

A Case Study in Project Management

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This assignment is presented in partial fulfilment of the requirements for the Masters Degree in Industrial Engineering at the University of Stellenbosch.

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Declaration

I, the undersigned, hereby declare that the work contained in this assignment is my own original work and has not previously in its entirety or in part been submitted at any university for a degree or course.

Ek, die ondergetekende verklaar hiermee dat die werk gedoen in hierdie werkstuk my eie oorspronklike werk is wat nog nie voorheen gedeeltelik of volledig by enige universiteit vir 'n graad of kursus aangebied is nie.

Synopsis

Project Management has already moved beyond the realms of an “order-winning”-criteria to a “necessary-to-survive”-criteria. Increasingly people are drawn into project management without the correct qualifications or sufficient education in project management, especially in the area of project risk management.

This project details the development of a case study in project management to facilitate this educational infilling in the services industry. This case study is based on a fictitious BPR project at an IT development company.

The developed case study is an alternative project for the post-graduate course in Project Management at the University of Stellenbosch’s Department of Industrial Engineering. Additionally, a tutorial in Microsoft® Project 2000® was also developed as supplementary material to this course.

Opsomming

Projek bestuur het alreeds verby die stadium beweeg waar dit gesien word as 'n voorsprong bo ander mededingende maatskappye. Al meer word mense in die dienste sektor met onvoldoende opleiding in projekbestuur, veral in die area van projek risiko bestuur, daarby betrek.

Hierdie projek bespreek die ontwikkeling van 'n gevallestudie om hierdie leemte aan te spreek, en is gebaseer op 'n besigheidsproses verbeteringsprojek by 'n IT ontwikkelingsmaatskappy.

Die ontwikkelde gevallestudie dien as 'n alternatiewe projek vir die nagraadse kursus in Projekbestuur wat aangebied word deur die Universiteit van Stellenbosch se Departement Bedryfsingenieurswese. 'n Addisionele tutoriaal in Microsoft® Project 2000® is ook ontwikkel om hierdie opleidingsproses te fasiliteer.

Acknowledgements

I would like to thank Dr. C.J. Fourie for his help, support and guidance, and especially for always having an open door to his office.

To my parents, André and Karin Boezaart, thank you for your faith in me and for always leading by example.

To my Heavenly Father without whom none of this would be possible, not even a single word.

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Glossary

<u>Abbreviation</u>	<u>Meaning</u>
AOA	Activity on Arrow
AON	Activity on Node
BAC	Budgeted At Completion
BCE	Base Cost Estimate
BCWP	Budgeted Cost of Work Performed
BCWS	Budgeted Cost of Work Scheduled
BTE	Base Time Estimate
CAPP	Computer Aided Project Planning
CIF	Composite Impact Factor
CLF	Composite Likelihood Factor
CPFF	Cost Plus Fixed Fee
CPI	Cost Performance Index
CPIF	Cost Plus Incentive Fee
CPM	Critical Path Method
EAC	Estimated At Completion
EC	Estimated Project Completion Cost
EF	Earliest Finish
ET	Estimated Project Completion Time
ETC	Estimated To Completion
FF	Free Float
FP	Fixed-price Contract
FPIF	Fixed-price with Incentive Fee
LF	Latest Finish
LF	Latest Finish
LRC	Linear Responsibility Chart
LS	Latest Start
PCAS	PERT Cost Accounting System
OSHA	Occupational Safety and Health Act
PERT	Programme Evaluation and Review Technique
PMBOK	Project Management Body of Knowledge
RC	Risk Cost
RCR	Risk Consequence Rating
RT	Risk Time

SOW	Statement of Work
SPI	Schedule Performance Index
TF	Total Float
TPM	Technical Performance Management
TRACE	Total Risk Assessing Cost Estimates
WBS	Work Breakdown Structure

1. Introduction

Project management has become an increasingly important aspect in the survival of modern businesses, not only in the manufacturing sector, but also in the services sector. The problem is, however, that most companies employ workers who are experts in their respective fields, but usually not in project management, to manage the company's projects.

Although it is extremely helpful and necessary to have a project manager who is experienced in the specific project's field, the person also needs thorough training in the finer points of project management. This is especially true in the services sector, where the majority of project managers are people who become very proficient in their work as, for example, a business consultant, and are then promoted to project manager. Although the person has experience in the running of a typical project, he or she still lacks the knowledge specific to project management. This is especially true for project risk management.

With this in mind, it was decided to develop a case study in the services sector, due to the abundance of manufacturing sector case studies available, and the apparent lack of availability of case studies in the services sector which includes a section on risk management.

The case study in this project was specifically developed as an alternative project for the post-graduate course in Project Management at the Department of Industrial Engineering at the University of Stellenbosch. In addition to the case study, a tutorial in Microsoft® Project 2000® was also developed so that the course participants would be able to complete the case study with the aid of this project management software.

This report consists of four main sections. The first section contains a detailed literature study on the main aspects of project management, ranging from project planning, to risk management and project control. The second section details the

development of the Microsoft® Project 2000® Tutorial. This tutorial acts as supplementary information to the course in Project Management at the Department of Industrial Engineering at the University of Stellenbosch.

The third section of this report describes the development process of the case study questionnaire. It was decided to develop a case study based on a Business Process Re-engineering project at an Information Technology company. The fourth section of this report details the development of the case study memorandum. Even though these two topics appear as separate chapters in this report, it must be stressed that they were both developed concurrently. This was done in order to ensure that the information provided in the questionnaire is sufficient in detail and explained clearly enough.

It is recommended that the students participating in the course complete the tutorial before attempting the case study. Completing the tutorial before the case study will aid the student in the completion of the case study, and save valuable time.

1.1 The Need for Project Management

Imagine the great pharaoh Cheops entrusts a person with the task of building the greatest pyramid ever. The person is allowed 20 years and 100 000 men. Money is not really a constraint, but it will become one if definite progress is not shown, due to the fact that there are wars that have to be supported and other projects that are running, as well as the uprising of the Israelites. A few of the questions that the project manager might be faced with could include the following:

- When are specific resources employed and used?
- How many blocks of sandstone have to be shipped from Ethiopia along the Nile River and when must they be shipped?
- How many granite blocks are needed to cover the softer sandstone base of the pyramids?
- Where can these blocks of granite be found?

- How will they be transported to Cairo?
- How are people going to place a 20-ton block of granite on top of a 40-story construction without the use of modern cranes?

As can be seen, this can become a very complex exercise, and the human aspects of the project were not even considered; things like water, food, healthcare, hierarchical structures and the like. Most people will start at the natural start and select a stand for the pyramid. But how does the project manager keep track of what has been completed, what is currently being completed and what still needs to be done? And what about the quality of the pyramid?

Careful and thorough planning can alleviate, and even eliminate, most of the problems in the examples mentioned above. That is if the world was a deterministic and certain world. In real life, however, there is this one little concept called uncertainty, which forces people to have to manage projects, and not only plan them. Uncertainty usually threatens the project's budget, schedule, performance or even the project specifications. This is where project management becomes extremely important. At some stage, the project manager has to decide which of the three project goals to trade off against the other, i.e. compensate on the schedule, budget or performance, or any combination thereof. Careful risk management and project control can reduce the uncertainty involved in executing the project to a great extent, but there will always be a level of uncertainty that will have to be managed.

Project management is still a fairly new concept around the world. It has only really been in use since the start of the previous century. Even then it was used mainly for large projects in the military, aerospace and construction industries. Today, it is used more regularly in industry, even for small projects, largely due to the fact that resources are becoming scarcer for the average business, and more stringent competition in the marketplace. Due to these factors, management usually demands a detailed project plan before the start of a project. This

requires that the project manager has to know beforehand all the required resources, their cost as well as the time duration for which they are required.

A further boost to the area of project management is the fact that computer technology has made it a much simpler exercise. This is due to the fact that computers can now do most of the detail calculations, and the project manager has more time available to really manage the project. The fact that information is now also available almost immediately, due to the internet and e-mail, the project manager can also manage the project more effectively, almost irrespective of the project location.

2. What is Project Management?

2.1 Projects Defined

2.1.1 The Characteristics of a Project

Before an attempt is made to define project management, a definition of what a project is, is given. A project is a series of related jobs directed toward some major output, which could require a large amount of time [1]. Projects are also unique and specific, with a specific need or purpose that has to be fulfilled by the specific deliverable [2]. Moreover, a project typically has the following characteristics [3]:

1. A project has a single, definable outcome or result, which is usually specified in terms of cost, duration or schedule, and performance requirements.
2. Every project is unique, in that it requires that something different be done in this project than in previous activities. A project is therefore a once-off activity that will never be repeated in exactly the same manner.
3. Projects are of a temporary nature. Once the desired result has been achieved, the organisation is disbanded or reconfigured to begin work on a new project.
4. Projects usually require skills and expertise from a wide variety of professions and organisations. A project therefore cuts across organisational boundaries and lines.
5. There is always a certain amount of unfamiliarity, given that projects differ significantly from what was done previously. This also leads to the fact that there is a definite element of uncertainty and risk in every project.
6. There is usually something at stake when a company starts a project. Otherwise there would be no point to the project.

7. A project is the process of working to achieve a specific goal. During this process, the project goes through distinct phases, or a project life cycle. As the project advances from one stage to the next, the people, tasks, organisations and resources change. The resource and expenditure builds slowly with each progressive phase, and peaks and declines as the project is completed. This concept will be discussed further in the following paragraph.

After the completion of all projects, the project team is disbanded, or move on to something else. With repetitive tasks, there is merely a change in the scheduling of the operations; the staff used is usually permanent. Seeing as there is a significant difference between a project and repetitive jobs, these two forms of tasks have to be managed differently.

Further distinction must be made between the following terms: *Project*, *Program*, *Task* and *Work Packages*. The term *program* is usually used to refer to an exceptionally large, long-range objective, which is broken down into certain *projects*. These *projects* are usually further broken down into *tasks*, and these are in turn divided into *work packages*. These *work packages* then further consist of *work units*.

2.1.2 The Life Cycle of a Project

The project life cycle is common amongst most projects. This life cycle is divided into stages, as shown in Figure 2.1 below [4]. The project starts off with the appointment of the project manager. Next, the project team and initial resources are assembled, and the work is organised. This is usually a fairly slow process. As the project now moves into the working phase, the momentum builds very quickly and progress is made rapidly. This usually carries on until the project is near completion. Completing the remaining few tasks usually seems to drag on, and appears to take extremely long, usually due to the fact that there are a number of sections and sub-tasks that have to come together.

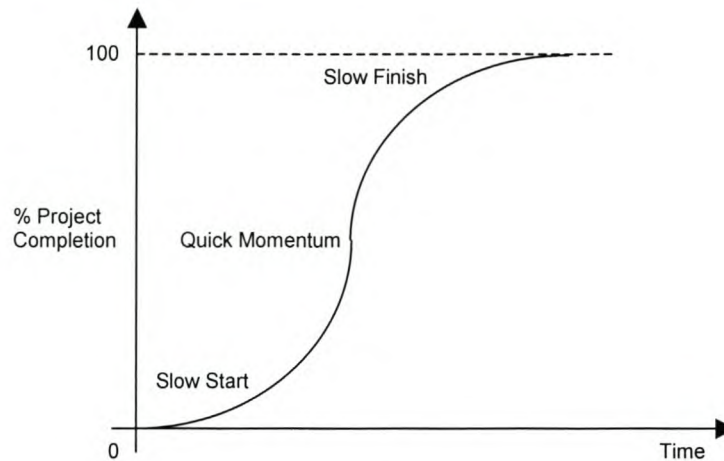


Figure 2.1: The Project Life Cycle Stages [4]

A project further has distinct phases, as shown in Figure 2.2 [4]. In this diagram, the project phases are plotted against the amount of effort required in order to complete that specific phase of the project.

All projects start with Conception, which is the first phase of the project. This is the stage of the project that requires the least physical amount of effort, but it is sometimes one of the most difficult stages in the project.

The next phase, Selection, is where the project manager and project team is selected. This is usually not a trivial exercise, seeing that the required expertise has to be found in order to make the project a success. Inevitably, all members of the project team must be able to get along professionally, due to the fact that they will be interacting with one another to a more or lesser extent.

The next phase in the project involves Planning, Scheduling, Monitoring and Control. In this stage, the work has already begun, and most of the energy that will be expended during the project will be expended during this phase. During the final phase, Evaluation and Termination, the project is evaluated to ensure that the customer requirements are met, and the project is terminated. Termination could be a lengthy exercise, seeing that all references must be established and documented for future use. Where maintenance forms part of the

project, this stage could become very long and could require large amounts of effort.

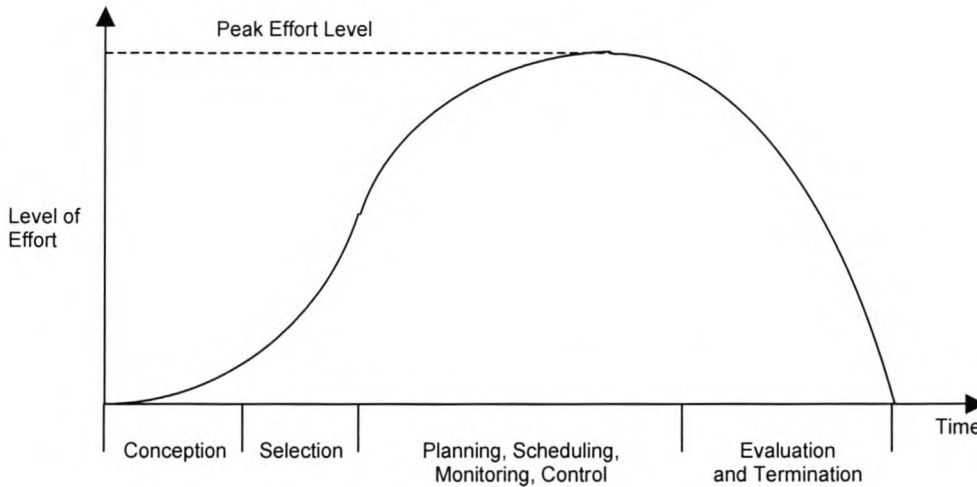


Figure 2.2: Time Distribution of Project Effort [4]

2.1.3 Project Complexity and Uncertainty

Next, an attempt is made to define project complexity and uncertainty. This is done due to the fact that these factors usually have a great influence on the decisions made during the project execution, as well as the costs involved in the project. Complexity can be roughly measured by the amount of groups and organisations that have to be coordinated during the project, the magnitude of the effort required, the diversity of skills and expertise needed to accomplish the work, and the amount of tasks that have to be completed. The project duration and resource commitments usually increase with an increase in the project complexity.

The uncertainty is measured roughly by the difficulty in predicting the final result in terms of time, cost and technical performance. Most projects have a specific amount of uncertainty in at least two of the three dimensions mentioned earlier (cost, schedule and performance), but the most complex of projects have a large degree of uncertainty in all three dimensions. This topic will be discussed in detail in Chapter 6.

Mention must be made at this stage of the “learning curve” effect. Although it will not be discussed in detail, it could have a significant impact on the cost, duration and technical performance of a project. In principle, the more a person repeats a similar task, the easier it becomes, and it can therefore be completed much faster than the previous attempt, which means there will be a decrease in labour hours and usually an accompanying decrease in resources used (less waste). This further reduces the uncertainty in a project.

The cost of a project usually increases proportionally as the project complexity and uncertainty increases. Cost consists not only of an economic value, but also of a time value. It should therefore be clear how the complexity and uncertainty could increase the cost of a project [3].

2.2 The Various Goals and Phases of Project Management

Before attempting to define what project management is, the performance requirements, or criteria, that have to be managed are discussed. The three main performance criteria of most projects are: Time, Cost and Performance (See Figure 2.3 below) [2]. These are often referred to as the three contrasting constraints, or the Triple Constraint. The project's performance, and therefore also the performance of the project manager, is usually measured by the degree to which these three criteria are met.

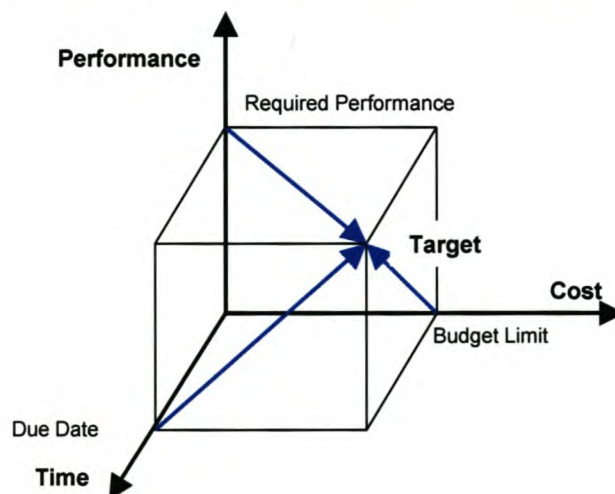


Figure 2.3: Performance, Time and Cost Project Targets [2]

The client is usually responsible for setting the performance, or specification, criteria. Quality forms an integral part of the specifications as set out by the customer.

Now that a firm background has been given to what a project is, and what needs to be managed, the question that arises is: what is project management? This concept is best explained by briefly discussing the different phases of project management (which coincides with the different phases of a project's life).

A project typically consists of the following distinct phases [5], which could, and usually are, overlapping to some degree (see Figure 2.4 [5] below):

1. The Concept Phase
2. The Definition and Proposal Phase
3. The Planning and Organising Phase
4. The Plan Validation Phase
5. The Performance or Work Accomplishment Phase, and
6. The Post-Accomplishment Phase

These phases can be interrelated, and are usually revisited at some stage during the execution of the project.

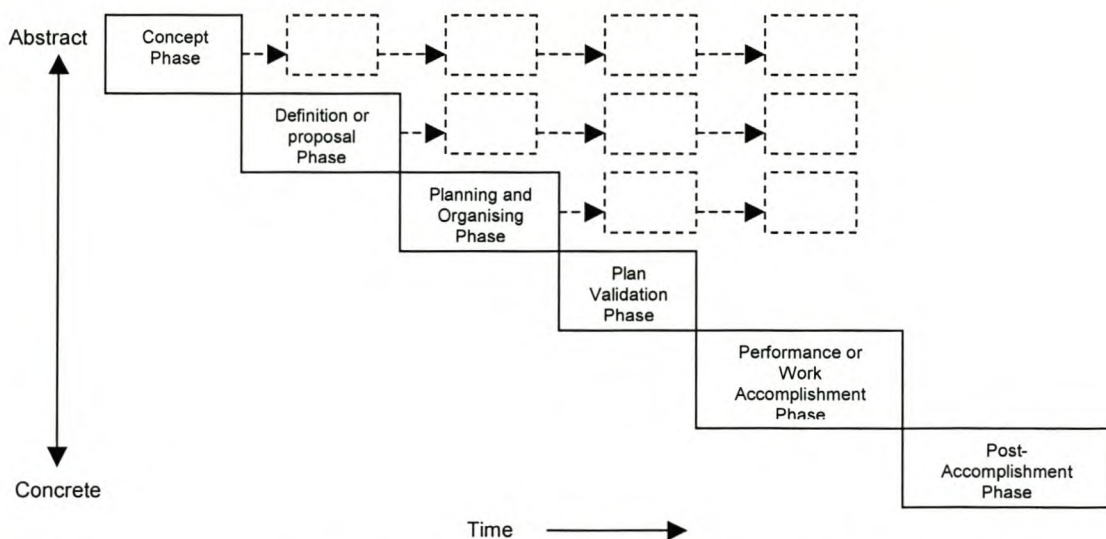


Figure 2.4: The Phases of a Project [5]

2.2.1.1 The Concept Phase

This phase starts with an initial concept to accomplish some goal. The first fixed aspect of a project is therefore the objective. The objective can be very clear, or quite vague, depending on what has to be accomplished. One advantage of a vague objective is that it rules out the possibility of eliminating alternative solutions to attaining the objective too early. However, it does also create more work for the project team, seeing as a number of alternative solutions then have to be proposed and tested, in order to find the best possible one.

Ruskin, et al. [5] suggests the following guidelines for stating the project objectives:

1. It should define what has to be accomplished, but not how, as far as possible. This will aid the project team in selecting the most appropriate solution.
2. It should be expressed as “shall” or “shall not”, in order for the objectives to be identified quickly and easily.
3. It should further be simple or “atomic”, i.e. as plain and clear as possible. This is done in order to provide clarity and to facilitate change control.
4. It should be able to be validated by means of testing, demonstration, analysis, or inspection to a level of precision that is higher than the required level of precision. This will aid in determining whether or not the requirement, or objective, has been met.
5. It should also identify whether the situation to which it is applicable is of nominal, worst case, or expected values. This will aid the suppliers of products or raw materials with respect to the level of quality of goods they have to deliver in order to achieve the required final objective.
6. It should specify when the objective must be obtained, and when it will not be needed any longer (disposal).

7. It should identify the mode to which the objective applies, i.e. sometimes, always. This will also guide the suppliers.
8. It should identify related requirements. This will help with the evaluation of the impacts of proposed changes.
9. It should further identify the source of the objective, i.e. who is going to use it (end-users or intermediate developers). This is done in order for the project team to know whom to contact in the event of possible changes.
10. It should be able to be satisfied by its end date with attainable and available resources.
11. It should have a unique label, in order to facilitate bookkeeping.
12. It should have a custodian in order to facilitate the management of the project. It further aids with the localisation of information as well as the implementation status.

It should be clear that the concept phase does not include how to accomplish the objective (s). This is done in a later stage. The project's objectives have to be explored fully in the concept phase, in order to optimise the means by which the objectives will be met.

It is important to note further that not only the project objectives are to be formulated in the concept phase, but that the relevant constraints are also identified. These constraints are usually budget or time constraints, or tool, personnel or procedural constraints. It is extremely important for the main constraints to be stated along with the objectives. A solution to the problem could otherwise violate a crucial constraint.

Once consensus has been reached amongst the project team members regarding the objectives, the critical constraints and the objectives have been clearly defined and developed, and it is agreed that the objectives can be met, the project moves on to the next phase, namely Project Definition.

2.2.1.2 The Definition and Proposal Phase

This phase consists of two sections. The first section consists of characterising the project. This is done by making assumptions and suggestions about the situation, alternative ways to achieve and realise the project objectives, decision criteria and models for the selection of the most appropriate alternatives, constraints, significant obstacles, resource schedules and budgets needed to implement the various alternatives [5].

The second section of this phase consists of the tentative selection of an overall approach that will be implemented in order to achieve the required objective(s). There are still numerous unknowns at this stage of the project, and a number of decisions are made tentatively, along with contingency plans in the event of unsatisfactory results from these decisions. If these decisions are too uncertain, two methods can be followed in order to reduce their uncertainty [5]:

1. Divide the project into two sequential projects. The first project's objective would be to gather as much information as possible in order to reduce the amount of uncertainty. The results of this project are then incorporated into the second project, whose objective is the achievement of the main objective.
2. Alternatively, the different alternatives can be pursued in parallel, until it becomes clear which alternative to use. This is usually a more expensive option, but it could be less time intensive than the first alternative.

The result of this phase of the project should be a clearly written, unambiguous project description. It should be presented in sufficient detail in order to support a proposal to the client or customer, and should include the following [5]:

1. How the work will be completed
2. Details of the project organisation
3. Details of the key personnel

4. A preliminary schedule, and
5. A preliminary budget

The main aim of this project description document is to convince the customer that the project can be done and that the project team is capable of doing it [3]. It is, however, difficult to decide how much detail to put into the report. Sufficient detail is required, but it must be remembered that approval for the project is only given after this phase. Therefore, not too much of the project must be completed in this phase, because the client might still change his/her mind.

It is ideal that the key personnel that will be involved in the actual project should assist in this phase of the project, seeing as they have the expertise and knowledge about their specific role in the project.

2.2.1.3 The Planning and Organising Phase

During this phase, the project team has to plan and organise the project. Detail plans should be prepared and all tasks should be identified. These tasks should also be allocated milestones and budgets as well as resource requirements.

This phase also includes the detailed building of a project team, or organisation. These people should be involved in the detail planning exercise, in order to make the plans more effective. As stated by Ruskin, et al [5]:

“...plans are most effective when they are developed by the doers, and the doers are best motivated by having a say in planning their work.”

In order for the project manager to best organise the project team, the nature, number and timing of all skills and traits must be identified. The project manager must then ensure that the planning is such that these three aspects are organised and available as required. These traits and skills could include the following: Technical Expertise, Communication, Leadership, “Followership”, Analysis skills, Initiative, Wisdom and Resourcefulness, to name but a few [2].

2.2.1.4 The Plan Validation Phase

This fourth phase of the project entails the validation of the plans that were made in the previous three phases. Validation is usually done for one, or both, of the following reasons [5]:

1. To validate or rectify any assumptions that were made in the project plan.
2. To identify and characterise critical aspects of the project so that it can go forward smoothly.

Plan validation consists of literature searches, field reconnaissance, experiments, interviews, and other forms of data gathering. If validation is not done correctly or efficiently, flaws in the plans, and especially in the assumptions made in the plans, will be exposed later in the project, usually at a substantially greater expense.

This stage should also include a worst-case scenario analysis of the project plan. This is done to ensure that there are enough resources committed to the project in the case of an error(s) being made. This area is called risk management, and will be discussed in more detail at a later stage (See Chapter 6).

If the team is not completely satisfied that the project will be a success, they should revisit the concept phase and see where certain aspects of the plan can be changed in order for the required objective to be achieved. If, however all parties involved are satisfied that the requirements can be satisfied with the current plan, the team can progress to the next phase.

2.2.1.5 The Performance or Work Accomplishment Phase

Seeing as all plans have been made and validated, it is now time for the project team to do what they set out to do: achieve the required objectives. This stage is where the project execution actually happens. It involves keeping track of all parts of the project and ensuring that everything is done according to plan, i.e. on time and within the required constraints. If some areas of the work take longer

than expected or over-utilises some of the resources allocated to it, the project plans have to be adjusted in order for the project to still be completed on time and with the allocated resources. Another significant portion of this phase is reporting on the results of the project. This is usually done as a specific milestone is reached. It is also very common for project managers to require progress reports at regular intervals from all the functions involved in the project. These aspects will also be discussed in more detail at a later stage.

2.2.1.6 The Post-Accomplishment Phase

This phase is entered into after the last of the project tasks are completed. It consists of, firstly, ensuring that the customer is satisfied and all aspects of the solution have been explained, as required by the customer. Secondly, all project documentation should be organised so that it can be used for future reference. Next, the equipment has to be restored for future use or decommissioned if it is of no further use.

The fourth aspect in this phase of the project involves the auditing and closing out of the project accounts. The next section, which is often neglected, is extremely important. It involves the project manager assisting the project staff in being reassigned to other projects, or their original jobs. The sixth aspect that has to be addressed is the settlement of any outstanding charges. It ties in closely with the final step in a project: invoicing and collecting any fees or payments that are due.

These different phases of a project form the blueprint on which the project manager bases his management of a typical project. Some of these phases will be revisited later in more detail.

3. Project Planning Techniques and Tools

3.1 The Need for Project Planning

Before we start to delve into what project planning is all about, let us first look at why we need to plan projects. Certainly, one would be justified in asking: "What about the plan that was set out in the Project Definition phase? Is it not adequate?" The answer to that would be a resounding "No" [5]. The plans that were generated in that phase of the project are usually not detailed enough to manage the project with. Recall from the previous chapter that the goal of the project proposal plans was to sell the project, not to manage it. There are mainly four reasons why projects need to be planned in detail. These are [6]:

1. **Coordination and Communication:** The project plan informs everyone involved of their, and others', specific duties. It is a way of discussing each person's responsibilities and this in turn helps to direct and control the work involved in the project. It is imperative to get the people who have to perform the tasks to plan their own tasks. They should know more about it than you do, and ultimately they have to complete it. Plans further show us how all the parts of the project fit together, which is essential for proper coordination of the project.
2. **Basis for Monitoring:** Projects usually do not go according to plan. Deviations from the plan can be detected by monitoring processes, and is the project manager's early warning system that there are problems that need to be resolved.
3. **Requirement Satisfaction:** It is sometimes necessary to create plans just in order to satisfy the client. These plans are usually a waste of time, seeing as they are very seldom followed, and are merely drawn up to satisfy some stated requirement. Plans are also used as a point of reference for any changes, which in turn helps the project manager to deal with the

client. The project plan will also help everyone to know when the objectives have been completed, and therefore when to stop.

4. Problem Avoidance: A good plan will help avoid problems later in the project's life, especially when the project is being executed. Plans can, however, not avoid problems altogether. Plans are a simulation of prospective work, and they allow flaws to be identified in order for it to be corrected in time.

3.2 The Elements of a Project Plan

There are mainly seven elements in a project plan. These elements are interrelated, as can be seen in Figure 3.1 below [6]. The first of these elements entails a detailed and complete Statement of Work (SOW). The next element is a statement of specific, measurable acceptance criteria for all deliverables. These are based on the SOW and performance specifications. It provides a clearly defined goal for all the project team members. The third element of importance in a project plan is the compilation of performance criteria that are not related to the deliverables. This could form part of the project when a company wants to comply with some standard, or have other governmental regulations to comply with.

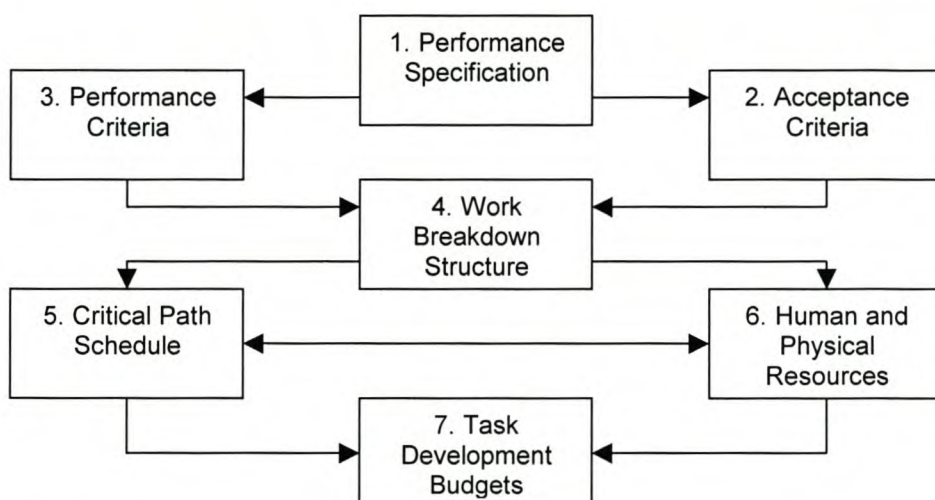


Figure 3.1: Relationships Between the Seven Project Plan Elements [6]

The fourth element is the Work Breakdown Structure, or WBS. This document identifies every single task in the project that needs to be completed in order for the project to be completed satisfactorily. This documented breakdown is based on the SOW and the performance criteria, whether they are deliverable or not. The next required element is a critical path network, which comprises of all the elements in the WBS. From this we can derive further charts and graphs like the Gantt chart, milestones and network diagram schedules.

The sixth element a project plan should include is a resource plan. This should accompany the WBS, and should state how the WBS will be accomplished. This plan should include both human and physical resources. The schedule will, to a large extent, depend on these resources. It is essential to determine the commitment levels of the resources, in order to ensure that the resources are not over-committed, but can actually do all the work in the allotted time frame.

The seventh and final element required in a project plan is the budget. It is necessary to create a budget for each task, based on the resources allocated to that task. The budget is further utilised when the project manager wants to calculate the viability of the project by means of a discounted cash flow analysis.

3.3 The Planning Process

Literature describes numerous different planning strategies for different activities. According to Mantel, et al [2], all these concepts and different planning processes can be captured in a single “generic” planning process. This is due to the fact that most of the planning processes only differ in nomenclature and not necessarily substance. Therefore, the planning process can be divided into 8 steps, or stages, as described below:

1. Develop the project concept and evaluate the concept.
2. Carefully determine and describe the project's deliverables and requirements.
3. Develop a prototype deliverable

4. Test the prototype, in order to ensure that it complies with all the requirements. If necessary, the prototype can now be remodelled and retested, depending on the need and results of the tests.
5. Integrate the prototype into the system for which it was designed.
6. Validate the deliverable (Does the deliverable work correctly?)
7. After validation, allow the client to test the deliverable.
8. Assuming the client is sufficiently satisfied with the deliverable, and knows how to operate it, the project is finished and the final documentation can be prepared and delivered.

The above process is a generic planning process, and can be applied to any field where planning is required.

3.4 The Statement of Work (SOW)

This document entails a verbal (narrative) description of the work requirements in order to complete the project [7]. This document is usually written by the secretarial staff on the project team, and then submitted to the various departments for verification and approval. It is, however, not uncommon for the customer to write it, even though the project manager then usually has to rewrite the SOW. The reason the project manager rewrites this SOW is to ensure that the project's line managers understand exactly what is required from them, and can give cost estimates and resource requirement estimates for their specific task(s).

Numerous governmental agencies, as well as private industries, have established documents that act as guidelines to the writing of SOW's. One such an example is the Statement of Work Handbook NHB5600.2, published by the National Aeronautics and Space Administration, or NASA, in February 1975. Excerpts and adaptations of the major elements of this handbook can be found in Kerzner [7] on pages 537 – 541.

3.5 The Work Breakdown Structure (WBS)

As soon as the project requirements have been defined and the Statement of Work has been compiled, we move on to create the Work Breakdown Structure, or WBS. The WBS is a breakdown of all the tasks into their subtasks, and further, until a desired level of detail is reached, and therefore defines the hierarchy of project tasks, subtasks and work packages. This document is useful in planning and scheduling exercises, as well as the allocation of responsibilities and the compilation of a project budget.

The WBS forms an integral part of the project, seeing as it provides a common framework from which the following can be achieved [7]:

1. A total project description can be compiled as a summation of the smaller elements.
2. The project manager, along with the other parties involved in the project, can plan the project.
3. The project manager can establish costs and budgets.
4. It enables the parties involved to keep track of the time, cost and performance of the project.
5. The company resources can be logically linked to the objectives.
6. Procedures for reporting the project status as well as the schedules can be established logically.
7. The planning of project control and network construction can be started.
8. Each element's responsibility assignment can be established.

The main reasons for compiling a WBS are, firstly, to make the control of the project easier, secondly, to facilitate the scheduling process, and thirdly, to aid in the estimation of the gross requirements regarding people, equipment and supplies [8].

A WBS can be compiled by following the general guidelines below, as suggested by Meredith, et al [4]:

1. List all tasks and their components in successively finer detail, with information from the SOW. The number of levels and the level of detail required in a specific WBS usually depends on the following [1]:
 - The level at which a single individual or business entity can be assigned responsibility and accountability to accomplish the task.
 - The level at which the budget and cost data is collected during the project execution.

Decomposition of a task should stop when the subtask portrays the following properties [3]:

- The task is clearly and comprehensively defined, in such a manner that the performing parties know exactly what they need to do.
- All resources, including labour, skills, equipment, facilities and materials, have been clearly identified.
- The task duration is accurately estimated.
- All related expenses for the task have been estimated.
- All parties responsible for executing the task have been identified.
- All deliverables, end items and outcomes as well as the requirements and specifications associated with the task are identified.
- All predecessors and pre-conditions have been defined and are identified.
- The required level of quality for the entry, process and exit conditions has been specified in the quality plan.
- All additional information is specified completely.

When all the abovementioned qualities are not met, the task is still too broad, and must be decomposed further. However, the breakdown should also not go so far that it makes the system unnecessarily cumbersome. If the tasks are broken down too finely, it could lengthen the project and increase the costs unnecessarily.

A task is generally sufficiently broken down when it displays the following characteristics [7]:

- Manageable – specific authority and responsibility must be assigned
- Independent – work must not depend on other tasks as far as possible
- Integratable – The entire package must be seen
- Measurable – Progress must be determined

Rosenau [6] presents a useful guide to factors that affect the size of a task. These include management effort, the number of tasks, financial and resource spending authorisation, task duration, monitoring accuracy, the company's experience with similar work and the task manager's skill. See Table 4.1 below for a clarification on how these factors affect the task size.

A project manager therefore has to conceptually decompose the project into smaller pieces, and these smaller pieces are then further broken down into even smaller pieces. This process continues until the pieces of the project are sufficiently realisable [5]. These smallest pieces of the project are then physically aggregated (actual work is completed) to progressively form larger pieces until the project deliverables are completed.

Factor	When to Use Smaller Tasks	When to use Larger Tasks
Management Effort	You can afford to spend more time to create a WBS	You want to spend less time creating a WBS
Number of Tasks	You want more detail	You want less detail
Spending Authorisation	You want to limit the amount of financial or resource commitment during a specific time interval	Task managers have previously demonstrated prudent use of money and resources
Task duration	You want to encourage faster completion of tasks	You can wait longer to see tasks completed
Monitoring Accuracy	You require or desire higher accuracy	You can tolerate less accuracy
Company's Previous Experience with Similar Work	Your company has little or no previous experience	Your company has expertise in specific work of the task (s)
Task Manager's Skill	You are using an inexperienced person	You are using an experienced person

Table 3.1: Factors That Affect Task Size [5]

- Next, all the relevant WBS data for each specific work package has to be identified. This data typically includes vendors, equipment, duration, materials, special specifications, and the like. The persons responsible for each work package must also be listed. It is useful to construct a Linear Responsibility Chart (LRC). (See later in this chapter for details on the LRC). This chart is useful when the project team is quite large, and makes it very clear who is responsible for what. The chart also highlights the critical interfaces between units that may require special attention from management. This chart will also allow the project manager to keep track of who has to report to whom, and the persons responsible for approving certain aspects of the project.

3. The third step in creating a WBS is to ensure that all work packages are reviewed with the people responsible for executing the specific work package. This is done in order to verify the accuracy of the WBS. The resource requirements, schedules and subtask relationships can now be aggregated in order to form the next higher level of the WBS. This continues, until the uppermost level is reached, which should have a project summary, a budget and the project schedule.
4. When compiling a budget for the purpose of developing a price for a proposal, the following four elements have to be included in the budget:
 - Direct budgets from each task
 - An indirect cost budget for the entire project (general and administrative costs, marketing costs, potential penalty charges, to name a few)
 - A contingency reserve for unexpected emergencies
 - Any residual costs, including profits derived from the project

This budget should not be the same as the budget the project manager uses to control the project. The reason is that the pricing budget could be overly optimistic or pessimistic, depending on the intention of the budget.

5. In a similar manner as described in the previous point with the budget, the milestones and schedule information can be aggregated into a Project Master Schedule. This schedule integrates all the schedules that are relevant to the project. It should be comprehensive, in that it should include contractual commitments, key interfaces and sequencing, milestone events and progress reports. A time contingency plan could also be included in case of emergencies. This master schedule is usually displayed in the form of a Gantt chart, and can easily be constructed in a program such as Microsoft® Project 2000®. See Chapter 6 for an introductory tutorial in this program.

The last two steps illustrate how the WBS can be used as a project monitoring and control tool.

6. The project manager is able to continually examine actual resource use by work package, subtask or task, with the aid of the WBS. It further facilitates problem identification, due to the fact that the project manager can compare actual to budgeted use of resources, finances and time. It is further possible for the project manager to make more accurate final cost estimates. It is important to examine resource usage in relation to performance, or achieved results, seeing as the budget might be exceeded, but the results might also be further along than expected. The scenario where the budget is on par but the results are below par can also be detected and corrective action taken.
7. The project schedule may also be subjected to the same comparisons as the ones made to the budget in the previous point. It might be necessary to assign additional resources to tasks that are falling behind in order to expedite them.

The WBS is usually presented as a list containing the tasks, subtasks and activities; each indented accordingly. See Figure 3.2 below for an excerpt from an example [1].

LEVEL				
1	2	3	4	
x				1 Optical Simulator Design
	x			1.1 System Performance Analysis
		x		1.1.1 Overall System Firmware and Software Control
			x	1.1.1.1 Logical Flow Diagram Generation and Analysis
			x	1.1.1.2 Basic Control Algorithm Design

Figure 3.2: WBS Extract [1]

The WBS document is usually structured in the same manner as the work will be performed. It therefore also reflects the manner in which project costs and data will be summarised, and later reported.

3.6 Linear Responsibility Chart (LRC)

The Linear Responsibility Chart (LRC), or sometimes called the Responsibility Matrix, is a tool which is used to effectively assign and keep track of all the relationships between the work packages as set out in the WBS and the people responsible for those work packages. As mentioned earlier, it highlights the critical interfaces between units that might need further attention from management [2].

This chart identifies the participants, and to what degree that person will perform an activity or make a decision. It is an attempt at clarifying the authority relationships that usually exist when functional units share common work [7].

A LRC should contain the following elements:

- General management responsibility
- Operations management responsibility
- Specialised responsibility
- Who must be consulted
- Who may be consulted
- Who must be notified
- Who must approve

The LRC is typically in the form of a matrix, with the tasks and subtasks on the vertical axis and the responsible person on the horizontal axis [2] (see Figure 3.3 below). As many links and dependencies on a LRC as seem relevant to the specific project can be created. For example, a specific department might have to

be notified of every task that is undertaken on the project, while other departments require only notification of specific tasks.

Shapes are often used to indicate the nature of the responsibility, but it is not uncommon to use numbers or letters. Departments, people or job titles can also be referenced with the symbols used.

WBS		Responsibility					
		Project Office				Field Operator	
Subproject	Task	Project Manager	Contract Administrator	Project Engineer	Industrial Engineer	Field Manager	
Determine Need	A1	○		●	▲		
	A2	■	○	▲	●		
Solicit Quotations	B1	○	■	▲		●	
Write Appropriate Request	C1	■	▲	○	●		
	C2		●	○	▲		
	C3	●	■	▲		■	
"	"						
"	"						
"	"						

▲ Responsible
 ● Support
 ○ Approval
 ■ Notification

Figure 3.3: Linear Responsibility Chart [2]

3.7 Scheduling Tools

In discussing the basics of the planning process, the project schedule cannot be ignored. It forms the cornerstone of the planning process and is one of the most important outcomes of the planning process.

But what is a schedule? A schedule can be considered as the conversion of a project action plan into an operating timetable. Therefore, it forms a fundamental basis for monitoring and controlling the time aspects of a project. Along with the budget and the project plan, it is the major tool for controlling the management of a project [4]. A detailed project schedule is of such high importance that it is a customer-specified requirement for most projects.

There is usually more than one schedule for a project. These might include the master schedule, the development and testing schedule, the assembly schedule, and so forth. The level of detail of each task will therefore differ on each schedule; e.g. the assembly task might not be broken down at all on the Master Schedule, but only its total estimated time shown, where it will be broken down into its finest detail on the assembly schedule. These schedules should be based on the WBS, and are usually compiled for each major task level.

There are generally two tools that are useful when compiling a schedule. These are network diagrams, or precedence charts, and bar charts. Each of these will be discussed in detail below.

3.7.1 Bar Charts

Bar charts were popularised during World War II by HL Gantt, and are therefore often called Gantt charts. These charts are frequently used for scheduling purposes. The chart consists of a horizontal scale, which is divided into time units (hours, days, weeks, months, years) and a vertical axis depicting work elements (tasks, activities, work packages, etc.). Figure 3.4 below depicts a typical bar chart used for scheduling purposes. This chart depicts five operations that have to be completed in twelve months. At construction, five open bars were used to represent the planned duration for each operation. This schedule is often referred to as the project baseline. As each task is completed, the bars are filled, as time elapses, with the current percentage of completion written underneath the bar.

These charts are very easy to construct, and also very easy to understand, hence their popularity. At a glance, the project manager, or any person on the project team for that matter, can see whether or not the project is ahead of schedule, behind schedule or on schedule. Unfortunately, these bar charts cannot solely be used to manage the project. This is due to the fact that they only provide information on the status of the project, and the interdependencies between the various tasks are not apparent.

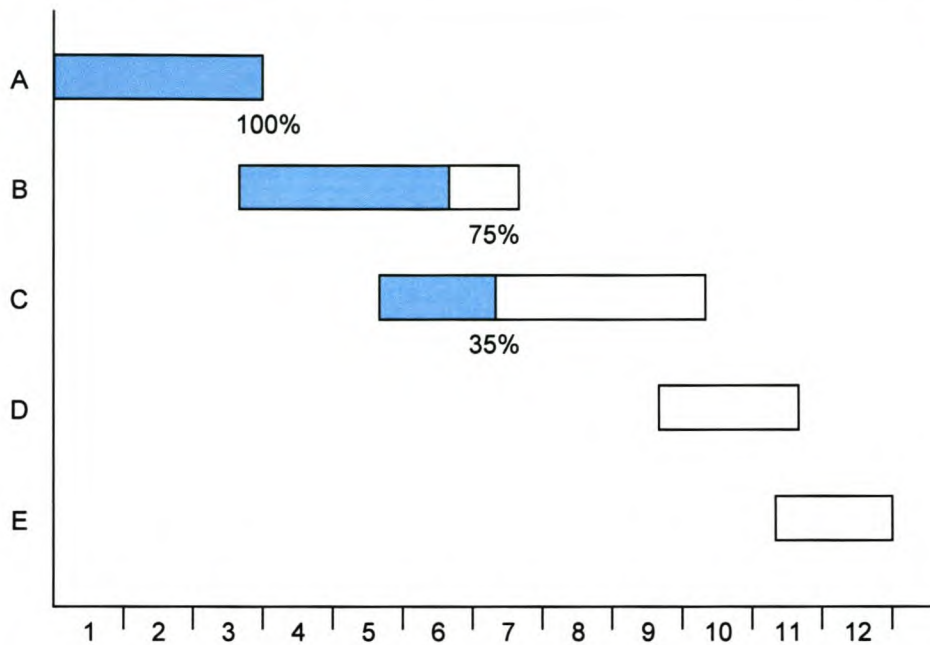


Figure 3.4: Bar Chart: Five Activities and a Twelve Month Duration

Furthermore, it is difficult to express the percentage completion, seeing as it has to be known in terms of what the project is, for example, 60% complete; i.e. is this expressed in terms of time, actual performance or finances used? Therefore, unless the task is linear, it is almost impossible to estimate the percentage completion. Due to this complexity, percentage completion is frequently taken as a percentage of the cost expended [6].

Bar charts are therefore much more useful as an indication of what has happened than as a planning tool in order to aid the project manager to manage the project from here onwards [6].

The bar chart is usually developed from a WBS analysis [3]. Each work package or element from the WBS must be represented on the bar chart as a scheduled activity. The tasks are usually sorted from earliest start date to latest start date before they are placed in the bar chart schedule.

Due to the fact that there is always some form of precedence in a project (certain tasks have to be completed before the next task can be completed), these relationships have to be determined before the project is scheduled [3]. The

precedence sequencing logic must be maintained during the compilation of the bar chart. It is of critical importance that the bar chart is kept up to date during the project execution, seeing as it is useless if the wrong current information is displayed.

Tied in with the concept of bar charts are milestones. Milestones are specific events that happen during the project completion. These milestones are usually shown on a calendar-style bar chart, and signify significant events along the road to the project's completion. The project's start and completion would be two large milestones, for example. Listing these milestones usually helps with the project planning process, especially when they have accompanying budgets and schedules. But similarly to bar charts, just having milestones cannot help the project manager much with the control of the project. They must be used in conjunction with a few other planning tools, in order for them to be effective. This is due to the fact that they also do not have any form of interdependencies or task clarifications attached to them. Network, or Precedence Charts, is a very useful addition bar charts and milestones.

3.7.2 Network / Precedence Charts

Precedence charts show the sequence of events and relative timing of all activities, or tasks, on any required level of detail [5]. The precedence chart is usually created by transforming the project's WBS into a network model.

The two most prolific network diagram methods are *PERT*, or *Program Evaluation and Review Technique*, and *CPM*, or *Critical Path Method*. These methods were independently developed in the late 1950's, PERT by the US Navy, Booz-Allen Hamilton and Lockheed Aircraft; and CPM by Dupont De Nemours Inc [2].

Both methods use networks to schedule and display task sequences. Both methods further identify a "critical path" of tasks that cannot be delayed without delaying the entire project. This implies inherently that both methods also point

out activities that have slack time (a time period with which the task can be delayed without delaying the project).

PERT networks generally employ an Activity-On-Arrow (AOA) approach, which means that an arrow represents an activity, and a node represents an event. With CPM, the activities are depicted as nodes, and arrows link the nodes to point out technological relationships between the different activities. This kind of network is referred to as an Activity-On-Arrow (AOA) network. It is typically easier to create an AOA network, and it is therefore also used more widely today [2].

Seeing as only a short discussion of the construction of these diagrams will be given here, the reader is referred to Nicholas [3] pages 193 – 222 for a more detailed discussion.

Before more detail is entered into about the construction of these networks, some of the terminology that is used in the construction of these diagrams has to be defined [2]:

Activity/Task: A single task, or set of tasks, that has to be completed in order for the project to be completed. Activities utilise resources and time.

Event: A clearly defined and identifiable state, which is reached with the completion of certain activities. They do not consume any resources or time, and are therefore achieved when all the preceding tasks (predecessors) have been completed.

Milestones: Noteworthy events that mark significant progress in the project's execution.

Network: This is a diagram of nodes that are connected by arrows. The nodes may represent either activities or events, and the arrows may represent activities or show technological relationships. The network usually flows from right to left, with the start of the project on the left hand side, and the end of the project on the right hand side of the diagram.

Path: This is a series of nodes (either events or activities) that are connected between any two events on a network.

Critical path: This is the set of activities, from start to finish, that cannot be delayed without the rest of the project being delayed.

Critical Time: This is the time it takes for all the activities on the critical path to be completed.

The terms described above are equally relevant to either the CPM or the PERT methods. CPM will be discussed first, seeing as it is the simpler of the diagrams to construct.

Critical Path Method (CPM)

As mentioned earlier, a CPM network is an Activity-On-Arrow type diagram. This means that each node represents a specific activity, and the arrows on the diagram merely point out the technological relationships between the various activities. The node contains the following information [9]:

1. The task name (X)
2. The task duration (D)
3. Earliest finish time (EF)
4. Earliest start time (ES)
5. Free float time (FF)
6. Latest start time (LS)
7. Total float time (TF)
8. Latest finish time (LF)

The letters in brackets correspond to the position in the node as shown in Figure 3.5 below.

