EXAMINING USER ACCEPTANCE AND EFFECTIVENESS OF CRITICAL CHAIN PROJECT MANAGEMENT: A LONGITUDINAL CASE STUDY

by

Terry (Chen-Yen) Lu

Submitted to the Information Systems Department in partial fulfilment of the requirements for the degree of

Master of Business Science

At the

University of Cape Town

February 2003

ACKNOWLEDGEMENTS

This case study was a meaningful learning experience for me. I would like to acknowledge the following organisation and people for their contributions to this case study:

- The Technology Development division of Siemens Southern Africa. I am especially grateful to Mr. Malan Smith (Division Head) and Mr Leon Benn (Project Manager) for their assistance and support. This case study certainly would not have been possible without their enthusiastic involvement and inspiration.
- Professor Derek Smith, my treatise supervisor. His patient support and thoughtful advice were instrumental and pivotal to this case study. Derek provided theoretical direction and practical guidance which helped me to put together the concepts presented in this case study.
- Mr Lionel Waker, my Masters program classmate. I am very thankful for his continuous support and encouragement. Lionel not only reviewed this paper with me but also provided much useful advice.
- Dr Dirk Grobler for introducing me to the Technology Development division of Siemens Southern Africa. I also attended and benefited from an excellent workshop on CCPM run by Dr Grobler.

I certify that this paper is my own work. All references have been accurately reported.

Terry Lu

ABSTRACT

The Information Systems (IS) industry does not have a good history of project delivery performance. Reports from the Standish Group (Schwalbe, 2002) revealed shocking statistics including low project success rate (below 30%) and high project schedule overrun rate. These poor performances exist despite the adoption of popular project management tools and methods including Critical Path Method (CPM) and Project Evaluation and Review Technique (PERT). Consistent, punctual and accurate project performance remains a key challenge in today's rapidly changing IS environment.

Critical Chain Project Management (CCPM), proposed by Eliyahu Goldratt (1997) based on the Theory of Constraint, is a systems-oriented approach to managing projects. By taking resource requirements into consideration, CCPM focuses on project scheduling and time management. CCPM claims the reduction or elimination of certain human behaviours and the management of critical resources in order to improve project delivery performance. The implementation of CCPM necessitates a change in organisations' project management approach.

This research studies a CCPM implementation case in an attempt to provide insight into CCPM's effectiveness and user acceptance in an IS environment. The case study, which lasted almost 2 years, started soon after the CCPM implementation was initiated at the research site and ended when the implementation was declared a success. CCPM assumptions, implementation issues, perceived usefulness and perceived ease of use of CCPM were examined in this research. The implications of research findings for CCPM are also included in this paper.

The CCPM implementation was considered successful because it achieved the implementation goal: better project delivery performance. In addition the implementation also enhanced the transparency of project progress and increased individual efficiency, which lead to less overtime work. Many issues including change resistance, implementation plan, top management support and training surfaced during the implementation process. A high level of perceived usefulness of CCPM was observed during the case study based on theoretical soundness and practicability. In comparison the issues and difficulties encountered during implementation lead to a lower level of perceived ease of use of CCPM.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1 PROJECT MANAGEMENT

Projects form part of the work performed by organisations. Requests that cannot be fulfilled within an organisation's normal operational limits are addressed by projects (PMI, 2000). Project management was developed to assist organisations in achieving project objectives. The field of project management is now well developed and widely accepted by both professional practitioners and academic researchers (White & Fortune, 2002).

Initially project management gained acceptance slowly and was applied only to large projects (Kerzner, 1998). In recent times organisations have recognised project performance as one of the critical success factors in reaching organisational goals and have focused on project management to improve project performance and increase competitive advantage (Kerzner, 2001; Pennypacker & Grant, 2002). Project performance is continuously being improved by the implementation of tools and techniques that are being implemented by organisations (Dinsmore, 1993).

Despite the long history of project management (some project management tools were developed more than 40 years ago) there is growing concern among practitioners that conventional techniques are inappropriate for managing projects within the contemporary context (Frame, 1994). Changes in the business environment create uncertainty and require creative and adaptive approaches to project management (Wysocki, Beck Jr. & Crane, 1995). Continuous improvement of tools and techniques is necessary as organisations strive for project management excellence and competitiveness (Kerzner, 2001).

1.2 PROJECT MANAGEMENT IN INFORMATION SYSTEMS INDUSTRY

According to Fowler and Walsh (1999) project management techniques are widely applied to Information Systems (IS) projects. Jurison (2002) suggests that the importance of project management within the IS industry is underlined by the fact that the majority of work in the IS industry is structured as projects.

The IS industry has been perceived as the one industry that performed poorly in terms of project delivery (Thite, 2000). Schwalbe (2002) notes in a CHAOS report published by the

Standish Group (an international market research firm) that the following numbers reflect the inability of the IS industry to successfully complete projects:

- only 28 percent of IS projects succeed,
- average cost overruns of IS projects are 45 percent,
- and average time overruns of IS projects are 63 percent.

Schwalbe (2002) notes that recent IS project performance has improved, but there is still a desire for further improvement. Newbold (1998) and Rand (2000) argue that conventional project management practices are not perceived to be effective. Ibbs & Kwak (2000) note that the IS industry has relatively low project management maturity compared to other industries such as engineering, construction and hi-tech manufacturing. The result of their research suggests that the IS industry, compared to the three above mentioned industries, has the lowest score in project scope management, project time management and project cost management (Ibbs & Kwak, 2000). Pennypacker and Grant's (2002) research findings also suggest that the information industry has a low average maturity in time management and schedule development. In light of this, there is an apparent rise in interest in the IS project management discipline (ISSIG, 1999).

Research by Yeo (2002) identifies project planning, and project management and control as two of the most critical failure factors in IS projects. Jurison (1999) includes project scheduling as part of the project planning process. Schmidt, Lyytinen, Keil and Cule (2001) note that unrealistic scheduling is among the list of most influential software project risk factors identified in the literature. White and Fortune (2002) agree and confirm that project managers frequently suggest a 'realistic schedule' as a critical factor affecting project performance. Schedule development and control are critical to project success as uncertainty and change become an indispensable part of IS projects (ISSIG, 1999).

1.3 THEORY OF CONSTRAINTS AND CRITICAL CHAIN PROJECT MANAGEMENT

Developed by Goldratt (1990a), the Theory of Constraints (TOC) is a system improvement philosophy that focuses on the overall performance of a system. Goldratt (1990a) maintains that the success or failure of a system lies in how well the system's component processes interact with each other. TOC contends that the constraints of a system, defined as the components with the weakest performance (therefore any system must have at least one constraint) have a substantial impact on the system's global goal. The overall performance of the system can be improved by exploiting and improving the constraints.

Based on the TOC, Critical Chain Project Management (CCPM) focuses on the scheduling of projects (Goldratt, 1997). TOC contends that systems are analogous to chains, hence the name Critical Chain. In CCPM each project is considered to be a system and each task within the project is considered to be a system component. Each task has both precedence and resource dependencies, which are taken into account when CCPM determines the overall duration of the project. The ultimate project milestone (synonymous to system overall performance) can be reached within a shorter time period (hence less resources required) if the individual milestone that is delaying the overall project schedule (system constraint) is successfully completed as a matter of urgency. By minimising and stabilising a project schedule, the other required resources for the project can be minimised and quality assured, thereby leading to the achievement of proposed project goal(s).

1.4 THE AREA OF RESEARCH

This research examines the application of Critical Chain Project Management (CCPM) within an IS environment. In particular, user acceptance and the effectiveness of CCPM will be examined.

Steyn (2000) suggests that the application of TOC concepts to project management represents a shift of paradigm in project scheduling. The author further notes that change is inevitable with the implementation of CCPM and resistance to change can be expected. Davis (1989) notes that the users' rejection of systems often obstructs performance improvements thereby undermining the effectiveness of the systems.

1.5 RESEARCH METHODOLOGY

Case studies are employed extensively in social science research (Yin, 1994) and have always attracted attention in the field of Information Systems (Lee, 1989). However case studies have been criticised for lacking rigour and for their inability to be generalised (Yin, 1994). A clear approach for implementing a case study has not always been available to researchers (Lee, 1989). Nevertheless the case study research methodology is appropriate to record the practitioner's knowledge of practices relating to the theory that is being researched (Benbasat, Goldstein & Mead, 1987). This is the methodology adopted in this research.

1.6 NECESSITY AND VALUE OF RESEARCH ON CCPM

Steyn (2002) suggests the importance of project scheduling is underlined by the fact that project duration is a major constraint for projects. The author cites three reasons for project duration to be considered as a constraint to projects:

- extended duration escalates project costs
- high contingency costs for project delays
- extended duration provides further opportunity to change project scope

The field of project management does not introduce new scheduling techniques very often, with widely adopted techniques such as Critical Path Method (CPM) and Project Evaluation and Review Technique (PERT) being developed in late 1950's. Since its introduction, CCPM has attracted a lot of attention and became a widely discussed topic in the world of project management (Cabanis-Brewin, 1999; Simpson, 1999; Wilkens, 2000). Practitioners and academic researchers debate whether CCPM is a new concept offering greater potential than conventional scheduling techniques or just a repackaging of existing concepts directing attention to the flaws of the latter (Steyn, 2000; Wilkens, 2000). Globerson (2000) argues that CCPM adds value to the present Project Management Body of Knowledge (PMBOK), compiled by Project Management Institute (PMI), in the areas of project planning, schedule development and activity performance and control. Globerson (2000) further suggests that CCPM should be incorporated into the PMBOK Guide.

Amid all the enthusiasm and criticism, cases focusing on real-world applications of CCPM are presented by authors such as Leach (1999) to demonstrate the effectiveness of CCPM in reducing project duration. However due to the numeric nature of project duration and schedule, the majority of cases quoted in the literature focus on the quantitative data. Rand (2000) notes that unlike conventional techniques such as CPM and PERT which deal with technical aspects of project management, CCPM focuses more on issues relating to human behaviour. Steyn (2000) suggests that it would be valuable to verify assumptions made by CCPM on human behaviour by providing scientifically acceptable evidence. According to Steyn (2002), the literature still offers little information on the practical results of CCPM application to single project scheduling. This research aims to collect such information and provide further insight into CCPM application within the IS industry.

1.7 OBJECTIVES OF THE RESEARCH

The objectives of this research are to:

EXAMINE USER ACCEPTANCE AND EFFECTIVENESS OF CCPM

As the primary objective, the research will examine the application of CCPM in an IS environment from the users' perspective. Data on user acceptance of CCPM can be useful in determining user approval of the human behavioural assumptions made by CCPM. The effectiveness of CCPM is measured qualitatively in this research.

PROVIDE INSIGHT INTO THE APPLICATION OF CCPM

The research aims to collect data to shed more light on CCPM application within the IS industry. One aspect of such insight relates to the key issues that have surfaced during the implementation process. These key issues can be identified as the critical success factors of a CCPM implementation, and practitioners of future CCPM implementations can be made aware of potential problems undermining and possibly interrupting the implementation process.

MAKE RECOMMENDATIONS

The ultimate objective of this research is to present IS practitioners with information and insights on CCPM application. Recommendations on possible actions that could contribute toward an effective implementation will be made by examining the implication of the research findings.

1.8 OVERVIEW OF TREATISE

An overview of pertinent literature relating to this research is presented in Chapter 2. Various project scheduling techniques are discussed. Scheduling problems encountered by the IS industry are also explored. CCPM, TAM and change management theories are also examined to provide a theoretical background for the research.

Chapter 3 begins by stating the research questions clearly. The nature of the research is discussed and the research methodology is outlined. The design of the research instruments used to collect data (including research process, data collection techniques, researcher role and unit of research) are explained. Issues relating to data collection and data integrity are also discussed.

Research results are outlined in Chapter 4. The techniques used to analyse data are explained, and the research findings will be presented and analysed. The implications of the analysis for both the research questions and CCPM are discussed.

Chapter 5 concludes this research paper. A summary of the research and its findings is presented. Limitations of the study are discussed. Recommendations for areas of future research are then presented.

2. LITERATURE REVIEW

2.1 INTRODUCTION

Project schedule management can be a significant factor contributing to IS project success or failure (ISSIG, 1999; Schwalbe, 2002) yet it is a complex process (ISSIG, 1999). The literature review initially examines the project scheduling problems experienced in managing IS projects by providing some background information on conventional project scheduling practices and IS project scheduling issues. This is followed by a brief discussion of Critical Chain Project Management (CCPM), the project scheduling theory that was implemented during this case study. Variables used in this research to determine user acceptance of CCPM were derived from the theoretical foundation provided by Technical Acceptance Model (TAM) and change management theories. The last section of this literature survey will examine TAM and change management theories.

2.2 DEFINING 'PROJECT' AND 'PROJECT MANAGEMENT'

PMI (2000, p. 4) depicts a project as a "temporary endeavour". The following characteristics of a project are highlighted by Kerzner (1998):

- A project has objective(s) to be achieved within specified constraints.
- A project has a commencement and a completion date. PMI (2000) suggests the duration of a project can range from a few months to several years, depending on the nature of the project.
- A project consumes resources to allow for the smooth operation of activities to achieve the desired objectives. According to McLeod & Smith (1996), the resources needed by the project could include people, money, tools and equipment, and administration.

Kerzner (2000, p. 2) further defines project management as "the planning, scheduling, and controlling of a series of integrated tasks such that the objectives of the project are achieved successfully and in the best interest of the project's stakeholders". PMI (2000, p. 6) adds that the process of project management involves the "application of knowledge, skills, tools, and techniques to project activities".

2.2.1 IS Project Types

According to ISSIG (1999), IS projects fall into one or more categories listed below:

- Software development projects including new development and enhancement of existing software.
- The selection, acquisition and implementation of software packages, including customisation where applicable.
- The selection, acquisition and implementation of computer hardware and equipment.
- The selection, acquisition and implementation of telecommunication and network products and services.
- Systems integration.

An IS project can be initiated and sponsored by the IS department of an organisation or be a component of a larger project that the IS department is not in charge of (ISSIG, 1999).

2.2.2 IS Projects Characteristics

Simpson III (1999) argues that the unique characteristics of IS projects are the main culprits for failure in project performance. Several authors (Nelson & Joshi, 1995; Simpson III, 1999) identify the core characteristics of IS projects which they contend are unique:

- *Number of users* – The number of users of the system affects IS project complexity. Users may come from one or many departments other than the IS department. People and political skills are essential if the project involves many users from different levels of the organizational structure.
- *User task comprehension and knowledge* – The uncertainty associated with an IS project is influenced by factors such as user task comprehension and knowledge. If the user understanding is inadequate, then highly skilled analysts may be needed to interpret user requirements.
- *Degree of structure* – Unstructured projects are often difficult to define. A well structured project could lead to well defined objectives, clear and well understood scope and user requirements, and accurate project specifications.
- *Degree of change* – The higher the degree of change that IS projects introduce to the users' work environment, the more significant the need is for people and political skill. These are needed to overcome users' resistance to change and to persuade users to cooperate.
- *Project size* – Large projects are more complex and may involve more subsystems. The interrelationships of the subsystems must be understood in order to integrate the subsystems. Complex dependencies have to be identified in order to avoid poorly defined tasks and reliance on a few key resources.

- *Degree of integration* – Another important dimension of IS projects is that of the degree of data integration among the systems or subsystems. Higher technical skills may be required to integrate data from different functional units and formats.
- *Project nature* – ISSIG (1999) attributes IS project uniqueness partly to the temporary nature of software. McLeod & Smith (1996) suggest that frequent changes are made to IS project objectives during project execution. ISSIG (1999) argues that additional functionality or performance goals specified at execution phase are partly responsible for the phenomenon. IS projects are therefore associated with more uncertainty and have become more unpredictable, which makes it more difficult to estimate the duration of projects correctly. This is perhaps the key unique characteristic of IS projects as most IS projects are related to software development, configuration or maintenance.

2.3 PROJECT SCHEDULING

PMI (2000) states that the purpose of project scheduling is to ensure that project goals are reached within the desired time period. An understanding of how much work is involved, the time it takes to complete tasks, and how the different aspects of a project will impact on each other is essential when planning a project (Vandersluis, 1997).

2.3.1 Schedule Development and Control

The start and end dates of project activities are determined in schedule development (PMI, 2000). According to PMI (2000) and Schwalbe (2002), the schedule development process may involve the application of one or more scheduling techniques including Gantt charts, critical path method and critical chain. Iterations of the schedule development process are often necessary before the project schedule is finalised. ISSIG (1999) posits that IS projects often adopt complex schedule development processes and require a high number of iterations of those processes.

PMI (2000) notes that when the schedule is finalised and the project is initiated, the project schedule is controlled by

- influencing factors that lead to schedule changes to ensure the changes are manageable
- determining the actual change
- managing the actual change

ISSIG (1999) maintains that schedule control is especially important to IS projects as an IS project typically affects other projects or parts of an organisation, ensuring that schedule

changes must be well communicated. Information on the planned and the actual duration of activities is a key input to the schedule control process (ISSIG, 1999).

2.4 PROJECT SCHEDULING TECHNIQUES

There are numerous scheduling techniques presently available and the following list provides a brief description of the ones that are most commonly used.

2.4.1 Critical Path Method (CPM)

Activities that are critical to the scheduled delivery of the final product are identified using network analysis (McLeod & Smith, 1996). A critical path of the project is then easily identified through the path that includes the critical activities. Delay in any of the tasks on the critical path will lead to a delay in the project end date (Maeurer, 1998). PMI (2000) notes that the main focus of CPM is to determine the least flexible activities in the project schedule by calculating float. In the CPM context, float represents the extra time for tasks (on top of the estimated duration) that is available due to dependencies and constraints related to another set of tasks which make it impossible for a third set of tasks to start before a certain date (Piney, 2000).

Kerzner (1998) posits that CPM is activity-oriented as the percentage of completion of each activity can be determined. Several authors (Kerzner, 1998; Uyttewaal, 1999) suggest that project managers use CPM to determine tasks affecting the project deadline and seek the best possible solution, based on cost and time, to ensure those critical tasks are completed on time and hence the project is completed on time. A major criticism of CPM is that resource availability is not part of the equation that takes both duration and cost into consideration for each activity (Kerzner, 1998). If the required resource for an activity is only available at certain times, preceding activities could have more float because they have to wait for the resource to become available. Uyttewaal (1999) argues that activities that were critical then become non-critical, and will cause the critical path to appear disjointed.

2.4.2 Gantt Charts

Project activities are mapped against time in Gantt charts (Jurison, 1999; Kerzner, 1998; McLeod & Smith, 1996). The activities and respective start and finish dates are displayed in a calendar format (Schwalbe, 2002). Several authors (Jurison, 1999; Maeurer, 1998; Schwalbe, 2002) attribute the strength of Gantt charts to the ease of chart creation, revision and comprehension. The authors also highlight limitations in capturing task precedence relationships as the weakness of Gantt charts. However variations of Gantt charts, such as the

one incorporated by project management software Microsoft Project, are now recording task dependencies and other task related information. Results of the research by White and Fortune (2002) suggest that Gantt charting is a widely adopted technique.

2.4.3 Milestone Schedules

The milestone schedule focuses on significant events of a project. These events are usually the critical activities affecting the project performance. According to Kerzner (1998) typical milestone schedules contain the following information:

- Project start date
- Project end date
- Other major milestones
- Data items (reports or deliverables)

2.4.4 Project Evaluation and Review Technique (PERT)

PERT is a network analysis technique that applies CPM to weighted average duration estimates (Schwalbe, 2002). One aspect that distinguishes PERT from the other scheduling tools is that PERT uses three time estimates (optimistic, most likely and pessimistic) for each task to address individual activity duration uncertainties (Maeurer, 1998; Schwalbe, 2002). According to Kerzner (1998) time is the main focus of PERT, with the emphasis being placed on events or milestones.

Kerzner (1998) suggests that the following benefits can be realised with the application of PERT to schedule projects:

- Alternative plans can be developed to calculate the probability of meeting deadlines.
- The effect of changes in the project can be evaluated as it attempts to address risks related to duration estimation.
- Complicated data can be presented in a well organised diagram.

At the same time however Kerzner (1998) and Schwalbe (2002) identify the disadvantages of using PERT:

- Due to its complex nature, PERT is not easy to develop and implement.
- PERT assumes that there are unlimited resources and all activities start as soon as possible. This assumption may be inappropriate and unrealistic.
- There is often a lack of historical information to support cost estimation.

Both authors further note that examples of PERT implementations are rarely found in practice and PERT is recommended only for large, complex projects.

2.4.5 Graphical Evaluation and Review Technique (GERT)

GERT is similar to PERT but allows for looping, branching and multiple project end results (Kerzner, 1998; PMI 2000). Maeurer (1998) maintains that although GERT is difficult to use as a controlling tool, it is useful in assisting with project simulation and allowing for exploration of potential project outcomes.

2.4.6 Work Breakdown Structure (WBS)

A project is structurally decomposed into work packages by a WBS (Kerzner, 1998; McLeod & Smith, 1996). Lewis (2001) notes that WBS provides an easy to understand graphical representation of project activities that can be referred to as the basis for schedule development and resource assignment. According to PMI (2000), WBS has the major drawback of not displaying task durations. Maeurer (1998) notes that recent variations of WBS take into consideration time, resource and task dependency constraints of the project and then assign time periods and resources to each composite part. Hill, Thomas and Allen (2000) suggest that WBS can be adopted as a useful tool for estimating task duration.

2.4.7 Project Management Software

Several authors (ISSIG, 1999; Kerzner, 1998; Schwalbe, 2002) mention different types of project management software that are available to assist schedule development and control. According to ISSIG (1999) project management software is frequently utilised for IS projects. ISSIG (1999) and PMI (2000) maintain that the outputs of project management software should be perceived and used as components of the overall project plan. Kerzner (1998) and Schwalbe (2002) highlight the following features that are offered by many project management software packages: planning, tracking and monitoring, reporting, and analysis.

Burke (1999) suggests that project management software offers fast and accurate calculation, which can provide useful inputs to high quality reporting. He adds that data can easily be edited in a well formed information structure, and complex analysis can be done rapidly. White and Fortune (2002) suggest that project management software is the most widely used project management tool. However, they note that project management software is perceived by project managers to be unsuitable for complex projects. Additional costs could be necessary as the software may require user training, maintenance and upgrading (Burke,

1999). Users could also become overly reliant on the software without fully understanding the underlying concepts (Schwalbe, 2002).

