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CRITICAL CHAIN PROJECT MANAGEMENT: A CASE STUDY IN SOFTWARE INDUSTRY

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Abstract - Critical Chain Project Management (CCPM) has been a controversial topic with extreme opinions on its merits. This is in turn partly due to dominance of theoretical debates in CCPM literature as opposed to empirical evidence and cases studies. This paper presents the findings of a case study research in software industry. Multiple semi-structured interviews and project documents were used. The paper provides insight into pre-requisites and practicalities of CCPM application such as accommodating iterative loops and reciprocal dependencies. The findings also provide some perspectives into current debates in CCPM literature concerning uncertainty, buffer sizing and dealing with large projects.

Index Terms - CCPM, Critical Chain Project Management, Case study, Software Projects

I. INTRODUCTION

The development of software makes a significant contribution to the world economy. In the year 2013, the software industry contributed $407.3 billion to the world economy [1]. Projects in this growing industry are often costly and complex. Software projects also have a high failure rate [2]. Importance, cost, complexity and high failure rates in software development necessitate better understanding of project failure and how it can be resolved. Goldratt [3] claimed that the core cause of project failure in most projects is “failure to manage uncertainty”. Thus he proposed CCPM as a systemic and systematic approach to overcome uncertainty. However, CCPM has been a controversial topic. On the one hand, it has made dramatic improvement in many projects [5] and has been endorsed by many scholars [6]. On the other hand, it has been criticised for over simplification [7] and for not being applicable to all projects [8]-[9]. Perhaps domination of theoretical debates in CCPM literature is one reason for extreme opinions on its merits. While criticisms about limitations of CCPM appear theoretically rational, examples of its successful application suggest otherwise. It seems theoretical debates overlook how concepts are adapted in actual projects. In order to explain how CCPM is actually used in practice in a variety of contexts and how some of the barriers discussed in the literature are confronted in real projects, more case studies are required. Case studies provide rich description that can highlight the relevance of current debates to practice. However, a recent literature analysis study [11] indicate that despite the need for more case studies on CCPM applications, case reporting papers still constitute a small segment (13%) of the total publications on CCPM. This paper presents a case study based on actual CCPM implementation in the software industry. The following sections first present some of the current debates on CCPM merits and applicability in the literature. The paper then briefly presents the methodology used in this research and the case description and analysis before moving to discussion and conclusions.

II. LITERATURE REVIEW

The first Critical Chain scholarly publication identified here is a PhD dissertation by Pittman [10]. Since then there has been increasing interest in Critical Chain and over 600 journal articles and papers in conference proceedings have been published related to this topic [6]. While CCPM mainstream advocate for a heuristic approach towards buffer sizing [3] CCPM literature is dominated by mathematical calculations for buffer sizing [6]. Debates on heuristic buffer sizing versus optimised buffer sizing has not yet been resolved and scholars [11] advocate investigation of the impact of either approach, as a stream for future research. Contrary to CCPM’s claim that it offers the ultimate solution for dealing with uncertainty, some scholars argue that plan-driven methods such as CCPM are more appropriate for projects with low uncertainty, while Agile methods can better deal with uncertainty [12]. This is because Agile methods promote iterative approach, while plan-driven methods emphasis upfront planning. Moreover, for constructing the critical chain, existence of a unidirectional sequence of activities or events is essential. Pittman [10] explicitly states this assumption: “No event can be repeated and no ‘looping back’ to predecessors is permitted”. This may suggest may not be applicable to projects that require iterations. This raises a question: how does CCPM implementation accommodate iterative loops? In CCPM, unlike Agile methods, scope is not something that will be figured out after the project has started. Yet, CCPM has been applied successfully to R&D projects [13] and research [14]. The question remains how in practice these concepts are applied to projects with high uncertainty?

Another important concept promoted in CCPM is 'no multitasking'. Some scholars suspect that it is not possible in large and complex construction projects to prevent multitasking. Morris [8] claims that this in turn limits CCPM applicability to small projects. However, CCPM has been applied to a large complex construction project in Brazil [15]. It is unlikely that the term multi-tasking as it is used in office-based environments is even relevant to the construction context. This is because while office workers might have multiple windows open at same time on their desk, construction workers for example would not be on two locations at once. This physical constraint reduces the chances of multi-tasking. Indeed, there are multiple interpretations of the meaning of multitasking, depending on the granularity with which we define a task. Some scholars [16], refer to tasks with hourly measures which indicate fine granularity while others [17] use terms such as "high level map" and "30,000-foot picture of the project." Multitasking in each of these contexts would have very different implications. Questions are how practitioners decide on the level of granularity in their projects and how those decisions impact the project?