ES	D	EF
	X	FF
LS	TF	LF

Figure 3.5: A Typical CPM Node [9]

The following general steps can be followed when constructing a CPM Network¹:

1. Make a list of all the activities in the WBS.
2. Determine the duration of each of the tasks (this is usually already done during the WBS construction exercise).
3. Determine the predecessors of every activity by careful inspection of each activity.
4. Determine the ranking of each of the activities. (The rank is given as the highest rank of the predecessors of the tasks + 1)
5. Draw up an activity list, which lists all the tasks according to rank.
6. Draw the diagram by firstly putting down all the nodes according to their predecessors (rank) and then by connecting the various dependent tasks by means of arrows. After all the nodes have been connected according to the precedence list, we proceed to fill in all the details in the nodes. This is discussed below.

When filling in the details on the nodes, all the information required is not available yet. Some calculations still have to be made. The nodes are completed by firstly filling in the name of the tasks, as well as their duration. The earliest start date is the next date after the latest of the earliest finish dates of the activity's predecessors. The earliest finish date is the earliest start date plus the task duration. This information should be completed by starting on the left hand

¹ These steps were compiled from the information given in [4], [5], [7], [9] and [10].

side of the diagram (at the start) and working towards the last activity on the right-hand side of the diagram.

Once these two spaces in the node for each of the activities have been completed, the latest start and finish dates should be completed by working back towards the start of the diagram. The latest finish date of the last activity is the same as the earliest finish date of that activity, and therefore the latest start date will also equal the earliest start date (which is the same as the task duration subtracted from the latest finish date). For all other activities, the latest finish date is a day earlier than the earliest of the latest start times of that task's activities. The LS and LF dates are completed in this fashion until the start of the project network is reached again.

Next, the total float (TF) and free float (FF) times have to be calculated. The total float time is calculated by subtracting the Earliest Finish (EF) time for that activity from the Latest Finish (LF) time for the same activity, or:

$$TF = LF_x - EF_x$$

The Free Float (FF) time is the number of time units between the Earliest Finish (EF) time of the specific activity and the earliest of the Early Start (ES) times of the followers of the specific activity.

Having completed this, the critical path of the network can be identified. It is the path of activities that do not have any slack time. These activities cannot be delayed without the entire project being delayed. The project's critical time is then the Earliest Finish time (or Latest Finish time) of the final Activity. If, for whatever reason, the project duration has to be reduced, one or all of the activities on the Critical Path's time has to be reduced. This can be done by allocating more resources, working overtime, etc. This concept is referred to as "Crashing" the project.

Figure 4.6 below is an example of a CMP network for a boiler house construction based on the activities in Table 3.2. (Derived from a project presented as part of

the Post Graduate course in Project Management at the Department of Industrial Engineering at the University of Stellenbosch in 2002)

#	Activities	Duration	Predecessors	Rank
	Project Start			
	Floor			
1	Construct Floor Slabs	8		1
	Bases and Frames			
2	Construct Chimney Base	3	1	2
3	Construct Boiler Bases	6	1	2
4	Construct Pump Bases	4	1	2
5	Erect Boiler House Frame	21	1	2
6	Construct Oil Tank Piers	3	1	2
7	Construct Oil Line Trenches	5	1	2
	Position Hardware			
8	Erect Precast Chimney	6	2	3
9	Position Boilers	2	3	3
10	Position Oil Tanks	1	6	3
11	Position Pumps	1	4	3
	Finishing			
12	Install Roof Decking	10	5, 8, 9	4
13	Erect Structures for Chimney Flue and Vent	3	8	4
14	Erect Flue Headers	3	8, 9	4
15	Brick Out and Fit Burners	6	8, 9	4
16	Fit Boiler Mountings and Controls	2	9	4
	Installation and Testing			
17	Install Oil Lines	10	9, 10, 7	4
18	Install Water Pipe System	40	9, 11, 12	5
19	Test Water Pipe System	5	18	6
20	Install Plant Wiring	30	13, 15, 16, 17, 19	7
	Commisioning			
21	Commisioning of Boiler House	3	14, 20	8

Table 3.2: Activities List for the Construction of a Boiler House

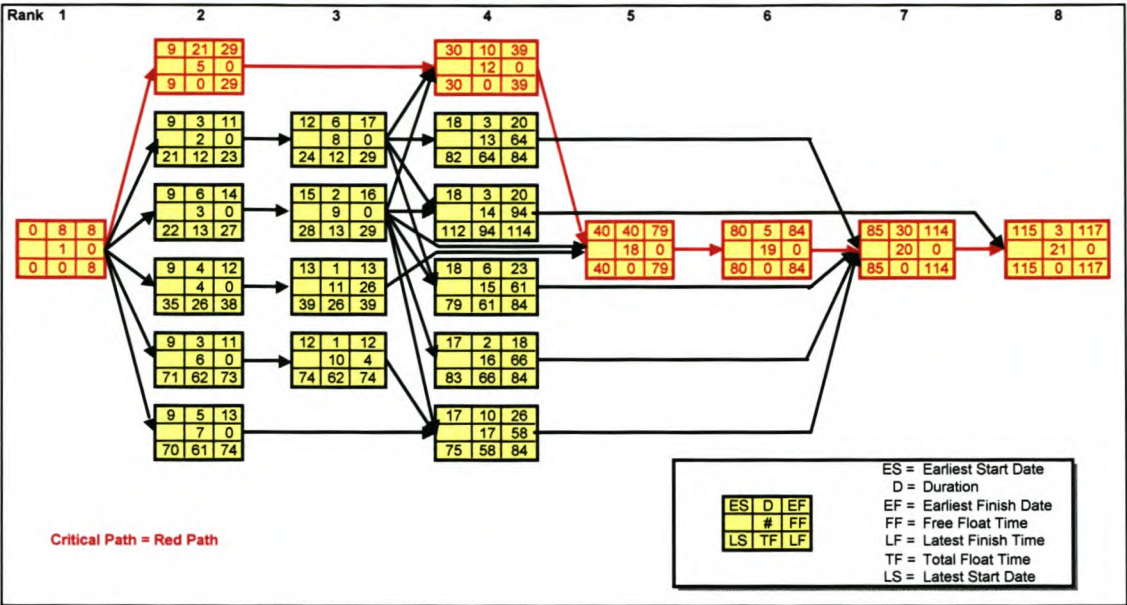


Figure 3.6: CPM Network for the Construction of a Boiler House

Program Evaluation and Review Technique (PERT)

The main difference between PERT diagrams and CPM diagrams are the fact that they are Activity on Arrow (AOA), or Activity on Line (AOL), diagrams and CPM diagrams are Activity on Node Diagrams (AON) as stated earlier. This implies that the ways activities are denoted differ. Figure 3.7 below shows the AOA diagram for a single activity with its corresponding events [3].

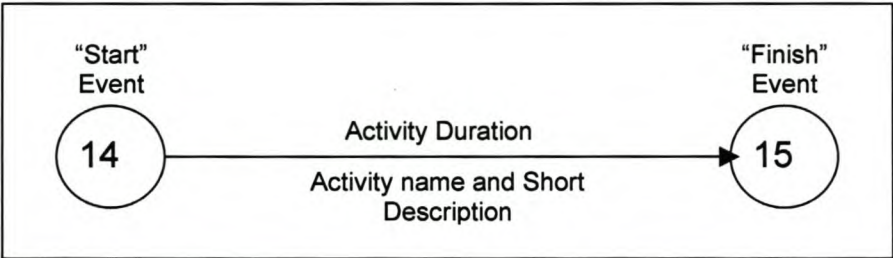


Figure 3.7: AOA Network Representation [3]

In the AOA method, the line represents the activity, with the activity duration and a short description on it as well. The name of the activity can either be written on

the arrow, or it can be derived from the numbers on the node. The two nodes represent the start and finish of that specific activity. The numbers inside the node only represents the event numbers. These are usually assigned according to the precedence diagram. The direction of the arrow indicates the flow of time on the project. The length of the line is of no significance whatsoever, unlike in Gantt-type charts where the length of the line indicates the duration of the activity.

In order to construct an AOA network, the project plan has to be transformed into a network. In order to do this, the various activities that will be required in order to complete the project, as well as their predecessors and duration, has to be known.

The construction of the AOA network is very similar to that of the AON network. All the nodes are firstly placed in the sequence in which they have to occur. The first circle (or node) represents the origin event, or the start of the first event of the entire project. An arrow is now drawn from this event to the next event, which represents the end of the first activity. Activities that have to be performed next are now added in series or parallel from the last node. The final node, or terminal node, represents the completion of the last activity in the project. Obviously, there can only be one start and one terminal event. All arrows usually progress from left to right, and for simplicity's sake, no doubling back of arrows or loops is recommended [10].

As in the case of the CPM network, all activities have to follow the order of precedence as defined by their immediate predecessors. If an activity is a predecessor for more than one activity, all the following activities originate from that node, and are drawn in parallel.

The completed AOA network looks very similar to the AON network, except for the fact that the activity names are recorded on the arrows and the nodes usually only contain the activity number.

In the case of a single activity that has more than one predecessor, a “dummy” activity has to be created, in order for the network to reflect that all preceding activities have to be completed before the specific activity can be started. This “dummy” activity serves only as a connector that illustrates the precedence relationships in the network. The reason dummy activities are used stems from the rule of AOA networks that a single arrow can represent at most one activity. A dashed arrow, rather than a solid-line arrow usually represents the “dummy” activity.

The latest start and latest finish times for the PERT network are calculated in the same manner as for the CPM method, as discussed in the previous section. The only difference is the representation. The latest start (LS) and earliest start (ES) times are written above the start of the arrow (which indicates a specific activity), and the Latest Finish (LF) and Earliest Finish (EF) times are written above the end of the arrow (See Figure 3.8 below [10]).

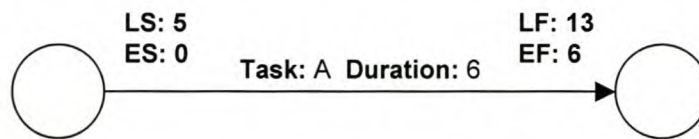


Figure 3.8: Typical PERT Node with Details Completed [10]

These two methods are used interchangeably, and what can be done with one, can also be done with the other. Which method is used depends purely on personal preference, unless the customer requires that a specific method be used. The author prefers the CPM method, due to the amount of information that can be portrayed more easily through this network representation method.

3.8 Time Estimates

Each of the tasks that the project consists of should be completed within a reasonable time. This time is called the task duration. The project time, or project duration, is therefore simply the sum of all the task durations. But exactly how long is a specific task's duration? What is a “reasonable time” to allow for it to be completed in? Seeing as the project has, by definition, not been done before, this

can be one of the most inaccurate estimations made on a project. The only way it can be guaranteed that the task will be completed within a specified time, is to actually allow an infinite amount of time for the task to be completed in [6]. Of course this is not realistic, and will never be approved, due to the reality of the three main constraints, as discussed previously (See Chapter 2.2). Therefore, ways of more accurately estimating task durations must be investigated.

Time estimation consists of two distinct issues; the first being the establishment of the number of labour hours required to complete a task (which is, of course, usually dependent on the skill level of the person executing the task), and the second being the determination of the elapsed time of the activity. The number of labour hours required is necessary in order to perform the cost planning on the project, and the determination of the elapsed time is necessary for the compilation of the overall project schedule.

There are mainly two time estimation techniques. These are PERT Time Estimating and Pragmatic Time Estimating. Each of these will be discussed below.

3.8.1 PERT Time Estimating

In projects where there are fairly uncertain task durations, PERT networks are very useful. In PERT Time Estimating, the problem of uncertain task durations is overcome by requiring three time estimates for each activity:

1. The most probable task duration (T_m)
2. The task duration that would be the most optimistic completion time; i.e. the shortest time that might be achieved 1 percent of the time such a task was carried out (T_o)
3. The task duration that would be the least optimistic; i.e. the time that would be exceeded only 1 percent of the time such a task was carried out (T_p).

By having these three estimates, the expected time to complete the task (T_e) can be estimated by means of the following equation:

$$T_e = \frac{T_o + 4T_m + T_p}{6} \quad (3.1)$$

The formula above has not been proved, and is also not provable [6], but has been shown to be fairly accurate when it comes to time estimation. It has to be remembered what is being attempted: an **estimation** of the task duration! The uncertainty of the time estimate can further be calculated. This uncertainty is called the standard deviation (or σ). This statistic is calculated by means of the following equation [6]:

$$\sigma = \frac{1}{6} (T_p - T_o) \quad (3.2)$$

The significance of the calculated standard deviation is the same as for the normal probability distribution; i.e. 2/3 of the time, the work will be completed within plus or minus 1 standard deviation of the expected time; 95% of the time, the task will be completed within 2 standard deviations of the time; and 99% of the time the task will be completed within 3 standard deviations of the time. This kind of time estimation is especially useful when the possibilities of time penalties are real, seeing as the possibility of exceeding the scheduled time can be estimated.

So now that the task time and the uncertainty of that duration have been estimated, how can the total project time be calculated? This is quite simple, as is demonstrated by equation 3.3 and 3.4 below:

$$T_{e,path} = T_{e,1} + T_{e,2} + T_{e,3} + \dots \quad (3.3)$$

$$\sigma_{path} = \sqrt{\sigma_1^2 + \sigma_2^2 + \sigma_3^2 + \dots} \quad (3.4)$$

Due to the lengthy nature of this technique, and the amount of effort required to make three time estimates for each task, it is usually performed with the aid of a computer-based project schedule plan, such as Microsoft® Project 2000®.

3.8.2 Pragmatic Time Estimation

The goal of pragmatic time estimation is to come to a sensible time estimate in which to complete a task if it is run in the intended way. This is usually done in a pooled, or group, format, where the project leader, task manager and a few (one to three) experts discuss what a suitable task duration would be. The experts are called in to bring in experience and expertise pertaining to the specific task, and the task manager is present to provide a sense of balance with respect to other tasks and other project time estimates. With exceedingly large projects, there is obviously not enough time to do this for every single task that has to be completed, but it is important that the project manager strive towards it. A practical compromise for this problem would be for the project manager to have deputies, which represents him/her at each of these task duration estimation meetings. It is important for the task duration estimation teams to base their estimates on who will complete the task and how the task will be completed.

3.8.3 Project Crashing

Project crashing is a deliberate shortening of not only the task duration of the tasks on the critical path, but also re-shuffling and re-planning the tasks in order to reduce the critical path time. This comes into effect when, after all the relevant calculations have been completed, the various task duration estimation meetings have been conducted and the final project duration time has been computed, the project is still going to run beyond the project schedule (even if these estimates were optimistic).

One of the best ways in which to realistically shorten the tasks' durations is by replanning the tasks, to ensure that there is a credible reason to believe that the task will be completed in a shorter time than the original estimate. Simply reducing each time estimate proportionally to the time over budget usually leads to unrealistic task durations for a number of tasks on the critical chain. Re-planning events would typically start from the beginning of the project, and continue until the project can be completed within the allotted time frame. When

doing this, an attempt should be made to compress tasks with low compression costs and risks. Care should also be taken not to create another critical chain!

If, after crashing all possible tasks, the project duration is still too long, re-planning the entire project becomes a serious consideration. Certain tasks should possibly be run in parallel, more efficient resources used, or a more efficient project plan conceived.

3.9 Cost Estimates

The cost of a project needs to be estimated for one of two reasons. Firstly, the project team must be able to sell the project, and secondly, the project team has to manage the project. When a detailed project cost plan has been developed, running over the estimated project cost can be avoided, or conversely, not winning the contract to complete the project due to over-inflated cost estimates for the project.

Cost estimates can be expressed in two ways: either as the number of labour hours required, or the actual monetary value required in order to complete the project [6]. The latter is more common, seeing as there are usually different hourly rates for different seniority levels, and one can then also take any materials required for the completion of the project into account on a monetary level.

3.9.1 Classification of Work Tasks and Costs

After the project has been divided into the various work packages according to the WBS, the project team, which includes representatives from the functional areas and contractors involved in the project, meet to discuss the work assignments. Possible standard practises are identified in order to facilitate the completion of the project. The work is further classified as being either developmental or off-the-shelf. The reason for this classification is that developmental work requires considerable effort in the cost estimation for the design, testing and manufacturing processes and procedures, due to the

uncertainty about what has to be accomplished. It is especially difficult to estimate the required labour hours for the completion of a project that falls under this classification.

The estimated costs are now classified as being either recurring or non-recurring. Non-recurring costs are those costs that occur only once. Recurring costs are costs that are encountered more than once. The recurring costs include labour costs, quality assurance costs, tooling costs, and the like.

There are mainly four (4) different cost estimation techniques used in practise today [3]. These include Expert Opinion, Analogy Estimates, Parametric Estimates, and Cost Engineering.

3.9.2 Expert Estimates

This is an estimate given by an expert who is able to provide a reasonable estimate due to his previous experience as well as his expertise. This type of estimate is usually only used when there is no sufficient information on which to base a detailed cost analysis and estimate. It is therefore usually only used for projects that are new and unique, and for which no previous similar projects exist on which to base estimates, or for projects that are very poorly defined.

3.9.3 Analogy Estimates

When the project under consideration is similar to a previous project, the project costs can be estimated by means of comparison. This is called analogy estimation. Of course, this does not only have to be on an overall project level, but on any level of detail. If only one element of a specific task correlates to a previous element of work done in a previous project, we can use the cost data from the previous project to estimate the cost of the new work element.

The estimate is usually adjusted to take the following into consideration [3]:

- Dates: Costs have to be projected forward to be realistic.

- **Project Scale:** If the project is twice as large as the previous project, the costs have to be adjusted according to predetermined size-cost relationships.
- **Location:** Costs have to be adjusted for site and regional differences.
- **Complexity:** If the project is more complex, the costs have to be inflated to compensate for the increased complexity.
- **Exchange Rates:** Costs have to be adjusted to take changing exchange rates into consideration.

Due to the fact that this method requires significant historical data in order to base the estimate upon, it usually involves a large database of significant information about previous projects. This means that the company wanting to employ this strategy needs to have very detailed information gathering and capturing systems and documentation in place.

3.9.4 Parametric Estimates

These estimates are derived from an empirical or mathematical relationship. It is often used in conjunction with the Analogy Method discussed in the previous paragraph in order to scale costs up or down. It can also be used independently when the various project costs are functions of the system parameters. These parameters can be physical parameters such as size, volume, weight or capacity or performance features such as speed, power, strength and output rate. This method is extremely useful when a quick cost estimate is required or when the preliminary design parameters are being set.

3.9.5 Cost Engineering

This is the most comprehensive form of cost estimation, and entails a detailed cost analysis of all individual cost categories at either the task level or work package levels. Seeing that it is the most comprehensive, it is the most time - and cost - consuming method, but also the most accurate. The steps in this method are the following: firstly break down the project into tasks and work

packages, and then divide these into cost categories. These categories can be as broad as materials, labour, or equipment, or can be narrowed down further.

As stated previously, this method can be very time consuming and elaborate, which might require a substantial amount of resources (either time, money or human resources). It is generally recommended that this method be used for the areas of the project that are crucial to the success of the project, and one of the previously mentioned estimation methods used for the non-crucial elements of the project.

4. Project Control

The controlling activity in project management happens when there is a difference between what was planned and what the actual current situation is. This is assessed by gathering information. The difference is unwanted, and the sooner it can be corrected and the project brought back on track, the better (and usually the cheaper as well). It can therefore be said that control is the act of reducing the difference between the actual and the planned scenarios.

Control is focussed on the three critical constraints of a project, namely cost, time and performance. A few issues that can cause the project to run out of control in each of the main constraint areas are [4]:

Performance:

- Unexpected technical problems
- Insufficient resources
- Quality or reliability problems
- Interfunctional complications
- Technological breakthroughs

Cost

- Work scope increases
- Initial estimates were too low
- Poor reporting
- Inadequate budgeting
- Prices of resources have changed

Time

- Too optimistic time estimates

- Incorrect task sequencing
- Resources unavailable when needed
- Preceding tasks incomplete when they were required
- Rework required on a section of the project

All the issues mentioned above can create difficulties if they are not resolved when they occur. This is the main function of project control: to identify problems and resolve them quickly.

So what is the difference between project planning and project control? Surely if one plans well, the chance of the project running out of control is very small, and then what is the need for project control? According to Daniel Roman [11]:

“Planning *anticipates* action, whereas control *initiates* action”

He further goes on to state that project planning and project control “both work towards similar ends:

- Planning concentrates on setting *goals* and *directions*; control *guides* the work toward these goals.
- Planning *allocates* resources; control ensures effective, ongoing *utilisation* of those resources.
- Planning *anticipates* problems; control *corrects* the problems.
- Planning *motivates* participants to achieve goals; control *rewards* achievement of goals.” [11]

Project planning is therefore only the first step of project control [3].

For a manager to be able to effectively manage and track a project, information has to be acquired at systematic intervals. Typically this would require the initiation of a project monitoring system, which could entail that specific functions deliver daily, weekly, or monthly reports, or that the project manager makes use of some form of computer aided system in order to track the progress of the

project. The details of this function are usually decided upon in the planning phase of the project.

In this chapter, the different types of control processes, the traditional method of project control, which emphasises the control of the costs incurred on a project alone, and the types of cost control accounting systems will be discussed. The last section will also cover the concept of performance analysis. Next, a discussion of the project control process will be provided, as well as a further discussion on such concepts as work authorisation and collecting relevant data. The areas in a project that the project manager should place emphasis on, such as quality control, schedule control and controlling changes in a project will further be discussed. Finally, a brief discussion of forecasting the “to complete” and “at completion” states of the project will be given.

4.1 Types of Control Processes

Controlling a project is not just as simple as noticing when something deviates from the original plan and then fixing it. It has to be decided beforehand what to look for and subsequently measure, when to measure for deviations, how much the actual situation can deviate from the planned situation before intervention, how intervention will take place, how to detect and prevent deviations before they even occur, amongst many other variables that have to be taken into account.

In order to facilitate this complex situation of controlling the project, there are mainly three processes into which all control efforts can be classified, namely cybernetic control, go/no-go control and post-control.

4.1.1 Cybernetic Control

This form of control process, also known as steering control, is by far the most common, and is usually recognisable by its automatic operation. When a system has to be controlled, the system’s outputs are looked at by means of some sensor, which looks for key features that needs to be controlled. These measurements are then transmitted back to a system, which compares them to a

set of predetermined standards. The differences between the actual output parameters and the planned output parameters are then fed to a decision maker, which analyses the differences, and decides whether or not the system has to be corrected. If there is such a need, the signal is sent to an effector, which makes the necessary adjustments [4].

This form of control is typically also called feedback control, and is characterised by this negative feedback loop, which causes the system to react opposite to the measured deviations. Figure 4.1 below shows a simple diagram of a typical cybernetic control system.

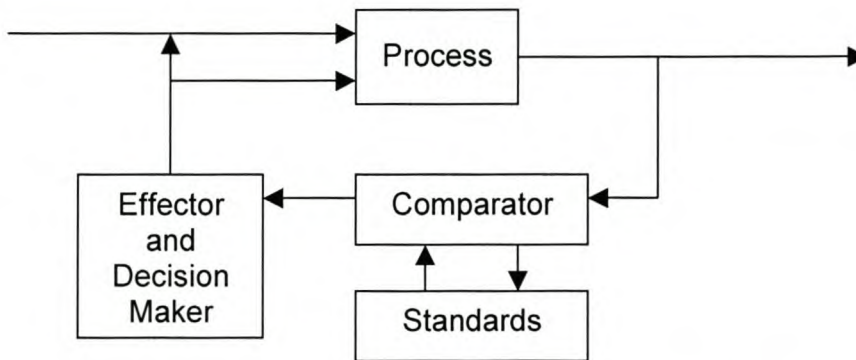


Figure 4.1: A Typical Cybernetic Control System [4]

Cybernetic control systems can further be divided into three sub-categories: *first-order* control systems, which are essentially the system described above, *second-order* control systems, which have a pre-programmed goal changer which can alter the standards according to a predetermined set of rules, or a computer program, and *third-order* control systems, which can change the goals without any predetermined rules or programs, by reflecting on system performance and deciding to react in undetermined ways [4].

Now, if this form of control is to be related into project management terms, it can be said that the system to be controlled is, quite obviously, the project. Seeing as the project is generally worked on by humans, it can be assumed that the control system is a third-order cybernetic control system. The comparators are the

people who work on the project and are responsible for monitoring and controlling their individual section of the project, and the standards are the project plan. The decision maker is the project manager, or the person responsible for the specific sub-project. If the project manager deems it necessary, changes to the project plan are given through to the people and divisions who work on the specific section that needs to be altered. These people are then, in effect, the effectors.

Of course, this is a very simplified control system for a project, seeing as changes do not only have to come due to deviations. Changes can be made to the project for numerous reasons, which will be discussed later in this chapter (see Section 4.5).

4.1.2 Go/No-Go Control

This is a very simple form of control, in that it merely tests for a condition, which has either been met or not. This form of control can be used on most sections of a project, where a person only has to know whether or not some condition has been met or not. This form of control only works when the controller uses it. The usage intervals are usually determined by time, calendar, or machine operating cycles. However, it is important that these controls be linked to the actual project plans and to the actual occurrence of real events, and not just simply the calendar.

4.1.3 Post-Control

This form of control is sometimes also referred to as Post-Project Control or Post-Performance Control. As the name states, this form of control happens after the project has been completed. The aim of post-control is not to make a brave attempt at salvaging the project after it has been completed, but rather to improve the chances for future projects to meet their goals.

This form of control is usually applied by means of a document that consists of four sections: The Project Objectives; Milestones, Checkpoints and Budgets;

Final Report on Project Results; and Recommendations for Performance and Process Improvements. Each of these sections contain detail descriptions of that specific area of the project, if it was accomplished, how it was accomplished, why it was not accomplished, and recommendations in order to make the next attempt more successful.

This type of control can also take on the form of a complete post-project audit. This audit should contain aspects such as the current status of the project, the future status, the status of crucial tasks, risk assessment, information pertinent to other projects and limitations of the audit. These aspects are only mentioned here, and the reader should refer to [4] pages 567 – 586 for a detailed discussion of the post-project audit. It has essentially the same goals as the post-project report mentioned in the previous paragraph, i.e. to ensure that future projects meet their goals more easily and effectively.

4.2 Traditional Project Control: Cost Control

The traditional method of project control is to determine the differences between the actual costs and the budgeted costs and attempting to correct them. This technique is also referred to as variance analysis. On its own, it is not very useful, seeing as it is not known what has been done or in what time things have been completed, i.e. the project might be over the budget at a specific stage in the project, but a substantially larger portion of the project might also have completed at the same stage. Therefore, information is also needed about work progress to be able to assess the current project situation effectively. The work progress at a given work status is usually given in terms of a completed percentage and earned value. Both these concepts will be discussed later in this chapter.

This method still makes out a large section of modern project control, but it is not the only measure used to control the project today. It is very important to determine which of the three constraints is more critical to the project, and then to subject the other constraints to the more critical constraint. If time is more important, then it is not necessary to worry too much about the cost. However, if

cost is the main constraint, techniques such as cost variance control are very important and will form a larger portion of the project control process. Again, it all comes down to balancing the triple constraint.

4.3 Cost Accounting Systems for Project Control

In the previous section, it was attempted to prove that the traditional method of cost management is not sufficient for complete project control. Numerous attempts have been made in order to eliminate the problems highlighted in the previous section, by attempting to develop a system that not only incorporates the costs, but also looks at the performance progress of the project. To this end, PERT/Cost systems were developed in the early 1960's [3].

4.3.1 PERT/Cost Systems

These systems are a significant improvement over the systems that were in place before it, i.e. traditional cost-accounting systems, in that it incorporated the work schedules with the costs. More significantly, this method gave birth to numerous more sophisticated cost accounting systems, the most notable of which is PCAS (PERT Cost Accounting System). This system integrates work packages, cost accounts and project schedules in a single project control package [3].

The two elements that are common amongst the different PCAS systems on the market today are that they firstly use cost accounts and work packages as basic data collection units, and secondly, they all use the concept of earned value (discussed later in this section) to measure project performance.

4.3.2 Work Package and Cost Account Control

Work packages and cost accounts are not only of importance for planning, but they are also invaluable when it comes to project control. To this end, each work package can be considered a contract for a specific job, each also having a manager who is responsible for overseeing the cost and work performance of that work package. A cost account is now simply made up from one or more work packages.

The early PERT/Cost systems were inadequate due to the fact that they could not handle overhead expenses effectively, and they consolidated and reported information at the project level only, which made it very difficult to identify any cost or schedule overruns at the work package level.

Work packages can be classified as being either end product, when they result in physical products and have scheduled beginning and end dates, or as level of effort, when they have no end product as such and are ongoing. It is clear from this that work package managers have no real effect on overheads, even though these overheads can be the cause of cost overruns. Modern PCAS's solve this problem in two ways. The first is that all overheads and fixed costs that can be assigned to a specific work package or cost account is assigned to that work package or cost account. The second way is to allocate all overheads and fixed costs that cannot be allocated to a specific work package to an overhead work package or numerous shorter work packages if the project is too long. These work packages are kept open for the duration of the project.

4.3.3 Earned Value Concept and Performance Analysis

The "earned value" concept roughly represents an estimate of the "percentage of work completed" up to a certain period [3]. This concept is used in most (if not all) projects where the costs are allocated to the specific work packages as time progresses and the resources are used (also referred to as time-phased budgeting). As mentioned earlier, this concept is used in PCAS systems as the second way of controlling the project.

Earned value gives an indication of the overall project progress in terms of performance, budget and schedule. By multiplying the budgeted cost of each task by the percentage of completion of that specific task and summing the individual earned values over all the tasks in the project this measure, also referred to as total earned value [2], can be determined. This calculation is easier said than done, though! The percent of an activity's budget spent rarely represents the actual amount of work completed on that task. The project or task

manager usually estimates this measure, seeing as, according to Mantel, et al [2]:

“...there is no satisfactory way to measure accurately the percent of completion of most tasks, let alone measure accurately the percent of completion of an entire project.”

However they go on to state that there are three conventions that have been adopted with regard to estimating the percentage of project completion. The first of these is the 50 - 50 convention, in which 50% of the task time is allocated to the task when it is initiated, and the other 50% when the task is completed. The second is the 100% method where 100% of the task time is assigned to the project on completion, and 0% before then. The third convention is to attempt to estimate the completion by dividing the cost expended by the total cost budgeted for the specific task. One could also use the ratio of the actual time expended to the total time budgeted for the task. One should only use these conventions on the tasks themselves, and not on the entire project, seeing that it might lead to serious misconceptions seeing as none of the conventions are very realistic.

There is a more efficient way to measure the project progress. This is done by measuring the project variances, like the cost and schedule variances, and determining certain indices, such as the cost performance index and the schedule performance index.

4.3.3.1 BCWP, ACWP, BCWS

Before an elaboration is given on cost and schedule variances, the concepts of BCWP, ACWP and BCWS must first be discussed. These are all elements used in calculating the actual variances and indices (discussed in the next section).

BCWP, or budgeted cost of work performed, is the amount of resources that were budgeted in order to perform the work that has been completed until now. This variable is in essence the same as the “earned value” concept discussed above. ACWP, or actual cost of work performed, is the actual amount of

resources that have been used in order to perform the work until now. BCWS, or budgeted cost of work scheduled, is the cost that was budgeted for the scheduled work that is supposed to have been completed up to this stage. This value can be calculated for the present period, the previous period, or everything up to date.

These elements are used in the calculation of the cost and schedule variances, which were mentioned earlier in this chapter.

It must be stated at this stage that the standard Project Management Institute convention is used, which specifies that negative variance is undesirable, as well as the convention that the cost and schedule variances are calculated by subtracting some measure from the earned value. The cost variance is the deviation of the actual costs from the budgeted costs, expressed as a percentage. The Schedule Variance is an indication of the deviation of the actual scheduled work completed from the scheduled work that had to have been completed. This leads to the following calculations [2]:

$$\text{Cost Variance (CV)} = \frac{BWCP - AWCP}{BWCP} * \frac{100}{1} \% \quad (4.1)$$

and

$$\text{Schedule Variance (SV)} = \frac{BWCP - BWCS}{BWCS} * \frac{100}{1} \% \quad (4.2)$$

Figure 4.2 [2] below, clarifies these concepts graphically.

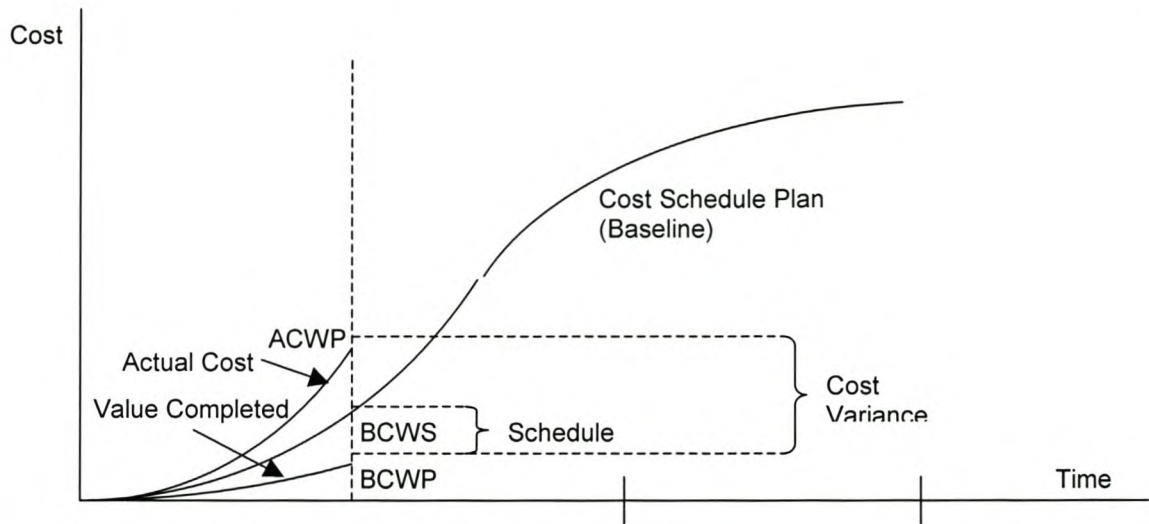


Figure 4.2: Earned Value Chart [2]

4.3.3.2 Performance Indices

The Cost Performance Index, along with the Schedule Performance Index, gives us an indication of the project's performance up to date. These are calculated as follow [2]:

$$\text{Cost Performance Index (CPI)} = \frac{BCWP}{ACWP} \quad (4.3)$$

and

$$\text{Schedule Performance Index (SPI)} = \frac{BCWP}{BCWS} \quad (4.4)$$

These indices are useful for making comparisons at different points in time, across different projects, or between different project managers. These values should preferably stay above 1.0; otherwise the project is running behind in either costs or schedule, which is undesirable for obvious reasons.

4.3.3.3 Forecasting "To Complete" and "At Completion"

From the calculations performed above, the estimated (remaining cost) to completion (ETC) as well as the projected (total cost) estimated at completion

(EAC) [2] can further be calculated. The ETC gives an indication of the expenses that can still be expected for the remainder of the project. The EAC, on the other hand, gives an indication, if the project continues along the current level of (in) efficiency of the way the project is being completed at present. One more variable has to be explained: Budgeted At Completion (BAC). This is the amount that was originally budgeted for spending on the specific task. The indices are now calculated as follow:

$$\text{Estimated To Completion (ETC)} = \frac{BAC - BCWP}{CPI} \quad (4.5)$$

and

$$\text{Estimated At Completion (EAC)} = ETC + ACWP \quad (4.6)$$

4.3.3.4 An Example

The above will now be illustrated by means of a simple example. Assume R 1500 was budgeted in order to complete a specific project task, and it was supposed to have been finished by today. Up to date, the project has only cost R 1350, but the project task is only 2/3 complete. We can now calculate the following:

$$\text{Cost Variance} = BCWP - ACWP = R\ 1500\left(\frac{2}{3}\right) - R\ 1350 = -R\ 350$$

$$\text{Schedule Variance} = BCWP - BCWS = R\ 1500\left(\frac{2}{3}\right) - R\ 1500 = -R\ 500$$

$$CPI = \frac{BCWP}{ACWP} = \frac{R\ 1500\left(\frac{2}{3}\right)}{R\ 1350} = 0.74$$

$$SPI = \frac{BCWP}{BCWS} = \frac{R\ 1500\left(\frac{2}{3}\right)}{R\ 1500} = 0.67$$

According to the figures above, more is spent than what is budgeted for, and more time is taken than scheduled for (as expected). The ETC and EAC can now be determined from these calculations.

$$\text{ETC} = \frac{\text{BAC} - \text{BCWP}}{\text{CPI}} = \frac{\text{R } 1500 - \text{R } 1000}{0.74} = \text{R } 676$$

And finally,

$$\text{EAC} = \text{ETC} + \text{ACWP} = \text{R } 676 + \text{R } 1350 = \text{R } 2026$$

This implies that another R 676 is still needed in order to complete the project task, at which point the entire task will cost R 2026, instead of the originally budgeted R 1500 if work is continued at a CPI of 0.74.

4.3.3.5 Updating Time Estimates

When work progress is reviewed, which should happen in shorter time intervals than the average length of the work packages, it might be necessary to update scheduled completion dates for certain work packages based upon current progress estimates. The forecasted finish date can be determined by adding the starting date to the time remaining. The remaining time can be determined in two ways. The first way is to calculate the time remaining as a function of current progress and the days worked up to date. Firstly, the percent progress per day has to be determined. This is done by dividing the percentage of the task completed so far by the days worked on the task so far, or:

$$\text{Percent Progress per Day} = \frac{\text{Percent of Task Completed so far}}{\text{Days Worked on Task so far}} \quad (4.7)$$

From this we can then calculate the time remaining:

$$\text{Time Remaining} = \frac{\text{Percent of Task Remaining}}{\text{Percent Progress per Day}} \quad (4.8)$$

The second way of determining the time remaining in order to complete a task is by obtaining an expert estimate. This is sometimes more accurate, seeing as the expert will usually subconsciously take any possible recent changes in the rate of progress into account.

Please note that if a task on the critical path will be delayed, the project completion date has to be adjusted accordingly, irrespective of the method used to determine the task's remaining time.

4.4 Project Control Process

The project control process essentially consists of three steps: Work authorisation, the collection of cost, schedule and work progress data, and scope, quality, schedule and cost control. The first two steps will be discussed in this section. The latter will be discussed separately in Section 4.5, Project Control Emphasis.

4.4.1 Work Authorisation

Work authorisation is the process of systematically authorising people in lower authority levels to complete certain tasks. This inherently means that the first step in work authorisation starts at the company's upper management when the project is authorised. It next moves to middle management, where the work is further divided, and the project manager, work supervisors and functional managers are authorised to spend project funds on personnel and materials. The work tasks are then given to the various work teams for them to begin working on the project. Similarly, after the upper management has approved the project plan and authorised the release of company funds for the project, the vendors and subcontractors are also authorised to start working on their specific tasks.

This process is formally divided into the following three (3) steps when dealing with larger projects [3]:

1. Contract Release

2. Project Release

3. Work Order Release or Requisition

The above three steps formalises the work authorisation process, which starts when the project or contract has been awarded to the company and the contract administrator compiles a contract release document that specifies the requirements for the completion of the contract. This document also gives the project manager the formal green light to commence with the project. The project accountant, or comptroller, now draws up a project release document that authorises the release of funds for the project.

Actual work on the project only begins when the work orders are released to the work teams. This might be in the form of shop orders, test orders or engineering orders. These work orders are a crucial part of the project control process, seeing as they contain crucial information, such as a statement of work, a time-phased budget (which contains labour hours, materials and other direct costs), schedules, milestones and the relationship of this work package to other work packages. It further contains the position of the task on the WBS (usually in the form of a numbering system), a cost account number and authorising signatures.

It is therefore critical for the work team to have a work order before they can actually begin their work.

4.4.2 Collecting Cost, Schedule and Work Progress Data

The next step in the project control process is the collection of cost, schedule and work progress data. This information is collected for the actual events that take place on each work order released.

This information is normally used by the PCAS system in order to generate work performance reports which contain similar values as the ones calculated in the previous section of this chapter (Chapter 4.3).

It is the responsibility of the work package overseer, being either the project manager or a functional manager, to assess the impact of work progress on the

work package's schedule. The responsible person has to check which tasks still have to be completed (are "open") and which have already been completed. The task times for each of these tasks, as written on the time cards, have to be tallied as well, and from this the supervisor has to make an estimate of the time remaining in order to complete the "open" tasks. This is then typically plotted on a Gantt chart, which gives a very clear visual representation of the status of the work package and all its subtasks.

As mentioned earlier, it is very difficult to estimate the time required to complete a task. Thompson [12] noted the following list of ten (10) conventional ways to measure ongoing project performance:

1. Supervision: The person overseeing the task estimates progress by direct observation, queries, written reports, and other project documents.
2. Milestones: These are easy to measure end-points of specific tasks or transition points between tasks.
3. Tests and Demonstrations: This is a good way of obtaining periodic measures of the progress of technical systems.
4. Design Reviews: At these meetings, the design or system's progress is measured against the planned progress.
5. Outside Experts: An outside expert, or panel of experts, reviews the status of the project by observation, queries and reviewing documentation.
6. Status of Design Documentation: The completeness of design documentation can be a good indication of the progress of a design.
7. Resource utilisation: Progress can be reflected in a change in resources (or a request for a change in resources).
8. Telltale tasks: During the early or intermediate stages of a project, tasks such as concept design, requirements and specification definition,

feasibility analysis, and so forth, have to be completed. If they are completed in the latter stages of the project, it could be a sign of a lack of progress.

9. Benchmarking and Analogy: The project, or elements of it, can be compared to other similar projects or tasks, as a matter of crude schedule comparison.
10. Changes, Bugs and Rework: A sustained number of changes, bugs and rework to the project might indicate a lack of progress, seeing that these should deteriorate toward the latter stages of the project.

The list above briefly describes some of the methods and signs that can act as indicators of project or task completion. The work package supervisor still has to give the periodic reports of work progress to his/her supervisor in order for them to make informed decisions concerning the project, whether it be schedule changes or changes in the budget.

A function of the work package supervisor is to tally the expenses incurred on the individual subtasks and report these to their supervisor. This includes the calculation of labour-hours and the subsequent conversion of these labour-hours into monetary terms. Direct costs and overhead costs of “open” tasks are usually calculated on a percentage completion basis and added to the cost calculations. As each task is completed, the relevant cost account also has to be closed, to ensure that no additional, unauthorised billing occurs against that specific cost account.

All the cost and schedule information for a specific period is compiled and reviewed before it is given to the project manager, who enters it into the PCAS system. He then uses the processed information from this system to make decisions regarding the three constraints of the project. This information further allows the project manager to make calculations regarding the estimated cost

and time to completion as well as the estimated cost at completion and an estimated time of completion, as discussed earlier in this chapter.

4.5 Emphasis of Project Control

This section highlights the third step in the project control process, which covers scope change control, quality control and schedule control. Cost control, even though it forms a major focal point of project control, was discussed earlier in this chapter, and the reader is referred back to the sections on traditional project control and cost accounting systems for a discussion of this topic (Chapter 4.2 and 4.3). Firstly, a short discussion on the control of changes to the project is given in this section.

4.5.1 Controlling Changes

Due to the very nature of projects, change is inevitable. If there was no such thing as change, it would make the life of a project manager very simple. Every project has some form of variability, or change, in it. Managing this change is one of the most difficult challenges that a project manager faces.

Changes to the project plan and the final item are sometimes inevitable, due to planning oversights, new opportunities, or events that no one could have anticipated in the original planning phase of the project.

Along with change usually come two tighter constraints. The project due date is usually emphasised and the resource limitations are usually further stressed. To be able to meet the now tighter first constraint, it is usually necessary to employ more resources in order to meet the new deadlines. In order to satisfy the second constraint, we have to either extend the project deadline, or alter the project scope [3]. Again it becomes very difficult to balance the triple constraint, and the project manager is usually forced to make a choice, seeing as these two constraints are directly opposing. The choice of which of the two constraints are more important is often given to the customer to make at this stage.

Some of the effects of changes in the project are now discussed, after which some of the reasons for change and change control systems and configuration management will be discussed.

4.5.1.1 Effects of Changes

Changes can have a great effect on the project as a whole, even if it is only a small change. In general, the larger a project is, the more changes can be expected and the greater the expected deviation from the planned budget and schedule objective.

When changes to the project are encountered, it usually causes problems to the project, which is counter to the intention of the changes. These changes are usually the main cause for budget and schedule overruns, lowered worker morale and poor relationships between the client and the project manager and the project manager and the functional managers and the functional managers and the project staff.

The further along the project, the greater effect the change will have on the project as a whole. Seeing as more work has been completed, it leaves more work to be undone. Say, for example, a change has to be made to the design of a component, but the product design phase has already been completed. This usually results in a significant cost increase and a loss of time, not to mention an increase to the scope of the project due to the fact that the manufacturing function has to be temporarily postponed until the part is corrected and remanufactured.

If changes are made to the project during the construction and installation phase, it will have an even greater effect on the project, as can be expected. It will firstly disrupt work which is going forward, secondly, materials which have become obsolete due to the changes being made might have to be scrapped, a part of the work which have been completed might have to be destroyed, which will in turn have a very large effect on the morale of the workers and project staff. Along with

these effects, the major effect of losing time and money is inherent, neither of which is conducive to a good project environment.

As can be seen in the above discussion, changes are usually detrimental to the project. Some changes can have a positive effect, but these are few and far between. It is generally better not to bring changes to the project past certain stages, except when they will have a positive effect on the rest of the project.

4.5.1.2 Reasons for Changes

There are countless reasons why changes are initiated. Harrison [13] (pages 242 – 244) attempts to group these reasons for change into 5 categories:

1. Changes during the early stages of development in project scope and specifications. When the work entails a greater form of uncertainty, it is more likely that the scope or specifications, or both, might change during the development stages. These changes are usually expensive to implement once the project has been approved, and must therefore be evaluated carefully.
2. Changes in the design due to omissions, errors, afterthoughts or revised needs, whether necessary or desirable. Errors and emissions must be corrected, but any changes to the project that are desirable, have to be questioned, especially if it brings alterations to the scope of the project.
3. Certain changes have to be made due to government mandate, being it for health, safety, labour or environmental reasons. Other bodies, like labour unions, suppliers, environmental groups or the community, might also cause changes to the project. These changes are usually mandatory.
4. Changes that might increase the rate of return on the project. These changes are difficult to justify, due the difficulty of estimating the rate of return. These decisions are usually referred to upper management.

5. Changes that might be improvements on the original designs. People always find ways of improving designs, but these might not necessarily increase the usefulness of the product, or improve any functionality of the final project. It is the project manager's responsibility to decide between what is necessary and what is desirable.

The above is a brief classification of the main reasons people bring changes to a project plan. In all of them, the benefits have to be weighed against the consequences of disrupting the project, and a responsible decision made on whether to implement the changes or not. The reader is referred back to the previous section for a clarification of the effect that even small changes can have on a project.

4.5.1.3 Change Control Systems and Configuration Management

In order to assist the project manager in reducing the number of changes and the negative impact that they might have on the project as a whole, a change control system can be implemented. This is a formal system for change review and control. The purpose of such a system is to firstly view and authorise all changes, sift through the changes and throw out the unnecessary ones, and to ensure that the related work is also revised and authorised [3]. Harrison [13] (pages 245 – 246) specifies that such a change control system should:

1. Continually identify changes as they occur in the project
2. Reveal the consequences of the changes in terms of their impact on costs, project duration and their effect on other tasks.
3. Should permit managers to analyse the changes, investigate alternative courses of action and allow them to accept or reject the changes.
4. Be able to communicate all changes to all the relevant parties.
5. Specify a detailed system for conflict minimisation and resolution.

6. Ensure the correct implementation of changes.
7. Give periodic reports on all changes and their impact on the project.

This process of systematic change control and coordination is also referred to configuration management in some industries, when they are incorporated into the systems development life cycle. The frequency and necessity for changes can be managed and controlled, and hopefully minimised, by such a configuration management approach. This approach should emphasise the following strict procedures, amongst others [3]:

1. Ensuring that the original work scope and works orders are clearly stated and agreed upon by all the relevant responsible parties.
2. Closely monitoring all work to ensure that all specifications are met, and not exceeded. This should not promote a spirit of mediocrity, but guard against the unnecessary use of valuable resources and time.
3. Carefully screening all tasks for cost and schedule overruns, and establishing quick corrective action procedures to prevent and stop overruns.
4. Ensuring that all discretionary changes are subject to a prespecified request and approval process.
5. Requiring strict control procedures from all subcontractors.
6. Freezing the project at a prespecified point to all further non-essential changes. Management and the customer must agree when this point will be. The sooner this point, the less likely it is that changes will adversely affect the project schedule and budget.

Below (Figure 4.3) [3] is a simple diagram that illustrates a typical change process for a large project. The person interested in making the changes should firstly prepare a change request document, which specifies the changes, reasons, and possible effects. Next, the change control board, which could consist of only the project manager, reviews the request and either sends it back for rework if additional information is required, rejects the proposal, or goes on to

evaluate the impact the change could have on the project. At this point the change is either accepted and implemented, or rejected.

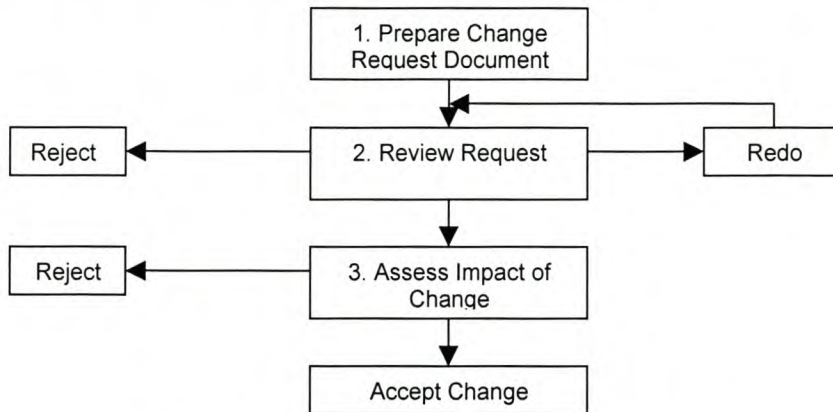


Figure 4.3: Change Request Process [3]

4.5.2 Scope Change Control

A change in the scope of a project is an alteration of the originally defined and agreed upon scope statement as it is specified in the project plan and the WBS. A change in project or task scope reflects changes in the requirements and work definitions, which typically results in an increase in the project cost and an extension of the project schedule. Both these effects are usually unwanted in the sense that they require more resources, which might already be scarce. It must also be stated that a scope change should have a positive effect on the overall project result, from a functionality point of view.