2.5 PROJECT SCHEDULING PROBLEMS

With many scheduling techniques and methodologies available, the IS industry is still struggling to keep projects on track. According to Maeurer (1998), software development projects consistently fail to be completed on time and the use of traditional scheduling techniques does not improve the situation. Plaza (2000) suggests that project managers are reluctant to use established schedule management tools including Gantt, PERT and CPM because they perceive those tools as being ineffective, difficult to understand and too costly to implement. The following section will discuss problems that are commonly experienced in IS projects when utilising traditional scheduling techniques, as well as factors that contribute to poor project scheduling.

2.5.1 Estimation Problems

Estimation determines project activity duration by considering information on project scope and resources (PMI, 2000). Burke (1999) and Hill, Thomas and Allen (2000) maintain that estimation accuracy affects the effectiveness of project management techniques. ISSIG (1999) notes that different estimation techniques may be adopted at different project phases. PMI (2000) identifies four techniques for activity duration estimation:

- Expert judgement - Any individual or team with specialised knowledge or skill can provide expertise to estimate effort and duration. ISSIG (1999) suggests that IS projects, particularly the software development and implementation projects, rely heavily on expert judgement to estimate activity duration. According to PMI (2000) the uncertainty and risk of the estimates produced by expert judgement can be reduced if such judgement is guided by historical information. Hill, Thomas and Allen (2000) however note that expert judgement does not necessarily require historical information but is dependent on the expert's past experience.
- Analogous estimating – By drawing information from a previous similar activity, the duration of a future activity is estimated. Hill, Thomas and Allen (2000, p. 14) suggest analogy estimation is particularly powerful if applied within a "stable technological environment with some degree of historical data available".
- Quantitatively based durations – The estimate is derived by quantifying the work to be performed (by adopting applicable measures) and multiplying the quantity by the productivity unit rate.

- Reserve time – A percentage of the estimation is often reserved to allow additional time for project activities to buffer against project uncertainties and risks. This percentage can be changed later as more information becomes available.

Several authors (Hill, Thomas & Allen, 2000; Vandersluis, 1995) are of the opinion that accurate estimation is difficult to achieve especially for development work such as software projects. Raz and Michael (2001) note the software development sector is characterised by high uncertainty. Research findings from Hill, Thomas and Allen (2000) reveal a mean of near 1% underestimation by most expert project managers of software development projects, although they also noted that the majority of task durations were overestimated. Abdel-Hamid, Sengapta and Swett (1999, p. 533) argue that the IS industry lacks the ability to "estimate software development costs and schedules with acceptable accuracy and consistency. While numerous cost and schedule estimation models have been developed, their accuracy has proven inadequate". For IS software development projects, documented procedures may provide the best activity duration estimates (ISSIG, 1999).

PMI (2000) highlights historical information as one of the key inputs to estimate activity duration. Kerzner (1998) and Burke (1999) state that the quality and accuracy of estimates can be improved by the availability of more detailed and accurate information. However, with factors such as the external environment, resource capabilities and activity definition varying significantly between IS projects, the applicability of historical data cannot be guaranteed (ISSIG, 1999). Careful consideration of project structure, environment, constraints and other factors affecting project performance must be applied when using historical information (ISSIG, 1999).

According to several authors (Goldratt, 1997; Lewis, 2001; Newbold, 1998; Schwalbe, 2002) reserve time is often wasted at the beginning of the project due to procrastination and uncertainty. The reserve time does not therefore serve its purpose of providing a contingency period for the project.

2.5.2 Uncertainty and Risk

Jaafari (2000, p. 89) defines project uncertainty as "the probability that the objective function will not reach its planned target value" and risk as "the exposure to loss or gain". According to Meyer, Loch and Pich (2002) uncertainty is inherent in most projects. ISSIG (1999) note that IS projects often have to contend with frequent changes as a result of changing IS technology and business needs. The processes and the results of IS projects are inherently

complex (Dawson & Dawson, 1998; ISSIG, 1999). Several authors (ISSIG, 1999; Jurison, 2002; Smith, McKeen & Staples, 2001) suggest that IS projects often include stakeholders from different departments and/or organisations, and are integrated with many existing business processes and technologies, while experimenting with untried technologies, new partners and challenging business strategies. These factors, plus other unique characteristics of IS projects mentioned earlier in this chapter, increase the level of IS project uncertainty and risk. The situation has been further complicated in recent years with IS becoming a significant part of organisations (Smith, McKeen & Staples, 2001).

Patrick (1999a) suggests that successful management of uncertainty is a key factor in improving project performance. The practice of project risk management (processes geared toward mitigating or avoiding negative impacts that risks could bring to projects [Meyer , Loch & Pich, 2002]) varies greatly between organisations (Smith, McKeen & Staples, 2001). The lack of standardisation in the acceptance and application of known risk management techniques is a great risk to the IS projects (ISSIG, 1999; Smith, McKeen & Staples, 2001).

Dawson and Dawson (1998) argue that the adaptation of current project planning techniques, which are deterministic in nature, is inadequate for planning projects involving risk and uncertainty. Leach (1999) adds that the traditional project management practices only provide a tool to analyse the impact of uncertainty on project completion and not a method to manage uncertainty. In order to minimise the impact of uncertainty on project schedules, management and team members can provide an estimate of the task completion dates (Patrick, 1999a; Lynch, 1998). With the estimated completion time of each task being given a safety margin, the total project schedule is lengthened (Newbold, 1998). Schwalbe (2002) suggests that in order to control schedule changes in IS projects, reality checks on scheduling must be performed by first ensuring that the project schedule is not unrealistic, and then tracking project progress against the schedule. According to Drummond (1999) project uncertainty will not necessarily be reduced over time in a changing environment. Jaafari (2001) adds that risk and uncertainty should be managed continuously throughout the project lifecycle.

2.5.3 Resource availability and levelling

ISSIG (1999) identifies people as the key resource in many IS projects. According to ISSIG (1999) activity duration is driven by the number of skilled people available at a planned date for an estimated amount of time. ISSIG (1999) highlights three characteristics of IS projects that make IS project human resource management a challenging task:

- People with specific technical skills are scarce.

- Development and training is often required to keep abreast of the latest technology.
- A combination of internal, external and offshore resources is often utilised by IS projects.

According to ISSIG (1999) people working in the IS environment often work on multiple projects during a time period. Lewis (2001) notes that productivity can be adversely affected by simultaneous involvement in multiple projects.

According to Abeyasinghe, Greenwood and Johansen (2001) conventional scheduling techniques such as critical path method (CPM) and programme evaluation and review technique (PERT) do not include information on resource availability until initial time-based calculation is complete. ISSIG (1999) stresses that the identification of required and available resource capabilities (defined by both experience level and ability of the resource) and assessments of the impact of assigning resources to activities are essential in the scheduling process of IS projects.

2.6 CRITICAL CHAIN PROJECT MANAGEMENT

Several authors (Gillespie, Patterson & Harmel, 1999; Newbold, 1997) are of the opinion that the Theory of Constraints (TOC, refer to chapter 1 for brief description of TOC) is well recognised and widely adopted in manufacturing environments. Gillespie, Patterson & Harmel (1999) suggest that increasing focus is being placed on the impact that TOC tools and principles can bring to other economic areas. Project management is one arena within which the application of TOC (CCPM) is receiving a lot of attention (Simpson III, 1999).

Globerson (2000) notes that CCPM differs from other scheduling techniques in that it takes resource dependencies into consideration when the project schedule is formulated. CCPM discourages the modification of a project schedule once has been defined in the initial phase of the project lifecycle (Leach, 1999). Elton and Roe (1998) suggest that CCPM reinforces discipline in project management.

The following section will present theoretical fundamentals for readers who are not familiar with CCPM. Assumptions regarding certain aspects of human behaviour are made in CCPM. These assumptions will be examined. This is followed by a discussion of how CCPM estimates task durations, and creates and controls the project plan. The section ends with a close examination of CCPM, in which both its strengths and its weaknesses are discussed.

2.6.1 Assumptions made by CCPM

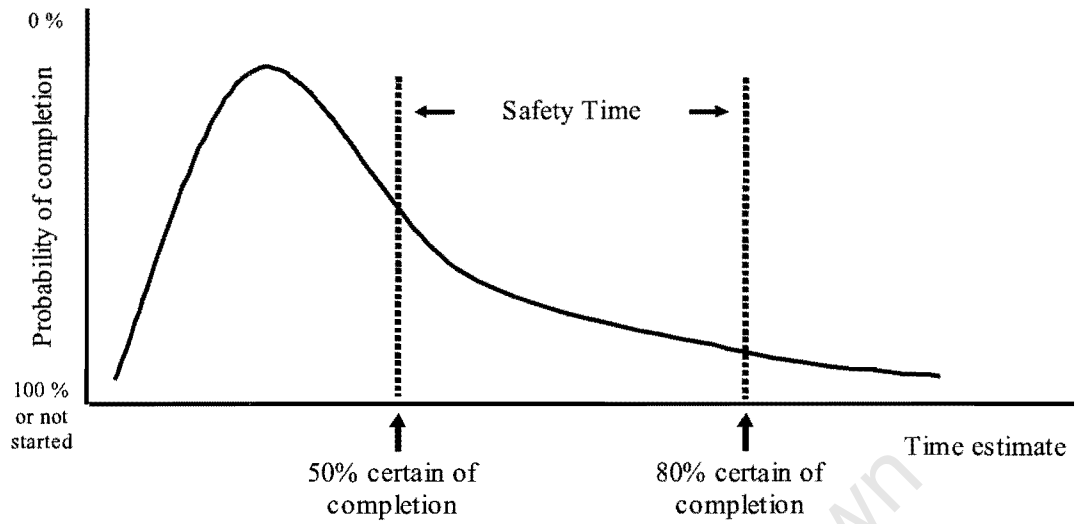

Figure 2.1 – Task Completion Probability Curve (Newbold, 1998)

The first assumption on which CCPM is based, is that past project schedules routinely contain a significant amount of safety time (Steyn, 2000). Figure 2.1 illustrates that project managers add safety time to the duration estimate in order to be at least 80% certain that the project will be completed on time (Newbold, 1998). CCPM further suggests that most of the safety time factored into the project schedule was not leveraged effectively as projects continue to fall behind schedule (Goldratt, 1997). CCPM, in an attempt to offer an explanation as to why safety time is wasted, is also based on the following assumption about human behaviour (Goldratt, 1997):

STUDENT SYNDROME

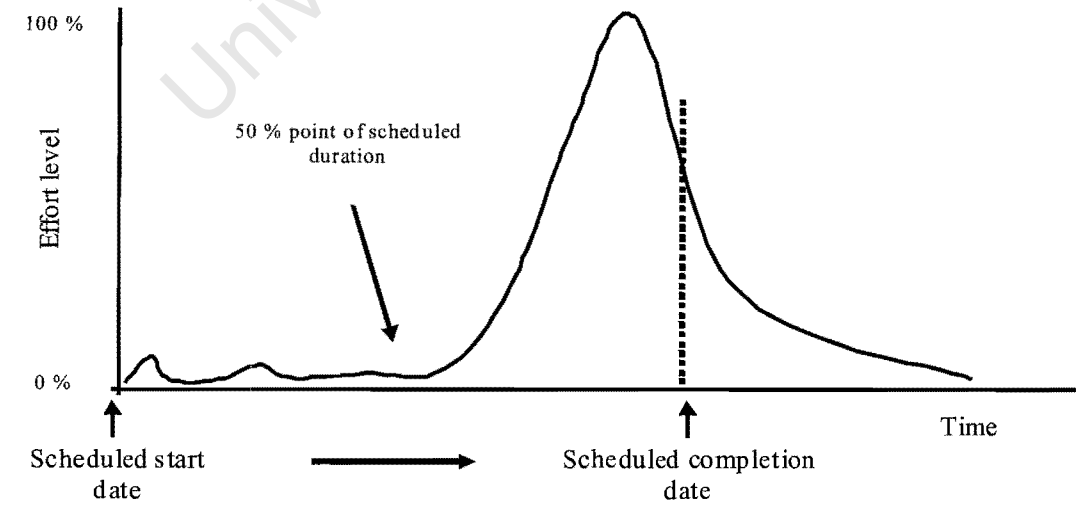

Figure 2.2 – Student Syndrome (Goldratt, 1997)

CCPM contends that procrastination is a common habit of humans. Figure 2.2 shows that the majority of the effort to complete the task only occurs after half of the estimated duration has passed (Goldratt, 1997). According to Newbold (1998) the more time given to people for the task, the later they will start as people look to start at the latest possible date. Delaying the initiation of the task until the last moment before completion wastes a lot of safety time.

MULTITASKING

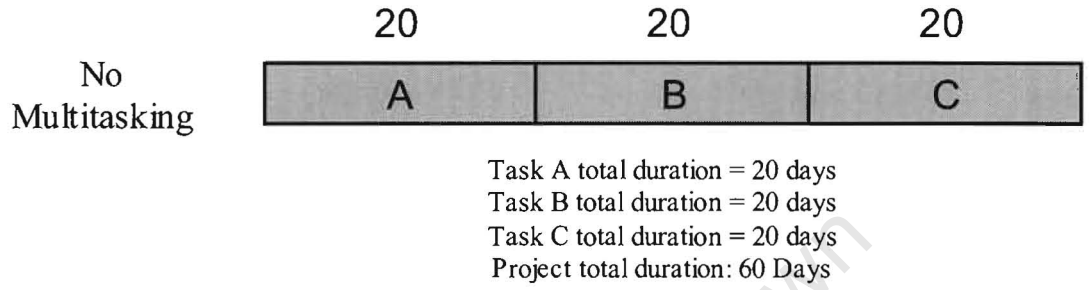

Figure 2.3 – Project schedule without multitasking (Goldratt, 1997)

The effect of multitasking is illustrated in figures 2.3 and 2.4. Multitasking involves task switching which inevitably incurs delay because extra effort is required to setup and prepare for the next task (Goldratt, 1997).

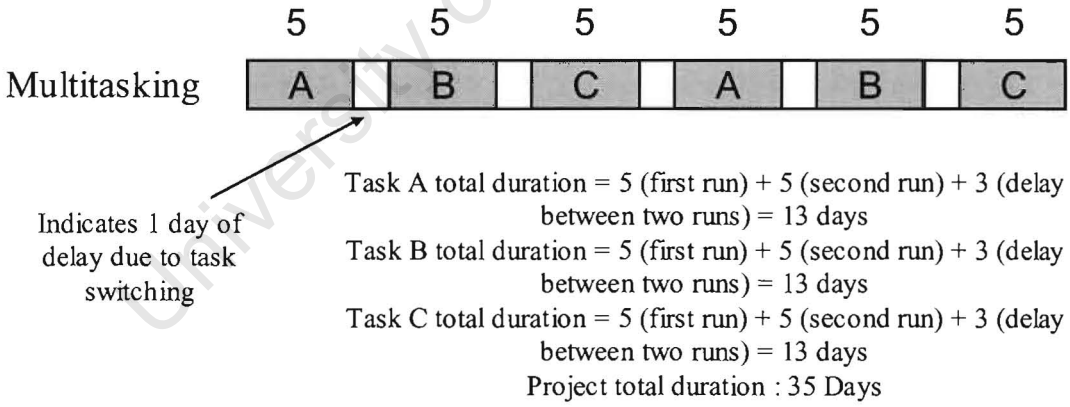

Figure 2.4 – The effect of multitasking (Goldratt, 1997)

Several authors (Leach, 1999; Newbold, 1998; Simpson III & Lynch, 1999) argue that multitasking becomes necessary as people frequently switch from one task to another without completing the task at hand. Simpson III and Lynch (1999) note that multitasking detrimentally affects project progress in two ways:

- Prolonged task duration – A task may take longer to complete because of the interruption by other tasks, forcing delays in the commencement of subsequent tasks.

- Decline in productivity – A lot of time is lost in the set up and set down time of tasks when switching between tasks.

THE PASSING ON OF PREVIOUS DELAYS

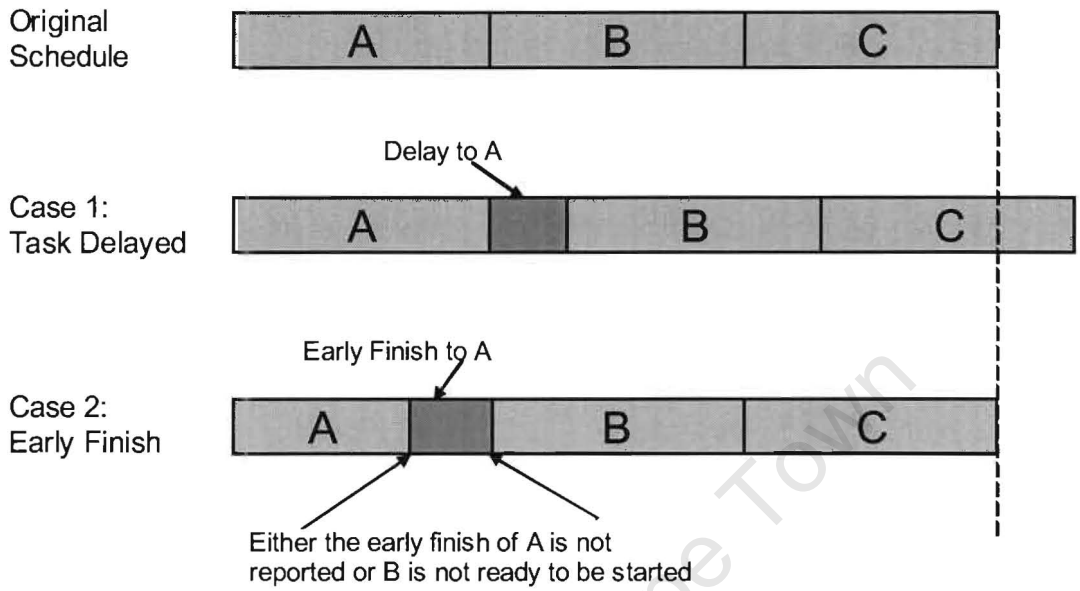

Figure 2.5 – The effect of delay and early finish of a previous task (Goldratt, 1997)

CCPM (Goldratt, 1997) posits that in most projects there is little or no reward for completing a task early. Scenario 1 in figure 2.5 illustrates that delays in the completion of tasks are passed on to the next step simply because the subsequent tasks cannot start unless products or results from the previous tasks have been obtained (Goldratt, 1997). Scenario 2 in figure 2.5 suggests that task B does not benefit from the early completion of task A (Goldratt, 1997) because the early completion is not reported or task B is not ready to be executed. Leach (1999) notes that if a task is completed within the estimated time, people do not start the next task but rather work on other tasks that are unrelated to the project they are assigned to.

According to Steyn (2000) traditional scheduling techniques make no provision for the influence exerted on project planning and control by typical human behaviours commonly observed in projects. Rand (2000) notes that CCPM focuses on addressing human behaviour issues during project planning and management in order to minimise the impact those issues have on the project.

2.6.2 50% estimation

In an attempt to avoid project schedules being prolonged by the incorporation of safety time, the CCPM approach removes the safety time from duration estimates and aggregates it as time buffers that are placed in the project schedule to protect tasks from uncertainty (Goldratt, 1997). CCPM contends that 50% of the original estimate can be regarded as safety time (Goldratt, 1997). Newbold (1998) suggests that the 50% mark represents an estimate with a 50% confidence level, namely there is a 50% possibility that the task will not be completed on time. CCPM maintains that the strategic placement and usage of time buffers will protect the project from the risk of task duration overrun.

2.6.3 Developing the Critical Chain Plan

When duration estimates are calculated, tasks will be scheduled into a project plan based on CCPM principles. Goldratt and Cox (1992) recommend a five-step process to create a project plan with CCPM:

1. Create the critical chain by identifying the constraints. In the project management context, the constraints of the project are the resource and activity dependencies that determine the sequence of dependent events (critical chain) which sets the minimum time interval of the whole project. The term 'drum' resource is adopted to represent a resource that is viewed as a constraint to the project duration.
2. Exploit the constraint by eliminating inefficiency from the constraint. CCPM takes away half of the individual activity time estimates and develops buffers for the project schedule.
3. Subordinate everything else, that is, the non-critical chain path. CCPM makes the effective management of the constraints the top priority by restricting the rate at which non-critical resources and activities process tasks to a level that is manageable by the constraints. Buffers (safety time) are now inserted into project schedules to protect the critical chain from any unexpected interruptions. Goldratt (1997) contends that buffers are more effective than original safety time as the buffers are inserted into places in the project plan where they are most needed.
4. Elevate the constraint by increasing its capacity above the level of demand. This may include the acquisition of additional resources. The constraint will become non-critical once its capacity has been upgraded.
5. Iterate the above steps and work on the next constraints while carefully avoiding the creation of a new constraint with the adjustments made in the previous steps.

2.6.4 Buffer and Buffer Management

CCPM utilises buffers to provide the safety needed in a project. In the context of CCPM, a buffer is an amount of time specifically added to a project to absorb impacts that uncertainty and other factors could have on the estimated project duration (Piney, 2000). There are three types of buffer, each being inserted in a different place with a different objective (Goldratt, 1997; Leach, 1999; Lynch, 1998; Newbold, 1998):

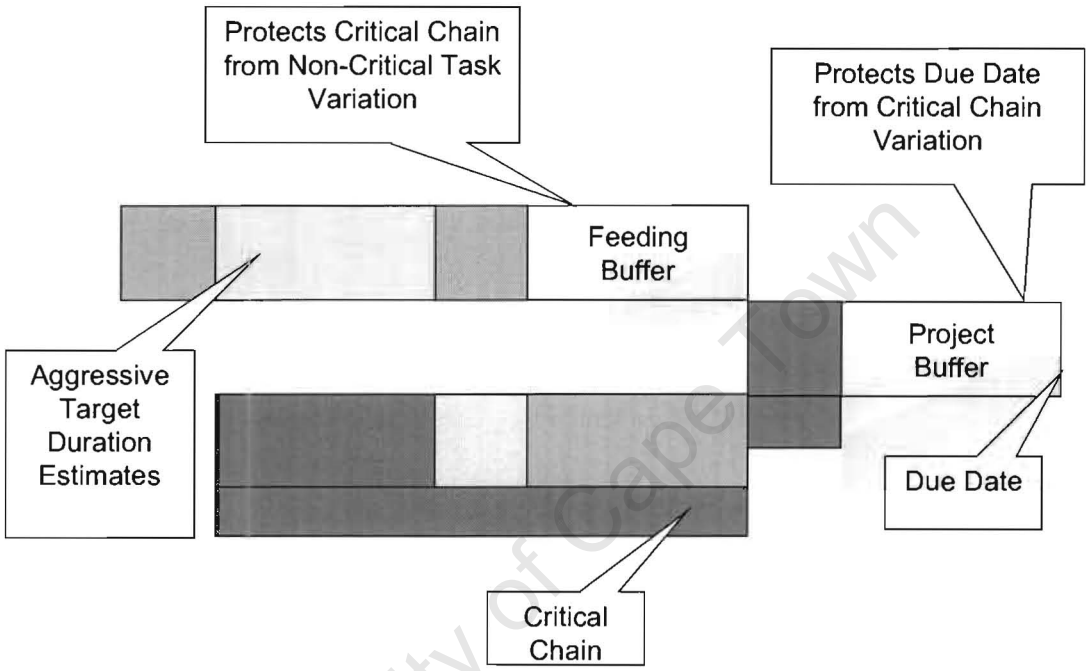

Figure 2.6 – A Critical Chain schedule with buffers (Adapted from Patrick, 1999b)

- Project Buffer – Inserting a project buffer at the end of the project activity path protects the overall project schedule, as illustrated in figure 2.6.
- Feeding Buffer – An aggregated feeding buffer is placed at the end of each path that feeds the critical chain in order to protect the critical chain from potential delays in the feeding path, as illustrated in figure 2.6.
- Resource Buffer – Applied only to critical chain activities, the resource buffer protects the critical chain from unavailability of resources.