III. METHODOLOGY

The case presented in this paper was one of several cases studied as part of a larger cross-industry research project. The broader research underpinning this paper explored where and why CCPM is applicable. This case stands out in that it reveals possible answers to some of the questions raised above. The following section describes the process of collecting and analysing data.

Sources of data: The project manager was the primary point of contact and interviews were the major sources of data in this research. Additional sources of information were also sought to enable triangulation of evidence, which increases the reliability of the data and the process of gathering it [18]. This included:

- Additional interviewees - in this case we interviewed the project consultant
- Documentation - including plans, schedules, and the firm's website
- Observation - the software as it is being used
- Secondary data - material recommended by interviewees such as books, websites, or concepts that influenced their thinking and was considered important to better understanding their rationale. Such material as well as learning about technical norms was used to verify and enhance the interview data [18].

The case investigation began with a structured interview to identify the basic characteristics of the case. General questions related to the size of the project and its complexity, duration, human resources and the process of obtaining and allocating human resources were asked. More specific questions were related to the strategic goal of the project, market uncertainty, technological uncertainty, system scope and pace of the project. These questions were driven by variables suggested in the classification studies within the success literature [12]. Since projects do not happen in isolation, some questions on the organization's strategy, related programmes and project portfolio were also included.

Given that project managers have different opinions on project success, we attempted to re-examine the notion of success in projects—without any prejudice—by capturing the project goal as it was expressed by the project manager. For this purpose, we used a Goal Tree which is a graphical, hierarchical representation of the system giving its goal, critical success criteria and necessary conditions [19]. Information from interview transcripts and project documents was used to construct the Goal Tree. The Goal Tree was then presented to the project manager for further clarification, modification, and for verifying its validity through eight specific tests called the Categories of Legitimate Reservation [20]. These tests guide us to check that, for example, the entities and relationships exist, and that they clearly and adequately describe the situation. This process was expected to confirm that the Goal Tree represented the intention of the project as it was perceived by the project manager. Consecutive interviewees focused on processes, challenges, and obstacles in achieving the goal. Interviews were repeated until the completion of the project and one retrospective interview was conducted shortly after the completion of the project.

IV. THE CASE

The case project took place in a private sector organization. This project was executed in a large and established organization, in other words, a mature setting. The company is a large multi-national developer of cloud-based software solutions for the freight forwarding industry. The company provides software as a service and releases a new version of its entire product every week. The case project was one of many projects executed by this company. This company used CCPM for its product development projects and this project was one of these product development projects.

The case project was created to deliver a business intelligence tool that collects data from various parts of the existing system and creates meaningful metrics. These metrics were used to analyse productivity and increase performance. The output in the project had two important components: a catalogue of the most useful metrics for different types of customers, and the software to support the analysis of the above catalogue.

A. Motives for using CCPM

The company had many projects and operations. The following describes characteristics that they used to classify an undertaking as a project. For an undertaking to qualify as a ‘project’, it should involve a set of tasks to be done by people from different teams. “The qualities that will drag it from an ad hoc approach to ...CCPM approach would be, that the project manager is not the resource manager, and multiple resource managers are involved” It seems that in this case, project management was considered as a mechanism for managing operations that require conflict resolution between different priorities. It was further explained that the reason for using CCPM was that the interactions of different teams were anticipated to result in undesirable effects. Such effects included shortages of resources and conflicts between resource managers and project managers. Working across different teams can be a source of network complexity, which was also identified as a reason for implementing CCPM. “If the project is complex and has a lot of parallel and separate pathways, we are more likely to use CCPM on it”

The company used Drum-Buffer-Rope [21] and CCPM alongside each other, and CCPM buffer penetration was prioritised over DBR buffer penetrations.

Another important reason for adopting CCPM was urgency. Interviewees emphasised CCPM is particularly applied to projects where due date is important or there are date-driven commercial obligation. “Urgency is a factor, the nature of the deadline … The stricter it is, the more likely that we will be using CCPM” Urgency suggests timely delivery as a key performance indicator for a project. However, for other operations, velocity was considered as the key performance indicator. The interviewee argued that velocity is a generally applicable performance indicator unless there is a specific deadline. Velocity measures the rate of producing an output.