Seeing as changes to the scope directly impacts the project costs and schedules, it has to be controlled carefully and cautiously. The aim of scope change control is therefore to firstly identify where changes in the scope occurred, secondly to ensure that these changes are necessary and will be beneficial to the project as a whole, thirdly to minimise and delimit the changes and finally to manage the implementation of scope changes. This is usually incorporated in the change control system, as described in the previous section of this chapter.

Mention must also be made of a phenomenon called “scope creep”. This happens when the project naturally grows in its scope as it progresses. This is

obviously an undesirable situation, which must be controlled, since it is almost impossible to avoid. The project manager can control this phenomenon by following the following five rules [2]:

1. Include a change control system in every project contract.
2. A change in the project must be initiated by a change order.
3. Changes must be approved in writing by the client as well as senior management.
4. It is essential to consult the project manager before the initiation of a change order.
5. Upon the approval of a change order, the project plan has to be adjusted to compensate for the changes, and the change order must be incorporated into the project plan.

It should be made clear that these steps will not eliminate project scope creep, but should minimise it substantially.

4.5.3 Quality Control

Quality can be defined as the ability to conform to the original requirements of the end-item, work processes and procedures. This is the end result that all projects should strive towards – conforming to the customer specifications. In order to accomplish this, the quality throughout the entire system must be controlled [7].

Quality control can now be defined as the management of the work required to complete a project according to the original requirements and specifications. It goes further in that we also have to take preventative measures to keep errors out of the work process, which leads to the identification and elimination of the sources of errors as they occur. This definition emphasises the fact that quality control is an ongoing process that should be done during the entire work process. In short, Quality control attempts to identify why requirements are not being met;

i.e. the identification of the sources of defects as well as the methods required to eliminate these problems [3].

It is therefore important to test and inspect the work continually throughout the process. This will aid in the identification of problems as early as possible. The reader is referred back to the discussion on the effects of changes in the project (see the previous section) in order to fully understand the implications of the early identification of the sources of errors.

How quality control will take place throughout the work process should be stipulated in a document called the quality Management Plan, which forms part of the overall project plan. This document describes the necessary conditions for each work package to be completed according to requirements and specifications. It further specifies the measures and procedures necessary to assess these ideal conditions as well as the progress towards meeting the work requirements.

Another aspect of quality control is tracking the project's performance with respect to technical requirements and modifying work as necessary. This methodology is referred to as Technical Performance Management (TPM). This methodology will not be discussed in this document, as it falls outside the scope of this project. The reader is referred to [3] pages 363 – 365 for a detailed description.

4.5.4 Schedule Control

As can be derived from the previous sections of this chapter on project control, schedule control is one of the most important aspects of project control.

The aim of project schedule control is to, firstly, keep the project on schedule, and secondly to minimise the schedule overruns. Poor planning is the root of most schedule overruns, seeing as it stems from a poor definition of the tasks and therefore also a poor time estimate for the tasks [6].

Of course, all causes for schedule overruns cannot be prevented, because of the uncertainty of this world in which some elements are outside the project manager's control, like the weather. There are, however some controllable causes for schedule overruns. These include multitasking, procrastination and task variability.

Multitasking dissipates energy from the tasks at hand, and usually results in increases in the elapsed time to complete the subtasks. The learning-curve effect can also be largely eliminated by multitasking, which is, for obvious reasons, not desirable. People generally want to start with a task as late as possible, which means that we effectively eliminate all the available slack time on a task. This in turn places this task on the critical path, which is undesirable [5].

In every project there are certain tasks that will be completed ahead of schedule, and some tasks that will be completed later than their scheduled due dates. Unfortunately, this variability in the task completion times usually does not balance itself out, again, usually for the latter case where we fall behind schedule. It is however, only the late tasks that have a significant effect on the schedule, seeing as in the event that a task finishes earlier, the successors might not know about it, or they might not have the required resources ready in order to take advantage of the saved time.

The controllable causes of schedule overruns can largely be eliminated by adhering to the following guidelines [5]:

1. Do not multitask. Assign priorities to tasks and complete them before moving on to the next task. This will reduce the elapsed time and it confirms to workers what they should be focussing on. It further allows the project team to take advantage of the benefits of the learning-curve effect.
2. Include time buffers in the schedule. A time buffer is an amount of time that is built into a task's scheduled time to account for the variability in the task's completion time. According to Goldratt [14] time buffers should be

included at the end of each sub-path in the project network that leads into the critical path, as well as at the end of the critical path. The size of the buffer depends on the perceived variability and uncertainty in the task. It is important that the project manager does not reveal the time buffers to the project staff. This is done in order to eliminate procrastination. (See Chapter 5.5.6 for a more detailed discussion on this topic.)

3. Frequently report on expected completion times. This information is important seeing as it can cause succeeding tasks to start earlier, if they are ready for it. It can also give successors time to gather the required resources if need be, and to finish the work that they are busy with in order to avoid forming a bottleneck.
4. Inform the project staff about the consequences of schedule delays. The people that have to be informed include the functional managers, subcontractors, and suppliers, as well as all other project staff. They should not only be informed of the consequences of falling behind schedule, but also of the benefits of finishing the tasks and the project earlier. These benefits most commonly include incentive payments or schemes.

It must be noted that any measure of these guidelines can, and should, be used on any specific project.

It is clear from the discussion in this chapter that project control is usually a very complex exercise. It is extremely important to have an integrated project control system, which should be well understood by all the people involved in this project. Controlling the project is of the utmost importance to the success of the project. If this function is not executed effectively, the project is liable to cost, schedule and performance deviations. This could lead to complete project failure, due to the fact that the project becomes too expensive, takes too long to complete or does not meet the customer's specifications.

5. Project Risk Management

5.1 Defining Project Risk and Risk Management

Risk is inherent in all projects. This is due to the level of uncertainty inherent in projects. When projects are planned, something that is going to happen in the future is being planned, and to have good control over events that have not yet taken place cannot really be expected. Due to the rapid technological advances made today, this is especially true for long-term projects. Our actions of today can, however, be directed in order to more accurately predict the behaviour of certain events when they do happen in the future. But what exactly is risk, and what does it mean to manage this risk?

Risk is a measure of the probability and the consequences of not achieving the project goals [7]. Stated otherwise, risk consists of the probability that an unwanted event occurs, and the adverse consequences of that unwanted event when it does occur [5]. Alternatively, risk can also be thought of, strictly in the project sense, as a function of the uniqueness of a project and the experience of the project team.

Risk consists of three components [7]:

- An event or an unwanted change
- A probability of the event occurring
- The consequences or the impact on the project if the event does occur

Put in simple mathematical terms:

$$\text{Risk} = f(\text{Event, Uncertainty, Damage}) \quad (5.1)$$

It is quite clear from this equation that the higher the uncertainty of the event happening, and the larger the damage that can be caused by the event, the higher the risk. This concept is graphically illustrated in Figure 5.1 below [7].

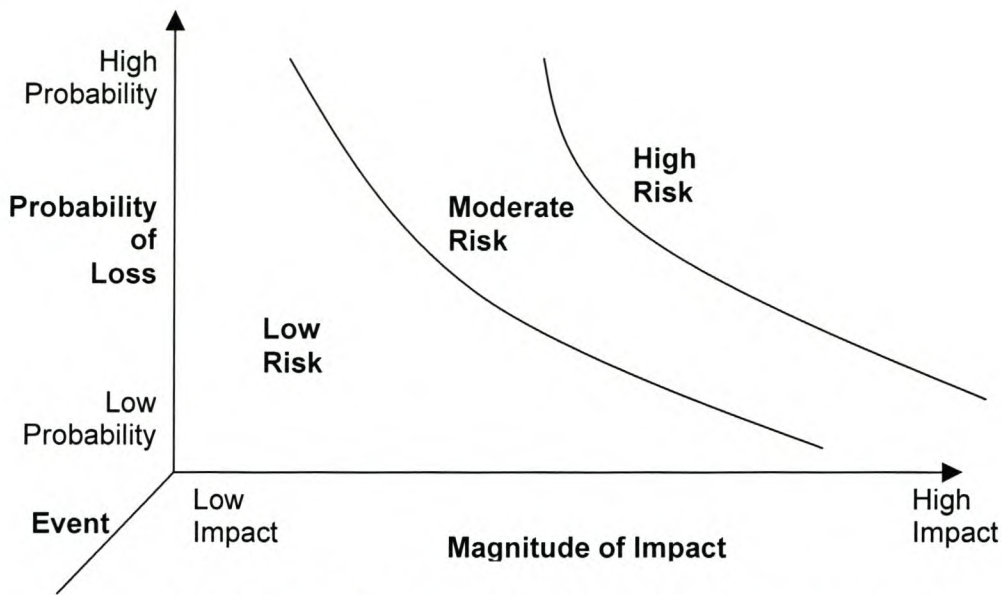


Figure 5.1: Overall Risk as a Function of its Components [7]

There is another element in risk that was not accounted for in equation 5.1, the cause of the risk, or the hazard. When this is taken into account, equation 6.1 can be rewritten as:

$$\text{Risk} = f(\text{Hazard}, \text{Safeguard}) \quad (5.2)$$

A good project management system should identify the hazards before the project starts, and have the capability to develop safeguards against these hazards. When enough safeguards are in place, an acceptable risk level is achieved.

Risk is usually very difficult to assess, due to the fact that the probability of failure, or the uncertainty, and the consequences of the failure are not easily measurable parameters, which is a reversion to some form of estimation, being it statistical or otherwise.

Risk will never be completely eliminated, only reduced. Risk can substantially be reduced by means of active risk management and an effective risk management system. But what is risk management?

Risk management is simply minimising the project risk. The Project Management Institute Body of Knowledge, PMBOK, gives three definitions for risk management [7]:

1. Risk management is the formal process by which risk factors are systematically identified, assessed and provided for.
2. Risk Management is a formal, systematic method of managing, which concentrates on the identification and control of areas or events that have the potential of causing unwanted change in a project.
3. Risk Management is the art and science of identifying, analysing, and responding to risk factors throughout the project's life in ways that benefits the project.

In short, project management is a means of, firstly identifying and measuring risk, and secondly developing, selecting and managing options in order to handle risks during the project. Proper risk management should be proactive by being aimed at managing possible future events that could lead to undesired changes. If we manage the risks properly, it should reduce the probability of having excessive budget or schedule overruns. In other words, it reduces the probability of an event occurring, as well as the magnitude of the impact on the project.

There are four main areas to consider when dealing with risk management. These are Risk Identification, Risk Analysis, Risk Assessment and Responding to Risk. These areas are usually all reviewed and managed in a thorough risk management system. The result of a system like this is that the project manager can make a decision to whether or not the project risk is acceptable. This depends largely on the risk tolerance level of the project manager. The likelihood of accepting and dealing effectively with risks is substantially increased if a decent risk management system is in place in all areas of the project.

5.2 Identifying Project Risk

It is very difficult to manage something if it has not been identified. Therefore, the first step in project risk management is risk identification. The thoroughness with which project risks are identified will largely determine the effectiveness of the entire risk management process. Although the emphasis is on the identification of high-level risks, the identification of lower level risks should not be neglected [2]. The accumulative effect of several of these low-level effects can be devastating to the project.

Understanding the risks involved in a project as well as the sources of these risks takes time, and the emphasis of risk management, and especially risk identification, should continually be on this [7]. It is important to note that risk identification should take place throughout all phases of the project. This will enable the project manager to effectively manage the project risks at their sources [3].

Risk identification is a thorough and detailed study of all possible sources of risk [2]. This process of risk identification should start early in the project concept phase, where the emphasis is on the identification of potentially high risks. These high risks can stem from the following factors:

- Using an unusual approach
- Attempting to further technology
- Training and applying new skills
- Developing and testing new equipment and procedures

Risks can be classified as being either internal or external [3]. Internal risk has its origin within the project, and there are two main categories, namely market risk and technical risk. Market risk is the risk of not meeting market needs or customer requirements. This can be due to poor definition of the market and customer needs, failing to identify changing needs, or failing to identify newly introduced competitive products onto the market. This risk can be reduced by a

thorough and accurate definition of the market requirements, by continually monitoring and updating these requirements, and by frequent market research.

Technical risk is the risk of not adhering to time, cost or performance requirements due to technical problems. This type of risk is typically high on projects where new technology is implemented.

External risks stem from sources outside the project, over which the project manager does not have much, if any, control. These include risks like weather, market conditions, government regulations, and interest rates, amongst others.

There are numerous methods for identifying project risk. The gist of these methods all relate to the classification of risk, and therefore also the identification, according to the source of that risk, rather than the possible effects of the risk [7]. These identification and classification methods allow the project manager to manage the risks where they originate.

One of the most common risk identification methods is to identify the risks according to the project chronology, i.e. according to the different project life-cycle phases [3]. This is a powerful method, seeing as it guides the project manager to focus his attention on the specific risks that relate to the specific phases of the project. For instance, in the early phases of the project there is a high overall project risk, seeing that a lot of work still has to be done towards establishing the project. Towards the end of the project the financial risk becomes very great, due to the fact that a substantial amount of resources would have been used by that stage. Figure 5.2 below demonstrates this concept [7].

Another method of identifying risk is the analogy method. In this method, records, post-completion reports and team members' notes from previous, similar projects are studied and scrutinised [3]. In order for this method to be effective, very good documentation of past projects is required. These documents can be used to draw up a risk checklist, which highlights areas of concern in previous projects

that could become problems in the new project. This checklist should also specify the relevant risk levels for each of the elements mentioned.

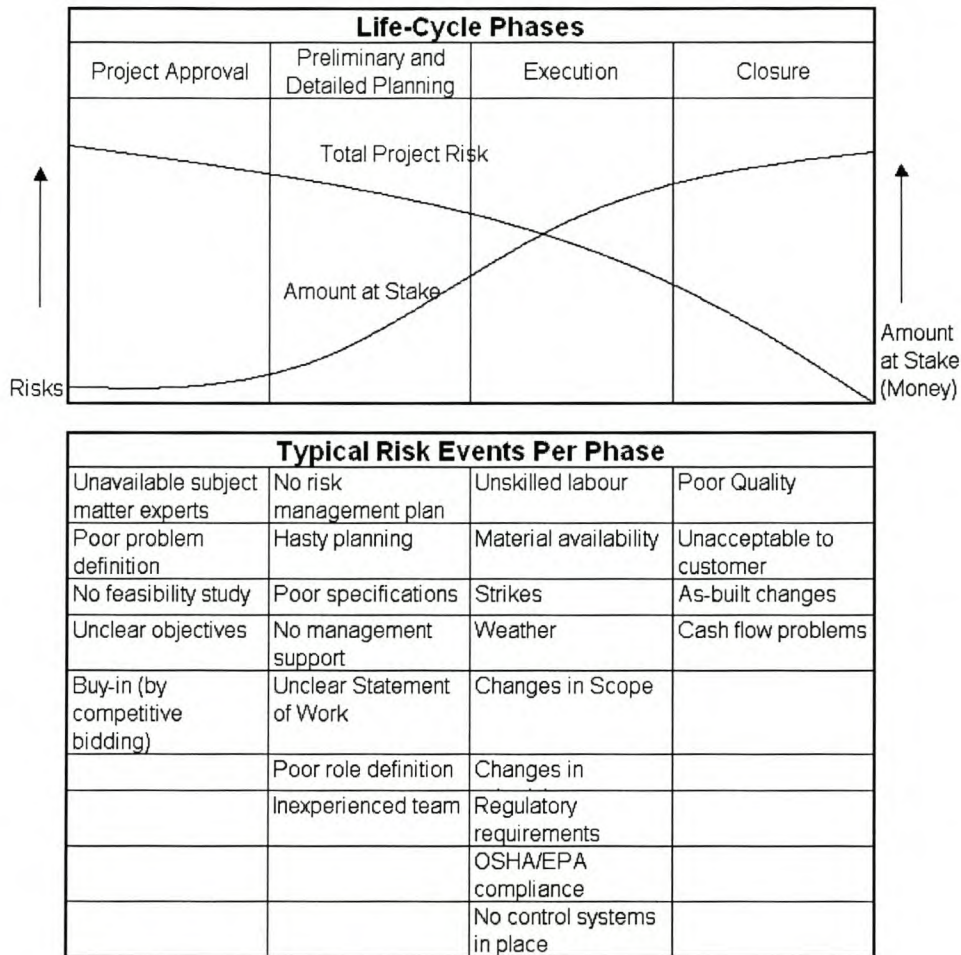


Figure 5.2: Life-Cycle Risk Analysis [7]

A further method of risk identification is an analysis of the WBS [2]. In this method, every work package is scrutinised for potential problems and assessed for possible sources of internal and external risk [3]. These work packages are assessed by utilising criteria like maturity, complexity and dependency, which usually gives a good indication of the risks involved in the specific work package [7].

Project flowcharts can also be used. These charts show the steps, procedures and flows between the tasks and the various activities. This method is very good

at pinpointing potential areas of concern. Further, the project network that was developed in the project-planning phase can be used to aid in the risk identification process.

The most comprehensive of the methods is the use of the collective expertise of the project team. This method aims to involve all the project staff in brainstorming sessions. The aim of these brainstorming sessions is to identify all possible risks and their causes. To aid the project team to identify the causes of an undesirable effect, or to identify the effect of a cause, they should make use of cause and effect diagrams, such as Ishikawa diagrams. These diagrams will not be discussed here, but the reader is referred to Kolarik [15] (pages 173 – 179) for a detailed discussion.

It must be noted that there are extensive military documents on the concept of risk management, which could be useful if they were to be adapted to fit the project. No detail will be given here of those documents, other than the name and number: DOD Directive 4245.7-M.

After the majority of the risks involved in the project have been identified, data pertaining to the probability of the risk, the distribution of the possible outcomes as well as the expected timing of each of the outcomes should be obtained. This is necessary in order to facilitate the next step in risk management, Risk Analysis.

5.3 Assessing Project Risk

Whether or not a risk is notable depends mainly on three factors: the likelihood of the effects of the risk becoming a reality, the impact these effects will have, and the consequence of the risk.

5.3.1 Risk Likelihood

Risk likelihood is the probability that the risk factor actually materialises. This likelihood, or probability, is often expressed as a number between 0 and 1.0. Here, 0 indicates that the risk will definitely not materialise, and 1.0 indicates that

the risk will definitely materialise. The probability can also be expressed qualitatively, as being high, medium or low [3]. Kerzner [7] classifies these three qualitative risk levels as follows:

- *High risk*: Likely to cause significant disruption to cost, schedule, performance, or quality, even with additional support.
- *Medium risk*: Could possibly cause some disruption, even with additional support. Potential problems could still be overcome.
- *Low risk*: Has little potential risk to the schedule, cost, performance or quality. These risks can be overcome by normal activity from the project staff.

This risk probability can also be expressed as a combination of the two methods used above, where numerical values are assigned to the three qualitative measures. An example of this is given in Table 5.1 below. Please note that these values are given only for illustrative purposes. The actual numbers used in a project will depend on the project and the risk factor involved in that specific project. For one project a certain risk might not be considered serious, and therefore the high risk boundary might only be at 0.8. For a high risk project, the same risk might be considered extremely serious, and the high risk boundary might be as low as 0.4, or even lower. These boundaries depend on the team's experience, which, naturally, makes it very subjective. It is therefore important to acquire as many ratings and estimates from as many people as possible and then determine some "mean value" for each of the measures.

Qualitative Measure	Boundaries
Low	0.00 - 0.20
Medium	0.21 - 0.50
High	0.51 - 1.00

Table 5.1: Risk Likelihood Qualitative Ratings for Quantitative Values

When multiple risks in a project are dealt with, and these risks are independent of one another, they can be amalgamated into a single risk rating factor, called the

composite likelihood factor (CLF). This factor is calculated by assigning a weight to each of the different risks. This weight is then multiplied with the risk likelihood, in a similar fashion as the calculation of the expected value as discussed in Section 5.4. Mathematically, this can be expressed as follows:

$$\text{CLF} = \text{Weight} * \text{Failure} \quad (5.3)$$

If the risks are not independent of one another, they can be combined into a single estimated risk factor. This interrelatedness is not always easy to see off hand. It can become much clearer by compiling a simple Influence diagram. This diagram can be compiled by means of the following simple steps [3]:

1. Make a list of all the risks
2. Space them apart on a page
3. Look at each individual risk and determine if they are influenced by any other risks
4. If there is a relation, draw a line between the relevant two risks.
5. An arrow can be used to indicate the direction of the dependence
6. The more connections there are at a specific risk, the more important the risk

This method, albeit very simple, helps in that it graphically represents the relations, which allows all the risks to be seen in context with each other. This usually makes the relations clearer and easier to see.

5.3.2 Risk Impact

Risk impact is the result of a risk actually materialising. This factor can be specified in terms of cost, schedule, performance and quality. The exact amount of impact can only be determined after the risk has materialised. However, an idea of the impact of certain risks on the project is required. The impact is therefore estimated beforehand. This estimate is usually based on the opinions of the project staff and experts. Again this can be fairly subjective.

The amount of risk impact can be expressed quantitatively in a similar manner as with Risk Likelihood in the previous section, i.e. numerically between 0 and 1.0, where 0 is now regarded as not serious and 1.0 regarded as catastrophic.

When dealing with multiple risks, this measure can also be combined if the risks are independent and different. This is done by assigning a weight to each specific risk, and then assigning an impact factor to each risk as well. These two values are now multiplied and summed for all the risks. This renders a Composite Impact Factor (CIF).

$$CIF = \sum_i (\text{Weight of Risk}_i \times \text{Impact Factor}_i) \quad (5.4)$$

Risk impact can further be expressed in terms of what we would need in order to recover if the risk actually materialised. This is usually expressed in terms of the triple constraint, i.e. cost, schedule and performance, but can also be expressed in terms of quality. This factor should be assessed for the entire project.

5.3.3 Risk Consequence

Risk consequence is a combination of risk likelihood and risk impact. It is usually expressed as a single numerical rating between 0.0 and 1.0. The higher the number, the worse the risk consequence [3]. This value is referred to as the Risk Consequence Rating (RCR) and is calculated in the following manner:

$$RCR = CLF + CIF - CLF * CIF \quad (5.5)$$

This factor gives an indication of the seriousness of the risk to the project's overall performance. The higher the value, the more important the risk factor is. this risk factor can also be expressed as an expected value (See Chapter 5.4).

5.3.4 Priority

In large projects with numerous risk factors, it can often be a struggle to identify which risks to focus on. This is where the risk consequence rate, as discussed

above, is very useful, in that it establishes a relatively objective basis from which the risks can be prioritised.

It is the responsibility of management to specify the tolerable levels of expected risk consequence ratings. This is so that the project manager can focus his attention on the risks with an RCR at that level or higher and not really be concerned about the risks at lower levels [7].

A drawback of only using this rating for identifying the most important risks and only managing them, is that, even though a risk might have a low priority, it might still have very serious consequences. The project manager therefore has to look at the seriousness of the risk consequences as well. If these consequences are serious enough, they should also be managed [3].

5.4 Analysing Project Risk

The objective of risk analysis is to illustrate the distributions, or risk profiles, of the possible outcomes of possible scenarios. This is realised by stating these outcomes as a probability distribution and to then use these distributions in order to evaluate the desirability of certain managerial decisions.

Numerous methods can be utilised in order to achieve this objective. Amongst them are: Network Analysis, Life-cycle cost analysis, Probability analysis (expected values), Graphical Analysis (decision trees), Estimating relationships, Decision Tables and Analysis, WBS Simulation and Simulation [2 & 7]. In this section, only discussions on Probability analysis, Graphical analysis, Decision tables and Simulation, as well as brief discussions of a few techniques that can be used when there is no data available, are given.

5.4.1 Probability Analysis

In order to generate statistical distributions, sufficient data is required, which is not always available [2]. In the event that this data is not available, the best guesses of team members can be used. This is done by obtaining an optimistic, pessimistic and realistic estimate of the possible outcome of a possible event

from numerous experts (See Chapter 5.4.5 for a more detailed discussion on this topic). From this, the distributions of the various events can be calculated by means of simple statistical techniques. Calculation of the type of distribution, along with all the required parameters, falls beyond the scope of this document. The interested reader is referred to Walpole, et al. [16] for a detailed discussion.

Once these distributions have been calculated, the concept of expected outcome value can be used [3]. The expected value of an outcome is the average outcome of that event, when repeated numerous times, accounting for possible occurrences of risk. Mathematically, this can be expressed as [3]:

$$E(\text{outcome}) = \sum (\text{outcomes} * \text{probability}) \quad (5.6)$$

Several values can be computed which will aid in the decision-making process. These variables are listed below:

$$\begin{aligned} \text{Risk Time (RT)} &= \text{Time to correct the results of a risk when it manifests} \\ &= \text{Corrective time} * \text{probability of risk} \end{aligned} \quad (5.7)$$

$$\begin{aligned} \text{Risk Cost (RC)} &= \text{Cost to correct the results of a risk when it manifests} \\ &= \text{Corrective Cost} * \text{probability of risk} \end{aligned} \quad (5.8)$$

These two values can be seen as “buffers” which should be added onto the planned project schedule, or Base Time Estimate (BTE), and the budget, or Base Cost Estimate (BCE). The estimated project completion cost (EC) and estimated project completion time (ET) can then be calculated as follows:

$$ET = BTE + RT \quad (5.9)$$

and

$$EC = BCE + RC \quad (5.10)$$

In the event that the risk cost or risk time cannot be calculated, the following formulas can be used as an estimate:

$$ET = BTE (1 + \text{probability}) \quad (5.11)$$

and

$$EC = BCE (1 + \text{probability}) \quad (5.12)$$

These calculations can be performed for each of the possible outcomes, or events, and a decision table drawn up which is used to weigh up the different possibilities. See Section 5.4.3 later in this chapter for an example of a decision table.

Further, these calculations can be performed for the project in its entirety, or on the individual work packages and tasks. When performing these calculations for the individual tasks, they simply have to be aggregated upward until the overall project level is reached. At this stage fairly good estimates should be available for the budget and the schedule, with built-in “buffers” to compensate for the probability of risks.

5.4.2 Decision Trees

A decision tree is a graphical method employed to facilitate the decision-making process. It is initiated by placing a single project in the middle of the diagram, with all outward branches representing the courses of action which could be taken in order to minimise the risk involved in the project. This diagram is used in order to assess which of the risk responses is expected to deliver the best results. This branch is obviously then the best course for action.

These diagrams allow the objective study of the events and alternatives, and from that discover the most effective course of action. These diagrams take on many forms, and the interested reader is referred to Winston [17] (pages 745 – 762) for an excellent discussion on decision trees.

5.4.3 Decision Tables

Most projects have a relatively large proportion of uncertainty. When confronted with a relatively large amount of uncertainty when making a decision, a decision table is usually a very helpful tool. It is also a very graphical way of explaining the decision process and validating decisions [3].

A decision table is built by firstly identifying various different solutions (alternatives) to a problem. Next, the factors that could affect these alternatives, also called the states of nature, have to be identified [7]. From these, the likely outcome of each alternative under the various states of nature is determined. A table, which reflects this matrix relationship, can now be drawn up (see Table 5.1 below).

Each alternative is now analysed with respect to the various states of nature, and the possible outcomes for each option within each state of nature calculated. The various alternatives can now be compared, and the best of these alternatives decided upon. How the alternatives are analysed depends on our viewpoint. If concerned with the probability of losing opportunities, the opportunity costs can be determined by subtracting the lower pay-off alternatives at each of the alternatives with the highest pay-off at that specific state of nature. The alternative with the lowest opportunity cost at each of the states of nature, is obviously now the most desirable alternative for that specific state of nature, again, depending on our strategy. If the risk is to be minimised, the alternative with the highest opportunity cost would not necessarily be the most attractive alternative. Rather, a thorough investigation to into the risks involved in each factor would be done, and the decision based upon that. See the example below for further clarification.

The average expected pay-off per alternative might also need to be determined. This is calculated by assigning a realistic weight to each of the states of nature, and multiplying these with the possible outcomes of each alternative for each

state of nature. These are then added up for each alternative, and an expected average obtained [2]. Again, this is explained in the example below.

5.4.3.1 Example.²

In Table 5.2 below, there are four decision choices, or alternatives (A_i), three states of nature (S_j), the probability of a state of nature occurring (p_j), and the outcomes associated with each alternative and state of nature combination (O_{ij}). The expected weighted average value of each alternative can now be calculated by means of the following equation, which was given in (equation 5.6):

$$E(A_i) = p_1(O_{i1}) + p_2(O_{i2}) + p_3(O_{i3}) + p_4(O_{i4}) \quad \text{for all values of } i$$

Alternatives	Probabilities	0.2	0.4	0.3	0.1	Expected Value
	States of Nature	High	Medium	Low	None	
A_1		2100	1800	2000	1500	1890
A_2		1800	2400	1900	1200	2010
A_3		1900	2000	1600	1000	1760
A_4		1200	1900	1400	1100	1530

Table 5.2: Typical Decision Table

These calculations are demonstrated for the second alternative in the table. The calculations are similar for all four alternatives.

$$\begin{aligned}
 E(A_2) &= 0.2 * 1800 + 0.4(2400) + 0.3 * 1900 + 0.1 * 1200 \\
 &= 2010
 \end{aligned}$$

This is then also the highest expected return alternative, and could be the route to follow. When looking at lost opportunities, the table will look as in Table 5.3 below. These values were calculated according to the discussion in Chapter 5.4.2 above.

² Adapted from an example in [2], pages 103 - 104

	Probabilities	0.2	0.4	0.3	0.1	Expected
Alternatives	States of Nature	High	Medium	Low	None	Value
A ₁		0	600	0	0	240
A ₂		300	0	100	300	120
A ₃		200	400	400	500	370
A ₄		900	500	600	400	600

Table 5.3: Decision Table for Determining Lost Opportunity Cost

From this it can be seen that alternative 2 still looks like the better option, even though alternative 1 is the best in three of the states of nature. This leaves the project manager with a difficult decision, for which he will have to take other factors into consideration.

5.4.4 Simulation

Simulation is a method of decision-making which has become very popular over the last few years. This is partly due to the fact that it is a very powerful tool which can be developed and used without interrupting the actual work flow [3]. It is further possible to test for numerous “what-if” scenarios, without having to experiment in practise where it would probably cost a lot of money. The advent of user-friendly computer simulation software has further boosted the popularity of simulation over the last few years.

One mathematical simulation technique which was developed a relatively long time ago and is still very effective is Monte-Carlo simulation. Monte-Carlo simulation is very useful for large, complex decision-making problems. For this method, a valid and representative mathematical model of the problem at hand has to be compiled. This model is now run and tested it for various different circumstances. In order to generate sufficient data to make accurate estimates and calculations, the model has to be run numerous times for each circumstance. Once enough data has been collected, this data is used to draw up statistical probability distributions of the outcomes. These can then be used for decision making purposes.

5.4.5 When no data is available

It is not uncommon for the scenario to arise where it is too difficult to estimate, or guess, the outcome of a specific event, especially when new techniques or new technology is being used. In this event, the assumption can be made that all outcomes are equally likely, which is not very realistic. The rationale behind this leads to the conclusion that this method is no more accurate than making rough estimates of the possible outcomes. Another route to consider when an estimate cannot be made is to analyse the scenario for the worst possible outcome. The best of these “worst cases” scenarios is then selected. This method is referred to as “Worst-case analysis”.

5.5 Responding to Project Risk

The ultimate aim in risk management is to take the appropriate actions in order to achieve the project's goals. This is achieved by revising the project's budget, schedule, performance and quality. Several actions can be taken in response to risk. However, the action we take depends on one of the following factors, amongst others [7]:

- Descriptive uncertainty: insufficient information regarding the actual hazards that caused the risk.
- Measurement uncertainty: insufficient information regarding the damage magnitude.
- Insufficient information regarding the probability of the occurrence.
- Voluntary risk: Personal benefit to the project manager for accepting the risk.
- Involuntary risk: risk forced upon the project manager.
- Confusion about the risk.
- Avoidability of the risk.
- Equitable risks: the existence of cost-effective alternatives.
- Inequitable risks: a lack of alternatives or the availability of only high-cost alternatives.

- Length of exposure to risks.

Even though reactions are influenced by the factors listed above, the actions taken concerning the risks fall into one of the following five categories:

- avoiding the risk,
- reducing the risk,
- transferring the risk,
- retaining the risk, or
- Knowledge and Research

Each of these response categories will be discussed in more detail below.

5.5.1 Risk Avoidance

Avoiding a risk implies avoiding the potential consequences of the failure as well as the probability of the failure [7]. Although some risks can be avoided by good decision making during the project concept planning phase and thorough project research [5], this might not always be possible. Risks can further be avoided by means of the following course of action, amongst numerous others [3]:

- Altering the original project concept requirements and defining them more completely
- Changing contractors
- Incorporating redundancies, contingency measures and safety procedures
- Extending the schedule
- Increasing the budget
- Changing the scope of the project
- etc.

Attempting to avoid risks usually implies that a large amount of management controls and monitoring systems have to be added. This in turn increases the complexity of the system, and therefore introduces new sources of risk. Avoiding risk usually also goes hand in hand with a reduction in the final project rewards. Due to this fact, it is sometimes better to reach a healthy balance of risk vs.

reward rather than to avoid risk altogether. It is however impossible to avoid all risks completely. Often when attempting to avoid a risk, it is simply transferred to another area.

5.5.2 Risk Reduction

Risk reduction is usually broken down into uncertainty reduction, consequence reduction, risk avoidance and risk transfer. The latter two sections are discussed in Chapter 5.5.1 and Chapter 5.5.3, respectively. In this section the focus will therefore be on uncertainty reduction and consequence reduction.

5.5.2.1 Risk Uncertainty Reduction

When the uncertainty of a risk is reduced, it can have one of two effects: it can either convert the risk to certainty, or it can merely reduce the probability of an outcome. Both of these results are favourable, depending on the cost. We can use one of the following methods in order to reduce uncertainty³:

1. Prototyping, simulating and modelling. All three these methods make use of a representation in order to investigate the selected aspects of a design, process.
2. Planning in detail: When detail planning is done, it relates to detail estimation, detail budgeting and detail scheduling. This is done in order to clarify the accomplishment of the project as a whole in advance.
3. Parallel Alternative Developments: This is in essence an alternative backup of the currently executed method. This entails a measure of double costs, in that an alternative is produced while the main method is being executed. This method becomes feasible when time is more important than cost. This kind of risk reduction relates to a reduction in overall failure risk, which is due to the fact that the combined failure probability is the product of the failure probabilities of the alternatives. (Assuming, of course, that their failure probabilities are independent).

³ This list was derived by combining information from [3], [6] and [5].

4. Checking References: This can only reduce uncertainties about certain individual abilities, but it does not improve them by itself.
5. Using Trained and Professional Staff: Training and certification can establish certain minimum competencies for the staff and reduce the downside uncertainties about them. Further providing the staff with incentives will aid in establishing determined and dedicated project staff. It is also useful to hire outside experts when needed; especially for critical review and work assessment.
6. Using Proven Technology: Technologies that have been tried and tested have a lower risk initially. Care must be taken not to dismiss new technology, seeing as it might have a very positive impact on the project.
7. Verifying the suitability of inputs: By performing extensive tests and evaluations, we can verify inputs, being either material or information. This is important, seeing as it could have an impact on the amount of future work that has to be performed.

These seven methods of risk reduction are very useful when it comes to reducing the uncertainty of specific project risks, and can be applied to most projects. However, the consequences of the risks must also be taken into consideration and those risks with the most severe consequences must be reduced as far as possible for the project to be a success.

5.5.2.2 Risk Consequence Reduction:

Reducing the consequences of a risk can be achieved by following two methods⁴:

1. Minimising system complexities: System risk and the consequences thereof increase with system complexity. A system can be simplified by decoupling related items and activities within the project. This means that they have to be made independent of one another, which ensures that in the event that one fails, the rest will not fail as well.

⁴ This list was compiled from information in [3], [5] and [6].

2. Providing margins or reserves: Reserves are purely there for the accommodation of mistakes. This inherently reduces the risk profile for that specific risk, seeing as there are additional resources, either time, funds, staff or materials available. This concept is discussed in detail in Chapter 5.5.6.

5.5.3 Risk Transfer

Risk transfer is a means of transferring all, or part of, a risk to another entity by some form of a contract. This can be achieved through performance incentives, warranties, cost incentives and contracting out, among others. In these agreements, the possible failure costs will be assumed by the contractor or another outside entity for a prearranged cost. This cost is not necessarily a monetary reward and could also be expressed in terms of schedule changes or product performance modifications. Risk transfer can only feasibly take place if the receiving party has proper and effective control over the risks involved, each party can bear the risks that the other party cannot better evaluate and if the customer is willing to pay for what really happens, and not what the supplier perceives will happen [5].

In a sense, risk transfer forms part of risk reduction, in that a specific type of risk is effectively reduced on one section of the project when it is transferred to another. Overall risk transfers do not reduce the overall project risk.

There are mainly two methods of risk transfer [5]. The first of these, the use of insurance, ties in with the four contractual schemes listed below. With this method, risk is transferred to a larger entity that can bear the risk. Contingency allowance, or reserves, is one version of insurance, when they are pooled by all entities involved.

The main contractual structures pertain to cost structures, as mentioned above. Some of the more commonly used cost structures used in contractual risk transfer are:

1. Fixed-price contracts (FP): Contractor assumes almost all of the risks for cost overruns.
2. Fixed-price with Incentive Fee (FPIF): Contractor accepts roughly 60% of the risk, and the client 40%.
3. Cost plus Incentive Fee (CPIF): Contractor assumes roughly 40% of the risk and the client 60%.
4. Cost Plus Fixed Fee (CPFF): Customer assumes almost all the risks.

The second method of risk transfer is to align responsibility and authority. These two can be aligned so that the person who actually has to do the work also has to make the decisions. This is effective due to the fact that, firstly, these decision makers judge external circumstances realistically when they know they have to carry out the decisions. Secondly, it is effective due to the fact that it is the same person, the decision maker knows his own capabilities. Thirdly, there is a drastic reduction in the amount of misunderstandings between the decision maker and the decision executioner, seeing as they are, again, the same person. Lastly, people who make their own commitments are more likely to put in the extra effort in order to fulfil those commitments.

It is, of course, impossible to transfer risk completely to another party. There are still consequences that we will have to deal with if the other entity does not complete their task on time or at all, even if they have to pay penalties, etc. There is usually a transfer in authority when a transfer in risk takes place. The more risk a single entity assumes, the more lucrative it must be for that entity, and the more management freedom it needs. For example, if a customer agrees to a CPFF contract, they will definitely want a larger stake of management oversight on the project. This is not only for the sake of reward, but it is also necessary in order for that entity to be able to effectively manage the risks.

Risk transfer usually means that another type of risk will be inherited. For instance if some of the financial risk is transferred by subcontracting some of the parts for a particular system out, an increased management risk is assumed, seeing as there are more logistical issues to manage.

5.5.4 Risk Retention

Risk retention, or risk assumption, is an acknowledgement of the existence of risk while accepting the consequences of the risk if the failure actually occurs [7]. Often the costs of avoiding, reducing or transferring a risk is too high, especially when the impact of that risk is not severe or fatal. When the cost exceeds the benefit, it is usually better to do nothing about the risk. It must be stressed that this response should only be used when there is absolute surety that the risk consequences are not going to be severe or fatal [3].

5.5.5 Knowledge and Research

This is a function that is initiated when the project manager assumes responsibility for developing extensive testing and simulation plans in order to predict the results of the risk. In order to achieve this, they make use of methods, techniques and tools which are available in decision analysis disciplines. Some of these tools were discussed earlier in this chapter (Decision Tables and Trees) and will not be discussed further at this stage.

Numerous other tools have been developed to help the risk management process, of which one of the more notable ones is *Total Risk Assessing Cost Estimates*, or TRACE, which was developed by the United States of America Army. This tool considers the cost of risk for a command and pools resources against the total assessed risk in order to share the resources according to needs over time [7].

5.5.6 Risk Plans (Contingency Planning)

A risk plan shows the project staff what risks will be reduced, and how. A plan should start with a list of all the risks whose consequences are the most unacceptable. The process that will be followed to alleviate the risk can be done as a “post-hoc remedial” action, which will compensate for the impact of the risk, preventative action can be initiated by preliminary risk symptoms, or action can be taken in parallel to the original plan [3]. Resources are then allocated to the

reduction of each risk a priori. Finally, the plan should address the remaining residual risk items by providing margins and contingencies [5].

Contingency can be thought of as an antidote to risk [6]. An increase in the amount of contingency inherently means a reduction in the overall risk. However, contingency comes at a cost, and has to be balanced against the triple constraint; i.e. the benefits of the contingency has to be weighed up against its effect on the budget, schedule and performance, along with its effect on quality.

With respects to the performance of the project, contingency planning should not be exaggerated. Even without the performance contingencies, the project's "lean" performance goal (announced performance less contingency) should still be attainable.

Due to the nature of projects, contingency is mostly measured in terms of the budget and schedule. Things usually require more time and money than is initially estimated by the project planners. Table 5.4 below gives an idea of all the elements that could affect either the cost or the budget as a whole.

Resource Availability	Security Clearances
Resource Conflicts	Remote Locations
Motivation	Currency Rates
Higher Priorities	Rate Changes
Interactions Between Project Staff	Travel Delays
Miscommunications	Customs Duty Clearance
Approvals	Customer Procedure Compliance
Support from Other Groups	Testing
Subcontractor delays	State of the Art
Labour Strikes	Computer Downtime
Mistakes	Staff Training
Inefficiency	Personnel Resignations

Table 5.4: Elements That Could Affect the Project [6]

Inserting Contingency:

There are mainly five (5) ways of inserting cost and budget contingency into the project plan [6]:

1. Have everyone who makes an estimate give a contingency for the time and costs. This is sometimes problematic, seeing as people then start adding contingencies to tasks that already have contingencies built into them.
2. Add a small amount of contingency (5% – 10%) onto each activity in the network. This method works fairly well, but is usually not very accurate, due to the fact that some activities can be estimated accurately, and some not. The contingency added to each element might either be inadequate or excessive.
3. Add an unplanned (and unrequired) activity. A drawback of this method is that it does not necessarily add a time contingency onto the schedule.
4. Add one or more additional, plausible tasks near or at the end of the network. It has the effect of pushing activities forward from the project's scheduled completion to the earliest possible point. This provides the schedule contingency. Seeing as these tasks have costs assigned to them, a cost contingency is also applied indirectly. This is a variation on the third method.
5. This method varies from the second method in that it is explained to each person involved in making estimates that the contingencies have to be as accurate as possible. The entire group can now discuss how much contingency to put onto each activity. This contingency should be decided upon based on the discussion in this chapter on the risks of the activity.

5.5.7 Risk Control

This is the process of continually sensing the condition of a program and developing options and “fall-back positions”. This will permit us to have alternative lower-risk solutions [7]. Risk control consists of monitoring the use of margins and reserves, reassessing risks, replanning risk reduction and evaluating the impact of proposed changes on risk.

Monitoring the use of margins and reserves:

Each person responsible for a specific area of the project where there are contingencies built in should periodically calculate the following two ratios:

1. The ratio, or margin, of reserve that has been consumed
2. The ratio, or percentage, of work that has been completed successfully.

The latter of the two ratios is based upon current estimates of total work required, as discussed in Chapter 4.3.

Reassessing Risks:

When the two ratios calculated in the previous section, the reserve ratio and the work completed ratio, and either, or both, these ratios exceed 1.0, it is recommended that the causes for the risks be reassessed and reanalysed. Reassessing the risks entails the identification of previously unidentified risks.

Replanning Risk Reduction:

Risk reduction plans should be revised periodically, based on the results of the risk reassessment in the previous section.

Evaluating the impact of changes on risk:

When new changes are proposed, the managers of the related elements that could be affected by the change should assess the risks that could be introduced by these changes. This should be done carefully and consistently, seeing as these changes are usually the cause of matters getting out of hand.

Project risk management is performed in a very specific context every time it is applied. It requires detailed knowledge and insight into the context of each project element. Albeit extremely important, these two factors alone will not help the project manager much if he does not know the mechanics of identifying, assessing, analysing and responding to risks, as discussed in this chapter.

6. Microsoft® Project 2000® Tutorial

Modern day project management has become fairly simplistic by means of effective and efficient computer software. Of the project management software programs that are available on the market today, Microsoft® Project 2000® is probably one of the most available and widely used. In this light, a tutorial in Microsoft® Project 2000® is included. It is recommended that the reader completes the tutorial before attempting to complete the case study that follows it. The entire tutorial is available in Appendix C. Additionally, the reader also requires access to a computer with Microsoft® Project 2000® installed on the machine.

This chapter gives a brief overview of the tutorial development process.

6.1 Layout and Framework

The framework of the case study is based on a case study that was developed by Dr. C.J. Fourie [18]. This case study covers most of the important features of Microsoft® Project 2000®, as will be needed by the reader attempting to successfully complete the case study that was developed as part of this thesis. The case study is also aimed at a wider audience. It is applicable to anyone wanting to learn the basics of Microsoft® Project 2000®. The example used in the tutorial is a simplified version of the case study which can be seen in Appendix A of this document.

The tutorial consists of four main parts: starting up, creating the project plan, evaluating the project plan, and checking the project progress. These four sections form the major tasks in project management with Microsoft® Project 2000®. A brief overview of each of these sections will be given shortly.

The tutorial was developed to make it as simple as possible to understand the tutorial and to use it. In this light, there are numerous screenshots included which will guide the user through all the steps that have to be taken in order to complete

the tutorial. These screenshots are backed up by short discussions on them, as well as an explanation on the functions illustrated and highlighted in the tutorial.

A brief introduction to the need for project management, what needs to be considered when considering the purchase of project management software, and management areas is provided as an introduction to the tutorial.

6.2 Starting Up

This section gives a brief overview of the main functions in the program. These functions include starting up the program, an explanation of the main toolbar and a brief overview of the standard menus that are used in the tutorial.

6.3 Creating the Project Plan

In this section, an overview is given of what must be accomplished in order to create an effective project plan. This section consists of three subsections, namely: setting the scene, entering the tasks, and entering the labour and resources.

In the first section, the user is guided through the activities that are necessary in order for the project to be placed in an effective global perspective. This includes setting up the working week and holidays, entering in the project start date, and so forth.

The second section consists of the user filling in the various tasks that will be required of the company in order to complete the proposed project. These tasks are then linked to human and material resources, and the duration of each of the tasks are also fed into the system.

6.4 Evaluating the Project Plan

This section, which forms the largest part of the tutorial, covers such aspects as determining the critical activities of the project, the project slack, resource

levelling, both manually and automatically, and finding general information on certain aspects of the project.

The user is led through a purposeful and fairly complete set of activities in the tutorial from which the user can effectively evaluate whether or not the proposed project plan is sufficient or not.

6.5 Checking the Project Progress

In this section, the user is supplied with actual start and finish dates of some of the activities in the project. The user is then led through a series of processes during which the user learns to control the project with the aid of Microsoft® Project 2000®. This includes entering the actual task information, comparing the actual project with the baseline on the grounds of cost, schedule and labour variance.

It must be stressed that this tutorial by no means completely covers all the functionalities in Microsoft® Project 2000®, but merely serves as a starting point for understanding this program, with the ultimate goal of applying it in the user's environment.

7. A Case Study in Project Management: The Problem

7.1 Developing the Case Study

7.1.1 General Considerations

It was decided that this case study would have a similar lay-out to the existing case studies used in the Post-Graduate course in Project Management at the Department of Industrial Engineering at the University of Stellenbosch. The general layout of this case study is as follows:

- **General Overview:** A short description giving basic background information required by the student in order to place the case study in context.
- **Dialogue:** A concise dialogue from which the student must compile an activities list, determine the task precedences and task durations.
- **Further Information:** Information regarding the project work week, starting date, expected completion date, labour types and skills required for the various activities, resources required for each task as well as cost information.
- **Assignments:** The various assignments are relayed to the student throughout the entire document, as the various topics are addressed. A clear, definite task assignment must, however, be given at the end of the problem statement document, in order to eliminate confusion about what is required of the student.
- **Project Control Exercise:** Some information is relayed to the students regarding the progression of the project, and it is required of the student to perform a complete project control exercise. These requirements are relayed to the student clearly after all the relevant information is detailed.

In order to be able to compile the problem statement as detailed above, a few tasks have to be completed first. These tasks are described in some detail in the following paragraphs.

7.1.2 Developing the Task List

The list of activities that are to be used in this case study was derived by carefully dissecting several case studies in Project Management that focus on Business Process Reengineering (BPR) projects at software development companies, as well as at other service providing companies.

The objective was to develop a generic set of steps that are representative of an actual BPR project at such a company. For obvious reasons, the number of activities has to be of such an amount that they convey the general process, but do not lead to confusion or unnecessarily complicate the entire project. A complete list of these activities can be found in the Case Study Questionnaire, which is given in Appendix A.

7.1.3 Developing the Dialogue

The dialogue was written whilst ensuring all tasks are logically linked (i.e. their precedences are correct), their durations are correct and the resources allocated to each task is realistic. The tone of the dialogue is casual, representing a typical work meeting. Resistance is shown by one of the people in the conversation with regards to cooperation, again to ensure that the dialogue reflects reality. Although one would not always encounter resistance, it is the norm rather than the exception, and it was therefore included. The entire dialogue can be followed in the Case Study Questionnaire in Appendix A.

As can be seen from the dialogue, all tasks and subtasks are rewritten in bold and in brackets after they are stated in the casual conversation. This is done in order to ensure that all students extract the same tasks from the dialogue. This ensures further that the examiner does not have to contend with numerous different task lists, and resulting miscalculations, as well as the incorrect transferral of crucial information pertaining to specific tasks.

The activities are mentioned in the dialogue in the same order as they appear in the activities list. Again, this is done in order to facilitate the examination process,

as well as the information transfer process in the problem statement. We can now simply refer to “Task 4”, instead of having to refer to “Develop Communications Plan”, for example. It is further simpler to indicate predecessors when we simply have to refer to a task number, instead of a complete task name. The task numbers are derived from the Microsoft Project numbers that is automatically assigned to each task when it is entered into the program. No milestones have been added, and it is therefore the responsibility of the student to add relevant milestones.