According to Goldratt (1997) buffer management involves updating the estimates of time-to-completion from currently active tasks to determine the level of buffer penetration. Newbold (1998) and Leach (1999) note that buffer management provides an indication of how much delay, if any, the project is experiencing and could act as a proactive project management tool.

Patrick (1999a) suggests that when the buffer consumption passes the delimited level, warning signs ought to be issued and if the situation deteriorates, actions must be taken to protect the critical chain and the overall project progress.

2.6.5 Strengths of CCPM

Wilkens (2000) notes that the focus of CCPM is where it should be, that is to achieve the goals of the project on hand and not the goals of other projects. CCPM aims to improve project performance by ensuring that projects are completed on time. CCPM attributes the failure in the management of project duration to certain human behaviour patterns. Several authors (Newbold 1998; Leach, 1999; Patrick, 1999a) are of the opinion that the human behaviour patterns addressed by CCPM are valid and can be found in many projects. The authors further suggest that CCPM presents a viable solution to address poor project time management. According to Steyn (2000) CCPM is simple to understand and quick to learn.

Newbold (1997) maintains that the addition of buffers in CCPM increases the reliability of the project completion date. Steyn (2000) notes that safety times are aggregated and individual task due dates are eliminated. According to Patrick (1999a) concentrated safety times protect activities that are critical to project success by allowing resources to focus on high priority tasks. The implications of reduction in project lead time, as a result of timely completion of tasks, are that projects are likely to be completed with no or very little additional cost (Newbold, 1997) and in accordance with the original scope (Lynch, 1998).

2.6.6 Weaknesses of CCPM

Rand (2000) notes that the recommendation made by CCPM to avoid milestones for individual tasks may be counter intuitive and unacceptable. Steyn (2002) suggests that a drastically different mindset is required for CCPM. According to Patrick (1999a) the implementation of CCPM requires not only a simple technical change but also a broad management change. Lynch (1998) adds that the changes will be significant. Lynch (1998) further suggests with the CCPM implementation it is particularly difficult to provide incentives for subcontractors to complete key tasks on time and prevent people from increasing task duration estimates to earn more time.

Elton & Roe (1998) are of the opinion that CCPM is based on the assumption that project management can be successfully accomplished in the same rational approach that is adopted in manufacturing management. The impersonal and rational approach suggested by CCPM might not be appropriate in the IS project management context, which typically involves a

higher level of uncertainty and human interaction than in the manufacturing environment (Pepin, 1999).

2.6.7 Critical success factors of CCPM implementation

Although CCPM implementation could be a difficult task, several core issues have been identified as the key to success when they are correctly addressed. Newbold and Lynch (1999) suggest three critical success factors of CCPM implementation:

- Establish realistic implementation goals – The organisation needs to understand the implementation objective and obtain the improvement that it desires the most.
- Keep the right leadership involved – According to Newbold and Lynch (1999) the biggest threat to a successful implementation is the lack of leadership involvement. Top management authorises project development and sanctions resource transfer, and therefore has tremendous influence over the project (Pinto, 1996). Leadership support involves active participation in the implementation process with direct responsibility taken over the implementation.
- Create and maintain the implementation plan – As simple as it may sound, incomplete implementation plans are not uncommon (Newbold & Lynch, 1999). The implementation plan has to adhere to the established goals and include the right people and resources.

2.7 CHANGE MANAGEMENT

According to several authors (Cabanis-Brewin, 1999; Newbold, 1998; Patrick, 1999a; Steyn, 2000) CCPM presents a different approach to project scheduling and a shift of focus. As CCPM attempts to alter project team behaviour (Leach, 1999), change management techniques are receiving more attention as there is evidence of a growing concern for securing successful implementations of CCPM (Steyn, 2000). Poorly managed implementation of systems that result in changes at all levels of the organisation could lead to resistance (Jurison, 2002). Kerzner (2001) defines the requirements for the successful implementation of a project management methodology:

- Identification of both the reasons to change and the underlying cause of these reasons
- Identification of an appropriate strategy to overcome resistance to change
- Application of change management principles to create and sustain the desired project management environment

Voropajev (1998, p. 17) depicts change management as the integral processes that protect projects "from the influence of external and internal change factors" and "introduce all necessary changes and control the process of changing". According to van der Waldt & Knipe (1998) change management is multidimensional and involves the following steps:

- inform involved personnel of the need for change
- identify change agents to facilitate the change
- establish a change supporting environment

Change agents in particular are important in the change management processes as they identify the need for change, establish the direction of change and facilitate the change (Jurison, 2002). In the context of project management, project managers often take on the role of change agents (van der Waldt & Knipe, 1998; Jurison, 2002). External consultants can also be employed as change agents, although often at a higher cost to the organisation (van der Waldt & Knipe, 1998). The position of change agent is a dynamic one as different roles are required by various aspects of change (Jurison, 2002). Markus and Benjamin (1996) suggest three role models for IS change agents:

- traditional IS change agent – views technology as the change agent and no change responsibility is assumed by the IS organisation beyond the building of technology
- facilitator – assists people or clients to achieve results
- advocate – attempts to influence the behaviour of people towards what the change agent desires

Although the change agent is important, all stakeholders must be involved in the change management process to avoid the assumption that change management is the responsibility of a small group of people within the organisation and to identify with the values and objectives of the organisation (Markus & Benjamin, 1997; van der Waldt & Knipe, 1998).

During the change management process a change management strategy is formulated (van der Waldt & Knipe, 1998). Several authors suggest the following principles be taken into consideration while formulating the change management strategy (Benjamin & Levinson, 1993; Frame, 1994):

- Establish a pro-change mind set by developing appreciation of change through education and training
- Analyse the scale of change and size of change effort
- Analyse and manage the commitment of the stakeholders
- Prototype the change and observe the response
- Incorporate change reviews into the management process

Van der Waldt and Knipe (1998) further suggest two critical variables in change management that must also be considered:

- organisational culture – The adaptation of organisational culture makes the change possible. In managing change, one must be sensitive to the presence of any person or group that could influence the culture of the organisation.
- resistance to change – The reasons for people's resistance to change could be perceptual, emotional, cultural, environmental or cognitive. Poor performance and irrational behaviour could result from poorly managed resistance to change. Effective management of resistance to change involves the identification of the origin and nature of resistance, diagnosis of the reason for resistance, implementation of resistance reduction actions, and evaluation of the process.

The importance of user acceptance of a new methodology is underlined by the fact that resistance to change has been highlighted as a critical factor influencing the change management process. User acceptance of CCPM is no exception and is examined by this research in terms of the Technology Acceptance Model (TAM), which measures user acceptance of new technologies. The reason behind the use of TAM is that TAM is practical in nature, which is suitable for this empirical case study. Furthermore TAM is well supported by several other empirical research studies (Chau, 1996). The next section examines TAM and provides further details of the model.

2.8 TECHNOLOGY ACCEPTANCE MODEL (TAM)

According to Chau & Hu (2001) behavioural intention, formalised by the Theory of Reasoned Action (TRA), has "emerged as a common anchor for examining individual technology acceptance and adoption". Two theories, the Technology Acceptance Model (TAM) and the Theory of Planned Behaviour (TPB), were derived from TRA. Compeau, Higgins & Huff (1999) note that both TAM and TPB view behaviour as the outcome of beliefs about technology and affective responses to the technology. While TPB supplies specific details that could better guide system development, TAM provides general information on users' opinions of a system (Chau, 1996). Chau (1996) suggests that TAM is better supported empirically and easier to apply in practice. TAM, proposed by Davis (1989), posits perceived ease of use and perceived usefulness as fundamental factors in the determination of user acceptance of new technology. Davis (1989) suggests that performance gains induced by the new technology can be reduced by poor user acceptance.

This research adopts the original form of TAM, as illustrated in figure 2.7. Davis (1989) suggests that system usage is affected by behavioural intention of the user. Behavioural intention is shaped by users' perception of usefulness and ease of use of the system (Davis,

1989). While both the perceived usefulness and ease of use are influenced by external variables such as the implementation process, the perceived usefulness is also indirectly influenced by the perceived ease of use of the system (Davis, 1989). This original form of TAM is the most empirically researched version of TAM with several recent TAM related research efforts adopting it (Chau & Hu, 2001).

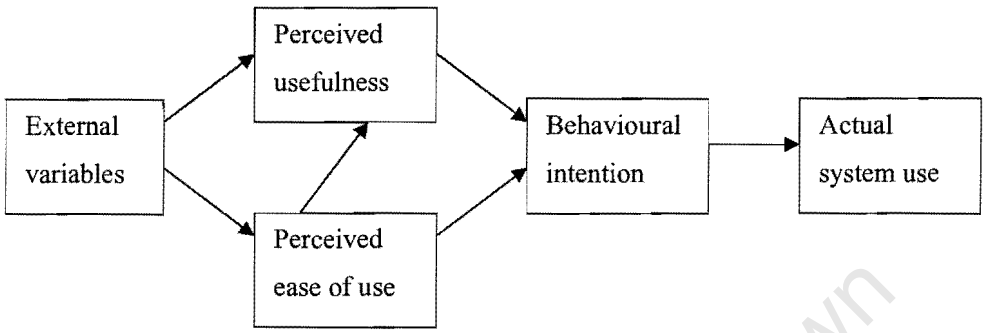

Figure 2.7 – Technology Acceptance Model without Attitude Construct (Venkatesh & Davis, 1996)

Davis (1989, p. 320) defines perceived usefulness as "the degree to which a person believes that using a particular system would enhance his or her job performance". Adams, Nelson & Todd (1992) suggest that perceived usefulness is closely linked to instrumentality, outcome expectation and extrinsic motivation. Perceived ease of use is defined by Davis (1989, p. 320) as "the degree to which a person believes that using a particular system would be free of effort". Perceived ease of use influences behavioural intention both directly and indirectly through perceived usefulness (Adams, Nelson & Todd, 1992). Davis (1989) states that systems that are easier to use are more likely to be accepted by users. The external variables influencing both perceived usefulness and perceived ease of use include system characteristics, training, user involvement in design and the nature of the implementation process (Venkatesh & Davis, 1996).

2.9 SUMMARY

The field of project management has been in existence for more than 40 years and is becoming a vital part of contemporary organisations. This is especially true for the IS industry as IS related work is often of a project nature. However there appears to be consensus on the dissatisfaction of IS project performance when the projects are managed using conventional project management techniques. Projects are often delivered later than the planned date while consuming more than the allocated resources.

Project time management and scheduling is considered to be a key area in project management theory. A review of conventional scheduling techniques has revealed the omission of details about resource requirement and availability from the project plans developed using those techniques. Further, estimation problems and increasing levels of uncertainty and risk result in poor project scheduling and control.

CCPM presents a different perspective on project scheduling by suggesting that certain human behaviour such as procrastination and multitasking are accountable for poor project scheduling. CCPM offers tools and techniques that attempt to enhance the control of project schedules so that the goals of the project are reached. The literature suggests that CCPM implementation is not an easy task and change management techniques are required. Through a case study, this research aims to gather more information on CCPM implementation issues and examine its effectiveness.

An examination of change management theory has identified change agents, the environment, and resistance to change as key factors in the change management process. This highlights the importance of user acceptance. A model to measure user acceptance of a system is presented by TAM. Variables including perceived usefulness and perceived ease of use are examined by TAM. The literature suggests that TAM provides users' opinions of a system. Furthermore TAM is empirically well supported and easy to apply.

3. RESEARCH METHODOLOGY

This chapter details the sample used to collect the data required for this research, and the issues affecting the choice of sample. Problems with the sampling technique and choice of sample are discussed. The procedures used in deriving the research instrument are explained, and the reliability and validity of the instrument are examined. The data collection techniques are also described.

3.1 RESEARCH QUESTIONS

This research examines the effectiveness of CCPM from several perspectives. First the assumptions made by CCPM are explored. A section of the questionnaires used in this research relates to assumptions regarding the existence of certain human behaviours during projects and the impact of those behaviours on project performance. The strengths and weaknesses of CCPM observed during the implementation are highlighted and compared to those identified in the literature as these strengths and weaknesses could significantly affect the effectiveness of CCPM in an IS environment.

CCPM effectiveness is also examined by this research from the perspective of user acceptance. Variables identified by TAM that measure user acceptance of a system are adopted in order to determine user acceptance of CCPM. The main focus is on the two most influential variables, namely perceived usefulness and perceived ease of use. External variables such as training and the implementation process are also examined by including relevant questions in the questionnaires and interviews. These two external variables were specifically examined because the other external variables such as system characteristics are included in the CCPM assumptions review and user involvement in design is not appropriate for this case study as the users were not involved in the design of CCPM.

At the top level the research seeks answers to two questions:

1. How effective is CCPM when applied in an IS environment?
2. Is CCPM easily accepted by users when applied in an IS environment?

This research attempts to answer the two top level research questions by gathering empirical data for sub-level questions which are derived from the two above-mentioned questions. The numbering of the following sub-level questions corresponds to the numbering of the top level questions.

1.1 Are assumptions made by CCPM valid?

1.2 What strengths and weaknesses of CCPM were apparent during the implementation?

2.1 What is the perceived usefulness of CCPM?

2.2 What is the perceived ease of use of CCPM?

2.3 What effects do variables such as the implementation process and training have on the user acceptance of CCPM?

3.2 METHODOLOGICAL ISSUES

3.2.1 Choice of Research Methodology

CCPM, proposed by Goldratt in 1997, is a relatively new theory compared with the other project scheduling techniques such as Critical Path Method and Project Evaluation and Review Technique. Steyn (2002) suggests that practical research data relating to CCPM implementations are not widely available at present. The currently available practical results tend to focus more on quantitative data due to the numeric nature of the project scheduling process. However CCPM focuses not only on project duration but also on human behavioural issues (Rand, 2000).

According to Benbasat, Goldstein and Mead (1987) case study research is particularly well suited to practice-based problems that are in their formative, early stages where the practical experiences of the actors and the context of action are important. The adoption of case study research methodology will allow the researcher to collect qualitative empirical data of CCPM application in an IS environment. The reasons behind the choice of the case study research methodology for this research are reflected in views expressed by Benbasat, Goldstein and Mead (1987):

- Case studies allow the researcher to make observations in the natural setting of the subject that is being studied, learn about the state of the subject and possibly generate theories.
- The researcher is given the opportunity to comprehend the nature and complexity of the process in practice through a case study.
- Case studies are appropriate for scarcely studied areas. It allows the researcher to explore, classify and develop hypotheses on the subject that is being researched. Case studies can focus on and examine the complexity of the subject as part of the knowledge building process.

The decision to adopt a case study research methodology is also supported by the following conditions which, according to Yin (1994), make case studies an effective research strategy:

- The research does not require or could not exert control over behavioural events.
- The research focuses on contemporary events.

3.2.2 Defining case study research methodology

Lee (1989) and Myers (1997) maintain that the case study research is the most frequently adopted qualitative research method in the IS field. Several authors (Benbasat, Goldstein & Mead, 1987; Myers, 1997; Yin, 1994) define the case study research methodology as an empirical inquiry that examines a contemporary phenomenon within its real life and natural context by employing multiple methods for data collection from one or several entities.

Benbasat, Goldstein and Mead (1987) identify the following key characteristics of a case study:

- One or more entities (such as teams or organisations) are examined in its/their natural setting.
- No experimental controls or manipulations are applied in the case study.
- The focus of case study research is on contemporary events.
- The researcher does not have to specify a set of independent and dependent variables prior to the research, and changes in research site selection and data collection methods are possible during the research. This specific characteristic, which makes the case study research method more flexible and open, suggests that the results of the research depend heavily on the integrative powers of the researcher.

3.2.3 The Nature of the Research

According to Yin (1994) case studies can be of an exploratory, descriptive or explanatory nature. The research questions implicitly exhibit the exploratory nature of this case study research. Yin (1994) suggests that exploratory case study should clearly state the following:

- What is to be explored – The sub-level research questions provide details of what this research is aiming to explore.
- The purpose of the exploration – The purpose of this research is clearly stated in the top level research question, namely to determine the effectiveness and user acceptance of CCPM.
- The criteria for a successful exploration – This research can be judged successful when it provides answers to the research questions and concludes with insight into a CCPM implementation. In addition this research intends to supply recommendations on effective

implementation actions and provide a list of critical success factors for CCPM implementation.

3.2.4 Philosophical Perspective of the Research

Three major philosophical research perspectives can be found in the literature (Lacity & Janson, 1994; Myers, 1997):

- Positivist – Positivist researchers believe that reality is objectively presented and can be depicted by properties that are independent of the observer and the research instrument. According to Kaplan and Duchon (1988), traditionally the positivistic perspective has been the dominant research paradigm for IS research. Sarker and Lee (2002) depict a positivistic view that combines the three positivist traditions:
  - The empiricist tradition, which, in search of the foundation of human knowledge, systematically collects and collates observable sensory data from the empirical experience of the external world.
  - The rationalist tradition, which argues that unquestionable logical and rational principles are the route to indubitable knowledge.
  - The critical rationalist tradition, which proposes the use of deductive methods to falsify the theory if the deductions and the empirical evidence do not match. The hypothetico-deductive model, derived from the critical rationalist tradition, compares the conclusion or prediction deduced from the theory statement with the empirical evidence. According to Sarket and Lee (2002) the hypothetico-deductive model is at the core of contemporary positivist research.
- Interpretive – The assumption made by interpretive researchers is that reality can only be understood through social constructions such as consciousness, language and shared meanings. Klein and Myers (1999) suggest that interpretive research is attracting increasing interest in recent years.
- Critical – Critical researchers believe that reality is a combination of events that were constituted in the past and are being reproduced by people.

According to Sarker and Lee (2002) case studies are usually associated with the positivist or interpretive approach, with neither being superior to the other. This research adopts the positivistic view that corresponds to the above-mentioned view depicted by Sarker and Lee (2002). The empiricist tradition is reflected in the research objective as this case study aims to capture empirical data from CCPM practitioners. The empiricist tradition is further supported by the fact that this case study follows a set of systematic documentation and rigorous research procedures defined by Yin (1994). The rationalist and the critical rationalist

traditions are reflected in the research questions as this case study aims to compare empirical evidence against the assumptions made by CCPM in project scheduling.

3.3 CASE STUDY DESIGN

The desired outcome of a case study design is an action plan that links the data that is to be collected to the initial research question in a logical way (Yin, 1994). The key elements of the case study design of this research are discussed in this section.

3.3.1 Case Study Process

In February 2000 the researcher began to search for an appropriate site to perform the case study. CCPM was not widely implemented in the South African IS industry when this research was initiated. The Technology Development (TD) division of Siemens Southern Africa was one of a few organisations to formally implement CCPM within an IS project environment executing mostly software development and testing projects. CCPM implementation within the division was initiated in November 1999. The researcher met with key personnel from the division in March 2000 and permission to perform the case study was obtained. The case study started in April 2000.

According to Yin (1994) time boundaries must be set to mark the start and end points of the case study in order to determine the limits of the data collection and analysis. It was difficult to set such time boundaries for this case study based on the rationale that the research findings would be more meaningful when the CCPM implementation reached a significant stage at the research site. Instead of physical time boundaries the researcher set logical boundaries for the research and decided to perform a longitudinal case study. The case study began 5 months after CCPM implementation was initiated in the TD division and ended in November 2001 when CCPM became the formal project management practice within the division. The overall duration of the case study was approximately 20 months.

The researcher spent 5 weeks during April and May 2000 at the research site to initiate the case study and gather data. During the 5 week period the researcher conducted interviews, made observations, reviewed documents and distributed questionnaires. Continuous communication was maintained between the researcher and staff of the TD division after the on site data collection period. Documentation recording progress of the CCPM implementation at the research site was sent to the researcher. In November 2001 the researcher revisited the research site and held discussion sessions with a few staff members of

the TD division. Questionnaires were also distributed to the entire TD division during the second visit.

3.3.2 Role of the Researcher

The role of the researcher in this case study was as an independent observer of the research subject. The researcher prepared and performed the case study by following procedures recommended in the literature, drawing mainly from Yin (1994). Details of the procedures and the reasoned decisions regarding data collection are discussed in later sections of this chapter. All the data collected during the case study was recorded and transcribed by the researcher. The electronic data were stored both in the researcher's PC and on the university network. A copy of the paper-based data was stored in the researcher's home while another copy was stored in the post-graduate's office at the university. Updates were applied to both copies and regular comparisons were made between the two copies to ensure data integrity.

3.3.3 Unit of Analysis

This research is a single case study research with embedded units and was carried out on one site only. The research was conducted at Siemens Information and Communications group, a subsidiary of Siemens Southern Africa. Figure 3.1 illustrates the organisational structure of Siemens Southern Africa.