As was explained in the methodology section a Goal Tree (as shown in Figure 1) was constructed. A Goal Tree is read from the top as follows: in order to have the goal… we must have success criterion … and in order to have success criterion… we must have necessary condition…

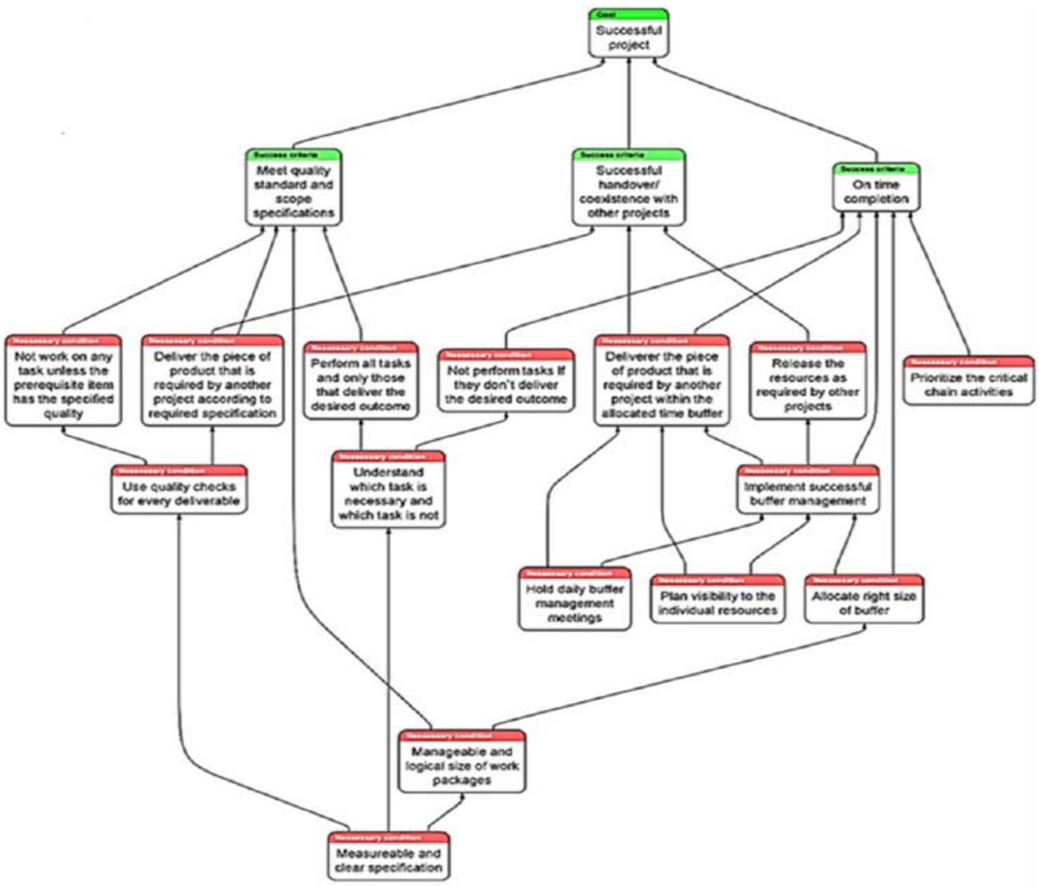

Figure 1 Goal Tree

B. Planning for CCPM

The first step in planning for CCPM was the development of the necessary condition network (NCN). Perhaps the most important function of necessity-based analysis was confirming that actions introduced in the project were necessary in order to achieve the goal and confirming that no non-essential activity was performed. In order to be able to use such a necessity-based analysis effectively, sufficient information was required. However, the following statement from the project manager expresses some level of uncertainty:

"We know what we want to achieve but we don't have the necessary specifications for it, because things evolve as the project progresses and the requirements become clear." To overcome uncertainty several strategies were used. The first strategy that enabled application of necessity-based analysis was to start with activities for which more information was available. More uncertain activities were not planned in detail early in the project. Another strategy was a "chunking process" to separate detailed task-oriented planning from overall planning. Large projects were broken into sub-projects; the outcome for each sub-project would be decided at the beginning of the entire project. However, the specific process-oriented details were not planned in the beginning. "We know from experience that project chunks bigger than 60 days tend to get interrupted by other commercial imperatives, and chunks that are less than 20 days are not worth project-managing... so you break it [the large project] into five or six sub-projects." The project manager differentiated process uncertainty from product uncertainty. She specifically emphasized the difference between them, as she put it, "what is to be achieved" and "how to achieve it". While all required tasks were not predictable at the beginning of the project, major events marked each sub-project. CCPM single project planning was then implemented within each sub-project. The scope of each sub-project was firmly decided before it began. Therefore, at the beginning of each sub-project they did have a measurable predefined goal for that sub-project. It was observed that the chunking process was used at different levels for different purposes. At the higher level it was used to break the project into sub-projects. The planning process and estimation focused particularly on these sub-projects. The short duration of sub-projects was associated with increased predictability. At the lower level chunking was used to break down activities into tasks of less than one day. The chunking process is not inherently different from work breakdown structure (WBS). However, it seems chunking as described here is not a deliverable-oriented decomposition of a project into smaller components as in backlog or WBS. Rather, it is process-oriented. Using the necessity-based logic, chunking as it is used in this context seems to have a sense of sequence and distance. It was more a case of envisioning a journey in terms of its phases and then the steps of the closest phase, rather than envisioning a product in terms of its components. A high level of granularity was observed. More detailed planning was perceived to improve accuracy: Such granularity was achieved by breaking the process of estimation into three independent processes. The first process was breaking down the activities. For this project each problem was broken into a single activity that had only one single marker. This process simplified the number of possibilities. The next step was to estimate how many iterations were required in order to deliver this marker. Finally, the duration for completing each task was estimated. Iteration was accommodated using a statistical approach. This is to say that it was well accepted that there would be multiple iterations to obtain the right specifications and that the number of these iterations was statistically predictable. "I say, 'In your experience how many iterations does it take to get it right?' So they will say 'nearly always two iterations and hardly ever four'. So you will put that iteration buffer as well, and we allow for 2 to 4 iterations, you see, you just take a statistical view of the problem, and accept the fact that you're living with distributions not absolutes." The duration of the task was estimated based on two figures produced by team members: the minimum and maximum time it would take to complete a task if it successfully produced the desired outcome at the first attempt. This differentiation between number of iterations and duration of the task itself provided a platform for communicating sources of uncertainty in estimates, thereby providing more accurate and reliable estimates. Centralized priorities with high level granularity as observed in this case were used to maximize performance and eliminate idle time for all resources, which in effect also increased both the required effort for planning as well as the impact of planning on execution. This in turn creates vulnerability to estimation errors in the planning process at the project level. "If we don't get it right, overloading can happen, and that kills everything" It also increased both the required effort for planning as well as the impact of planning on execution. "If we don't get it right, overloading can happen, and that kills everything, everything, misusing the tool can cause lots of problems. With CCPM, if you don't put the feeding buffers in the right places then obviously you are not absorbing variations, you are not planning it properly and therefore it will be doomed to fail" This may justify the numerous papers in the CCPM literature trying to add mathematical rigour to buffer sizing. However, it was argued that working in a large company with many ongoing projects provides possibilities to statistically predict the duration of such activities. Such a prediction when applied to a large number of tasks and projects would diminish the effect of outliers. "Obviously that (estimated) time will change, something will go out, something will be added…but then it will all average out. The whole point of CCPM is to capitalize on your gains and not allow your losses to delay the project too much." Moreover, it will improve over time as the attitudes of the team in terms of overestimation and underestimation are studied. "So we work out who the optimists are, or who the pessimists are, and we gradually evolve." The above statement shows learning was happening in the case organization from one project to another. It was argued that due to past experiences with Agile, some team members would exhibit resistance to committing themselves to estimating. It was argued that using the estimation processes described earlier managed such resistance and also reduced the risk of scope creep. The interviewees appeared to strongly believe that separating different aspects of uncertainty facilitates the process of estimation and provides a high level of transparency. For example, sometimes estimates also include time that is not spent on a task but is included in the estimation when large chunks of tasks are estimated in anticipation of interruptions. On this project, estimates were only based on touch time. Interruptions were dealt with through buffer management and staggered starts. In fact, using highly granular estimates reduced unknowns.