7.1.4 Determining the Resources and Resource Allocations

Actual case studies were found in order to develop a realistic resource pool for the case study. The number of resources required in order to complete each task in the project was determined by allocating certain resources to the specific tasks, which was also based on the actual case studies that were reviewed.

It was found that if the numbers quoted in the case studies were to be used, the project described in this case study would be hopelessly understaffed. It was therefore decided to increase the number of available resources, in order for the project to be marginally staffed. This means that if there was no time constraint on the project other than its intended duration, by using all the resources, the project would not require overtime from its resources in order to be completed. However, if any schedule changes were to be made that would reduce the project duration, additional resources would be required at an additional cost. The resources assigned to the project, along with their rates and opportunity costs are detailed in Table 7.1 below:

Resource	No. Avail.	Standard Rate	Overtime Rate	Cost / Use
Senior Analyst	1	R 200.00 / hour	R 300.00 / hour	R 0.00
Junior Analyst	13	R 100.00 / hour	R 150.00 / hour	R 0.00
ITDS Programming Manager	2	R 150.00 / hour	R 225.00 / hour	R 0.00
Senior ITDS Programmer	3	R 100.00 / hour	R 150.00 / hour	R 0.00
Junior ITDS Programmer	4	R 68.75 / hour	R 103.13 / hour	R 0.00
Laptop Computer	12	R 20.00 / hour	R 20.00 / hour	R 100.00

Table 7.1: Available Resources in the Case Study

A complete list of where each resource is used, and the amount of hours that each resource is used for, is included in the Case Study Memorandum, which can be seen in Appendix B.

7.1.5 Theoretical Questions

Throughout the case study, the student's knowledge of specific theoretical aspects is tested. These areas are:

- The roles and attributes of the project manager
- The organisational project structure
- Computer Aided Project Planning system attributes and selection
- Critical Path Method (CPM) network theory
- Risk identification and management
- Project Control

The reason for the testing of the students' theoretical knowledge is to ensure that they understand the theory behind project management, not only the practical application. It further aims to highlight to the student the theoretical aspects that need to be addressed when dealing with an actual case, as well as when these issues need to be dealt with.

8. A Case Study in Project Management: The Solution

8.1 Introduction

The solution to this case study was developed in parallel with the questionnaire. This was done in order to ensure that the questions were formulated correctly, without contradictions, and to further ensure that the volume of work required from the students does not become too excessive. The entire Case Study Memorandum can be seen in Appendix B. This chapter aims to briefly explain how the solutions were generated, as well as why certain solutions were not generated. It will follow the flow of the Case Study Questionnaire, which is the same as the flow of the Case Study Memorandum.

8.2 Assignment 1: Organisation and Project Leader Selection

8.2.1 The Role and Qualities of the Project Manager

This is the first of the theoretical questions in this case study. The answer was developed through researching several documents and textbooks on project management [2, 3, 6, 7]. The main solution as to the role of the project manager is given in a diagram format. This was done, seeing as there could be several variations in how the students describe the roles of the project manager, and a graphical representation makes it easier for the examiner to know whether or not the student is correctly explaining the roles of the project manager. A list of additional roles and attributes is also given, and it should be expected of the students to elaborate slightly on these.

8.2.2 Selecting the Project Organisational Structure

An overview is given of the three main organisation structures used in project management today; namely the Matrix Organisational structure, the Functional Organisational structure and the Separate Business Unit project organisational structure. A short list of the advantages and disadvantages of these structures is

also provided. In conclusion, a suitable structure for the case study project is recommended with a few reasons given.

8.2.3 CAPP Selection

Guidelines are discussed on whether or not a person should implement a CAPP system for their specific project. These guidelines are very general, and it is expected of the student to include reference to these guidelines in their solutions. A short list of the main selection criteria for a CAPP system is also given and slightly elaborated on. Finally, samples are given of what is more or less expected of the students regarding the student's decisions to either implement/not implement a CAPP system, as well as to which CAPP system they are planning on implementing.

8.3 Assignment 2: Project Planning and Risk Identification

8.3.1 Task List, WBS, Baseline CPM Network

In this section, the full baseline planning report should be developed. This entails the development of a task list, a WBS, as well as a baseline CPM network. Additionally, the resources have to be appointed and the resource loading completed in such a manner that they have minimal overlap without causing a delay in the project completion time. A resource loading chart and resource sheet should also form part of the deliverables for this section of the case study.

Task Precedence List: This list was developed before the majority of the case study, as described in the previous chapter, in that the tasks and their precedences form the basis of the rest of the project. This complete list can be seen in the Case Study Memorandum in Appendix B.

Work Breakdown Structure: The WBS was developed shortly after the task list and precedences. This was done to ensure that the tasks follow logically, and that the tasks do not overlap. It graphically represents what is said in the case study dialogue (Chapter 3 of the Case Study Questionnaire in Appendix A). The WBS can be seen in the Case Study Memorandum in Appendix B.

Baseline CPM Network: The CPM network was developed in Microsoft Excel, to ensure that the calculations needed in the development of the CPM network are done consequently and correctly. The matrix structure of MS Excel also makes it a very suitable application for this. The CPM network was initially developed before the Case Study dialogue, but was redeveloped after the dialogue was developed to ensure that the dialogue was developed correctly and effectively. This CPM network was also compared to the CPM Network generated by Microsoft® Project® after the project tasks, durations, resources and costs were read into Microsoft® Project®. The MS Excel version of the CPM Network can be seen in the Case Study Memorandum in Appendix B. The MS Project® version can be seen in the attached software copy of the MS Project® baseline file.

Baseline Gantt-Chart: The Gantt-chart of the project was derived from Microsoft® Project® after the tasks, their durations, their costs and resources were read into the program. This chart can be viewed in the Case Study Memorandum in Appendix B.

Required Resource List and Chart: The required resource list was also extracted from MS Project® after all the tasks, their durations, the resources required and the resource costs had been imported. This list states the required number of hours from each resource for the entire project. Additionally, this information is portrayed in graph format. Both the resource list as well as the resource chart can be viewed in the Case Study Memorandum in Appendix B.

Baseline Costing Report: This report was developed in order to determine what the baseline cost of the project is. It was developed for each resource used in each task and subtask, and then aggregated as the WBS level of the specific task increased. This report can be seen in the Case Study Memorandum Appendix B.

8.3.2 Qualifying CPM Networks

This theoretical question was again answered by means of a short literature study and a summary of the masses of information available on this topic. A

thorough overview is given to explain how the CPM network system works. The advantages of the CPM network over the PERT networks are also discussed briefly.

8.3.3 Risk Identification

In this question, it is expected of the student to develop a list of risks, their consequences and contingencies, as well as to develop a “new” CPM network that shows how the student incorporated contingencies into the project planning process. Due to the variety of answers that can be expected, a complete solution to this problem cannot be provided. However, an extensive list, which was adapted from [19], of the possible risks, their expected consequences and possible contingencies for the risks are given here. Some guidelines are further supplied to the examiner regarding certain aspects that have to be addressed by the student when compiling a solution to this problem.

8.3.4 Project Crashing

In this question, the student is given an alternate, earlier, date for the project to finish. It is the task of the student to sufficiently adapt the baseline planning effort in order to provide a viable solution to the “new” problem.

Certain guidelines are supplied to the student in order to eradicate any possible confusion or irregularities regarding the answering of the question.

The solution to this question can also not be supplied, due to the variety of answers that can be expected from the students. However, specific guidelines are given as to which tasks can be crashed, and guidelines that the student have to comply to in order to complete the crashing exercise successfully.

A full baseline costing report is also expected of the student. It should have the same structure as the cost report given in Appendix F of the Case Study Memorandum. All areas amended by the crashing exercise should be addressed correspondingly in the costing report.

8.4 Assignment 3: Project Control Exercise

8.4.1 Project Control

In this question, the student has to develop a complete progress report from project cost data given to him/her.

The answers supplied to this question are worked out completely, and given in two parts: Project Variances and Project Estimations.

Project Variances:

Under project variances, all possible variation calculations were supplied. These include:

- Time Variance
- Cost Variance
- Schedule Variance
- Schedule Performance index
- Cost Performance Index

Even though the results of the calculations above can lead to similar conclusions about the project status, they are all given for completeness sake. Some students might not calculate all the complete list of variances, and it therefore also necessary to provide a complete list of possible variance calculations. The same is applicable to the list of estimations given below.

Project Variances:

The following project estimations are supplied to the examiner:

- Estimated Cost to Completion
- Estimated Cost at Completion
- Required Performance

The reader is referred to the Case Study Memorandum in Appendix B for details regarding these calculations. The significance of each of these indices is also explained there.

9. Summary, Conclusions and Recommendations

9.1 Summary

Project management is widely seen as critical to project success. The problem, in the majority of cases, is that the person supervising the project management of a specific project does not have adequate training in project management. Although the person might have the technical knowledge, which is critical to the success of the project, he might lack specific project management knowledge, especially in the areas of risk management and project control.

This research study and case study development project was aimed at bridging this gap, through the creation of tools to aid the education of current and prospective project managers. These tools include a comprehensive case study which details the project planning process, contains a section on risk management, and a comprehensive section on project control. An additional tool is a tutorial in Microsoft® Project 2000®. This tool was developed as a supplement to the case study, but can be completed independently, due to the fact that the example on which the tutorial is based is an independent example, albeit based on the complete case study which was developed.

The case study is based on a business process reengineering project at an Information Technology development company. Although fictitious, the tasks, their duration and resources are based on the amalgamation of information gathered through numerous actual case studies found in literature.

In order to ensure that all relevant areas of project management are covered by the case study, a comprehensive literature study on project management was undertaken. The emphasis of this literature study was on project planning and risk management, due to the fact that these are the areas in which the majority of project managers have received inadequate training. Consequently this forms the emphasis of the case study.

Developing a case study is not as menial a task as one would think. It involves constant reiteration and information addition as the development process continues. The questionnaire and memorandum should be developed concurrently, in order to ensure that the information provided in the questionnaire is, firstly sufficient, and secondly descriptive enough.

Although the case study was developed as an alternative project for the post-graduate course in project management at the Department of Industrial Engineering at the University of Stellenbosch, it can be presented as a completely independent project. It is, however, recommended that the person wanting to attempt the case study completes the tutorial in Microsoft® Project 2000® as well. This will greatly aid the person in the completion of the case study. Further, the person should have a fair amount of academic knowledge of project management. This knowledge can be gained by a series of lectures, as is the case with the post-graduate course, or a comprehensive study of the first section of this thesis project.

9.2 Conclusions

The developed case study and tutorial provides the material to effectively and sufficiently bridge the gap in project management knowledge in, especially, the services sector. Emphasis is placed on risk management, where the largest knowledge gap lies. It is imperative to understand that these tools will not reduce the knowledge gap on their own. Dedicated completion of the tutorial and case study should, however, reduce this knowledge gap considerably.

The developed material can also be applied successfully as a project and tutorial for a post-graduate programme in project management, as was the original intent of this project.

A thorough study of the literature study in this document will further reduce the knowledge gap substantially. To the author's knowledge, no single document or book exists that contains such a broad scope of project management topics as

was covered in this literature study, even though these topics were only covered superficially. Most books and research are usually focussed on a few aspects of project management, and only fleetingly discuss other areas, such as risk management within projects in the services sector.

9.3 Recommendations and Future Study Possibilities

This project topic does not lend itself to more expansive studies. However, it is recommended that the interaction between risk management and project control be researched further. Also, the incorporation of risk management into the Tutorial on Microsoft® Project 2000® could be expanded further. The development of further tutorials in the areas of risk management within the services sector is recommended, in order to further fill the inadequacy in this region.

The amount of research done on risk management in the services sector is sadly lacking, and it is an area which offers extensive future research possibilities. It is apparent from literature that the majority of Risk Management strategies are aimed at the manufacturing sector, and the relevance of these strategies in the services sector is to be questioned.

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Appendices

Appendix A: Case Study Questionnaire



University of Stellenbosch
Department of Industrial Engineering



A Case Study in Project Management – Questionnaire

Developed by: T.C. Boezaart (12333514)

For

Dr. C.J. Fourie

19 November 2003

Declaration

I,, herewith confirm that the answering of this Assignment is my own work, and that I have not discussed the Assignment or the answer with anyone other than my course leader.

Signed at on (date)20.....

Signature

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1. Introduction

1.1 Introduction to Business Solutions Consulting Incorporated

Business Solutions Consulting (BSC) Inc. was established in 1980 in a small town called Stellenbosch in South Africa. This company was initially established as a spin-off company by the University of Stellenbosch's Department of Industrial Engineering. Initially run by faculty staff, the company grew rapidly and became a completely independent entity. BSC Inc. still contributes largely to the Department of Industrial Engineering in terms of research funds, practical projects for students, part-time work for post-graduate students and practical research.

The company is spearheaded by Dr. C.J. Fourie, who joined the company after retiring from the academic environment in 1995. His sound business principles and practices quickly established the company as a major player in the South African consulting market, regularly winning contracts over other larger multinational consulting companies. The atmosphere at BSC Inc. is relaxed, yet highly professional, and an open-door policy is practised throughout the entire company.

When joining BSC Inc. as an analyst, one would start out as a junior analyst, progress to senior analyst, or project leader, and then become an account manager. Account managers with a sound track record and a history of sound judgements and successful projects, are invited to become consulting managers. There are three consulting managers at BSC Inc. who report to Dr. Fourie, the Chief Executive Officer (CEO).

1.2 Introduction to IT Development Solutions, Inc.

The software development world is becoming increasingly competitive, and long lead-times for the development of software solutions are taboo. It's an extremely competitive market, where major players are regularly swallowed up by smaller,

A Case Study in Project Management: Questionnaire

more responsive and agile companies. In this light, IT Development Solutions, Inc. (ITDS) is convinced that they can reduce their software development lead time by means of a BPR project focussed on their software development process.

ITDS mainly conducts three kinds of projects. The first is the development of new software solutions due to new market demands. The second type is the updating of existing software solutions due to changes in the marketplace and the ever improving computer hardware market. The third kind of project is the development of a new software solution for an existing problem for which there is an existing software solution that has been proven inadequate.

The software development time-span is extremely variable, and depends largely on the type of software being developed, as well as the functionalities needed in the final computer program. Therefore, IT Development Solutions, Inc. handles the development of each software solution as a separate, unique project. This means that a lot of time is spent on the project planning and documentation processes surrounding the actual development.

IT Development Solutions, Inc. does not have the in-house expertise to execute a business process reengineering (BPR) project. Knowing this, IT Development Solutions, Inc. approached Business Solutions Consulting (BSC) Inc., who has a proven track record of successful BPR projects, to manage and coordinate this BPR project. A clean slate with respects to process visibility and cooperation has been given, but the cost of the entire BPR project must be reduced to a minimum.

Your consulting manager, Mr. T.C. Boezaart, suggests that you, a new Senior Analyst and project leader in the company, should manage this project, seeing that you have only worked on construction and manufacturing BPR projects. Successful completion of this project would inevitably mean a broadening of not only your own skills, but also the areas in which BSC Inc. can use you.

2. Assignment 1

Justify your consulting manager's decision on making you project leader by expanding on the roles that will be required of you as project manager, as well as the qualities you should possess in order to be an effective and professional project manager.

Now that you are also convinced that you possess the necessary qualities required to be an effective project manager, one of your first tasks is to select an effective organisational structure for the project. Compare the major organisational structures, state which structure you would choose and also state why you chose the specific structure that you did by elaborating shortly on the advantages and disadvantages that the selected type of organisational structure has above other structures in this project.

Determine whether or not it is feasible to use a CAPP System for this project. Explain which criteria you would evaluate in order to select an appropriate CAPP software program in order to help you to facilitate the project planning process. On the basis of these guidelines, explain which software package you would select, and why.

3. Information Gathering Meeting

Having selected the organisational structure, the information gathering process is started by a series of conversations with a couple of experienced senior project managers, Mike and Charles, at BSC, Inc. They have both worked on software development BPR processes in the past. The conversation went somewhere along the lines of the following:

Project Manager: Good morning guys. Thank you for taking the time to attend this meeting.

Mike & Charles: Morning.

Project Manager: Dr. Fourie said you are the guys to talk to when it comes to software development BPR projects. Apparently you guys are the guru's!

Mike: Yip, but I still don't understand why they gave a greenie like you such an important project. Maybe we should leave you to figure it out on your own, hotshot!

Charles: Come on Mike, you were also where he is now, and after all, we are all on the same team, so let's try and help him. He might even be your boss one day!

Mike: Whatever! Ok, I'll try to be more cooperative. I suppose the sooner I help him the sooner he will be out of my hair!

Project Manager: Ok, guys. I know it's an important project and you guys are much more experienced than I am, but how am I going to become experienced if I am not exposed to projects of this importance. I am also nervous about it, but it does not change the fact that I still have to complete it successfully. ITDS is potentially a very big client, and we really have to make sure that we do a good job on this project.

Charles: You're right. We really have to do a good job on this one. Ok, you have my full attention for the next few hours, but I have a

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- few projects running which really need my attention. Can we wrap this up as soon as possible please?
- Project Manager: Ok. But before we get started, Mike, can I count on your support, please?
- Mike: Ok. I suppose I don't really have much of a choice in the matter. Let's get started please.
- Project Manager: First things first. I have selected an organisational structure according to what you guys have done in the past. Mr. Boezaart also helped me with this.
- Mike: Well, glad you could sponge off us! Just a joke!
- Charles: The first work package is what we commonly refer to as Vision and Plan Generation. (***Vision and Plan Generation***) This package consists of several steps which have to be completed before we can go on to the next phase. Mike, Interrupt if you think I'm leaving anything out.
- Mike: Don't worry, I will!
- Charles: Thanks. The first task in this work package is to determine whether or not you have the management at ITDS's full support (***Solidify Executive Sponsorship***). You should do this yourself, but get the help of their Programming Manager. This should not take you more than a day, but it is critical that this is done. Without their full cooperation, the project will not be successful.
- Mike: Yes. I've had problems like that in the past, and the complete project fell to pieces at about the half way mark.
- Project Manager: Ouch! That must have been painful; having invested all that time and money and not getting any results!
- Mike: Yip, but fortunately we identified it as one of the major risks, so we were able to come off not too badly. Back to business. Once you've made sure that you have management's backing, you have to select the project team, and make sure

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that they are all available and ready (**Establish Project Teams**). This is usually not a very complicated task, but it can be a little difficult to contact everybody. You should also do this. It establishes your authority over the project.

Project Manager: How long should I budget for this?

Charles: I think probably two days or so.

Project Manager: How long is "or so"? Sorry, but I have to be quite accurate with these things, otherwise I am sure to run out of time at the end.

Mike: Who do you think you're talking to? A couple of rookie project managers? We know this business much better than you do, buddy.

Charles: Ok, Mike! Relax! The kid has a point though. Two days should be a good estimate, but if you push it you could do it in one day. Bargain on two days, though! This is of course assuming everyone is contactable. I would also suggest you do this yourself. It just enforces your authority over the project.

Project Manager: Ok. What next?

Mike: The next two things you have to do in parallel to each other. You have to define a project organisation and determine the scope of the project (**Define Project Organisation and Scope**), and develop a communications plan (**Develop Communications Plan**). The first of these should take you one day at most, and you will need a Junior Analyst with a laptop to help you. The Communications plan can take up to three days, and you can give this to two Junior Analysts with one laptop between them.

Project Manager: Is that accurate enough Charles?

Charles: Yes, I would have suggested the same durations. Once the organisation is accurately defined and the communications

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plan is ready, the next major step is to compile a complete project plan (**Develop Project Plan**). This can be tricky, and involves quite a lot of communication between you and the rest of the project team. It is crucial for it to be done accurately and correctly. If you get this one right, the rest of the project will be a breeze, so take your time.

Project Manager: I know. This has proven the crux of many of the previous projects on which I've worked before. How long do you think I should spend on this?

Mike: Bargain on about ten days. It is a complicated process. The previous two tasks usually form part of this document, so you have to make sure you complete them first. As Charles said, take your time on this. If you really need to, you can cut this time by about 5 days, but you will pay for it later! You will need the help of three Junior Analysts on this, as well as a laptop for each of them, just to smooth things over a bit. And of course, you have to help these guys with this!

Project Manager: It feels like this is the end of the first phase of the project. Am I right?

Charles: Yip. This is the end of the first work package. Don't underestimate it though. It can be tricky and many projects have failed because these things were not done meticulously.

Mike: The next work package is a biggy. But make sure the previous one is completely finished before you try to jump ahead to this one. You'll probably spend most of your time and money on this one. We call it the assessment and identification work package (**Assessment and Identification**).

Charles: Ooh, yes. This is quite a big one. But it can be broken down quite nicely, and lots of the stuff can be done in parallel, if

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you have enough manpower. Lots of time can be saved if this phase is completed with lots of people. It can also cost you a lot of money, though. Just don't let your analysts spend too much time trying to find the small stuff. The emphasis here is on identifying the big possible improvers quickly. The quicker, the better. But they must still be thorough enough not to skip over some of the slightly hidden stuff.

Project Manager: I'm losing you guys a little. Sorry. Maybe I'll understand better when I know what this phase entails.

Mike: Sorry, I forgot for a second you are still a greenie! Ok, this step consists mainly of five sub-steps, of which four can be done concurrently if you have the manpower available. These tasks all break down quite nicely. I suggest you break them down before you give them to your new junior analysts to do. They will be a bit overwhelmed otherwise.

Project Manager: Let me get this straight. Five tasks that each break down into further subtasks?

Charles: Yip. These five tasks are: assessing the process as-is (**As-Is Process Assessment**), assessing the organisation as-is (**As-Is Organisational Assessment**), assessing the financial aspects of the as-is process (**As-Is Financial Assessment**), assessing the IT infrastructure of the company (**As-Is IT Assessment**) and finally developing the reengineering opportunities report (**Develop Report of Reengineering Opportunities**).

Project Manager: Yikes! That's quite a mouth-full. I understand what you meant when you said the new analysts might be a little overwhelmed! How do these things break down?

Mike: Fortunately most analysts already know intuitively how these things are broken down. Nevertheless, don't take a chance

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on them guessing the steps. Rather break it down for them, just to make sure all your bases are covered. Remember that you ultimately carry the responsibility for this project and management will be after your head if your analysts leave out steps!

Project Manager: I realise that, but thanks for the warning!

Charles: Ok, let's break them down one by one. Mike, feel free to jump in whenever I leave something out. We can start with the As-Is Process Assessment. This task consists of firstly analysing all process facets that are relevant to this BPR project (**Analyse All Process Facets**). This sub-task is usually the most unpredictable one when it comes to estimating its duration. I usually allow about twenty days for it, but some of my guys have analysed similar processes to the one you're working on in ten days, and other teams have taken thirty days. But twenty days should be a good start for an estimate.

Mike: Yes, this sounds about right. A good starting point, but just be careful with this one. Make sure you have a safety margin built into this. You will need quite a lot of people on this one. From our side you will need four Junior Analysts, yourself, and three laptops, and from ITDS's side you will need their Programming Manager, a Senior Programmer and a Junior Programmer.

Charles: Next, we have to develop process maps of all the processes that are being analysed (**Develop Process Maps**). This is usually done while we analyse the various processes, but we have to have moved along a bit with the process analysis. I would say start this task about four days after you have started the previous one. It doesn't take too long. I would give it about three days or so, depending on your junior

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- analysts, of which you'll need three. You will also need one of the ITDS Junior Programmers and three of our laptops.
- Mike: I think three days should give you enough time. Remember most of your analysts are just out of University, and they must have drawn up hundreds of these things.
- Charles: Ok. You next have to gather process data (**Gather Process Data**). It is a good idea to do this after you've drawn up the process maps, because the process maps will help a lot in knowing where and when we have to gather the data. Again, this should not take you very long if your process analysis is going well. I'd say about two days with two Junior Analysts and a laptop.
- Mike: Hang on there Charles. Don't forget that they still have to gather financial data as well, but this can also be done while they gather the other process data (**Gather Financial Process Data**). Again, this shouldn't take more than two days with two junior analysts and a laptop.
- Project Manager: What is this financial data you are talking about? I thought it was the bean counters' job to worry about the financial stuff at ITDS.
- Charles: Thanks, Mike. I almost forgot about that one! This data is what you will use to measure whether or not the changes you make actually worked, in financial terms.
- Project Manager: Ok, I understand. The academic term for those measures are Financial Performance Measures, but let's not get technical!
- Charles: The next task that you have to complete is to analyse the Activity Based Costing information (**Analyse ABC Costing Information**). But this only gets developed when you do the As-Is Financial Assessment, which is usually done at the same time as this Process Assessment task. It usually only

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takes about three days to do this with one Junior Analyst, one ITDS Senior Programmer and a laptop, but quite a bit of flexibility in your project team is required here.

Mike: Usually more than just a bit! For some reason we usually have problems with the willingness with which the various teams want to exchange information. Somehow they think it is as if the other team is stealing their stuff, and they forget that we are all on the same team!

Charles: Yes, this is sometimes a big risk. Make sure you explain to your guys that they are all on the same side! Otherwise this task can drag you out for weeks!

Project Manager: I'll make a mental note of that one, thanks. This could probably set one back quite a bit when we start to duplicate work!

Mike: Hey, this guy is catching on quite quickly! Maybe he's not as green as we thought, Charles!

Project Manager: Thanks Mike, great to see the old dog is also coming around!

Charles: Ok guys, enough of that. We still have a lot of tasks to go through, so let's get moving.

Mike: Aw, lighten up Charles. There's always time for a little joke!

Charles: I know. I just have to be out of here fairly soon, so I'd like to get this done with. After you have analysed the ABC information, you have to perform automated simulations (**Perform Automated Simulations**). This is where you run simulations with the data that you gathered to make sure that the data you have is correct and representative of the process. All the previous subtasks in this task have to be finished before we start this, because we need the information. It takes a while to set up these simulations, so I would give it about ten days. What do you think Mike?

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- Mike: Considering that we sometimes have the wrong data and have to gather the correct data, ten days sounds about right. You'll also need three Junior Analysts each armed with a laptop if you want to do it in ten days!
- Charles: Good. After we have performed these simulation runs, we can really identify the process improvement opportunities (**Identify Process Improvement Opportunities**). This can sometimes be done quickly, depending on how sharp your analysts are, but I would say no more than two days or so. Remember that they will have run the simulations already and analysed the output data from this process as well. Use three Junior Analysts as well as a Senior Programmer from ITDS. The three Junior Analysts should each have a laptop as well.
- Mike: I think that about concludes this task, hey Charles?
- Charles: Yes, I can't think of anything else. Do you have any questions thus far?
- Project Manager: No. I'm still with you guys. What is the next task?
- Mike: The As-Is Organisational Assessment is usually a short task, and sometimes not necessary at all. I have a feeling that you will have to look at it in your case, though. It is an assessment of the organisational structure that is in place at ITDS. I just have a feeling that they can run their projects better if they rethink their organisational structure a little. Anyway, one of your Junior Analysts will have to assess possible organisational design issues (**Assess Possible Organisational Design Issues**) along with a Junior Programmer from ITDS and a laptop. Just make sure he doesn't spend too much time on it. It shouldn't take him more than tree days at the most. If you don't feel like there are any problems with the way they run their projects from an

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organisational point of view, don't waste time on this. Move on. Remember that this can be done at the same time as any of the other three assessments in this work package.

Project Manager: Ok, what next?

Mike: This is the other big one, which could take a bit of time. The As-Is Financial Assessment should not be underestimated. It involves quite a few steps, and none of them should be neglected. The first thing to do is an evaluation of ITDS's competitors (**Competition Evaluation**). One of ITDS's Junior Programmers should be able to help no more than two of your Junior Programmers with this, and they should be able to finish this in two days. They should be able to manage with one laptop between them.

Charles: At the same time, you can engage in a benchmarking exercise (**Benchmarking**). This will give you a good feel of what needs to change and what ITDS's competitors are churning out. Again, this should not take you more than two, maximum three days if you use one Junior Analyst with a laptop.

Mike: I would say three days, just to be safe.

Project Manager: This is great, thanks guys. We are really making some progress.

Charles: Don't get too excited yet, young man. We still have a lot of ground to cover! The next thing you have to do to finish this task is to gather the relevant costing and financial process data (**Costing and Process Data Collection**). You don't have to wait for anything to do this, except your people. You can start this at the same time as the competition evaluation. You'll need two Junior Analysts with a laptop each and a Senior Programmer from ITDS.

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- Project Manager: Can't the same guys who do this for the process assessment also do this at the same time?
- Charles: They can, but the type of data they have to gather usually differs and the guys usually look at different things, so I usually keep them separate. This should also not take longer than three days in total.
- Mike: Yeah, that sounds about right. We next have to develop the ABC model that we were talking about analysing in the process assessment task (**Create ABC Model**). If you gathered the correct data, this should get done in about two days. If the data is not correct, an extra two days can be spent on this quite easily. But we are positive, aren't we!
- Project Manager: Yip, very positive. Those days might come in very handy later!
- Charles: Don't bargain on them, buddy! They are usually gulped up by much more serious problems.
- Project Manager: Who will I need on this subtask?
- Charles: I would say use the same resources as you did in the previous subtask.
- Program Manager: So two of our Junior Analysts, two laptops and a Senior Programmer from ITDS?
- Mike: Yip. After you have collected the costing and process data, you have to run more simulations with the data you gathered earlier. This will help you to identify some of the bottlenecks (**Identify Bottlenecks by Running Simulation of As-Is Data**). You'll need two of our Junior Analysts, two laptops and some input from a Junior Programmer at ITDS. This simulation is specifically run on the performance data, so that ITDS can see where they spend most of their money and time.
- Project Manager: And who the slow programmers are!

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- Charles: The idea is not to point a finger, but to address a serious situation that has developed over a period of time.
- Project Manager: I know, I was just joking! What's next?
- Mike: Hang on. I haven't suggested a duration yet! Bargain on about five days. After all the subtasks have been completed for this task, your guys still have one subtask of compiling a report of their findings (**Identify Financial Improvement Opportunities**), but they shouldn't spend more than a day on it. Use two Junior Analysts, one ITDS Junior Programmer and two laptops for this. That's the end of the financial assessment. Not much financials involved, but it is based on financial performance indicators, so we'll stick with that!
- Charles: The next task is the As-Is Information Technology assessment. This will be particularly interesting at ITDS, seeing as it is one of their main drivers for their solutions development process.
- Project Manager: Yes, this should be interesting.
- Charles: The first thing that you'll have to do is to check what the latest technology available is (**Conduct IT Scan (New Technologies)**), whether here in South Africa, or abroad. This can be a little time consuming, seeing as a lot of time is spent on the internet looking for the latest IT technology, and there is a lot of it! Bargain on about four days if you use one Junior Analyst with a laptop.
- Mike: Yes, that sounds about right. Four days and one analyst should get you quite a nice overview of what is available.
- Charles: After this, you have to determine the possible value of these new technologies you identified to ITDS (**Establish Value of New Technologies**). This can be a little tricky, and you will need a lot of input from the ITDS guys here. Let the Junior Analyst you used in the previous subtask work with their

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Programming Manager on a laptop. This can take up to four days, but it is essential that it is done correctly, so don't neglect it!

Project Manager: I understand the importance of this for ITDS, so don't worry, I will make sure it gets done thoroughly.

Charles: The next thing is to assess whether ITDS is ready for this technology or not (**Assess Readiness to Implement New Technologies**). This can be tricky, and one of your Junior Analyst will have to work closely with a Senior Programmer at ITDS. He will also need a laptop. It might mean that they will have to upgrade all their systems, so make sure you do this right. You can do this straight after the IT scan.

Project Manager: How long will this take?

Mike: I would say about five days at the most.

Charles: Sounds right. A further task that can be completed after the value of the new technologies has been established is to identify the high value vs. low readiness technologies (**ID High Value/Low Readiness Technologies**). These are all the technologies that can contribute greatly to the process, but can be installed very easily. This shouldn't take very long if you've done your work when you were establishing the value of the new technologies. I would guess about two days or so if you use one Junior Analyst and one of the ITDS Junior Programmers.

Mike: That long? Remember all the hard work has been done. It's just a matter of going through a list with the IT guys. I wouldn't spend more than a day on it.

Charles: You're right. One day should be ample. At the same time, one should identify and eliminate the low value technologies (**Identify and Eliminate Low Value Technologies**). This should also not take more than a day if you get a Junior

Programmer from ITDS to help one of our Junior Analysts. The next task is a little trickier. It involves a process of constantly monitoring factors that could improve the readiness level of ITDS to implement new technologies (**Monitor Factors that Might Improve Readiness Levels**). This is a process, and can take a while, but I think the most important aspect is for you to just identify the factors and to monitor them for a week or so, and then tell their IT guys to carry on monitoring it, and when they are ready, to implement the new technologies. So give it about six days. Don't allocate more than one Junior Analyst with a laptop to this subtask. It's ample.

Mike: That's a good idea, Charles. It can be a tricky job, but six days should be enough.

Project Manager: When do I start doing this?

Mike: It can be done as soon as you complete the Readiness Assessment. Remember, after you have completed all the subtasks for this task that you have to write a report on your findings in this task (**Identify IT Improvement Opportunities**). It's very important, and you will need three of your Junior Analyst who'll need two laptops and a Senior Programmer from ITDS to get this done. You should be able to do this in a day.

Charles: All that is left to do now in this work package is to develop a report of the reengineering opportunities we identified throughout the previous four assessment tasks. This is fortunately not a very complicated procedure, and shouldn't take very long, seeing as we have already compiled reports at the end of each assessment, which details what was found during that specific assessment.

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- Mike: Yes, but I think it is still important to break it down into smaller chronological tasks. I would suggest the following four subtasks: Firstly, conglomerate all the assessments' findings (**Conglomerate Assessment Findings**), which shouldn't take more than three days if you use two Junior Analysts and a laptop. Secondly, rank the opportunities according to their possible impact on reducing the process time (**Rank Opportunities**). This should not take more than a day with the help of two Junior Analysts and a laptop. The third step is to develop recommendations on how to implement these opportunities (**Develop Recommendations**). This is not that simple, but shouldn't take more than three days or so if you use the same resources as in the previous step. Finally, we have to draw up a report with all the opportunities and recommendations (**Draw up Report for Management**). You and three of your analysts should be able to do this in two days, with the help of two laptops. They should be quite proficient at report writing after their Master's degrees!
- Charles: They sure should be! I like the idea of breaking this task down. It makes sense.
- Project Manager: Hopefully that is the end of this phase! You guys were right, it's quite a biggy!
- Charles: Yes, it is the end. It is now up to management to decide which of the opportunities to implement. It is usually done quite quickly, and they don't easily reject your suggestions, because you know the project and the process.
- Project Manager: I sure hope so! What is the next thing on the agenda?
- Mike: The next work package is the development of new processes (**Develop New Processes**). After management has approved some, or hopefully all, of you

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- recommendations, they will have to be implemented. Before you can implement them, you have to develop them, though!
- Charles: That makes sense! This process is quite generic, and cannot really be broken down much. Nevertheless, we will break it down into five relatively large tasks. This process shouldn't be difficult if you did your work in the previous work package well!
- Mike: Yes, *if* you did your work well! I'm just kidding. I have a lot of confidence in you!
- Project Manager: Ha Ha! Whatever!
- Charles: The first task is to develop some ideas as to what you would like the system to be when you are finished (**Determine To-Be System**). Remember that you cannot get to your destination if you don't know where it is! If we assume that you did your work in the previous task properly, it should take about four days or so for three Junior Analysts with two laptops to develop a few decent alternatives.
- Mike: Sounds about right. It can be done quicker, if you have a few sharp analysts, but four days should be enough.
- Charles: The next task is to develop the steps with which you are going to get from the old system to the new system (**Determine Steps (Ideas) to Attain To-Be System**). Get your three top Junior Analysts with two laptops on this. Remember that ITDS still has to keep working while you change their process. You can't just stop the shop for a month while you change their process. This task could take you a while, I'd say about fifteen days, because you have to make sure everything is going to be right. Nothing can go wrong while you implement the new process. The consequences of a mistake could be devastating for them.

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- Project Manager: I know. I had a bad experience when I was still an analyst. It wasn't pleasant at all.
- Mike: Let's not scare him too much Charles. He still has a lot to do!
- Charles: Ok, but it is important. The next task is to test the various alternatives and their underlying assumptions, to make sure that they will work (**Test Ideas and Assumptions**). This is where we can eliminate some of the not-so-good alternatives. It usually involves a few simulation runs as well, and can therefore be quite a drawn-out process. I would say you should be able to do this in about ten days if you use three sharp Junior Analysts and two laptops.
- Mike: It can be done sooner if you have enough manpower, but it's going to cost you in terms of salaries and wages. But I'd say ten days are enough.
- Charles: Once you have sifted out the worst of the alternatives, you have to expand the remaining alternatives to a state where they can be thoroughly analysed and assessed (**Create Sufficient Detail to Develop Business Case**). You shouldn't spend more than five days on this task. Your junior analysts should already have a good feeling of which alternative will be the most likely candidate. You'll only need two of them, each with a laptop, though.
- Mike: It's something they should feel in their guts. Don't neglect this stage; you still have to prove to other people, like management, why you choose the alternatives that you would choose.
- Charles: Yip. That's very important. And on that topic, the last task is to develop a simulation or some form of visualisation of the best alternatives (**Develop Simulation or Visualisation**). This will go a long way to establishing which of the alternatives will result in the best solution. Be especially

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- accurate when you do this. Take about ten days and use four Junior Analysts with three laptops between them. They will need the computing power!
- Project Manager: That long? It sounds like too much time considering we created simplified simulations of the alternatives already.
- Mike: Remember that those simplified versions are no where near accurate enough. They only gave you an idea about which alternatives are the worst ones. You have to start from scratch again with these models. So I'd say ten days aren't too much.
- Project Manager: Ok, I understand. What's next?
- Charles: That's the end of this work package. We now move on to the final work package of the project, namely Implementation and Monitoring (**Implementation and Monitoring**). This is where a lot of time and money is also spent.
- Mike: More than you think!
- Charles: Some of the tasks in this work package could easily be mistaken for falling under the previous work package, but it is important to note that they form part of this phase, seeing as we have already developed numerous alternatives for the new process.
- Mike: Yeah, they confused the hell out of me the first time I had to do this!
- Charles: The first task is to identify the tangible benefits of each alternative (**Identify Tangible Benefits**). This is not as simple as it sounds, but a decent simulation model will take you a long way with this. I'd say this should take you about three days if you use three Junior Analysts, two laptops and one of ITDS's Senior Programmers.
- Mike: Yes, if the simulation models were accurate enough. The next task is to assess the risk factors of each alternative and

rank them and discuss them openly (**Assess Risk Factors**). You don't have to wait for the benefits to have been identified before you do this. They might help when you have to assess the risk levels, so use those findings as soon as they become available, but don't hang around waiting for them. You can do the risk assessment without them. It is also important to assess the risk level ITDS is willing to tolerate. Ask their Programming Manager to help your guys with this. Eliminate the alternatives for which the risk levels are too high. This should take you about four days if you use three Junior Analysts and two laptops. Be sure that you do this properly. You don't want to eliminate the goose that lays the golden eggs!

Project Manager: I sure don't want to be responsible for that one! It would probably mean my job!

Charles: At least! Nevertheless, just do a thorough job and you should be fine! After the benefit identification and risk assessment you should have decided on which process to implement, the next step is to draw up a final recommendations document (**Develop Final Recommendations Document**). This is to explain to management why you chose the solutions that you did. This shouldn't be too hard, and four of your analysts with three laptops should be able to do this in two days max, but then you should also help them.

Mike: Now comes the fun part! You have to implement the new process, once management has decided to agree with your ideas (**Implement New Process**). This can take a while, depending on the steps you decided upon earlier. I should think it shouldn't take you more than twenty five days, but you'll need quite a bit of manpower. If I was ITDS, I'd be quite upset if it took longer than that. Use yourself to help

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three analysts with three laptops. You'll also need help from their Programming Manager as well as a Senior Programmer.

Project Manager: Geesh! That's quite a lot of people!

Charles: Yes, you would have already spent so much time there, I'm sure that at this stage they'd want it finished! Once you have implemented the process you would have to make it operational (**Make New Process Operational**). This involves the preliminary training of the ITDS programmers as well as doing a few test runs to ensure the process actually works! Give yourself five days for this. Remember you're not changing their work, just the way they're doing it. So the training won't take very long. You'll need the same resources as you used in the previous task.

Mike: I'd hope it works! After all this stuff I'd be so upset if it didn't, I'd fire myself!

Charles: I agree! But we still have to evaluate the new process to make sure it delivers what we promised (**Evaluate New Process**). This is the final chance we will have to fine-tune the new process. Take your time with this. I'd say give it ten days, to make sure all the bugs are ironed out. You'll need input from a Junior Programmer and a Senior Programmer at ITDS, as well as two Junior Analysts with a laptop, and yourself, of course!

Project Manager: Is that it then? I sure hope so. I didn't expect this process to be so cumbersome. But I suppose if you want to do something properly...

Mike: Yip, it takes time and effort to do something properly! One last thing, before you think you are completely in the clear. Remember that if you don't teach these people to continually monitor and improve their systems, they will soon be back

where they are now (**Train Programming Supervisors**). You can do this at the same time as the new process evaluation. You'll need an ITDS Programming Manager to be trained by a Junior Analyst with a laptop. Just make sure that he explains to them exactly how to monitor their process and to let us know ASAP when the thing starts to run out of control again. Don't waste time on this. Get it done in two days maximum!

Charles: The final step is to hand over the project deliverables (**Hand Over Project Deliverables**). It should be quite simple, but it involves handing over all the relevant documentation, explaining to them exactly what we have done, answering all final questions, and collecting our final paycheque from them. We're not in the charity business, you know! It shouldn't take you more than a day to do this. You'll need to do this personally with their head Programming Manager, and you'll need a laptop to help you with your presentation. After this, you can buy your team a round of beers at Barney's!

Project Manager: Thank you for all your help guys! I really appreciate it. On the topic, though, can I buy you guys a drink at Barney's after work tonight?

Mike: I knew there was a good reason for helping this kid!

Charles: That would be great. See you around six?

Project Manager: Perfect! See you guys there!

4. *General Information*

4.1 *Project Times*

According to company policy, a standard 40-hour work week is to be used on this project. It is also policy that the BCS offices close over Christmas for a two-week period, so that work can start again on the first working day after 2 January of the next year (i.e. work starts again on 5 January 2004). The work week starts on a Monday at 08:00 and finishes on a Friday at 17:00. Lunch is usually taken at 12:00 for one hour.

The project is due to start on Monday, August 4, 2003. This is the earliest time that the ITDS personnel are available, due to their current project load. This date could present a problem, due to the duration of the project. The project will extend over the Christmas and holiday period, during which there are numerous public holidays as well, which have to be taken into consideration. ITDS requires that the project be completed “sometime” in February 2004. This could make the timing on this project extremely critical.

4.2 *Resources*

At BCS, the resource types in Table 4.1 below have been made available for this project. The standard cost of each resource, as well as their crashing cost, and cost per use is also given. For overtime, 50% is to be added to the standard costs in all cases except for the laptop computers.

Resource Type	Standard Cost	Crashing Cost	Cost / Use
Senior Analyst	R 200.00 /hour	R 250.00 /hour	R 0.00 /use
Junior Analyst	R 100.00 /hour	R 130.00 /hour	R 0.00 /use
Laptop Computer	R 20.00 /hour	R 20.00 /hour	R 100.00 /use

Table 4.1: Available BCS Resources

ITDS have made a number of their staff from middle management down available. These people will not be paid by BSC for their contributions, but a loss in productivity at ITDS must be considered when utilising these people. In Table 1 below, an estimated amount of lost productivity per day of use per employee type at ITDS is given. This is in effect the amount of money which ITDS loses due to the fact that these people do not work on their ITDS work.

The Crashing Time in Table 4.2 below is the time that it would take for, say a Programming Manager, to complete the same task that a Junior Programmer does in one day. A Programming Manager can be used to do the functions of a Senior Programmer and a Junior Programmer, but a Junior Programmer cannot be used to do the tasks required of a Programming Manager or a Senior Programmer. Similarly, a Senior Programmer cannot be used to complete the tasks required of a Programming Manager, but can be used to complete a Junior Programmer's tasks.

Employee Type	Estimated Loss	Crashing Time
Programming Manager	R 1200.00 per day	0.5 days
Senior Programmer	R 800.00 per day	0.7 days
Junior Programmer	R 550.00 per day	1 day

Table 4.2: ITDS Employee Details

Overtime can be used when dealing with ITDS Staff, but they have to be paid by BCS for this. Their overtime fees are calculated in the same manner as that of the BCS employees, i.e. 50% added to their normal rates, or expected losses, in this case.

Resources cannot be used for only a fraction of a day. Once a resource has been used, even for only an hour, the person is to be compensated for the entire day's work.

5. Assignment 2

From the information given in the previous two sections, you now have to develop a full baseline project report. This report should include a precedence list for all tasks, a complete work breakdown structure (WBS), as well as a baseline CPM Network.

Your manager has a preference towards the use of PERT Network charts, which are Activity-On-Arrow charts. Explain the basics of these networks to him. Further, justify your use of CPM Networks and list a few of the advantages and disadvantages of each.

You must draw up a resource loading such that tasks requiring similar skills have minimum overlap without causing any delay in project completion time. The required resource sheets and graph should form part of your final report.

Cost reporting will further form an integral part of your management plan. Full reporting must be done on all costs, such as labour costs and equipment cost, according to the figures provided in the previous section.

As part of the initial project planning document, the management at ITDS requested that all the major risks in the project be identified, and a thorough explanation of each, their consequences, as well as possible contingencies included into the report. Develop a final baseline planning CPM network which includes these contingencies.

Upon deliverance of this baseline project planning report to the ITDS Senior management team, they were most displeased with the projected finish date. They were hoping to have the entire project finished by 15 January 2004, in order for the (hopefully) improved process to be up and running and in place before the arrival of a major potential customer. This customer is planning on touring the ITDS facilities in order to determine whether or not their working procedures and ethics are according to his/her company's standards. The senior management

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team at ITDS has full confidence in your being able to improve their process to a level of unparalleled excellence, but time is of a major concern for them. They realise that moving the delivery date forward would involve extra costs, but that is not such a major concern, yet. However, if the costs exceed a reasonable level, the project will be cancelled.

Explain how you would reduce the project duration in order to accommodate the required completion date. Develop a report that will convince the senior management team at ITDS that you are able to complete this project on or before 15 January 2003. Explain why you would “crash” the specific tasks that you decided upon to “crash”. The client would also like a complete cost breakdown of this “new” shortened project plan. Furthermore, you should include a list of all additional resources in the final project report.

You must include a final cost for normal completion of the project, as well as a total cost for completing the project on or before 15 January 2004.

Please Note:

- When adding human resources in order to “crash” a project task, an additional laptop is to be used for every single BSC person added to the project. This is not necessary for the ITDS personnel.
- When higher-level ITDS Personnel is used in order to reduce the project task time, the total task time is affected by the amount indicated in Table 4.2, and the amount of BSC personnel required for that task should be increased according to the time saving in the following manner:

For every 15% of time reduced by the more senior ITDS person used, at least one BSC Junior Analyst is to be added. The number of personnel that has to be added has to be rounded up.

6. *Assignment 3*

After the successful start of the project, certain events did not go exactly according to plan. Some of the laptops were not available immediately, as well as some of the Junior Analysts at BCS. This all led to excess spending when the project resources became available. A few other project risks also became a reality, and further jeopardised the project.

Table 6.1 below lists the current financial status of the project after 5 weeks.

End of Week	Budgeted Cost Of Work Scheduled	Budgeted Cost of Work Performed	Actual Cost of Work Performed
1	R 25,000.00	R 34,000.00	R 36,000.00
2	R 49,000.00	R 48,000.00	R 53,000.00
3	R 82,000.00	R 83,000.00	R 88,000.00
4	R 97,000.00	R 102,000.00	R 110,000.00
5	R 121,000.00	R 135,000.00	R 145,000.00
6	R 144,000.00		
7	R 176,000.00		
8	R 192,000.00		
9	R 234,000.00		
10	R 248,000.00		
11	R 267,000.00		
12	R 298,000.00		
13	R 310,000.00		
14	R 343,000.00		
15	R 403,000.00		
16	R 456,000.00		
17	R 487,000.00		
18	R 511,000.00		
19	R 555,000.00		
20	R 589,000.00		
21	R 603,000.00		
22	R 678,000.00		
23	R 711,000.00		
24	R 724,000.00		
25	R 758,000.00		
26	R 769,000.00		
27	R 781,000.00		
28	R 799,000.00		
29	R 818,000.00		
30	R 834,000.00		

Table 6.1: Project Progress Status

A Case Study in Project Management: Questionnaire

(Note: The figures given in Table 6.1 above are hypothetical figures, and do not correspond to the actual figures of the project. Your answers to this question should, however, be based on the figures given here.)

The senior management at ITDS is worried about overspending and under-performing. They have requested a full progress report in order to evaluate the time, cost and schedule variances. As part of this report, you also have to include the expected cost required in order to complete the project, the total expected cost when the project is complete, and the performance rating figure at which the project team has to work in order to complete the project within the original budget.

Appendices

Appendix B: Case Study Memorandum



University of Stellenbosch
Department of Industrial Engineering



A Case Study in Project Management – Memorandum

Developed by: T.C. Boezaart (12333514)

For

Dr. C.J. Fourie

19 November 2003



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1. Introduction

This document contains the proposed solutions to the Project Management Case Study: “A Case Study in Project Management”. The majority of the solutions given here are general solutions to the questions asked, and it is the responsibility of the examiner to ensure that the variations that might occur in the students’ answers are compensated for. All answers pertaining to theoretical topics, as well as the Project Control Exercise, are given as textbook answers.

The sample Project Baseline answer is also provided, and the students should all be able to develop similar answers before project crashing is executed. No answer is provided for the crashing exercise, but merely guidelines as to possible areas that have to be addressed in the crashing exercise. The CPM network and resource list is also not provided for any events that happen after the project baseline is completed. It is the responsibility of the examiner to judge the individual student’s project crashing effort individually.