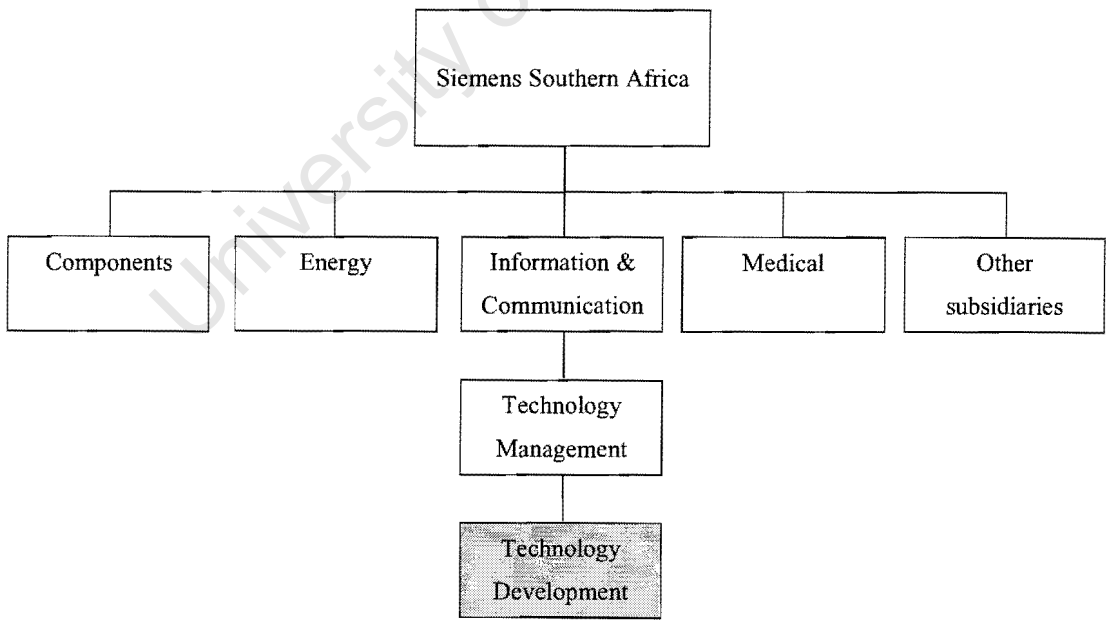

Figure 3.1 – Organisational structure of Siemens Southern Africa

3.3.3.1 COMPANY BACKGROUND

Siemens Southern Africa employs more than 3200 people. It reported a turnover of over R5 billion for the 2001/2002 financial year. Siemens Southern Africa is majority-owned by the parent company, Siemens AG of Germany. An intimate work relationship exists between Siemens Southern Africa and Siemens AG. While the head office of Siemens Southern Africa is based in Midrand, Johannesburg, Siemens Information and Communications group is based in Waterloo, Pretoria, some 100 kilometres away.

The unit of analysis for this research is the Technology Development (TD) division of the Technology Management department within Siemens Information and Communications group. The division of Technology Management consisted of approximately one hundred and sixty people. It is responsible for activities such as product development and verification, fault finding, country specific adaptation of products, tender preparation, customer query handling, technical consultation and configuration management. The Technology Development division is specifically involved in the development and customisation of Siemens Information and Communications products.

The division was the main focus of this case study. Project teams and individual team members were the embedded units within the Technology Development division. While the overall project performance of the division was examined in this research, the embedded units were not overlooked as interviews were performed on a one-to-one basis to gather inputs from individual team members.

3.3.3.2 PROJECT TEAMS

The Technology Development division is structured according to technologies, with various project teams operating within the division, as illustrated in figure 3.2. There were four project teams in the division, one of which was established at a later stage of the case study. The case study primarily focused on three of the four project teams:

- Mobile Core – The team was involved in mobile network projects for both Siemens Limited and Siemens AG in Germany. The team was responsible for customisation and development of GSM software. Mobile Core was the first team in the division to implement CCPM. Seven projects had been completed using CCPM when the case study was initiated. Several Mobile Core team members were interviewed during the case study. The early part of the case study focused on Mobile Core as it was the most experienced team in executing projects with CCPM.
- Intelligent Services – The team was involved in both the development and testing of software for the intelligent network platform. It was responsible for cellular applications

and services such as Vodacom's Pre Paid Service and Virtual Private Network. Intelligent Services was the second team in the division to implement CCPM. Intelligent Services had completed two projects using CCPM when the case study was initiated. Several team members of Intelligent Services were interviewed during the case study.

- Wireline Networks – This team was involved in services such as project specific adaptations of the world market base. Wireline Networks had just begun the CCPM implementation process when the case study was initiated. Two questionnaires, designed to gather data on user acceptance of CCPM, were distributed to the Wireline Networks team members. The researcher also observed meetings that were held between Wireline Networks and an external consultant as part of the CCPM implementation process.

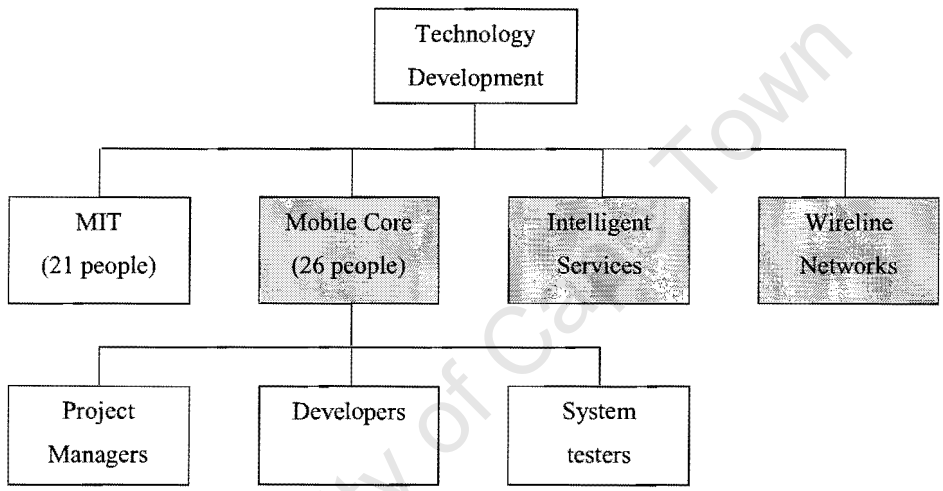

Figure 3.2 – Team structure within the Technology Development division

There were three categories of team members within each team. They were the project managers, developers and system testers. The developers and system testers were involved in different phases of the project, with the project managers overseeing the whole project and team. There were also group leaders within each group of team members. For example the system testers would report to the system test group leader and the group leader represented the group. In total the four project teams consisted of 88 people including 11 project managers.

3.3.3.3 PROJECT PROCEDURE

Projects typically consisted of four phases with milestones at the end of each phase. A project started with a 'kick off meeting', which initiated the 'Pre-Analysis' phase. Reaching the 'B130' milestone ended the 'Pre-Analysis' phase. All members of the project team were involved in this phase as the team gathered information, discussed project details and

prepared resources needed for the project. Project scheduling and task duration estimation were also included in the 'Pre-Analysis' phase. The 'Analysis' phase followed the completion of the 'Pre-Analysis' phase. During the 'Analysis' phase the developers analysed specifications, concepts and other project details. The 'Analysis' phase was complete when the 'B200' milestone was reached, which started off the 'Development' phase. The developers designed and then coded the software product during the 'Development' phase. The 'B410' milestone concluded the 'Development' phase and marked the beginning of the final phase of the project, the 'Test' phase. In the 'Test' phase the system testers tested the product developed by the developers in the previous phase. The 'Test' phase and the project ended when the final 'B600' milestone was reached. The duration of the final phase of a project was usually longer than the other phases of the project.

When each milestone was reached, meetings were held to review the project phase that was about to be concluded and to initiate the next project phase. Other meetings were held during each project phase if necessary.

3.3.3.4 THE NATURE OF PROJECTS

The projects that the Technology Development division worked on were mostly sub-projects of projects based in Germany. The completion dates of the sub-projects had to be met by the division as the deadlines were milestones of bigger projects. The projects mostly involved software development and testing work.

3.3.3.5 FORMER PROJECT MANAGEMENT PRACTICE

The Technology Development division previously employed a method which was termed the "check list" method. Based on expertise and past experience, the project teams were able to determine the tasks that had to be carried out in a project. These tasks were then included in the checklists which were examined at the end of each project milestone. If all the tasks listed on the checklist of a particular milestone were completed, then the milestone had been reached.

Task durations were also determined by expert judgement based on applicable historic data from completed projects. Other project management tools such as the Gantt chart and PERT chart were not used frequently. The division found it difficult to keep the charts up to date, therefore the perceived benefits that those charts were expected to bring were not effectively reaped during execution. Critical Path Method was not used at all by the division.

3.3.3.6 PROJECT ENVIRONMENT

The project teams within the division were operating under a multi-project environment. The division completed approximately forty projects a year, with six or seven projects running concurrently at any given time. The projects were not of a constant size. Different projects had lead times ranging from a few weeks to several months. Typically Mobile Core executed projects that ran for a few months, while team Intelligent Services and Wireline Networks executed project that ran for 6 months or longer.

The fact that several projects were executed concurrently required resources to be shared across the division. It was a common practice to have project members of a project team also working in the other project teams. There was no formal procedure to schedule shared resources. Unplanned resource sharing was not uncommon. Resource management was therefore a key issue within the division.

3.3.3.7 MOTIVATION BEHIND THE SHIFT TO CCPM

Prior to the CCPM implementation, the checklist / milestone project management practice was considered to be effective for the Technology Development division. The effectiveness of the former practice (with CCPM being the current project management practice) was illustrated through project performance. More than eighty percent of the projects initiated in the division were delivered according to the predetermined scope, within budget and on time. This result is contrary to the widely recognised problem of poor project performance within the IS industry as suggested by statistics reported by the Standish Group (Schwalbe, 2002) already discussed in chapter 1.

The main drivers behind the adoption of CCPM included not only project performance improvement but also cost reduction. The top management of Siemens Information and Communications Group set a strategic goal of budget reduction during 1999. This prompted each division within the company to produce strategies to lower costs. The director of the Technology Management division came across the Theory of Constraints and studied CCPM. The division experienced low income growth in 1999 although more projects were completed. Furthermore substantial amounts of overtime, which incur extra costs, were often necessary to ensure the prompt completion of projects. The concern of low income growth, together with the strategic focus to reduce costs, resulted in the decision that CCPM would be implemented as the formal project management practice within the Technology Development division. The objectives that the division set for the CCPM implementation included that of better control of project progress and better scheduling of project activities. The division expected benefits such as budget reduction to be reaped by achieving the objectives of CCPM implementation.

This would be the result of improved scheduling, which would lead to a lower overtime requirements.

3.3.3.8 CCPM IMPLEMENTATION PROCESS

The CCPM implementation was preceded by a workshop providing background knowledge of CCPM. An external consultant was appointed to prepare the materials and conduct the workshop. After the workshop the external consultant met with the project managers to establish templates in Concerto, the adopted project management software which created project plans based on the CCPM concept and principles. The templates were then presented to all members within the project team and discussed among them. After adjustments had been made to the templates, the project team began scheduling the first project that was due to start. The CCPM implementation officially began at that point.

Concerto was not the only software tool available when the CCPM implementation was initiated. The management also examined another software tool but found Concerto a more suitable solution based on the circumstances for this CCPM implementation.

Regular consultation and check-in sessions were held with the external consultant during the implementation process. The progress of the implementation was closely monitored by top management together with the external consultant. Workshops, if necessary, were conducted to address issues, problems or difficulties that had arisen during the implementation. Review sessions were conducted at the end of each project to examine the implementation results.

3.3.3.9 KEY RESEARCH ISSUES

According to Benbasat, Goldstein and Mead (1987), confidentiality and benefits to the organisation are the two key issues that have to be addressed in obtaining co-operation from the research site. When the site selection process began, the researcher approached the director of the Technology Management division. The two above mentioned key issues were discussed with the director and consensus was reached. Siemens Southern Africa prohibits the publication of sensitive business information. The confidentiality concern was conveyed to the researcher. The researcher suggested that a draft of the research thesis would be presented to the director of Technology Management division and amendments would be made if the draft inappropriately contained any sensitive information. The director agreed to this suggestion and also realised that the research could bring additional understanding to the organisation with regard to the CCPM implementation.

3.3.4 Data Collection Techniques

The problem investigated by this research is of an organisational nature. According to Myers (1997), the increased use of qualitative research methods in IS can be attributed to the general shift in focus from technological to managerial and organisational issues. Myers (1997) further suggests that qualitative research makes use of qualitative data including interviews, documents, and participant observation data to understand and explain social phenomena. Yin (1994) argues that as many data sources as possible should be used in a case study as various sources are complementary. Steyn (2000) notes that interviews, observations and surveys are appropriate tools that can be employed to research the human behavioural issues discussed in CCPM. Although case study research can include both qualitative and quantitative data (Yin, 1994), this research will place more emphasis on the qualitative data.

Several tools and techniques were used in collecting empirical materials during this research:

3.3.4.1 INTERVIEW

According to Yin (1994) interviews provide essential evidence for case studies as most case studies are concerned with human affairs and interviewees can provide useful insights into the situation that is under scrutiny. This research used focused interviews, where a pre-determined set of questions was asked during the interview (Yin, 1994).

The set of open-ended questions (see Appendix B), which reflected the research objective and were used as the guideline for the interviewer throughout the interview, were derived from Newbold and Lynch's (1999) critical success factors for CCPM implementation discussed in chapter 2. The interview questions focused on gathering empirical data relating to the research questions discussed in chapter 3. The interviewees were asked to describe their experience with CCPM and the implementation process. Specific issues explored included assumptions made by CCPM, training for the implementation, top management support, and implementation plans and goals.

In order to standardise the interview process and ensure that questions were not omitted during the interview, each interviewee was asked the same set of questions. However additional questions were asked when the interviewer felt the need to further explore a particular point mentioned by the interviewee. The questions were open-ended hence the interviewees were not restricted to a predetermined set of answers. This interviewing format allowed the interviewing process to remain open and reduced the limitations that might

otherwise have been exerted upon the interviewees during their thinking and answering process. It is common for case study interviews to be of an open-ended nature (Yin, 1994).

Team \ Role	Project Manager	Developer	System Tester
Mobile Core	1	2	5
Intelligent Services	2	2	1

Table 3.1 – Project team and role information of the Interviewees

A total of thirteen people were interviewed during this case study. These people were chosen with the assistance of a member of staff in the Technology Development division who was closely involved in the execution of the CCPM implementation process. The thirteen interviewees were selected for two reasons:

1. They represented all areas in the project teams as illustrated in table 3.1, giving a balanced perspective spanning the project teams and taking into consideration the diverse range of views expressed. The intention was to select people with both negative and positive views of the CCPM implementation process in order to provide a balanced sample.
2. They were closely involved in the implementation process, giving them practical experience of CCPM at the time when the interviews were conducted. Hence only team Mobile Core and Intelligent Services were included in the interviewee selection list as team Wireline Networks has just initiated the CCPM implementation at the time when the interviews were conducted.

The thirteen interviews lasted from fifteen to thirty minutes each. Each interview began with the interviewer briefly explaining the objective of the interview and the case study. The interviewees were provided with a clear direction to help them focus on the questions and answer appropriately. The interviewer took notes on interviewee's responses during the interview. The notes were reviewed after the interview and the main points were summarised by the interviewer.

In addition to the thirteen interviews, two other members of the Technology Development division (one of whom was a senior member of staff) were regularly consulted. The intention of the additional discussions was to provide the researcher with the senior management's perspective on the management of the implementation process and the steps undertaken to steer the division towards the desired outcome of budget reduction and project performance improvement.

3.3.4.2 DIRECT OBSERVATION

Data gathered from observations can provide additional information about the research topic (Yin, 1994). Direct observation of several meetings and discussion sessions was performed during the case study. The researcher wrote notes during the meetings and reviewed the notes after the meetings. Meetings attended by the researcher included:

- meetings between external consultants and project managers prior to the CCPM implementation for the Wireline Networks project team. The objective of the meetings was to create a general template for software tools that could be referenced as the foundation for future project schedules. The total duration of the meetings was 2 days. The meetings provided an opportunity for the researcher to observe how the implementation process was initiated and how the division prepared team Wireline Networks for the implementation.
- a follow up meeting where external consultants and all project team members of Wireline Networks project team were present. The meeting allowed the team members to examine the newly created template and discuss any queries about the template. This meeting examined the users' acceptance of CCPM by exploring their feelings towards the concept.
- a meeting of the project management forum of Siemens. An external consultant presented the CCPM concept to the participants. This meeting provided insight into the training for CCPM provided by the TD division.

3.3.4.3 DOCUMENTATION

The primary purpose of documentation data is to provide further support using evidence from other sources (Yin, 1994). Several documents were provided by the division and reviewed by the researcher during the research. Three categories of documents were reviewed:

- Company information – These documents provided background information on the division and the company. Documents detailing organisational structure, employee and team lists, company policy and business objectives were included in this category.
- Project details – Project schedules, meeting minutes and other project documents that were created during project execution. These documents presented the researcher with insights into projects that were managed with CCPM.
- CCPM implementation process information – Several documents were created to record details of events that occurred during the implementation process. Project management roles and responsibilities, and the resources that were required for the CCPM implementation were defined in the specification document. The other documents included in this category recorded the outcomes of meetings and workshops held between consultants and team members during the implementation. These documents uncovered the CCPM implementation progress and other issues. The division also surveyed the

project teams that had implemented CCPM with the intention of determining the successfulness of the implementation. The results of the survey were made available to the researcher.

3.3.4.4 QUESTIONNAIRE

Questionnaires can be a data source for both quantitative and qualitative research methods (Myers, 1997). Yin (1994) suggests that various research tools are not mutually exclusive hence making it feasible to use questionnaires within a case study.

External Variables	Perceived Usefulness	Perceived Ease of Use
• system characteristics	• work more quickly	• easier to learn
• training	• job performance	• clear and understandable
• user involvement in design	• increase productivity	• easy to become skilful
• nature of the implementation	• effectiveness	• easy to use
	• make job easier	• controllable
	• useful	• flexible

Table 3.2 – Variables used to form questions in the questionnaire (Davis, 1989; Goldratt, 1997; Venkatesh & Davis, 1996)

Three questionnaires were used to collect data in this research. Table 3.2 presents a list of variables referenced by the researcher when developing the questionnaire. The questionnaires were designed with the intention of gathering data to help answer the research questions. The research objectives were the main focus and hence variables found in TAM (Davis, 1989; Venkatesh & Davis, 1996) and CCPM literature (Goldratt, 1997) formed the basis from which questions were developed. The first two questionnaires were designed at the beginning of the case study and the third questionnaire was designed near the end of the case study. The researcher developed all three questionnaires. The TD division head and a senior project manager verified the questionnaires. The researcher made necessary changes during the verification process before distributing the final version of the questionnaires to the targeted audiences. The questionnaires presented in the appendices represent the final version.

The first questionnaire (see Appendix C) targeted the Wireline Networks project team. The questionnaire was distributed to the team members before they attended a CCPM workshop and received training on CCPM. The questions focused on the team's expectation of the CCPM concept and implementation process. The questionnaire was preceded by a brief introduction to the intention of the questionnaire. Background information on the team members was then gathered. The aim was to determine the team's level of preparedness for

the CCPM implementation. Expectations of the team members were then examined with the intention of exploring the team's perception of the CCPM concept. Additional comments regarding CCPM and the implementation were requested from the team members. 20 questionnaires were distributed and 11 were returned to the researcher.

The second questionnaire (see Appendix D) targeted the same project group after the team had attended a CCPM workshop for training. The questions in the second questionnaire focused on the team's acceptance of the CCPM concept. The questionnaire began with a brief introduction describing its aim. General questions were first asked to determine the perceived usefulness and ease of use of CCPM. Questions regarding the assumptions made by CCPM were then asked to assess the team's perception of the CCPM concept. The users were then asked, through questions exploring implementation issues, to highlight any concerns they might have with the implementation process. Once again additional comments regarding CCPM and its implementation were requested from the team members. 20 questionnaires were distributed and 15 were returned to the researcher.

The third questionnaire (see Appendix E), which was distributed to all project teams in the division, focused on the result of the CCPM implementation. The questionnaire was distributed 19 months after the case study started, as the longitudinal case study was reaching a logical end point, which presented visible results of the CCPM implementation to the division and the research. These results will be discussed in chapter 4.

Although still based on the variables listed in table 3.2, the questions in the third questionnaire also referenced the data that was gathered from the documentation, interviews and observations prior to the distribution of the questionnaire. The questionnaire first briefed the team members on the questionnaire objective, and then asked to team members to indicate their project team and role. The intention was to be able to distinguish data from different perspectives caused by differences in project teams and roles. Perceived usefulness, perceived ease of use and issues on the implementation process were then explored. The results of the implementation were then examined by asking the team members to answer questions linked to the implementation objectives.

The third questionnaire was designed in electronic form, which was different to the paper-based approach adopted in the first two questionnaires. The intention behind the use of electronic format was to facilitate distribution and collection as the third questionnaire targeted a larger audience than the first two questionnaires. 88 questionnaires were distributed and 18 were returned to the researcher.

The response rates of the questionnaires were 55%, 75% and 20% for the first, second and third questionnaire respectively. The first two questionnaires were targeted at a specific team while the researcher was at the research site. Therefore it was easier to track the distribution of the questionnaires, which led to a higher collection rate. The third questionnaire was targeted at the whole TD division while the researcher was not at the research site. It was physically impossible to track the distribution of the questionnaires, which made questionnaire collection from a larger audience a more difficult task.

3.4 METHODOLOGICAL CONCERNS FOR THE CASE STUDY

Every instance of a case study research is subject to four methodological concerns: construct validity, internal validity, external validity and reliability (Lee, 1989; Yin, 1994). Yin (1994) suggests that these four concerns can be viewed as tests to establish the quality of the empirical research. This is illustrated in table 3.3.

Methodological Concerns	Case Study Tactics	Phase of Research in which Tactic Occurs
Construct validity	• Use multiple sources of evidence • Maintain chain of evidence • Have key informants review draft case study report	• Data collection • Data collection • Composition
Internal validity	• Do pattern matching • Do explanation-building • Do time-series analysis	• Data analysis • Data analysis • Data analysis
External validity	• Use replication logic in multiple-case studies	• Research design
Reliability	• Use case study protocol • Develop case study database	• Data collection • Data collection

Table 3.3 – Tactics for case study methodological problems (Yin, 1994, p. 33)

3.4.1 Construct validity (making controlled observations)

The case study researcher is responsible for developing a set of measures to ensure that objective judgements are used to collect data. While controlled observation is accomplished in research such as laboratory and statistical experiments, it is more difficult for IS case researchers to perform the same task in real world case settings.

