ABSTRACT

Critical Chain Project Management: An Overview

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The purpose of this thesis is to introduce to the reader Critical Chain Project Management, which is the application of the Theory of Constraints (TOC) process to project management. Eli Goldratt describes the process in the book Critical Chain. Applying Critical Chain protocol will improve the projects due date performance and the quality of deliverables, whatever the project or circumstance. To prove these claims this document explores specific case studies of recent implementations of Critical Chain. It then goes back to look at the history of project management and some of the innovations that led to Critical Chain, including an in depth look at Theory of Constraints. It concludes by exploring the TOC approach to causing change in thinking processes and how this would be done for Critical Chain. This document is written to be accessible to any reader regardless of the level of prior exposure to the Theory of Constraints.

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CRITICAL CHAIN PROJECT MANAGEMENT: AN OVERVIEW

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By

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DEDICATION

There are many people to thank that have helped me get to the point of having a completed thesis, something I never thought would never happen. That being said, there are a few people this thesis belongs to beyond just me. I would like to first dedicate my thesis to my Dad for teaching me early on in my life the importance of school and logic. Next, I want to thank my fiancée, Rachel, for always being there with emotional support and helping with one of my many edits. I would also like to thank my Mom for her refusal to let me quit even when it seemed bleak. Last but certainly not least, I would like thank Dr. Elisabeth Umble for being so generous with her time and so flexible working with me for the past year and a half.

CHAPTER ONE

What is Critical Chain?

The purpose of this thesis is to introduce the reader to Critical Chain Project Management, which is the application of the Theory of Constraints (TOC) process to project management. Eliyahu Goldratt describes the Critical Chain process in the book *Critical Chain*. Applying Critical Chain to a project will improve the project's due date performance and quality of deliverables, in most cases. This report is written in such a way as to be accessible to any reader even without prior exposure to the Theory of Constraints.

Problems with Project Management

The Project Management Body of Knowledge defines a project as a "temporary endeavor undertaken to create a unique product, service or result."[1] Professionals in all walks of life are engaged in projects all throughout our lives. Therefore, it would seem that people should intuitively be able to manage projects as professionals without a great deal of effort. However, as any project management professional will tell you, this belief is mistaken. Projects are typically behind schedule, content is compromised, and/or they exceed their budget.[2]

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[1] Project Management Body of Knowledge

[2] "Grey Critical Chain Project Scheduling Technique And Its Application." Page 36 Column 2

There are certain aspects of the human behavior that project managers must face. These are described by Goldratt in his business novel *Critical Chain*, and one of these is time—the massive amounts of safety time a person will allow himself if given the opportunity. Why one adds so much safety time is the combination of many different factors. People in charge of tasks typically add extra time because of Murphy's Law. Parkinson's Law and the Student Syndrome are also factors. Finally, project managers add to the problem by requiring their employees to multitask. The result of this is huge amounts of safety time included in individual task times. This extends the overall duration of the project.

Murphy's Law, Parkinson's Law and the Student Syndrome

Murphy's Law states, "Everything that can go wrong will go wrong and at the worst possible moment." Many people live their lives in constant fear of this rule. A lesser-known but equally important rule for projects is Parkinson's Law: "Work expands so as to fill the time available for its completion."[3] For project management, these are two of the most relevant behavioral laws, and Critical Chain presents a perfect way to counteract both of them.

Murphy's Law becomes harder to deal with because of another quirk of human nature-- the Student Syndrome. The Student Syndrome can be seen in the practices of generations of students for which it was named. It is another name for procrastination. For most students, work on a school project will not begin until it absolutely has to. Goldratt reasons that the Student Syndrome is typically responsible for a phenomenon often seen in projects: executing one-third of the work for a project requires the first two-

[3] *The Economist* by Cyril Northcote Parkinson

thirds of the available time, and the final two-thirds of the work requires the last one-third of available time.[4] This causes project managers to add extra safety time on top of the already padded estimate of the time required.

Parkinson's Law is another obstacle for project managers to overcome. For example, a manager gives a worker a task. If the manager allows an hour for the task, how long will it take? According to Parkinson's Law, the task will take an hour even if in reality it should only take forty minutes. Why is this? For the worker, there is no incentive to finish early. If the work finishes early, the most likely occurrence is that he or she is given more work, and if the task given is a recurring one, the employee would be expected to complete it the next time as quickly as he or she did before. In practice, management actually punishes workers for excellent performance, when it should be rewarding them. Furthermore, the next worker is unlikely to be available to start if the task is handed over to early. They are probably doing something else. For a project manager, the difficulty is to get workers to give them reliable due-dates and notification if they finish their task early.

This is where Critical Chain comes in to save the day. In *Critical Chain*, Goldratt allows tasks only fifty percent of the estimated time allotted to them. [5] Where did Goldratt derive this number? To find an estimate for the completion date of an activity in a project, project managers will often ask workers when they think they will be able to

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4 McFarland, Allison J. "Avoiding Project Management Pitfalls." Journal of Park & Recreation Administration 20.1 (2002): 116-129. Academic Search Complete. EBSCO. Web. 22 Oct. 2011.

