UNIVERSITY OF VAASA
FACULTY OF TECHNOLOGY
INDUSTRIAL MANAGEMENT

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CRITICAL CHAIN PROJECT MANAGEMENT CASE STUDY IN A MULTI-PROJECT ENVIRONMENT

Master's Thesis in
Industrial Management

VAASA 2015

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KEY CONCEPTS AND ABBREVIATIONS

Definitions of some key concepts of the CCPM theory:

- Bottleneck: The capacity limiting process step.
- Constraint: A process or step that limits throughput, or performance relative to the goal.
- Critical Chain: The set of tasks which determines – with consideration to resource availability – the overall duration of a project.
- Drum resource: In a multi-project environment, the resource that is most often overloaded. Sets the rate at which work progresses, thus the term ‘drum’.
- Feeding buffer: A feeding buffer is placed at each point where a non-critical chain joins the critical chain. Protects the critical chain from disruption on tasks feeding it, and allows for early task starts.
- Goal: The reason a system exists.
- Multi-tasking: Performing more than one task at the same time, without having a clear and consistent priority among the tasks. Increases the time it takes to complete a task, and thus tends to increase the project duration.
- Project buffer: Placed after the final task of a project. Protects the project completion date from delays.
- Resource buffer: Placed on the critical chain before the resources start work. Makes sure that resources are available to start work on time or (if possible) early.
- System: A network of independent components which work together to accomplish the goal of the system. Catalyst Systems organization (with a few minor external resources) is the system in my research.
- Throughput: The rate at which the system creates money (through sales).
- Work-in-process: WIP is work sitting in a system waiting to be finished.

Definitions of some key concepts used in Wärtsilä Catalyst Systems:

- Catalyst delivery model: A delivery/quality model developed by previous thesis worker Joona Piirto. Contains NOR delivery milestones and checkpoints.
- Catalyst delivery schedule: Contains the detailed schedules and progress percentages of all delivery projects, and project related tasks for each project team member.
- Catalyst Master Production Schedule – MPS: An excel listing of all current and future projects. Contains all the major information of a project at one glance.
- Catalyst Project Manager: An owner of the catalyst delivery project. Each project is owned by one of the two project managers.
- EBIT: Earnings Before Interest and Taxes
- IDM: A document management environment in Wärtsilä Intranet.
- KPI: Key process indicator
- NOR/CSO deliveries' weekly meeting: A meeting in which the progress of all projects is reviewed and discussed with key project personnel. Urgent tasks and possible red flags are assessed in it.
- NOR: Wärtsilä NOx Reducer, the main catalyst product.
- Workspaces: A document management environment in Wärtsilä Intranet. Slightly more user-friendly than IDM.

CCPM definitions derived from the books Project Management in the Fast Lane (Newbold, 1998) and Critical Chain Project Management (Leach, 2005). Catalyst Systems' concepts explained in my own words.

FIGURES

TABLES

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Degree:	Master of Science in Economics and Business Administration
Major:	Industrial Management
Year of Entering the University:	2005
Year of Completing the Master's Thesis:	2015 **Pages:** 80

ABSTRACT:

This thesis focuses on the customer delivery project management in Catalyst Systems, Wärtsilä Finland Oy. The purpose of the thesis research is to discover whether the Critical Chain Project Management method should be implemented in the Catalyst Systems delivery projects. The thesis research is a case study with a deductive research approach.

The literature review consisted of three sections. Firstly, the framework and operating environment of the Catalyst Systems customer delivery projects, and the basic terminology of CCPM were clarified. In the second section the unwanted effects commonly occurring in project management were reviewed. Lastly, the CCPM implementation critical success factors relevant in the Catalyst Systems project environment were studied.

The research data was gathered via personal semi-structured interviews. The data grouping, analysis, ranking, and interpretation methods commonly used in Wärtsilä were leveraged. The literature review and the interview data analysis combined provided the answers to the research questions. The research revealed that Wärtsilä Catalysts Systems delivery project management would likely benefit from implementing Critical Chain Project Management, and the implementation was thus strongly recommended.

KEYWORDS: Critical Chain Project Management, customer delivery projects, environmental systems

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Tutkielman nimi:	CRITICAL CHAIN PROJECT MANAGEMENT CASE STUDY IN A MULTI-PROJECT ENVIRONMENT
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Opintojen aloitusvuosi:	2005
Tutkielman valmistumisvuosi:	2015 **Sivumäärä:** 80

TIIVISTELMÄ:

Tämä tutkimus keskittyy asiakastoimitusprojektien hallintaan Wärtsilä Finland Oy Catalyst Systemsissä. Tutkielman tarkoituksena on selvittää tulisiko Critical Chain Project Management ottaa käyttöön Catalyst Systemsin toimitusprojekteissa. Tutkimus toteutetaan tapaustutkimuksena, ja tutkimusote on deduktiivinen.

Kirjallisuuskatsaus jaettiin kolmeen osa-alueeseen. Ensimmäisenä perehdyttiin Catalyst Systemsin asiakastoimitusprojektien toimintaympäristöön ja puitteisiin, sekä Critical Chain Project Managementin peruskäsitteistöön. Toisessa osiossa tarkasteltiin projektinhallinnassa usein esiintyviä ei-toivottuja ominaisuuksia. Viimeisenä pohdittiin Catalyst Systemsin projektiympäristön CCPM-käyttöönoton kannalta olennaisimpia menestystekijöitä.

Tutkimusdata kerättiin henkilökohtaisilla puolistrukturoiduilla haastatteluilla. Datan lajitteluun, järjestelyyn analysointiin ja tulkitsemiseen käytettiin Wärtsilässä yleisesti käytössä olevia metodeja. Tutkimuskysymyksiin pystyttiin vastaamaan yhdistämällä kirjallisuuskatsaus ja tutkimusdata-analyysi. Tutkimus osoitti että Wärtsilä Catalysts Systemsin toimitusprojektien hallinta varsin todennäköisesti hyötyisi Critical Chain Project Management-metodin käyttöönotosta. Näin ollen metodin käyttöönotto on erittäin suositeltavaa.

AVAINSANAT: Critical Chain Project Management, customer delivery projects, environmental systems

1. INTRODUCTION

This research is focused in finding out whether the Critical Chain method should be applied in Wärtsilä Catalyst Systems organisation, and more precisely in its delivery project management. The projects in question are customer delivery projects concentrating on delivering catalyst systems and products to Wärtsilä Marine Solutions' customers and Energy Solutions' delivery projects. Catalyst Systems is a part of the Marine Solutions organization, and the way of working regarding the delivery of the Catalyst equipment varies depending on the project scope. As for Energy Solutions, their project team delivers the catalyst equipment along with the rest of the project scope to the customer. In practice the research clarifies how the Catalyst System organisation would benefit from implementing Critical Chain Project Management, and whether these benefits outweigh the implementation efforts and possible costs.

The research includes the formulation of an initial plan for the implementation. In the initial plan I describe the required changes in the current business environment in order for the implementation to be successful, and what the first steps of action are. Moreover, some tools for Critical Chain Project Management are suggested, and a rough cost estimate of the implementation presented.

1.1. Motivation for the research subject choice

The need for this research arises from actual day-to-day challenges in the Catalyst Systems delivery project management. It has been seen over the course of the last three years that there is a need for more effective and focused management of the delivery projects. This need naturally stems from the constant requirement of becoming more cost effective; practically speaking this means that the EBIT of the business needs to be increased. Critical Chain Project Management certainly has potential to help Catalyst Systems get there: according to Millhiser & Szmerekovsky (2012: 72) the number of case studies of successful project execution due to CCPM is "burgeoning". However, I find improving the quality of the work life for everyone involved with Catalyst delivery projects an equally good motivation. It is scientifically proven that good project performance generates high job satisfaction, while reducing high stress levels caused by overrun deadlines, consumptive arguments, and divisive finger pointing (Umble & Umble, 2000: 28). In addition, both the Delivery General Manager Tomi Ylikantola and

I are somewhat interested in being forerunners in the field of Critical Chain Project Management in Wärtsilä project management in Finland.

The research subject emerged directly from my own field of work. In the organization, we had long been looking for distinguished and structured ways to manage several simultaneous projects which use the same resources. There is a substantial supply of courses marketed to companies about project portfolio management, which concentrate on development projects. Project portfolio management training offerings from the viewpoint of customer delivery projects on the other hand are non-existent, due to the unique characteristics of each customer delivery project environment. The research problem at hand is significant both as a scientific study and for the organization in question, since Critical Chain Project Management likely offers answers to the above stated challenges.

1.2. The objective of the research

At any given time point, there are always several different customer delivery projects in progress within Catalyst Systems. These projects might vary somewhat scope-wise, but mostly use the same resources inside and outside the organisation. Obviously each project will also be in a different stage – some starting, some ending, and some ongoing. In the course of the past few years the requirement to learn how to more efficiently manage these parallel-running projects has been acknowledged. Critical Chain Project Management is by definition a methodology for planning, executing and managing projects in single and multi-project environments (Goldratt UK: What is Critical Chain, retrieved 3.3.2015). Hence, I believe that CCPM may be the best approach to take in order to achieve our goal of improved all-around project management. Therefore, the research questions of the thesis are as follows:

1. Would Wärtsilä Catalyst Systems delivery project management benefit from implementing Critical Chain Project Management?
2. If yes, how should the implementation of Critical Chain Project Management be carried out?
    i. Initial implementation plan

1.3. Research design and approach

Yin (1994: 19) describes research design as an action plan for getting from an initial set of questions to some set of conclusions. In order to answer the research questions laid in this thesis, the research presented here is a case study with a single-unit of analysis – the Wärtsilä Catalyst Systems organization, which is a part of Environmental Solutions in the Marine Solutions division. The undersigned is employed by Catalyst Systems as a Senior Project Manager, and the thesis subject has been chosen in collaboration with the Catalyst Systems management.

The research approach of this research is deductive. Deductive research by definition follows a conscious course from a general law to a specific case (Kovács & Spens, 2005). The logic of deductive research is followed so that in the theoretical part of the thesis the laws of the project management world are examined from the Critical Chain Project Management perspective, and in the analysis phase the CCPM knowledge is used to interpret the research data collected from the case study organization. Thus the information achieved in the literature review, combined with the research data analysis will result in discovering whether Critical Chain Project Management should be introduced in the case study unit of the research; the Catalyst Systems delivery project management.

The data collection method of the research is interview conduction. The research work includes interviews of all relevant Catalyst Systems delivery project personnel. Different issues were emphasized in project team member interviews compared to the Catalyst Systems Management interviews. In the interview data analysis this two-fold interview approach is taken into account. The data grouping, analysis, ranking, and interpretation methods commonly used in Wärtsilä are leveraged in the data analysis. The literature review and the interview data analysis combined provide the answers to the research questions.

1.4. Delimitation of the subject

The actual possible implementation of the Critical Chain Project Management approach to the catalyst delivery projects is outside the scope of this research. If it were included, the scope of the research would become much too wide. There are also some doubts that even if Critical Chain Project Management proves to be of use to catalyst delivery projects, it might currently be too early for it considering the age and maturity stage of the organisation. Nevertheless, it is very much possible that the implementation will take place sometime in 2016.

2. THEORETICAL BACKGROUND

Project Management Institute evaluates that in 2014, only 50% of projects completed in the original schedule, 55% managed to keep the original budget, while 44% experienced scope creep or uncontrollable scope changes (Capturing the Value of Projects, 2015: 24). Critical Chain Project Management has the power to turn these discouraging numbers around: this project management approach has the advantage that the time planned for the project is actually achieved (Watson, Blackstone & Gardiner, 2007: 397). Millhiser & Szmerekovsky also report “renewed worker enthusiasm, enhanced sense of teamwork, and more joy in work” (2012: 75). Critical Chain is said to be a particularly good choice for multi-project environments as it provides tools to tackle two typical challenges experienced in those environments, namely resource management and multitasking (Lechler, Ronen & Stohr, 2005: 55 and Steyn, 2002: 77). These factors are very likely to contribute to a higher percentage of successful projects in the organizations employing CCPM.

In Critical Chain Project Management literature and scientific articles a number of recurring themes are detectable. From the viewpoint of conducting additional research finding patterns tends to be a good sign. In this section I will review the CCPM literature focusing on the themes most relevant to my case study research. Firstly, the concepts of Critical Chain and Critical Chain Project Management will be explained. Then I will cover the unwanted effects in project management, and in the third part I will concentrate on the critical success factors for implementation.

2.1. Background and basic terms

2.1.1. Wärtsilä and the Catalyst Systems project environment

Wärtsilä provides its customers in the marine and energy market with complete lifecycle power solutions, focusing on creating better and environmentally compatible technologies and related services. In 2014 net sales totalled EUR 4.8 billion. Wärtsilä has 17,700 professionals in 70 countries and is listed on the NASDAQ OMX Helsinki, Finland. Wärtsilä’s mission, vision, and values are presented below in figure 1. (Wärtsilä Corporate presentation 2015). Finding growth in the environmental solutions market is one of Wärtsilä’s strategic goals.

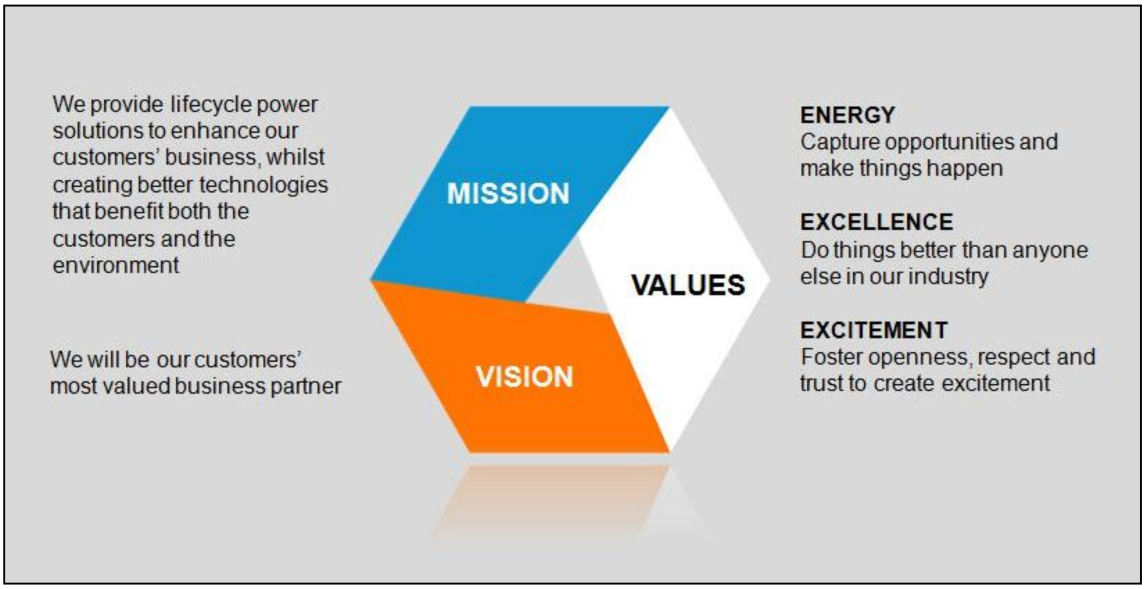


Figure 1. Wärtsilä's mission, vision, and values.

This research is a case study focusing on the customer delivery projects in Wärtsilä Catalyst Systems. The Catalyst Systems delivers SCR and oxidation based technologies for reduction of Nitrogen Oxides (NOx), Carbon Monoxide (CO) and some Hydrocarbons (HC). The systems are delivered to Marine Solutions' and Energy Solutions' customers, as well as Service customers through retrofitting. (Wärtsilä Compass, accessed 30.10.2015.)

Wärtsilä Catalyst Systems is a part of the Environmental Solutions business line, in the Marine Solutions business area. Environmental Solutions develops and delivers products that help to protect the environment. Catalyst Systems strives to become the most respected player in field of catalyst systems for engine applications – especially known for quality and service. The organizational structure of Environmental Solutions and the position of Catalyst Systems is shown in figure 2.

The Catalyst Systems organization consists of four departments: Research and Development, Sales, Product Management and Engineering, and Delivery. While it is the Delivery team responsible for the customer delivery projects, there are specialists in all departments whose competence in required in the delivery projects. A typical delivery project team has representation of the following fields of expertise: catalyst engineering, automation and electrical engineering, design engineering, mechanical engineering, process engineering, project purchasing, and application management. Therefore personnel from all four departments are involved in the delivery project management. External to the Catalyst Systems organization, the customer delivery projects utilize a strategic purchaser and a business controller.