Guidelines are given throughout the document pertaining to the answering of specific questions where no textbook solution is available. In electronic format, hyperlinks can be followed in this document to facilitate the paging process to and from the Appendices.



2. *Assignment 1: Organisation & Project Leader Selection*

2.1 *The Role and Qualities of a Project Manager*

Justify your consulting manager's decision on making you project leader by expanding on the roles that will be required of you as project manager, as well as the qualities you should possess in order to be an effective and professional project manager.

Answer:

Role of the Project Manager:

The student should describe the project management structure detailed in Figure 2.1 below.

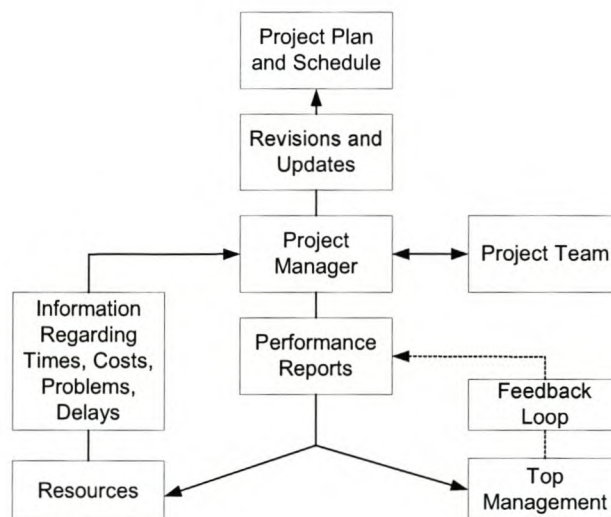


Figure 2.1: The Role of the Project Manager

Additional Roles of the Project Manager:

- Planning for resources required towards project goal achievement
- Organising the people and other resources
- Providing leadership for the project team members
- Identifying and using relevant information to manage the project



- Facilitate the project management process through tools and techniques
- Conduct periodic evaluations of project results and redirect or reprogram
- Be aware of the influence of the organisational culture ambience
- Keep the customer informed and happy
- Keep the project owner or senior management informed

Attributes of an effective project manager:

- Detail organisational knowledge
- Effective communicator
- Clearly defines and explains tasks and problems
- Good social skills (understands others)
- Maintains good interpersonal relationships
- Suggests solutions
- Facilitates
- Seeks to resolve conflicts

(Additional attributes:

- Anticipates conflict
- Anticipates problems
- Develops teamwork
- Keeps departments focussed on their responsibilities
- Avoids supervising functional departments
- Avoids uncertainties
- Keeps the customer updated regarding all aspects of the project)

2.2 Selecting the Project Organisational Structure

Now that you are also convinced that you possess the necessary qualities required to be an effective project manager, one of your first tasks is to select an effective organisational structure for the project. Compare the major organisational structures, and state which structure you would choose and state also why you chose the specific structure that you did by elaborating slightly on



the advantages and disadvantages that the selected type of organisational structure has above other structures in this project.

Answer:

Below follows a description of some of the main project management organisational structures, as well as the final decision for this project. This is only a guideline, and the motivation for each student must be considered when examining this question, and credit given where due.

Introduction

What is a suitable project organisation? Before we answer this, let us first look at the different types of organisational structures, set forth the selection criteria for the specific structure of the organisation, and then select an organisational structure that is the most suited to this project.

Organisational Structures

The project organisational structure is often a temporary structure that utilizes specialists from different departments within the organisation and is headed by a project manager. This project manager has to coordinate the activities within the project and monitor the costs and schedule the resources and activities. (See the previous section for more specific detail on the project manager's roles and duties).

There are mainly three organisational structures used in project management. These are 1) the functional organisation structure, 2) the internal and external matrix structure (or just the matrix structure) and 3) the separate business unit structure.

The Functional Organization Structure:

In this structure, the organisation has functional departments that manage and control the various projects. These projects can be single-function projects or multi-function projects. In the latter, the various functional units combine to

complete the project with the use of the respective departments' resources. See Figure 1 below.

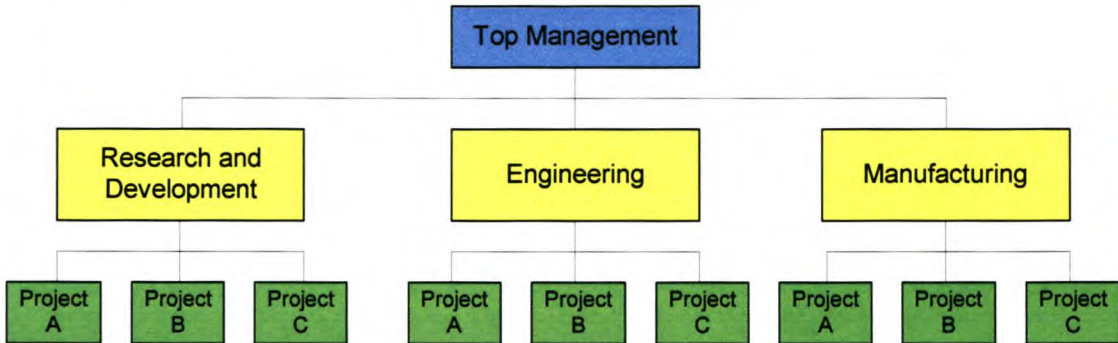


Figure 2.2: Functional Project Organization Structure

This kind of structure is suitable for projects that are small and short term, of known technology, draw mainly on the resources of only one functional unit and require few liaisons with the environment. Finally, this structure is suited for projects for which technical quality is the prime consideration. This structure has the following advantages:

- A team member can work on several projects.
- Technical expertise is maintained within the functional area.
- The functional area is a “home” after the project is completed.
- There is a critical mass of specialized knowledge. Disadvantages of this

organisational structure include:

- Aspects of the project that are not directly related to the functional area get short-changed.
- Motivation of team members is often weak.
- Needs of the client are secondary and are responded to slowly. **The**

Matrix Organisational Project Structure:

This project structure is useful when specific people from specific departments, usually specialists, are used to interact on specific projects. In the internal matrix structure, specific functional departments handle these projects, and in the

external matrix structure, an external manager with his own project management division manages the projects. See figure 2 below for a graphical representation.

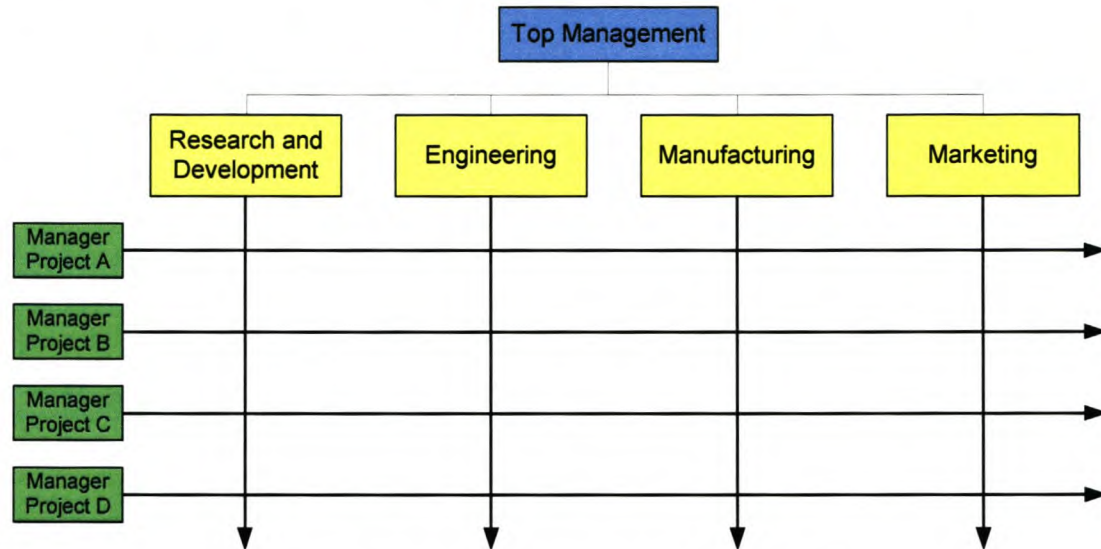


Figure 2.3: Matrix Organizational Structure

This project management structure is the most widely used, and is suitable for use in the following conditions: Multi-discipline projects, multi-project contexts, medium length projects, projects requiring a balance between quality, cost and schedule time, projects in which the levels of resource requirements fluctuate and in projects where the managing of multi-disciplinary projects and the improvement of technical knowledge is required. Furthermore, it is also recommended for projects in organisations in which the climate is healthy and top-management wants to be involved. It has the following advantages:

- Enhanced inter-functional communications.
- Pinpointed responsibility.
- Duplication of resources is minimized.
- Functional “home” for team members.
- Policies of the parent organization are followed. Some of the

disadvantages of this structure are:

- Team members have too many bosses.



- Success of the project depends on the project manager's negotiating skills.
- There is potential for sub optimization. ***The Separate Business Unit***

Project Structure:

This kind of structure is one where the company has an entirely separate projects division. This division runs all major projects with their own staff and resources, without the use of resources, human and otherwise, from other departments. See figure 3 below for a diagrammatic representation of this structure.

This structure is very suitable for organisations that run major long-term, projects for which resources are not constrained and that have a very urgent time constraint, rather than a tight financial constraint. This project management organisational structure has the following advantage, amongst other:

- The project manager has full authority over the project.
- Team members report to only one boss.
- Shortened communication lines.
- Team pride, motivation, and commitment are high.

Disadvantages of this structure includes:

- A duplication of resources.
- Organizational goals and policies are ignored.
- There could be a lack of technology transfer.
- Team members have no functional area "home."

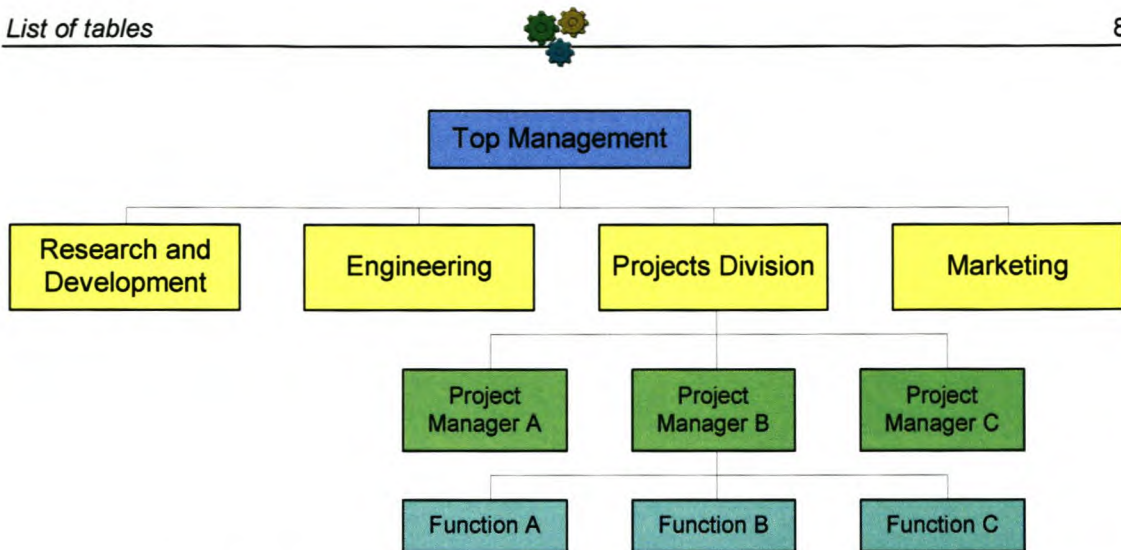


Figure 2.4: Separate Business Unit Organizational Structure

A Suitable Structure for this Project

So which one is more suited for our project? Let us set forth the boundaries of our project: Long-term projects last longer than a year, and short-term projects lasts at most one month. We have a project that is not quite long-term or short-term, lets call it medium term. We definitely have a time constraint on the project. It has to be finished by January 2004, in time for the client's inspection of ITDS (if the cost of shortening the project justifies this) and we also have a financial constraint.

This project does not really fit in the "Separate Business Unit" organizational structure. It definitely does not fit into the functional structure, because of the duration of the project and the costs involved. That would mean that it is best suited for the matrix organizational structure. This would therefore be our organizational structure of choice.

Each student's solution to this problem must be evaluated independently. The student should motivate his/her answer in sufficient detail in order for them to convince the examiner that it is the right structure to use in this project.



2.3 CAPP Selection

Determine whether or not it is feasible to use a CAPP System for this project. Further explain what criteria you would evaluate in order to select an appropriate CAPP software program in order to help you to facilitate the project planning process. On the basis of these guidelines, explain what computer package you would select, and why.

Answer:

Before we start looking at what type of computer-aided project planning system we need, it might be a good idea to first see whether or not it is feasible to use one. The alternative, of course, is to do everything by hand. The following are good guidelines:

1. Project duration:

If there are more than 25 tasks in the project, the project duration is more than 75 days, the budget is higher than R100 000, there are more than 5 workers or there are more than three resource types, it is worthwhile for the company to invest in CAPP software.

2. Project Complexity:

The project could also justify the use of a CAPP system where certain tasks depend on the delivery of certain pieces of equipment, there are many milestones to report on, there are more than two project locations or there might be more than two organisations working on the project.

3. Relationships within the project:

If there are very complex inter-relationships between the various tasks and activities within the project, the project also calls for CAPP software to be used.



4. Project costs:

If the project has a high budget (higher than R 100 000 typically) and track has to be kept of a lot of payments and financial allocations, CAPP software could also be very useful.

5. How frequently updates have to occur:

If there are very frequent updates, it could defeat the purpose of CAPP software, because the project manager would be spending more time on updating the computer system than actually managing the project.

The five most important criteria for selecting a computer-aided project planning system are:

1. Ease of starting up:

It must be simple for the organisation to set up projects and input all the relevant data. It must also be easy for the organisation to customise the program to conform to their needs.

2. Ease of updating:

The objective of CAPP software is to make the life of the project manager easier, not bog him/her down with extra computer work. Therefore, if the user wants to change something, he should only change the source, and the program should update automatically from there, thereby eliminating unnecessary computer work by the project manager.

3. Compatibility with other software:

The software must be able to export certain results to other programs, like e-mail, so that the information can be sent and communicated to other people involved in the project.

4. Quality of Outputs:

The outputs delivered by the software must always be valid and correct (according to the inputs given). There must be no reason for the user to



have to “second-guess” the software outputs. The outputs must also be simple to understand and clear in their objective.

5. Price and Support:

The software must be delivered at the right price to the organisation. It is of no use for a company who only does two or three projects a year to buy the most expensive software packages available. They will probably never use the full functionality of the program, and therefore waste money. There must also be very efficient support available for the software, in case of failure on the software or operator's part. The support must be efficient and fast.

The student should qualify why they have decided upon or against a CAPP software system. A discussion along the following lines is acceptable:

“It was felt that this project requires the use of CAPP software to facilitate in the cost allocation and to keep track of the progress of the various tasks, because of the duration of the project. The cost of the project was also taken into consideration, and was a main decider on the specific CAPP software package selected.”

The student should qualify their decision on deciding upon an appropriate software package that would comply with the criteria explained above. Something along the lines of the following paragraph should suffice:

“After numerous CAPP software packages were presented to the project manager, and after many a business lunch with the representatives from the various suppliers of these software packages, Microsoft Project was selected as the CAPP software of choice for this project, based on its ease of use, compatibility with other software, price, and mainly its support (which is available online 24 hours a day).”



3. Assignment 2: Project Planning & Risk Identification

3.1 Task List, WBS, Baseline CPM Network

From the information given in the two sections (See Section 3 and 4 of the Questionnaire), you now have to develop a full baseline project report. This report should include a precedence list for all tasks, a complete WBS, as well as a baseline CPM Network.

You must draw up a resource loading such that tasks requiring similar skills have minimum overlap without causing any delay in project completion time. The required resource sheets and graph should form part of your final report.

Cost reporting will further form an integral part of your management plan. Full reporting must be done on all costs like labour costs and equipment cost according to the figures given in Section 4 of the questionnaire.

Solutions:

(Click on Hyperlink for quick paging)

1. *Task Precedence list:* See [Appendix A](#)
2. *Work Breakdown Structure:* See [Appendix B](#)
3. *Baseline CPM Network:* See [Appendix C](#)
4. *Baseline Gantt-Chart:* See [Appendix D](#)
5. *Required Resource List and Chart:* See [Appendix E](#)
6. *Baseline Costing Report:* See [Appendix F](#)

(See attached software copy (MS Project®) of baseline project for further details)



3.2 Qualifying CPM Networks

Your manager has a preference towards the use of PERT Network charts, which are Activity-On-Arrow charts. Explain the basics of these networks to him, and justify your use of CPM Networks and list a few of the advantages and disadvantages of each.

Answer:

A CPM network or “Critical Path Method” network is an activity-on-node network representation of the entire project, instead of an activity-on-arrow network like the PERT networks. Each node in the CPM network represents an activity. Each node also includes all the information for each specific task, like the task name (#), the task duration (D), earliest start date (ES) for that specific task, the earliest finish date (EF) for that task, the latest start date (LS) for the task, the latest finish date (LF) for the task as well as the total float time (TF) and the free float time (FF). See Figure 4 below for a sample node representation.

ES	D	EF
	#	FF
LS	TF	LF

Figure 4: Example of a node in a CPM network

Task Name (#): The name of the task or the number of the task (usually the number).

Task Duration (D): The duration of each task needed to complete the project. (Specified in days, hours, months, weeks, etc.)

Earliest Start Date (ES): The earliest that the specific task can start, given the conditions of its predecessors.



Earliest Finish Date (EF): This is the sum of the earliest start date and the duration of the task. This is in effect the earliest that this task could finish.

Latest Start Date (LS): This is the latest date that the task could finish without affecting the completion date of the project. This is the Latest Finish Date less the task duration.

Latest Finish Date (LF): This is the latest date that the task can finish on without affecting the project's completion date.

Total Float Time (TF): This is the difference between the Latest Finish Date (LF) and the Earliest Finish Date (EF) of the task. This represents the float time that the resource has with respects to the finish date of the project. This is in effect the amount of "play" that the task has.

Free Float (FF): This is the number of time units between the Earliest Finish Date (EF) of the task and the earliest of the Earliest Start Dates (ES) of the successors of the task. This represents the float that the task has with respects to its successors. I.e. it is the time that the task can start late without affecting its successors.

It is felt that the CPM method is a more useful method of constructing the network, because of the amount of information that can be conveyed on a single node, whereas the PERT activity-on-arrow diagram only allows limited information on each arrow. There is no other really significant difference between the two methods, as the computations needed to complete the actual diagram are in essence the same.

3.3 Risk Identification

As part of the initial project planning document, the management at ITDS requested that all the major risks in the project be identified, and a thorough explanation of each, their consequences, as well as possible contingencies



included into the report. Develop another baseline planning CPM network which includes these contingencies.

Answer:

Appendix G shows a fairly exhaustive list¹ of possible risk areas in this BPR implementation process, their consequences and contingencies.

Due to the variety of risks that can be expected from each of the students, a “model” answer for the CPM Network section of this question cannot be developed. The examiner should ensure that the major risks listed by the student are incorporated into the CPM network and baseline planning report. It is essential that a methodical risk assessment exercise is described by the student, that the student states valid reasons for the risks, their consequences and the possible effects of the risks. It must be clear from the student’s answer that he/she understands that risk management does not consist merely of allocating contingencies to the affected tasks, but that it is a formal process that must be executed in order for risk management to be successful.

3.4 Project Crashing

Upon deliverance of the baseline project planning report to the ITDS Senior management team, they were most displeased with the projected finish date. They were hoping to have the entire project finished by 15 January 2004, in order for the (hopefully) improved process to be up and running and in place before the arrival of a major potential customer. This customer is planning on touring the ITDS facilities in order to determine whether or not their working procedures and ethics are according to his company’s standards. The senior management team at ITDS has full confidence in your being able to improve their process to a level of unparalleled excellence, but the time is a major concern for them. They realise

¹ This list is adapted from Al-Mashari, M, Zairi, M: “BPR Implementation Process: An Analysis of key success and failure factors” as published in Business Process Management Journal, Vol. 5, No. 1, MCB University Press, Bradford, UK, 1999, pages 87 – 112.



that moving the delivery date forward would involve extra costs, but that is not yet a major concern. However, if the costs exceed a reasonable level, the project will be cancelled.

Explain how you would reduce the project duration in order to accommodate the required completion date. Develop a report that will convince the senior management team at ITDS that you are able to complete this project before 15 January 2003. Explain why you would crash the specific tasks that you decided upon to crash. The client would also like a complete cost breakdown of this “new” shortened project plan. Include all additional resources in this project report.

You must include a final cost for normal completion of the project, as well as a total cost for completing the project on or before 15 January 2004.

Notes:

- When adding human resources in order to “crash” a project task, an additional laptop is to be used for every single BSC person added to the project. This is not necessary for the ITDS personnel.
- When higher-level ITDS Personnel is used in order to reduce the project task time, the total task time is affected by the amount indicated in Table 4.2, and the amount of BSC personnel required for that task should be increased according to the time saving in the following manner:

For every 15% of time reduced by the more senior ITDS person used, at least one BSC Junior Analyst is to be added. The number of personnel that has to be added has to be rounded up.

Answer Guidelines:

All tasks that are “crashed” should be on the Critical Path of the network and have a duration of more than 1 day. These tasks include:

- 3: Establish Project Teams
- 5: Develop Communications Plan
- 6: Develop Project Plan
- 9: Analyse All Process’ Facets
- 14: Perform Automated Solutions



- 15: Identify Process Improvement Opportunities
- 34: Conglomerate Assessment Findings
- 36: Develop Recommendations
- 37: Create Report for Management
- 39: Determine To-Be System/Process
- 40: Determine Steps (Ideas) to Attain To-Be System/Process
- 41: Test Ideas and Assumptions
- 42: Create Sufficient Detail to Develop Business Case
- 43: Develop Simulation/Visualisation
- 46: Assess Risk Factors
- 47: Develop Final Recommendations Document
- 48: Implement New Process
- 49: Make New Process Operational
- 50: Evaluate New Process

All crashed tasks should show an increase in resources used. Ensure that all guidelines given in the notes are followed strictly. The student should clearly explain what additional resources are to be used when crashing each of the tasks, as well as the possible gain from each increase in resources.

Ensure that a reason is given by the student for each specific task that he/she has decided to crash.

Check calculations of task times, Earliest Finish and Start Dates, Latest Finish and Start Dates as well as Free Float and Total Float Times.

A full costing report is to be included for the “Crashed” project. It should be similar to the cost report included in the previous question (i.e. for the baseline project (See [Appendix F](#))).



4. Assignment 3: Project Control Exercise

4.1 Project Control

After the successful start of the project, certain events did not go exactly according to plan. Some of the laptops were not available immediately, as well as some of the Junior Analysts at BCS. This all lead to excess spending when the project resources became available. A few other project risks also became a reality, and further jeopardised the project.

Below is a table of the current financial status of the project after 5 weeks. All figures are in R 000's.

End of Week	Budgeted Cost Of Work Scheduled	Budgeted Cost of Work Performed	Actual Cost of Work Performed
1	R 25,000.00	R 34,000.00	R 36,000.00
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30	R 834,000.00		

Table 4.1: Project Progress Financial Figures



(Note: The figures given in Table 4.1 above are hypothetical figures, and do not correspond to the actual figures of the project. Your answers to this question should, however, be based on the figures given here.)

The senior management at ITDS is worried about overspending and under-performing. They have requested a full progress report in order to evaluate the time, cost and schedule variances. As part of this report, you also have to include the expected cost required in order to complete the project, the total expected cost when the project is complete, and the performance rating figure at which the project team has to work in order to complete the project within the original budget.

Answer:

This section of the solution must include the majority of the calculations outlined below. The results of these calculations should be presented in a separate report, called a progress report.

4.2 Project Variances

4.2.1 Introduction

This section will aim to illustrate the variances in time, cost and the schedule. These will be explained in each section. A few acronyms that will be used in this section are:

- BCWS = Budgeted Cost of Work Scheduled
- BCWP = Budgeted Cost of Work Performed
- ACWP = Actual Cost of Work Performed
- BAC = Budgeted Cost at Completion



4.2.2 Time Variance (TV)

The time variance is the variance in actual time (in weeks) spent on the project from the originally scheduled time. A positive figure for this relationship means that the project is ahead of schedule.

$$\begin{aligned}
 \text{Time Variance (TV)} &= (\text{Time where PV} = \text{EV}) - \text{Time Now} \\
 &= (\text{BCWP/BCWS}) * \text{Time} - \text{Time Now} \\
 &= (\text{R } 135\,000 / \text{R } 121\,000) * 5 - 5 \\
 &= 5,5785 - 5 \\
 &= \mathbf{0,5785 \text{ positive}}
 \end{aligned}$$

This means that it we are in effect almost 0,6 weeks ahead of schedule for this project.

4.2.3 Cost Variance (CV)

The cost variance is the difference between the actual amount spent on the project thus far and the budgeted amount of time that was supposed to have been spent on the project up to this stage. It gives us a good indication of the cost projections of the project.

$$\begin{aligned}
 \text{Cost Variance (CV)} &= \text{BCWP} - \text{ACWP} \\
 &= \text{R } 135\,000 - \text{R } 145\,000 \\
 &= \mathbf{\text{R } 10\,000 \text{ negative}}
 \end{aligned}$$

This means that we have exceeded the planned cost by R 10 000, which is not bad, considering that we are more than half a week ahead of schedule.

4.2.4 Schedule Variance (SV)

The schedule variance (SV) is the difference between the scheduled budgeted cost of the project at this stage and the budgeted cost of the work that have been performed thus far.

$$\begin{aligned}
 \text{Schedule Variance (SV)} &= \text{BCWP} - \text{BCWS} \\
 &= \text{R } 135\,000 - \text{R } 121\,000 \\
 &= \mathbf{\text{R } 14\,000}
 \end{aligned}$$



This means that we have exceeded the planned cost up to date by R 14 000, which can be expected, seeing that we are ahead of schedule. This positive schedule variance just reiterates the fact that we are ahead of schedule. We have, in fact, completed about 16% of the project.

$$\begin{aligned}
 \% \text{ Complete} &= \text{BCWP} / \text{BAC} * 100 \\
 &= \text{R } 135\,000 / \text{R } 834\,000 * 100 \\
 &= \mathbf{16.1871\%}
 \end{aligned}$$

4.2.5 Schedule Performance Index

The Schedule Performance Index (SPI (E)) is another indicator of whether or not the project is running on, ahead of, or behind schedule. A value of 1 would indicate that the project is running exactly on schedule. A value larger than 1 would indicate that the project is running ahead of schedule.

$$\begin{aligned}
 \text{SPI (E)} &= \text{BCWP} / \text{BCWS} \\
 &= \text{R } 135\,000 / \text{R } 121\,000 \\
 &= \mathbf{1,1157}
 \end{aligned}$$

This also proves that we are ahead of schedule, as indicated in the Time Variance calculation above.

4.2.6 Cost Performance Index

Another indicator of the project performance is the Cost Performance Index (CPI (E)), which is the ratio of the planned costs to the actual costs.

$$\begin{aligned}
 \text{Cost Performance Index (CPI (E))} &= \text{BCWP} / \text{ACWP} \\
 &= \text{R } 135\,000 / \text{R } 145\,000 \\
 &= \mathbf{0,9310}
 \end{aligned}$$

If this figure is larger than 1 it means that the work rate is not high enough, and it is costing us more to do the work than we budgeted for.

4.3 Project Estimations

4.3.1 Introduction

The estimations discussed below gives us a relative “ballpark” figure of what we can still expect to pay for the project (Estimated Cost to Completion), what we will have spent by the end of the project (Estimated Cost at Completion), and the work rate required to complete the project within the estimated figures (Required Performance).

4.3.2 Estimated Cost to Completion

This is, as the name indicates, the costs we estimate will still be incurred until the completion of the project. This cost is based on the amount that we have already spent and on the CPI (E) as calculated in the previous section.

$$\text{Estimated Cost to Completion (ETC)} = (\text{BAC} - \text{BCWP}) / \text{CPI (E)}$$

$$\begin{aligned} \text{With the CPI (E)} &= \text{BCWP} / \text{ACWP} = 0,9310 && \text{(see Section 4.1.6)} \\ &= (\text{R } 834\,000 - \text{R } 135\,000) / 0,9310 \\ &= \text{R } 750\,805,59 \end{aligned}$$

This means that we can expect to spend another R 750 777 until the completion of the project, if the project was to be finished within 30 weeks.

4.3.3 Estimated Cost at Completion

The Estimated Cost at Completion (EAC) is the estimated total project cost at the end of the project, based on the current figures.

$$\begin{aligned} \text{Estimated Cost at Completion (EAC)} &= \text{ACWP} + \text{ETC} \\ &= \text{R } 145\,000 + \text{R } 750\,805,59 \\ &= \text{R } 895\,805,59 \end{aligned}$$

The cost for the 30-week completion time is only R 61 805,59 or about 7.4% higher than the budgeted R 834 000. This could be due to all the delays and

having to work faster and also possibly having to work overtime to complete the project on time.

4.3.4 Required Performance

The Required Performance is also expressed as a Cost Performance Index (CPI (P)). This is the work rate that the project has to be completed at to ensure it finishes on the estimated budget.

$$\begin{aligned}
 CPI (P) &= (BAC - ACWP) / (BAC - BCWP) \\
 &= (R\ 834\ 000 - R\ 145\ 000) / (R\ 834\ 000 - R\ 135\ 000) \\
 &= R\ 689\ 000 / R\ 699\ 000 \\
 &= 0,9856 \\
 &= 98,57\ \%
 \end{aligned}$$

This means that the work has to continue at 98,57% performance for it to be completed at the right time within the estimated figures for the 30-week completion time.

It is further required of the student to explain the results above according to the comments made above, and give a brief conclusion of the current state of the project.

Appendix A: Project Task List

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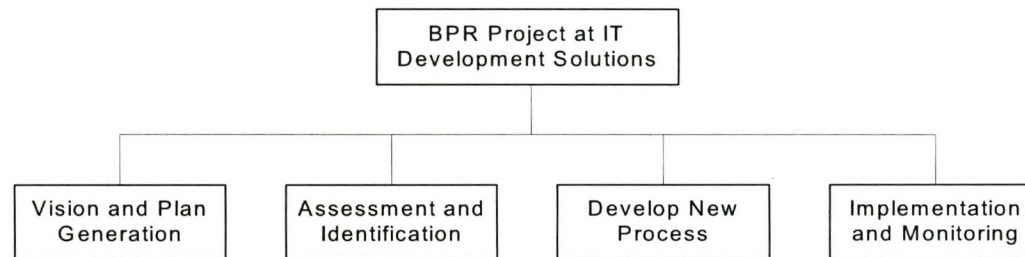
Actual Task #	MS Project #	Work Package / Task / Subtask	Predecessors	Duration (days)	Resources					
					Senior Analyst	Junior Analyst	ITDS Program Manager	ITDS Senior Programmer	ITDS Junior Programmer	BCS Laptop
	1	Vision and Plan Generation								
1	2	Solidify Executive Sponsorship	0	1	1					
2	3	Establish Project Teams	2	2	1					
3	4	Define Project Organisation and Scope	3	1	1	1				1
4	5	Develop Communications Plan	3	3		2				1
5	6	Develop Project Plan	4, 5	10	1	3				3
	7	Assessment and Identification								
	8	As-Is Process Assessment								
6	9	Analyse All Process' Facets	6	20	1	4	1	1	1	3
7	10	Develop Process Maps	Start of 9 (4 days)	3		3			1	3
8	11	Gather Process Data	10	2		2				1
9	12	Gather Financial Process Data	10	2		2				1
10	13	Analyse ABC Costing Information	22	3		1		1		1
11	14	Perform Automated Simulations	9, 11, 12, 13	10		3				3
12	15	Identify Process Improvement Opportunities	14	2		3		1		3
	16	As-Is Organisational Assessment								
13	17	Assess Possible Organisational Design Issues	6	3		1			1	1
	18	As-Is Financial Assessment								
14	19	Competition Evaluation	6	2		2			1	1
15	20	Benchmarking	6	3		1				1
16	21	Costing and Process Data Collection	6	3		2		1		2
17	22	Create ABC Model	21	2		2		1		2
18	23	Identify Bottlenecks by Running Simulation of As-Is Data	21	5		2			1	1
19	24	Identify Financial Improvement Opportunities	19, 20, 22, 23	1		2			1	2
	25	As-Is IT Assessment								
20	26	Conduct IT Scan for New Technologies	6	4		1				1
21	27	Establish Value of New Technologies	26	4		1				1
22	28	Assess Readiness to Implement New Technologies	26	5		1		1		1
23	29	ID High-value/Low Readiness Technologies	27	1		1			1	
24	30	ID and Eliminate Low-Value Technologies	27	1		1			1	
25	31	Monitor Factors that Might Improve Readiness Level	28	6		1				1
26	32	Identify IT Improvement Opportunities	29, 30, 31	1		3		1		2
	33	Develop Report of Reengineering Opportunities								
27	34	Conglomerate Assessment Findings	15, 17, 24, 32	3		2				1
28	35	Rank Opportunities	34	1		2				1
29	36	Develop Recommendations	35	3		2				1
30	37	Create Report For Management	36	2	1	3				2

Actual Task #	MS Project #	Work Package / Task / Subtask	Predecessors	Duration (days)	Resources					
					Senior Analyst	Junior Analyst	ITDS Program Manager	ITDS Senior Programmer	ITDS Junior Programmer	BCS Laptop
	38	Develop New Process								
31	39	Determine To-Be System/Process	37	4		3				2
32	40	Determine Steps (Ideas) to Attain To-Be System/Process	39	15		3				2
33	41	Test Ideas and Assumptions	40	10		3				2
34	42	Create Sufficient Detail to Develop Business Case	41	5		2				2
35	43	Develop Simulation/Visualisation	42	10		4				3
	44	Implementation and Monitoring								
36	45	Identify Tangible Benefits	43	3		3		1		2
37	46	Assess Risk Factors	43	4		3				2
38	47	Develop Final Recommendations Document	45, 46	2	1	4				3
39	48	Implement New Process	47	25	1	3	1	1		3
40	49	Make New Process Operational	48	5	1	3	1	1		3
41	50	Evaluate New Process	49	10	1	2		1	1	1
42	51	Train Programming Supervisors	49	2		1	1			1
43	52	Hand Over Project Deliverables	50, 51	1	1		1			1

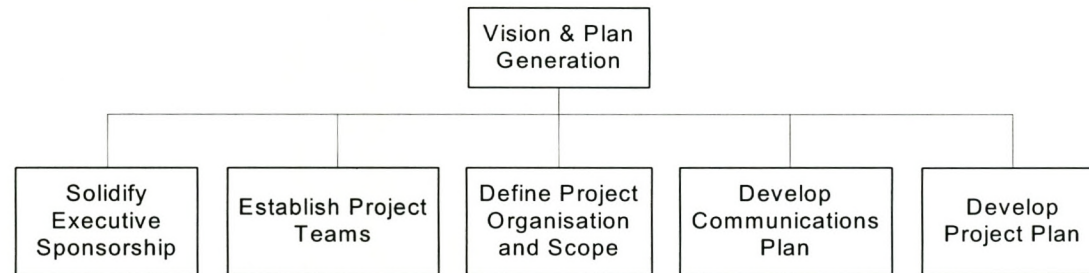
Appendix B: Work Breakdown Structure

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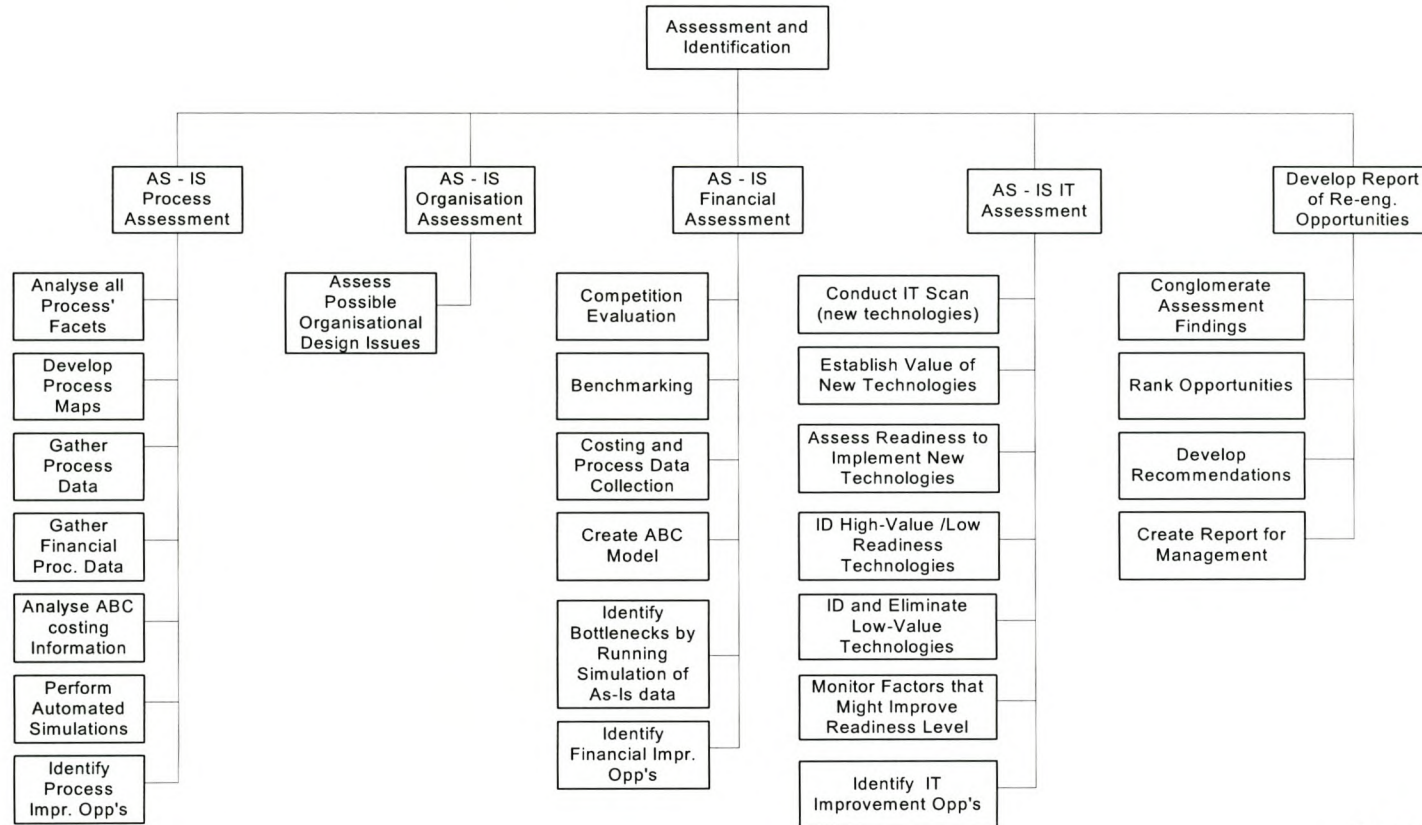
BPR Methodology for IT Development Solutions



Vision and Plan Generation

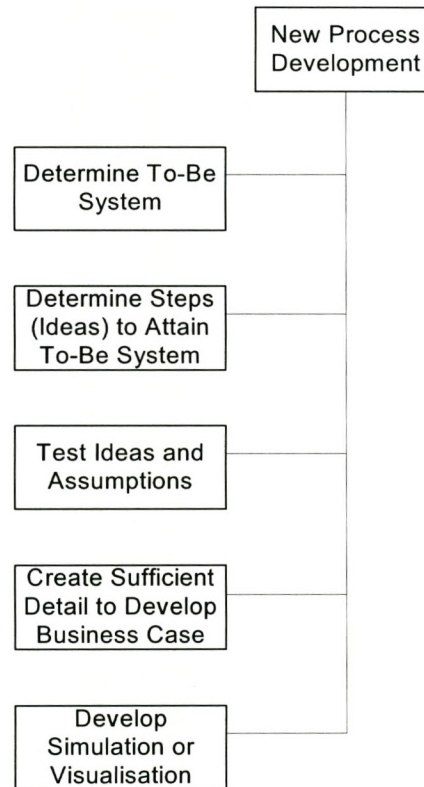


Assessment and Identification



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Develop New Process



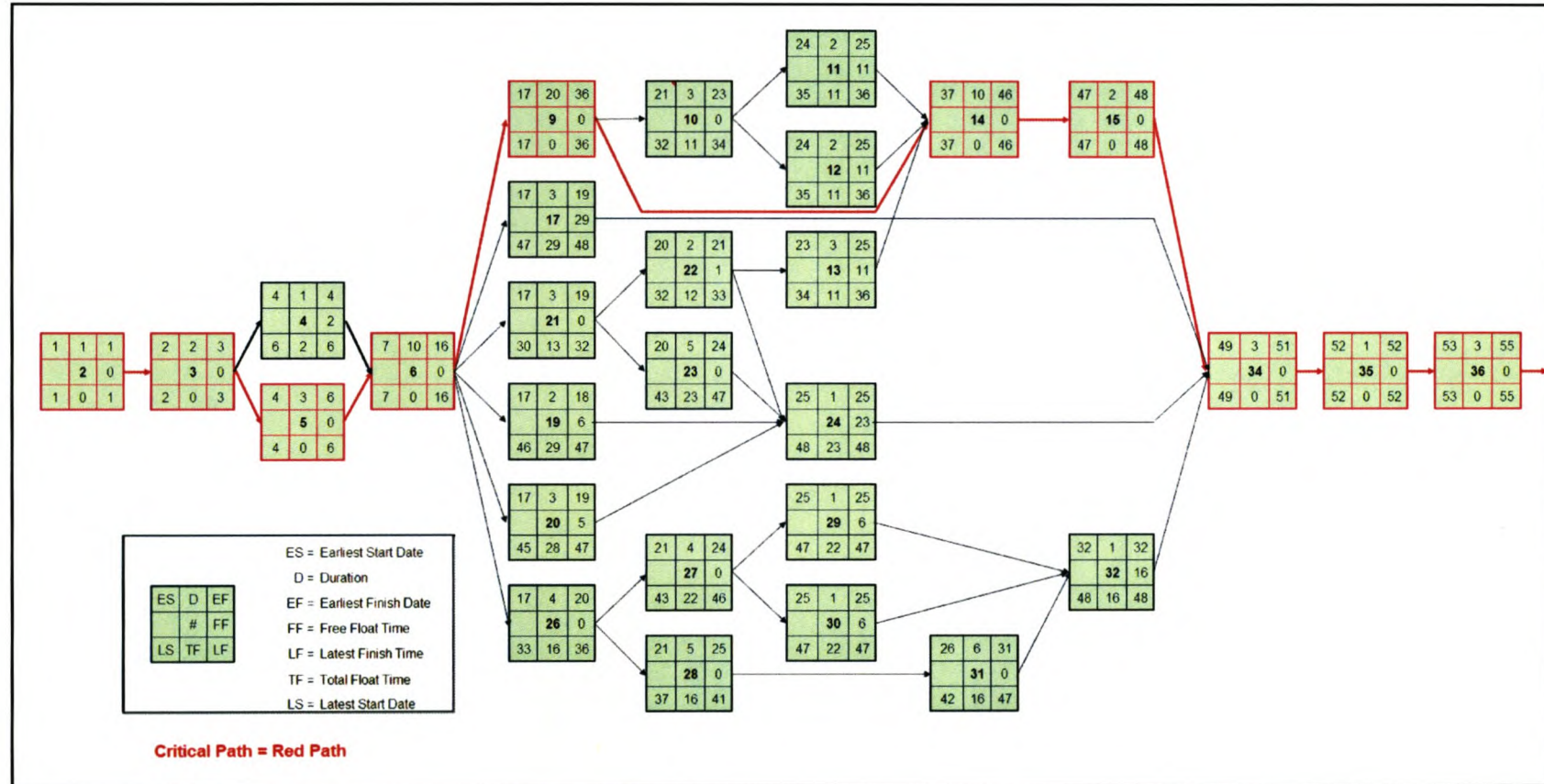
Implementation and Monitoring

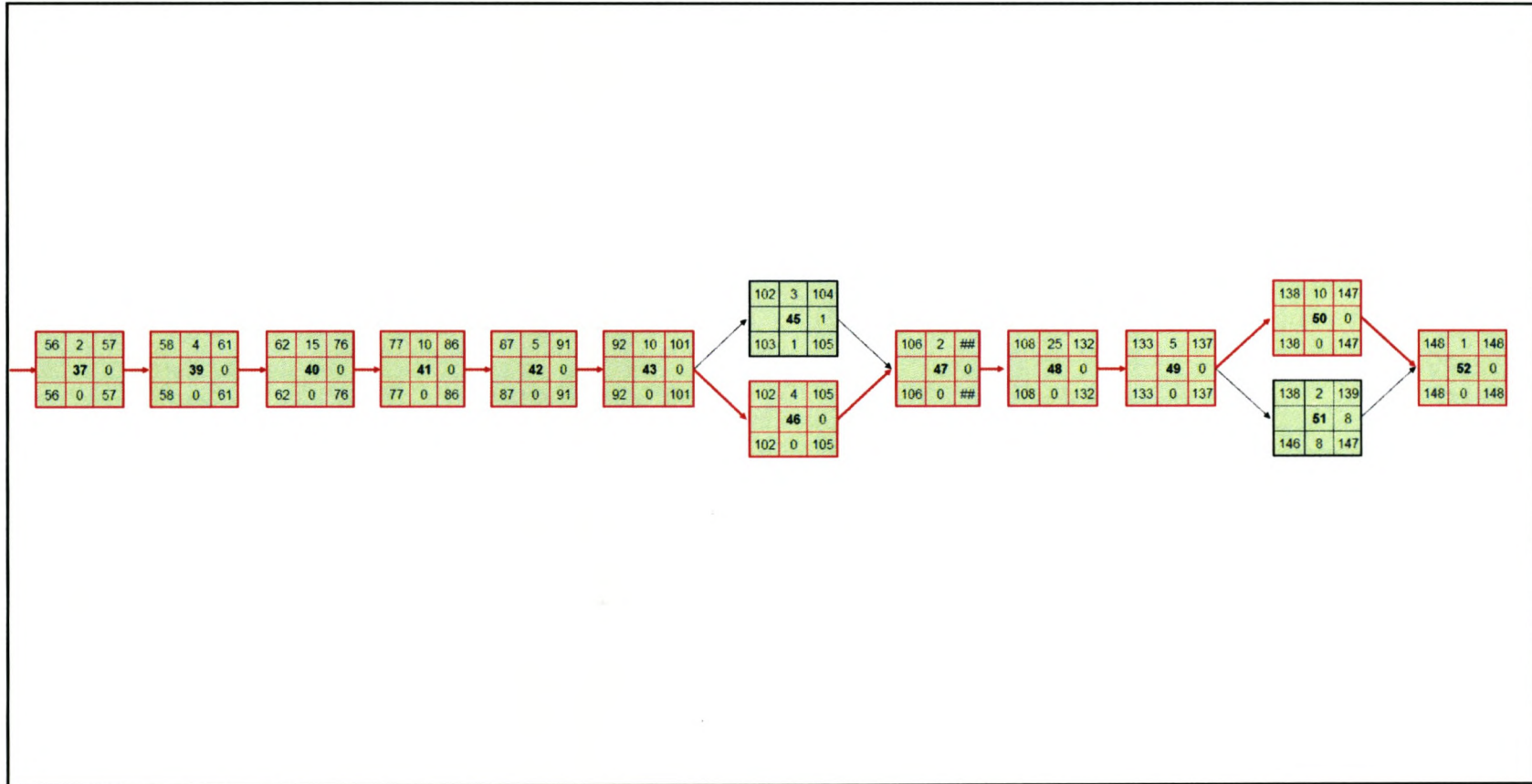


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Appendix C: Baseline CPM Network

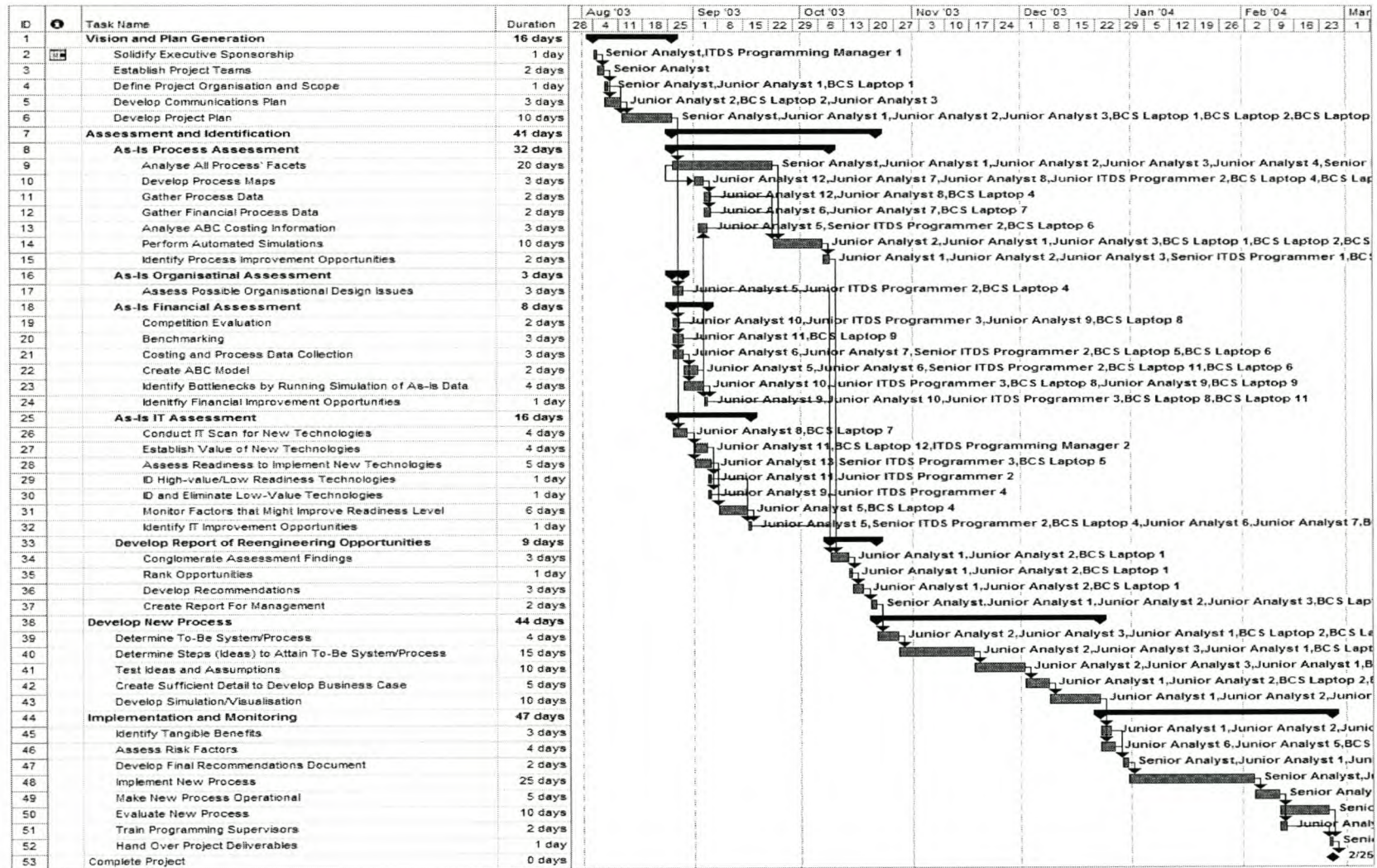
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Appendix D: Baseline Gantt-Chart