5 Goldratt, E. 1997. "Critical Chain," The North River, Great Barrington, Mas.

complete the activity. However, as previously illustrated, the worker has no incentive to give an aggressive estimate because that only raises expectations. With all the distractions and multitasking a worker faces, it is no wonder that the worker will end up giving a time estimate with plenty of safety time. Figure 1 shows that, rather than give an estimate that only allows a 50 percent chance of finishing work on time, workers will typically offer a "safe" estimate so that they are 85 to 95 percent confident that they can finish – even though this gives an estimate that is at the outer edge of the actual time necessary to complete the task. The task will not be completed early or even on time because Parkinson's Law and the Students' Syndrome mean that all the safety time will be wasted, and then it only takes one unforeseen problem to put the task behind schedule. The task will eventually be completed barely on time or late, have reduced features, and/or will be over budget.

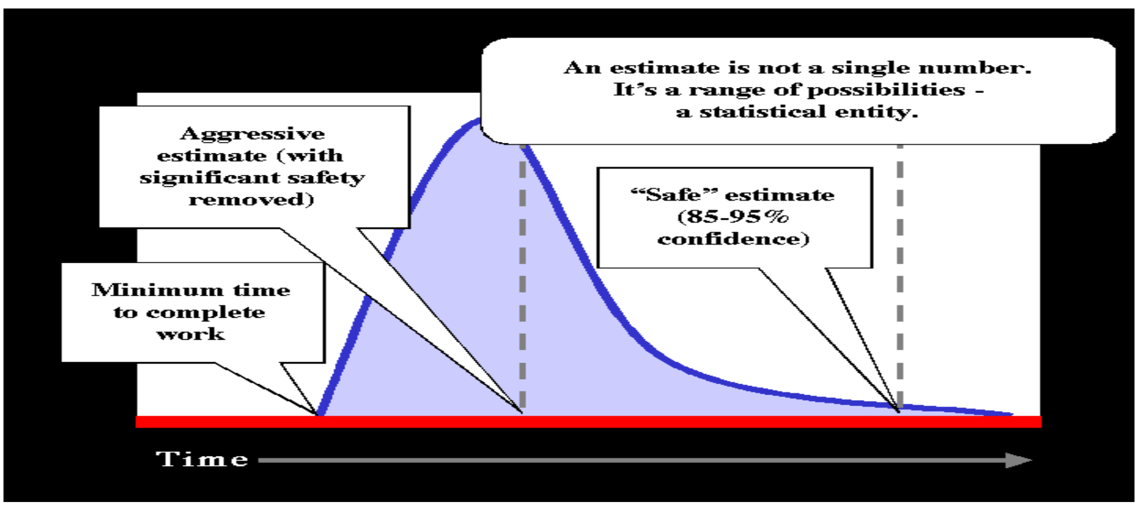

Figure 1[6]

[6] Patrick, Francis S. "Critical Chain Project Management: Getting Out From Between Parkinson's Rock and Murphy's Hard Place."

Multitasking

Multitasking is something we all do in our daily lives, and it does not seem to have much of a negative impact. The question is, how does multitasking hurt projects? Multitasking hurts projects lengthening lead times for project tasks and wastes time with unnecessary set-up time in between tasks.

Consider the example given in *Critical Chain* of an employee with three tasks to complete.[7] Each task takes 10 days to complete and is a preceding event to other tasks in projects. No matter how the employee orders all of the tasks, they will be finished by day 30. But, not wanting to upset anyone, the employee decides that the most logical step is to spend 5 days on each task in order to finish. This multitasking will cause the first activity to be completed on day 20 instead of day 10. The second activity will take 5 more days than it would without multitasking, and the third task will be completed on time. However, the task time or processing for each activity has doubled from 10 days to 20 days and this causes problems other than just a late finish time for the first two activities. Long lead-time also means that materials and workers on tasks now must be available earlier than expected because of the multitasking. For example, activity three may have had a preceding task that required workers or materials from other projects that should not have been needed until day 20, but because the project was being multitasked the resources were needed on day 10. Tying up the resources with long lead-times costs the company money because the resources are now unable to be put to work on other projects during this time.

[7] Goldratt, *Critical Chain*

The example above does not include information about set-up times for the tasks. When there is set-up time involved, this would mean that multitasking not only extends the lead-time of the activities, but also extends the completion time of all the activities by the amount of extra set-ups that must be done for each task. For example, if multitasking caused a worker to set-up twice for each activity, this would extend the project by simply doubling the set-up time required to complete each task.