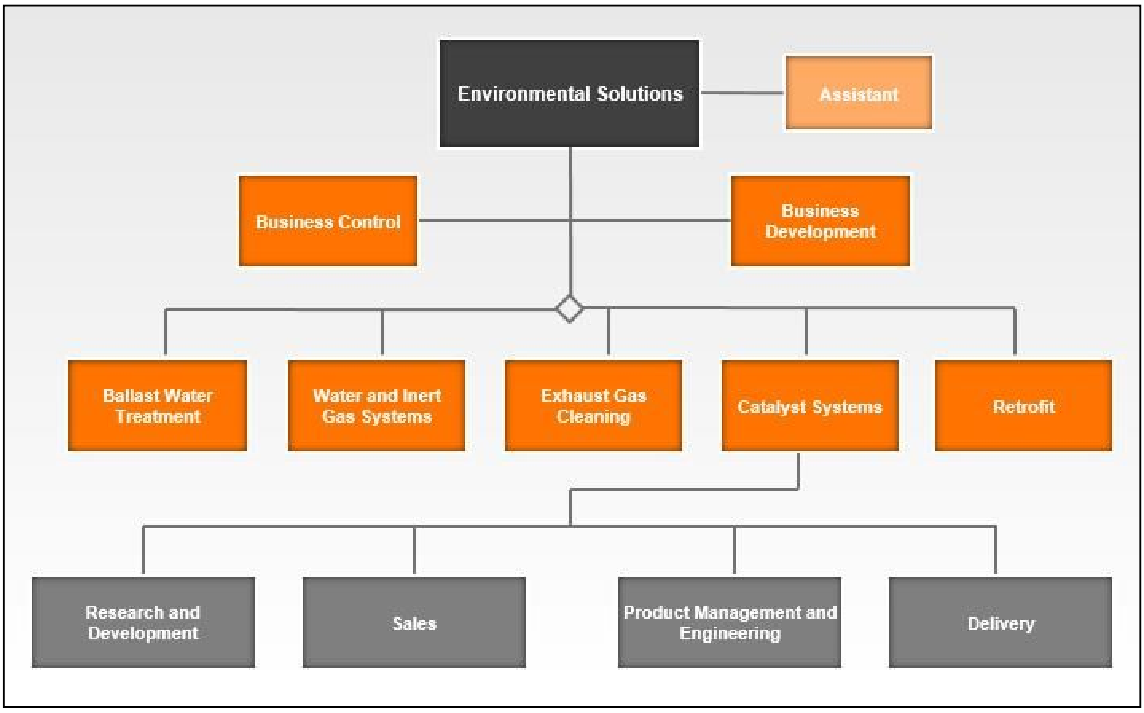


Figure 2. Organizational structure of Environmental Solutions and Catalyst Systems.

2.1.2. Critical Chain explained

Revisiting the Key Concepts and Abbreviations section, we remember that by definition Critical Chain is the set of tasks which determines the overall duration of a project, taking resource availability into consideration (Newbold, 1998: 264). The Critical Chain is seen as the system's constraint, i.e. the factor limiting the project system's throughput (Leach, 2005: 243). In multi-project environments where management of several simultaneous projects using the same resources is required, resource management is a cause of constant distress (Lechler et al, 2005: 46). Perhaps that is why the resource availability considerations of Critical Chain Project Management seem to concentrate mainly on people. Resources performing the tasks on the critical chain are seen as critical resources (Dilmaghani, 2008: 15). The team members as project resources is also the viewpoint of this thesis.

According to Kramer and Jenkins (2006, retrieved 28.9.2015) Critical Path is defined as follows: "The continuous string(s) of critical activities in the schedule between the Start and Finish of the project. The sum of the activity durations in the Critical Path is equal to the Project's Duration." Note that a reference to resources is completely missing from the Critical Path description. Of course, it is possible to perform resource allocation also on a Critical Path schedule. However, the Critical Chain is not the same thing as the resource-levelled Critical Path schedule (Leach, 2005: 243), since the Critical Chain is formulated with much more aggressive task duration estimates.

2.1.3. Critical Chain Project Management defined

The concept of Critical Chain Management was introduced in 1997 in Eliyahu M. Goldratt's book Critical Chain. Critical Chain methodology is based on a management paradigm called the Theory of Constraints (TOC), developed by Goldratt in 1984 in Israel (Dilmaghani, 2008: 13). Goldratt's own company Goldratt UK describes CCPM as a methodology for planning, executing and managing projects in single and multi-project environments (Goldratt UK: What is Critical Chain, retrieved 3.3.2015).

The key elements in Critical Chain Project Management include such as reduction of task duration estimates, buffer calculations and management, progress and performance measurement and reporting, as well as task and resource priority management (Raz, Barnes & Dvir, 2003: 24). The risk management approach of CCPM also differs significantly from other project management approaches (Robinson & Richards, 2010: 1). Employing Critical Chain Project Management starts with three major steps (Newbold, 1998: 55):

1. **Identify the key tasks.** These are the tasks forming the Critical Chain.
2. **Exploit the performance on the key tasks.** The project team must do everything in their power to keep the key tasks on time.
3. **Subordinate to the key tasks.** Ensure that everyone in the project organization is committed to protecting the key tasks, and actively working to keep their schedule.

2.2. Unwanted effects in project management – is CCPM the solution?

Since project management is utilized in a countless number of fields and industries, the project world is extremely diverse. However, the problems, pitfalls, and challenges are notably similar everywhere (Umble & Umble 2000: 27). Based on this notion Umble & Umble present two central conclusions (2000: 27). The first conclusion is that the primary root causes of the persistent project management problems are the same everywhere, and the second that the widely used conventional project management techniques are fundamentally defective. Yet, literally no one suspects the validity of the project system (Leach, 2005: 10). Leach also adds that according to Goldratt, the core problem leading to all project failure is failure to efficiently manage uncertainty (1999: 40). These core problems lead to certain undesired effects. These unwanted effects are presented below.

2.2.1. Excessive activity duration estimates and scarcity of positive variation

Uncertainty will always be present in project environments due to common and special cause variations. Common cause variation is inbuilt in the system and can be predicted to some degree, whereas special cause variation is the result of unpredictable problems (Schneider-Kamp, 2002: 5). Uncertainty can be described as "the degree to which it is difficult to predict any particular outcome before it happens" (Robinson & Richards, 2010: 2). Schneider-Kamp declares uncertainty the great enemy of planning (2002: 5). Thus, project plans must always contain a certain amount of contingency; otherwise it is impossible to make realistic commitments due to the unavoidable uncertainty factor (Robinson & Richards, 2010: 2). As the success of a project is often measured in terms of how well the budget and schedule were held, a significant portion of the project manager's energy will usually be spent on tackling this uncertainty.

According to Leach project team members tend to assume that the project manager wants low-risk activity times (1999: 42). One could say that this is a logical assumption. Surely the project manager wants the schedule to be a feasible one. It is also noteworthy that in some project systems not meeting the schedule determined in the project plan is even punished. Even if no direct punishment will occur, many companies have rewarding systems where individuals' bonus salaries will depend on how well they have met their predefined goals. Keeping delivery dates and deadlines is a common predefined goal. Therefore not keeping the deadlines will lead to the loss of the personal bonus, which can consequently be seen as an indirect punishment. It is understandable that people will much rather swell their activity estimation times than risk losing their bonuses. This leads to *sandbagging*, "the practise of knowingly asking for substantially more time or budget than the job requires" (Robinson & Richards, 2010: 3).

Furthermore, it is common psychology that people feel good about themselves when they finish a task by the due date, while being late and finishing after the due date causes them to feel stressed and generally bad. This is another factor reinforcing project team members' attempts to estimate high probability completion times (Leach, 1999: 42).

Despite the generally good intentions of both the project team members and the project manager, adding unnecessary contingency can considerably increase the project budget and schedule. This is definitely a problem, as it is widely perceived in the project management world that minimizing the overall duration of projects should be the number one objective and a major matter of management concern (Herroelen & Leus, 2001: 6). In an era of increasing financial pressure in firms, no project organization can afford to overlook this. Many continue to use the same old project management methods and expect to get different outcomes. A smart project manager will look for fresh new ways to minimize the project lifespan, and critical chain project management offers one of them.

It is extremely important to understand that it is futile to protect a single task against all possible risks. All possible risks will never materialize, but when the project schedule is built with the safety margin internal to the task, time is spent as they had (Raz el al, 2005: 25). So in reality, buffering each task individually translates to wasting time. The end result is that with traditional methods, positive variations in task completion times rarely contribute to overall project duration, while delays always do (Schneider-Kamp, 2002: 7). The ability to turn this persistent phenomenon around offers great profits to any project organization.

Another unpleasant side effect of sandbagging is that in the project execution phase the project personnel are aware that they have plenty of extra time in their activity durations, since they themselves inserted the slack to the schedule by giving an inflated activity time estimation. This in turn is likely to drive them towards another unwanted behavioural pattern, procrastination (Rand, 2000: 175). Procrastination is discussed in more detail further below.

With Critical Chain Project Management in place, scheduled task durations will be significantly cut down. The duration of a task in the project schedule should be such that there is 50% chance of completing it in the allocated time, instead of the commonly preferred 95% likelihood (Raz et al, 2003: 25). The time saved by removing individual task contingency is replaced with a *project buffer*. The length of the buffer can be calculated with various different methods, but the resulting buffer length is usually between 30% and 50% of the entire project duration (Herroelen & Leus, 2001: 12). The following figure from Raz et al (2003: 25) compares the conventionally composed project schedule with the Critical Chain one:

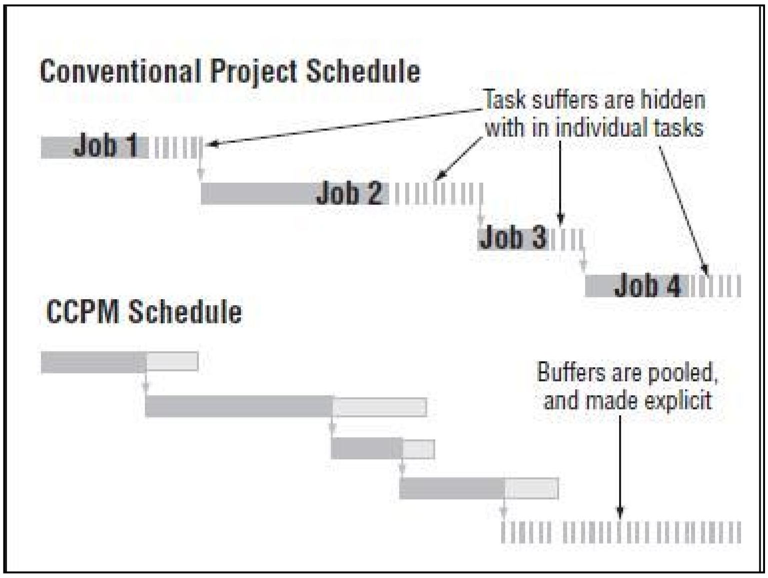


Figure 3. Conventional project schedule versus CCPM schedule.

While the figure shows both projects with identical overall project durations, some suggest that with Critical Chain scheduling the expected total duration of a project will shorten radically (e.g. Umble & Umble, 2000: 30). In practise however, the task owners might be more accepting of stripping their tasks from their individual safety times, if the total project length is not shortened (Raz et al, 2003: 25). This is noteworthy, since dissatisfaction for task duration estimates decreases the likelihood of a successful Critical Chain Project Management implementation (Repp, 2012: 142). It is up to the project manager to evaluate whether they want to actively shorten the total project duration, or if they would rather to remove the individual buffer times and merely transfer them to the end as the project buffer, while keeping the total length. Both scenarios will lead to the project schedule holding better than before.

In addition to decreasing the total project duration, pooling together the safety margins of individual tasks improves the project's protection against uncertainty (Raz et al, 2003: 25). It is even argued that it is possible to simultaneously accomplish both: "The result of this (CCPM scheduling) is project models that reflect a shorter overall cycle time while at the same time provide a higher degree of schedule and cost risk protection." (Robinson & Richards, 2010: 5). An additional advantage of scheduling projects the Critical Chain way is that transparency is increased. According to Robinson and Richards traditional project management practices have evolved to conceal the existence this protection which is evidently wasteful (2010: 2). With Critical Chain Project Management there is no more hidden waste. Increased transparency is in general highly valued in today's business environment.

2.2.2. Procrastination

It is a well-known fact in the business world that work will typically take up the time which was originally allocated for it. If a meeting is set up to take 60 minutes, that hour will most often be used even if only 30 minutes would have been adequate. This is a universal phenomenon and it also holds true for individual tasks in the project schedule. This phenomenon is called the Parkinson's Law. It means that people tend not to finish their assignments ahead of time even when they have an opportunity to do so (Lechler et al, 2005: 51). The safety time is wasted, as Goldratt phrased it in the Theory of Constraints language (Leach, 1999: 42).

Parkinson's Law too is an undeniable part of the project management environment, and one root cause behind it is the prevalence of procrastination. Procrastination is indeed so common, that according to Leach you can be described as *normal* when this behaviour is a part of your working pattern (2005: 71). Procrastination can best be described with a simple figure (Leach, 1999: 43):

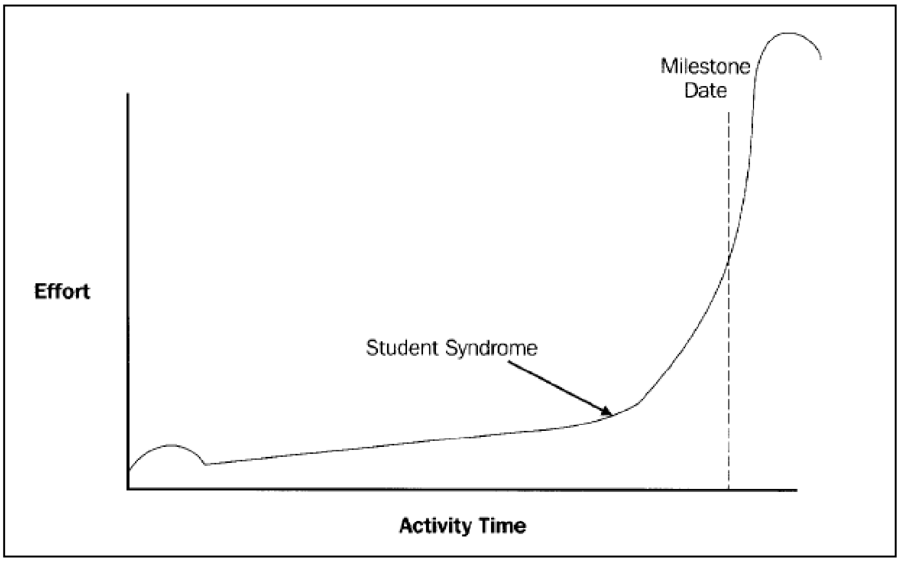


Figure 4. Illustration of the student syndrome.

The figure shows that generally people will do less than one third of the required work at the beginning of a task, or when it is assigned to them. They then realize that they have plenty of time to finish the activity and leave it waiting, typically as something more urgent emerges. Traditionally the project management environment is not short of these more urgent occurrences. The majority of the work is usually done in the last third of the activity duration as the task deadline approaches. Many times it leads to missed deadline. This phenomenon is often referred to as the Student Syndrome, since the prevalence of this work pattern is a classic among students: they will only study for the exam or write an assignment a week or even a few days before the deadline. Robinson & Richards (2010: 3) summarized the Student Syndrome perfectly: “Many tasks or activities are only executed when the level of urgency associated with them is sufficiently high to justify the effort required to accomplish them”.

The result of procrastination is that the contingency time placed in the project schedule for an activity is often wasted before any actual work has even been started (Leach 1999: 42). It is very common to find aspects related to the task which end up requiring more time than we estimated before starting the actual work (Robinson & Richards, 2010: 3). Thus, if any problems and delaying factors with a task are to arise, they are more likely to arise in the last third of the activity time when more effort has been put to it. However, eating up the contingency time beforehand is now leaving the task performer with little or no time to recover from unexpected challenges. Another expected consequence is hence that people will feel that the original duration estimate was undersized to begin with, when in fact the contrary is true (Leach, 1999: 42). This might cause a vicious circle and deepen the problem in the future even further.