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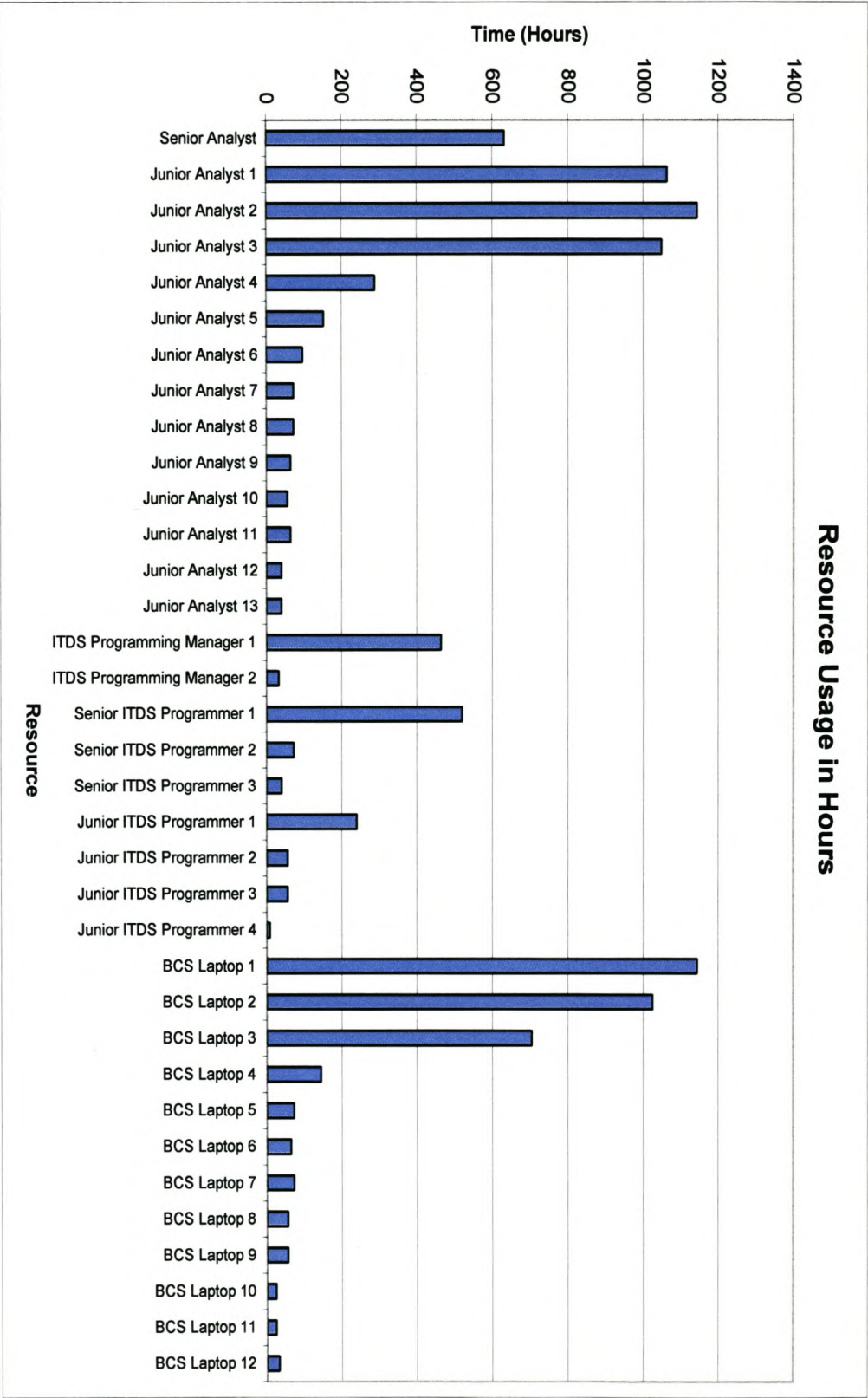
Appendix E: Required Resource List and Charts

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A Case Study in Project Management: Memorandum

Resource	Hours
Senior Analyst	632
Junior Analyst 1	1064
Junior Analyst 2	1144
Junior Analyst 3	1048
Junior Analyst 4	288
Junior Analyst 5	152
Junior Analyst 6	96
Junior Analyst 7	72
Junior Analyst 8	72
Junior Analyst 9	64
Junior Analyst 10	56
Junior Analyst 11	64
Junior Analyst 12	40
Junior Analyst 13	40
ITDS Programming Manager 1	464
ITDS Programming Manager 2	32
Senior ITDS Programmer 1	520
Senior ITDS Programmer 2	72
Senior ITDS Programmer 3	40
Junior ITDS Programmer 1	240
Junior ITDS Programmer 2	56
Junior ITDS Programmer 3	56
Junior ITDS Programmer 4	8
BCS Laptop 1	1144
BCS Laptop 2	1024
BCS Laptop 3	704
BCS Laptop 4	144
BCS Laptop 5	72
BCS Laptop 6	64
BCS Laptop 7	72
BCS Laptop 8	56
BCS Laptop 9	56
BCS Laptop 10	24
BCS Laptop 11	24
BCS Laptop 12	32

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Appendix F: Project Cost Report

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#	Task Name	Time	Duration	Rate	Cost/Use	Cost	Total Cost
1	Vision and Plan Generation	688.00	16 days				R 59,140.00
2	Solidify Executive Sponsorship	16.00	1 day				R 2,800.00
	Senior Analyst	8.00		200	0	R 1,600.00	
	ITDS Programming Manager 1	8.00		150		R 1,200.00	
3	Establish Project Teams	16.00	2 days				R 3,200.00
	Senior Analyst	16.00		200		R 3,200.00	
4	Define Project Organisation and Scope	24.00	1 day				R 2,660.00
	Senior Analyst	8		200		R 1,600.00	
	Junior Analyst 1	8		100		R 800.00	
	BCS Laptop 1	8		20	100	R 260.00	
5	Develop Communications Plan	72	3 days				R 5,380.00
	Junior Analyst 2	24		100		R 2,400.00	
	Junior Analyst 3	24		100		R 2,400.00	
	BCS Laptop 2	24		20	100	R 580.00	
6	Develop Project Plan	560	10 days				R 45,100.00
	Senior Analyst	80		200		R 16,000.00	
	Junior Analyst 1	80		100		R 8,000.00	
	Junior Analyst 2	80		100		R 8,000.00	
	Junior Analyst 3	80		100		R 8,000.00	
	BCS Laptop 1	80		20	100	R 1,700.00	
	BCS Laptop 2	80		20	100	R 1,700.00	
	BCS Laptop 3	80		20	100	R 1,700.00	
7	Assessment and Identification	3992	41 days				R 311,270.00
8	As-Is Process Assessment	2688	32 days				R 216,870.00
9	Analyse All Process' Facets	1760	20 days				R 156,900.00
	Senior Analyst	160		200		R 32,000.00	
	Junior Analyst 1	160		100		R 16,000.00	
	Junior Analyst 2	160		100		R 16,000.00	
	Junior Analyst 3	160		100		R 16,000.00	
	Junior Analyst 4	160		100		R 16,000.00	
	ITDS Programming Manager 1	160		150		R 24,000.00	
	Senior ITDS Programmer 1	160		100		R 16,000.00	
	Junior ITDS Programmer 1	160		68.75		R 11,000.00	
	BCS Laptop 1	160		20	100	R 3,300.00	
	BCS Laptop 2	160		20	100	R 3,300.00	
	BCS Laptop 3	160		20	100	R 3,300.00	
10	Develop Process Maps	168	3 days				R 10,590.00
	Junior Analyst 7	24		100		R 2,400.00	
	Junior Analyst 8	24		100		R 2,400.00	
	Junior Analyst 12	24		100		R 2,400.00	
	Junior ITDS Programmer 2	24		68.75		R 1,650.00	
	BCS Laptop 4	24		20	100	R 580.00	
	BCS Laptop 7	24		20	100	R 580.00	
	BCS Laptop 10	24		20	100	R 580.00	

#	Task Name	Time	Duration	Rate	Cost/Use	Cost	Total Cost
11	Gather Process Data	48	2 days				R 3,620.00
	Junior Analyst 8	16		100		R 1,600.00	
	Junior Analyst 12	16		100		R 1,600.00	
	BCS Laptop 4	16		20	100	R 420.00	
12	Gather Financial Process Data	48	2 days				R 3,620.00
	Junior Analyst 6	16		100		R 1,600.00	
	Junior Analyst 7	16		100		R 1,600.00	
	BCS Laptop 7	16		20	100	R 420.00	
13	Analyse ABC Costing Information	72	3 days				R 5,380.00
	Junior Analyst 5	24		100		R 2,400.00	
	Senior ITDS Programmer 2	24		100		R 2,400.00	
	BCS Laptop 6	24		20	100	R 580.00	
14	Perform Automated Simulations	480	10 days				R 29,100.00
	Junior Analyst 1	80		100		R 8,000.00	
	Junior Analyst 2	80		100		R 8,000.00	
	Junior Analyst 3	80		100		R 8,000.00	
	BCS Laptop 1	80		20	100	R 1,700.00	
	BCS Laptop 2	80		20	100	R 1,700.00	
	BCS Laptop 3	80		20	100	R 1,700.00	
15	Identify Process Improvement Opportunities	112	2 days				R 7,660.00
	Junior Analyst 1	16		100		R 1,600.00	
	Junior Analyst 2	16		100		R 1,600.00	
	Junior Analyst 3	16		100		R 1,600.00	
	Senior ITDS Programmer 1	16		100		R 1,600.00	
	BCS Laptop 1	16		20	100	R 420.00	
	BCS Laptop 2	16		20	100	R 420.00	
	BCS Laptop 3	16		20	100	R 420.00	
16	As-Is Organisational Assessment	72	3 days				R 4,630.00
17	Assess Possible Organisational Design Issues	72	3 days				R 4,630.00
	Junior Analyst 5	24		100		R 2,400.00	
	Junior ITDS Programmer 2	24		68.75		R 1,650.00	
	BCS Laptop 4	24		20	100	R 580.00	
18	As-Is Financial Assessment	512	8 days				R 34,450.00
19	Competition Evaluation	64	2 days				R 4,720.00
	Junior Analyst 9	16		100		R 1,600.00	
	Junior Analyst 10	16		100		R 1,600.00	
	Junior ITDS Programmer 3	16		68.75		R 1,100.00	
	BCS Laptop 8	16		20	100	R 420.00	
20	Benchmarking	48	3 days				R 2,980.00
	Junior Analyst 11	24		100		R 2,400.00	
	BCS Laptop 9	24		20	100	R 580.00	
21	Costing and Process Data Collection	120	3 days				R 8,360.00
	Junior Analyst 6	24		100		R 2,400.00	
	Junior Analyst 7	24		100		R 2,400.00	
	Senior ITDS Programmer 2	24		100		R 2,400.00	
	BCS Laptop 5	24		20	100	R 580.00	

#	Task Name	Time	Duration	Rate	Cost/Use	Cost	Total Cost
	BCS Laptop 6	24		20	100	R 580.00	
22	Create ABC Model	80	2 days				R 5,640.00
	Junior Analyst 5	16		100		R 1,600.00	
	Junior Analyst 6	16		100		R 1,600.00	
	Senior ITDS Programmer 2	16		100		R 1,600.00	
	BCS Laptop 6	16		20	100	R 420.00	
	BCS Laptop 11	16		20	100	R 420.00	
23	Identify Bottlenecks by Running Simulation of As-Is D	160	4 days				R 10,080.00
	Junior Analyst 9	32		100		R 3,200.00	
	Junior Analyst 10	32		100		R 3,200.00	
	Junior ITDS Programmer 3	32		68.75		R 2,200.00	
	BCS Laptop 8	32		20	100	R 740.00	
	BCS Laptop 9	32		20	100	R 740.00	
24	Identify Financial Improvement Opportunities	40	1 day				R 2,670.00
	Junior Analyst 9	8		100		R 800.00	
	Junior Analyst 10	8		100		R 800.00	
	Junior ITDS Programmer 3	8		68.75		R 550.00	
	BCS Laptop 8	8		20	100	R 260.00	
	BCS Laptop 11	8		20	100	R 260.00	
25	As-Is IT Assessment	456	16 days				R 33,860.00
26	Conduct IT Scan for New Technologies	64	4 days				R 3,940.00
	Junior Analyst 8	32		100		R 3,200.00	
	BCS Laptop 7	32		20	100	R 740.00	
27	Establish Value of New Technologies	96	4 days				R 8,740.00
	Junior Analyst 11	32		100		R 3,200.00	
	ITDS Programming Manager 2	32		150		R 4,800.00	
	BCS Laptop 12	32		20	100	R 740.00	
28	Assess Readiness to Implement New Technologies	120	5 days				R 8,900.00
	Junior Analyst 13	40		100		R 4,000.00	
	Senior ITDS Programmer 3	40		100		R 4,000.00	
	BCS Laptop 5	40		20	100	R 900.00	
29	ID High-value/Low Readiness Technologies	16	1 day				R 1,350.00
	Junior Analyst 11	8		100		R 800.00	
	Junior ITDS Programmer 2	8		68.75		R 550.00	
30	ID and Eliminate Low-Value Technologies	16	1 day				R 1,350.00
	Junior Analyst 9	8		100		R 800.00	
	Junior ITDS Programmer 4	8		68.75		R 550.00	
31	Monitor Factors that Might Improve Readiness Level	96	6 days				R 5,860.00
	Junior Analyst 5	48		100		R 4,800.00	
	BCS Laptop 4	48		20	100	R 1,060.00	

#	Task Name	Time	Duration	Rate	Cost/Use	Cost	Total Cost
32	Identify IT Improvement Opportunities	48	1 day				R 3,720.00
	Junior Analyst 5	8		100		R 800.00	
	Junior Analyst 6	8		100		R 800.00	
	Junior Analyst 7	8		100		R 800.00	
	Senior ITDS Programmer 2	8		100		R 800.00	
	BCS Laptop 4	8		20	100	R 260.00	
	BCS Laptop 5	8		20	100	R 260.00	
33	Develop Report of Reengineering Opportunities	264	9 days				R 21,460.00
34	Conglomerate Assessment Findings	72	3 days				R 5,380.00
	Junior Analyst 1	24		100		R 2,400.00	
	Junior Analyst 2	24		100		R 2,400.00	
	BCS Laptop 1	24		20	100	R 580.00	
35	Rank Opportunities	24	1 day				R 1,860.00
	Junior Analyst 1	8		100		R 800.00	
	Junior Analyst 2	8		100		R 800.00	
	BCS Laptop 1	8		20	100	R 260.00	
36	Develop Recommendations	72	3 days				R 5,380.00
	Junior Analyst 1	24		100		R 2,400.00	
	Junior Analyst 2	24		100		R 2,400.00	
	BCS Laptop 1	24		20	100	R 580.00	
37	Create Report For Management	96	2 days				R 8,840.00
	Senior Analyst	16		200		R 3,200.00	
	Junior Analyst 1	16		100		R 1,600.00	
	Junior Analyst 2	16		100		R 1,600.00	
	Junior Analyst 3	16		100		R 1,600.00	
	BCS Laptop 1	16		20	100	R 420.00	
	BCS Laptop 2	16		20	100	R 420.00	
38	Develop New Process	1880	44 days				R 126,380.00
39	Determine To-Be System/Process	160	4 days				R 11,080.00
	Junior Analyst 1	32		100		R 3,200.00	
	Junior Analyst 2	32		100		R 3,200.00	
	Junior Analyst 3	32		100		R 3,200.00	
	BCS Laptop 1	32		20	100	R 740.00	
	BCS Laptop 2	32		20	100	R 740.00	
40	Determine Steps (Ideas) to Attain To-Be System/Process	600	15 days				R 41,000.00
	Junior Analyst 1	120		100		R 12,000.00	
	Junior Analyst 2	120		100		R 12,000.00	
	Junior Analyst 3	120		100		R 12,000.00	
	BCS Laptop 1	120		20	100	R 2,500.00	
	BCS Laptop 2	120		20	100	R 2,500.00	
41	Test Ideas and Assumptions	400	10 days				R 27,400.00
	Junior Analyst 1	80		100		R 8,000.00	
	Junior Analyst 2	80		100		R 8,000.00	
	Junior Analyst 3	80		100		R 8,000.00	
	BCS Laptop 1	80		20	100	R 1,700.00	
	BCS Laptop 2	80		20	100	R 1,700.00	

#	Task Name	Time	Duration	Rate	Cost/Use	Cost	Total Cost
42	Create Sufficient Detail to Develop Business Case	160	5 days				R 9,800.00
	Junior Analyst 1	40		100		R 4,000.00	
	Junior Analyst 2	40		100		R 4,000.00	
	BCS Laptop 1	40		20	100	R 900.00	
	BCS Laptop 2	40		20	100	R 900.00	
43	Develop Simulation/Visualisation	560	10 days				R 37,100.00
	Junior Analyst 1	80		100		R 8,000.00	
	Junior Analyst 2	80		100		R 8,000.00	
	Junior Analyst 3	80		100		R 8,000.00	
	Junior Analyst 4	80		100		R 8,000.00	
	BCS Laptop 1	80		20	100	R 1,700.00	
	BCS Laptop 2	80		20	100	R 1,700.00	
	BCS Laptop 3	80		20	100	R 1,700.00	
44	Implementation and Monitoring	3176	47 days				R 287,180.00
45	Identify Tangible Benefits	144	3 days				R 10,760.00
	Junior Analyst 1	24		100		R 2,400.00	
	Junior Analyst 2	24		100		R 2,400.00	
	Junior Analyst 3	24		100		R 2,400.00	
	Senior ITDS Programmer 1	24		100		R 2,400.00	
	BCS Laptop 2	24		20	100	R 580.00	
	BCS Laptop 4	24		20	100	R 580.00	
46	Assess Risk Factors	192	4 days				R 15,880.00
	Junior Analyst 4	32		100		R 3,200.00	
	Junior Analyst 5	32		100		R 3,200.00	
	Junior Analyst 6	32		100		R 3,200.00	
	ITDS Programming Manager 1	32		150		R 4,800.00	
	BCS Laptop 1	32		20	100	R 740.00	
	BCS Laptop 3	32		20	100	R 740.00	
47	Develop Final Recommendations Document	128	2 days				R 10,860.00
	Senior Analyst	16		200		R 3,200.00	
	Junior Analyst 1	16		100		R 1,600.00	
	Junior Analyst 2	16		100		R 1,600.00	
	Junior Analyst 3	16		100		R 1,600.00	
	Junior Analyst 4	16		100		R 1,600.00	
	BCS Laptop 1	16		20	100	R 420.00	
	BCS Laptop 2	16		20	100	R 420.00	
	BCS Laptop 3	16		20	100	R 420.00	

#	Task Name	Time	Duration	Rate	Cost/Use	Cost	Total Cost
48	Implement New Process	1800	25 days				R 162,300.00
	Senior Analyst	200		200		R 40,000.00	
	Junior Analyst 1	200		100		R 20,000.00	
	Junior Analyst 2	200		100		R 20,000.00	
	Junior Analyst 3	200		100		R 20,000.00	
	ITDS Programming Manager 1	200		150		R 30,000.00	
	Senior ITDS Programmer 1	200		100		R 20,000.00	
	BCS Laptop 1	200		20	100	R 4,100.00	
	BCS Laptop 2	200		20	100	R 4,100.00	
	BCS Laptop 3	200		20	100	R 4,100.00	
49	Make New Process Operational	360	5 days				R 32,700.00
	Senior Analyst	40		200		R 8,000.00	
	Junior Analyst 1	40		100		R 4,000.00	
	Junior Analyst 2	40		100		R 4,000.00	
	Junior Analyst 3	40		100		R 4,000.00	
	ITDS Programming Manager 1	40		150		R 6,000.00	
	Senior ITDS Programmer 1	40		100		R 4,000.00	
	BCS Laptop 1	40		20	100	R 900.00	
	BCS Laptop 2	40		20	100	R 900.00	
	BCS Laptop 3	40		20	100	R 900.00	
50	Evaluate New Process	480	10 days				R 47,200.00
	Senior Analyst	80		200		R 16,000.00	
	Junior Analyst 2	80		100		R 8,000.00	
	Junior Analyst 3	80		100		R 8,000.00	
	Senior ITDS Programmer 1	80		100		R 8,000.00	
	Junior ITDS Programmer 1	80		68.75		R 5,500.00	
	BCS Laptop 1	80		20	100	R 1,700.00	
51	Train Programming Supervisors	48	2 days				R 4,420.00
	Junior Analyst 1	16		100		R 1,600.00	
	ITDS Programming Manager 1	16		150		R 2,400.00	
	BCS Laptop 2	16		20	100	R 420.00	
52	Hand Over Project Deliverables	24	1 day				R 3,060.00
	Senior Analyst	8		200		R 1,600.00	
	ITDS Programming Manager 1	8		150		R 1,200.00	
	BCS Laptop 1	8		20	100	R 260.00	
53	Complete Project	0	0 days			R 0.00	R 0.00
	Senior Analyst	0				R 0.00	
Total Project Cost =							<u>R 783,970.00</u>

Appendix G: Risks, Consequences and Contingencies

	Risk Area	Consequence	Contingency
1	Factors Related to Management Systems Change		
a	Inadequate communication of need to change	Resistance to change, Time delays	Develop clear, effective communications plan
b	Hiding uncertainties in communication	Inaccurate risk assessment, Project Failure	Develop clear, effective communications plan
c	Poor communication between BPR team and other personnel	Misunderstandings, Time delays, Increased Cost	Develop clear, effective communications plan
d	Resistance to Organisational Change	Time delays	Increase Schedule time, communicate need for change effectively
e	Lack of adequate planning for resistance to change	Time Delays, Cost Increase	Increase schedule time
f	Demand for change exceeds the capacity to absorb	Time Delays, Cost Increase	Monitor processes early enough to identify need to change early
g	Lack of cross-functional cooperation	Work duplication, Time delays, cost increase	Develop clear, effective communications plan, Increase Schedule time for cross-functional tasks
h	Middle management impermeability	Time delays	Increase Schedule time, communicate need for change effectively
i	Lack of trust between management and employees	Negativity, Slower workrate, Time delays	Develop clear, effective communications plan
j	Tendency to copy others (previous processes)	Inaccurate process changes, Time delays, Cost Increase	Promote original idea generation
k	Lack of understanding of BPR	Time delays	Proper training for personnel
2	Factors related to management support		
a	Lack of sustained management commitment	Project Failure or Shelving	Thorough Management briefing of need for process changes
b	Lack of top management support and attention	Project Failure	Thorough Management briefing of need for process changes
c	Lack of visible sponsorship of senior management	Time delays, Project Failure	Thorough Management briefing of need for process changes
d	Difficulty in finding suitable project team members	Time Delays, Cost Increase	Find team members early, Increase schedule time
3	Factors related to organisational structure		
a	Inadequate communication between team members	Time delays	Develop clear, effective communications plan, Increase Schedule time
b	Inadequate team skills	Time delays	Train project teams adequately, Increase Schedule time and/or resources
c	Unclear job definitions	Time delays, Cost Increase, Confusion	Develop clear WBS, Increase schedule time
d	Inflexible hierarchical structures	Time delays, Project Failure	Promote "flat" organisational structure, Increase schedule time
4	Factors related to BPR project management		
a	Inadequate planning	Project Failure, Cost Increases, Time Delays	Thorough planning, increase schedule time
b	Compressing time needed to succeed	Cost Increases, Quality Decreases	Effectively crash project where needed, Increase resources
c	Variable quality of ideas	Time delays	Increase schedule time
d	Incomplete restructuring	Project Failure	Set clear goals and objectives from start
e	Inability to control BPR process efforts	Project Failure, Cost Increases, Time Delays	Develop effective project planning document, additional resources, increase schedule time
f	Lack of clear performance measures	Time delays, Cost Increases	Develop clear goals and objectives, Increase schedule time
g	Poorly defined needs	Time Delays, Cost Increases	Effective Client consultation, Increase schedule time, additional resources
h	Difficulty in measuring BPR project performance	Time Delays, Cost Increases	Develop clear performance goals, Increase schedule time
i	Spending too much time on analysing existing processes	Time Delays, Cost Increases	Reduce schedule time
j	Short-term view and "quick-fix" mentality	Project Failure	Detailed explanation of project process
k	Inadequate determination of scope and change	Time Delays, Cost Increases, Project Failure	Develop clear scope and change goals, Increase schedule time
l	Re-engineering the wrong processes	Project Failure	Effective Client consultation, Increase schedule time, additional resources
m	Lack of required resources	Project Failure, Time Delays	Increase resources, "reserve" resources in advance, Increase schedule time
n	Unsound financial condition	Project Failure/Shelving	Ensure available funding, Set realistic budget
o	Unrealistic scope and expectations	Project Failure	Clearly define project scope and realistic expectations based on facts
p	Poor implementation	Project Failure, Cost Increases, Time Delays	Clearly defined project goals and objectives, Increase schedule time, Additional resources
q	Lack of external consultant's support	Project Failure	Ensure system maintenance contract
r	Inadequate identification of customer's needs	Project Failure, Cost Increases, Time Delays	Effective Client consultation, Increase schedule time, additional resources
5	Factors related to IT infrastructure		
a	Failure to deliver systems on time	Project Failure, Cost Increases	Increase resources on time-constrained tasks
b	Lack of documentation	Project Failure, Time Delays	Ensure continuous documentation, Increase resources
c	Loss of human expertise	Time Delays, Cost Increase	Ensure continuous contracts of team members, Increase salaries and wages
d	Insufficient understanding of current IT systems	Project Failure, Cost Increases	Gather sufficient documentation, Hire external Consultant, Increase resources, Increase Costs
e	Lack of IT expertise	Time Delays, Cost Increases	Increase Resources, Train current employees
f	Difficulty in simulating new business process	Time Delays, Cost Increases	External consultants, Increase schedule time
g	Failure to continually assess emerging IT capabilities	Project Failure	Continually assess new IT capabilities and determine value to ITDS
h	Failure to aggressively use IT enablers	Project Failure	Assess value of new IT enablers and use if appropriate

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Appendices

Appendix C: Microsoft® Project 2000® Tutorial



University of Stellenbosch
Department of Industrial Engineering



Microsoft[®] Project 2000[®] Tutorial

Developed by: T.C. Boezaart

For

Dr. C.J. Fourie

26 November 2003

Opsomming

Hierdie tutoriaal maak deel uit van 'n Meesters Graad projek in Bedryfs Ingenieurswese aan die Universiteit van Stellenbosch. Dit is ontwerp met die doel om die leser 'n breë riglyn te gee van die hoof funksionaliteite van Microsoft® Project 2000®. Nieteenstaande word meeste van die belangrikste areas in Projekbestuur deur hierdie tutoriaal gedek, en dien as supplementêre materiaal tot die oplossing van die gevallestudie wat vir hierdie Meesters graad tesis ontwikkel is.

Synopsis

This tutorial forms part of a Master's Degree in Industrial Engineering thesis at the University of Stellenbosch. It was designed to give the reader a broad outline of the main functionalities of Microsoft® Project 2000®, and is by no means comprehensive. However, most of the important aspect of project management is covered by this tutorial, and supplements the solving of the case study that was developed for the Masters degree thesis.

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1. Introduction

In most cases project management goes much further than just controlling the project. It spans a much wider category of activities, which include, amongst others, project control. It is the aim of this tutorial to aid the user in becoming more effective at project management through the use of good project management software.

In order to manage a project, certain aspects that have to be managed in a project must be focussed on. These include the project, project tasks, task duration, task relationships, resources and costs.

The project's start and finish dates have to be managed, in order to ensure that the project starts on schedule, and remains on schedule, in order to ultimately complete the project on time. Furthermore the project's time and money constraints have to be managed in order for the project to be completed within the specified amounts.

Project tasks can be managed by means of a detailed WBS breakdown of the project tasks into manageable work packages. When attempting to manage the project tasks' duration, the duration of the task needs to be estimated. This can be done in one of four ways:

1. From experience

2. Probabilities: $\frac{O + 4M + P}{6}$
(where O = Optimistic estimate
M = Mean estimate
P = Pessimistic estimate)

3. π or Ceiling Method

4. History

With respects to managing task relationships, the predecessors and successors, as well as the finish-to-start times, amongst others, have to be determined.

Managing resources is critical to project success. Not only does the required number of resources for each task have to be managed, but also who and what these resources might be. This is necessary in order to be able to minimise the required resources for the entire project, and therefore stay within the time and financial constraint of the project. It is therefore also critical to manage all project costs, while still ensuring that the project resources are sufficient, and the project performance is also sufficient.

In order to facilitate this management process, it can either be done by hand or computer. Some factors that need to be addressed in order to decide whether or not a computer software program should be used, include:

- Number of tasks
- Relationships between the tasks
- Project duration
- Project Costs

Once it has been decided that the project warrants the use of a computer program, which program to use must be decided upon. This is done by assessing the following factors:

- Ease of starting up
- Ease of updating
- Compatibility with other software
- Output quality
- Price
- Support

Due to the factors discussed above, a decision to use Microsoft® Project 2000, is made, on which the rest of this tutorial will be based.

2. Starting Up

This section briefly explains the basics of starting up Microsoft® Project 2000®.

2.1 Start-up

Start up Windows and then Microsoft® Project 2000®, in order to activate the project management software. When starting up, the main screen, shown below, is activated.

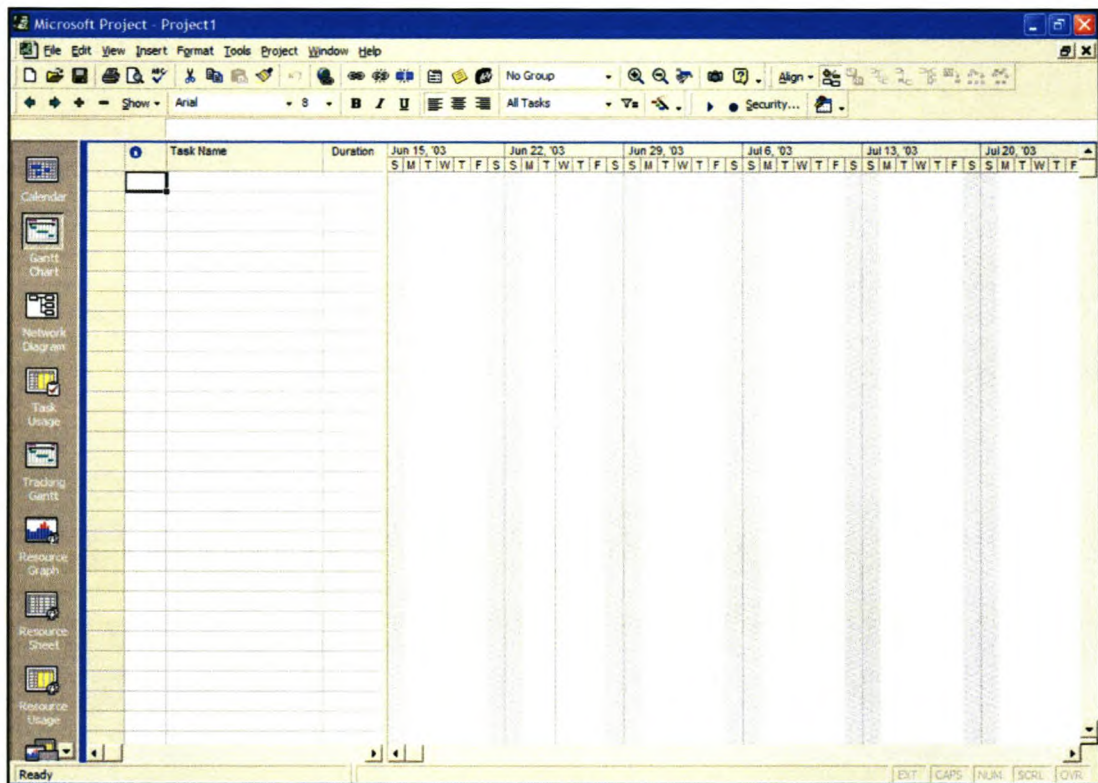


Figure 2.1: Start-up Screen

The mouse has the following functions in MS Project 2000:

- Left Click: Select Item
- Right Click: Functions
- Dragging and dropping is possible.

All other mouse functions are standard.

2.2 Menus

The standard toolbar in MS Project is similar to the toolbars used in other Microsoft programs, like Word and Excel (See Figure 2.2 below). Below follows a quick overview of the most commonly used pull-down menus:

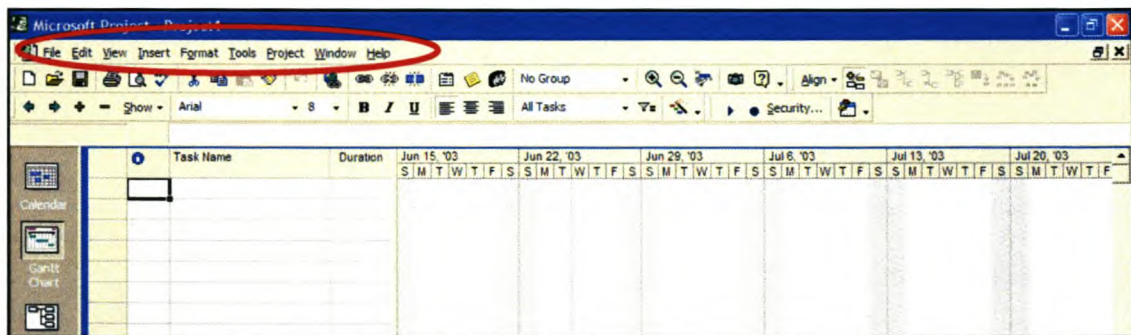


Figure 2.2: Main Toolbar

File Menu:

The File menu (Figure 2.3 below) has three main functions included in its drop-down list, namely, New, Open and Save. Clicking on New will activate a completely new and blank project. Open allows the user to access saved projects. Save allows the user to save the current project either with a baseline (more details will be given later), or without a baseline.

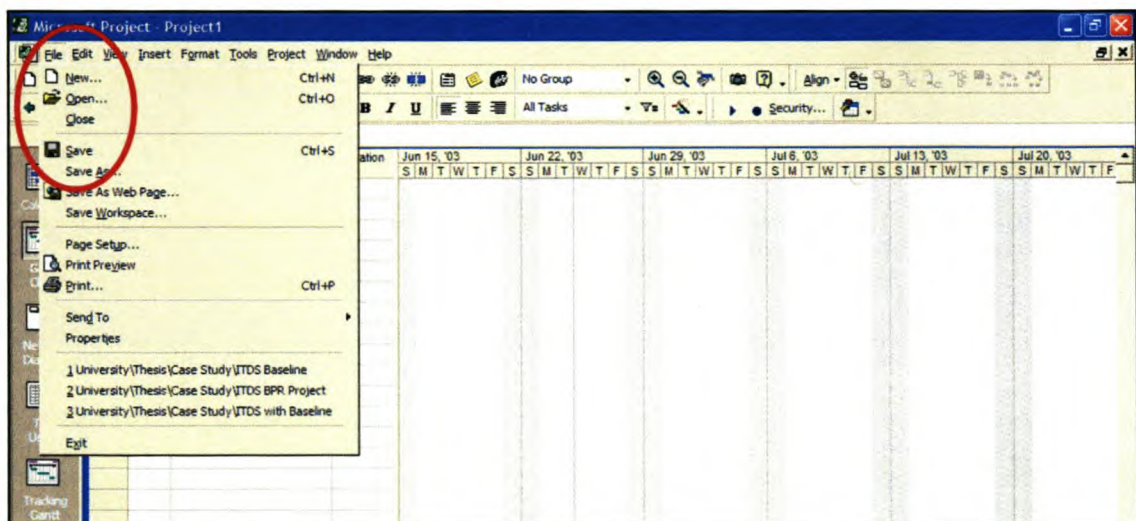


Figure 2.3: File Toolbar

Edit Menu:

The main functions on the “Edit” menu (See Figure 2.4 below) are Link, Unlink and Split. These can be selected by clicking on Edit, and then any of the actions the user would like to perform (circled in red), or by simply clicking on the icons on the toolbar (circled in green).

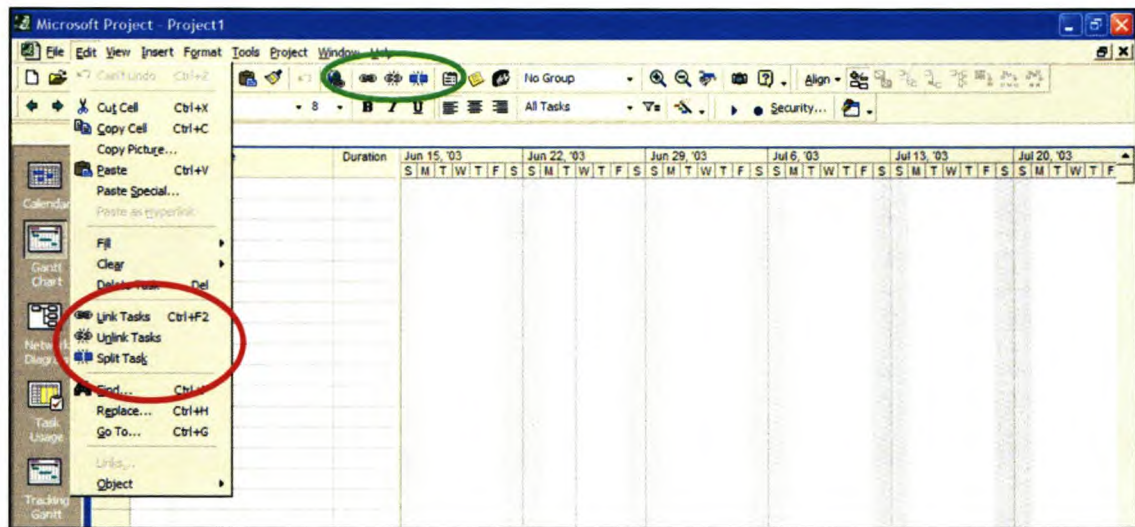


Figure 2.4: Edit Menu

Linking tasks allows the user to force the program to schedule the start of the second task to be linked after the completion of the first linked task. More than two tasks can be linked by means of selecting all the tasks that have to be linked, and simply selecting “Link Tasks” in the “Edit” menu, or by simply pressing Ctrl + F2 on the keyboard (shortcut key). In this case, the tasks will be linked in order of selection. I.e. if we select the third tasks first, the first task second, and the second task third, the third task will be scheduled first, the first task will be scheduled to start after the completion of the third task in the list. The second task will then, quite obviously, be scheduled to start after the completion of the first task in the list.

Unlinking tasks simply removes the precedence order created by linking the tasks. Splitting a task allows the user to complete a task at a later stage, after it has been begun. This is useful for when a person needs to wait for a piece of a

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program to be completed before he can complete his program, which he has already started. The duration of the split can be set by the user, as well as after what duration the user would like to create the split.

View Menu:

The View menu (See Figure 2.5 below) allows the user to select which view he/she would like to see. The main views are: Calendar, Gantt, Network and Tables. These views can be selected by clicking on View and then the appropriate selection (both circled in red), or by simply clicking the desired view's shortcut in the shortcut toolbar on the left of the screen (circled in green).

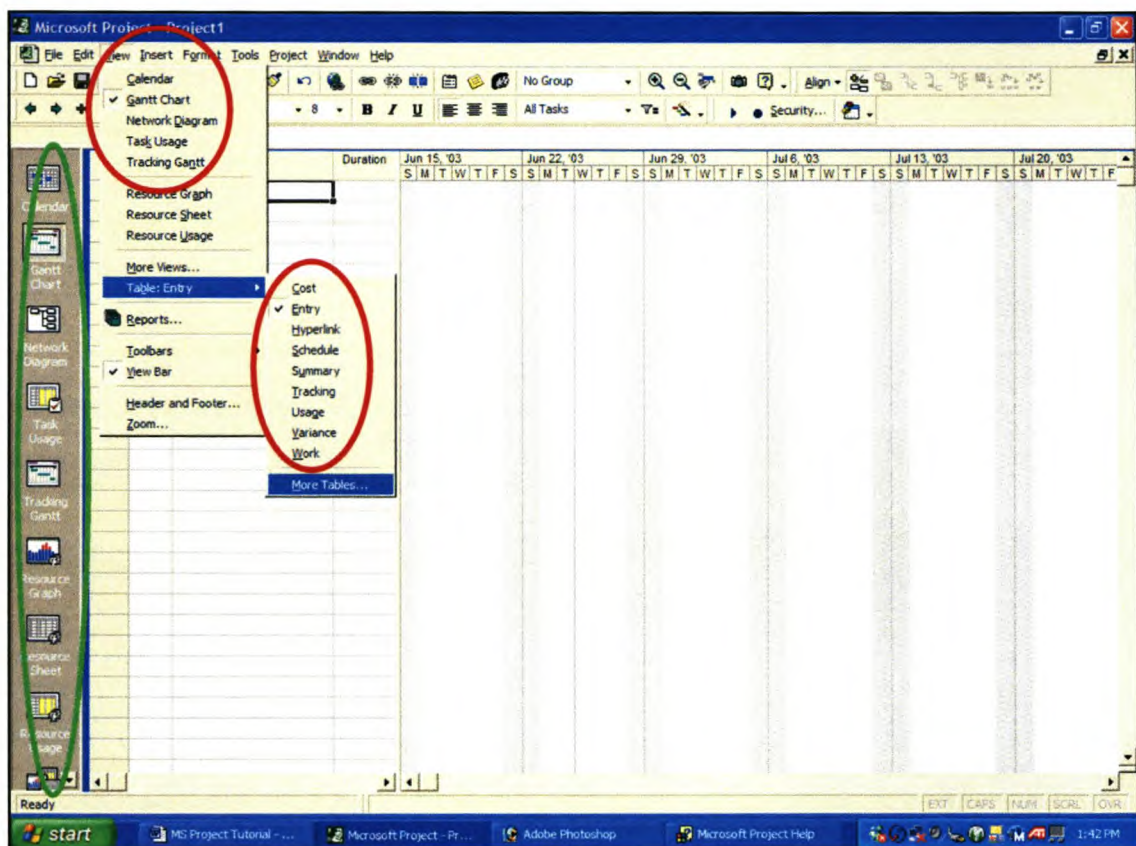


Figure 2.5 View Menu

The Calendar view gives the user a view of the current month's calendar, along with all the tasks that have to be completed during the month. The user is also able to scroll through months to view the tasks that have to be/had to be

completed during the specific month. The Gantt chart view is the default view for Microsoft® Project 2000®. This view displays the project Gantt chart, along with a table of all tasks and milestones, as well as their duration, start and finish date, the required resources and the task predecessors.

The Network view provides the user with the CPM network for the task. This network lists the tasks, their duration, earliest and latest start dates, earliest and latest finish dates, as well as the total and free slack of all tasks, in network form. This is basically another graphical representation of the Gantt chart that contains more information.

The Tables view allows the user to specify the accompanying information in the Gantt chart view. The user is able to select the specific information to be viewed, which is then displayed in table form next to the Gantt chart, thereby replacing the existing information.

The user is also able to display the toolbars they prefer to have on the screen. This can be achieved by clicking on View, then hovering on Toolbars, and then selecting the required Toolbars. Figure 2.6 below demonstrates this graphically.

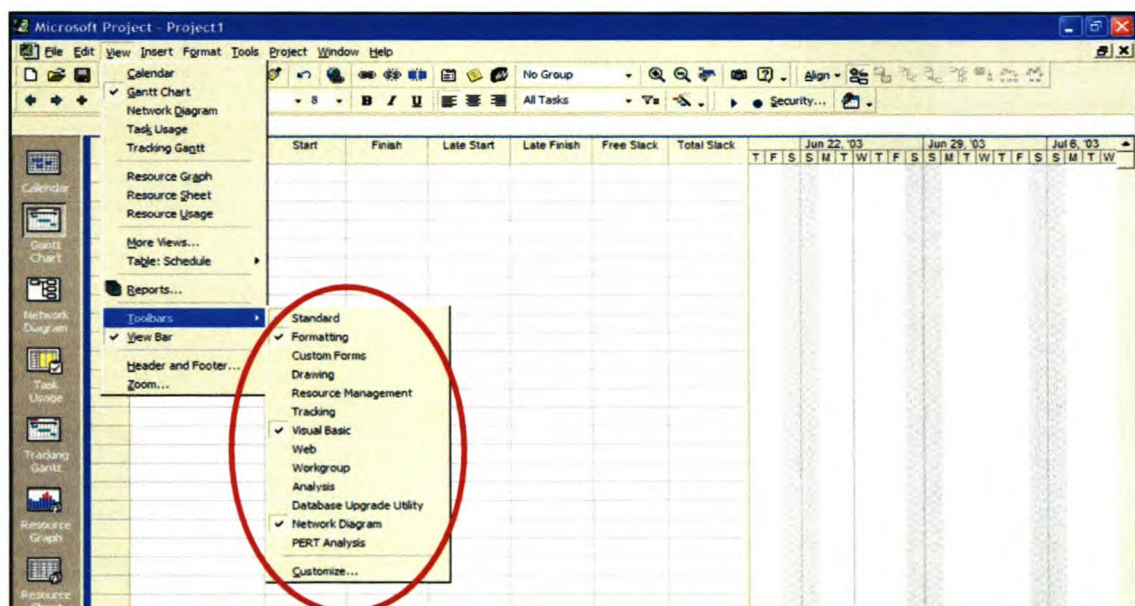


Figure 2.6: Selecting the Appropriate Toolbars

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The Toolbar menu can also be accessed by clicking the right mouse button whilst the mouse cursor is in the grey toolbars area. This is often simpler and quicker than the method described above. By hovering over a Toolbar button, the function of that button is displayed to the user.

Project Menu:

The two main functions in the Project drop-down task list is: Task information, and Project Information, as can be seen in Figure 2.7 below (circled in red).

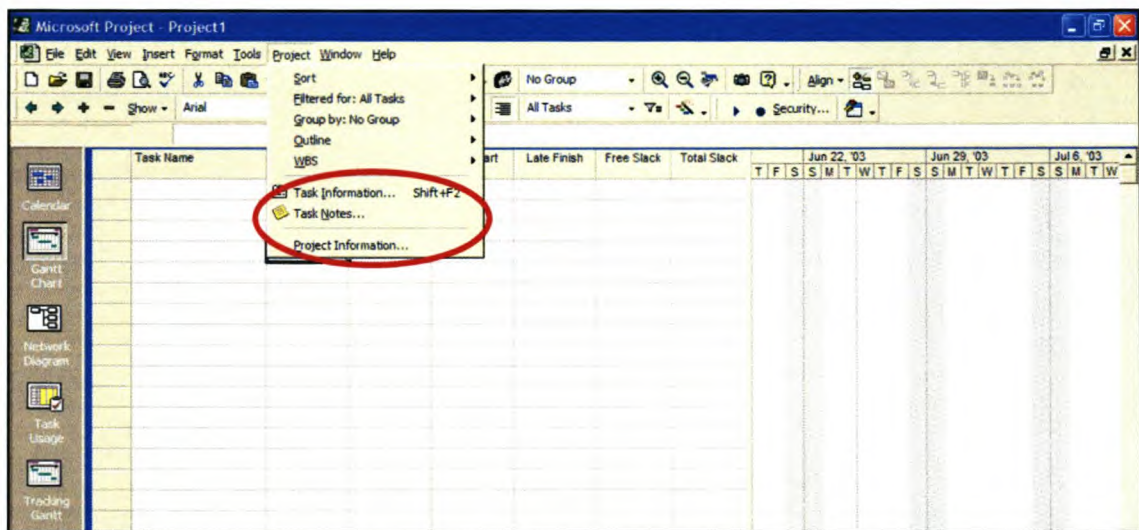


Figure 2.7: Project Menu

The task information and project information functions can be accessed by first clicking on “Project” and then selecting the required option. Alternatively, the task information can be accessed by simply clicking on the shortcut icon on the main toolbar (see Figure 2.8 below).

Windows Toolbar:

This toolbar allows the user to split the current display, or to remove the current window split. This is useful for when the task has a large number of tasks, and the user would like to view the task details, as well as the Gantt chart and task list. The window shown in Figure 2.9 below has been split, and the task

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information of the highlighted task in the upper window can be seen in the lower window.