Critical Chain Solution

The Critical Chain is defined by Goldratt as “the longest chain [not path] of dependent tasks. In this case, ‘dependent’ refers to resources and resource contention across tasks/projects as well as the sequence and logical dependencies of the tasks themselves.”[8] The project-management issues discussed above can be solved using Critical Chain. The first step is planning out one’s project. The crucial step in planning is identifying the Critical Chain, because this involves application of the Theory of Constraints method. In Theory of Constraints, first you must find the limitation of the system, called the constraint. In projects, the Critical Chain is the constraint. Next, you must determine task duration. As previously discussed, Goldratt simply divided the initial estimate in half. Finally, safety time should be added to the project as a whole and not to each individual task. That safety time should be used to create buffers.

The three types of buffers in Critical Chain are the Project Buffer, Feeding Buffers and Resource Buffers. The Project Buffer is the amount of time between the expected end of the last task in the project and project due date. Before Critical Chain, the entire amount of safety time was distributed among individual tasks. The Project Buffer

[8] Goldratt UK, Critical Chain

in Critical Chain is initially all the safety time that was stripped out of the individual tasks. Feeding Buffers are inserted between the ends of non-Critical Paths and the Critical Chain to provide safety for the Critical Chain, ensuring that delays on tasks outside the Critical Chain do not cause delay on the Critical Chain which would lengthen the whole project. Resource Buffers ensure that workers and materials are available to the Critical Chain when needed.

Executing and Reviewing the Plan

The next step according to Goldratt, is to begin by executing a plan that includes two significant components.[9] The first component is to define the priorities for every resource. Each resource in the project will be prioritized according to its relation to the Critical Chain. The priority order is the Critical Chain, feeding buffers, resource buffers, and then the rest of the tasks. The second component is that all tasks should be finished completely before workers move on to the next task. This helps remove the temptation to multitask to try to finish tasks quicker, when it actually slows down tasks.

The last step in Critical Chain is monitoring the plan as the project is advancing.[10] The two areas of concern that a project manager must monitor during the project are the buffers and the remaining duration of tasks. Buffer management is the management of the three buffers discussed above: resource buffers, feeding buffers, and project buffers. Buffer management is about ensuring the integrity of those buffers, and it is imperative because if the buffers fail, the Critical Chain will lengthen and that will extend the duration of the entire project. The Critical Chain extending beyond the project buffer will

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[9] Goldratt UK, Critical Chain

[10] Goldratt UK, Critical Chain

cause the project to either run over budget trying to fix the problem, compromise the scope of the project to remove or shorten certain tasks, or just be finished late. Remaining duration is important because tasks should be monitored by the remaining duration instead of the percentage complete. Percentage complete is a poor estimate because assumes equal time is required to complete all parts of a task. For example, a task may be 80 percent complete, but the last 20 percent of the work will take almost as long as the first 80 percent. If the project manager can only see percentage of the task complete, he or she will have a hard time recognizing problem areas. But, if the project manager can determine the remaining duration, he or she can easily recognize if there is a problem and be able to take action to resolve the issues causing the task to be slowed down.

CHAPTER TWO

Examples of Critical Chain Project Management

Chapter Two will provide examples of the application of Critical Chain Project Management. Specifically, it will consider examples from implementations by the U.S. Air Force and the U.S. Coast Guard. For each example given, I will examine the implementation and results of using Critical Chain Project Management.

The US Air Force

William Best discusses the implementation of Critical Chain at Warner Robins Air Logistics Center.[11] Warner Robins, located in southern Georgia, is a maintenance and repair facility for the United States Air Force. In 2004, the Air Force completed a major revision of their maintenance and repair procedures thanks to a lean initiative, which had "significantly reduced the number of days required for the repair and overhaul of the C-5 Galaxy aircraft from nearly 360 days in late 2000 to about 240 days"[12] by 2004. In lean initiative, a company works eliminate waste in its processes. Even with the elimination of wasteful activities, the large reduction in lead-time was not satisfactory. The Air Force still had ten percent of the total C-5 Galaxy aircrafts fleet on the ground at Warner Robbins. Getting those C-5s up and flying was crucial to our war effort in Iraq.

The lean techniques had produced many major improvements on their own but they also revealed more problems in the system. The first complication involved resource

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11 Best, William D. Critical Chain Project Management Flies

12 Best, William D. Critical Chain Project Management Flies

constraints. Resource constraints occur when two or more tasks require the same worker or material (a resource) at the same time. According to Best, when resources become scarce, the first priority for resources would go to the planes closest to completion even if those planes were ahead of schedule. Working on planes already ahead of schedule would put planes that also needed the resource behind schedule. The problem led to many delays because planes were now either behind or ahead of schedule, and as the delays grew, the Air Force began to work on projects on a firefighting basis, jumping from one project that was behind schedule to another. The second complication was that tasks were allowed enormous safety time buffers because of the uncertainty caused by not following a plan for the projects, and this caused Parkinson's Law to take effect. For example, mechanics were given 22 days to finish a project, and they would always take the full 22 days even if they did not need 22 days because they were only given a plane every 22 days.