There is great irony in this. Contingency time was originally inserted into the project schedule to prevent delays. The purpose of contingency is to protect the project schedule from unpredictable occurrences i.e. special cause variation. Because of the natural behavioural patterns of people it will in many cases do exactly the opposite, while leaving the project manager and the project personnel wondering why the project schedules seem impossible to keep. Procrastination is another root cause for scarcity of positive variation.

The added pitfall of procrastination is that busy people in high demand are particularly prone to wait until activities become very urgent before starting to work on them (Leach, 2005: 71). Perhaps these people are so used to working with a high level of urgency and constant firefighting that they no longer take it seriously. Unfortunately, this means that the bottleneck resource is even more likely to procrastinate than other project resources. Since the work of the high demand people is often located on the critical path, there is an elevated probability to delay the whole project with this sort of "normal" behaviour. That way the negative effect of procrastination is multiplied when it comes to the bottleneck resource.

2.2.3. Failure to report and pass on early completions

Unfortunately, from the project team members viewpoint in most project environments there are negative repercussions for being late, while there is little or no incentive to finish early (Leach, 1999: 42). Newbold words it simply: "the penalty for being late is much greater than the reward for being early" (1998: 29). In practise this means that when someone has several tasks to complete, they will be inclined to choose working on those which are in the greatest risk of running late. This distracts them away from considering the actual priorities of tasks, those which are based on more concrete things than mere deadlines visible in individual's calendars. For example, sometimes the project of a certain customer is valued higher than that of another one. Sometimes the company will have to pay substantial penalties for finishing a certain project late, while a delay in another project will have no such consequences. However, it is highly unlikely that the project worker is aware of all of these circumstances, and it should not be required of them either. All of this goes on to show that dates, deadlines and milestones in the project schedule should not be the sole determinant of project task priorities.

There are several mechanisms which indicate that finishing early is – or at least seems to be in project team members' eyes – discouraged. Firstly, when an employee finishes a task early it is usually interpreted by the employer as released capacity. Surely the employee now has vacant time in their hands. As a result, the employee will likely be assigned more work. (Schneider-Kamp, 2002: 7) Many employees will find this an unwanted consequence of finishing early; they feel they are almost being punished for good performance. If the organization is in a situation where no additional work can be assigned to that specific employee, the employee might try to artificially extend the task duration. This is because people generally do not want to end up with nothing to do. According to Newbold in those circumstances people are likely to engage in varied activities to avoid finishing the task or tasks at hand. They might take an extra vacation, clean their workstation or desk, attend in less than urgent meetings, or just generally slow down (1998: 29). This, again, is Parkinson's Law playing havoc with the project schedules.

Secondly, many people must record their working hours per project on specific systems. The fact is that no employee is productive 100 % of time. The non-productive time must also be recorded somewhere. This might result in not reporting some tasks as completed, even when they in reality are. These tasks and the projects they are a part of then get to function as sort of left-over contingency funds both in terms of time and money (Robinson & Richards, 2010: 3). This is likely to happen especially when the project is using external employees whose companies charge to the project (Leach, 1999: 43). Moreover, employees having to record their working hours are even more likely to extend their task durations according to Newbold's description, presented above.

Given the fact that finishing late comes with a punishment (even if that is just the dissatisfaction of the project manager or the projects worker's own feeling of inadequacy) project workers will try to protect themselves from it to their best abilities. Let us consider a design engineer in a project organization. If she consistently finishes the design of a certain product earlier than finishing has been estimated, it is very likely that the project manager or managers in charge of the projects will reduce the time scheduled for future design work. This puts the design engineer at increased risk of finishing the design late in the projects to come. Thus, she will not finish early, or at least will not report it (Umble & Umble, 2000: 28). Another reason the design engineer may choose to not report an early finish is that unused contingency is often viewed as a sign of prior sandbagging (Robinson & Richards, 2010: 3).

Instead of finishing early the design engineer might decide to use the residual time for superficial improvements to the design. When left with extra time, people might also perform additional check-ups on their work. Cosmetic improvements of this sort usually function more as a guise than actually add any real value to the project as a whole (Robinson & Richards, 2010: 3). This is another way in which Parkinson's Law manifests itself, and additional proof that project plans are time-wise self-fulfilling prophesies (Umble & Umble, 2000: 28 and Lechler et al, 2005: 51).

These phenomena frequently prompt the – most likely overloaded – project team member to ask themselves this question: what is my motivation to finish early when those who need my task output most likely won't start early even if I do? Quite often, no such motivation can be found. The overloaded project worker does not finish early because it will not help anyone (Newbold, 1998: 29). Even if they do, the time advantage achieved is most likely not forwarded along the project, as the successor task accountable may see the early delivery merely as an added safety time for their own task (Patrick, 1999, accessed 11.9.2015). These factors, and the culture discussed in this chapter as a whole strongly endorse the local optima. In project management context it means delivery on the scheduled date, but not before (Leach, 1999: 43). When combined with other unwanted effects of project management, such as the unintentional wasting of contingency time, it is no wonder such large portion of projects end up finishing late.

2.2.4. Multitasking

One of the core presumptions of the Critical Chain philosophy is that multitasking is a source of project inefficiency (Lechler et al, 2005: 55). According to Newbold multitasking is allowing (or being given) more than one task to be worked on simultaneously (1998: 21). He also suspects multitasking to be an outcome of over-commitment, indicating that enthusiastic or dutiful employees might be more prone to it. Due to its various negative impacts on project performance, avoiding pressures to multitask is one of the key elements of the Critical Chain approach (Lechler et al, 2005: 48). If it is successfully decreased or even eliminated, considerable reductions in project throughout times will be seen. This shorter cycle time per individual project enables the project system to carry out more projects with the same resources.

Several Critical Chain Project Management sources explain the motivations and circumstances behind multitasking, but in 2015 – in the era of chronic overburdening of work force in the Western world – elaborating on them seems almost futile. It is worth mentioning though, that Robinson & Richards note that “the shared resource multi-project model for managing projects creates a (third) problem called multitasking” (2010: 3). This is partly explained by the fact that in multi-project environments each project owner tends to view their own project as the top priority. Consequently, each project owner will exert pressure on the project team members to execute the tasks of their project first (Lechler et al, 2005: 48). These findings reveal that in certain project environments avoiding multitasking will be more difficult than in others, namely where there are multiple projects to be carried out with limited resources.

Project work sometimes involves quite a bit of waiting. Project workers everywhere are probably familiar with the situation in which one is unable to proceed with a task before receiving input from someone else. Since multitasking makes good use of this time, it must improve efficiency. This is the common reasoning behind it. Even management steps to this peril when assuming that all resources operating at full utilization equals with their organization running at its full productive potential (Robinson & Richards, 2010: 4). Multitasking people are evidently in constant demand, and hence satisfying the employer’s expectation of being fully utilized. These incorrect assumptions are embedded into the system, making the harmful side-effects of multitasking oftentimes difficult to detect and expose.

Then there are the other, more subtle advantages of simultaneously holding several balls in the air. Your project manager or colleagues are much more likely to forgive you for not completing a task on time or completing it inadequately if they know that you have the constant pressure of several important tasks on your shoulders. Also, someone who is working on twelve urgent things at any given time is somewhat more likely to be recognized as a valuable resource, than someone who is only working on one. (Newbold, 1998: 21.) As a result, convincing the project personnel and management that these harmful side-effects are real may be more complicated than it at first glance seems.

Why is multitasking so poisonous then? Concisely put, it causes delays, additional setups, and a loss of focus, all of which are the perfect building material of an overdue, overrun-budget project. The more projects are running simultaneously, the more these adverse effects surface (Umble & Umble, 2000: 29). The project personnel is under the constant pressure to be doing something else than they are actually doing, and many are very much used to this. The end result is multitasking at its worst: all tasks take a long time to finish, and none of them finish early (Newbold, 1998: 29). The following figure illustrates the outcomes of multitasking:

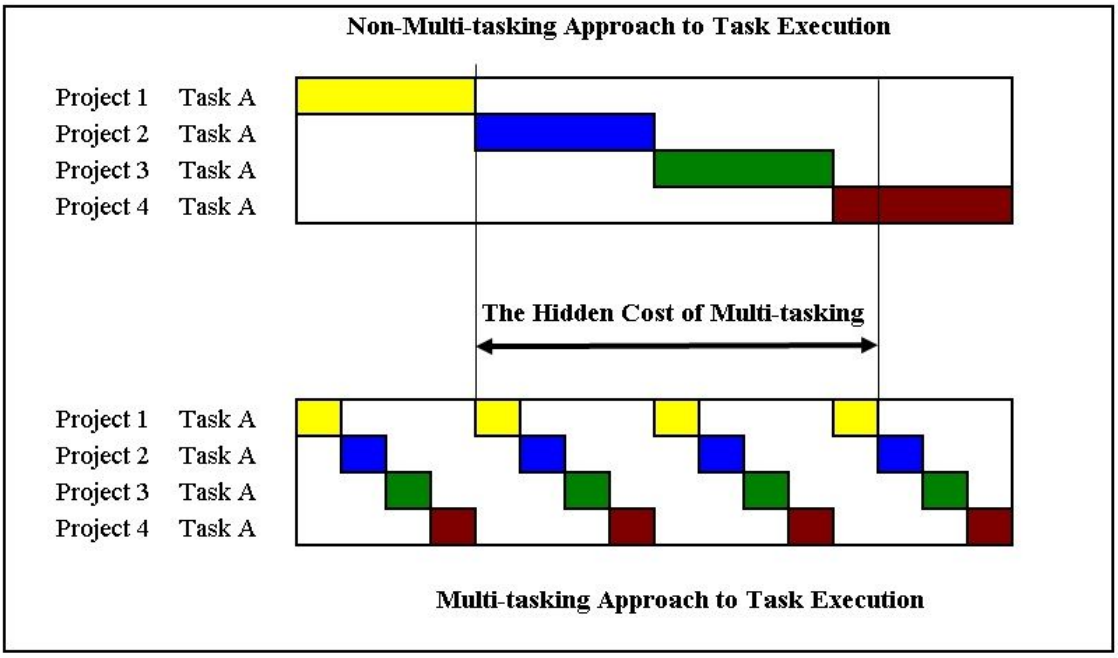


Figure 5. The negative effect of multitasking.

Notice that with the preferred, non-multitasking approach Project 1 got Task A completed much earlier than it did when the project worker was switching between tasks. If multitasking is a standard way of working in a company, there is also another danger: the time it took for the projects to reach completion of Task A has now become the normal task duration for Task A. After all, it is supported by experience and perhaps even performance data (Leach, 2005: 98). Unfortunately, the reality is often closer to the lower graph, as project workers are expected to *show progress* on all waiting tasks, rather than actually completing them one by one (Robinson & Richards, 2010: 4). In the situation displayed above, this will delay the completion of three tasks out of four. Or, when the task priority management is unclear, Project 3 might get task A completed before any of the other projects, even if projects 1 and 2 are more urgent. Obviously, wise management will not prioritize *showing* progress over *actual* progress, but due to the issues discussed previously in this chapter, this behaviour and favouring it is often subconscious.

The multitasking situation demonstrated in figure 3 is still overly optimistic in one sense: it contains zero setup time. This is unrealistic, as most people require a certain recovery and setting-up time when swapping between tasks. The costs associated with setup times are twofold; obvious and hidden. For once, there is the direct time people need in order to find the right materials, to reconnect with the subject, and to in general mentally tune in (Newbold, 1998: 27). The hidden costs are much trickier to spot and comprehend. When someone has several tasks to be completed, they have to keep track of the developments related to all of those tasks (Newbold, 1998: 28). Are there any changes in the project scope or customer requirements? Are all specifications and guidelines still the same as they were last week? What were the nine other things I had to keep in mind for these tasks? One has to keep looking over their shoulders constantly, which consumes a lot of energy and thus increases inefficiency. The bottom line is that the value of all futile setup time for the project, and ultimately for the customer is nil.

Many sources talk of *bad* multitasking, as to say there is such a thing as *good* multitasking. According to Leach (2005: 99) this is in fact the case. He states that "bad multitasking is multitasking that extends the duration of a project task". Thus, there are some circumstances under which multitasking could be accepted. The project manager just needs to be absolutely certain that each project worker knows the priorities between different tasks and organizes their work accordingly (Newbold, 1998: 22). Another requirement is to confirm that one task is completed before moving on to the next (Herroelen & Leus, 2001: 10). There may well be other means to ensure these things, but with the Critical Chain method it is ingrained, as it strictly requires providing resources information to determine which task to work on next (Leach, 2005: 99).

Then how does a manager know whether multitasking is taking its toll on their organization? Discovering the answer could be easier than thought. Any organization, for which the term *firefighting* describes the ordinary mode of operations, can be assumed to suffer seriously from the undesired side effects of multitasking (Robinson & Richards, 2010: 4). We can conclude that such a project organization may well be a good candidate for a Critical Chain Project Management implementation.

2.2.5. Project delays caused by path merging

Most projects are complex enough to contain multiple task paths. The nature of projects dictates that all paths must eventually merge into the critical chain – or path, in more traditional project management terms. Connected to this subject is scarcity of positive variation, which was discussed in chapter 2.2.2. From there we learned that positive variation occurs seldom. Now, thorough research shows that even when it does occur and is successfully reported, the delays caused by path merging will usually override the achieved advantage (Schneider-Kamp, 2002: 7). The observation is clearly illustrated a simple figure (Leach, 1999: 44):

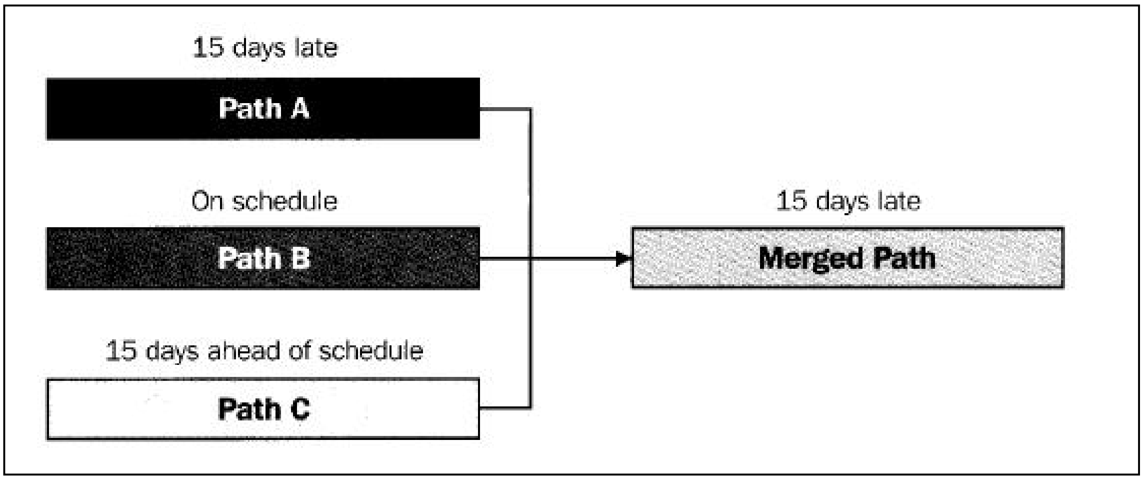


Figure 6. Impact of delays in merging paths.

Even with an extremely simple project with only three paths, the effect of the delay in Path A is passed on as a whole, while the advantage of Path C being ahead of schedule is lost in its entirety. More complex projects provide countless more possibilities for such delays, multiplying the adverse effects by the end of the project. It is almost as if path merging forms a *filter* eliminating positive fluctuations where they would be available (Leach, 2005: 96). As a result, when no proper protecting mechanisms are used, delays in non-critical activity chains which merge into the critical chain are prone to cause unwelcome delays on it. (Cohen, Mandelbaum & Shtub, 2004: 40-41). This unfortunate effect is often made worse by the fact that usually path merges occur near the project end date. This explains a part of the observation that projects always seem to run into most trouble near the end.

So when you create the project schedule in the traditional way, you are more or less inviting these problems in path emerging points. In that case, after these points a successor activity can only begin after the path with the longest delay has completed. (Schneider-Kamp, 2002: 7). And those delays almost always occur. However, according to the Critical Chain philosophy, the activities on the critical path should always be enabled to start when the previous activity or activities on the path are finished. They must not be required to wait for any sub-critical activities. (Rand, 2000: 175) As a remedy, Goldratt introduced the concept of a feeding buffer, illustrated in figure 5 (Raz et al, 2003: 26).

