same for all projects. Resource buffers, which act as alarm clocks to alert resources to be ready to start an activity, must be as an integral part of the communications system. Resource managers must be an integral part of the dynamic project reporting process.

Performance Reporting

- Buffer reporting, including Buffer Penetration reports, are key to managing the Critical Chain project.
- Comparison of percentage of Critical Chain completed to percentage of

Project buffer consumed provides the best estimate of project completion date.

- The rate of consumption of the buffer (either as a percentage or expressed as days consumed per time period) over time, is a good indicator of whether protection of the project is increasing or decreasing.

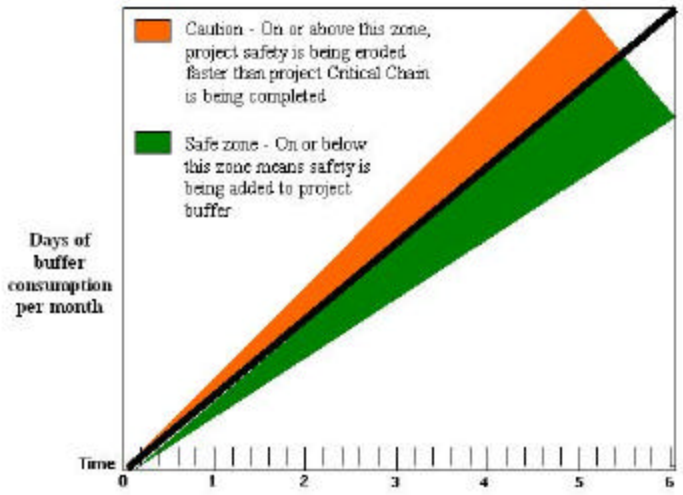

Figure 8 - Buffer penetration (Days per month trend)

Project Risk Management

Critical Chain is not a replacement for project risk management. The two are complementary.

In many project management environments, the risk of finishing projects late is very high. The entire Critical Chain methodology is designed to substantially reduce risk, by minimizing current practices such as managing task execution to due dates, and allowing tasks to be performed in a non-dedicated way. Critical Chain uses pooled protection (buffers) at the right points in a project, and between projects to reduce destabilizing the environment.

In effect, without buffers any significant variation today can change a plan. The presence of buffers will stabilize the plan, acting as a schedule contingency reserve.

Risk management in planning is performed to identify, analyze and respond to project risks. It results in an understanding of how much time should be allocated to the project buffers. What critical chain highlights is the uncertainty found in task estimates, and therefore project estimates that comes from the bad multitasking, non-dedicated resources, etc. Once this is seen, management has the choice of accepting that the project duration is very uncertain and that the project requires a significant schedule contingency reserve or changing the system within which the project is performed. If the system is changed, then the uncertainty may be reduced along with the duration. To the degree that the system is not changed, the buffers for a given project will be larger.

Critical Chain focuses on factors that occur frequently in organizations and

cause significant variation in task performance. In most environments, there is bad multitasking, Student Syndrome and Parkinson's Law. As discussed above, and in the Critical Chain literature, some of these problems, in turn, lead to cost overruns poor quality and the pressure to reduce specifications. In other words, they have a significant impact on the triple constraints of project management.

Critical Chain, through the use of buffer management, contributes to risk monitoring and control during the project's execution. It makes it easier to identify the presence of project problems early in the project's life, and to differentiate between problems based on their impact on the project end date. Buffer management also helps to pinpoint the cause of project problems.

Executives claim that this focus allows managers to put needed attention on exceptions, without having to reschedule the project or go off in many different directions at once.

Project Procurement Management

Critical Chain supports the sometimes controversial notion that procurement "subordinates itself to the project". This means that the cycle time of the project is the principal priority. If the organization has to spend more to get a critical supplier to deliver earlier, and that early delivery is valued higher than the additional procurement cost, then the procurement will be made at the higher cost. Procurement must not be focused on finding the lowest bidder or complying with policies that are in conflict with the project time objective. Meeting project completion time and quality requirements are important criteria for supplier selection.

Procurement Planning

- Make or buy analysis is done, not with traditional cost accounting methods, but with throughput accounting - how much is the improvement in project cycle time worth?
- The impact of reducing the Critical Chain duration is considered when making these decisions on those tasks that can be contracted to outside vendors.

Solicitation

- Vendors are encouraged to submit alternative bids that would show trade-offs among shorter cycle times, cost and risk.

CONCLUSION

Many organizations today must achieve a major breakthrough in project cycle time in order to stay competitive. They must drive more projects through their organization to increase throughput. To make things more difficult, this often must be done without increasing the number of people allocated to projects. Many organizations do not have the option of hiring additional people. In expanding economic conditions, skilled resources are difficult to find. In tough economic times, executives are reluctant to hire, even though the demands for new projects remains.