To further reduce flow-through days—the time the planes sat on the ground the Air Logistics Center decided to adopt Critical Chain Project Management. Flow-through days are the number of days required to complete repairs and maintenance on a plane. The Air Logistics Center was determined to meet a target of 160 flow-through days. This led to numerous challenges. One challenge was to lower work-in-process inventory without incurring additional cost from overtime or additional personnel. Another complication was changing the traditions and attitudes of the employees who were used to doing things the old way. They needed to shift from an aircraft-level priority to a task level priority and overcome a due date driven mentality.

The Air Logistics Center needed to re-educate their employees to focus on the task at hand and to complete one task at a time so that their planes could be finished faster. This was toughest when planes were almost completed and ready to be flight tested, but task priorities required work to be done on airplanes at the beginning stages of repair. In that situation logic might seem to dictate that you should finish a plane, but doing so would require engineers to work on multiple projects and cause delays for other airplanes. Therefore, the temptation to finish nearly completed planes had to be resisted as it actually undermined the optimal strategy.

Using Critical Chain Project Management, the Air Logistics Center was able to lower its work-in-process inventory from 12.5 planes to 7.5 planes and flow-through days from 240 days to 160 days. This increase in efficiency led to an additional $49.8 million available to the Transportation Working Capital Fund and savings of $2.37 billion based on the replacement value of the aircraft. Along with the reduction of work-in-process, Critical Chain Project Management also re-energized the lean efforts of the Air Logistics Center and helped identify inefficiencies in the system. For example, management recognized the paint barn (the building responsible for painting all the planes) as a constraint during the process of implementing Critical Chain. To resolve this problem, the Logistics Center upgraded the Paint Barn and developed a schedule so that the building was always working. Those changes meant that the Paint Barn could now paint C-5's in less than half the time of the benchmark commercial facility, and C-5's are much bigger than the commercial planes.[13]

[13] Best, William D. Critical Chain Project Management Flies

The U.S. Coast Guard

Commander Marty Oard, Executive Officer US Coast Guard, provides another example of a successful implementation of Critical Chain Project Management. The "Yard" as Oard calls it, is a textbook example of an organization in need of Critical Chain Project Management.

"The Yard" is a project-based organization that, in the past, had some exposure to Theory of Constraints. This made the transition to Critical Chain Project Management easier. The organization also had all the negative human elements of project management that one might expect, such as the Student Syndrome, Parkinson's Law, and large amounts of safety in task time. Oard states it "is important to understand that this is not done consciously, but sub-consciously. In other words, they are sub-consciously ensuring that they are on time the majority of the time."[14]

Oard describes the implementation of Critical Chain Project Management at the Yard in ten steps. These steps can be divided into two sections: the plan and its implementation.

Management's first decision was to begin planning for the Yard using backwards scheduling from the last task to the first task. Management decided to use backward scheduling because backward scheduling allows managers to choose the latest possible start time. This was difficult initially because they were not familiar with backward scheduling, but it was a necessary shift in focus to preparations with the end goal in mind. Backward scheduling may seem counterintuitive, but scheduling for the latest possible

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[14] Implementation of Critical Chain Project Management at the Page 2

start will guard against wasting time because workers only have enough time to finish their task. It also saves money by not using resources before they are needed. The second step is determining task duration. At the Yard, the Coast Guard accomplished this by cutting task duration estimates in half (just as Goldratt suggests), achieving a fifty percent chance of task completion within the time allowed. The third step is resolving resource conflicts in the project. To achieve this, they level the resources. Leveling or resource leveling, is the process of increasing the length of the project by the amount of time needed to resolve resource conflicts. As Oard explains, "If two developers are needed during a 2 week period, but only one is available, then the length of time necessary to complete four week[s] worth of work will be four weeks, not two weeks unless an additional developer is hired."[15] The fifth step is to identify the Critical Chain. This must be done after the task and resource relationships have been clarified. As previously stated, the Critical Chain is simply the longest chain of dependent events

Implementing Critical Chain Project Management is not simple and requires change in the culture of the organization; however the benefits can be tremendous. Oard explains that once, the Yard implemented Critical Chain, it "could accomplish more work within a given period of time," freeing up cutter days (cutter days are the work days available for highly valued ship cutters), and led to higher employee morale and more effective and organized work. And, since senior operational and maintenance managers had a higher level of confidence in Yard project management, it also led to better decisions.

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15 Implementation of Critical Chain Project Management at the Yard Page 4

CHAPTER THREE

The History of Project Management

Chapter Three will focus on the history of innovations in project management and reflect on how each development added on to the other to help create the basis for Critical Chain. The four major innovations discussed in this chapter are: Critical Path Method, Program Evaluation Review Technique, and the Theory of Constraints. Each one made an advancement in either project management or management theory that created the environment in which Critical Chain could be developed and implemented. In the process of discussing what each innovation has added to project management, chapter three will also discuss how each prior development is lacking some quality that Critical Chain provides.