C. Executing CCPM

The project used a team consisting of seven people, all of whom were involved in multiple projects in the same organization. The project manager addressed the team members by their roles. She actually expressed a level of flexibility with regard to human resources as can be observed in contractor-type projects with a statement such as: "You can mix and match and swap them in and out...Rather than assigning the testing task to an individual, assigning it to the testing group, and then someone from that team who is the most available, or whatever the circumstances are, someone will pick that up and will complete the task." The case project was executed and managed alongside other activities in the organization. Priorities were established centrally for the whole organization. A software programme based on a combination of CCPM and DBR facilitated a synchronized buffer management system. The same programme also provided information for each individual human resource. This process synchronized individual priorities with the overall priorities. "[each employee has] a complete overview of all the work that is released and, based on where things are in terms of buffers. [Employees] are allowed to make a decision as to which task they should be working on next" The centralized priorities are a mixture of CCPM and DBR. "We stagger the release of time-sensitive projects and then allow non-time-sensitive projects to flow around those, to utilize non-constrained resources, and then we let operational work flow around those, to use all the leftover resources. We have a very efficient high velocity system, without compromising the buffer management system." The above statement indicates that projects and non-project activities were happening in parallel for the best use of resources. With the first priority given to time sensitive projects, resources were able to work on non-time sensitive projects or operation tasks as they were waiting for their turn in the time sensitive project. Despite the management awareness of TOC doctrine, they did not leave resources idle even in the form of a buffer. At this point it is important to note that some scholars [22] argued that while managers try to plan for full capacity, such behaviour will lead to lower productivity due to the fact that variability is inevitable. The result of their simulation-based study in multi-project environments suggests that full allocation of resources reduces the overall throughput. However, in this case resources were allocated only to one critical activity on CCPM, but they were also allowed to work on non-critical activities and non-project activities to fill any spare time. This centralized management of resources was expected to also identify constrained resources in the organization and ideally reduce their workload. Interestingly, unlike with other TOC practices, such a constrained resource was not seen as a leverage point. Instead, it was a problem to be addressed and resolved. This difference exists because it is not desirable to fully exploit a human resource. Another observed practice in this project was visibility of information to each individual resource. "Keeping an eye on how much buffer penetration they used and it's not just for the project manager to know that, but also to provide that visibility to the individual resources, so that the project manager doesn't become the constraint on the project. If everybody knows this information, then it makes everything run a lot smoother" The visual presentation of the buffer was also observed in this project. A multi-project colour-coded was used to facilitate the implementation of buffer management. An important means of communication was the visual presentation and the special software which was used alongside buffer management daily stand-ups to discuss completion of task against time. In addition, a monthly review of overall performance was performed which was particularly focused on issues related to scope. The relay race was another practice that was observed. The first attribute of the relay race is that team members enter and leave the project. Another attribute of the relay race is the high pace of passing the baton. Similarly, since projects were characterized as urgent, waiting times between tasks were expected to be minimized. "We are trying to minimize the handover delay, so that the Critical Chain can move on uninterrupted." The relay race process was facilitated by a practice called countdown. The countdown process not only requires the next resource to be on standby and ready, but also requires the working resource to signal his/her progress frequently. Using the centralized priority discussed above, the following resource picked tasks that were short (less than six hours) and interruptible. These two criteria were expected to confirm that the following resource could drop his/her current task and attend to the critical activity. It was argued that an estimated six-hour work might take longer, or a job that was expected to be interruptible might turn out to be not interruptible.

However, the combination of both is highly unlikely. In addition, constant signals prevented any allocation of critical activity being delayed. Another observation was the use of TOC thinking processes during execution. The project manager described how this saved time in the execution process and identified non-value adding activities. The Evaporating Cloud in particular was used for analysing assumptions and making decisions. The whole organization follows particular rules that facilitate decision-making. Rules appear to be heuristic and based on past experience. An example of such a rule is the condition that a resource on standby to work on Critical Chain activity should not start work on any task longer than six hours. Other rules include: "Only start what you can finish...Once you start a work item you need to finish it...Internal workflows are almost uninterruptible but for the handover between work items there can be an interruption, meaning that they can go from one project to another project" The above examples show a rule and conditions to which it applied. These rules were guided by no multitasking principle commonly known in CCPM. Spelling out the rules as above helped individual resources that were constantly involved in multiple projects to make a decision on what to do next. "They are constantly trading off between 'do I start to work on this work item on this project or do I work on the work item on the next project?'"The above statement clearly shows the schedule was used for prioritization and along with heuristic rules constituted a decision-making support system to be used throughout the execution process. The schedule was indeed a major coordination mechanism that not only coordinates people but also aligns their decisions with the overall objective of the organization. The project was completed successfully within the normal variation classified as zone two buffer or yellow zone.