Yin (1994) suggests that the following three tactics can improve construct validity:

- The use of multiple sources of evidence – This case study gathers data from multiple sources including interviews, observation, documentation and questionnaires. The details of the data collection process are described in earlier sections of this chapter.

- Maintain a chain of evidence – "The principle is to allow an external observer to follow the derivation of any evidence from initial research questions to ultimate case study conclusions" (Yin, 1994, p. 98). Yin (1994) suggests the establishment and sufficient citation of a case study database to reflect adherence to this principle. The case study database is discussed in more detail later in this section.
- Have the key informants review the draft report – Various drafts of this report were reviewed by the research supervisor. The final draft was reviewed by both the research supervisor and the research site director. Written commentaries or feedback were requested from the reviewer with each round of review.

3.4.2 Internal validity (making controlled deductions)

Mathematical formulae are often employed in making controlled or logical deductions from the data collected during the research. Given the qualitative nature of the data collected in this research, mathematical deductions are not applicable. Yin (1994) notes that internal validity is a concern only for explanatory case studies and not for exploratory case studies such as this research.

3.4.3 External validity (allowing for generalisability)

The unique and non-replicable characteristics of the case study make it difficult to generalise and extend the findings of the study to other cases. Lee (1989) notes that no theories (including IS theories) are generalisable on the basis of a single experiment. Only through the execution of more case studies would this problem, which is characteristic of case study research, be overcome.

3.4.4 Reliability (allowing for replicability)

Systematic replication of research is usually employed to ensure the objectivity of the research. However it is often difficult to find IS case studies with the same configuration. Yin (1994) suggests that the usage of the following two items will improve the reliability of the case study:

- Case study protocol – The case study protocol includes the research instruments, the procedures and the general rules that should be followed when the instruments are used. The details of the above mentioned elements are included in earlier sections of this chapter.
- Case study database – A central database was established by the researcher to store all the empirical data collected during the research. The database includes case study notes and documents. The case study notes contain data from the interviews, observations and

questionnaires. The notes, in the format of Microsoft Word files, have been categorically organised to allow for easy retrieval. The case study documents include the documents relevant to the case study that have been obtained from the research site. All documents have been stored by the researcher and those that are not subject to sensitivity concerns are readily available.

3.5 SUMMARY

This research seeks to answer two questions concerning the effectiveness and user acceptance of CCPM. Case study research methodology was chosen because of its suitability to comprehend the nature and complexity of a process in practice. This research adopted the positivistic view as the researcher seeks to objectively present the reality through the depiction of properties that are independent of the observer and the research instrument.

The Technology Development division of Siemens Southern Africa was the selected research unit as it represented a project-based IS environment engaged in a CCPM implementation. The division includes several project teams which followed a formal project management methodology that produced above industry standards project performance. The division however decided to implement CCPM in search for higher performance level and cost reduction.

Several tools and techniques including interview, direct observation, document and questionnaire were adopted in this research. Each of the tools and techniques was employed after taking into consideration the objectives of this research and the suggested case study standards highlighted in the literature. Furthermore various tactics were adopted to address methodological concerns that are commonly associated with case study research.

Theoretical and practical preparations of this research were highlighted in this chapter. The next chapter will expose research findings and analyse the implications of the findings.

4. DATA ANALYSIS AND FINDINGS

This chapter examines the data collected during the case study and details the findings. The analytic strategy and techniques that were adopted are discussed. This is followed by the analysis of data gathered using the four data collection techniques namely interview, questionnaire, observation and documentation. The implications of the findings in terms of the research questions and CCPM theory are then presented.

4.1 ANALYTIC STRATEGY AND TECHNIQUES

Yin (1994) emphasises that an analytic strategy helps a case study researcher to choose appropriate techniques to successfully complete data analysis. Data and evidence must be treated fairly to produce convincing analytic conclusions and rule out substitute interpretations (Yin, 1994). The general analytic strategy was guided by the theoretical orientation of the research. The theoretical orientation is based on the case study objective and design and is reflected in the research questions. Yin (1994) notes that the analytic strategy of following theoretical orientation is preferable to developing a case description as the former strategy helps the research to focus on certain relevant data and ignore other data.

Yin (1994) notes that a major strength of case study research is the ability to record changes over time. This research adopts time series analysis as the dominant analytical technique. Yin (1994) suggests that time series analysis is made possible by recording events that happened during the case study in detail and with precision. The embedded units (project team members) of this case study are also analysed to provide auxiliary data to the time series analysis.

4.2 DATA ANALYSIS

Four data collection techniques were used at different stages of the case study. The strength of each technique determined the timing of its execution. Observation was first performed to establish the context of the case study. Interviews were then conducted to focus directly on the research topic and provide further insights. Questionnaires were distributed at the early and late stages of the case study to record the changes that had occurred during the case study. Documents were reviewed as they became available throughout the case study.

Due to the qualitative nature of this research, descriptive analysis was used to examine data. The following section examines data gathered using the four techniques in the sequence in which the techniques were used.

4.2.1 Observation

4.2.1.1 OPEN DAY FORUM OF THE TECHNOLOGY MANAGEMENT DIVISION

The forum took place in early April 2000. Members of the technology management division (including the TD division) and senior management of Siemens Southern Africa participated in the forum. The researcher was given the opportunity to become acquainted with several members of staff from the TD division. The researcher also gained a basic understanding of the organisation's business objective and focus. Relevant details were discussed in chapter 3.

4.2.1.2 CCPM PRESENTATION TO SIEMENS PROJECT MANAGEMENT FORUM

An external consultant presented CCPM to the project management forum of Siemens in early April 2000. The underlying concept of CCPM was introduced to the forum attendants, who were the project managers within Siemens Southern Africa. The results of CCPM implementation to date (team Mobile Core and Intelligent Services) were also shared with the attendants. The main objective of the forum was to establish a platform for project management within Siemens Southern Africa. The forum aimed to create learning opportunities and promote project management by involving all project managers within Siemens Southern Africa and making them aware of available tools and technologies.

The researcher observed the interaction between the external consultant and the project managers. Overall the project managers were positive about CCPM implementation, but they also expressed concerns relating to the replacement of existing project management practices that had helped the Technology Management division to complete more than 80% of projects on time.

4.2.1.3 CCPM IMPLEMENTATION INITIATION MEETING

This meeting was held in early April 2000 when team Wireline Networks started the CCPM implementation process. The project managers of team Wireline Networks met with an external consultant, who ran the CCPM workshop for the project teams in the TD division. The aim of the workshop was to create a general project schedule template.

According to the project managers, team Wireline Networks executed projects that were very different in nature and duration to those executed by other project teams in the division. This made it necessary to create a new project schedule template. The schedule of a complex project executed by the team was first examined in conjunction with a process handbook that served as the formal project guideline for the team. The project managers and the external consultant scrutinised each task on the project schedule and specified the purpose of each task.

Some tasks were split into separate tasks in order to clearly define each task. Hidden tasks (activities carried out by team members during the project but not defined in the project schedule) were also uncovered.

The duration of each task was estimated based on past experience. Resources who were responsible for the tasks and their execution were also determined. The tasks were then sequenced using the identified information. The intention of the specification of task details was to achieve better control over task progress during projects. For instance, although time was previously given to team members to prepare for meetings, the assigned time did not appear as a task on the project schedule. The project managers had no control over the assigned time as the team members often used the meeting preparation time to work on other tasks (of the same project or other projects).

During the discussion, the project managers discovered that time was often wasted when team members waited for the milestone declaration. The tasks that were not dependent on the completion of the previous milestone were delayed until milestone declaration even though those tasks could have been started earlier. The delay often withheld potentially critical resources. Another finding related to the influence of external parties. In the past when projects relied on external parties to complete certain tasks, the external parties were not included as resources on the project schedule. Project managers had little control over the external parties which could potentially delay project progress.

4.2.1.4 WIRELINE NETWORKS TEAM MEETING

This meeting was held in late April 2002 and was attended by all members of the Wireline Networks team and an external consultant. The objective of the meeting was to introduce the project schedule template created in the meeting between the project managers and the external consultant. The team members were given the opportunity to familiarise themselves with the interface of the project management software, Concerto. The meeting also encouraged the team members to voice any concerns they might have had about the project schedule template and the CCPM implementation process.

Task information updates and other functionalities of the software, Concerto, were shown to the team members. The team members did not express concerns regarding the schedule template or the software. However several team members suggested that problems could arise when the template was applied to live projects. Adaptation to specific projects might become necessary.

During the meeting, the project managers and the external consultant emphasised that the software was just a tool to monitor the overall progress. Communication between team members and project managers was the key to success with CCPM. For instance if a resource finished a task earlier than scheduled, the resource would communicate with the resource manager to update schedules.

4.2.2 Interview

Question \ Response	Positive	Neutral	Negative
Perceived usefulness (the CCPM concept)	10	2	1
Perceived ease of use (implementation)	1	4	8
External variables (resources, tool, training and top management support)	5	6	2

Table 4.1 – Summary of interview responses

Table 4.1 provides a summary of all the interview responses. The data gathered from the thirteen interviews are summarised into three categories. The three categories reflect the purposes of the questions asked in the interviews. Perceived usefulness is represented by the interviewees' opinions on the effectiveness of CCPM in addressing student syndrome and multitasking. The interviewees' views of the implementation process characterise CCPM's perceived ease of use. The interviewees' assessments of external variables (including top management support, the adopted project management software and training) provided insight into implementation resource availability and adequacy. The difference between project team and team member roles was taken into account when examining each category.

Three frames of mind were identified to represent the responses and sentiments expressed by the interviewees. A response is labelled as positive when an interviewee expresses approval, contentment or agreement. When the interviewee answered the question with criticism, the response was labelled as negative. Neutral response suggested the lack of positive or negative views expressed by the interviewee.

4.2.2.1PERCEIVED USEFULNESS (THE CCPM CONCEPT)

Team \ Response	Positive	Neutral	Negative
Mobile Core	8	0	0
Intelligent Services	2	2	1

Table 4.2 – Perceived usefulness response summary per project team

Table 4.2 shows data relating to perceived usefulness of CCPM by the project teams. It suggests that team Mobile Core expressed more approval of the CCPM concept than team Intelligent Services. A possible reason could be that team Mobile Core implemented CCPM earlier than team Intelligent Services, giving team Mobile Core more exposure to the CCPM concept. The difference in the level of experience with CCPM could contribute to higher levels of approval of the concept, as a more experienced team would have received more opportunities to validate the CCPM concept against practical experience. One interviewee from team Intelligent Services suggested that the team was still in the learning phase for the application of the CCPM concept.

Role \ Response	Positive	Neutral	Negative
Project Manager	2	1	0
Developer	3	0	1
System Tester	5	1	0

Table 4.3 – Perceived usefulness response summary per team member role

Table 4.3 summarises the perceived usefulness responses according to different team member roles. The difference in the role of the project team members does not appear to influence the approval of the CCPM concept, as illustrated in table 4.3. Positive views were conveyed by most interviewees across all roles.

Ten out of the thirteen interviewees believed that the CCPM concept was sound. They suggested that CCPM was not a difficult concept to understand and learn. One interviewee noted the usefulness of general knowledge in project management when learning the CCPM concept. The interviewees, who were positive about the CCPM concept, believed that the project team could benefit from the adoption of CCPM. All the interviewees recognised the existence of multitasking and student syndrome within the division. However the interviewees believed that multitasking was necessary within the TD division because there was a shortage of resources for projects. As a result resources were being shared across projects and multitasking arose from working on more than one project simultaneously.

According to the interviewees, previous projects were completed on time because significant amounts of overtime hours were clocked.

The interviewees also noted several other benefits of adopting CCPM, including

- an enhanced overview of the project progress
- higher transparency of potential delays caused by unforeseen variables as a result of better reporting mechanisms
- better structured execution of project tasks
- improved control of project lead time.

However several interviewees also suggested that while it was easier to identify problems causing delays in the project schedule, CCPM did not necessarily help in diagnosing and solving the problem.

Three interviewees expressed concerns relating to the fact that CCPM does not include information on the difference in the capabilities of the resources. The interviewees cited the difference between the IS project environment (consisting of project team members) and the manufacturing environment (consisting of production machinery) to demonstrate the importance of information about the skill level and expertise of the resource. Several interviewees also referred to the nature of work in the IS project environment. They suggested that the buffer management offered by CCPM is inadequate to protect projects from uncertainty, as project deadlines can potentially be dictated by external forces including clients and vendors. Deliverable variances and task execution dependencies on external resources can consume an unexpected amount of time and cause delays in project schedules.

Negative views were expressed by one interviewee suggesting that the CCPM concept is based on the assumption that people are providing incorrect estimations. According to the interviewee the assumption has the potential to stimulate resistance to implement CCPM, as team members are accused of adding unnecessary safety time to project schedules.

4.2.2.2 PERCEIVED EASE OF USE (IMPLEMENTATION)

Team \ Response	Positive	Neutral	Negative
Mobile Core	1	2	5
Intelligent Services	0	2	3

Table 4.4 – Perceived ease of use response summary per project team

Table 4.4 shows the project teams' perception of how easy or difficult it was to apply CCPM. It suggests that CCPM's perceived ease of use appears to be consistent across the two project teams. Both teams expressed more negative judgements than positive feedback.

Role \ Response	Positive	Neutral	Negative
Project Manager	0	1	2
Developer	1	2	1
System Tester	0	1	5

Table 4.5 – Perceived ease of use response summary per team member role

Table 4.5 illustrates the summary of responses for the different team member roles on CCPM's perceived ease of use. It suggests that the system testers are more sceptical than other roles about CCPM's perceived ease of use. Several system testers suggested that the concept was difficult for them to implement because system testing is the last phase of the project and usually the longest of all project phases. According to the system testers the majority of buffers were consumed when the project reached the testing phase and substantial amounts of time-related pressure were placed on the system testers. The system testers also contended that the group did not have enough resource capacity to perform the system testing tasks assigned to them.

The interviewees viewed the CCPM implementation as a culture changing exercise. While changes induced by the CCPM implementation were welcomed by some interviewees, other interviewees expressed resistance to change by suggesting that they were not motivated to change the way they executed project tasks. Two interviewees suggested that additional time-related pressure was exerted on the project team members as a result of greater transparency of task duration and project progress.

Experience with CCPM was considered by several interviewees as useful in successfully applying CCPM to projects. The interviewees noted that during the initial phase of implementation they found it difficult to perform certain tasks such as assigning resources to projects without prior experience. The situation was worsened by the fact that the project team could encounter projects consisting of different types of work. Therefore, the project team could not always rely on past experience, and adaptation to the different situations created additional challenges for the team members. Interviewees noted that they sometimes found it difficult to follow the Critical Chain project schedule and still felt the need to stay busy all the time even though only the drum (critical) resources should have been constantly

busy. One interviewee suggested that it would take more than one year for the TD division to achieve the desired results from the CCPM implementation.

Concern relating to project schedule administration was articulated by the interviewees. The interviewees understood the need to monitor and update project progress on a daily basis in order to identify and address problems at an early stage. However interviewees noted that CCPM incurred extra administration overhead which could be time consuming. One interviewee suggested that, in the initial phase of implementation, overtime was required to ensure CCPM was working well. Several interviewees mentioned that appropriate timing of the CCPM implementation was important. According to the interviewees, additional administration and operational overheads incurred by CCPM can exert time pressure on the project team members when they are working under demanding project schedules.

Numerous interviewees suggested that CCPM could potentially have some negative impacts on the team spirit of the project teams. Prior to the introduction of CCPM project team members could organise time to help each other with certain tasks. However project team members would now be required to execute the assigned tasks within a predetermined time period and could not multitask to work on anything else. As a result the interviewees believed that less interaction between team members would take place within the project team.

4.2.2.3 EXTERNAL VARIABLES (RESOURCES, TOOL, TRAINING AND TOP MANAGEMENT SUPPORT)

Team \ Response	Positive	Neutral	Negative
Mobile Core	5	1	2
Intelligent Services	0	5	0

Table 4.6 – External variables response summary per project team

Table 4.6 provides a summary of project teams' responses regarding the influence of external variables on the CCPM implementation. It illustrates that the interviewees from team Mobile Core expressed more positive sentiments on the external variables (based on their practical knowledge with CCPM) than the interviewees from Intelligent Services. Members of team Intelligent Services did not comment much on the external variables as they were relatively inexperienced with CCPM.

Role \ Response	Positive	Neutral	Negative
Project Manager	0	3	1
Developer	2	1	0
System Tester	3	2	1

Table 4.7 – External variables response summary per team member role

Table 4.7 summarises the external variable influence responses according to different team member roles. Overall the developers and system testers appeared to be more positive than the project managers, as suggested by table 4.7. The difference in views expressed could possibly be attributed to the different management perspectives facing the project manager and the team members. Differences in required tasks and roles could lead to differences in the resources and support that the project managers and team members seek.

All interviewees agreed that training on CCPM was useful for its implementation. The workshop prior to the implementation provided solid background knowledge of CCPM to initiate the implementation. Overall the interviewees were positive about the resources and support provided by top management. One interviewee commented on the differences in top management and project team perspectives and suggested that the perceived progress of, and the expected results from, the CCPM implementation could differ between top management and the project teams.

Several interviewees commented on the project management software adopted for CCPM implementation, Concerto. The interviewees noted that it was not easy to adapt to Concerto and more training was needed. According to the interviewees, in some situations, such as updating task information, it was time consuming to use Concerto. Project plan templates were created in Concerto and project plans were created using the templates. The interviewees suggested that it was very important to create the templates correctly with relevant information so that the correct project plans could be created. Mistakes in the creation of templates could lead to time consuming corrections at a later stage.

4.2.2.2 DISCUSSION SESSIONS

Regular discussion sessions were held between the researcher, a senior project manager and the head of TD division during the 5 week data collection period. Background information, questionnaire development and case study progress were the main topics of the discussion sessions. Findings from the collected data were also presented to the project manager to

uncover implementation issues and determine how the implementation process could be improved.

4.2.3 Questionnaire

Three questionnaires were distributed during the case study. The first and second questionnaires were distributed to team Wireline Networks at the early stages of the case study, and after the CCPM workshop. The sample size of the first and second questionnaires comprised the whole Wireline Networks team.

The third questionnaire was distributed to all the project teams within the TD division at the concluding stage of the case study. Eighteen responses were received. Eight out the eighteen responses were from people who started working in the TD division after CCPM had been implemented. Their responses to the questionnaire were likely to be influenced by their lack of participation in the whole implementation process. Therefore, those eight responses were excluded from the analysis. The sample size, which aims to represent the project team members who were already working in the TD division when the CCPM implementation was initiated, was then reduced to 10. The 10 respondents included 2 members from Intelligent Networks, 3 members from Mobile Core and 5 members from Wireline Networks (see appendix H). Data on the number of people who went through the whole implementation process was not available but the respondents represent a minimum of 20% of the targeted population.

The responses are categorised into three groups: strongly disagree to slightly disagree (1 to 3), neutral (4) and slightly agree to strongly agree (5 to 7). Detailed records of the responses are included in the appendices (F, G and H). The average (mean) of the responses for each question is also calculated (by summing all the response scores and dividing the sum by the number of responses) and presented in the tables below. The response average provides a weighted score for each question.

4.2.3.1 PRE-WORKSHOP QUESTIONNAIRE

Table 4.8 below provides feedback data on respondents' background information. Most respondents believed that they did not have a lot of experience in project scheduling and had limited knowledge of Critical Chain, as table 4.8 suggests. About half of the respondents did not believe that they were adequately informed and prepared for the workshop.

Question \ Response	Mean	1-3 (1 is the minimum level of agreement)	4	5-7 (7 is the maximum level of agreement)
Previous experience in project scheduling and management	3.3	73%	0%	27%
Background knowledge on Critical Chain	2.6	73%	9%	18%
Well informed and prepared for the workshop	3.4	55%	27%	18%

Table 4.8 – Respondents' background information

Question \ Response	Mean	1-3 (1 is the minimum level of agreement)	4 (Neutral)	5-7 (7 is the maximum level of agreement)
Satisfied with the previous project management practice	4.4	36%	18%	46%
There is a need for new project management practice in the division	4	46%	18%	36%

Table 4.9 – Respondents' attitudes toward previous practice

Table 4.9 shows the summary of respondents' attitudes toward the previous project management practice. The attitudes were balanced, as suggested by the means. About half of the respondents were content with the previous practice. The same number of people did not feel the need for a new project management practice in the division. Thirty six percent of the respondents were not pleased with the current practice and perceived the need for a new project management practice.

Table 4.10 below supplies data on the respondents' expectations of CCPM. The responses on the expectations of CCPM were consistent with the data gathered from the interviews. At least 60% of the respondents expected CCPM to be useful in improving project performance and working conditions. More than 70% of the respondents believed the division would benefit from CCPM. Most respondents agreed (at least to a certain extent) that CCPM was not difficult to understand. The expectation of CCPM's perceived ease of use was not one sided, with 46% of the respondents considering the CCPM implementation to be difficult. 36% of the respondents expected CCPM to bring changes and new responsibilities.

Question \ Response	Mean	1-3 (1 is the minimum level of agreement)	4 (Neutral)	5-7 (7 is the maximum level of agreement)
CCPM difficult to understand	2.6	73%	9%	18%
CCPM difficult to implement	4.3	36%	18%	46%
CCPM induces changes	4.2	36%	28%	36%
New responsibilities and roles to be assigned	4.4	28%	36%	36%
CCPM to improve project performance	5.4	9%	18%	73%
CCPM to improve working conditions	5.2	18%	18%	64%
Division to benefit from CCPM	5.5	9%	18%	73%

Table 4.10 – Respondents' expectations of CCPM

4.2.3.2 POST WORKSHOP QUESTIONNAIRE

Question \ Response	Mean	1-3 (1 is the minimum level of agreement)	4 (Neutral)	5-7 (7 is the maximum level of agreement)
CCPM difficult to understand	2.1	86%	0%	14%
Agree with the CCPM concept	5.5	7%	7%	86%
CCPM is applicable to the TD division	5.3	7%	7%	86%
CCPM will improve project performance	5.1	7%	20%	73%

Table 4.11 – Respondents' attitudes toward CCPM

Table 4.11 provides data on respondents' attitudes toward CCPM. The post-workshop attitudes toward CCPM were consistent with the data gathered from the questionnaire prior to the workshop and the interviews. 73% of the respondents believed that CCPM was useful in improving project performance. 86% of the respondents easily understood and agreed with the CCPM concept while suggesting that the concept was applicable to the TD division.