Critical Path Method-History

In his article, "A Brief History of Scheduling," Patrick Weaver details the history of the Critical Path Method (CPM) of Project Management. It was developed in the late 1950's when E.I. du Pont de Numours (Du Pont) started looking for "useful things to do with its UNIVAC1" (Du Pont's newest computer system) "Du Pont's Management felt that 'planning, estimating and scheduling seemed like a good use of the computer."[16] The job of programming the computer went to Morgan Walker, who with the assistance of James E. Kelley and others, developed CPM.

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[16] A Brief History of Scheduling - Back to the Future - page 6

The main problem CPM was trying to solve was the time-cost conundrum. The conundrum was the high cost associated with making up for lost time on a project. However, Walker and Kelley noticed that adding workers just to certain tasks would lead to great results with low costs.

In 1959, a group led by John Mauchly and Jim Kelley had to save CPM from being scrapped because Du Pont, who paid for its development, saw little future in it, even though it had just saved Du Pont "25 percent on shutdowns."[17] To commercialize CPM, they focused on CPM's applications to scheduling rather than the cost component, and simplified the process required to make a schedule. The first company to buy into CPM was Catalytic Construction of Philadelphia in 1961.[18]

Critical Path Management-Process

Critical Path Management, according to the Project Management Body of Knowledge, "calculates a single, deterministic early and late start and finish date for each activity based on specified, sequential network logic and a single duration estimate."[19] The critical path of a project is the longest through the project and has the least amount of slack.

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17 A Brief History of Scheduling - Back to the Future - page 7

18 A Brief History of Scheduling - Back to the Future - page 7

19 A Guide to the Project Management Body of Knowledge page 67

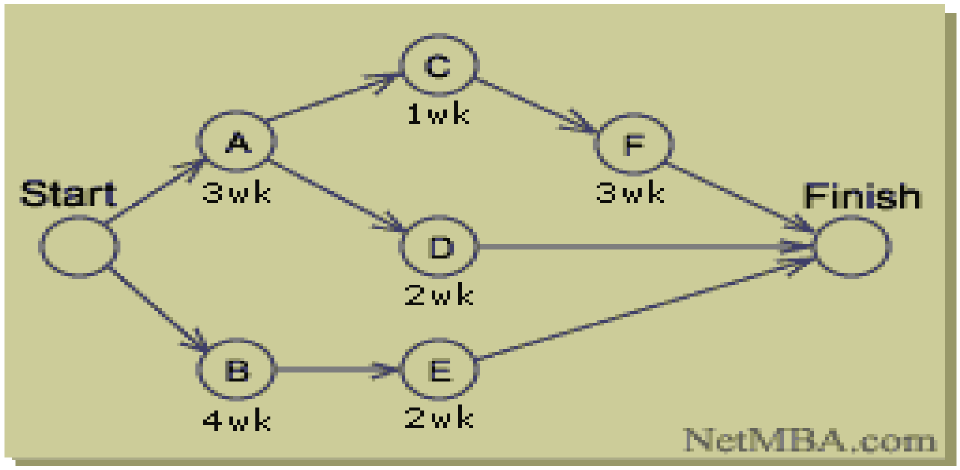

Figure 2[20]

To calculate the critical path of a project similar to the one in Figure Two simply sum up the total duration of the tasks in each path through the network and find the longest network path. For example, if you add up the durations of tasks A, C, and F (shown underneath the nodes above) you get a duration of 7 weeks. For path A and D the duration is 5 weeks and for path B and E it is 6 weeks. Since path A, C, and F has the longest path duration of 7 weeks it is considered the critical path because it determines the length of the entire project. CPM can also be used to make schedule trade-offs through the determination of slack. By determining the earliest and latest start and finish date of each activity, one can calculate the total slack of each task in the project. Slack is defined by Schwalbe as "the total amount of time an activity may be delayed without delaying a succeeding activity or the project finish date."[21]

In addition, we can determine path slack. For example, the slacks of the ACF path in Figure 2 above is zero because it is the critical path and cannot be delayed without

20 http://www.netmba.com/operations/project/cpm/

21 Schwalbe Chapter 6

delaying the project. The slack for A-D is two weeks because it can be delayed two weeks if necessary without delaying the project, and the slack for B-E is one week because it can be delayed one week. This slack could become invaluable if the project had activities that required the same resources.

Critical Path Method- Critical Chain

The Critical Path Method was influential in the early part of modern project management history. It shows project managers where to focus their control efforts on the critical path. CPM also allows project managers to effectively speed up their projects by showing them where added resources would be the most effective—on the Critical Path.

Critical path assumes that the paths through the network are independent and ignores potential resource conflicts, i.e., a single resource cannot be responsible for activities on more than one path. On the other hand, Critical Chain is a method that considers potential resource conflicts and takes them into consideration when scheduling a project resulting in much more realistic schedule.