V. DISCUSSION

While this case was a small project occurring in large organizations, the case provides some very interesting evidence on the possibility of applying CCPM to a large complex project. This project was defined as a subset of a larger undertaking. One can argue the case project was in effect a 'work stream' of a large and complex project. This suggests that in practice several Critical Chains were accommodated by breaking the project into several small sub-projects. This practice has been also applied to a large complex construction project in Brazil [15], where "weekly small projects put together to create a bottom-up Work Breakdown Structure". In this case, CCPM multi project prioritisation method was applied to coordinate subprojects of a number of large-complex projects. The case also makes some clarification about the nature of multi-tasking. As was discussed in the literature review, debates against and for multi-tasking do not have the same interpretation on what is the size of a task. Tasks in this project were all less than a day in duration. Project team members clearly worked on multiple projects. However, at any given time team members were focused on one task that lasted for a few hours. In fact, this organization incorporated an iterative approach and adapted CCPM (a plan-driven method) to deliver a new version of its entire product every week. This high level of agility resonates with recent findings that show despite Agile's theoretical stand, in practice there is no significant relationship between upfront planning effort and using either Agile or plan-driven project management methods [23]. These findings indicate being agile does not necessarily require adopting an Agile method. The case demonstrated use of "Critical Chain at sub-project level and iteration at higher level" as well as "Reciprocal iteration within tasks and Critical Chain at the project level" [6]. Another interesting observation from this case was related to buffer sizing. CCPM literature shows a divide on this issue. While mainstream CCPM suggests using heuristic buffer sizing, numerous mathematicians offer buffer sizing techniques all based on one argument: projects happen once. The case project exhibited an effective use of mutual adjustment and learning in order to set buffer sizes. A concept that may have been overlooked in mathematical debates on buffer sizing is that while projects are unique, they occur in organizations with ongoing business. The case indicated that learning occurs from one project to another project. It also demonstrated an ongoing improvement and mutual adjustment of estimating task times and buffer sizing. Managers in the case organization took account of the estimator's attitude (some people are optimists, others are pessimists) and the level of uncertainty of various tasks collectively and continuously adjusted buffer sizes and duration estimates based on experience. The case, therefore, illustrates that adjusting buffer sizes in an evolving and adaptive manner is possible.

CONCLUSION

This paper reports a case study research that presents how CCPM was adopted and adapted to the context of software development. This case study provides insight into practical aspects of the application of CCPM to the software industry in particular. The findings of this study strongly suggest that successful application of CCPM relies on the establishment of a measurable and precise goal at the beginning of the project. Definition of a measurable and precise goal can be facilitated by strategies such as breaking projects into small undertakings, and using necessity-based logic. In the planning process, a valid and useful estimate of time requires a high level of granularity and precise definition and measurement of activities. Such estimates also require distinguishing among several expected features of tasks: touch time; task duration that includes interruptions; and task duration that distinguishes predicted iterations from duration of tasks without iteration. These distinctions allow visibility of the sources of uncertainty and transparency when calculating estimates. In the execution process, successful application of CCPM requires transparency and centralized decision support; it can be further enhanced by practices such as countdown, visual presentation of buffer penetration, internally established heuristics, and TOC thinking processes. The case demonstrates how CCPM multi-project approach facilitated synergy and allowed learning across entire organization.The findings also provide insights into current debates on CCPM literature. The case findings suggest that reliance on heuristics rather than mathematical analysis may be justified considering mutual adjustment and learning that occurs from one project to another. It also demonstrates that both iterative loops and reciprocal dependencies can be accommodated in CCPM.

REFERENCES

[1] Gartner. (2014). Market Share: All Software Markets, Worldwide, 2013. from http://www.gartner.com/newsroom/id/2696317

[2] Standish Group (2012). CHAOS 2012 report Agile Projects Successful 3X More than Non-Agile Projects. [Online]. Available at: http://www.sds-consulting.com/blog/agile-projects-successful-3x-more-non-agile-projects.