Critical Chain is an exciting new option that gives organizations the ability to increase the number of projects that can be done by the same number of resources and to reduce the average duration of projects. Critical Chain Approach enables organizations to confront the problems that may exist both on systemic and individual project levels to achieve these benefits.

We choose to see Critical Chain as a logical extension of current project management practices. To focus on the differences may be academically interesting, but it is counterproductive from a practical point of view. While some far-reaching changes in current practices are required to implement Critical Chain successfully, the majority of knowledge imbedded in the PMBOK® Guide remains a valuable treasure chest and an excellent springboard from which to move forward.

Glossary of Critical Chain Terms

bad multitasking - The behavior of people who split their time between multiple project tasks in a way that extends the cycle time of individual projects or multiple projects and often results in poor quality results.

buffer - An amount of time that represents a schedule contingency reserve. Buffers are included at various points in a project task network. They provide the ability to eliminate any padding, from individual task duration estimates and to clearly show the predicted and potential project schedule. They are managed to assess the degree of risk remaining for on-time project completion. Buffer durations are best determined through risk analysis.

common cause variations - Those causes of variation that are intrinsically part of the process, even after risk mitigation actions, and consistent over time. Common cause variation, handled thorough Critical Chain planning and management, can be controlled, and therefore allow the project performance to be predictable. Common causes must be addressed at a systemic level. Ultimately, buffers are established to handle the common cause variation that is accepted for the project.

constraint - In the Theory of Constraints and Critical Chain, a constraint is the most significant leverage point for improving a system. In Critical Chain, the constraint is the cycle time of projects, both individually and the combined cycle time of the entire collection of an organization's projects.

Critical Chain - 1. The longest set of interrelated tasks in the project. It may be identical to the Critical Path or not, as the Critical Chain may include tasks with resource dependencies but without logical dependencies. 2. The overall approach that is a special application of the Theory of Constraints to project management.

Critical Chain plan - The schedule that shows the Critical Chain and all feeding paths, with all buffers inserted to protect the project. The individual task estimates included in the plan reflect only dedicated effort. Usually, the plan is shown in Critical Path format, with the Critical Chain highlighted across the paths.

Critical resource - When considering all of the projects that an organization has in place, this is the resource that most impacts the cycle time of the combination of projects.

cycle time (project) - The length of time from the start of the project until its completion. Project duration.

Drum - The factor or resource used to determine when a new project can be scheduled. Usually, the Drum is the critical resource. However, sometimes the Drum is a policy.

Drum buffer - A period of time ahead of which work being turned over to a Drum resource must be completed. This ensures that the Drum will not be starved for work due to late completion of a preceding task.

Feeding buffer - Feeding Buffers are time periods without scheduled work placed at points where a non-critical chain tasks join the Critical Chain. This buffer protects the Critical Chain from any delays on the tasks feeding it. A Feeding buffer is normally 50% of the total time allocated to the tasks on that feeding chain, though this can vary and is best determined by performing risk analysis on the tasks in the non-critical path.

multi-project environment - An environment that exists in most organizations where more than one project is active at any point in time, and active projects share some common resources.

operating expense - All the money, which an organization spends to turn inventory/investment into throughput.

Parkinson's Law - Work expands to fill the time available. For example, a software engineer who has done the mandatory work for a task before the due date decides to add some "bells and whistles" that are not mandatory.

Project buffer - The Project buffer is a time period with no scheduled work, placed after the final task of a project in order to protect the completion date from delays, especially along the Critical Chain. The Project buffer time is normally 50% of the total time estimates of all the tasks on the Critical Chain, though this can vary and is best determined by performing risk analysis on the tasks. An average cost is applied to the project buffer for budgetary purposes, since the project is expected to consume the buffer as it proceeds to completion.

relay runner work ethic - The relay runner goes as fast as possible to complete her leg of the race and pass the baton to the next runner. In a project, a task is completed as quickly as possible and the work or resource handed off to the successor(s). The relay runner work ethic is a prerequisite to healthy performance in any project environment. If it is in place and rewarded, then punitive management for late task delivery can be eliminated.

Resource buffer - The Resource buffer is intended to alert resources to their approaching responsibility to the Critical Chain. It is like an alarm clock. It DOES NOT lengthen the estimated time of the project.

strategic resource - See Critical Resource.

Strategic Resource buffer - A time period during which the critical resource will have no scheduled work. This insulates each project that uses the strategic resource from impacts of previous projects and ensures that future projects will not be impacted by uncertainty affecting the strategic resource.

student syndrome - A human behavior where a person waits until close to a due date to begin working on a task. Procrastination

Throughput - The rate at which an organization generates money through sales. Usually, this is revenue received from customers minus the cost of raw materials (directly variable cost).