PERT- History

Program Evaluation and Review Technique (PERT) was a development of the U.S. Navy Special Projects Office in the late 1950s. During the mid-1950s, the Navy was involved in the Polaris Missile Project. The Polaris program took place during the early stages of the Cold War and was designed to allow the U.S. to strike anywhere in the world using submarines with nuclear missiles.

PERT was developed over the course of a few months from January to July 1957. The team was led by Wil Fazar who “quickly described the features of a system including ‘a precise knowledge of the sequencing of activities’ and ‘a careful time estimate for each activity, ideally with a probability estimate of the times the activity might require’.”[22] The biggest proponent of PERT was the leader of the Polaris Program, Admiral Raborn. Strangely, although PERT was designed by the Navy, it was never widely used on the Polaris Missile Project, but Raborn advertised the use of PERT and used it “to ‘manage his external environment’” during the project.[23]

One of the lasting impacts of PERT was its introduction of the term Critical Chain. The longest path in CPM was originally called the Main Chain. The core difference in the development of CPM and PERT was the focus on cost. Du Pont Project timelines were generally known and predictable from years of experience in the field. The known tasks times made cost savings the main focus of CPM originally. The Navy’s Polaris program was brand new technology and was also considered such a high priority that cost was barely a factor. The main concern for PERT was “determining the probability of an event happening by some future date.”[24]

PERT- Process

The Program Evaluation and Review Technique is defined by the Project Management Body of Knowledge as using a “sequential network logic and a weighted average duration estimate to calculate project duration.”[25] PERT uses probabilistic time

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22 A Brief History of Scheduling - Back to the Future – page 5

23 A Brief History of Scheduling - Back to the Future – page 6

24 A Brief History of Scheduling - Back to the Future – page 8

25 A Guide to the Project Management Body of Knowledge page 67

estimates to attempt to find the best approximation to a realistic project completion date. Probabilistic time estimates means that for a task an optimistic time, most likely time and pessimistic time are all estimated instead of just the most likely time. The probabilistic time estimates for each task are then entered into the PERT weighted average formula:

$$\text{PERT weighted average}^{26} = \frac{\text{Optimistic} + 4(\text{Most Likely}) + \text{Pessimistic}}{6}$$

The PERT weighted average formula gives the project manager more a more realistic time estimate to use for planning. For example, suppose a project manager has a project with an optimistic time of 18 days, a most likely time of 24 days, and a pessimistic time of 36 days. Using the PERT weighted average formula gives the project manager:

$$\text{PERT weighted average} = \frac{18 + 4(24) + 36}{6} = 25$$

This one extra day longer than the CPM estimate which would have been the most likely time, 24 days.

PERT Versus Critical Chain

PERT was an early effort to reduce the uncertainty inherent in estimating the completion time of tasks. The effort to reduce risk is also a key component in Critical Chain, but Critical Chain would say the extra effort required by PERT is unnecessary.

[26] Schwalbe Chapter 6

Instead of using a formula to reduce risk, Critical Chain uses safety time at the end of the Critical Chain to account for risk in the project system as a whole rather than at the individual task level seen in PERT. This means that in Critical Chain, only the most likely time is necessary.

Theory of Constraints

Theory of Constraints (TOC) is a management philosophy that was developed by Dr. Eliyahu Goldratt in the 1980s and 1990s. He presented the TOC management thinking process in a series of novels. The first novel, *The Goal*, was published in 1984 and has since been revised multiple times. The third novel, *Critical Chain*, was published in 1997 and introduced the TOC thinking process to Project Management.

At its most basic level TOC answers three questions for managers:[27]

• What to change?

• What to change to?

• How to cause the change?

Any process, according to Goldratt, is like a chain in that it is only as strong as its weakest link. Theory of Constraints defines the weakest link in the system as the system's constraint. Since a system's performance is defined by its constraint, the main purpose of TOC is to find the constraint and to improve system performance.

The five focusing steps are:

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[27] Goldratt's "Theory of Constraints" Thinking Processes:A Systems Methodology linking Soft with Hard

1. Identify the constraint: What is holding back the process?
2. Exploit the Constraint: How do we get the best use out of the constraint?
3. Subordinate other activities to the constraint: Is everything else organized to help the constraint?
4. Elevate the constraint: Invest in the constraint to increase its output.
5. If anything has changed, go back to step 1: Prevent inertia from becoming a constraint.