[3] Goldratt, E. M. (1997). Critical chain. Great Barrington, MA: North River Press.

[4] Kendall, G. I. (2010). Theory of Constraints Strategy. In J. F. Cox & J. G. Schleier (Eds.), Theory of constraints handbook (pp. 519-550). New York, NY: McGraw-Hill

[5] Realization Technologies. (2016). $5 Billion in additional cash and profits. Retrieved from http: //www.realization.com/results/mro-turnaround

[6] Mirzaei, M., & Mabin, V. J. (2018). A review of the scholarly literature on CCPM: a focus on underpinning assumptions. International Journal of Project Organisation and Management, 10(3), 242-267

[7] Herroelen, W., Leus, R., & Demeulemeester, E. (2002). Critical chain project scheduling: do not oversimplify. Project Management Journal, 33(4), 46-60.

[8] Morris, P. W. G. (2013). Reconstructing project management. Cambridge, MA: John Wiley and Sons Ltd

[9] Raz, T., Barnes, R., & Dvir, D. (2003). A Critical Look at Critical Chain Project Management. Project Management Journal, 34(4).

[10] Pittman, P. H. (1994). Project management: a more effective methodology for the planning and control of projects (Unpublished doctoral dissertation). University of Georgia at Athens.

[11] Ghaffari, M. and Emsley, M.W (2015). Current status and future potential of the research on critical chain project. PM World Journal 4(9).Retrieved from http://pmworldlibrary.net/wp-content/uploads/2015/09/pmwj38-Sep2015-Ghaffari-Emsley-research-on-critical-chain-second-edition.pdf

[12] Shenhar, A. J., Tishler, A., Dvir, D., Lipovetsky, S., & Lechler, T. (2002). Refining the search for Project success factors: a multivariate, typological approach. R&D Management, 32(2), 111-126. doi:10.1111/1467-9310.00244

[13] Hameri, A. P., & Heikkila, J. (2002). Improving efficiency: Time-critical interfacing of project tasks. International Journal of Project Management, 20(2), 143-153. doi:10.1016/S0263-7863(00)00044-2

[14] Fenbert, J. A., & Fleener, N. K. (2002). Implementing TOC multiproject management in a research organization. In Proc. 2002 PMI Res. Conf., Project Management Institute, Newton Square, PA (pp. 225-229).

[15] Archibald, R. D. (2007). The Application of SDPM, Critical Chain and Portfolio Project Management Principles to the Construction of the 670 km Urucu/Manaus (Petrobras) Pipeline. In PMI Global Congress Proceedings, Cancun, Mexico Retrieved from http://www.pmi.org/learning/application-spdm-critical-chain-7329

[16] Srinivasan, M. M., Best, W. D., & Chandrasekaran, S. (2007). Warner Robins Air Logistics Center streamlines aircraft repair and overhaul. Interfaces, 37(1), 7-21. doi:10.1287/inte.1060.0260

[17] Newbold, R. C., & Lynch, B. (2014). The project manifesto: transforming your life and work with critical chain values. Lake Ridge, VA: ProChain Solutions, Inc.

[18] Yin, R. K. (2003). Case study research: design and methods (3rd ed.). Thousand Oaks, CA: Sage Publications.

[19] Dettmer, H. W. (2011). Strategic navigation. from http: //www.goalsys.com/books/documents/Strategy-Development-AGILEConference.pdf

[20] Dettmer, H. W. (2007). The logical thinking process: a systems approach to complex problem solving. Milwaukee, WI: ASQ Quality Press.

[21] Cox, J. F., Boyd, L., Sullivan, T. T., Reid, R. A., & Cartier, B. (2012). The Theory of Constraints International Certification Organization Dictionary, Second Edition Retrieved from http: //www.tocico.org/?page=dictionary

[22] Ben-Zvi, T., & Lechler, T. G. (2011, August). Resource allocation in multi-project environments: Planning vs. execution strategies. Paper presented at the 2011 Proceedings of PICMET '11: Technology Management in the Energy Smart World (PICMET), Portland, Oregon, OR.

[23] Vinekar, V., & Huntley, C. L. (2010). Agility versus maturity: Is there really a trade-off? Computer, 43(5), 87-89. doi:10.1109/MC.2010.1

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