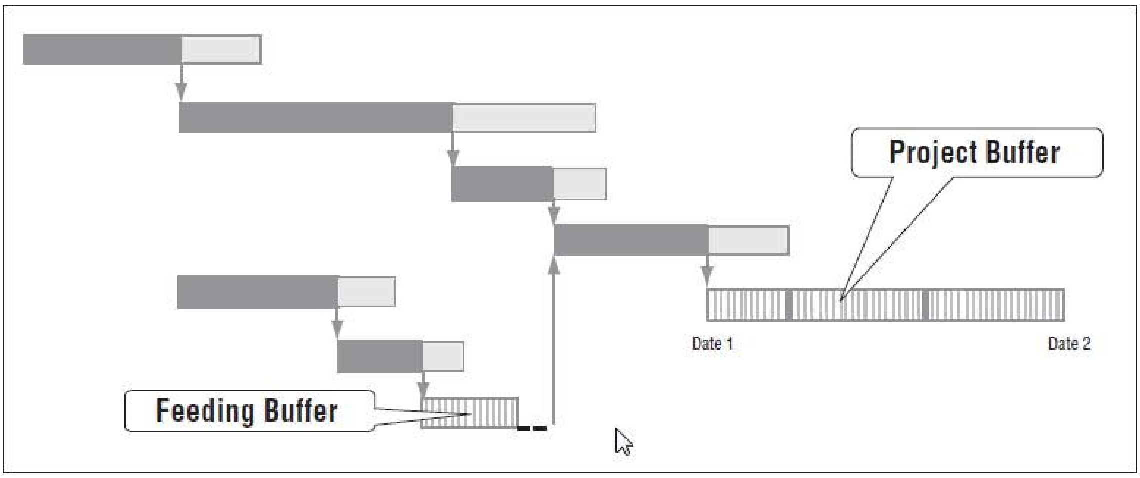


Figure 7. Project schedule with feeding buffer.

We see that the feeding buffer is ultimately formed the same way as the project buffer. The safety margin of each individual task on the non-critical chain is reduced so that the task has a 50 % chance of completing in the scheduled time. Then a buffer is placed on the non-critical chain before it emerges to the critical chain. This is the feeding buffer, the length if which according to some sources should be 50 % of the non-critical chain preceding it (Herroelen & Leus, 2001: 12). Other sources say that the length can be adjusted as seen fit by the project manager (Raz et al, 2003: 26). A further benefit of the feeding buffers are that besides protecting the project as a whole, they provide a way to measure the feeding chains, without taking the focus away of the critical chain (Leach, 2005: 96).

Feeding buffers nevertheless have their critics too. Raz et al present cases where the feeding buffers are problematic to implement (2003: 27-28). The authors claim that the feeding buffer concept presumes a project to have feeding chains starting and running in parallel, and eventually emerging into one. Raz et al believe that in reality many projects have several project deliverables and are thus more complex than this, beginning with a core of central activities separating into parallel tracks which merge at various intersection points. In a complex project of this kind a task may have both predecessors and successors from different chains. That will make calculating and positioning the feeding buffers substantially more difficult. Herroelen & Leus also remark that insert feeding buffers might result in the critical chain no longer being the longest path in the project network (2001: 14). On the other hand, Critical Chain Project Management today is largely run with the help of software, which supposedly can resolve these issues.

2.2.6. Loss of focus

The unwanted effects discussed above in detail can in themselves be seen as symptoms of lost project management focus. There are also other rather subtle aspects of established project management approaches which may easily cause project managers to lose focus. For example, the critical path might change during a project, causing the project manager to get confused or out of touch with their project. Some project environments utilize only earned value based project control. The downside is that earned value as a measurement considers money, and not schedule importance (Leach, 1999: 44). This might distract the project manager to put too much focus on an individual activity, instead of protecting the completion of the whole project. This is harmful, as “the focus must be shifted from assuring the achievement of task estimates and intermediate milestones to assuring the only date that matters - the promised project due date” (Herroelen and Leus, 2001: 4). Sometimes, if a project manager has forgotten this important focus, they may engage in tampering. Tampering is the attempt to fix any variation within the statistical limits of common cause variation, and is always harmful to performance (Leach, 1999: 44).

Further aspects causing loss of focus exist on a more fundamental level. With the conventional project management mindset, management attention is largely on the performance of single projects. Management is focused on ensuring that each single project would meet its goals in terms of time, cost, and scope. What is often not thoroughly understood is that these projects do not exist in a vacuum; they are run in a system where an occurrence in one project will have an effect on the other projects. According to Lechler et al, this leads to *local* – rather than *global* – optimization in multi-project environments (2005: 48).

Goldratt, on the other hand, advised project managers to always think global and not local. He was a strong endorser of the throughput mindset, which emphasizes increasing throughput over the traditional mindset concentrating on lowering costs (Newbold, 1998: 121). The throughput mindset requires substantial understanding of cause and effect. The project manager must understand the impact of an action or decision taken in one part of the project on the other parts of said project, and ultimately the project system as a whole. (Rand, 2000: 147) So for the project manager to stay focused on the right things they need to have the ability to consider how actions in one project affect reaching the organization's targets overall. It is argued that this indeed is the greatest advantage of Critical Chain Project Management; the focus is on maximizing the performance of the whole system (Lechler et al, 2005: 55).

2.3. Critical success factors for CCPM implementation

Transforming an ordinary project management environment into a Critical Chain Project Management environment requires both management and project employees to make drastic changes in their mindset and behaviour. Lechler et al describe the change process as "a paradigm shift from a local to a global perspective, and from one's own accountability to common goal accountability" (2005: 48). Hence all the issues which potentially influence the success of the transition need to be acknowledged and carefully studied. In this section, the key success factors for Critical Chain Project Management implementation are presented and reviewed. The relevancy of each success factor was determined in the context of Wärtsilä Catalyst Systems, so that only the applicable success factors are described here.

2.3.1. Identified need for change

A discussion regarding this topic with a Theory of Constraints professional Jyrki Ylipulli in Wärtsilä revealed that before implementing any Critical Chain concepts, a clear need for improvement should be identified in the project environment. If Critical Chain Project Management is not needed, implementing it will not be beneficial. In fact, it will be costly and might even end up being counterproductive. It was stated that not every organization needs for example a shortened lead time. Nonetheless, in the current business atmosphere in Finland it is hard to imagine an organization not wanting either increased output with the same resources, or the same output with fewer resources. Perhaps the motivation for jumping on the CCPM boat could be the same as was for the development of the approach in the first place. According to Rand (2000: 174) the reason for developing Critical Chain Project Management was the presence of persistent problems in project environments which the existing methods, approaches and even expensive software have not been able to eradicate. Surely all project organizations are familiar with issues such as late completion, budget overruns, and the need to cut the scope or contents to be delivered. Thus we may conclude that at least a certain curiosity or a theoretical interest should be present in any project environment.

As soon as the need for change is recognized in the project environment, and initial interest towards the elements of Critical Chain Project Management has risen, management or whoever is the potential CCPM driver should seek to identify the problems which implementing Critical Chain Project Management would be required to solve. So, when we know that things need to change, we must then ask why they need to change; what are our goals? Any organization aiming at implementing Critical Chain Project Management should have their goals clearly identified, since the targets of CCPM implementation have a proven effect on its success. The probability of success is increased if the implementation driver is one of the following: enhanced way of managing project resources, increased on-time delivery, increasing chances that projects are completed, speeding up new product introduction, or achieving financial benefits (Repp, 2012: 144). For example, a major supplier of large power generators wanted to increase the speed of developing new products, and after CCPM implementation was able to accomplish a 61% increase in number of projects completed (Realization, 2012, retrieved 8.9.2015).

The next step is to investigate whether the conditions in the organization are favourable for Critical Chain Project Management implementation. These conditions are such as a solid foundation in project management fundamentals, sufficiently small project organization, familiarity with network-based scheduling techniques, the presence of an invested CCPM driver, having a schedule or quality focus rather than budget focus, and previous use of cost and time tracking. (Repp, 2012: 54-55, 94, 97). Furthermore, Huang, Rong-Kwei, Chung, Hsu and Tsai (2013: 56) note that when considering Critical Chain Project Management implementation, reducing local task duration variations or adding more resources should not be the first priority; instead it should be stabilizing the system. The question here remains, what if the system is already stable but on a non-satisfactory level.

Resource management in a multi-project environment is always somewhat demanding. This is also a recognized weakness in current widespread project management theory and practice (Lechler et al, 2005: 46). Repp demonstrates that projects frequently battle over resources in multi-project organizations, whereas after the adoption of Critical Chain Project Management projects have access to the required resources without internal fights (2012: 27). This indicates that in many cases the requirement for improved resource management could be the identified need for change. Goldratt's book Critical Chain (1997) originally addressed the multi-project resource management inadequately, but the CCPM methodology has since been sufficiently complimented in this regard (Steyn, 2002: 77).

While it is true that an extremely skilled and experienced project manager might be able to keep their projects on track even in more chaotic circumstances where all or most of the undesired project management effects are present, not all project managers can be extremely skilled and experienced. As Robinson and Richards put it: "There is still a need to find an approach to project management that … can be taught to and successfully applied by the majority of project managers of *average abilities and experience*." They go on to state that the Critical Chain method has been field tested and further refined since the late 1990's, and could very potentially be the approach enabling even less experienced project managers to perform outstandingly. (Robinson & Richards, 2010: 1) So from this perspective, even a project environment without chaos or substantial trouble might recognise a need for change in its project management practises.

2.3.2. Management commitment and focus

Management commitment and correct focus are widely perceived as one of the most significant, if not *the* most significant Critical Chain Project Management implementation success factors. Repp (2012: 122) conducted in-depth interviews with various people who had been involved in a Critical Chain Project Management implementation processes across different organizations, and found that in both multi-project and single-project implementations, leadership support is perceived to be the most significant factor for success. Huang et al found similar results in their case study (2013: 65) and concluded that the single most crucial success factor is top management support and commitment. So leadership commitment both is crucial for a successful implementation in actuality, and is perceived as such by the people in the implementing organization. This works adversely too, as Repp found via statistical analysis that the most detrimental factor influencing CCPM success rate is the lack of leadership support (2012: 124). Especially middle management resistance is prone to cause difficulties (Repp, 2012: 142). At this point, it might even be beneficial to extend the commitment requirement slightly to cover all stakeholders, since "obtaining *endorsement of project stakeholders* is an important success factor for implementing CCPM in an organization" (Dilmaghani, 2008: 47).

Figure 6 presents Newbold's illustration of how to achieve continuous improvement through Critical Chain Project Management (1998: 150). Here, management effort is specified in four different boxes, and obviously the process will not work unless management fulfils the expectations set for them. The expectations set on management in CCPM literature seem somewhat radical at places. For example, in the Huang et al case study, management had committed a whole month of time in order to adopt the new philosophy and to help the rest of the organization to adopt it too (2013: 64). So, actual hands-on work is expected from management – not just verbal commitment. Obviously, after the initial CCPM implementation phase management will have a number of on-going tasks as well, for example prioritizing all new projects according to the drum resource, and sticking to the Critical Chain induced project task priority list (Leach, 2005: 162-163). This topic appeared in the conversation held with Jyrki Ylipulli too, as he stated that after the CCPM rollout management should never start dispensing tasks overrunning the Critical Chain Project Management System. The project managers will hastily start complaining that the system is not reliable, and if the system is not trusted it will eventually collapse. On the hand, management commitment shows at the end of the supply chain too; Pai reported that the customers of the CCPM case study company Synergi had renewed credence in Synergi's commitment to them (2014: 19).

Figure 8. Continuous improvement according to CCPM.

According to Lechler et al (2005: 48) Critical Chain Project Management offers simple resolutions which help managers to focus on the essentials even in a complex multi-project environment. For example, the requirement that management focus should always be on the constraint (Leach, 2005: 58), is relatively easy to grasp. Nevertheless, for management to be aware of this or any of the other requirements the Critical Chain method utilization places on them, they need sufficient CCPM understanding. It is also necessary since after Critical Chain Project Management has already been deployed, there will still be occasional hesitation and reversion to the pre-CCPM approach among the project personnel (Huang et al, 2013: 64). Management needs a certain level of CCPM knowledge to offer support to their organization in those situations.

2.3.3. Change management and training

Shifting from traditional project management practises to the Critical Chain world requires a major behavioural change as well as a paradigm shift from a local to a global perspective; a project culture where the focus is turned from one's own accountability to common goal responsibility (Lechler et al, 2005: 48). Thus, the perspective adopted to change management regarding the Critical Chain Project Management implementation should be about carrying out this paradigm shift. A paradigm shift is a fundamental change in beliefs, and as such it is bound to be met with substantial resistance. The following figure summarizes the commonly experienced layers of change resistance from the Theory of Constraints perspective (Goldratt-Ashlag, 2010, retrieved 9.9.2015):

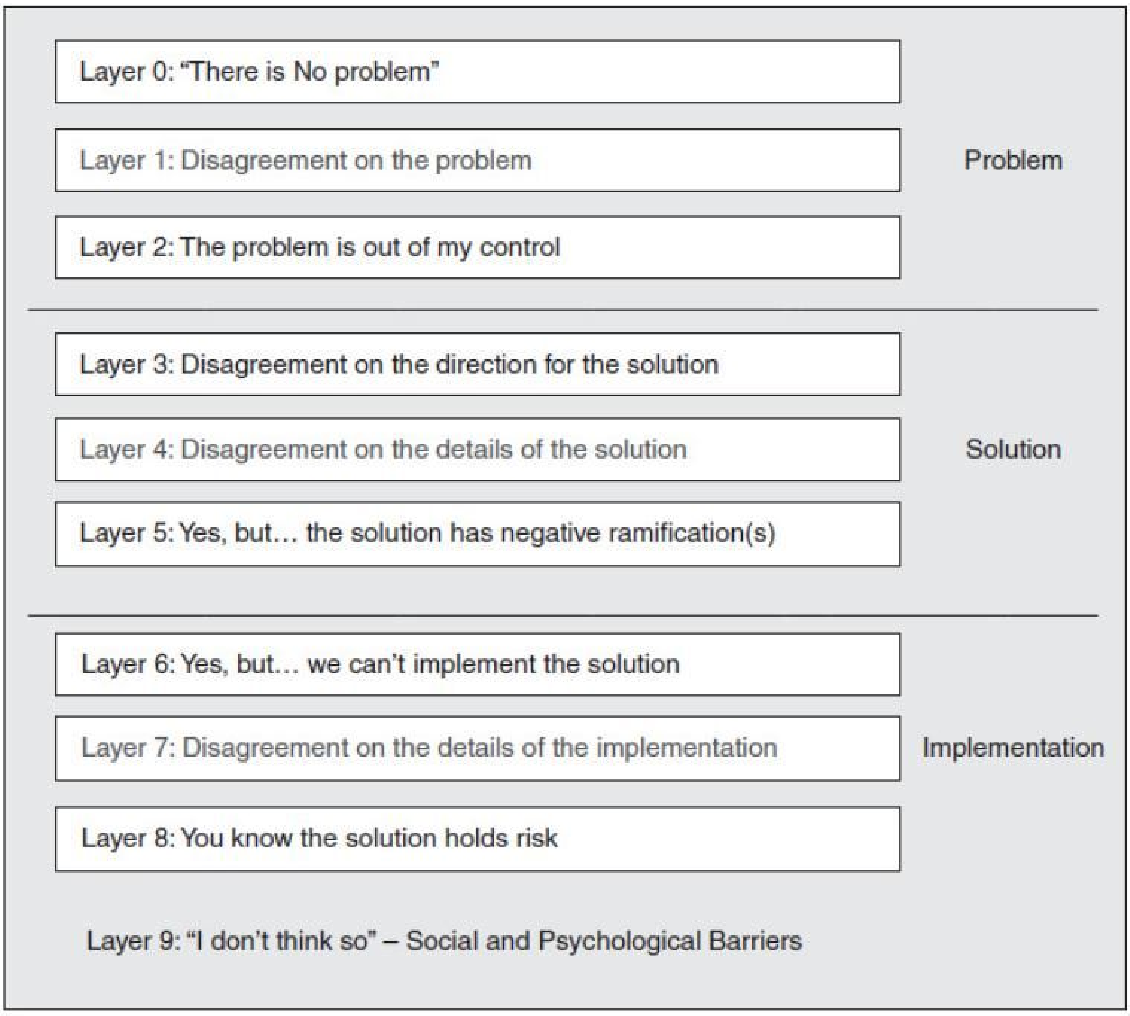


Figure 9. The layers of resistance according to TOC.