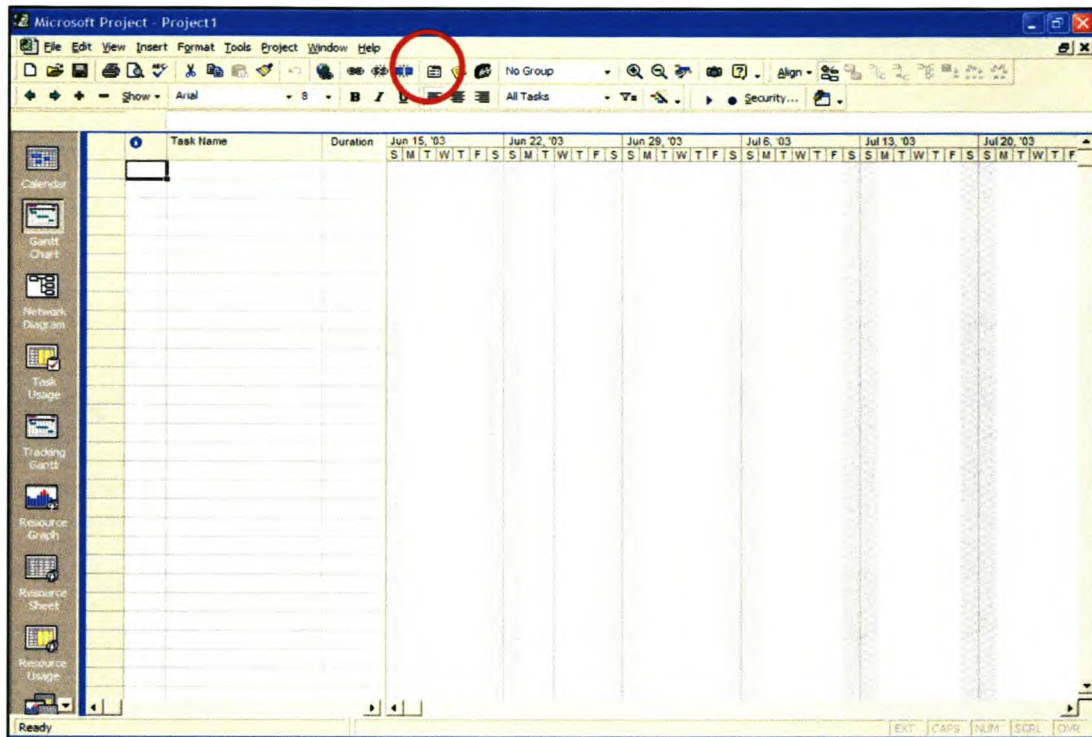


Figure 2.8: Task Information Icon

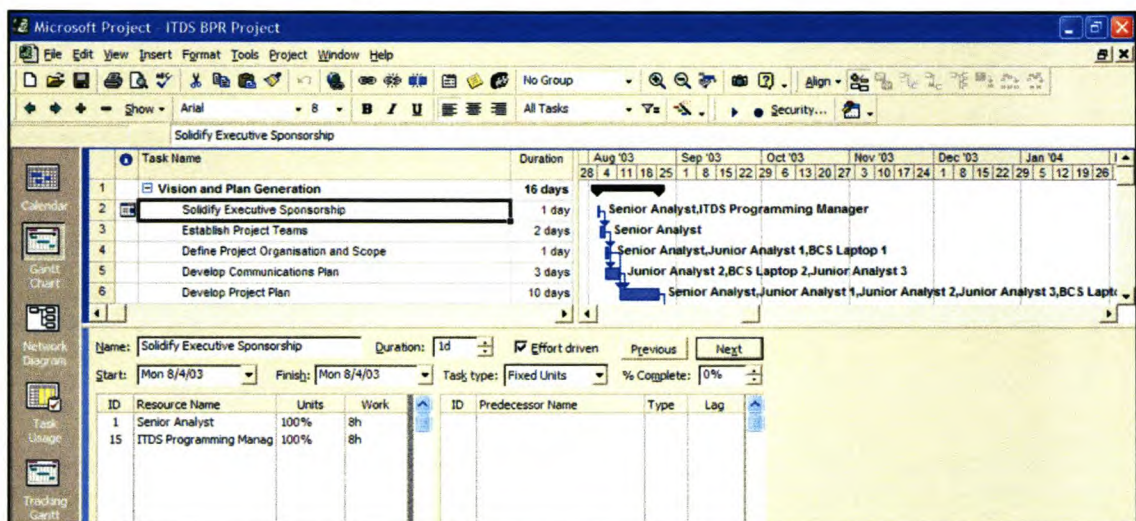


Figure 2.9: Split Window with Task Information

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Help Menu:

The Help menu is useful in supplying information regarding most of the functionalities in Microsoft® Project 2000®. Of importance is the “Getting Started” link. This link leads provides the user with a basic overview of getting started with Microsoft® Project 2000® (see Figure 2.10 below). It provides a quick overview of the main functionalities of Microsoft® Project 2000®, gives an overview tutorial on the main functionalities, and provides a roadmap for building a new project in Microsoft® Project2000®.

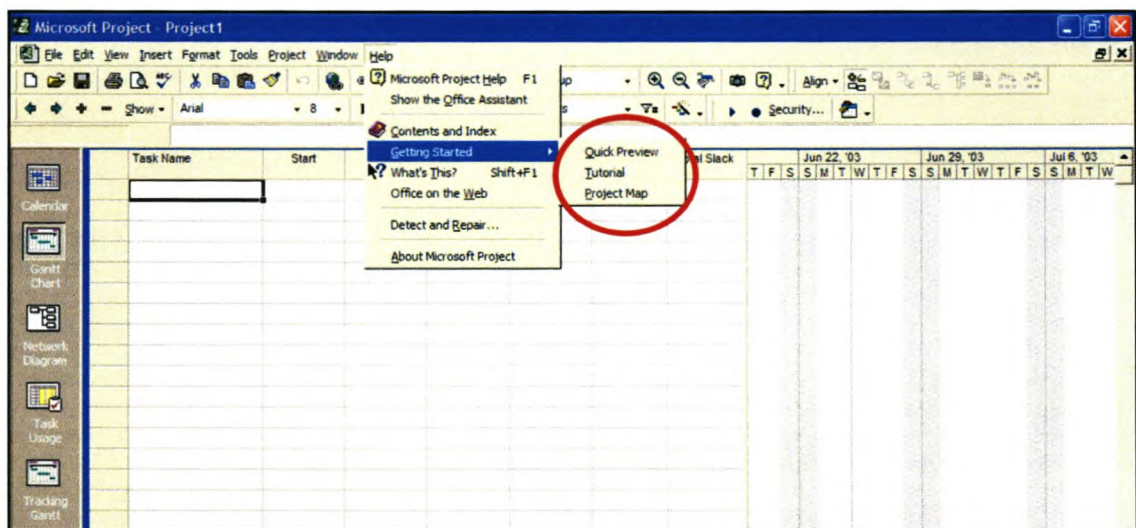


Figure 2.10: Help Menu

3. Creating the Project Plan

Now that the user has a general idea about the toolbars and their functions, we need to start managing a project. The aim of this section is to give the user a basic overview of entering a project into Microsoft® Project 2000®. This requires numerous steps, of which the first is to set the overview scene of the project.

3.1 Setting the scene

The project is started by setting the following parameters:

- Project Start date
- Project Schedule start date
- The cost currency
- The working time and holidays have to be specified

Additionally, the following parameters have to be adjusted:

- Activate outline numbering
- Specify manual resource levelling.

Refer to the tutorial /worksheet in Appendix A of this document and find the required project information. Below follows a description of how this information is to be entered into Microsoft® Project 2000®.

Entering the date:

To enter the project dates, first click on Project and then on Project Information. A pop-up box appears. The project start date can now be entered into this box (See Figure 3.1 below).

Entering the “Schedule From” Information:

The Schedule From information is also read into Microsoft® Project 2000® on the Project Information input Box (See Figure 3.1 below). We will select the default value for this field here; i.e. Schedule from: Project Start Date. It can also be specified that the program must start the scheduling from the project end date.

This is useful in the case where the project does not have a fixed starting date, but a definite ending date, or deadline.

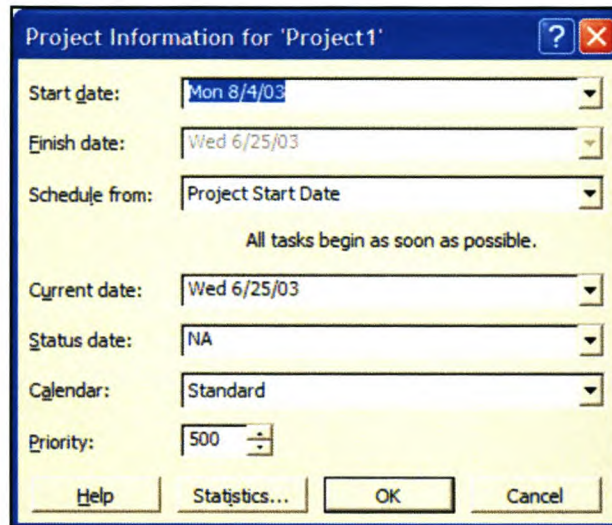
The image shows the 'Project Information for 'Project1'' dialog box. It contains several fields: 'Start date' (Mon 8/4/03), 'Finish date' (Wed 6/25/03), 'Schedule from' (Project Start Date), 'Current date' (Wed 6/25/03), 'Status date' (NA), 'Calendar' (Standard), and 'Priority' (500). Below these fields is the text 'All tasks begin as soon as possible.' At the bottom are buttons for 'Help', 'Statistics...', 'OK', and 'Cancel'.

Figure 3.1: Project Information Input Box

Change the Project Currency:

The currency to use in a specific project can also be specified. This is done by typing in the symbol for that specific currency. For example, if South African Rand was specified as the project currency, the symbol for Rand (R) must simply be typed into the Currency field (see Figure 3.2 below).

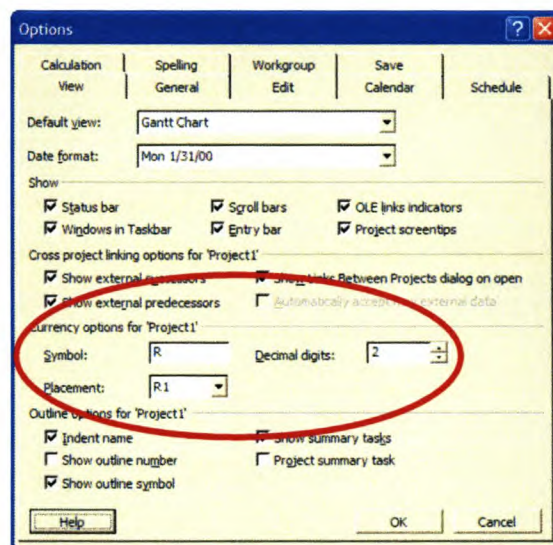
The image shows the 'Options' dialog box with the 'Schedule' tab selected. The 'Currency options for 'Project1'' section is circled in red. It contains a 'Symbol' field with 'R' entered, a 'Decimal digits' field with '2' entered, and a 'Placement' dropdown menu set to 'R.1'. Other sections visible include 'Calculation View', 'Spelling General', 'Workgroup Edit', 'Save Calendar', and 'Outline options for 'Project1''.

Figure 3.2: Options Editing Box

To generate the pop-up box in which to type the symbol, select “Tools”, then “Options”. This then produces this pop-up box (see Figure 3.2 above). Simply type in the symbol in the “Currency options for ‘Project X’” section of the “View” tab. The number of decimal digits can also be specified, as well as the placement of the symbol (either in front of the amount, or after, or with a space between the symbol and the amount).

Changing the working time and holidays:

It is also possible to change the working time, and mark specific days as holidays, or non-working days. This is very useful, especially if the project is done in an industry where the working time differs from the standard work-week. Being able to change the working status of a day is useful, due to the fact that most countries have different public holidays, and working days differ from each country. See the Information Page in Appendix A for the public holidays and working week times for this specific tutorial.

The working times and holidays are changed by first selecting “Tools”, and then “Change Working Time”. This then produces the pop-up box that can be seen in Figure 3.3 below.

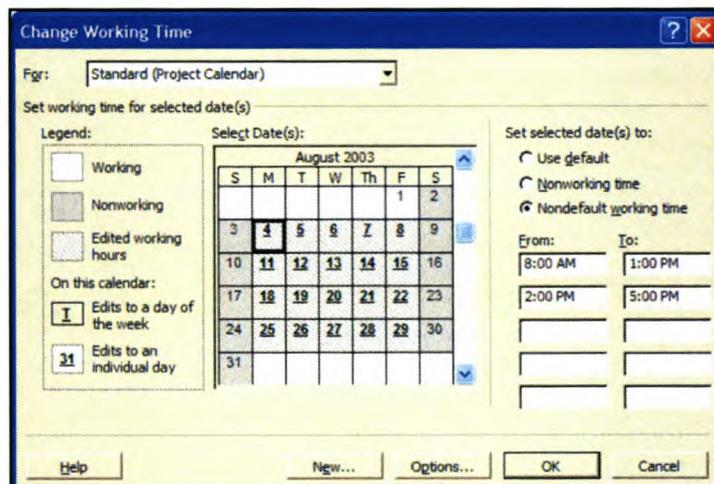


Figure 3.3: Change Working Time Edit Box

In order to change the working week, simply highlight the days for which the times have to be changed, and then type in the times in the “Set Selected Date(s) to:” to the relevant working times for the project. Holidays can be selected by highlighting the specific day, and then changing its option to “Nonworking time” by clicking in the radio button. The program now knows that that day is not available to work on, and now schedules the project accordingly.

Alternatively, the day on which the working week starts, in which month the fiscal year starts, the daily default start and end times, the number of working hours per day, the number of working hours per month, and the number of working days per month can also be specified. This is done by selecting the “Options” button (circled in green in Figure 3.3 above), and then changing the specific options in the “Options” pop-up box (see Figure 3.4 below).

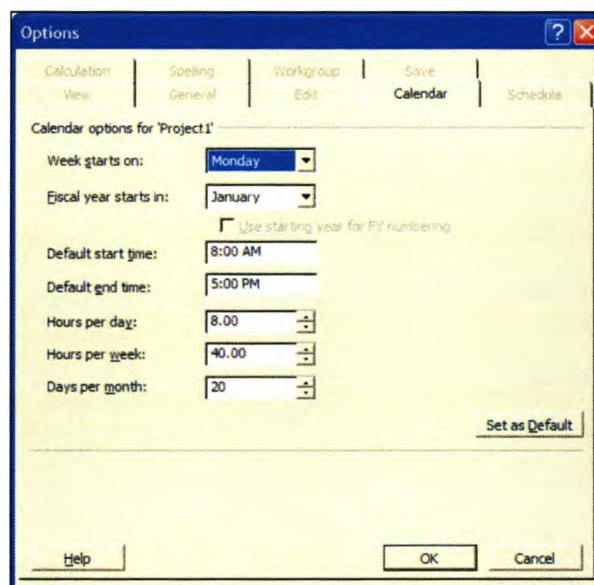


Figure 3.4: Calendar Options Box

A couple of options must now be changed, before commencing with the rest of the project.

Outline Numbering:

The outline numbering option must be changed; i.e. switched on. This is done by simply clicking in the radio button after selecting “Tools”, then “Options”, and then the “View” tab on the Options pop-up box (see Figure 3.5 below). The reason for this is to ensure that the project is numbered correctly. If this option is selected, an overview task will be numbered with a whole number, e.g. 3. All subtasks of task numbered three will be numbered with a digit corresponding to the rank of the task, e.g. subtask 3 of overview task 3 would be visibly numbered 3.3.

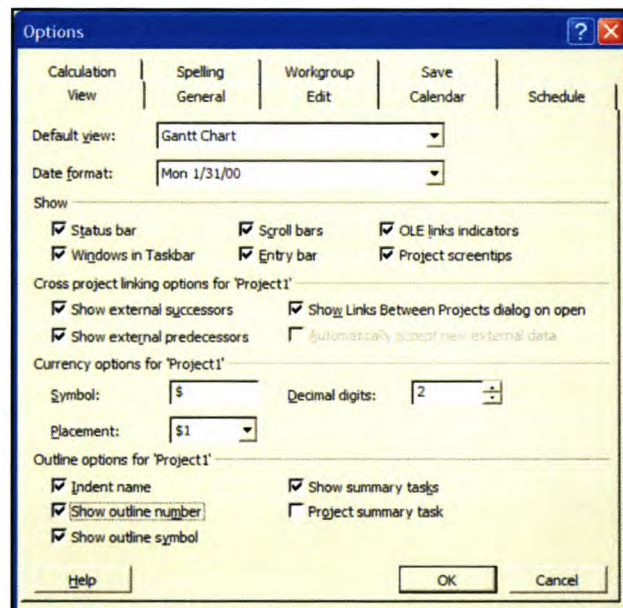


Figure 3.5: Options Box to Change Outline Numbering

Resource Levelling Options:

It is possible for the program to automatically level the resource usage, i.e. minimise the overtime that a specific resource uses at a specific stage by assigning the task to other resources. Generally, it is better to do the resource levelling manually, seeing as additional resources might be added, and the resource load not just spread amongst the existing resources. It is, however, quite useful to see how the program levels the resources. It could aid in assigning overtime to specific resources.

This option can be set by firstly selecting “Tools” and then selecting “Resource Levelling...”. This then produces the Resource Levelling Options Box (see Figure 3.6 below). Simply select either the manual or automatic radio buttons in order to select the desired option.

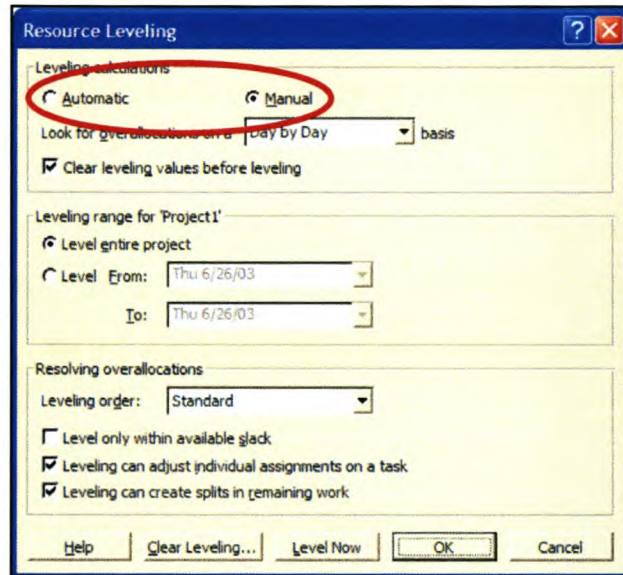


Figure 3.6: Selecting Manual Resource Levelling

Having completed all these tasks, the scene has now been set for the project to be based on. All background information has been entered, and the initial options selected. Our next task is to enter the tasks into the program.

3.2 Entering the Tasks

Entering the Tasks' Names:

Next, the tasks have to be entered into Microsoft® Project 2000®. This is done by simply typing in the task name into the Gantt chart view. If a task list already exists in Microsoft® Excel®, it can be pasted directly into Microsoft® Project 2000®. Disregard the numbering at this stage. Microsoft® Project 2000® will automatically assign numbers to each of the tasks. Figure 3.7 below shows how

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the entering of the task names is done. This should be done for all the tasks on the Information Sheet provided in Appendix A.

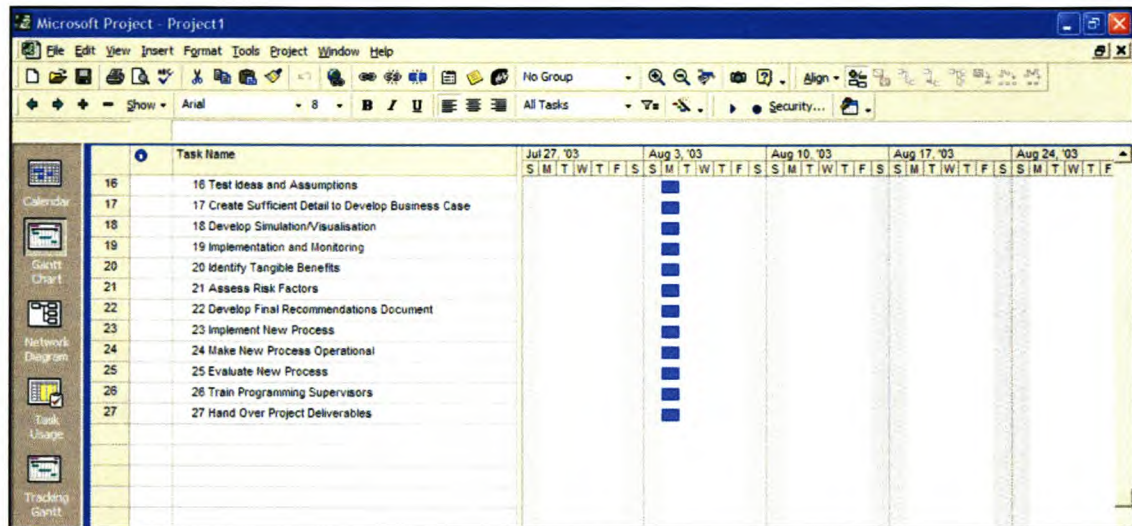


Figure 3.7: Entering the Project Tasks

Once all the tasks have been entered, a bit more detail regarding these tasks have to be filled in. Firstly, all the tasks' durations will be filled in.

Entering Tasks' Durations:

The tasks' durations are entered by simply typing in the specific task's duration into the cell adjacent to the task name, in the Duration column (see Figure 3.8 below). The duration can be entered in minutes (m), hours (h), days (d), or weeks (w). Milestones are tasks with no duration (0d). The duration of all the tasks, as provided on the Information Sheet, must now be entered into Microsoft® Project 2000®.

Overview tasks do not have times assigned to them at this stage. This is due to the fact that the subtasks have, firstly, not been identified in Microsoft® Project 2000®, and secondly the relevant tasks have not been linked, as yet. The next task is to specify, or outline, the subtasks.

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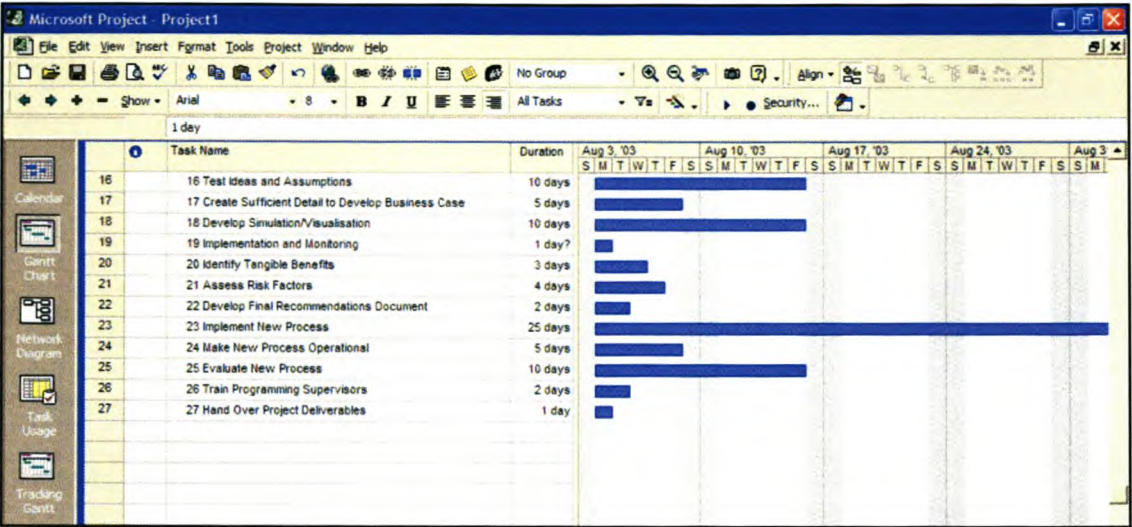


Figure 3.8: Entering the Tasks' Durations

Outlining Subtasks:

Subtasks are outlined by simply highlighting the subtask and then clicking on the arrow pointing right on the toolbar (see Figure 3.9 below, circled in red). Notice that the numbering next to the specific task also changes to the relevant outline number. This must be done according to the highlighting in the Information Sheet provided in Appendix A for all the subtasks.

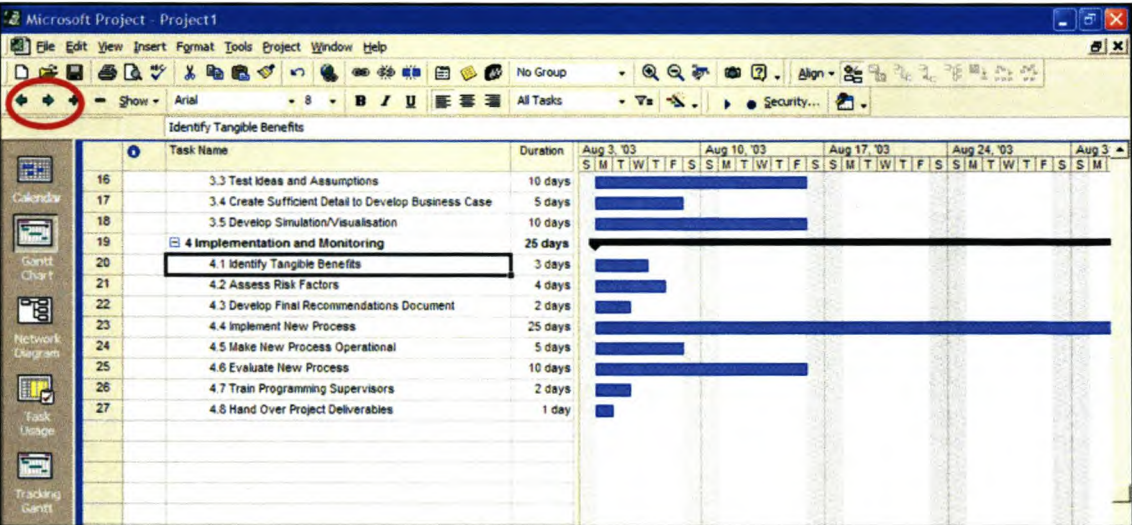


Figure 3.9: Specifying the Subtasks

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Also notice that all overview tasks now gets a time bar in the Gantt chart. This is to indicate the duration of that task, which is the same as the duration of its longest subtask, as well as identify the specific subtasks for that overview task, or work package.

Schedule Subtasks:

The next step is to link all the related tasks to one another. This is done by linking the tasks as explained earlier in this tutorial (see Section 2.2.2). This is demonstrated by means of an example. Assume that task 2.2 is a predecessor of task 2.3. Now highlight 2.2, and then 2.3, and then click on the “Link” button, as shown in Figure 3.10 below. Task 2.3 is now scheduled to start after Task 2.2 is completed. This must be done for all subtasks according to the information supplied on the Information Sheet in Appendix A.

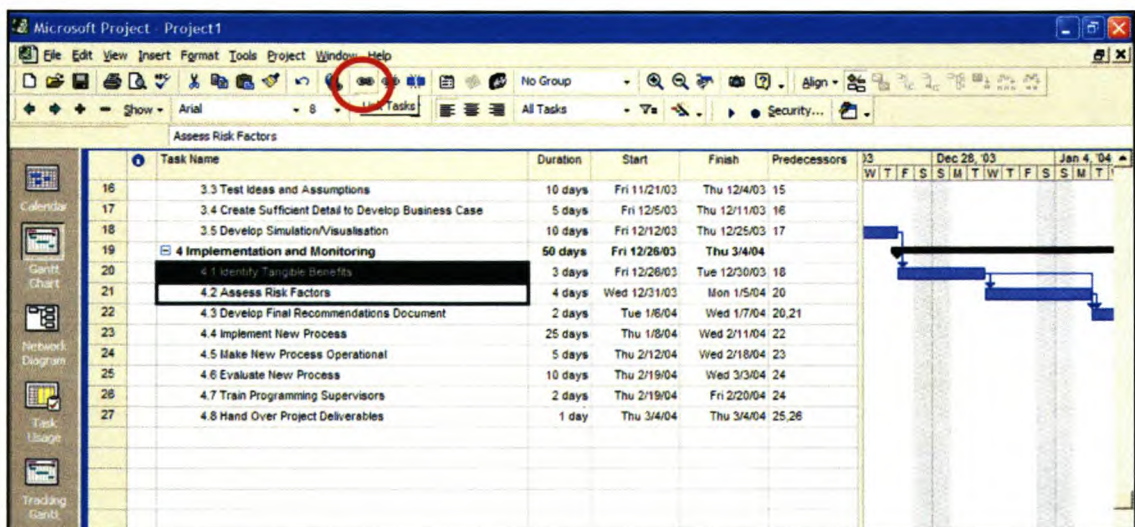


Figure 3.10: Scheduling the Subtasks

Alternatively, this can also be done by selecting View, then Table: Entry, and moving the vertical bar to the right, in order to reveal the “Predecessors” column. Each predecessor can now be entered manually.

Scheduling Summary (Overview) Tasks:

The next step is to schedule all the overview, or summary tasks. This is simply done by highlighting the various tasks (place cursor on tasks, press Ctrl-button and mark next summary task, according to precedences), and linking them by clicking on the “Link” button. Figure 3.11 below demonstrates this.

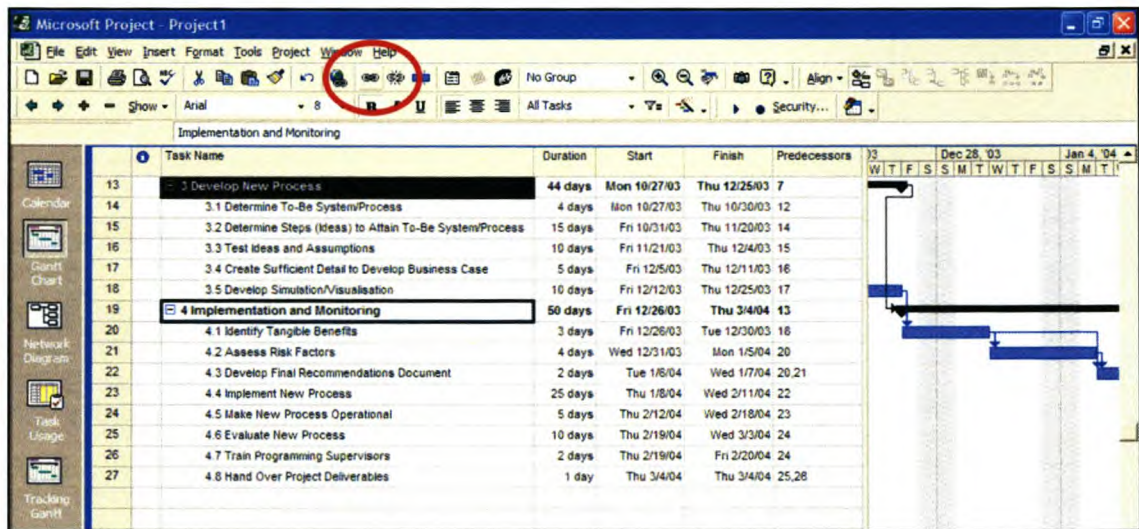


Figure 3.11: Scheduling the Summary Tasks

Now that these steps have been completed, the Gantt chart can be viewed. In order to do this, you might need to use the “Zoom In” button on the toolbar. This is also a good time to save the project. This can be done by selecting “File”, and then “Save”. Choose the “Save without a baseline” option at this stage.

3.3 Labour and Material Resources

The next task is to create a list of all the labour and material resources required for this project.

Creating a Resource List:

A list of all resources has to be created, before the resources can be assigned to the specific tasks. This is done by clicking on the “Assign Resources” button (the button with the two faces on), and simply typing in all the names of the resources in the “Assign Resources” box (see Figure 3.12 below). Remember that one entry

represents a single resource. If more than one specific type of resource is required, a new name has to be assigned to it, and also entered into the table as a separate resource.



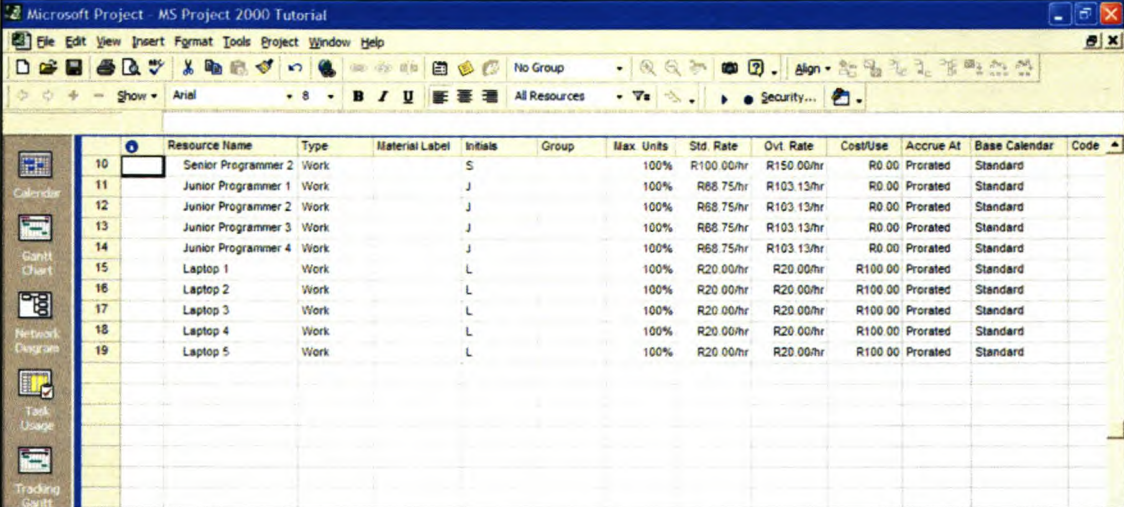
Figure 3.12: Filling in the Resource List in the Assign Resources Box

The resources are all provided in the Information Sheet in Appendix A. Due to the fact that the Computer Laptops have a standard rate per hour, these have to be handled as labour resources as well. When all the resources have been entered into the resource list, clicking on the “Close” button will automatically transfer all these resources to the Resource Sheet.

Seeing as there are no further materials required for this project, a material resource list does not have to be created. This function is typically necessary for a building project, where resources like sand, concrete and brick are required.

Assigning Costs to Resources:

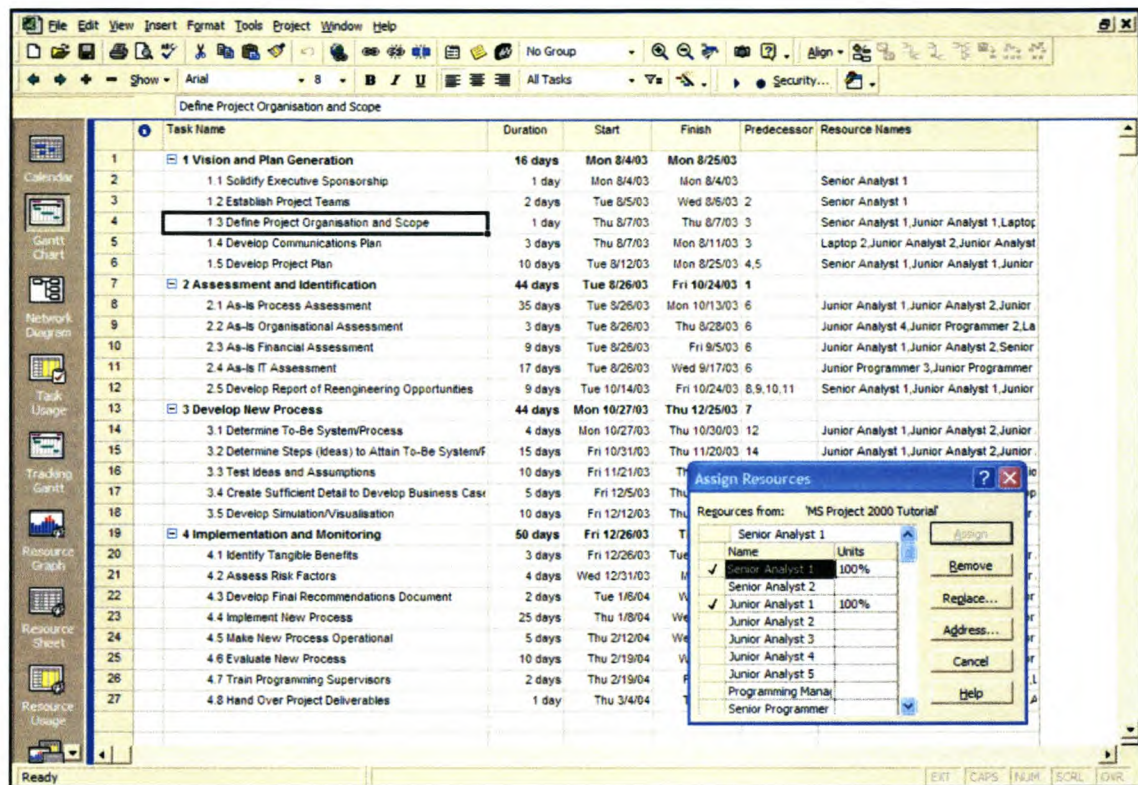
The “Resource Sheet” can be accessed by clicking on the icon in the vertical toolbar on the left hand side of the display. From the main toolbar, select “View”, then “Table” and then “Entry”. The rates for each of the resources now have to be entered into the table (see Figure 3.13 below). These rates can be found in Appendix A on the Information Sheet. Also note that the laptops have a cost per usage assigned to them. This must also be entered into the Resources Sheet.

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	Resource Name	Type	Material Label	Initials	Group	Max Units	Std. Rate	Ovt. Rate	Cost/Use	Accrue At	Base Calendar	Code
10	Senior Programmer 2	Work		S		100%	R100.00/hr	R150.00/hr	R0.00	Prorated	Standard	
11	Junior Programmer 1	Work		J		100%	R68.75/hr	R103.13/hr	R0.00	Prorated	Standard	
12	Junior Programmer 2	Work		J		100%	R68.75/hr	R103.13/hr	R0.00	Prorated	Standard	
13	Junior Programmer 3	Work		J		100%	R68.75/hr	R103.13/hr	R0.00	Prorated	Standard	
14	Junior Programmer 4	Work		J		100%	R68.75/hr	R103.13/hr	R0.00	Prorated	Standard	
15	Laptop 1	Work		L		100%	R20.00/hr	R20.00/hr	R100.00	Prorated	Standard	
16	Laptop 2	Work		L		100%	R20.00/hr	R20.00/hr	R100.00	Prorated	Standard	
17	Laptop 3	Work		L		100%	R20.00/hr	R20.00/hr	R100.00	Prorated	Standard	
18	Laptop 4	Work		L		100%	R20.00/hr	R20.00/hr	R100.00	Prorated	Standard	
19	Laptop 5	Work		L		100%	R20.00/hr	R20.00/hr	R100.00	Prorated	Standard	

Figure 3.13: Resource Cost Assignment***Assigning Resources to Tasks:***

The next step is to assign the resources required by each task to that specific task. This is done by, firstly, clicking on the “Gantt Chart” icon on the vertical left-hand toolbar, and then selecting the “Assign Resources” icon (two faces) from the main toolbar. Now select a specific subtask, and assign the required resources to that subtask (see Figure 3.14 below). Be careful not to assign resources to summary tasks. This will give inaccurate results. The required resources for each task in this tutorial can be found in the Information Sheet in Appendix A. Remember to close the Assign Resources box when you have assigned all the resources to their tasks.

Microsoft® Project 2000® Tutorial**Figure 3.14: Assigning Resources to Subtasks**

This is the end of the project planning step. The next objective is to evaluate the project plan that has just been created.

4. *Evaluating the Project Plan*

Now that a project plan has been developed, it has to be determined whether or not it is a worthwhile plan to follow. This is done by reviewing and evaluating several aspects of the project plan. These aspects include the general project information, CPM network and critical activities, Critical activities on the Gantt-chart, finding slack on the project, finding resource over-allocations, finding the cost of a specific task, and finally, finding the total cost of the project.

4.1 *Project Information*

The most important general project information is the finish date, which can be found by clicking on “Project” and then on “Project Information...” and then simply reading it from the table (see Figure 4.1 below, circled in red).

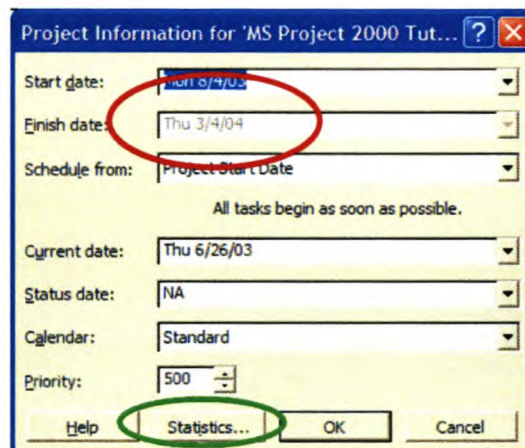
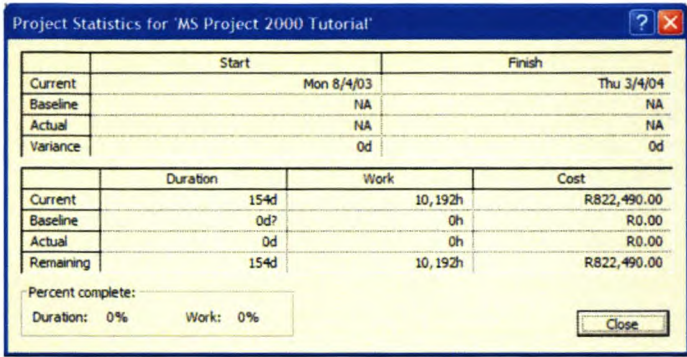


Figure 4.1: General Project Information

More specific information can be found by clicking on the “Statistics” button at the bottom of this box (see Figure 4.1 above circled in green & Figure 4.2 below).

A variety of reports are available by clicking on “View”, and then “Reports”. These reports are very useful, depending on the information required by the user.



	Start	Finish
Current	Mon 8/4/03	Thu 3/4/04
Baseline	NA	NA
Actual	NA	NA
Variance	0d	0d

	Duration	Work	Cost
Current	154d	10,192h	R822,490.00
Baseline	0d?	0h	R0.00
Actual	0d	0h	R0.00
Remaining	154d	10,192h	R822,490.00

Percent complete:
Duration: 0% Work: 0%

Close

Figure 4.2: Project Statistics

4.2 Critical Activities in the Task List

The user might want to view the critical activities in the task list, in order to make certain decision regarding these activities. This can be done by selecting the Gantt chart view, and selecting “Format”, and then “Text Styles”. A new pop-up box appears (see Figure 4.3 below), from which the user now selects the “Critical Tasks” field in the “Item to change” field.

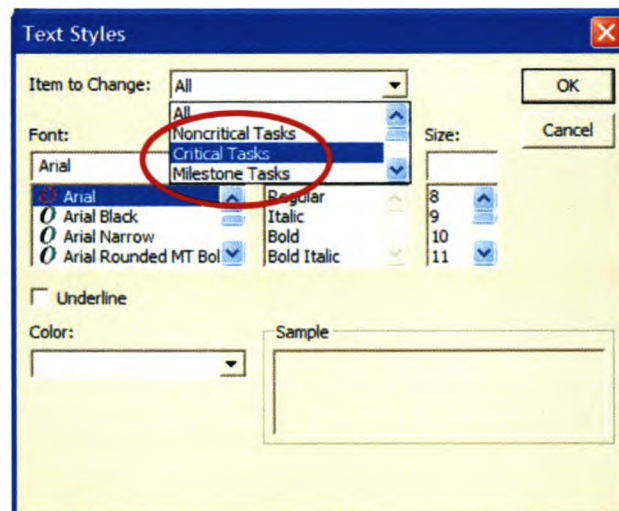


Figure 4.3: Selecting to Change Properties of the Tasks in the Task List

Next, the user must select the colour to change the font to (select red). The result of this exercise is that all the critical activities in the tasks list is now in red, which makes them easier to identify (see Figure 4.4 below).

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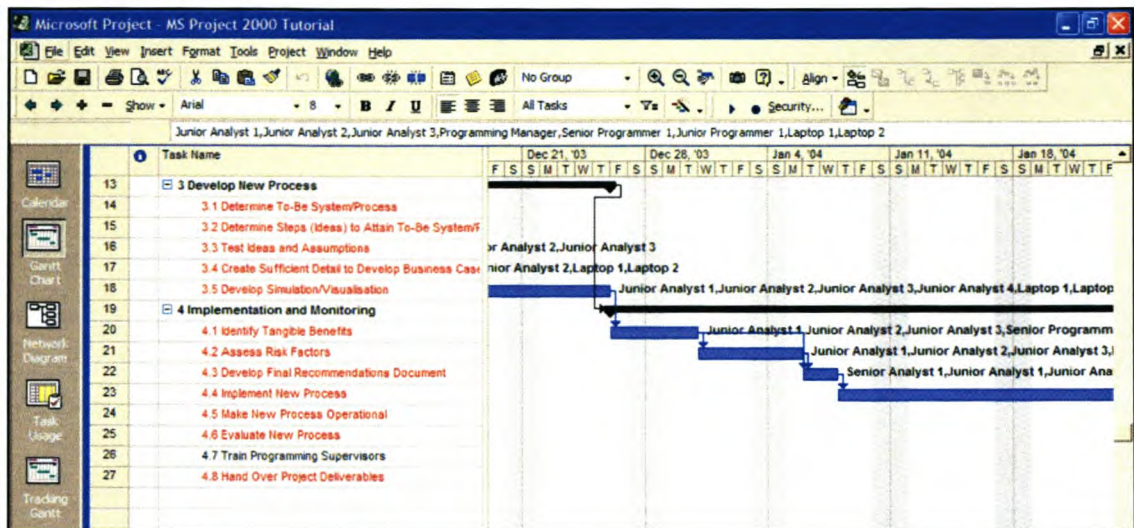


Figure 4.4: Critical Activities Highlighted in red in the Task List

4.3 Critical Activities on the Gantt-Chart

Similarly, the critical activities on the Gantt chart may also be highlighted. Again, this can easily be done by the following procedure. Firstly, select the Gantt chart view. Next, click on “Format”, and then the “Gantt Chart Wizard”. Now select the “Critical Path” (see Figure 4.5 below), and click on “Finish”.

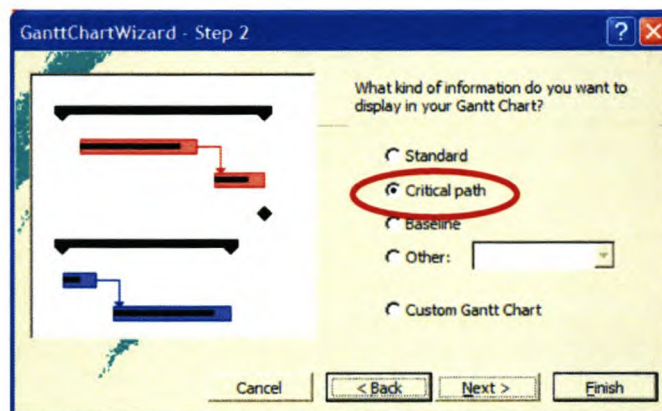


Figure 4.5: Highlighting the Critical Activities on the Gantt Chart

Now click the “Format It” button (see Figure 4.6 below) to format the Gantt chart.

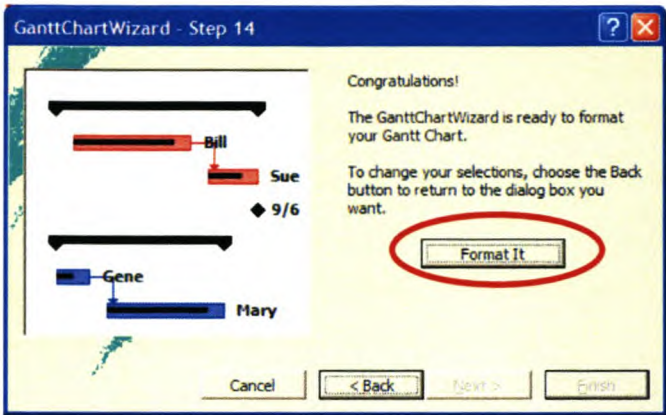


Figure 4.6: Highlighting the Critical Activities on the Gantt Chart

By clicking on the “Exit Wizard” button, the Gantt chart is modified so that all the critical activities are highlighted in red (see Figure 4.7 below).

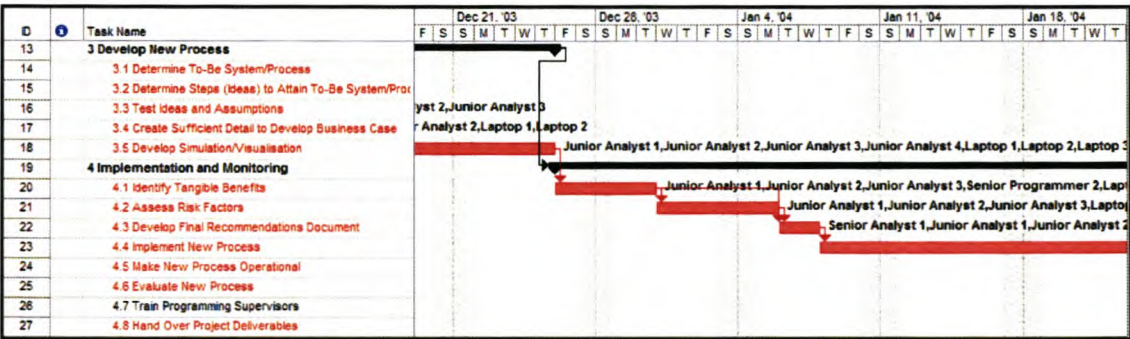


Figure 4.7: Highlighted Critical Activities in the Gantt chart

4.4 Finding Slack in the Project

In order to find the slack times in the project, the user has to be in the Gantt chart view (Select View, then Gantt Chart). Once in the Gantt Chart view, the schedule has to be viewed. This can be done by selecting View, then Table, and then select Schedule (see Figure 4.8 below). Once in “Schedule View”, drag the divider bar across to the right, in order to reveal the entire table. From this table the free slack per activity, as well as the total slack per activity can be read off (see Figure 4.9 below).