Question \ Response	Mean	1-3 (1 is the minimum level of agreement)	4 (Neutral)	5-7 (7 is the maximum level of agreement)
Need to stay busy all the time	4.5	33%	0%	67%
Often switch between tasks	6.3	0%	0%	100%
Student syndrome exists	4.7	20%	27%	53%
Often experience interruptions	6	0%	13%	87%
Often work on tasks unrelated to project	4.9	20%	13%	67%
Important to half task duration estimates	4.4	20%	33%	47%
Important to allow inactivity of non-critical resources	4.2	33%	27%	40%
Important to eliminate multitasking	5.5	13%	13%	74%

Table 4.12 – Respondents' sentiments about the symptoms addressed by CCPM

Table 4.12 shows data relating to the sentiments of the respondents about symptoms addressed by CCPM. At least half of the respondents agreed with the existence of the student syndrome and multitasking symptoms depicted by CCPM. The respondents felt most strongly about multitasking, with all suggesting that they often switched between tasks, and more than 60% contending that they often worked on tasks not relevant to the project, and were often interrupted during work. It is therefore not a surprising to see that 74% of the respondents suggested it was important to eliminate multitasking, while only 47% believed that duration estimates should be halved.

Table 4.13 below summarises the respondents' attitudes toward the CCPM implementation. The attitudes tended to be negative. 53% of the respondents believed that there was inadequate preparation and training for the implementation while 60% asserted that there were inadequate resources for the implementation. 47% of the respondents believed that CCPM would be difficult to implement, while approximately the same number of respondents had the contrary opinion. After attending the workshop, more people (compared with the data

from the pre-workshop questionnaire) were convinced that the CCPM implementation would not bring unnecessary changes and additional responsibilities. 47% of the respondents were not certain whether the implementation would be an effective exercise for all the team members involved.

Question \ Response	Mean	1-3 (1 is the minimum level of agreement)	4 (Neutral)	5-7 (7 is the maximum level of agreement)
Inadequate preparation and training for the implementation	4.4	27%	20%	53%
Inadequate resources for the implementation	4.5	33%	7%	60%
Difficult to implement CCPM in the division	4.2	40%	13%	47%
Implementation will induce unnecessary changes	3.1	67%	20%	13%
Implementation will bring additional responsibilities	3.5	53%	27%	20%
Implementation will not be effective for all team members	4.5	20%	47%	33%

Table 4.13 – Respondents' attitudes toward CCPM implementation

4.2.3.3 POST IMPLEMENTATION QUESTIONNAIRE

Question \ Response	Mean	1-3 (1 is the minimum level of agreement)	4 (Neutral)	5-7 (7 is the maximum level of agreement)
CCPM is applicable in your project team	6.1	0%	0%	100%
CCPM implementation induced significant change	4.4	20%	30%	50%

Table 4.14 – Respondents' attitudes toward CCPM

Table 4.14 presents data relating to respondents' post implementation attitudes toward CCPM. All of the respondents felt that CCPM was applicable within their respective project teams. Half of the respondents believed that significant changes were induced by the CCPM implementation.

Question \ Response	Mean	1-3 (1 is the minimum level of agreement)	4 (Neutral)	5-7 (7 is the maximum level of agreement)
Implementation process was easy to follow	5.4	0%	20%	80%
Preparation and training was adequate for the implementation	5.7	0%	30%	70%
Easy to switch from previously adopted practice to CCPM	4.5	20%	20%	60%
Adequate change management for the implementation	4.5	30%	0%	70%
There were individuals who made implementation difficult	5.2	20%	0%	80%
External consultant made implementation easier	4.2	30%	20%	50%
Resource for the implementation was adequate	4.3	40%	10%	50%
Adequate top management support for the implementation	6.4	0%	0%	100%

Table 4.15 – Respondents' sentiments of CCPM implementation issues

Table 4.15 provides data representing respondents' post implementation sentiments regarding CCPM implementation issues. All the respondents were positive about the top management support given to the CCPM implementation, with 70% suggesting that there was adequate training and change management for the implementation. 80% of the respondents found it easy to follow the implementation process while 60% easily switched from the previous project management practice to CCPM. Half of the respondents agreed that hiring external consultants was beneficial and that there were adequate resources for the implementation.

The respondents' post implementation sentiments regarding CCPM implementation results are presented in table 4.16 below. Half of the respondents believed that multitasking was reduced by CCPM. 80% of the respondents suggested that student syndrome was addressed by CCPM and that projects were completed on time, on brief and on budget. 50% of the respondents felt that overtime effort was not greatly reduced by adopting CCPM, but suggested that time buffers were useful in the management of uncertainty and helped to reduce project risks. Overall the respondents were very positive about the CCPM

implementation with 80% of the respondents suggested that the implementation was successful to a certain extent.

Question \ Response	Mean	1-3 (1 is the minimum level of agreement)	4 (Neutral)	5-7 (7 is the maximum level of agreement)
Multitasking addressed by CCPM	4.5	30%	20%	50%
Student syndrome addressed by CCPM	5.3	10%	10%	80%
CCPM allowed you to focus on critical tasks	4.8	30%	10%	60%
Project are completed on time, on brief and on budget	5.3	20%	0%	80%
Overtime work was greatly reduced	3.3	50%	20%	30%
CCPM is useful for time critical projects	4.1	30%	20%	50%
Buffers helped to manage uncertainty and reduce risks	4.9	10%	40%	50%
Implementation is overall successful and worthwhile	5.4	20%	0%	80%

Table 4.16 – Respondents' sentiments of CCPM implementation results

4.2.4 Documentation

4.2.4.1 RESOURCE AND RESPONSIBILITY SPECIFICATION

The first document reviewed by the researcher was a specification detailing project management roles and responsibilities, and resource requirements for the CCPM implementation. The document clearly specified the implementation goals and responsibilities for different levels of project and resource management within the organisation. The following were the key goals extracted from the document:

- A master schedule containing the sequence of tasks for all projects in the division was to be maintained by the division manager. Projects (new and existing) were scheduled around the drum resource capacity. The division manager was also responsible for tracking the buffer status and adjusting the buffer size if necessary.

- Project managers had to ensure that each project had a valid plan and schedule with the critical chain identified. Project progress had to be updated regularly and controlled by buffer management. Buffers were to be monitored and managed in conjunction with resource managers.
- A resource manager had to exist within each resource group (developers and system testers). They were responsible for assigning resources within the group to both scheduled project tasks and unscheduled tasks. Resources would only be assigned to a task when required (as indicated on the master schedule) and upon completion of the previous task. A master resource file containing resource capacity details was to be maintained by the resource manager. Drum resources and future resource requirements had to be identified.
- Individual resources were to work only on tasks assigned by the resource manager. The assigned task was to be started immediately using the responsible resource's full capacity. Individual resources were responsible for providing the resource and project managers with accurate information on task progress and potential task delaying risks.
- Education and training on CCPM and Concerto was provided to relevant resources. Management reports and information were provided to project and resource managers.

4.2.4.2 SURVEY OF TEAM MOBILE CORE

A survey was distributed to team Mobile Core by TD division prior to the case study. The objective of the survey was to determine the attitudes toward CCPM implementation in order to provide the management with some data on the progress of the implementation. The respondents represented approximately 80% of the targeted population.

Table 4.17 below summarises the responses from the Mobile Core team's CCPM implementation survey. 83% of the respondents believed that they were adequately informed of the CCPM implementation. 60% of the respondents suggested that the system tester group benefited from the CCPM implementation. This result was consistent with interview data, in which most system tester interviewees were positive about the perceived usefulness of CCPM. The feelings about CCPM's influence on work independence were equally divided between agreement and disagreement. 67% of the respondents argued that they used CCPM reports to determine work schedule. All the respondents agreed that CCPM provided more control over activities. Half of the respondents were not certain of CCPM's influence on working conditions.

Question \ Response	(strongly disagree) to (disagree to certain extent)	(possibly agree)	(agree to certain extent) to (strongly agree)
Well informed of the CCPM implementation	0%	17%	83%
CCPM benefits the system tester group	20%	20%	60%
CCPM restricts independence and exerts more control on me	50%	0%	50%
I use CCPM reports to determine project task/activities	33%	0%	67%
CCPM provides much better control of activities	0%	0%	100%
CCPM improves working condition	17%	50%	33%

Table 4.17 – Responses of Mobile Core team survey

4.2.4.3 WORKSHOP REPORTS

Project team members and an external consultant held various workshops to determine the causes of issues and difficulties experienced during the CCPM implementation. The Theory of Constraints principle, which contends that the unpleasant effects or undesirable symptoms experienced by the organisation or people associated with the system are often the result of one or a few core problems, was applied in the workshops.

The undesirable symptom identified in the first workshop was that the system testers were having difficulties implementing the CCPM concept. This view was consistent with the data gathered from the interviews. In the interviews the system testers argued that the group was under-resourced and did not have enough buffers to utilise.

The subsequent workshop identified the core problems to be system tester resource capacity management and information availability. Goals, including the effective management of resource capacity and ensuring that information requirements were fulfilled when needed, were set to try and resolve the core problems. Specific steps included:

- Resource capacity had to be correctly reflected in the master resource file used to schedule projects.
- Top priority was to be given by the system testers to tasks that fell within their responsibility.

- All activities that occupied the system testers for longer than a specified period of time had to be scheduled into the project plan. These activities included training, which formed part of the system testers' development plans to increase resource capacity and prepare for the fulfilment of future resource requirements.
- System testers were to be responsible for preparing duration and effort estimates based on relevant documentation. They also had to specify documentation and information requirements in order for the project managers to ensure that the information was available when required.

4.2.4.4 IMPLEMENTATION RESULTS REPORT

Documents containing the implementation results were provided to the researcher. According to the report 90% of the projects executed by the TD division were completed on time. The implementation results were also measured through the profit and productivity growth of the TD division after CCPM was implemented. The measurements linked directly to the implementation goals of cost reduction (which leads to higher profit) and higher project performance (which is achieved through increased productivity).

Between 1999 (when CCPM implementation was initiated) and 2001 (when this case study concluded), TD division's revenue grew by more than 40%. This led to a growth in profit of more than 140%. Productivity growth was measured at more than 14% for the same period. These figures are in line with those of previous years when CCPM was not implemented. The biggest gain came from productivity growth, where the reported figure was almost twice as high as the figure from 1998.

4.3 IMPLICATIONS OF FINDINGS FOR RESEARCH QUESTIONS

4.3.1 CCPM assumptions

4.3.1.1 SAFETY TIME ABUNDANCE AND 50% ESTIMATION RULE

Strong views were observed during the case study regarding the CCPM assumption that there is more safety time than necessary in the division. It was suggested that the assumption could result in resistance to the implementation of the theory. People rely on their past experience to estimate task duration and if the inference is questioned then they may feel that their ability and expertise are not trusted.

The 50 % estimation rule also received some criticism, which questioned the method's scientific foundation. It was suggested that the method's simplicity undermines its ability to manage the complexity of estimation. Different projects include tasks that are composed of different activities. Therefore, one single simple method of duration estimation might not be suitable for all tasks.

4.3.1.2 STUDENT SYNDROME

The existence of student syndrome was acknowledged in the case study. Late starts to tasks were attributed to delays in other tasks and time spent on tasks that were relevant to the project but were not scheduled on the project plan. Time wastage due to multitasking was also mentioned.

CCPM was regarded as an effective solution to address student syndrome. The management and the project teams focused on the scheduled task completion date prior to CCPM implementation. However from the time when CCPM was implemented more emphasis was placed on the starting dates of project tasks.

A task was not released to the relevant resource until the task was ready to be started and the resource was ready to begin work on the task. This provided the project managers with tighter control on the project progress. All resources, including both internal and external, were included in the project plan. This allowed the project managers to monitor resource consumption with more precision. The project team members however suggested that their independence and control over their work had been restricted.

4.3.1.3 MULTITASKING

Multitasking was the most widely recognised symptom addressed by CCPM. Project resources often experienced interruptions and worked on tasks that were not relevant to the assigned project. Inadequate resources, which caused resource sharing across multiple projects, were regularly mentioned and blamed for the existence of multitasking.

In comparison with student syndrome, CCPM was not perceived to be as effective in addressing multitasking. The differences between the IT project and the manufacturing environment were often cited. It was suggested that it is easier to block away interruptions and eliminate multitasking in a factory. Machinery can be set up to handle only one task and no other tasks will be queued for that particular machine. Human resources on the other hand are allocated more complicated tasks. An interruption as trivial as a customer complaint phone call could cause people to pause the task on hand.

The case study data suggested that it is important to clearly define roles and responsibilities when attempting to eliminate multitasking. An environment, where interruptions are channelled to the resources responsible for handling such interruptions, is necessary to reduce the risk of multitasking.

4.3.1.4 PASSING ON OF PREVIOUS DELAYS

Delays caused by external resources, which were not included in the project plan, could significantly impact project duration as project managers have no control over the external resources. Time was also wasted through waiting for milestone declarations before starting tasks that were not dependent on the milestone.

By providing better control of the project progress, possible delays in tasks were identified in advance and actions were taken to prevent tasks from completing after the scheduled date. CCPM was considered to be useful in addressing the symptom of passing on previous delays.

4.3.1.5 SUMMARY OF CCPM ASSUMPTIONS FINDINGS

The existence of 3 CCPM assumptions (student syndrome, multitasking and the passing on of previous delays) were acknowledged in the case study. Findings also suggest that the user accept CCPM as an effective tool in addressing these assumptions. The 50% estimation rule however was not supported by the user. The suggestion of the need for a more scientifically proven estimation method was received in this case study.

4.3.2 Implementation issues

4.3.2.1 TOP MANAGEMENT SUPPORT

Organisational politics is a powerful but frequently overlooked influence in promoting the successful implementation of project management practices (Pinto, 2000). The support of top management during the CCPM implementation was important. It is not uncommon to have organisational policy changes associated with the implementation. In order to ensure that the necessary changes are made without any impediment, proper authorities must be assigned. The support and resources made available by top management is therefore of critical importance to the implementation.

In Siemens' case, the involvement of top management began as soon as the TD division initiated the implementation process. A team from top management attended a CCPM course. The divisional director of the Technology Management division was enthusiastic about the

implementation. The implementation was therefore driven from a high management level. Project teams that implemented CCPM were aware of the support from the top management.

Management stressed the importance of keeping an open mind about new methodology and change. Managers consented to the view that projects are subsystems of larger systems (the department, division or organisation). Therefore it is important to consider how the outcome of the project will affect the outcome of the larger systems. Often conflicts of interests may occur and a trade off or compromise has to be made.

4.3.2.2 IMPLEMENTATION PLAN

The implementation plan was thoroughly executed. Clear goals were established for the implementation. From management's perspective the goals were practical. However from the project team's perspective certain goals were not achievable. Although informed about the implementation, team members suggested that they did not feel well prepared for the CCPM training. Some team members believed that it was useful to be informed early and have access to more information on CCPM.

4.3.2.3 COMMUNICATION

The management opened up communication channels throughout the organisation during the CCPM implementation to maintain effective communication between the project teams and the management. Different expectations of the CCPM implementation were found at different levels of the organisational hierarchy. Management expected results that were not achieved by the project teams as they were expecting and working toward a different set of results. Effective communication can be used to match the expectations of both management and staff, which ensures that both are working towards the same goal. Meetings were held regularly throughout the implementation for the management to express support to the project teams and for the project teams to express concerns and perceived problems to the management. Open communication channels were also important in the management of resistance to change during the CCPM implementation.

4.3.2.4 RESISTANCE TO CHANGE

When CCPM was introduced, it was regarded as a major mind shift from conventional project management practices. Resistance to change is prevalent among organisations and their members (Price, 1998). The Technology Development division encountered difficulties (including resistance to change) when implementing CCPM and brought in external consultants for assistance. Workshops were held by the external consultants to identify the

sources of resistance to change and propose appropriate actions to reduce or eliminate resistance to change. Three main causes of change resistance were identified:

- Too busy – This was especially true for the Intelligence Services team as CCPM was implemented during a busy period for the project team. Team members were occupied by their project work and did not have much spare time and energy for the implementation. This resulted in limited focus on change.
- Team members had less control over their own time – A CCPM project schedule clearly prescribes which project task is to be done by which team member at which stage of the project. In the past management had less control over when a task was to be initiated. The team members could work according to their own schedule as long as they completed the required tasks before the deadline. However that freedom was taken away from the team members and replaced with a packed schedule as task duration estimates were halved. The non-drum resources found it difficult to work under such tight control because they would stay idle at times dictated by the CCPM schedule, despite their tendency to stay busy all the time. The drum resources found it especially difficult to accept the revised project schedule. They often worked overtime to complete the assigned work and had been accustomed to making their own task scheduling decisions.
- Fear of change –Team members were comfortable with the way their work was done and feared that change could bring complications to their working environment. This fear could be translated to:
  - fear of threat to expertise – Team members could have felt that their positions were threatened by other members of staff when changes were to be made.
  - fear of threat to established resource allocations – Although the CCPM schedule tried to ensure that adequate resources were available for the project, team members still had to place complete trust in the schedule.
  - fear of threat to established power relationships – Often when changes are made, the reporting structure of the organisation is changed. Although the position of the team member could stay the same, he or she might have less influence on the team.

Change management is essential if a CCPM implementation is to be successful. In this case study external consultants were employed to introduce change management expertise and enhance communication. Management believed that the timing of change management was key as the longer the CCPM implementation progressed, the higher the resistance to change would become, particularly if that resistance was not managed early enough. Acceptance and buy-in at the project team level began with the project managers (or other key people in the team) who then communicated with the team members. All stakeholders were identified and

involved from the early stages. Management also promoted an organisational culture that welcomed change. The results of the post implementation survey suggested that the project teams recognised management's effort in change management.

4.3.2.5 TRAINING

Training was perceived as an important step in the implementation process at both the management and project team level. Management specifically employed external consultants to host training workshops to provide background information on CCPM and guide the teams through the implementation process. Firm top management support ensured that training was provided. The individual team members, through interviews and questionnaires, suggested that training was important for their involvement in the CCPM implementation. The team members' approval of the importance of CCPM training may have been based on the fact that many team members felt they did not have a solid theoretical background on CCPM, and lacked previous experience in project scheduling and management. Both management and project teams suggested that adequate and appropriate training contributed positively towards the implementation results.

4.3.2.6 TOOL

A software tool, Concerto, was adopted for this particular CCPM implementation. Several users suggested that initial setup and training was important to ensure smooth adoption and utilisation of the software. The tool adopted by an organisation for CCPM implementation is likely to be new and unfamiliar to the users, such as the situation presented in this case study. It would therefore be useful to take the tool into account when considering change management policies and training.

4.3.3 Perceived usefulness of CCPM

CCPM was considered to be beneficial, by both management and project teams, for the TD division. This perception was independent of the stage of implementation. Furthermore the perceived usefulness of CCPM was not affected by team members' role differences. Even though difficulties were encountered during the implementation process, management and project teams never lost faith in CCPM. This could suggest that the people involved in this case study firmly believed that CCPM is a sound theory that can practically resolve some of the problems associated with conventional project management techniques. This positive view on perceived usefulness of CCPM was further supported by the fact that the implementation yield higher productivity and job performance, which lead to less overtime work.

4.3.4 Perceived ease of use of CCPM

The project teams were not positive about the ease of use of CCPM. This perception was evidently present across different roles within different project teams. Both the project teams and management thought that the CCPM theory was clear, understandable and easy to learn. Management believed that the implementation of CCPM was controllable. However the project teams did not perceive CCPM to be easy to master. The interview and questionnaire results suggested that those who were having problems adjusting to changes caused by CCPM had more negative views about the perceived ease of use of CCPM. From management's perspective it was assumed that such negative views would not be raised. However management took many steps, including seeking the assistance of an external consultant, to resolve this issue.

4.3.5 User expectation

The TD division expected the CCPM implementation to shorten project lead times and reduce overtime. This was accomplished with a certain degree of success. While the whole division agreed that overtime was reduced, the project team members suggested that it was not a significant reduction, whereas management claimed that overtime was greatly reduced. The expectation of CCPM increasing project progress transparency was also realised as both management and the project teams had more control over the project schedule. However the project team members did not expect CCPM to induce as much inflexibility in their work as they in fact experienced during the CCPM implementation. The project team members referred to the dynamic IT environment in suggesting that CCPM is more appropriate in a production environment.

4.4 IMPLICATIONS OF FINDINGS FOR CCPM THEORY

4.4.1 Determining drum resource(s)

Identifying the drum resource is a crucial step in CCPM implementation. However, the TD division encountered some problems in executing this task. Two views were observed among project team members while determining who the drum resource for a particular project was. One view suggested that team members recognised the importance of being the drum resource, which highlighted their value within the project team or the organisation. The team members were linking the drum resource role with overtime work. Team members with this view feared that when labelled as a non-critical resource (non-drum resource), they might be questioned as to why they were working overtime (and getting more salary from overtime)

when they did not have to. Some team members however held very different views and did not want to be a drum resource, as they perceived that this might have created extra work for them during the project.

Different groups of team members (under the same project team) who executed tasks at different stages of the project could also have different opinions as to who was the drum resource. Often the group of team members who worked during the final phase of the project felt that they were under immense pressure because they were responsible for finishing the project. They assumed that they were the drum resource for the project and therefore had to handle such pressure. However it was discovered during the case study that the group of people who execute tasks at the end of project are not necessarily the drum resource for every project.

4.4.2 Different skill levels

Recognising the level of expertise that existed within each project team for each type of task was important in determining the resource availability and schedule. Each individual team member had different skill levels and CCPM did not clearly define when resource requirements were established. Resource skill levels had a direct impact on how the drum resources were identified and scheduled.

It was not uncommon to have more than one team member who was capable of executing a particular project task. However due to different levels of skill, expertise and experience, the execution time for that particular task would differ from one team member to another. A decision had to be made as to who should be responsible for completing that task. The duration of the project could vary depending on whether the best available resource was assigned to the appropriate task. Although project managers would like to have each of the project tasks executed by the most skilful and experienced team member, this may not always be the best arrangement for the project or the project team. Given the fact that actual project experience is an important training method, in the long term it may be beneficial for the team to assign the less experienced team members to tasks with which they are unfamiliar. This will allow them to gain valuable experience.

Decisions on assigning resources could be made based on the following considerations:

- Prioritise according to project importance – Some project managers may argue that all projects are important to the organisation. However there are some projects that are more critical than the others. It is often useful to study the consequences of not finishing the

project on time. If a project is of high importance to the organisation, then it is essential to make sure that the best resources work on the appropriate tasks.