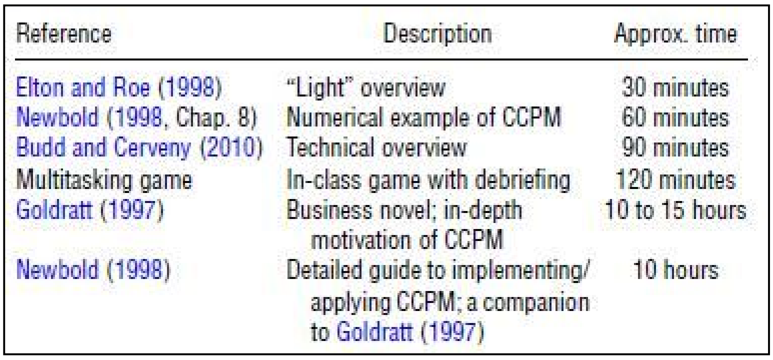
What is presented above is exactly the usual offset on resistance to change: it hinders development and causes problems. Another perspective exists though: a certain degree of change resistance is essential for any stable system (Leach, 2005: 203). Hence resistance to change cannot be deemed good or bad as such. Of course, when you actually want to carry out a fundamental change in an organization such as CCPM implementation, resistance to change is more a burden than an asset and needs to be addressed with a diverse range of tools. For that purpose, below is presented a set of advice from Critical Chain Project Management literature on how to carry out the change management process.

Repp lists the most important change management factors to be involving all stakeholders – including the customers, suppliers, and contractors – in the CCPM rollout planning and execution, maintaining the commitment through the implementation, and reinforcing CCPM behaviours via performance management (2012: 144). Realization (Multi-Project Critical Chain: Three Vital Points, 2007, retrieved 11.8.2015) insists that when switching from traditional project management to the Critical Chain one, you should concentrate on policies, not behaviours. On the other hand, the takes on the topic of behaviours versus policies and tools vary considerably. For example Newbold, whose company ProChain Solutions Inc. has long been involved with extremely successful Critical Chain implementations, claims that employing tools, such as software and extensive personnel training will not lead to substantial improvements. He specifically states that it is behaviour change which creates the real improvements (Newbold, 2008: 2).

More specific advice can also be found. Repp suggests conducting an initial workshop at the beginning of the implementation. Her interviews also revealed that specifically middle management is influential in carrying out the change management process, so particular attention should be paid on the CCPM buy-in of these people (Repp, 2012: 146). Huang et al instruct those who implement Critical Chain Project Management to ensure that quick and clearly visible wins are available. Evidently, this has the power to rapidly turn resistance to change into momentum for change (2013: 65). Realization presents three particularly useful policy changes: 1) replacing measurement requiring individual task finished on time with measurements driving low work-in-process, 2) endorsing a minimum length of buffer time in each project, 3) freezing project due dates so that only top management is allowed to change them (Multi-Project Critical Chain:

Three Vital Points, 2007, retrieved 11.8.2015). These are effective ways to help the personnel accept and actively support the new project management policies.

One specific matter to consider in the organization pursuing Critical Chain Project Management implementation is the possible presence of a CCPM Champion, a kind of a guru who has previous experience and knowledge and can take responsibility for the training for example. Repp summed up the experiences about Critical Chain Project Management champions with a single quote from an interview respondent: "Without the champion's high level of commitment and daily involvement, we would have failed to make the necessary changes, and CCPM would have been perceived by the project personnel as another management flavour of the month" (2012: 32). The presence of the CCPM reference points or experts will help in executing change management successfully, but it is also a significant supporting factor for maintaining the desired changes once they have been applied (Dilmaghani, 2008: 48). If the champion is from outside the Critical Chain implementing organization, for instance an external consultant, the necessary time of their attendance should be carefully considered. Millhiser & Szmerekovsky justifiably present their concern for the sustainment of the CCPM methods once the champion is no longer present (2012: 73).



Reference	Description	Approx. time
Elton and Roe (1998)	"Light" overview	30 minutes
Newbold (1998, Chap. 8)	Numerical example of CCPM	60 minutes
Budd and Cerveny (2010)	Technical overview	90 minutes
Multitasking game	In-class game with debriefing	120 minutes
Goldratt (1997)	Business novel; in-depth motivation of CCPM	10 to 15 hours
Newbold (1998)	Detailed guide to implementing/ applying CCPM; a companion to Goldratt (1997)	10 hours

Figure 10. Resources for teaching Critical Chain Project Management.

It is stated in several sources (for example Lechler, 2005: 56, Raz et al, 2003: 24, Repp, 2012: 55) that the Critical Chain Project Management training given to the personnel of the implementing organization should be extensive, and will thus initiate substantial costs. Millhiser & Szmerekovsky usefully summarize different resources available for teaching Critical Change Project Management (2012: 68). The resources are presented in figure 8. The teaching resources are shown with their respective extent, which helps in selecting the right material according to the time available for the training.

In addition to the initial Critical Chain Project Management training, some attention should be paid also on post-implementation training. Huang et al suggest that follow-on training be given during the first year of implementation (2013: 66). The purpose of this is to strengthen the Critical Chain knowledge and to prevent the personnel from reverting back to previous ways of working. Preferably, the follow-on training should be carried out by CCPM experts. In case Critical Chain Project Management is decided to be implemented, a training plan for the Catalyst Systems' CCPM rollout will be created outside the scope of this thesis. The training plan will be based on the premises and considerations presented in this chapter.

2.3.4. Buffer management and measuring project performance

In many project environments buffers are both determined and managed with informal methods, based on the intuition of the project manager and project team members (González, Rischmoller & Alarcon, 2004: 2). Obviously, a disorganized and un-standardized way of buffer management creates many problems, leading to project delays and downright failures. Even Critical Chain Project Management has been criticized for lacking mathematical analysis (Ashtiani, Jalali, Aryanezhad & Makui, 2007: 1), but this concern no more valid nowadays. Buffer management in present-day Critical Chain Project Management has a solid base in statistics (for example Ashtiani et al, 2007, Herroelen & Leus, 2001, and Leach, 2005: 93). Buffer management considerations relevant to organizations targeting at implementing CCPM successfully are illustrated in this chapter.

As previously indicated, including safety time for individual activities incorporates an enormous amount of waste in the project schedule. Removing this waste is beyond doubt an effective way to expedite project completion (Umble & Umble, 2000: 30). Once the safety time and sandbagged buffers from individual activities have been removed, other ways to protect the project have to be utilized. In the Critical Chain Project Management world this is done with three different types of buffers. The concepts of project buffer, feeding buffer, and resource buffer were explained in 'Definitions and key concepts', and described in more detail in section 2.2. Placing and managing the buffers correctly also helps in avoiding many of the unwanted effects in project management described previously in said section.

Failure in proper buffer management is linked to Critical Chain implementation failures (Repp, 2012: 47). Repp (2012: 99) found that "low-success CCPM implementations did not develop plans and take action when action was indicated". Therefore, it is crucial to create an adequate buffer management plan and then follow it rigorously. One has to be slightly careful not to exaggerate in buffer sizing though, since that might lead to loss of business opportunities (Millhiser & Szmerekovsky, 2012: 70), in the form of lost offers for example. It is essential to note that applying controlling actions extensively, for the wrong reasons, or at the wrong time will work counterproductively in terms of the project performance. Patrick (1999, retrieved 11.9.2015) insists that the project team ought to plan and act to recover as per indicated by the buffer status, but *only* when needed so that unnecessary distraction of project resources is avoided, as they need be allowed to focus on the work they are doing. Reacting unnecessarily to common cause variation through buffer management is likely to influence project performance negatively (Repp, 2012: 46).

One of the greatest benefits of buffer management the Critical Chain way is that it has been proven to provide a simple and consistent view of the project status (Dilmaghani, 2008: 41). The project and feeding buffers are divided into three sections according to the *fever chart* demonstrated in figure 9 (Patrick, 1999, retrieved 11.9.2015). Consequently, the project buffer consumption rate (sometimes called the buffer burn rate) can be used as a reliable method to both monitor and report the project status.

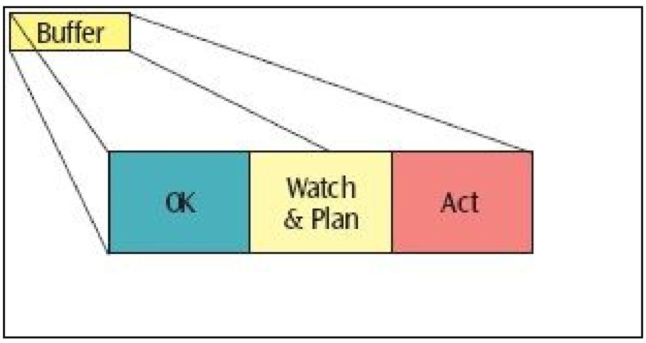


Figure 11. Buffer fever chart.

The buffer is divided into green, yellow, and red parts, and the buffer consumption is the key to managing project performance. Staying in the green zone indicates that the project is proceeding as it should. Buffer penetration in the yellow zone raises a flag to determine corrective actions in case the situation deteriorates further. Should it happen that the threshold to the red zone is crossed, the mitigation plan will then be put into action (Patrick, 1999, retrieved 11.9.2015). As the project performance monitoring in traditional project management is based on an estimated percentage of what has been done so far, it might be difficult for project team members to differentiate critical tasks from non-critical. CCPM buffer management directs the focus to right tasks, since it evaluates the impact of each task on the project buffer (Repp, 2012: 188). Additionally, *early indications* of possible problems are enabled, which offers the project manager enough time to come up with the solution before project due date is endangered (Sood, 2003, retrieved 11.9.2015).

In addition to providing a very effective project control tool, buffer management the Critical Chain Project Management way also provides history data for measurement purposes (Sood, 2003, retrieved 11.9.2015). With the data available from buffer monitoring and recording, creating performance indicators is convenient and simple. Monitoring the buffer burn rates over time will indicate for example where task duration estimates need to be adjusted or any other improvements made. Perhaps surprisingly, Huang et al found buffer management to have an extremely positive effect on the level of communication in the organization utilizing it. Consequently, some interviewees in their case study even perceived Critical Chain mainly as a "communication vehicle" (Huang et al, 2013: 65).

2.3.5. Software considerations

Widely used project management techniques such as Critical Path Management (CPM) and Program Evaluation Review Technique (PERT) are based on an assumption of unlimited resources. In reality, this is of course never the case; resources in a project management organization are always scarce, or at least not infinite. This is known as the Resource Constrained Project Scheduling Problem (Dilmaghani, 2008: 12). Rand argues that the creation of Critical Chain Project Management was initiated because the Critical Path method repeatedly fails and that even expensive software does not prevent this from happening (2000, 174). Does Critical Chain Project Management software perform better in this sense? In this chapter the relevant aspects related to choosing and running CCPM software are reviewed.

Adopting the Critical Chain way of project management requires departing from almost all of the commonly accepted practises of managing projects, but also the use of particular software indented for CCPM (Raz et al 2003, 24). More specifically, successful implementation of CCPM requires a software tool that supports the concepts of buffer creation and management (Raz et al 2003: 30). This is one of the two major sources of cost related to implementing Critical Chain Project Management; culture change and acquirement of software tools. Raz et al stated (2003: 30) that the array of available software tool options is limited and bound to be somewhat expensive. Now, this statement was made in 2003, and twelve years in the software industry is quite a long time. A more recent summary about the current project management software tools with Critical Chain capabilities is available from Millhiser & Szmerekovsky (2012: 75). It is presented in figure 10.

Tool	Company	Year	Website
Agile-CC for AdeptTracker	WangTuo Software	2008	http://www.adepttracker.com/index.html
Aurora-CCPM	StottlerHenke Associates, Inc.	2011	http://www.stottlerhenke.com/product/products/aurora-ccpm/
BeingManagement CCPM	Being Co. Ltd.	2011	http://www.toc-ccpm.net/eng/index.html
cc-Pulse/cc-MPulse	Spherical Angle	2011	
CCPM+	Advanced Projects, Inc.	2011	http://www.advanced-projects.com/home.aspx
Concerto	Realization Technologies, Inc.	2011	http://www.realization.com
Lynx	A-Dato Scheduling Technology	2011	http://www.a-dato.net
ProChain	ProChain Solutions, Inc.	2011	http://www.prochain.co
PSNext	Sciforma Corp.	2011	http://www.sciforma.com

Figure 12. Project management software with CCPM capabilities.

Reviews and evaluations of all these software solutions are easily found online, and some even in scholarly articles. For example, ProChain is said to be a useful tool which enables project management the TOC way while also supporting the psychology behind it (Rand, 2000: 174). ProChain and a few other software tools have the advantage that they are run as add-ons to Microsoft Project, which is probably the most widely used project scheduling software across project management organizations. As is visible from figure 10 there are many probably reasonable alternatives to choose from but according to Robinson and Richards it is the details and features of the implementation environment which should navigate the software choice (2010: 9). So each project organization must review the software offering from its own grounds in order to make the most suitable choice.

Whenever implementation of new software tools is considered, two things must be assessed with care; their compatibility with existing systems and the transition period from old to new. This applies to Critical Chain Project Management software too. In fact, Repp goes as far as stating that proper integration of the CCPM software tool into legacy systems is one of the crucial factors to the implementation success (2012: 34). An evaluation about the available Critical Chain software solutions was carried out in Wärtsilä in 2014. One of the key findings was that SAP integration of CCPM software was strongly discouraged. While SAP add-ons exist, for the Critical Chain software to function appropriately most or all SAP data would need to be organized in a certain way. With a system as rigid as SAP, the workload might become too extensive.

Finally, let us consider a few user related issues. It has already earlier been asserted that implementing CCPM requires extensive training from the paradigm shift angle. In addition, adequate training of the new software must be given project personnel at an early stage. Repp has listed early training on the CCPM software as yet another success factor related specifically to the change process (2012, 55). Jyrki Ylipulli, the TOC professional in Wärtsilä, stated in a discussion regarding Critical Chain software that the tool needs to be simple and pleasant to use as people naturally resent entering data to different systems. It is seen as extra work to begin with. Thus, we can conclude that the user interface must have a high degree of user-friendliness in order to encourage the project personnel for the primarily unpleasant task of data feeding.

2.3.6. The reward system and other human resource concerns

In any professional community it is crucial to set meaningful, feasible performance objectives, to monitor whether the actual performance level meets these targets, and to provide pertinent feedback to employees. According to Lechler et al these are especially important issues in a project management environment, due to the dynamic nature of projects (2005: 53). Transforming a traditionally managed project environment into a Critical Chain managed one requires a fundamental change in all of these areas. Schneider-Kamp states that un-learning must always precede learning, and this holds true particularly well in the case of Critical Chain Project Management implementation; old habits must be unlearned and then replaced with new ones (2002: 8).

The Critical Chain Project Management philosophy requires task performers to start an activity as soon as they have the input, work full-time on the activity with no multitasking, and pass on the activity as soon as it is completed (Leach, 1999: 47). Project team members must understand that a certain level of common cause variation is allowed, thus being faster or slower than the estimate is and in no way a sign of failure. Performance appraisal of project workers should not concentrate on keeping or not keeping deadlines, but on monitoring whether the employees work effectively on their Critical Chain system assigned activity, and report their own progress openly (Schneider-Kamp, 2002: 8). These prerequisites raise a set of questions which are particularly interesting from the human resources viewpoint. With what mechanisms and incentives are we going to encourage people adhering to these practices? How is it possible to monitor whether or not they are doing so? How are we going to reward it if and when they do?

In their Three Vital Points slide, Realization gives a very rough-level instruction for keeping employees on the right track: "Replace measurements that require individual tasks to finish on time with the ones that drive low work-in-process" (retrieved 11.8.2015). As was demonstrated before, the CCPM specific buffer status fever chart provides such a measurement tool. However, Dilmaghani cautions that buffer status should never be used to directly measure the project team members' performance, as that will direct the personnel more towards the old milestone and date oriented mindset (2012: 54). Leach outlines that the managers should always evaluate the project team members positively if they are working on the activities according to the CCPM activity performance paradigm, while disregarding the actual durations tasks consume (Leach, 1999: 48). This idea may sound rather utopian to those used to an ordinary project environment, also it still does not provide us with anything tangible. While the above stated might be good general guidelines, they do not elaborate how to persuade the CCPM way of working on an individual employee level.