Prior to the five focusing steps Goldratt added two more steps to help managers identify the constraint. The extra steps are first to define the system's goal, and second is to determine proper, global, and simple measures of performance.[28]

In *The Goal*, Goldratt uses the example of a manufacturing company to describe the TOC process .[29] At the beginning of the book, Goldratt describes a troubled plant that has too much inventory and yet also cannot get any orders out on time. To help him resolve the problems, the plant manager, Alex Rogo, turns to an old acquaintance, Jonah, to help him learn to how attack his plant's problems. Jonah walks Alex through the steps of TOC. First, define the goal of the firm. The firm is there to make money, Alex eventually realizes. Then Jonah gives Alex the simple, proper, global measurements for his firm, the most crucial of which is throughput. Throughput represents the rate at which the system is actually producing sales. It measures whether the system is producing anything that is being bought or is just producing things to store as inventory.

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[28] Goldratt's "Theory of Constraints" Thinking Processes:A Systems Methodology linking Soft with Hard

[29] Goldratt, *The Goal*

Jonah then walks Alex through the five focusing steps. Initially, Alex identified the constraint by going through the plant records and talking to foremen. He discovered the plant's furnace was the constraint. It was not capable of keeping up with the demand of the plant currently and therefore constrained the plant's workload. Once Alex identified the constraint, he then proceeded to step two and prioritized the processing of products through the machine, choosing those products that produced the highest rate of throughput as the highest priority products. Alex then followed step three by making sure to organize the schedule for production so that the furnace would always have items to work on. When that still was not enough capacity, according to step four Alex outsourced some of the furnace work to an outside company, which had extra capacity.

After resolving the initial constraint, the plant had plenty of capacity. Sales then became the constraint for the company, and Alex had to go through the steps again. He identified sales as his constraint; he reworked all the preexisting orders to fulfill them sooner than originally planned. He then put the whole company's effort toward sales. He found a major outside order from a French company that was willing to purchase to large quantities. But, they wanted the items in an undeliverable time frame for Alex. Alex kept digging and found they could only use small batches at a time and would prefer just-in-time deliveries of the goods in small batches rather than one giant batch. The large order was also enough to significantly boost his plant's financials. In fact, they boosted his financials enough that at the end of the book he is offered a promotion.

Critical Chain is not the epitome of project management because it replaces everything that came before, but because it has built on the other approaches to project management. CPM introduced the idea of focusing attention on the single longest series of dependent steps. PERT has had a few long lasting impacts, the first being the introduction of the term Critical Path. Second, the focus on time estimates for individual tasks that are weighted by the likelihood of completion is something also seen in Critical Chain. Critical Chain may just be an application of Theory of Constraints, but TOC and the idea of constraints needed to be developed before the inception of Critical Chain. In the end, each of these innovations added something to Critical Chain and holds an important place in Project Management history.

CHAPTER FOUR

Introduction-Convincing someone to do Critical Chain

The Theory of Constraints and its application to project management (Critical Chain) has a well-documented history of success if correctly implemented. Successful implementation of TOC or Critical Chain does not just rely on a full understanding of the TOC procedure. Implementation also necessitates a thorough understanding of how to change the minds of others regarding previously held beliefs. The Theory of Constraints defined the resistance to change people feel as the seven layers of resistance and developed the logical thinking tools to overcome those layers of resistance.[30]

Seven Layers of Resistance

The first layer of resistance to change occurs when there is no acknowledgement of the problem itself. If the problem is never recognized, then the change agent will never be able to convince anyone to change anything. In project management, identifying the problems is easy because they are universal – projects are behind schedule, over budget and content is compromised. Because all projects have generally similar problems it is easily accepted that there is a problem for the change agent to address. Thus, if the problem is stated properly everyone will agree that there is a problem to be overcome.

The second layer of resistance to change is a lack of understanding the problems. For example, you must convince project managers that the way he or she is estimating project task times is incorrect. Getting task time estimates is a process that project

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[30] Iowa State University Layers of Resistance

managers think they get right. The problem is just that “bad things happen” or the task durations are too difficult to estimate. The change agent can combat this by using the Theory of Constraints thinking process. Current reality trees and evaporating clouds allow a change agent to clearly explain the process to clients.

A current reality tree (CRT) is defined by William Dettmer as: “a logical structure designed to depict the state of reality as it currently exists in a given system. It reflects the most probable chain of cause and effect, given a specific, fixed set of circumstances.”[31] Basically, a current reality tree defines a problem or situation as it is right now down to one or two critical root causes using cause and effect logic. Cause and effect logic, when presented correctly, easily convinces most people that the tree is correct. An evaporating cloud (EVC) is defined by Dettmer as: “a necessary condition structure designed to identify and display the important elements of a conflict situation and open people’s minds to ways to resolve it.”[32] An EVC is used to convince people that there is more than one way to overcome an issue and that most of the time, what is preventing two parties from solving an issue is faulty assumptions. The EVC allows parties to think outside the box by forcing them to confront their assumptions.