- Long-term goal and strategy – The goal of completing the project on time, within budget and according to scope should merely be seen as the short-term goal. Developing the skills, knowledge and experience of the project team must be recognised as the long-term goal. If a particular expertise is lacking within the project team, then developing it through execution of project tasks will improve the skill level of project team members and the overall competence of the project team. In other words the 'bottleneck' is being reduced.
- Resource dependency – There are times when the project manager has no choice but to assign resources inefficiently because some resources could be needed for other concurrent projects. In this situation, the most important issue for the project manager to address is to ensure that there are enough resources scheduled to complete the project on time.

4.4.3 Project lead time

CCPM's proposition of halving estimated project/task duration was a major departure from conventional theory. The idea of removing fifty percent of the time estimated for any project tasks could be difficult to accept for some people or organisations. In this case study, some members of the project teams implementing CCPM were struggling with this concept. Several team members suggested that the rule was arbitrary and not well supported by scientific evidence. The concepts presented in CCPM are easy to comprehend. However, the methodology used to derive the task duration is not well supported.

An inherent problem associated with the 'halving estimated duration' concept is that the original estimation could be wrong. Most IT professionals are still using informal guesswork, based on past experience, when estimating task duration. Although in this case study this intuitive guesswork method worked well for the Technology Development division, the likelihood of deriving inaccurate estimations was still high. Furthermore the team members could have inserted more safety time for project tasks when estimating the duration after being educated with the CCPM concept and knowing that the estimations would be halved. This would undermine the effectiveness of the CCPM concept.

A formal methodology or formula would be useful in resolving this particular concern. There is a need for a more structured way of estimating task duration. The thinking behind the 'halving estimated duration' concept is plausible. However it may not be appropriate for

every task. For certain tasks a higher percentage of estimated duration could be taken away, while for some other tasks more than fifty percent of the original estimation should be kept in order to allow enough time to complete the task.

4.4.4 Buffer Management

After careful consideration, buffers were inserted into the project schedule to protect the project from the influences of uncertainty when progressing. However the usage of the buffers has to continuously be updated and monitored. When there are signs of buffer overrun, the cause of the overrun has to be determined quickly and actions taken to rectify the situation. One interesting finding of this case study in relation to buffer management is the question of who should update the project schedule with the latest available information on project progress and resource consumption. In the beginning of the implementation, the group leaders were responsible for such tasks. This was done to create a central point for updating all details without creating confusion among team members. Individual team members were given update rights and access to the software tool at a later stage. Management wanted the team members to be able to have a better overview of the whole project through the process of updating project progress. In general the team members did not object to this idea. However some team members saw the updating task as extra burden on their busy project time schedule and indicated a preference for group leaders to execute the task. A solution combining both approaches is recommended. The team members should be responsible for updating details of individual tasks while the group leaders could update the schedule when a particular stage of the project comes to an end.

4.5 SUMMARY

The findings collected from the four adopted data collection techniques were presented in detail in this chapter. Descriptive analysis was used to examine the collected data. Consistency was observed among the findings of different data collection techniques as no apparent contradiction among data was presented. The participants of the CCPM implementation and this case study were mostly positive with a few expressed negative views and concerns related to theoretical, implementation and political issues.

The data were analysed with the time series analysis technique to identify changes observed during this case study. The implications of the research findings were presented in detail in this chapter and summarised in the next chapter. The next chapter will also conclude this case study and provide details on the research limitation while recommending future research directions.

5. CONCLUSION

5.1 CONCLUDING REMARKS

Modern organisations seek to obtain competitiveness through many means, including major reductions in project cycle time (Kendall, Pitagorsky & Hulett, 2001). The management of Information Systems projects has received a great deal of attention in recent years as the industry continues to demonstrate poor project delivery performance. Conventional project management practices and scheduling techniques, which were developed years ago, have not been able to adequately improve the situation.

Critical Chain Project Management (CCPM) is essentially a project scheduling technique based on Goldratt's Theory of Constraints (Goldratt, 1990a). CCPM focuses on the scheduling and management of resources that are critical to projects. It contends that projects can be delivered on time by improving the usage of critical resources and correcting certain human behaviour that could cause delays in the project schedule.

A case study was conducted in this research to determine the effectiveness and user acceptance of CCPM in an IT project environment. The assumptions which CCPM is based on, the CCPM implementation issues, and the perceived usefulness and perceived ease of use of CCPM were specifically examined in this research.

In this longitudinal case study it took 2 years for a division with approximately 150 people to declare the CCPM implementation a total success in that the goals of budget reduction and higher project completion rate were achieved. As suggested by Kendall, Pitagorsky and Hulett (2001), significant changes in project management practices were required before adopting CCPM. Both the management and staff of the division realised that change does not occur instantly and change management was applied to resolve issues raised by implementing changes and CCPM.

Top management support was considered to be essential as it provided the required resources for the implementation. In this case study top management supplied substantial and adequate support. An implementation plan was important to ensure the division was progressing towards the intended goal. The division staff felt that training (for both CCPM fundamentals and tools adopted for the implementation) was vital to the initiation of the implementation.

Top management supplied training through an external consultant, which worked well for the division.

Both management and staff had confidence in the perceived usefulness of CCPM. They suggested that the effects of student syndrome, multitasking and the passing on of previous delays were present in the division and truly detrimental to the success of projects. The perceived ease of use of CCPM was however not as obvious among the management and staff of the division during the implementation process. The 50% estimation rule and changes implemented to correct behaviours such as student syndrome and multitasking were considered to be more suitable for the manufacturing environment and impractical in a project environment. However most resistance and obstacles were resolved through effective communication (in many forms including workshops), consistent top management support and a well-established implementation plan.

The findings of this research suggest that CCPM is applicable and effective in an IT project environment. CCPM induced higher project constraint awareness and increased project progress transparency. The effectiveness of CCPM is emphasized by the fact that a higher project completion rate was achieved with CCPM implementation despite the fact that the previous project management methodology was already effective in producing a project completion rate which is above industry average. However significant changes are necessary to ensure the implementation produces desired results. Change management is strongly linked to the user acceptance of CCPM. Top management support, training, a practical implementation plan and adequate time are all essential in achieving effective implementation of CCPM.

5.2 LIMITATIONS OF THIS RESEARCH

The applicability of the findings of this research is limited by the fact that only a single division was examined. Although this research examined a multiple project environment that included several project teams, single case studies have limited generalisability as each case study could reflect a unique representation of theory application.

Single case study could also result in the omission of other factors that may have affected the outcome of a CCPM implementation. Although in this case study the implementation of CCPM brought about satisfactory results with key implementation objectives achieved, one could question the existence of other factors which could have produced the same outcome if CCPM was not implemented.

The adoption of TAM in this research is limited in that the strengths of the relationships between the variables which formed the research questions were not tested. This case study does not aim to test or verify TAM but the relationships between the variables may provide useful insights while searching for answers to the research questions.

Another limitation of this research is the sample size used for the distribution of questionnaires. Although the nature of this research is primarily qualitative, it would be useful to include some quantitative analysis as well. The number of statistical techniques that could be applied to the collected data was restricted by the small sample size. Hence the reliability of the analysis of such data was undermined.

This case study is also limited by the researcher's ability to collect, interpret, analyse and present research findings. Although guidelines for conducting qualitative research as recommended in the literature were followed when the case study was carried out, the methods adopted by the researcher are by no means the only available techniques to obtain data and findings in research of this nature.

5.3 AREAS FOR FUTURE RESEARCH

Gorla (1989) emphasised the importance of identifying areas for future research for guiding research efforts and accumulating a single body of knowledge.

More exploratory case studies can be conducted in the IT industry to verify the findings of this research. In particular the implementation issues and user acceptance of CCPM could receive more attention in future research with the aim of developing best practices and implementation guidelines for future CCPM implementations. The strengths of the relationships between the TAM variables which formed the research questions could also be examined in greater detail. Furthermore future case studies could aim to discover the existence and effects of other variables that could impact the process and outcome of a CCPM implementation.

The 50% principle suggested by CCPM for task duration estimation is contentious and worthy of further investigation. Pepin (1999) argued that the principle of reducing task time estimates by 50% over-simplifies the complex issue of estimation and overlooks the uncertainty associated with each task. Kendall et al. (2001) suggested that in real world scenarios a range of 30% to 50% is more common and practical. Future research could verify this range and develop a scientific rule for task estimation based on CCPM assumptions.

Project management is a complicated process that involves many tasks. The adoption of one theory will not necessarily solve all the problems and ease difficulties. Maeurer (1998) argues that project schedules might become too detailed and difficult to manage if one places too much emphasis on project scheduling. Many project management maturity models have been developed in recent years with as many as 27 models being included in a list published by the Project Management Institute (Pennypacker & Grant, 2002). The main purpose of the project management maturity model is to gain a thorough understanding of the organisation's position and intended growth direction in terms of project management practices. Since effective project management practices were already in place in the unit that was studied this research, future research could look to link project management maturity models with the decision to implement CCPM. This would provide a better understanding of the applicability of CCPM and the appropriateness of the timing of CCPM implementations.

6. REFERENCES

Abdel-Hamid, T.K., Sengapta, K. & Swett, C. 1999, "The Impact of goals on software project management: An Experimental Investigation", *Management Information Systems Quarterly*, vol. 23, no. 4, pp. 531-555.

Abeyasinghe, M.C.L., Greenwood, D.J. & Johansen, D. E. 2001, "An efficient method for scheduling construction projects with resource constraints", *International Journal of Project Management*, vol. 19, no. 1, pp. 29-45.

Adams, D.A., Nelson, R.R. & Todd, P.A. 1992, "Perceived Usefulness, Ease of Use and Usage of Information Technology: A Replication", *Management Information Systems Quarterly*, vol. 16, no. 2, pp. 227-247.

Burke, R. 1999, *Project Management: Planning and Control Techniques*, Third Edition, Promatec International, Cape Town.

Benbasat, I., Goldstein, D. K. & Mead, M. 1987, "The Case Research Strategy in Studies of Information Systems", *Management Information Systems Quarterly*, vol. 11, pp. 369-386.

Benjamin, R.I. & Levinson, E. 1993, "A Framework for Managing IT-Enabled Change", *Sloan Management Review*, vol. 34, no. 4, pp. 23-33.

Cabanis-Brewin, J. 1999, "Debate Over CCPM Gets a Verbal Shrug from TOC Guru Goldratt", *PM Network*, vol. 13, no. 12, pp. 49-52.

Camblin, M. & Schrimsher, T. 1998, "Pump Up Your Project Scheduling", *PM Network*, vol. 12, no. 1, pp. 36-39.

Chau, P.Y.K. 1996, "An empirical assessment of a modified Technology Acceptance Model", *Journal of Management Information Systems*, vol. 13, no. 2, pp. 185-204.

Chau, P.Y.K. & Hu, P.J.H. 2001, "Information Technology Acceptance by Individual Professionals: A Model Comparison Approach", *Decision Sciences*, vol.32, no.4, pp699-719.

Cleland, D.I. & King, W.R. 1988, *Project Management Handbook*, Van Nostrand Reinhold, New York.

Cohen, P., Hilburn, M. & Reinhardt, D. 1999, An empirical investigation into IT project schedule mismanagement & critical chain project scheduling, Empirical Research Report, Department of Information Systems, University of Cape Town.

Compeau, D., Higgins, C.A. & Huff, S. 1999, "Social Cognitive Theory and Individual Reactions to Computing Technology: A Longitudinal Study", *Management Information Systems Quarterly*, vol. 23, no. 2, pp. 145-158.

Cook, S.C. 1998 (accessed on 8 February 2000), "Applying Critical Chain to Improve the Management of Uncertainty in Projects", thesis submitted to the *Sloan School of Management at the Massachusetts Institute of Technology*, http://www.prochain.com/ittnightvision.asp.

Davis, F. D. 1989, "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology", *Management Information System Quarterly*, vol. 13, pp. 319-340.

Dawson, R.J. & Dawson, C.W. 1998, "Practical proposals for managing uncertainty and risk in project planning", *International Journal of Project Management*, vol. 16, no. 5, pp. 299-310.

Dekom A.K., 1987, *Practical Project Management*, Random House Business Division, New York.

Dinsmore, P. C. 1993, *The AMA Handbook of Project Management*, AMACOM, New York

Drummond, H. 1999, "Are we any closer to the end Escalation and the case of Taurus?" *International Journal of Project Management*, vol. 17, no. 1, pp. 11-16.

Elton, J. & Roe, J. 1998, "Bringing Discipline to Project Management", *Harvard Business Review*, vol. 76, no. 2, pp. 153-159.

Fowler, A. & Walsh, M. 1999, "Conflicting perceptions of success in an information systems project", *International Journal of Project Management*, vol. 17, no. 1, pp. 1-10.

Frame, J.D. 1994, *The New Project Management: Tools for an Age of Rapid Change, Corporate Reengineering and Other Business Realities*, CA: Jossey-Bass, San Francisco.

Gillespie M.W., Patterson M.C. & Harmel B. Nov/Dec 1999, "TOC Beyond Manufacturing", *Industrial Management*, pp. 22-24.

Globerson, S. 2000, "PMBOK and the Critical Chain", *PM Network*, vol. 14, no. 5, pp. 63-66.

Goldratt, E.M. 1990a, *Theory of Constraints*, North River Press, Great Barrington, MA

Goldratt, E.M. 1990b, *Essays on the Theory of Constraints*, North River Press, Great Barrington, MA.

Goldratt, E.M. 1994, *It's Not Luck*, North River Press, Great Barrington, MA.

Goldratt, E.M. 1997, *Critical Chain*, North River Press, Great Barrington, MA.

Goldratt, E.M. & Cox, J. 1992, *The Goal: A Process of Ongoing Improvement*, North River Press, Great Barrington, MA.

Goldratt, E.M. & Fox, R.E. 1986, *The Race*, North River Press, Great Barrington, MA.
Goldratt Institute 1999 (accessed on 17 October 1999), "Success Stories: Case Studies", http://www.goldratt.com/success.htm

Gordon-Davis, D. 1997, "Project management", Unpublished Seminar Paper, Department of Information Systems, University of Cape Town.

Gorla, N. 1989, "Identifying MIS Research Issues Using a Research Framework", *Information and Management*, vol. 17, no. 3, pp.131-144

Grobler, D. (presenter) 1999, materials from the Workshop on Critical Chain Project/Resource Capacity Management & Outcomes-based Scoping and Design of Projects, *Dirk Grobler & Associates CC, copyrighted by Avraham Y. Goldratt Institute.*

Hill, J., Thomas, L.C. & Allen, D.E. 2000, "Experts' estimates of task durations in software development projects", *International Journal of Project Management*, vol. 18, no. 1, pp. 13-21.

Ibbs, C.W. & Kwak, Y.H. 2000, "Assessing Project Management Maturity", vol. 31, no. 1, pp. 32-43.

Information Systems Specific Interest Group (ISSIG) 1999, "Applying the PMBOK® Guide to IS Projects", Final Draft.

Jaafari, A. 2000, "Management of risks, uncertainties and opportunities on projects: time for a fundamental shift", *International Journal of Project Management*, vol. 19, no. 2, pp. 89-101.

Jurison, J. 1999, "Software Project Management: The Manager's View", *Communications of the Association for Information Systems*, vol. 2, article 7.

Jurison, J. 2002, "Integrating project management and change management in an IS curriculum", *Communications of the Association for Information Systems*, vol. 8, pp26-40.

Kaplan, B. & Duchon, D. 1988, "Combining Qualitative and Quantitative Methods in Information Systems Research: A Case Study", *Management Information Systems Quarterly*, vol. 12, pp. 571-586.

Kegan, R. & Lahey, L.L. November 2001, "The Real Reason People Won't Change", *Harvard Business Review*, vol. 79, no. 11, pp. 85-92.

Kemerer, C.F. 1997, *Software Project Management: Readings and Cases*, Irwin, Chicago

Kendall, G.I., Pitagorsky G. & Hulett D. 2001 (accessed on 13 November 2002), "Integrating Critical Chain and the PMBOK Guide", *International Institute for Learning Inc.*, http://www.iil.com/members/criticalchain-pmbok.pdf

Kerzner, H. 1998, *Project Management: A Systems Approach to Planning, Scheduling and Controlling*, John Wiley & Sons, New York.

Kerzner, H. 2000, *Applied Project Management: best practices on implementation*, John Wiley & Sons, New York.

Kerzner, H. 2001, *Strategic Planning for Project Management Using a Project Management Maturity Model*, John Wiley & Sons, New York

Klein, H.K. & Myers, M.D. 1999, "A set of principles for conducting and evaluating interpretive field studies in Information Systems", *Management Information Systems Quarterly*, vol. 23, no. 1, pp. 67-94.

Lacity, M.C. & Janson, M.A. 1994, "Understanding Qualitative Data: A Framework of Text Analysis Methods", *Journal of Management Information Systems*, vol. 11, no. 2, pp. 137-155.

Leach, L.P. 1999, "Critical Chain Project Management Improves Project Performance", *Project Management Journal*, vol. 30, no. 2, pp. 39-51.

Lee, A.S. 1989, "A Scientific Methodology for MIS Case Studies", *Management Information Systems Quarterly*, vol. 13, pp. 33-52.

Lewis, J.P. 2001, *Project Planning, Scheduling, and Control: A Hands-on Guide to bringing Projects in on Time and on Budget*, Third Edition, McGraw-Hill, New York.

Licker, P. 1999, Class Notes, *INF515W*, Department of Information Systems, University of Cape Town

Lientz, B.P. & Rea, K.P. 1995, *Project Management for the 21st Century*, Academic Press, San Diego

Lynch, B. 1998 (accessed on 7 February 2000), "Benefits of Critical Chain Project Management", *ProChain Solutions Inc*, http://www.prochain.com/article_03.asp.

Maeurer, T.R. 1998, "Implementation of the Critical Chain Project Management Methodology in IBM's S/390 Software Development Environment", Research Paper, *Massachusetts Institute of Technology.*

Markus, M.L. & Benjamin, R.I. 1996, "Change Agentry – The Next IS Frontier", *Management Information Systems Quarterly*, vol. 20, no. 4, pp. 385-407.

Markus, M.L. & Benjamin, R.I. 1997, "The Magic Bullet Theory in IT-Enabled Transformation", *Sloan Management Review*, vol. 38, no. 2, pp.11-25.

McLeod, G. & Smith, D. 1996, *Managing Information Technology Projects*, Boyd & Fraser Publishing Company, USA.

Meyer, A.D., Loch, C.H. & Pich, M.T. 2002, "Managing Project Uncertainty: From Variation to Chaos", *MIT Sloan Management Review*, vol. 43, no. 2, pp. 60-67.

Munns, A.K. & Bjeirmi, B.F. 1996, "The Role of Project Management in Achieving Project Success", *International Journal of Project Management*, vol. 14, no. 2, pp. 81-87.

Myers, M.D. 1997 (accessed on 14 March 2000), "Qualitative Research in Information Systems," *Management Information Systems Quarterly,* vol. 21, no.2, pp. 241-242. *MISQ Discovery*, http://www.auckland.ac.nz/msis/isworld/

Nelson, A.C. & Joshi, K. 1995, "Application of a matrix approach to estimate project skill requirements", *Information & Management*, vol. 29, pp. 165-172.

Newbold, R.C. 1997 (accessed on 7 February 2000), "Introduction to Critical Chain Project Management", *ProChain Solutions Inc.*, http://www.prochain.com/article_01.asp.

Newbold, R.C. 1998, *Management in the Fast Lane: Applying the Theory of Constraints*, St. Lucie Press, Boca Raton, FL.

Newbold, R. & Lynch, W. 1998 (accessed on 7 February 2000), "Practical Ideas for Implementing Critical Chain Management", *ProChain Solutions, Inc.*, http://www.prochain.com/article_02.asp.

Newbold, R. & Lynch, W. 1999 (accessed on 7 February 2000), "Critical Chain: Critical Success Factors", *APICS Constraint Management SIG* Phoenix AZ, http://www.prochain.com/CCSuccessFactors.asp.

Noreen, E., Smith, D. & Mackey, J.T. 1995, *The Theory of Constraints and its implications for Management Accounting*, The North River Press, USA.

Patrick, F.S. 1999a (accessed on 10 February 2000), "Critical Chain Scheduling and Buffer Management: Getting Out From Between Parkinson's Rock and Murphy's Hard Place", *PM Network*, vol. 13, no. 4, http://www.focusedperformance.com/articles/CCPM.htm.

Patrick, F.S. 1999b (accessed on 10 February 2000), "Program Management – Turning Many Projects into Few Priorities with TOC", *The National Project Management Institute Symposium* Philadelphia, http://www.focusedperformance.com/articles/multipm.htm.

Pennypacker, J.S. & Grant, K.P. 2002, "Project Management Maturity: An Industry-Wide Assessment", *Proceedings of PMI Research Conference*, pp. 431-438

Pepin, R. 1999, "Application of Critical Chain to Staged Software Development", Research Paper, *Massachusetts Institute of Technology.*

Piney, C. 2000, "Critical Path or Critical Chain, Combining the Best of Both", *PM Network*, vol. 14, no. 12, pp. 51-54.

Pinto, J.K. 1996, *Power and Politics in Project Management*, Project Management Institute, USA.

Pinto, J.K. 2000, "Understanding the role of politics in successful project management", *International Journal of Project Management*, vol. 18, no. 2, pp. 85-91.

Plaza, T.J. 2000, "Seven Excuses for Resisting Schedule Management: Introducing Schedule Management into Your Organisation – Part 1", *PM Network*, vol. 14, no. 3, pp. 56-60.

P.M.I. 2000, *A Guide to the Project Management Body of Knowledge (PMBOK Guide)*, Project Management Institute, Pennsylvania USA.

Price, B. 1998, Managing organisational change, Unpublished Seminar Paper, Department of Information Systems, University of Cape Town.

Rand, G. K. 2000, "Critical chain: the theory of constraints applied to project management", *International Journal of Project Management*, vol. 18, no. 3, pp. 173-177.

Raz, T. & Michael, E. 2001, "Use and benefits of tools for project risk management", *International Journal of Project Management*, vol. 19, no. 1, pp. 9-17.

Reiss, G. 1992, *Project Management Demystified*, E & FN Spon, London.

Rizzo, T. 1999, "Operational Measurements for Product Development Organisations – Part 2", *PM Network*, vol. 13, no. 12, pp. 31-35.

Sarker, S. & Lee, A.S. 2002, "Using a Positivist Case Research Methodology to test three competing theories-in-use of Business Process Redesign", *Journal of the Association for Information Systems*, vol. 2, article 7.