It is a somewhat common outlook in academic literature that applying the Critical Chain Project Management approach requires wide-ranging changes regarding the implementing organization's human resource culture (for example Schneider Kamp, 2002: 8 and Raz et al, 2003: 30). When only a single sub-organization in a large international company is intending to adopt CCPM, carrying out such extensive human resources policy changes is in all probability impossible. Nevertheless, in such companies development discussions between each employee and their manager are usually held on a regular basis. In these development discussions performance targets are set and reviewed annually. It is very simple to set these individual targets in accordance with the Critical Chain Project Management essentials. That way the possible bonuses that project team members receive based on their performance are also tied to the members' compliance with the Critical Chain methods.

Tying the rewarding system to success in the Critical Chain Project Management execution also provides a way to strengthen the personnel's commitment to CCPM in the long run. In their case study research, Huang et al found that "sharing the benefits of improvement with employees through bonuses and pay raises provides momentum for sustainability" (2013: 66). Enforcing sustainability on an employee level is valuable in its own right, but also because of the acknowledged shortcoming of CCPM in respect of company-level long term planning. Because of the novelty of the TOC performance measurements in general, aligning management decision making with the long term CCPM goals can be confusing (Watson et al, 2007: 399).

3. RESEARCH METHODS AND DATA

3.1. Data collection

The research data was collected through personal interviews of the Catalyst Systems' personnel, and some key stakeholders outside the organisation. The semi-structured interview style was used. A set of pre-decided questions were asked and the direction and structure of the interview guided to some extent, but room was also left for the interviewees to raise topics that were not asked about directly. The aim was to allow the interviewees to explain their views and opinions about project management in Catalyst Systems in a straightforward and honest manner. The semi-structured interview method was chosen because it is especially suited to researching attitudes, beliefs, values and motives (Barriball & While, 1994: 329).

Two set of interview questions were formulated; one for catalyst delivery project team members and another for Catalyst Systems management. The names and titles of those interviewed are listed as an appendix, as well as are the two sets of interview questions and the interview reports. When interviewing the case study organization's project personnel, the main focus was in finding out to what degree the unwanted project management effects are currently present in the Catalyst Systems customer delivery projects. Robinson & Richards warned that "one should not expect their presence in an organization or project to be easily detectable" (2009: 2) so I did not expect the investigation to be an easy one. The main purpose of the Catalyst Systems management interviews was detecting potential commitment to CCPM implementation. The special characteristics and outcomes of the management interviews are explained in more detail in chapter 4.10.

The interviews were recorded, so as to enable the recordings' use as backup when required. As the interviewer and respondents know each other from before, a convenient level of informality was retained in the interviews despite the recording. The familiarity between the interviewer and the respondents also ensured that the interviewees did not feel they had to give answers which they believe are the socially more acceptable ones, which can often be a challenge in a personal interview situation (Barriball & While, 1994: 331). Interviewer friendliness, approach, and attitude towards the interviewees are important reliability and validity factors in personal interviews (Barriball & While, 1994: 332). In this case study, the familiarity and good relations between the interviewer and the interviewees also thus increases the validity and reliability of the collected research data. Transcribing the interview recordings was seen unnecessary; additional documentation of the data attained in the interviews was managed by making notes during the interviews. Interview reports with the questions and their answers were then written in Microsoft Word directly after the interviews, the following day at the latest. This was necessary to enable the sorting of the research data.

3.2. Data grouping and analysis method

The research data attained from the interviews was grouped based on the written interview reports. A specific Excel sheet was created for the grouping and analysis purposes. First a division was made: the Catalyst Systems management content of the interviews was separated from the other content, namely the unwanted project management effects in Catalyst Systems. The analyses of the two topics were separated on their own Excel sheets.

Unwanted project management effects in CS delivery projects
Sandbagging
Procrastination
Failure to pass on early completions
Multitasking
Project Resource Management
Does CS have well organized resource management?
Does CS have considerable identified bottlenecks?
Is idle time a problem in CS projects from the cost aspect?
Measurements
Is the project progress well tracked?
Do the KPI's fulfil the organization's needs?

Table 1. Research data analysis grouping: business input.

The analysis was carried out after the data collection was completed and interview reports written. Some initial interpretations are bound to be made already during the interviews (Kohn, 1997: 6) so as the interviewing process proceeded, some ideas were formed based on the interviews already made. For example, during the first interviews it was already suggested on several occasion that the delivery project schedules not holding was an issue in the case study organization. Also, in order to increase the researcher's understanding on the topic, the respondents in the subsequent interviews were asked why they might think the project schedules are unreliable and floating. This way some minor hypotheses are formed and tested throughout the data collection process (Kohn, 1997: 6).

The data analysis consisted of three parts: the business input, the as-is analysis, and finally the CCPM proposal. The interview respondents' answers to the research interview questions – yes, no, or cannot say – were recorded under the business input section. In as-is analysis a business criticality value (scale 1-10) for each unwanted project management effect was determined in collaboration with the Catalyst Systems Delivery General Manager. An effect score for each project management phenomenon was calculated by multiplying the business criticality value by the occurrence – in practise either the yes or no answer depending on the question. The studied project management features were then ranked according to the calculated effect score, the one with the highest effect score being number one, the one with the second highest being number two, and so forth. The ranking is shown in table 2 in the analysis summary. The business impact of each unwanted effect was evaluated again together with the Delivery General Manager. In practise the business impacts of each project management phenomenon are the consequences of the phenomenon occurring in Catalyst Systems.

The as-is analysis contained two additional evaluations: 'Where are effects occurring' and 'How are effects occurring'. These assessments were based on the interview data; the respondents did not give plain yes or no answers, but also actively reflected on the topics enquired about, which provided valuable input to the evaluation. After the as-is analysis was completed the ways Critical Chain Project Management could improve the situation in Catalyst Systems were briefly highlighted. Combining the business input, as-is analysis, and the CCPM solutions the research analysis fluently connected the formal secondary data attained from the Critical Chain Project Management scholarly articles and literature with the informal primary data collected in the interviews. The findings of the research data analysis are presented below in chapter 4 in their entirety.

3.3. Research reliability and validity

The lack of standardization in semi-structured interviews might raise concerns about the reliability of the research methods (Saunders, Lewis & Thornhill, 2012: 381). Usually it is questioned whether another researcher would discover similar information. The results achieved in this case study reflect the reality of Catalyst Systems delivery project management in 2015, and are not required to be repeatable as such. However, all research procedures and methods used were recorded so that re-analysing the research is possible any time. In order to ensure reliability, Yin (1994: 37) suggests performing case study research so that your work is always capable of being audited. This case study had a supervisor from inside the organization studied, who participated in all phases of the research, and hence the audition eligibility principle was followed from the very beginning.

Three types of bias were relevant to consider and eliminate regarding this specific case study. The primary concern was response bias, i.e. a respondent providing only a limited view of the situation in the studied organization (Saunders, 2012: 381). This was avoided by not presenting the delivery project team members with information about the unwanted effects in project management and their linkage to Critical Chain Project Management prior to the interviews. Otherwise the respondents could have attempted to understate and undermine the possible occurrence of the undesirable project features in the case study organization. The second bias to account for was perceived interviewer bias, meaning that the interviewer imposes their own beliefs through the wording, or through the manner of interviewing. Avoiding it was important, as I am a previous delivery project employee myself. Eventually it was easy to step outside this framework and distance myself from the project environment as I had been on a rather long leave, which gave me more credibility as an external researcher.

The third relevant bias was participation bias, which means that certain desired interviewees may refuse or be too busy to participate in a research interview, resulting in biased data (Saunders, 2012: 382). This was ultimately not an issue of concern, since all relevant delivery personnel agreed to be interviewed. Additionally, alternate-form reliability measure was used to ensure the reliability. The wordings of certain questions were altered slightly from one interview to the other, yet keeping the essential contents of the question consistent (Litwin, 1995: 81).

According to Silverman, another word for validity is truth (2000: 175). In more academic terms, it is an assessment how well an account, an index or a score measures what it purports to measure (Litwin: 1995, 85). In this case study validity was assured by using data grouping, analysing and ranking methods commonly in use in Wärtsilä development projects. Choosing these techniques also ensured the construct validity, i.e. finding the right operational measures for concepts which are being reviewed (Yin, 1994: 33). Moreover, the use of the methods commonly used in Wärtsilä ensures the comparability of the CCPM implementation assessment with other intra-company development initiatives.

The internal validity of a research study is the extent to which you can establish causal relationships based on the study (Yin, 1994: 33). Based on the findings of this research it is obvious that the presence – and in some cases prevalence – of the unwanted project effects has an impact on the due date and overall performance of the delivery projects. However, due to the case study environment being highly complex and dynamic in nature, no definite causal inferences can be made based on the research analysis.

Identifying the values and bias relevant to the research, including the researcher's own, increases the validity of a research (Saunders, 2012: 384). The biases were identified and explained above, when discussing reliability. In order to further ensure the validity of the research results, interview questions were worded as clearly and unambiguously as possible. In case there was any uncertainty about the respondents' understanding of the question, the question was rephrased and asked again.

4. RESEARCH ANALYSIS AND FINDINGS

4.1. Unwanted project management effects in Catalyst Systems: Sandbagging

The effect score of sandbagging was calculated to be 513, and it ranked fourth in criticality out of the nine project management effects examined. Eleven out of the fifteen interviewee respondents recognized that sandbagging was present in Catalyst Systems project schedules. They elaborated most on three project phases or areas where the task duration estimates are significantly longer than would be necessary: early on in the project in order intake phase, in the “Supply of” -tasks in the Delivery Schedule, and with the external design work. Thus these are the areas of the delivery projects where the effects of sandbagging are most prominent in Catalyst Systems. It was seen that the order intake phase is considerably longer than it should be. As a result, the project buffer which is ten working days in catalyst delivery projects is often used very early in the project. The “Supply of” -tasks are in fact not tasks at all, but time reserved in the project schedule for the lead time of the materials purchased for the project. These lead time reservations were said to be needlessly long for some components. The delivery project schedule template was originally created for a novel project, and thus the time allocated for external design work is now perceived to contain a significant amount of buffer. So the detail design duration was determined with the assumption that the product needs to be entirely redesigned for each project, but that is usually not the case nowadays.

Certain suspicions were raised by the interviewees concerning the approach to delivery project schedules formulation in Catalyst Systems. It was speculated that the task duration estimations have never been evaluated very precisely, and that the reason for sandbagging might thus not be trying to secure the timely completion of the tasks but rather negligence in this sense. Two project team members directly stated that they had never been asked to estimate the durations of their own project tasks, even though they were not asked this. In a sense, the sandbagging in the case study organization is two-fold: in addition to admitted deliberate sandbagging, the task durations are also not assessed or known and thus estimated on the safe side. As a result, the task durations in the project schedule are thus not taken highly seriously, and the project schedule is not trusted. To conclude, one interview respondent articulated that “the duration estimates are not present in our everyday life".

The business impacts of sandbagging are relatively straightforward to detect. Firstly, the project durations are significantly lengthened. It is noteworthy that the lengthy lead time of the NOx Reducer was seen by WHO to be unnecessary and hard to conceive, to harm our competitive strength, and to generate extra costs on the project portfolio level. Thus careful attention should be paid to reducing the current lead times, which are 25 weeks for Marine Solutions projects and 24 weeks for Energy Solutions projects. As a by-product of sandbagging and the prolonged project durations, the resource utilization is on an ineffective level. This is problematic since the number of customer delivery projects and therefore the workload are believed to increase in the near future, which will result in requirement for additional resources. If the resource utilization rate were higher, this requirement would occur at a later stage than it will with status quo.

As demonstrated in chapter 2.2.1. Excessive activity duration estimates and scarcity of positive variation, with Critical Chain Project Management the negative effects of sandbagging can be eliminated due to applying the 50% completion chance rule. Catalyst Systems is a relatively compact organization with a high level of visibility across the unit, so decreasing the task duration estimates in agreement between the management, project managers, and other project personnel is likely to be fairly easy. Reaching consensus is both crucial and possible, but negotiation and evaluation together with all parties are required. Apart from the possible implementation of Critical Chain Project Management, a matter worth of considering would be further customizing the project schedule for each project. The schedule should be formulated in the order intake phase taking into consideration the special characteristics of each project (or lack of thereof) and the total work load in the project system, and not always rigidly according to the project schedule template. As a consequence the need for excessive task duration estimates would be decreased.

4.2. Unwanted project management effects in Catalyst Systems: Procrastination

The calculated effect score for procrastination was 693, which was the second highest score of the studied project management effects indicating that it both common in Catalyst System critical to the success of the projects. The portions of the delivery project named to suffer most of effects of procrastination were software related tasks, and application and commissioning related tasks. In addition, concerns about the quality of the project documentation suffering as a consequence of procrastination also emerged. Two respondents described the work load and arrangements of some Catalyst System specialists using very similar wording: "they have so much work all the time that they do their project tasks when they are needed." The statement reflects two problems in Catalyst Systems project management. Firstly, the Delivery Schedule is not recognised as a binding project schedule, but more as an indicative schedule proposal. The ExWorks date – the delivery date – of the project is what the project managers and personnel commit to, other than that the project schedule serves as suggestive information. Secondly, the definition of late is nebulous, and inconsistent among the project team members. A task is not necessarily considered late even if it appears so in the project schedule. Only when the delay has had significant negative consequences is it recognised, until then the task is considered to be "kind of late" or "a bit late."

Procrastination is closely connected to Parkinson's Law (Robinson & Richards, 2010: 3), according to which "work expands to fill – and often exceed – the time allowed" (Schneider-Kamp: 2002: 6). Parkinson's Law was widely recognised and admitted to being heavily present in Catalyst Systems. For example, it was stated that meetings do not only occasionally tend to expand to consume all of the allocated time, but they are in fact *difficult to end* ahead of time. This applies to project meetings as well as other meetings.

Several respondents were able to recognise possible root causes for procrastinating. The workload in Catalyst Systems was said to be uneven i.e. differ greatly from time to time and resource to resource, but generally on a high level, and procrastination was perceived inevitable under the circumstances of a high workload. On the other hand, it was evaluated by some that procrastination was most prevalent when workload was on a lower level, as people tend to become more passive in that situation. The positive stress resulting from a sufficient workload was said to eliminate procrastination. Interruptions and disturbances brought on mainly by emailed questions and issues to attend were seen as a major reason for procrastination and the prevalence of Parkinson's Law. The words the interviewees chose to describe this issue are revealing: such expressions as "endless emails", "all possible questions pour in via email", "I have to drop everything to answer the emails instantly", "there are so many emails that all of them are not read" were used. Another suggested root cause was the lack of clear boundaries set for the level of research and development work in projects. This confusion results in delayed starting with both customer delivery project and R&D project related tasks, leading to delays in completion.

Procrastinating was widely regarded as a personality trait by the interview respondents, and thus it was believed that it is difficult to eliminate it entirely from the project environment. Despite of seeing procrastination as a rather permanent characteristics feature, one interviewee brought up organizational culture and whether it encourages this kind of behaviour. Regarding Catalyst Systems their concern is justified at least to a degree. Procrastination was to a certain extent accepted, if not encouraged by management as they understood that people cannot work with 100% efficiency all the time.

As the result of procrastination and the student syndrome, little time is left for solving problems when they arise, since the safety time is already consumed beforehand. With too little time for corrective actions where necessary, the quality of the product and the documentation suffer and each deviation or surprise leads to a delay in the project schedule. The business impact of these phenomena is thus compromised quality and unwanted flexibility in the project schedule, both very serious issues. Sandbagging and procrastination also both work in favour of each other, often reinforcing one another; employees know that task durations are buffered, and thus procrastinate more liberally.

Implementing Critical Chain Project Management offers a remedy for this vicious circle, as Critical Chain project schedules remove surplus buffers and discourage procrastination. Moreover, when multitasking is minimized, the need for procrastination decreases even without extra effort. Regardless if Critical Chain Project Management is implemented in Catalyst Systems or not, there is a certain aspect to their project schedule management which has substantial development potential. Both traditional project management techniques and the Critical Chain method require determining a precedence and resource feasible baseline schedule (Lechler et al, 2005: 50), but the baseline schedule management is not used in Catalyst Systems currently. All delivery project schedules are located in one MS Project file, while still being disconnected from each other. No baseline schedule is created for each of the projects, thus allowing for the constant changing of timetables without any recorded tracks or possibility to measure the solidity of the schedules afterwards. It is also noteworthy that there are certain characteristics in the Catalyst Systems Delivery Schedule resembling of CCPM features, but since MS Project is not designed for that purpose it does not do a very good job at it.