The third layer of resistance to change occurs when the party in need of change does not agree with the direction of the solution the change agent recommends. The problem here is convincing the party in need of change that the solution the change agent advises is better than the alternatives. For project management, this means convincing workers on individual tasks that they do not need more time or resources to complete

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[31] Dettmer Chapter Four

[32] Dettmer Chapter Five

tasks on time. This is difficult, because even after the party is shown the current reality tree, the answer is so easily understood that they actually believe that they knew it all along. The answer to the third layer of resistance is in the ability of the evaporating cloud to break conflicts and to show the party that change agent is only trying to help.

Layer four of resistance to change occurs when the party in need of change challenges whether the suggested changes will actually accomplish their goal. For instance, Critical Chain claims to be able to deliver projects on time, on budget, and with the specified scope on a consistent basis. To someone who has been working in project management for a while, Critical Chain's claims would seem almost impossible to achieve. To combat this assertion, TOC thinking processes have the future reality tree (FRT). Dettmer defines a future reality tree as "a sufficiency-type logic structure designed to predict how changes to the status quo would affect reality—specifically to produce desired effects (DE)."[33] In plainer terms, a FRT tree is designed to show the causes and effects of implementing a change in a system. It allows the change agent to logically explain how the changes will create gains for the party's specific environment. This allows the party to see that the change will be effective for him or her specifically and will not be effective only in a previous situation-dependent case for someone else.

After the change agent has convinced the party there is a problem and that there is a viable solution, it will not be long before someone comes up with a situation where the solution will cause a negative effect. The fifth layer of resistance to change happens when the change is challenged because of a negative side effect. For example, one unintended consequence of Critical Chain might be that some people may lose their jobs because

[33] Dettmer Chapter Six

they will no longer be needed. Theory of Constraints handles the problem of unintended consequences with negative branch trees. Negative branch trees are branches of the future reality tree from layer four. Negative branches are utilized anywhere one sees an unintended consequence that needs to be avoided. In the example above, a negative branch tree's solution might be to add more work instead of eliminating employees when the efficiency of work increases. Negative branches save time and make it easier to convince someone because the change agent has already anticipated the unintended consequences and provided a solution for each situation.

The sixth layer of resistance to change occurs when the change agent is told that there are some significant obstacles to the implementation of the change. The fifth and sixth layers of resistance are very similar, but it is important to understand that the difference between the two is that the fifth layer is about negative consequences that will happen with change, whereas the sixth layer of resistance is about why the change cannot be implemented *at all*. An example of this kind of resistance occurs when the party in need of change says that the change cannot be implemented because the organization does not have enough people. The Theory of Constraints thinking process overcomes this layer of resistance with the prerequisite tree. Dettmer defines a perquisite tree as "a logical structure designed to identify all obstacles and the responses needed to overcome them in realizing an objective, usually an injection from a Future Reality Tree. It identifies minimum necessary conditions without which the objective cannot be achieved."[34] The prerequisite tree allows the change agent to logically explain how the plan for implementing the change in the system works. In the example above where the

[34] Dettmer Chapter Seven

issue is lack of employees, this would simply mean that the organization should hire more employees or consider outsourcing or overtime.

The seventh and final layer of resistance to change requires digging up all the fears that went unsaid from the parties in the previous levels. However, there is no TOC thinking process designed specifically to address these concerns. The seventh layer is like the fifth step in the 5 focusing steps because it really says go back to start. The previous six steps define ways to overcome the concerns of the parties involved. If their concerns were not met, it was because they were never spoken so that they could be addressed.

How does the Logical Thinking Process relate back to Critical Chain?

For a Critical Chain project, the biggest determinate of success or failure will be whether the group undertaking the project actually bought into the process of Critical Chain. This is because, while Critical Chain is simple enough to understand and seems very logical, it can often go against societal norms—for example, society considers being a good at multitasking a very desirable characteristic. It can also appear too harsh when a person's or team's safety time for a task is taken away. After all, the persons or teams can legitimately say "we always had barely enough time to finish before. How are we supposed to finish with half that time?" Of course, Critical Chain teaches us that they do have enough time. It is just a matter of using that time correctly. To fully capitalize on their time, employees need to be focused on the task at hand and not on their resistance toward management for implementing "another stupid program." This is where the logical thinking process comes in.

The logical thinking process is another application of Theory of Constraints, just like Critical Chain. The purpose of the logical thinking process is to give users of Theory of Constraints practices, such as Critical Chain, a formalized process to institute the practice. Using the structure of TOC also proves the utility of TOC to more than just manufacturing and service operations. The logical thinking process convinces employees, through their own logic, of the validity of an idea and even allows and encourages them to voice all of their concerns. This provides an employee an opportunity to come to terms with Critical Chain on their own using logic and without it being forced on to him or her.

Conclusion

In conclusion, the future for project management is not in the development of a process that works for completing projects on time, on scope, and on budget. Critical Chain has a proven ability do all that for most projects. Instead the focus will be on understanding human psychology and how to convince your employees to support Critical Chain logic. Successful project managers will be defined by whether or not they understand the seven layer of resistance; instead of how well they estimate project task times. Critical Chain has changed everything.

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