Schmidt, R., Lyytinen, K., Keil, M. & Cule, P. 2001, "Identifying Software Project Risks: An International Delphi Study", *Journal of Management Information Systems*, vol. 17, no. 4, pp. 5-36.

Schuyler, J. 2000, "Exploiting the Best of Critical Chain and Monte Carlo Simulation", *PM Network*, vol. 14, no. 1, pp. 56-60.

Schwalbe, K. 2002, *Information Technology Project Management*, Course Technology – Thompson Learning, Boston.

Simpson III, W.P. 1999 (accessed on 8 February 2000), "Critical Chain: A New Approach for IT Projects Management", *PMI Information Systems SIG* Orlando FL, *ProChain Solutions Inc*, http://www.prochain.com/ITCCProjectManagementprint.asp.

Simpson III, W.P. & Lynch, W. 1999 (accessed on 8 February 2000), "Attacking Unproductive Communication and the Case for Clear and Stable Priorities", *PMI' 99* Philadelphia PA, *ProChain Solutions Inc*., http://www.prochain.com/PMIPriorities.asp.

Smith, H.A., McKeen, J.D. & Staples, D.S. 2001, "Risk Management in Information Systems: Problems and Potential", *Communications of the Association for Information Systems*, vol. 7, article 13.

Starrett, E.C.L. 1998 (accessed on 3 April 2000), "Measurement 101", *Measurement Crosstalk*, http://www.stsc.hill.af.mil/crosstalk/1998/aug/measurement.html.

Steyn, H. 2000, "An investigation into the fundamentals of critical chain project scheduling", *International Journal of Project Management*, vol. 19, no. 6, pp. 363-369.

Steyn, H. 2002, "Project management applications of the theory of constraints beyond critical chain scheduling", *International Journal of Project Management*, vol. 19, no. 6, pp. 75-80.

Thite, M. 2000, "Leadership styles in information technology projects", *International Journal of Project Management*, vol. 18, no. 4, pp. 235-241.

Uyttewaal, E. 1999, "Take the Path That is Really Critical", *PM Network*, vol. 13, no. 12, pp. 37-39.

van der Waldt, G. & Knipe, A. 1998, *Project Management for Strategic Change and Upliftment*, International Thomson Publishing, Johannesburg.

Vandersluis, C. 1995 (accessed on 3 April 2000), "Metric Madness? Project Management Can Help", *Computing Canada*, Plesman Publications, http://www.hmssoftware.ca/articles/cc20.html.

Vandersluis, C. 1997 (accessed on 3 April 2000), "Keeping Track of IT Projects", *Computing Canada*, Plesman Publications, http://www.hmssoftware.ca/articles/cc39.html.

Venkatesh, V. & Davis, F.D. 1996, "A Model of the Antecedents of Perceived Ease of Use: Development and Test", *Decision Sciences*, vol. 27, no.3, pp. 451-481.

Voropajev, V. 1998, "Change management – A key integrative function of PM in transition economics", *International Journal of Project Management*, vol. 16, no. 1, pp. 15-19.

White, D. & Fortune, J. 2002, "Current practice in project management – an empirical study", vol. 20, no. 1, pp. 1-11.

Wilkens, T.T. 2000, "Critical Path, or Chain, or Both?", *PM Network*, vol. 14, no. 7, pp. 68-74.

Wysocki, R.K., Beck Jr., R. & Crane D.B. 1995, *Effective Project Management: How to Plan, Manage, and Deliver Projects on Time and within Budget*, John Wiley & Son, New York.

Yeo, K. T. 2002, "Critical failure factors in information system projects", *International Journal of Project Management*, vol. 20, no. 3, pp. 241-246.

Yin, R.K. 1994, *Case Study Research Design and Methods*, SAGE Publications, California.

Young, T.L. 1996, *The Handbook of Project Management: a Practical Guide to effective policies and procedures*, Kogan Page, London.

7. APPENDICES

7.1 APPENDIX A – GLOSSARY

50% Estimation Rule – CCPM contends that 50% of project task time estimates can be seen as ineffective safety time wasted through human behaviours such as Student Syndrome, multitasking and Parkinson's Law. CCPM therefore proposes the extraction of safety time from the original task estimate and uses it as buffers for the project.

Buffer – Time extracted from the original task estimates and re-inserted into the project plan at specific places, functioning as a contingency reserve to protect the project from late completion. Project schedule risks can be assessed through buffer management.

Critical Chain Project Management (CCPM) – Based on the Theory of Constraints, CCPM is a system-oriented approach to project scheduling. It involves the elimination of Student Syndrome, multitasking and Parkinson's law to produce a more efficient project schedule. It also aims to improve project progress transparency and risk management through strategically placed buffers.

Critical Chain project plan – A project plan developed using CCPM principles. The tasks that will critically affect the project duration are identified and linked in the project plan in an attempt to identify bottlenecks.

Drum Resource – The resource that is critical to project completion. CCPM will look to increase the capacity of the drum resource and/or place some buffer around the drum resource to protect the overall schedule.

Feeding Buffer – An aggregated feeding buffer is placed at the end of each path that feeds the critical chain in order to protect the critical chain from potential delays in the feeding path.

Multitasking – Simultaneous involvement in multiple tasks/projects. CCPM contends that splitting time between multiple tasks/projects will result in the inability to focus and lead to longer task execution time and poorer deliverable quality.

Parkinson's Law – The principle which asserts that task duration will expand and fill the available time.

Project Buffer – A project buffer is inserted at the end of the project activity path to protect the overall project schedule.

Resource Buffer – Applied only to critical chain activities, the resource buffer protects the critical chain from unavailability of resources.

Student Syndrome – The principle that contends that procrastination (leaving tasks until the deadline) is an inevitable part of human behaviour.

Technology Acceptance Model (TAM) – A theory developed by Davis (1989) measuring user acceptance of new technology. Key variables examined by the model include the perceived ease of use and usefulness of the new technology, which together with other external variables form user behaviour.

Theory of Constraints (TOC) – A system improvement theory developed by Goldratt (1990a). The aim of TOC is to continuously identify and increase the capacity of the weakest link in a system in order to achieve maximum return on overall system performance.

7.2 APPENDIX B – INTERVIEW QUESTIONS

Training

- Do you feel that the training (the workshop) has provided you with enough knowledge to implement and use CCPM?
- Do you feel comfortable with the training? Do you feel that there are better ways to attain the knowledge?
- Do you feel the CCPM concept is sound and will work in the project team and division?

Implementation

Symptoms addressed?

- Did CCPM address the issue of uncertainty (e.g. unexpected events) well?
- Did CCPM effectively eliminate multitasking?
- Do you feel that you are not in control of your work (limited freedom in choosing what to do next) after CCPM has been implemented?
- Do you feel that you are too busy / don't have enough time to adjust and fully implement CCPM?

Establish realistic implementation goals

- Were the goals, purpose and benefits of CCPM implementation made clear to you?
- Do you feel that the implementation goals are beneficial to the project team and division?
- Do you feel that the goals are difficult to reach?
- Do you feel that the team has stay focused on the implementation objective throughout the implementation process?
- Did you experience any difficulties or problems during CCPM implementation?

Keep the right leadership involved

- Do you feel that the management has provided adequate support, guidance and resources for the implementation?
- Do you feel that the management has taken an active role and assumed responsibility in the implementation process?
- Do you feel that the implementation is influenced by any external forces or other divisions/organisations that are not within the team's control?

Create and maintain the implementation plan

- Do you feel that the implementation plan is feasible?
- Do you feel that you are well informed of the implementation plan?

Tool used (Concerto)

- Do you feel that Concerto is easy to use?
- Do you feel that Concerto has adequate functionalities to scheduling projects for your project team?

7.3 APPENDIX C – PRE CRITICAL CHAIN WORKSHOP QUESTIONNAIRE

This questionnaire is designed to determine what your expectation of Critical Chain is prior to the workshop. Please complete the form as soon as possible, and return it to Terry Lu, who is situated at the desk behind Yvonne Raper.

Background information

Please circle the number that you feel is the most appropriate response to the question, where 1 is the minimum and 7 is the maximum level of agreement.

Previous experience in project management, specifically in project scheduling

1 2 3 4 5 6 7

Level of background knowledge on Critical Chain prior to the workshop

1 2 3 4 5 6 7

The level at which you feel that you are informed and prepared for the workshop

1 2 3 4 5 6 7

Are you satisfied with the current project management practice/scheduling method implemented in the division?

1 2 3 4 5 6 7

Do you feel that there is needs to change the current project management practice/scheduling method?

1 2 3 4 5 6 7

Expectations

Please circle the number that you feel is the most appropriate response to the question, where 1 is the minimum and 7 is the maximum level of agreement.

Do you expect the concepts presented in Critical Chain difficult to understand?

1 2 3 4 5 6 7

Do you expect the concepts presented in Critical Chain difficult to implement?

1 2 3 4 5 6 7

Do you expect changes in the way you perform your work once Critical Chain is introduced to the division?

1 2 3 4 5 6 7

Do you expect new roles and responsibilities to be assigned to you by implementing Critical Chain in the division?

1 2 3 4 5 6 7

Do you expect Critical Chain to improve on project management process performance?

1 2 3 4 5 6 7

Do you expect Critical Chain to improve on your working condition?

1 2 3 4 5 6 7

Do you expect the division to benefit from Critical Chain?

1 2 3 4 5 6 7

Additional comments

If you have had any discussion on Critical Chain with colleagues (from the teams that are already implementing Critical Chain), please write down what your impression is from those discussions.

If you have any other comments regarding the Critical Chain workshop, please specify in the space below.

Thank you for your cooperation

Malan Smith & Terry Lu

7.4 APPENDIX D – POST CRITICAL CHAIN WORKSHOP QUESTIONNAIRE

This questionnaire is designed to find out what you thought of the Critical Chain concept after attending the workshop. It should only take about 10 minutes to complete. Please complete the form as soon as possible, and return it to Terry Lu, who is situated at the desk behind Yvonne Raper.

General information

Please circle the number that you feel is the most appropriate response to the question, where 1 is the minimum and 7 is the maximum level of agreement.

The concept of Critical Chain was difficult to understand and comprehend.

1 2 3 4 5 6 7

Do you agree with the concept?

1 2 3 4 5 6 7

The concept is applicable to this division.

1 2 3 4 5 6 7

The performance of the project management process will be improved by implementing the concept.

1 2 3 4 5 6 7

Symptoms described in Critical Chain

Please circle the number that you feel is the most appropriate response to the question, where 1 is the minimum and 7 is the maximum level of agreement.

You feel compelled to stay busy all the time.

1 2 3 4 5 6 7

You often find yourself switching between tasks.

1 2 3 4 5 6 7

Do you agree that student syndrome (leaving work until the latest possible start date) exists in the division?

1 2 3 4 5 6 7

You often experience interruptions.

1 2 3 4 5 6 7

During a typical working day, you often handle tasks that are unrelated to the project that you are currently assigned to.

1 2 3 4 5 6 7

For each of the following concepts, please indicate its importance in your current work environment, where 1 means least important and 7 means most important.

Halving task estimates

1 2 3 4 5 6 7

Allowing non-critical project team members to be inactive at times

1 2 3 4 5 6 7

Eliminating multitasking

1 2 3 4 5 6 7

Implementation

Please circle the number that you feel is the most appropriate response to the question, where 1 is the minimum and 7 is the maximum level of agreement.

There is not enough preparation and training for the implementation.

1 2 3 4 5 6 7

There is not enough resource for the implementation.

1 2 3 4 5 6 7

It would be difficult to implement Critical Chain in our work environment.

1 2 3 4 5 6 7

The implementation will bring unnecessary changes to the way you work.

1 2 3 4 5 6 7

The implementation will bring you additional unnecessary responsibilities.

1 2 3 4 5 6 7

The implementation will not be effective for all team members. That is, some team members would still perform their work the same way as before.

1 2 3 4 5 6 7

Additional comment

If you have any comment regarding the Critical Chain concept and the implementation, please provide them on the other side of this sheet.

7.5 APPENDIX E – POST IMPLEMENTATION QUESTIONNAIRE

This questionnaire is designed to gather data for a Critical Chain post-implementation research. It should take no more than 15 minutes to complete. Please complete the form as soon as possible and return it to Leon Benn.

Team (Please circle the one that you belong to)

● IS ● MC ● MIT ● WN

Role (Please circle the one that is applicable to you)

● Project Manager ● Project Team Member

When you first joined the division

● Critical Chain was not in place ● Critical Chain was in place

Critical Chain – the concept

Please circle the number that you feel is the most appropriate response to the question, where 1 is the minimum and 7 is the maximum level of agreement

The concept is applicable to the software development environment such as the one in the Technology Development division, particularly your team.

●1 ●2 ●3 ●4 ●5 ●6 ●7

The implementation of the Critical Chain concept brought a big change to the way you work and required a major mind shift from your part.

●1 ●2 ●3 ●4 ●5 ●6 ●7

Implementation issues

Please circle the number that you feel is the most appropriate response to the question, where 1 is the minimum and 7 is the maximum level of agreement

The implementation process was easy to follow.

●1 ●2 ●3 ●4 ●5 ●6 ●7

There was enough preparation and training for the implementation.

●1 ●2 ●3 ●4 ●5 ●6 ●7

It was easy to change from the previously adopted project management practice to the Critical Chain concept.

●1 ●2 ●3 ●4 ●5 ●6 ●7

There was enough change management practice in place to ensure a smooth transition from the previously adopted project management practice to the Critical Chain concept.

●1 ●2 ●3 ●4 ●5 ●6 ●7

There were individuals who did not cope with the implementation well and made the implementation more difficult.

●1 ●2 ●3 ●4 ●5 ●6 ●7

External consultant(s) helped to make the implementation easier.

●1 ●2 ●3 ●4 ●5 ●6 ●7

There were enough resources for the implementation.

●1 ●2 ●3 ●4 ●5 ●6 ●7

There was enough top management support for the implementation.

●1 ●2 ●3 ●4 ●5 ●6 ●7

Please specify if you feel that there are any resources lacking that would have made the implementation more successful?

Please specify if you feel that there is anything else that could have made the implementation more successful?

Implementation results

Please circle the number that you feel is the most appropriate response to the question, where 1 is the minimum and 7 is the maximum level of agreement

The implementation addressed the issue of multitasking.

●1 ●2 ●3 ●4 ●5 ●6 ●7

The implementation addressed the issue of student syndrome (only start the task on the latest possible start date).

●1 ●2 ●3 ●4 ●5 ●6 ●7

The implementation allowed you to prioritise your tasks (able to focus more on the critical and relevant tasks).

●1 ●2 ●3 ●4 ●5 ●6 ●7

Projects are been completed on time without sacrificing quality and functionality.

●1 ●2 ●3 ●4 ●5 ●6 ●7

Overtime work was greatly reduced.

●1 ●2 ●3 ●4 ●5 ●6 ●7

The implementation was useful especially for projects where 'time to market' is important.

●1 ●2 ●3 ●4 ●5 ●6 ●7

The concept of placing and managing buffer in projects made uncertainty associated with software development projects much easier to manage and greatly reduces the risks.

●1 ●2 ●3 ●4 ●5 ●6 ●7

Overall, the implementation was successful and a worthwhile effort.

●1 ●2 ●3 ●4 ●5 ●6 ●7

Additional comment

If you have any comment regarding the Critical Chain concept and the implementation, please provide them in the space below. Thank you.

7.6 APPENDIX F – RESULTS OF PRE CRITICAL CHAIN WORKSHOP QUESTIONNAIRE

Responses to Questions

Eleven responses were received. The numbers in the following table represent the number of responses for the associated question and score.

Question \ Response	1	2	3	4	5	6	7
Background information							
Previous experience in project management, specifically in project scheduling	3	1	4	0	1	0	2
Level of background knowledge on Critical Chain prior to the workshop	5	2	1	1	0	1	1
The level at which you feel that you are informed and prepared for the workshop	2	3	1	3	0	0	2
Are you satisfied with the current project management practice/scheduling method implemented in the division?	0	1	3	2	2	2	1
Do you feel that there is needs to change the current project management practice/scheduling method?	0	3	2	2	2	0	2
Expectations							
Do you expect the concepts presented in Critical Chain difficult to understand?	4	3	1	1	1	0	1
Do you expect the concepts presented in Critical Chain difficult to implement?	1	1	2	2	2	1	2
Do you expect changes in the way you perform your work once Critical Chain is introduced to the division?	1	1	2	3	1	1	2
Do you expect new roles and responsibilities to be assigned to you by implementing Critical Chain in the division?	0	0	3	4	2	1	1
Do you expect Critical Chain to improve on project management process performance?	0	0	1	2	3	2	3
Do you expect Critical Chain to improve on your working condition?	0	0	2	2	2	2	3
Do you expect the division to benefit from Critical Chain?	0	0	1	2	2	2	4

Additional Comments

If you have had any discussion on Critical Chain with colleagues (from the teams that are already implementing Critical Chain), please write down what your impression is from those discussions.

- "Yes, with the Mobile Core group. They have implemented the new process and it seems to work well!"
- "The problem comes in with the input from sources over which on has no control. In other words delays in other parts of the world which do not use Critical Chain but upon whose input we are dependent here."

If you have any other comments regarding the Critical Chain workshop, please specify in the space below.

None.

7.7 APPENDIX G – RESULTS OF POST CRITICAL CHAIN WORKSHOP QUESTIONNAIRE

Responses to questions

Fifteen responses were received. The numbers in the following table represent the number of responses for the associated question and score.

Question \ Response	1	2	3	4	5	6	7
General information							
The concept of Critical Chain was difficult to understand and comprehend.	5	7	1	0	2	0	0
Do you agree with the concept?	1	0	0	1	2	9	2
The concept is applicable to this division.	0	0	1	1	7	5	1
The performance of the project management process will be improved by implementing the concept.	0	1	0	3	4	6	1
Symptoms described in Critical Chain							
You feel compelled to stay busy all the time.	1	0	4	0	6	3	1
You often find yourself switching between tasks.	0	0	0	0	2	7	6
Do you agree that student syndrome (leaving work until the latest possible start date) exists in the division?	0	1	2	4	3	4	1
You often experience interruptions.	0	0	0	2	3	3	7
During a typical working day, you often handle tasks that are unrelated to the project that you are currently assigned to.	0	0	3	2	6	2	2
indicate importance of the following in your current work environment							
Halving task estimates	0	1	2	5	4	3	0
Allowing non-critical project team members to be inactive at times	1	2	2	4	2	2	2
Eliminating multitasking	1	0	1	2	0	6	5

Question \ Response	1	2	3	4	5	6	7
Implementation							
There is not enough preparation and training for the implementation.	1	1	2	3	5	1	2
There is not enough resource for the implementation.	0	2	3	1	5	2	2
It would be difficult to implement Critical Chain in our work environment.	0	3	3	2	3	3	1
The implementation will bring unnecessary changes to the way you work.	2	2	6	3	2	0	0
The implementation will bring you additional unnecessary responsibilities.	0	4	4	4	2	0	1
The implementation will not be effective for all team members. That is, some team members would still perform their work the same way as before.	0	1	2	7	1	2	2

Additional Comments

If you have any comment regarding the Critical Chain concept and the implementation, please provide them on the other side of this sheet.

- "All interruptions and fault report handling tasks will have to be controlled and scheduled if the Critical Chain is to work in our group."

7.8 APPENDIX H – RESULTS OF POST IMPLEMENTATION QUESTIONNAIRE

Responses to questions

	Yes	No
When you first joined the division, Critical Chain was in place already.	8	10

Eighteen responses were received. Eight out the eighteen responses were from people who started working in the TD division after CCPM was implemented, hence they did not go through the implementation process from the beginning. Their responses to the questionnaire were likely to be influenced by their lack of participation in the whole implementation process. Therefore those eight responses were excluded from the analysis.

The numbers in the following table represent the number of responses for the associated question and score.

Respondent profile

Team \ Role	Project Manager	Project Team Member	Total
Intelligent Services	0	2	2
Mobile Core	2	1	3
WN	0	5	5
Total	2	8	10

Question \ Response	1	2	3	4	5	6	7
Critical Chain – the concept							
The concept is applicable to the software development environment such as the one in the Technology Development division, particularly your team.	0	0	0	0	2	5	3
The implementation of the Critical Chain concept brought a big change to the way you work and required a major mind shift from your part.	1	0	1	3	3	1	1

Question \ Response	1	2	3	4	5	6	7
Implementation issues							
The implementation process was easy to follow.	0	0	0	2	4	2	2
There was enough preparation and training for the implementation.	0	0	0	3	0	4	3
It was easy to change from the previously adopted project management practice to the Critical Chain concept.	1	0	1	2	3	3	0
There was enough change management to ensure a smooth transition from the previously adopted project management practice to the Critical Chain concept.	1	1	1	0	3	4	0
There were individuals who did not cope with the implementation well and made the implementation more difficult.	1	0	1	0	3	2	3
External consultant(s) helped to make the implementation easier.	1	1	1	2	3	1	1
There were enough resources for the implementation.	1	0	3	1	2	2	1
There was enough top management support for the implementation.	0	0	0	0	0	6	4
Implementation results							
The implementation addressed the issue of multitasking.	0	2	1	2	1	3	1
The implementation addressed the issue of student syndrome (only start the task on the latest possible start date).	0	1	0	1	3	3	2
The implementation allowed you to prioritise your tasks (able to focus more on the critical and relevant tasks).	0	1	2	1	2	2	2
Projects are been completed on time without sacrificing quality and functionality.	0	1	1	0	2	4	2
Overtime work was greatly reduced.	1	4	0	2	2	1	0
The implementation was useful especially for projects where 'time to market' is important.	1	1	1	2	3	2	0

Question \ Response	1	2	3	4	5	6	7
Implementation results							
The concept of buffer management made uncertainty associated with software development projects much easier to manage and greatly reduced the risks.	0	0	1	4	1	3	1
Overall, the implementation was successful and a worthwhile effort.	0	1	1	0	2	3	3

Additional comment

Please specify if you feel that there are any resources lacking that would have made the implementation more successful?

None.

Please specify if you feel that there is anything else that could have made the implementation more successful?

None.

If you have any comment regarding the Critical Chain concept and the implementation, please provide them in the space below. Thank you.

- "The Concerto Software at times is clumsy to use. Feeding buffers are difficult to view, thus diminishing the importance of these tasks in the greater scheme. When tasks are completed early, the associated dates are adjusted accordingly. This leads to resources stalling these tasks to "pad" buffers and buy additional time."
- "Like the concept."