4.3. Unwanted project management effects in Catalyst Systems: Failure to pass on early completions

Based on the business input drawn from the research interviews and the business criticality evaluation, “failure to pass on early completions” reached an effect score of 480. Auxiliary FAT testing was identified as a project stage to suffer of the negative effects of failure to pass on early completions. It was explained that there had been some occasions when the auxiliary FAT could have been held ahead of schedule, but the possibility had not been communicated to the right people, thus wasting this opportunity. Project team members being required to independently find documents they need in order to start their own tasks from IDM was stated to be another situation where early task completions are often not passed on in the project schedule. Three out of ten respondents also spontaneously mentioned system-originated problems, as the interfaces between certain systems do not work optimally; sometimes the automated design completion notifications are not generated when a design is completed.

Since failure to pass on early completions ranked only fifth the direct business impacts could be seen as less significant. On the other hand, when asked whether failure to pass on early completions occurs in catalyst delivery projects, 80% of interview respondents admitted it does and numerous elaborated that this phenomenon has another very unfortunate by-product. The amount of non-productive work for everyone involved in delivery projects increases, since substantial initiative from everyone is required for the project to proceed. Several interviewees described their project work as constant “asking, requesting, monitoring and reminding". As a result of this reactive querying culture the level of initiative, responsibility and trust gradually decrease. These effects are visible in the Catalyst systems project work, as one respondent admitted “I often only complete my tasks after I have been reminded five times”.

It is important to understand that the deterioration of the organizational culture is an indirect business impact of failure to pass on early completions. This unwanted project management effect also commonly plays a part in the emergence of the work peak at the end of the projects, which means that the project delivery date is kept only with “burnout heroics and compromised quality” (Patrick, 1999, accessed 11.9.2015). This phenomenon is detectable in Catalyst Systems too. Thus, as for failure to pass on early completions, the indirect business impacts might be more significant than the direct ones, which are systematically losing the advantage of being ahead of time, and increased amount of non-profitable work in delivery projects.

According to Watson et al CCPM is designed to create schedules which enforce timely completion of projects, while providing a method to *proactively* managing those schedules so that the harm caused by variation in task completion time is mitigated (2006: 397). It is particularly the special use of buffers in Critical Chain Project Management which guarantees that the benefits from early completion of tasks are utilized and even accumulated later on in the project. A certain amount of surprises and delays are inevitable in projects due to special cause variation, but exploiting early finishes helps to offset these setbacks. Leveraging the early completions is important as it enables us to accelerate the project completion, thus releasing the resources available for other projects (Patrick, 1999, retrieved 11.9.2015). This way implementing Critical Chain Project Management for Catalyst Systems delivery projects would also benefit the research and development project work that many delivery project team members have. As stated in chapter 2.3.4., buffer management in the Critical Chain Project Management way also enhances communication, thus reducing the prevalence and negative outcomes of failure to pass on early completions.

4.4. Unwanted project management effects in Catalyst Systems: Multitasking

In the research data analysis multitasking reached an effect score of 747, which is the highest of all the project management effects studied. Multitasking turned out to be an exceptional feature in Catalyst Systems delivery projects in more ways than one. Firstly, almost every respondent admitted to engaging in multitasking in their daily work. Even the few who did not identify multitasking as their own working approach or recognize its negative impacts, did not deny its existence and commonness in Catalyst Systems. Secondly, elimination of multitasking was generally believed to be *entirely impossible* as the respondents were not able to imagine a project environment without constant surprises and interruptions, and the idle time when waiting for input for their own tasks from someone else. Several notified that they were forced to multitask, as not all project work is visible in the Delivery Schedule. The diverse questions and requests from the customers, shipyards, and ship owners comprise a major portion of some project employees' work. It is impossible to forecast the amount of these questions or when they will arise, and thus the time used for them cannot be scheduled as such.

The third distinctive feature of multitasking is that it is impossible to identify the stages of the delivery projects where it is most prevalent; this work pattern and its negative side effects are ingrained in almost all aspects of project management in Catalyst Systems. However, it is rather easy to recognize the extremely counterproductive effects it has specifically on delivery project resource management, prioritizing and efficiency of project work, and perhaps most importantly job satisfaction in general.

Numerous interview respondents indicated that the Catalyst Systems employees must endure incessant interruptions and distractions in their working environment. Many acknowledge that they are the greatest source of inefficiency, while some actually believe that having as many tasks as possible simultaneously in the pipeline *improves* efficiency. Some admitted they immediately stop working on their current task when they are interrupted by for example an important email which requires their reply or attention. This may happen repeatedly during the course of one day. Interestingly, it was found many project team members in fact *actively* engage in multitasking to maintain their interest and attention on the project tasks. This harmful approach seemed to be commonly adopted as normal. On the other hand, some suffer tremendously of the chaotic circumstances brought on by the disruptions and the lack of clear priorities.

The lack of clear priorities between project tasks was identified as one of the major root causes for the rampant multitasking. Many respondents stated that they had no other way of knowing the priorities of their project tasks, than deciding them independently. When work is poorly organized priorities are not clear, people are burdened as they are under constant pressure to re-evaluate their priorities and in general “stay on top of things". In reality this often leads to increased mistakes and quality problems, because of losing track of what one is supposed to do and when. This was said to be the case especially for projects with a high level of nonstandard features.

The most significant business impacts of multitasking in Catalyst Systems are its contributions to project length and project schedule instability. This is noted in project management literature too: Lechler et al explicitly declare that multitasking has a considerable negative impact on the due date performance in a multi-project system (2005: 55). Secondly, the performance and resource utilization rate are far from the optimum. Project resource management in Catalyst Systems is discussed in detail below. The business is also negatively influenced by the ineffectiveness and quality problems rooting from the chaotic multitasking environment. The solutions for these problems (minimize negative effects) are inbuilt in the Critical Chain Project Management system, as in CCPM resources are required to work on one task at a time. This enables efficient prioritization of resource attention. The task conduction in CCPM is software-directed, so the priorities, sequence and timing of project tasks are clear considerably easing the project work. If it is impossible to schedule all project work, Critical Chain schedule could be followed six hours a day, and the remaining time could be left for the non-CCPM work.

4.5. Delivery project resource management in Catalyst Systems

Project resource management ranked number three with effect score 640. Resource management was one of the most discussed topics in the interviews, as the project personnel had plenty of opinions and confusion regarding it. The roles and distribution of responsibilities between e.g. project managers, line managers, and other managers seemed to be unclear. There was no consensus or knowledge about whose job project resource management is overall. Some though they know, some admitted they do not know, some just vaguely stated that resources are managed "somewhere else." So evidently there is not only lack of communication about the resource management responsibility in delivery projects, the responsibility is in fact not clearly defined or assigned to anyone at all.

When the respondents were asked whether Catalyst Systems has an organized method for managing the project resources, only one out of fifteen gave an affirmative answer, while twelve replied no and two could not say. Several elaborated that the word organized was the problem, as there is no pre-structured system for prioritizing and allocating the resources between different projects. The line managers know the workload of their own teams, and project team members are generally informed what needs to be done and when, but the no one is governing the project work – tasks, their owners, schedules and relative priorities – as a whole.

Further hindering the management of resources in projects was the manner of delegation. The project tasks are allegedly assigned with undue ambiguity; it is assumed that project team members know what is expected of them, so the specifics are often left open for the task performer to interpret. More precise communication and delegation was considered necessary. It was highlighted that especially project schedules are not communicated or properly deployed in the resource pool. Subsequently, employees prioritize their project work based on what they feel like doing, or as one respondent framed it: “I just pick the task I imagine is most urgent and complete it”.

Prioritizing issues were previously identified as a business impact of multitasking, and the same holds true for insufficient project resource management. The lack of overall project work management makes prioritization between projects difficult. In practise, project tasks are often completed in the wrong order. Additional business impact of resource management deficiency is that efficient project portfolio management is impossible and thus absent in Catalyst Systems. Of course, Critical Chain Project Management enhances and simplifies resource management as resource conflicts are removed, multitasking is minimized, and priorities are always clear. Critical Chain cannot however redefine the roles in Catalyst Systems or assign the resource management responsibility to the right party. Those issues need to be solved in another way, most preferably before implementing CCPM.

4.6. Project resource bottlenecks

An effect score of 433 was calculated for project resource bottlenecks, ranking it sixth among the studied project management features in Catalyst Systems. Thirteen among fifteen respondents were able to detect and name a specific bottleneck, or several of them. It is noteworthy that from the Critical Chain perspective, the effortless identification of bottlenecks is beneficial. The full bottleneck analysis is available in appendix X, but a few are worth highlighting. The four project stages gathering most mentions were detail design (and related issues), project specific electrical and automation design, project purchasing, and the auxiliary FAT testing, which all were referred to four times.

It was stated that the solving of issues or challenges is frequently postponed to the FAT testing phase, piling the FAT up with work that should have been done beforehand. Another suggested explanation for the existence of bottlenecks was the confusion about roles and responsibilities. The actual task owners completing their work insufficiently or not at all, leaving work for others to cover – often simply because they have forgotten – was also named as a root cause. Some project resources are regularly needed in several places simultaneously because of travelling to business trips, which often occur at short notice. These resources may then become temporary bottlenecks in the projects running at that moment.

The business in Catalyst Systems is impacted by the existence of resource bottlenecks through the resulting schedule delays and ineffective resource utilization. Also, certain resources are periodically overloaded. Consequently the system throughput level is compromised and more resources are required to deliver the projects, than would be if the existing bottlenecks were utilized more efficiently. There is a constant perceived need for more resources, which in reality is unfounded. CCPM could most probably improve the situation as the workflow of bottlenecks is optimized, which directly increases the project system's throughput capacity. The unnecessary postponing work to FAT will not be possible any longer, since the CCPM software governs the sequence and completion of tasks. Aside from Critical Chain Project Management implementation, it is advisable to ensure everyone in Catalyst Systems is committed to the same goals.

4.7. Idle time in Catalyst delivery projects

Idle time in projects placed eight in the analysis of Catalyst Systems delivery project features, with effect score 133. Thus, the direct business impact is relatively low, but the issue links to a greater context of understanding the Catalyst products' cost structure. While fixed costs are reality, it would be highly beneficial for all project personnel to recognize the connection between time and money in the project environment. The respondents were asked whether or not the idle time in Catalyst Delivery projects are a problem from the cost aspect. The replies divided equally between yes, no, and cannot say, and varied from one extreme to the other. Some stated that idling time is obviously a problem in the projects from the cost aspect, others strictly denied, while some saw that there is an indirect cost effect. Many noted that the idle time is used for other work. Also, it was claimed that the customers do not want their products faster than the current lead time.

Idling occurs early in the projects, mostly in the order intake phase. This is largely because the product specifications are often negotiated and customer approval awaited after the contract has been signed. The existing two week project buffer is thus regularly consumed during the first 1-3 weeks of the project. Overall, unless the prompt continuation of a project is required or initiated by a stakeholder, the project manager and team do not actively seek to do so. While this approach might not be fundamentally good or bad, it has certain ramifications. The longer the projects are the more multi-tasking and individual level detail management are required. With longer projects, the likelihood of scope or specification changes also increases.

The business impacts of project idle time are decreased resource utilization rate and lost profitability when the cost of a delivery project is unnecessarily high. Critical Chain Project Management enables improved control of the project schedules, leading to minimized idle time in projects. As an added advantage, the project personnel will be able to avoid the rush and work peak at the end of the project, which currently occurs in order to for the promised delivery time to be kept.

4.8. Tracking and reporting the delivery project progress

The effect score of tracking and reporting the delivery project progress was calculated to be 140, ranking it seventh in the analysis. Most discussion and elaboration on the topic regarded the Catalyst Systems Delivery Schedule, i.e. the project schedule compilation in an MS Project file. The logic of determining the task completion percentages was said to have been both unclear and changing, contributing to the perceived inconsistency of the progress reporting. The task progress reporting was believed to be (somewhat/largely) based on interpretations and individual approaches of the project managers and personnel, making the progress tracking vulnerable to distrust. Additionally, there were some difficulties regarding the memo from the weekly project meetings: the purpose of it was not understood by everyone, several admitted they never read the memo, and some criticized it for not containing the necessary information. Based on the above-mentioned issues, it was feared that the personnel excluded from the immediate core of project management was in no way aware of the project progress.

There are two further notions relevant and worth recognizing. Firstly, the opinions as to what is an adequate level of project progress tracking differ enormously between the project personnel. Secondly, many state that the current level is adequate, but have difficulty elaborating when asked to describe the exact means of existing progress tracking and reporting. Based on the input from the interviewees, we can assume Catalyst Systems has excellent premises for efficient project progress tracking, but may have communicated it insufficiently. The respondents found especially the nonstandard features difficult to track/follow and report.

The business impacts of confusing project progress tracking and reporting are impeded project portfolio management and unclear priorities leading to project tasks being completed in an incoherent order. Especially the vacation periods cause challenges, as the stand-ins may interpret the progress tracking differently than the standard project personnel. Enhanced awareness about the project statuses would decrease stress in the project team and increase management focus when decision making would be based on trustworthy information and facts. The buffer management in Critical Chain Project Management, the details of which were described in section 2.4., offers an extremely clear and simple way to track projects. CCPM buffer management also mitigates the suspicions towards the truthfulness of the reported numbers, as the project progress tracking is no longer be based on interpretations and varying individual approaches.

4.9. Delivery related measurement awareness and perceptions

The project feature with the least business impact was found to be delivery related KPI knowledge and perceptions, with effect score 80. There are however considerable misconceptions about what is measured in Catalyst Systems. The existing KPI's are widely unknown: a third of the respondents did not know *any* KPI’s, while four out of fifteen respondents admitted to not knowing all of them. It is unfortunate that the substantial (QC) work done in this area during 2013 does not seem have to been adopted or deployed on a satisfactory level.

The problems described by the respondents were various. Several stated that the key process indicators are never presented to them in any way. The KPI’s were also said to contain significant uncertainties, and to illustrate the activities and work of the delivery projects poorly. The human factor was estimated to be rather high, meaning that there is substantial opportunity to select what is expressed and what is not. Four interviewees mentioned that there should only be such key process indicators which potentially have an impact on the daily activities and work; indicators with nice-to-know information were considered redundant. Thirteen out of fifteen respondents were interested in measuring waste in one form or another.

The business impacts here are largely the same as in the section 4.8. Were the key process indicators adequate and trusted, management decisions and feedback would be easier to accept when supported by the KPI's. The overall understanding about delivery projects would be improved in the whole organization, and management focus enhanced. Again, buffer management in Critical Chain Project Management offers remedies to the identified challenges in Catalyst Systems. With the common goal mentality required with CCPM people also stop sub-optimizing, i.e. inserting the KPI data selectively. The "peer pressure" to comply with the CCPM system and measurements works in favour of the system and each individual.

4.10. Initial Catalyst Systems management commitment to CCPM

Contrary to project team members' interviews, a brief Critical Chain Project Management presentation was given to each manager before the research data collection interview. This was necessary in order to discover the interest or initial commitment towards the Critical Chain Project Management ideas, concepts and philosophy. Only one out of five executives was familiar with CCPM prior to the presentation. Nonetheless, the response and reactions of the management were altogether extremely positive and encouraging. All management interviewees considered the presented ideas and concepts excellent and rational, even if they had not previously encountered this specific philosophy.

Four respondents believed that Critical Chain Project Management could/might work in Catalyst systems, while one could not say. One stated it was not a matter of belief, since CCPM verifiably works in similar environments. Three believed with some reservation, i.e. had some doubts and several unanswered questions, which was expected considering the brevity of the CCPM information presented preceding the interview. It was stated that it is most essential to predetermine who leads the project system and the projects in CCPM.

When asked whether they believed that implementing CCPM would be beneficial for Catalyst Systems, four replied yes whilst one could not say. Two even elaborated that the possible implementation should take place as soon as possible in the near future well before the anticipated volume increase in the delivered products and projects. In contrast, one estimated that the current volume and workload was manageable even with the existing methods. Even they stated that the delivery project system had significant room for improvement and unexploited capacity, and believed that CCPM may help the organization to improve and leverage that capacity. It was noted that taking action to improve the project management (and) is inevitable, but that undisturbed deliveries to the customer have to be secured in the transition phase. Yet another important notion was that it was believed implementing Critical Chain Project Management might reveal yet undiscovered challenges the organization may have.

Since each management interviewee respondent gave an affirmative answer to either of the two questions concerning the suitability and benefit of CCPM in the case study organization, all five were interpreted to be initially interested in CCPM implementation and thus potentially committed to it. Notably, no negative answers were given to either question. Building on these premises, there are several requirements which must to be fulfilled in case the affirmative implementation decision is made (in case the project passes Gate 2). The initial commitment must be utilized through comprehensive communication and adequate training. Management must gain sufficient understanding of the foundations, philosophy, and operating principles of Critical Chain Project Management. This crucial as such, but also in order to guarantee that management has the ability support the delivery project team members according to their needs, before, during and after the CCPM implementation phase. Management must in addition have a clear and accurate view about what is required of them in the Critical Chain Project Management environment; what their responsibilities and tasks are. Should CCPM be implemented in Catalyst Systems, a specific change management plan will be created outside the scope of this thesis. The CCPM change management plan will describe the precise methods how these above identified requirements are fulfilled.

5. SUMMARY AND CONCLUSIONS

5.1. Research analysis results and discussion

The primary Critical Chain Project Management implementation success factor is the identified need for change in the organization. The problems the CCPM implementation is expected to solve must be identified and understood in the project environment. The research analysis revealed that the Catalyst Systems delivery project environment is subjected to a complex loop of multitasking, insufficient resource management, procrastination, disorganized prioritizing, and sandbagging, where one reinforces the other in an ever changing sequence. It is impossible to determine with certainty which is a cause and which an effect. However, the unwanted effects and their consequences are verifiably present; therefore we can conclude that there is an identified need for change in Catalyst Systems. A summary of the analysed project management features along with their calculated effect scores and ranking is presented in table 2.

Project management feature	Effect score	Ranking no.
Multitasking	747	1
Procrastination	693	2
Does CS have well organized resource management?	640	3
Sandbagging	513	4
Failure to pass on early completions	480	5
Does CS have considerable identified bottlenecks?	433	6
Is the project progress well tracked?	140	7
Is idle time a problem in CS projects from the cost aspect?	133	8
Do the KPI's fulfil the organization's needs?	80	9

Table 2. Project management features in Catalyst Systems ranked according to the effect score.

The aim of this research was to find out whether the Critical Chain method should be applied in Wärtsilä Catalyst Systems organisation, and more precisely in its delivery project management. Originally, the research questions of the thesis were set as:

1. Would Wärtsilä Catalyst Systems delivery project management benefit from implementing Critical Chain Project Management?

2. If yes, how should the implementation of Critical Chain Project Management be carried out?
    a. Initial implementation plan

Basing on the findings of the research analysis, we are able to answer the first research question. There is a very high probability that Wärtsilä Catalysts Systems delivery project management would benefit from implementing Critical Chain Project Management, and the implementation is thus strongly recommended.

Critical Chain Project Management will contribute to minimizing the negative effects of the project features presented in table 2, but additionally, increased awareness of the financial value of time is needed, along with changes in the underlying attitudes. Delivery project management in Catalyst Systems is supposed to be founded on the Delivery Schedule, but views on the relevance and validity of the scheduled dates vary. In practice project progress is dictated by constantly floating individual interpretations of the tasks' required completion dates. In the Critical Chain Project Management environment the project progress is not left depending on interpretations, as resources are expected to complete the assigned tasks as soon as possible instead of a scheduled date in the distant future.

Regardless of which techniques or systems are implemented, in order to gain significant improvements the Catalyst delivery project personnel must be genuinely committed to the projects, and the tasks they are accountable for. Furthermore, a system perspective ought to be adopted: everyone involved in delivery projects must understand that they are part of a multi-project *system,* where actions in one part of the project have an effect on the other parts of said project, and ultimately the project system as a whole. This ensures a correct CCPM-aligned focus: maximizing the performance of the whole project system instead of attempting to sub-optimize individual projects.

The research work of this thesis was carried out according to the plan, following the research design and approach determined in the beginning. The objectives laid for the thesis were completely achieved, both in an academic sense and from the Wärtsilä viewpoint. Based on the research analysis findings, the first research question was answered above. Chapter 5.2. below describes how the second part of the research problem is resolved.

5.2. Result utilization and following actions

The results and conclusions accomplished in this thesis will be utilized in the Catalyst System organization in their entirety. A development project has already been established, and will proceed according to the Wärtsilä operational development project gate model. The gate model outline is pictured in figure n, along with the phases and the initial schedule of the Critical Chain Project Management implementation project.

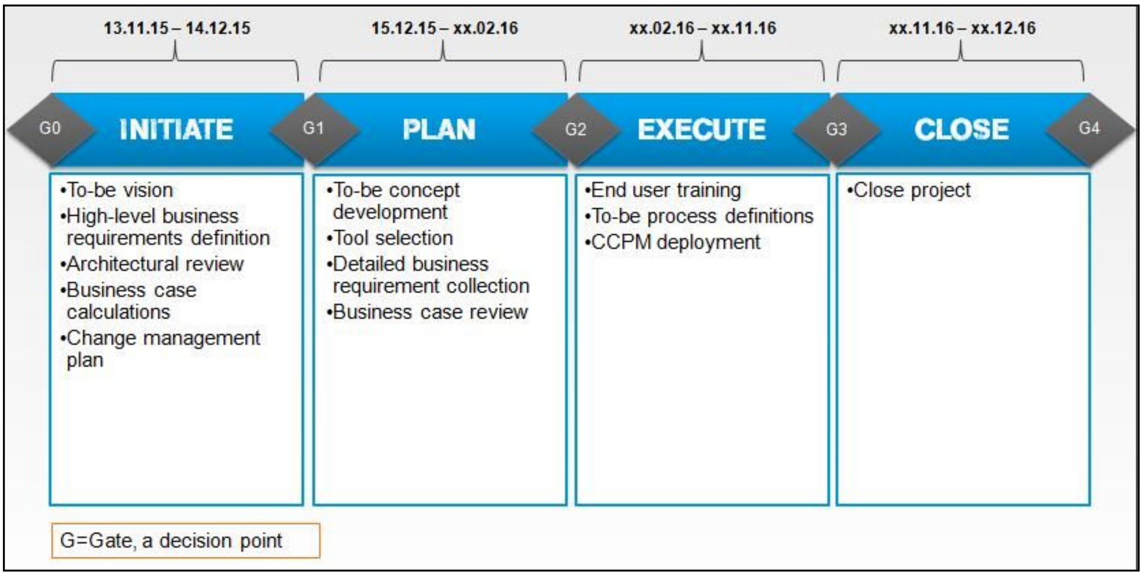


Figure 13. Initial CCPM implementation project plan.

The initiation of a development project – the project gate 0 approval – requires the formulation of an initial project proposal. The purpose of the project proposal is to describe the background of the project, and to justify why a project should be started and resources allocated for further assessment work. It is a detailed plan for the initiate phase and a rough plan for the entire project. The Critical Chain Project Management implementation project proposal (appendix n) was created as a part of the thesis work. Figure n lists the CCPM implementation project proposal table of contents. The CCPM implementation project proposal will be presented in the Catalyst Systems November 2015 management team meeting by the undersigned, who will also be the project manager of the CCPM implementation project. The Gate 0 decision will be made in the November management team meeting.

Figure 14. CCPM project proposal table of contents.

If Gate 0 is approved, the CCPM implementation project enters the initiate phase. Currently, three core actions have been defined for the initiate phase. Firstly, business case calculations (including for example the return on investment) will be carried out with the Wärtsilä business case calculation template. Secondly, a specific change management plan for the Catalyst Systems CCPM implementation will be created. The change management plan will be based on scientific premises, and it will include a detailed training plan for the CCPM implementation project. Lastly, a benchmarking excursion to an international Wärtsilä location already employing Critical Chain Project Management is planned for the end of November 2015. The benchmarking trip participants will include at least the CCPM project manager, representatives from the project team, and certain members of the Catalyst Systems management team. The initiate phase will end 14th of December, when the Gate 1 decision is made in the December Catalyst Systems management team meeting.

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Design Manager, 31.8.2015.

Director, Catalyst Systems, 23.9.2015.

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General Manager, PME, 20.8.2015.

General Manager, R&D, 21.7.2015.

General Manager, Sales, 14.9.2015.

Product Manager, NOR, 17.9.2015.

Project Manager A, 5.6.2015.

Project Manager B, 1.6.2015

Project Manager C, 18.6.2015

Senior Automation Expert, 10.9.2015

Senior Development Manager, Operational Excellence, 28.5.2015

Strategic Purchaser, 7.9.2015

Supply Expert, 15.7.2015

Supply Expert Trainee, 13.7.2015

APPENDICES

Appendix 1. Interview template for project team members

1. Esiintyykö Catalyst Systemsin asiakastoimitusprojekteissa näitä ilmiöitä projektimaailmasta?
    a. Excessive activity duration estimates
        i. (Selitetään sandbagging ilmiönä.) Esiintyykö sandbaggingiä meillä?
        ii. Ovatko meidän delivery schedulesta löytyvät aika-arviot taskeille realistisia?
        iii. Mitä ajattelisit, jos niistä poistettaisiin multi-tasking? Esim. että projektin IDM-dokumentin luomiselle annettais viiden päivän sijasta aikaa vaikka puoli tuntia?
    b. Parkinson's law ja procrastination
        i. (Selitetään Parkinson's Law ilmiönä.) Onko tämä mielestäsi totta Catalyst Systemsissä?
        ii. Kuinka suuri osa projektien taskeistä on mielestäsi valmiita
            1. Etuajassa?
            2. Juuri ajoissa?
            3. Myöhässä?
    c. Failure to report and pass on early completions
        i. Onko koskaan tullut vastaan sellaisia tilanteita, että joku projektiorganisaatiossa saa oman taskinsa valmiiksi, mutta siitä ilmoittaminen jää roikkumaan tai unohtuu? Eli että projekti ei etene ihan vain siitä syystä, ettei seuraava "askel" tiedä voivansa jo jatkaa. Kuinka usein?
        ii. Käykö sulle itselle niin koskaan?
    d. Multitasking
        i. Montako toimitusprojektia on kerrallaan meneillään?
        ii. Onko mahdollista arvioida kuinka monta projekteihin liittyvää taskia sinulla on yleensä työn alla? (Edes suuntaa-antava arvio?)

iii. Entä yhden päivän aikana, kuinka montaa erillistä työtehtävää keskimäärin yhden päivän aikana työstät?

iv. Olisko helpompi tehdä töitä, jos työn alla olisi aivan oikeasti vain yksi tai kaksi asiaa kerrallaan? Mutta kuitenkin sillä tavalla, että taskiesi tekemisen edellytykset olisi kunnossa, eli aikaa ei tarvisi käyttää odotteluun.

e. Loss of focus

i. Onko meillä mielestäsi toimiva järjestelmä tai mittari, mistä saisi selville että missä vaiheessa kunkin projektin eteneminen on? Mikä?

2. Resurssienhallinta
   a. Onko meillä mielestäsi järjestäytynyt systeemi projektin resurssien hallintaan (esim. priorisoimiseen projektien välillä.)
   b. Missä resurssimielessä sijaitsee pullonkaula? Eli kuka on projektin henkilöistä kuormitetuin?
   c. Onko ”idle time” mielestäsi projekteille ongelma kustannusmielessä?
3. Mittarit
   a. Ovatko tämänhetkiset Delivery-puolen (toimitusprojektien) mittarit sinulle tuttuja?
   b. Mikä niissä toimii?
   c. Missä olisi kehitettävää?
   d. Jos ei tarvitsisi ottaa huomioon mitään teknisiä esteitä, minkälaisen mittarin suunnittelisit toimituspuolelle? Eli mitä olisi tärkeintä mitata, tai millä voitais parhaiten pureutua suurimpiin kompastuskiviin?
4. Parannusehdotukset/muutostoiveet
   a. Minkä toivoisit muuttuvan projektinhallinnassamme? Joko toiminintatavoissa tai tuloksissa.
   b. Mitä meidän pitäisi itse sinun mielestäsi tehdä parantaaksemme projektienhallintaa?

Appendix 2. Interview template for management

1. Esiintyykö Catalyst Systemsin asiakastoimitusprojekteissa näitä ilmiöitä projektimaailmasta?
    a. Excessive activity duration estimates
        i. (Selitetään sandbagging ilmiönä.) Esiintyykö sandbaggingiä meillä?
        ii. Ovatko meidän delivery schedulesta löytyvät aika-arviot taskeille realistisia?
        iii. Mitä ajattelisit, jos niistä poistettaisiin multi-tasking? Esim. että projektin IDM-dokumentin luomiselle annettais viiden päivän sijasta aikaa vaikka puoli tuntia?
    b. Parkinson's law ja procrastination
        i. (Selitetään Parkinson's Law ilmiönä.) Onko tämä mielestäsi totta Catalyst Systemsissä?
        ii. (Selitetään student syndrome) Entä uskotko, että meillä esiintyy student syndromea?
        iii. Jos, niin olisiko sinun mielestäsi student syndromen eliminoiminen toivottavaa?
    c. Multitasking
        i. Olisko helpompi hallita resursseja, jos työn alla olisi aivan oikeasti vain yksi tai kaksi asiaa kerrallaan? Mutta kuitenkin sillä tavalla, että taskien tekemisen edellytykset olis kunnossa, eli aikaa ei tarvisi käyttää odotteluun.
        ii. Uskotko että alaisesi viihtyisivät/performoisivat paremmin ilman multi-taskingiä?
        iii. Näetkö multitaskingin eliminoimisen mahdollisena?
    d. Loss of focus
        i. Onko meillä mielestäsi toimiva järjestelmä tai mittari, mistä saisi selville että missä vaiheessa kunkin projektin eteneminen on? Mikä?
2. Resurssienhallinta

a. Onko meillä mielestäsi järjestäytynyt systeemi projektin resurssien hallintaan (esim. priorisoimiseen projektien välillä.)

i. Organisaationa? Jos niin mikä?

ii. Miten itse hallitset omat resurssisi? Miten päätät esim. yksittäisen ihmisen prioriteetit tai sen kuka uuden tehtävän tai taskin ottaa?

b. Missä resurssimielessä sijaitsee pullonkaula? Eli kuka on projektin henkilöistä kuormitetuin, drum resource?

c. Onko drum resourcen etsiminen (ylipäätään) mielekästä organisaatiossamme?

d. Onko ”idle time” mielestäsi projekteille ongelma kustannusmielessä?

3. Mittarit

a. Ovatko tämänhetkiset Delivery-puolen (toimitusprojektien) mittarit sinulle tuttuja?

b. Mitä mieltä olet niistä?

c. Jos ei tarvitsisi ottaa huomioon mitään teknisiä esteitä, minkälaisen mittarin suunnittelisit toimituspuolelle? Eli mitä olisi tärkeintä mitata, tai millä voitais parhaiten pureutua suurimpiin kompastuskiviin?

4. Parannusehdotukset/muutostoiveet

a. Minkä uskot olevan syynä liukuviin projektiaikatauluihin?

b. Minkä toivoisit muuttuvan projektinhallinnassamme? Joko toiminintatavoissa tai tuloksissa.

c. Mitä meidän pitäisi itse sinun mielestäsi tehdä parantaaksemme projektienhallintaa?

5. Management specific

a. Onko critical chain tai theory of constraints millään tasolla sinulle entuudestaan tuttu?

b. Uskotko että critical chain pm voisi toimia catalyst systemsissä?

c. Entä pidätkö sen käyttöönottoa tarpeellisena organisaation koko/kuormitus huomioonottaen?

Appendix 3. Data analysis template: unwanted effects in project management

Interview analysis: Catalyst Systems delivery projects										
	Business input				AS - IS Analysis					CCPM Proposal
	Occurring?									
	Yes	No	Cannot Say	Total Responses	Business Criticality	Effect Score	Where are effects occurring	How are effects occurring	What are the business impacts	How could CCPM improve the situation
Unwanted project management effects in CS delivery projects										
Sandbagging										
Procrastination										
Failure to pass on early completions										
Multitasking										
Project Resource Management										
Does CS have well functioning and organized resource management?										
Does CS have considerable identified bottlenecks?										
Is idle time a problem in CS projects from cost aspect?										
Measurements										
Is the project progress well tracked?										
Do the KPI's fulfill the organization's needs?										

Appendix 4. Data analysis template: initial management commitment

Initial Catalyst Systems Management Commitment to Critical Chain Implementation				
	Business management input			
	Yes	No	Cannot Say	Total Responses
Previous familiarity with CCPM/TOC				
Do you believe that CCPM would work in CS?				
Would it be beneficial to implement CCPM in CS?				
Initial commitment to implementing CCPM in the near future				