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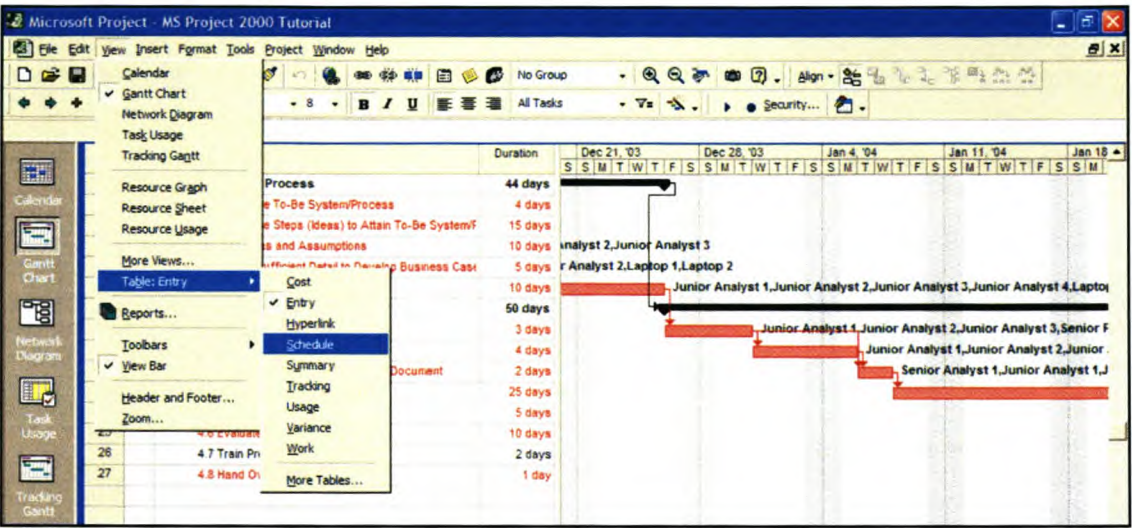


Figure 4.8: Finding the Slack Times

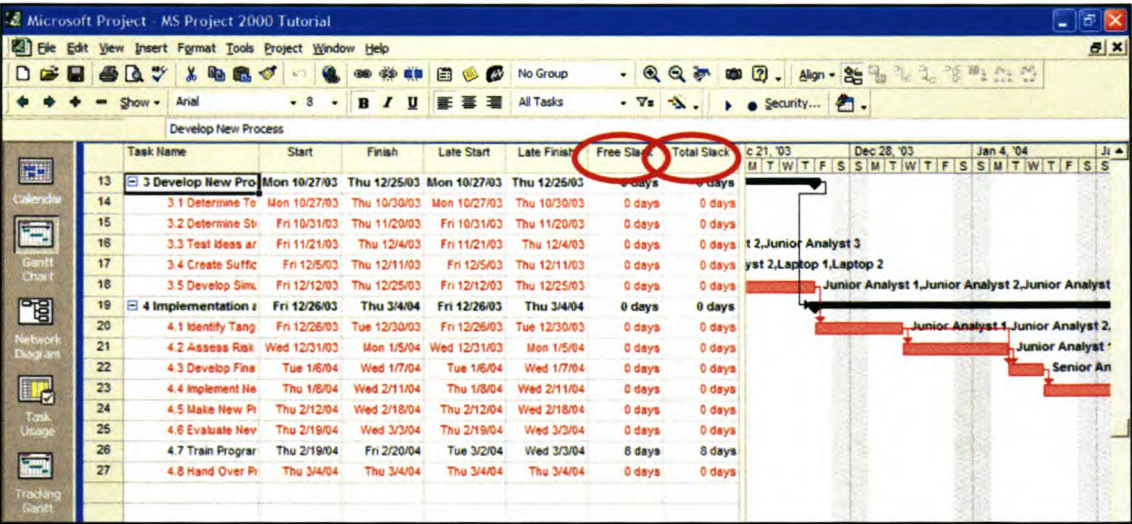


Figure 4.9: Reading off the Free Slack and Total Slack Times

4.5 Finding the Critical Activities and Slack in the Gantt Chart

If the user should wish to find the slack time in the project in the Gantt chart, he/she would have to firstly select the Detail Gantt chart view (select “View”, then “More Views” and then “Detail Gantt” and then click on “Apply”) the slack time can now be found by reading it off the table (see Figure 4.10 and 4.11 below)

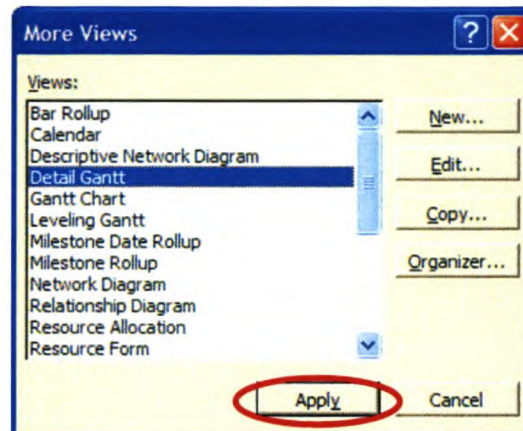


Figure 4.10: Viewing the Detail Gantt Chart

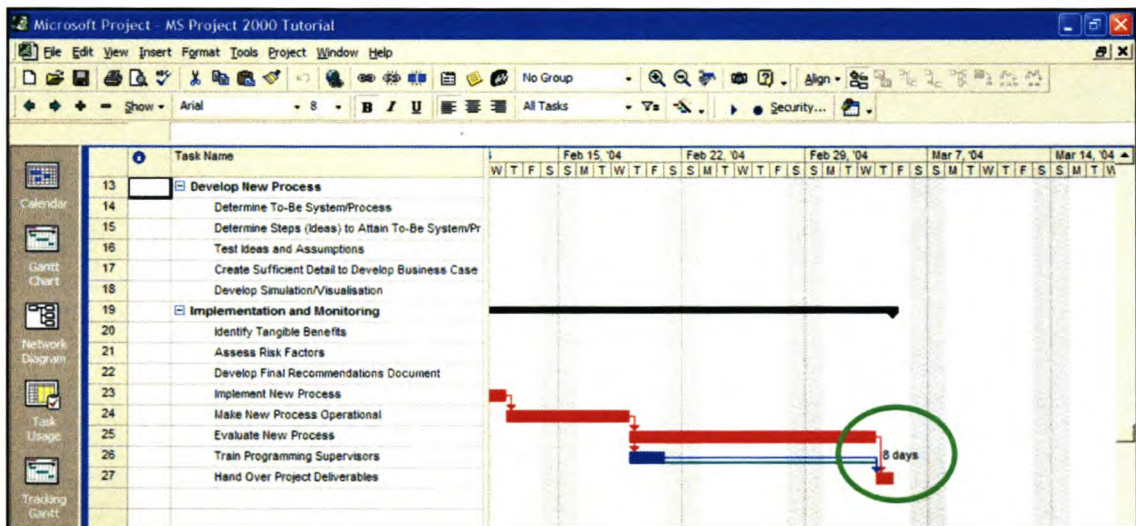


Figure 4.11: Reading the Project Slack from the Detail Gantt Chart.

This method does exactly the same as the previous paragraph; the difference being that the user now has a visual representation of the slack time of the activity on the actual Gantt Chart (refer to Figure 4.11 above; circled in green).

To Exit this detail Gantt chart view, simple select “View”, and then “Gantt Chart.”

4.6 Finding Resource Over-allocation

In order to resolve possible resource over-allocations manually, it is necessary to firstly be able to see where the over-allocations occur. Two options are available in order for the user to view the resource over-allocations: by viewing the

“Resource Graph” and the “Resource Usage”. It would be desirable to view the graph in order to determine the date of over-allocation, and it would then be further desirable to view the “Resource Usage” in order to determine which task is over allocated. these two items can be found by selecting “View” and then selecting either “Resource Graph” or “Resource Usage”.

Resolving Resource Over-Allocation

Resource over-allocations can be resolved either manually or automatically. For this exercise, Microsoft® Project 2000® will be allowed to resolve the resource over-allocations. It will, however, be demonstrated how a resource over-allocation can be resolved manually, for the sake of completeness.

Manual Resource Over-allocation Resolution:

To manually resolve a resource over-allocation, first enable the Gantt chart view. Now, select the over-allocated task (the task where the resources are over-allocated at), and then select the “Resource Assignment” button (the button with the two faces on in the toolbar). Now enter a new resource entity in the table of resources, and assign this resource to the task (see earlier in this chapter). Now update the “Resource Sheet” (all the costs) in order for the program to correctly calculate the project costs.

Alternatively, adjust the “Units” in the “Resource Assignment” pop-up box to 200% (to indicate two people), or 300% (to indicate 3 people). This is illustrated in Figure 4.12 below.

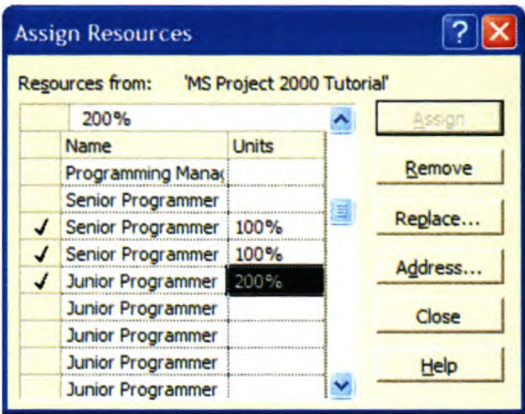


Figure 4.12: Assigning Additional Resources to Over-allocated Tasks

Automatic Resource Over-Allocation Resolution:

To automatically level the resource usage, make sure to check the slack time on the times that are over-allocated, seeing as these times might change during the automatic resource levelling process.

This feature is activated by selecting “Tools”, then “Resource Levelling” (see Figure 4.13 below). Next, select “Automatic”, and then “Level Entire Project” (see Figure 4.14 below). Also, check the “Level Only” checkbox. The project resources can now be levelled by merely selecting “Level Now” (see Figure 4.14 below; circled in green).

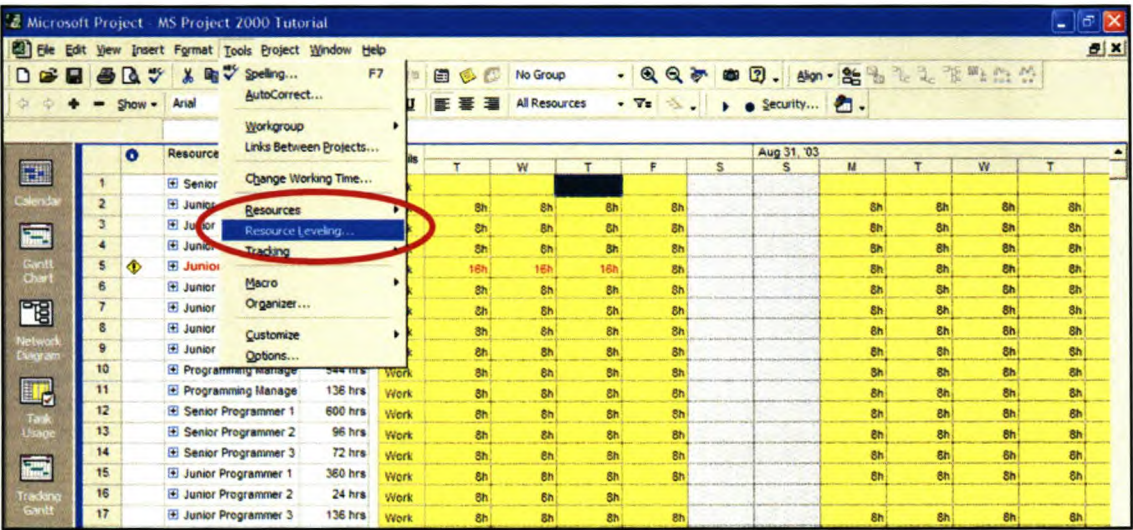


Figure 4.13: Setting Automatic Resource Levelling

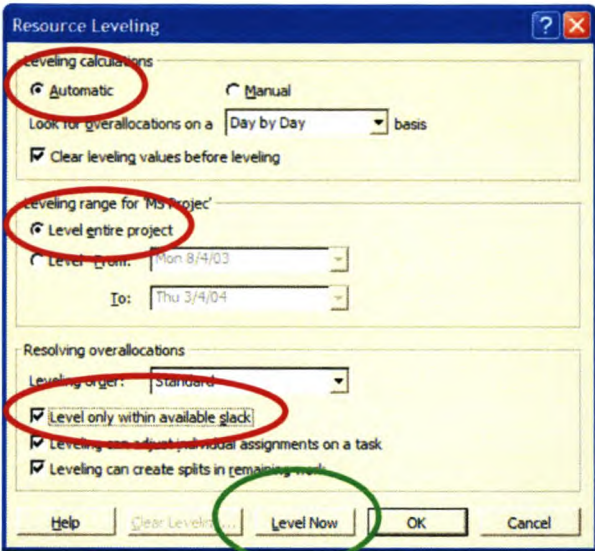


Figure 4.14: Levelling the Resources Automatically

4.7 Finding the Cost of a Task

If we want to know how much a specific task is going to cost, we can find this cost in the Gantt chart view (select “View”, then “Gantt Chart”). Click on “View”, then “Table”, and then “Cost” (see Figure 4.16 below). We can now see the costs for each task by simply dragging the divider bar over to the right.

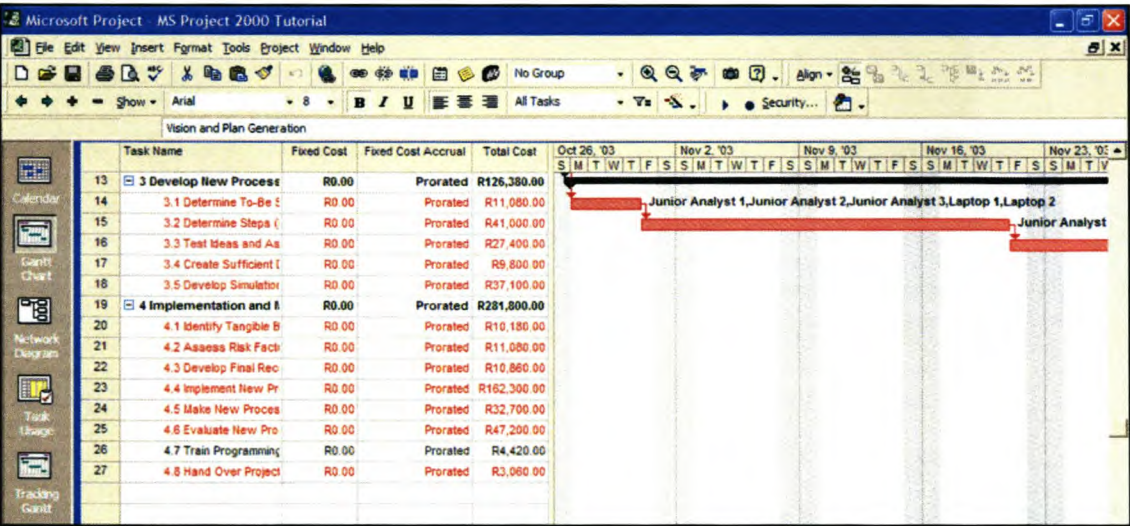


Figure 4.15: Viewing the Cost of a Task

4.8 Finding the Cost of the Entire Project

Finding out the total cost of the project is essential for reporting to the project stakeholders. Once the project planning has gone this far, it is very simple to find the total project cost. This can be found by selecting “Project” from the main toolbar, and then selecting “Project Information” (see Figure 4.16 below). By now selecting the “Statistics” button from the pop-up box (see Figure 4.17 below), another pop-up box appears which shows all the project specifics, including the total project cost (see Figure 4.18 below; Total Project Cost is circled in green).

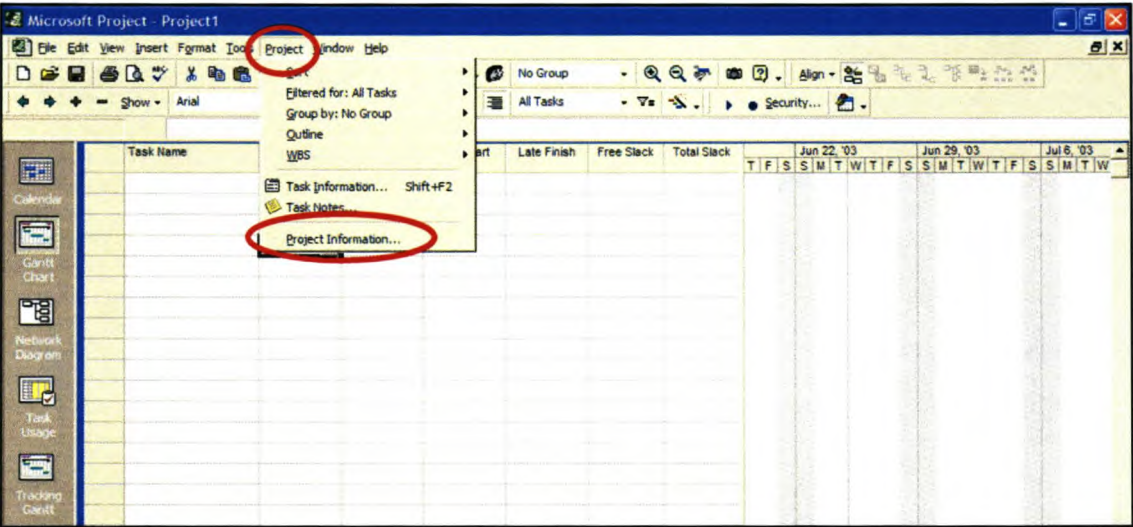


Figure 4.16: Finding the Total Project Cost

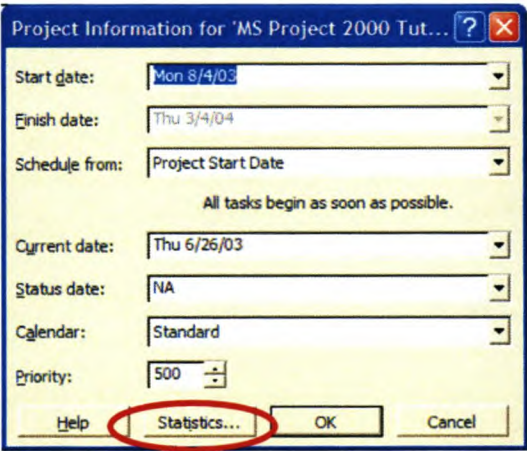


Figure 4.17: Selecting the Statistics Option

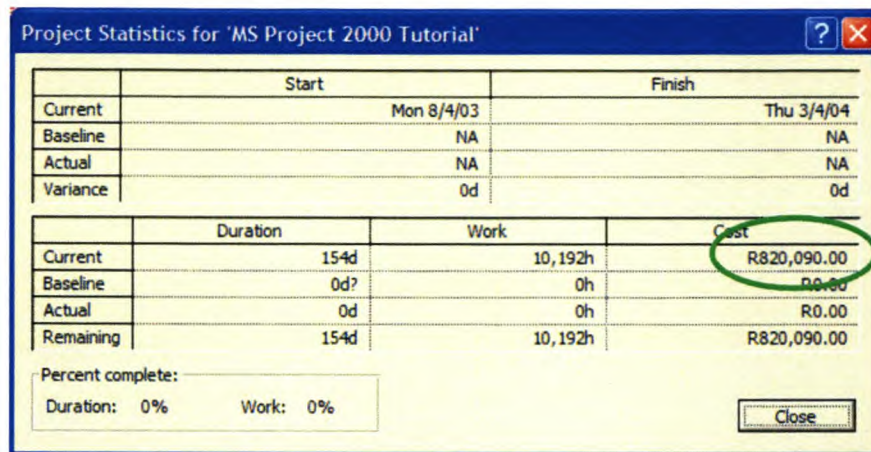


Figure 4.18: Viewing the Total Project Cost

4.9 Saving the Project Plan as the Baseline

When the user is completely satisfied with the project plan as a whole, he/she can save it as a baseline. This is needed in order to use the baseline as a measurement of the evaluation of the actual progress once the project has started.

To save the project as a baseline, select “Tools”, and then “Tracking”, and then select “Save Baseline” (see Figure 4.19 below). Next, select “Entire Project” from the pop-up box, and select “OK” (see Figure 4.20 below). The project plan has now been saved as a baseline.

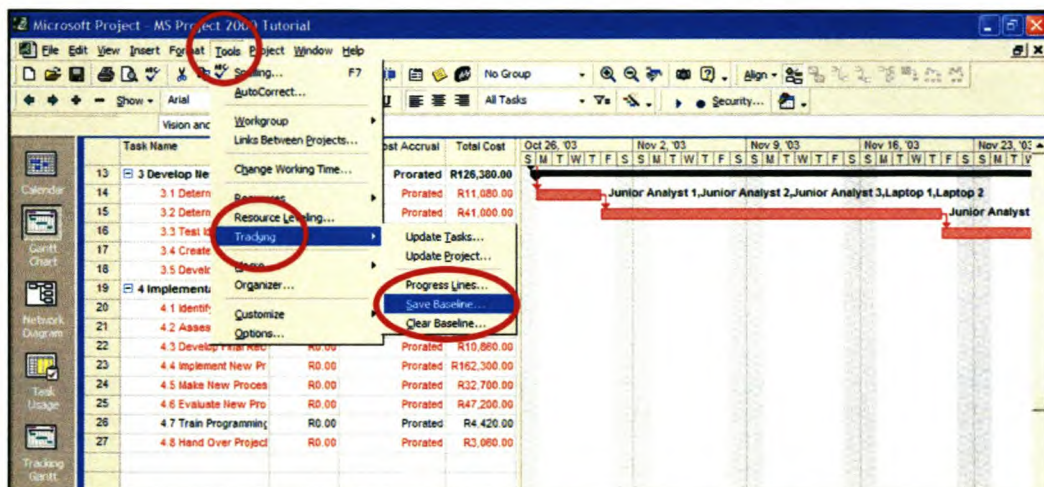


Figure 4.19: Saving the Project Baseline

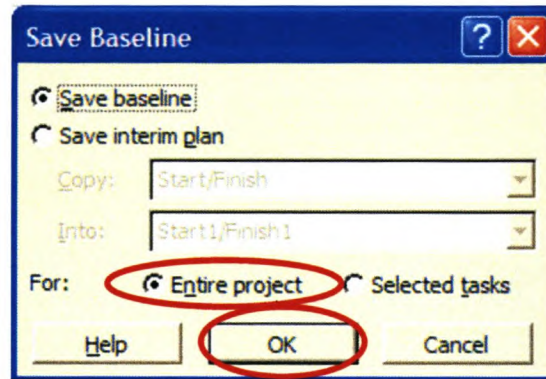


Figure 4.20: Saving the Project Baseline for the Entire Project

Save the entire project again as a whole by selecting “File” and then “Save”, as shown in the previous chapter.

At this stage, the project plan is complete, and a copy of the Gantt Chart view can be printed. This is done by selecting “File” and then “Print Preview”, to ensure that the project layout is correct, and then selecting “Print”.

This concludes the development of the project plan. All that is left to do now is to manage the project, in order to ensure that it stays as close as possible to the baseline that was created in the preceding two chapters.

5. Checking Project Progress

Now that a decent project plan has been created, it has to be ensured that the project runs accordingly. This is called “tracking the project progress”.

Tracking and checking the project progress can be achieved on a detail level, as well as a minimal level. For the purposes of this tutorial, only minimal tracking will be discussed.

In order to complete this exercise, consult the information given in the Information Sheet in Appendix A.

5.1 Entering Actual Start and Finish Dates

Once the project has been underway for some time, and some of the tasks have actually been started and completed, this information can be added to our baseline project plan and checked for numerous indicators for whether or not the project is still on track. Consider the information given on the Information Sheet in Appendix A.

The various start and finish dates of the completed tasks can be entered by firstly selecting the task to track. Now select “Tools”, then “Tracking” and then “Update Task” (see Figure 5.1 below), and then simply enter the actual start and finish dates for that specific task (see Figure 5.2 below) and click on “OK”.

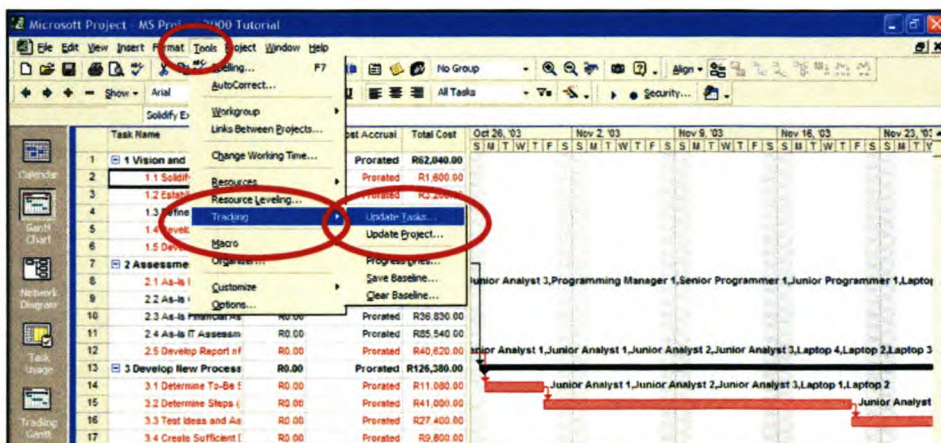


Figure 5.1: Updating the Tasks Start and Finish Dates

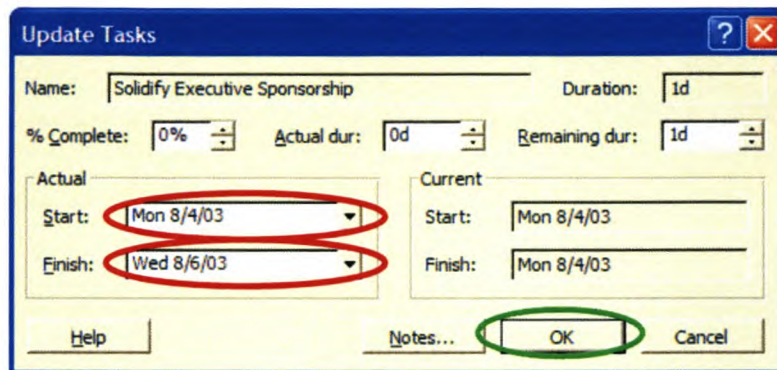


Figure 5.2: Updating the Task Start and Finish Dates

5.2 Comparing the Actual Project to the Baseline Project

Once all the actual dates and information for all the completed and current tasks have been completed, the next step is to compare the actual project to the baseline project plan.

This is simply done by selecting “View”, and then “More Views”. From the pop-up box (see Figure 5.3 below), select “Tracking Gantt”, and then “Apply”.

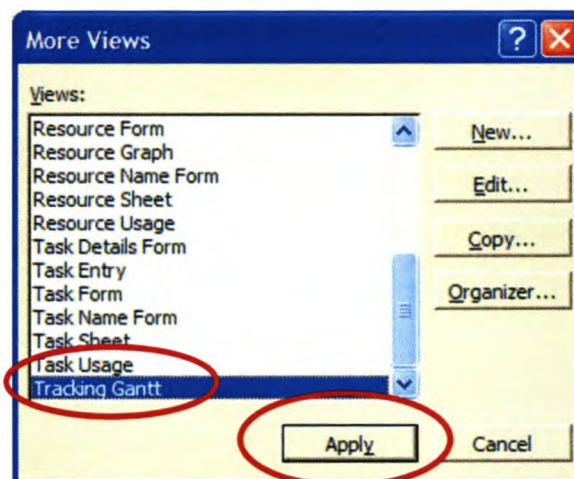


Figure 5.3: Selecting the Tracking Gantt View

Once in the Tracking Gantt chart view, the areas where there are overruns (circled in red in Figure 5.4 below) can be seen, as well as the projected new finishing date for the project will be (circled in green in Figure 5.5 below).

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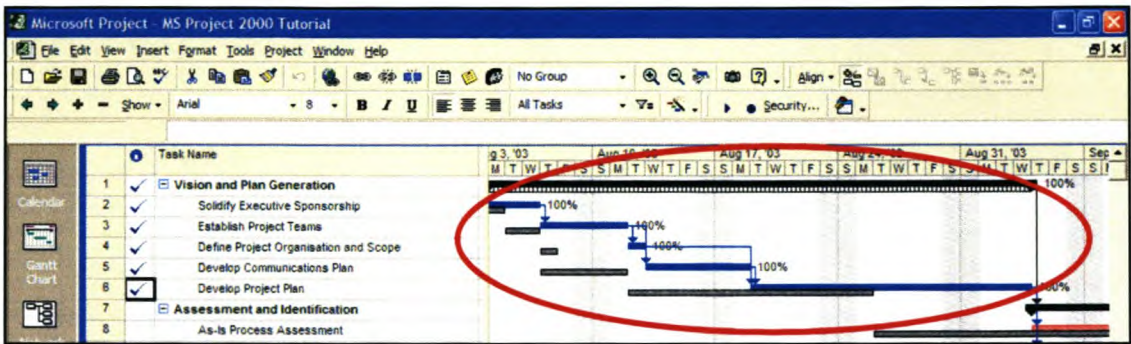


Figure 5.4: Project Overruns

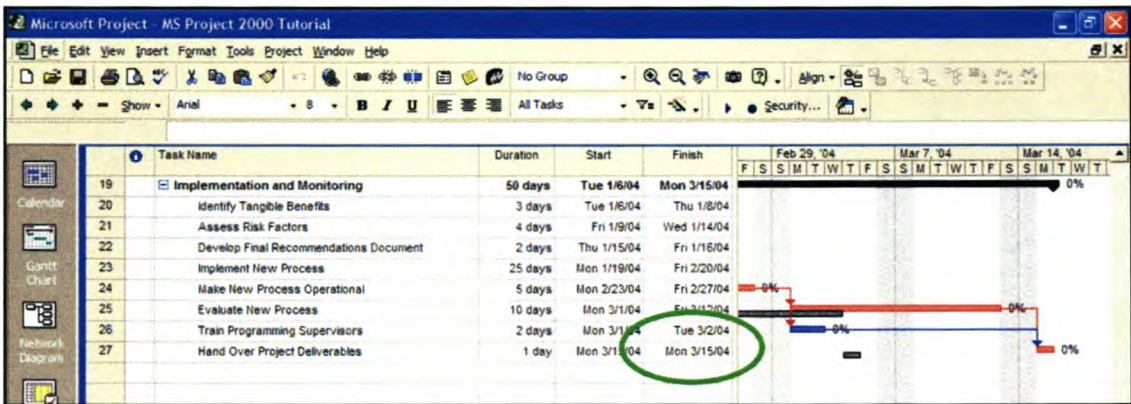


Figure 5.5 New Project Finishing Date

5.3 Viewing a Specific Day

If it is required to see what is going on during a specific day, simply select “View”, and then “Calendar”, and then select the day in question. In this example, assume that the day in question is 20 August 2003 (see Figure 5.6 below).

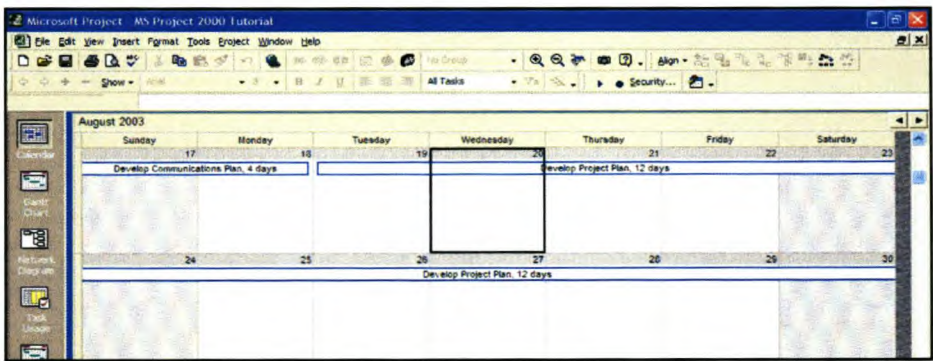


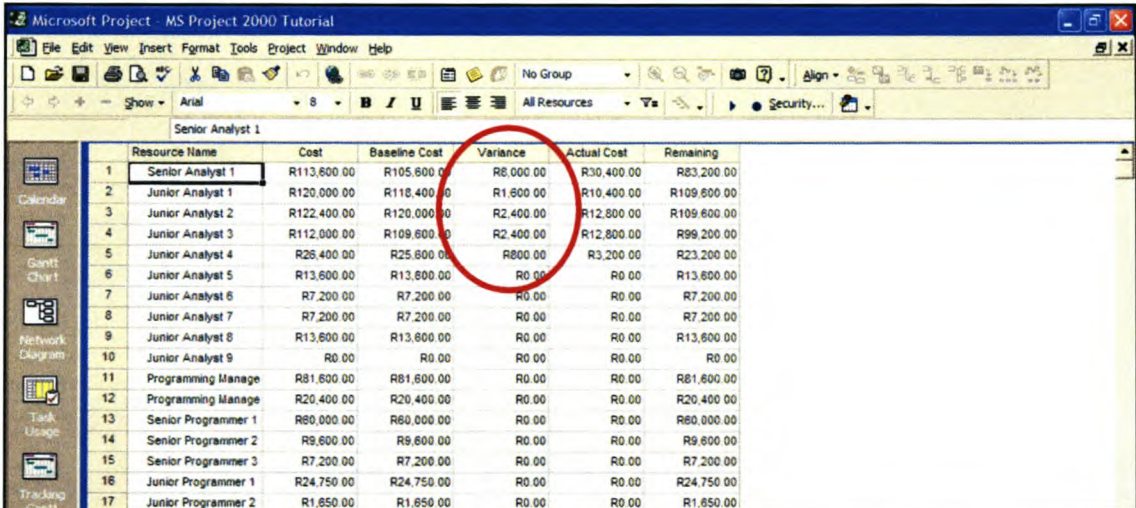
Figure 5.6: Viewing a Specific Day

5.4 Checking Cost, Labour and Schedule Variances

It would also be desirable to view the variance in the cost, labour and schedule compared to the baseline project.

For the cost and resource variance, the software needs to be in the “Resource Sheet” view. We can simply select “View”, and then “Resource Sheet” in order to generate this view.

To view the cost variance, we select “View”, then “Table”, and then “Cost”. This will show us the variances in cost for each resource (see Figure 5.7 below).

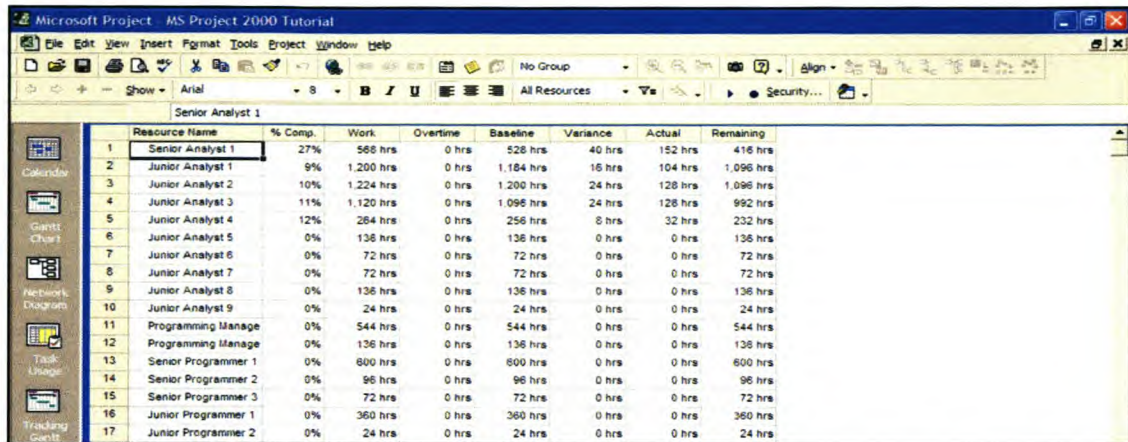


Resource Name	Cost	Baseline Cost	Variance	Actual Cost	Remaining
1 Senior Analyst 1	R113,600.00	R105,600.00	R8,000.00	R30,400.00	R83,200.00
2 Junior Analyst 1	R120,000.00	R116,400.00	R3,600.00	R10,400.00	R109,600.00
3 Junior Analyst 2	R122,400.00	R120,000.00	R2,400.00	R12,800.00	R109,600.00
4 Junior Analyst 3	R112,000.00	R109,600.00	R2,400.00	R12,800.00	R99,200.00
5 Junior Analyst 4	R26,400.00	R25,600.00	R800.00	R3,200.00	R23,200.00
6 Junior Analyst 5	R13,600.00	R13,600.00	R0.00	R0.00	R13,600.00
7 Junior Analyst 6	R7,200.00	R7,200.00	R0.00	R0.00	R7,200.00
8 Junior Analyst 7	R7,200.00	R7,200.00	R0.00	R0.00	R7,200.00
9 Junior Analyst 8	R13,600.00	R13,600.00	R0.00	R0.00	R13,600.00
10 Junior Analyst 9	R0.00	R0.00	R0.00	R0.00	R0.00
11 Programming Manage	R81,600.00	R81,600.00	R0.00	R0.00	R81,600.00
12 Programming Manage	R20,400.00	R20,400.00	R0.00	R0.00	R20,400.00
13 Senior Programmer 1	R80,000.00	R80,000.00	R0.00	R0.00	R80,000.00
14 Senior Programmer 2	R9,600.00	R9,600.00	R0.00	R0.00	R9,600.00
15 Senior Programmer 3	R7,200.00	R7,200.00	R0.00	R0.00	R7,200.00
16 Junior Programmer 1	R24,750.00	R24,750.00	R0.00	R0.00	R24,750.00
17 Junior Programmer 2	R1,650.00	R1,650.00	R0.00	R0.00	R1,650.00

Figure 5.7: Cost Variance Table

Similarly, if the Labour Variance needs to be viewed, select “View”, then “Table”, and then “Work” (see Figure 5.8 below).

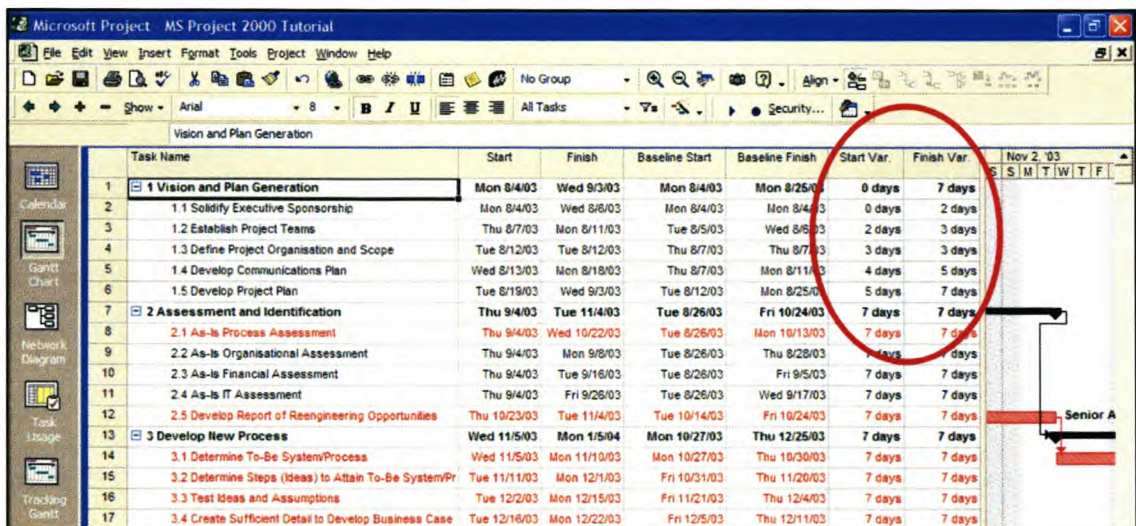
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Resource Name	% Comp.	Work	Overtime	Baseline	Variance	Actual	Remaining
1 Senior Analyst 1	27%	566 hrs	0 hrs	526 hrs	40 hrs	152 hrs	416 hrs
2 Junior Analyst 1	9%	1,200 hrs	0 hrs	1,184 hrs	16 hrs	104 hrs	1,096 hrs
3 Junior Analyst 2	10%	1,224 hrs	0 hrs	1,200 hrs	24 hrs	128 hrs	1,096 hrs
4 Junior Analyst 3	11%	1,120 hrs	0 hrs	1,096 hrs	24 hrs	128 hrs	992 hrs
5 Junior Analyst 4	12%	264 hrs	0 hrs	256 hrs	8 hrs	32 hrs	232 hrs
6 Junior Analyst 5	0%	136 hrs	0 hrs	136 hrs	0 hrs	0 hrs	136 hrs
7 Junior Analyst 6	0%	72 hrs	0 hrs	72 hrs	0 hrs	0 hrs	72 hrs
8 Junior Analyst 7	0%	72 hrs	0 hrs	72 hrs	0 hrs	0 hrs	72 hrs
9 Junior Analyst 8	0%	136 hrs	0 hrs	136 hrs	0 hrs	0 hrs	136 hrs
10 Junior Analyst 9	0%	24 hrs	0 hrs	24 hrs	0 hrs	0 hrs	24 hrs
11 Programming Manager	0%	544 hrs	0 hrs	544 hrs	0 hrs	0 hrs	544 hrs
12 Programming Manager	0%	136 hrs	0 hrs	136 hrs	0 hrs	0 hrs	136 hrs
13 Senior Programmer 1	0%	600 hrs	0 hrs	600 hrs	0 hrs	0 hrs	600 hrs
14 Senior Programmer 2	0%	96 hrs	0 hrs	96 hrs	0 hrs	0 hrs	96 hrs
15 Senior Programmer 3	0%	72 hrs	0 hrs	72 hrs	0 hrs	0 hrs	72 hrs
16 Junior Programmer 1	0%	360 hrs	0 hrs	360 hrs	0 hrs	0 hrs	360 hrs
17 Junior Programmer 2	0%	24 hrs	0 hrs	24 hrs	0 hrs	0 hrs	24 hrs

Figure 5.8: Labour Variance Table

Alternatively, these variances can also be viewed on the Gantt chart. This is accomplished by selecting the Gantt chart view (select “View”, then “Gantt Chart”), and then selecting “View” again, followed by “Table”, and then “Variance”. This gives the time, or schedule, variance from the baseline (see Figure 5.9 below).



Task Name	Start	Finish	Baseline Start	Baseline Finish	Start Var.	Finish Var.
1 Vision and Plan Generation	Mon 8/4/03	Wed 9/3/03	Mon 8/4/03	Mon 8/25/03	0 days	7 days
2 1.1 Solidify Executive Sponsorship	Mon 8/4/03	Wed 8/6/03	Mon 8/4/03	Mon 8/4/03	0 days	2 days
3 1.2 Establish Project Teams	Thu 8/7/03	Mon 8/11/03	Tue 8/5/03	Wed 8/6/03	2 days	3 days
4 1.3 Define Project Organisation and Scope	Tue 8/12/03	Tue 8/12/03	Thu 8/7/03	Thu 8/7/03	3 days	3 days
5 1.4 Develop Communications Plan	Wed 8/13/03	Mon 8/19/03	Thu 8/7/03	Mon 8/11/03	4 days	5 days
6 1.5 Develop Project Plan	Tue 8/19/03	Wed 9/3/03	Tue 8/12/03	Mon 8/25/03	5 days	7 days
7 2 Assessment and Identification	Thu 9/4/03	Tue 11/4/03	Tue 8/26/03	Fri 10/24/03	7 days	7 days
8 2.1 As-Is Process Assessment	Thu 9/4/03	Wed 10/22/03	Tue 8/26/03	Mon 10/13/03	7 days	7 days
9 2.2 As-Is Organisational Assessment	Thu 9/4/03	Mon 9/8/03	Tue 8/26/03	Thu 8/28/03	7 days	7 days
10 2.3 As-Is Financial Assessment	Thu 9/4/03	Tue 9/16/03	Tue 8/26/03	Fri 9/5/03	7 days	7 days
11 2.4 As-Is IT Assessment	Thu 9/4/03	Fri 9/26/03	Tue 8/26/03	Wed 9/17/03	7 days	7 days
12 2.5 Develop Report of Reengineering Opportunities	Thu 10/23/03	Tue 11/4/03	Tue 10/14/03	Fri 10/24/03	7 days	7 days
13 3 Develop New Process	Wed 11/5/03	Mon 1/5/04	Mon 10/27/03	Thu 12/25/03	7 days	7 days
14 3.1 Determine To-Be System/Process	Wed 11/5/03	Mon 11/10/03	Mon 10/27/03	Thu 10/30/03	7 days	7 days
15 3.2 Determine Steps (Ideas) to Attain To-Be System/Pr	Tue 11/11/03	Mon 12/1/03	Fri 10/31/03	Thu 11/20/03	7 days	7 days
16 3.3 Test Ideas and Assumptions	Tue 12/2/03	Mon 12/15/03	Fri 11/21/03	Thu 12/4/03	7 days	7 days
17 3.4 Create Sufficient Detail to Develop Business Case	Tue 12/16/03	Mon 12/22/03	Fri 12/5/03	Thu 12/11/03	7 days	7 days

Figure 5.9: Schedule Variance

5.5 Printing the Tracking Gantt

The Tracking Gantt chart can be printed for reporting purposes by simply selecting “View”, then “More Views”, and then selecting “Tracking Gantt” from the

pop-up box, and selecting “Apply”. The software program is now in the Tracking Gantt view, and from here it is possible to print this view by selecting “File”, then “Print Preview”, in order to check the layout of the chart, and then selecting “Print”. This will print a copy of the tracking Gantt, and concludes this tutorial.

References

1. Fourie, C. J.: "Project Management with Microsoft Project 2000: A Quick Tutorial", Version 6, Unpublished class tutorial developed by the author for presentation as part of the Project Management Post-Graduate Course at the Department of Industrial Engineering, University of Stellenbosch, 2002
2. Microsoft® Project 2000® Help Files

Appendix A

<i>Appendix A</i>	<i>Tutorial Information Sheet</i>
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Tutorial: BPR Project at an IT Company

Actual Task #	Work Package / Task / Subtask	Predecessors	Duration (days)	Resources						Actual Start	Actual Finish
				Senior Analyst	Junior Analyst	ITDS Program Manager	ITDS Senior Programmer	ITDS Junior Programmer	BCS Laptop		
1	Vision and Plan Generation										
2	Solidify Executive Sponsorship	4-Aug-03	1	1						4-Aug-03	6-Aug-03
3	Establish Project Teams	2	2	1						7-Aug-03	11-Aug-03
4	Define Project Organisation and Scope	3	1	1	1				1	12-Aug-03	12-Aug-03
5	Develop Communications Plan	3	3		2				1	13-Aug-03	18-Aug-03
6	Develop Project Plan	4, 5	10	1	3				3	19-Aug-03	3-Sep-03
7	Assessment and Identification										
8	As-Is Process Assessment	6	35		3	1	1	1	2		
9	As-Is Organisational Assessment	6	3		1			1	1		
10	As-Is Financial Assessment	6	9		2		2	1	2		
11	As-Is IT Assessment	6	17		3		1	2	2		
12	Develop Report of Reengineering Opportunities	8, 9, 10, 11	9	1	3				2		
13	Develop New Process										
14	Determine To-Be System/Process	12	4		3				2		
15	Determine Steps (Ideas) to Attain To-Be System/Process	14	15		3				2		
16	Test Ideas and Assumptions	15	10		3				2		
17	Create Sufficient Detail to Develop Business Case	16	5		2				2		
18	Develop Simulation/Visualisation	17	10		4				3		
19	Implementation and Monitoring										
20	Identify Tangible Benefits	18	3		3		1		2		
21	Assess Risk Factors	20	4		3				2		
22	Develop Final Recommendations Document	20, 21	2	1	4				3		
23	Implement New Process	22	25	1	3	1	1		3		
24	Make New Process Operational	23	5	1	3	1	1		3		
25	Evaluate New Process	24	10	1	2		1	1	1		
26	Train Programming Supervisors	24	2		1	1			1		
27	Hand Over Project Deliverables	25, 26	1	1		1			1		

Resource	Standard Rate	Overtime Rate	Cost / Use
Senior Analyst	R 200.00 / hour	R 300.00 / hour	R 0.00
Junior Analyst	R 100.00 / hour	R 150.00 / hour	R 0.00
ITDS Programming Manager	R 150.00 / hour	R 225.00 / hour	R 0.00
Senior ITDS Programmer	R 100.00 / hour	R 150.00 / hour	R 0.00
Junior ITDS Programmer	R 68.75 / hour	R 103.13 / hour	R 0.00
Laptop Computer	R 20.00 / hour	R 20.00 / hour	R 100.00

Tutorial: BPR Project at an IT Company

Actual Task #	Work Package / Task / Subtask	Predecessors	Duration (days)	Resources						Actual Start	Actual Finish
				Senior Analyst	Junior Analyst	ITDS Program Manager	ITDS Senior Programmer	ITDS Junior Programmer	BCS Laptop		
1	Vision and Plan Generation										
2	Solidify Executive Sponsorship	4-Aug-03	1	1						4-Aug-03	6-Aug-03
3	Establish Project Teams	2	2	1						7-Aug-03	11-Aug-03
4	Define Project Organisation and Scope	3	1	1	1				1	12-Aug-03	12-Aug-03
5	Develop Communications Plan	3	3		2				1	13-Aug-03	18-Aug-03
6	Develop Project Plan	4, 5	10	1	3				3	19-Aug-03	3-Sep-03
7	Assessment and Identification										
8	As-Is Process Assessment	6	35		3	1	1	1	2		
9	As-Is Organisational Assessment	6	3		1			1	1		
10	As-Is Financial Assessment	6	9		2		2	1	2		
11	As-Is IT Assessment	6	17		3		1	2	2		
12	Develop Report of Reengineering Opportunities	8, 9, 10, 11	9	1	3				2		
13	Develop New Process										
14	Determine To-Be System/Process	12	4		3				2		
15	Determine Steps (Ideas) to Attain To-Be System/Process	14	15		3				2		
16	Test Ideas and Assumptions	15	10		3				2		
17	Create Sufficient Detail to Develop Business Case	16	5		2				2		
18	Develop Simulation/Visualisation	17	10		4				3		
19	Implementation and Monitoring										
20	Identify Tangible Benefits	18	3		3		1		2		
21	Assess Risk Factors	20	4		3				2		
22	Develop Final Recommendations Document	20, 21	2	1	4				3		
23	Implement New Process	22	25	1	3	1	1		3		
24	Make New Process Operational	23	5	1	3	1	1		3		
25	Evaluate New Process	24	10	1	2		1	1	1		
26	Train Programming Supervisors	24	2		1	1			1		
27	Hand Over Project Deliverables	25, 26	1	1		1			1		

Resource	Standard Rate	Overtime Rate	Cost / Use
Senior Analyst	R 200.00 / hour	R 300.00 / hour	R 0.00
Junior Analyst	R 100.00 / hour	R 150.00 / hour	R 0.00
ITDS Programming Manager	R 150.00 / hour	R 225.00 / hour	R 0.00
Senior ITDS Programmer	R 100.00 / hour	R 150.00 / hour	R 0.00
Junior ITDS Programmer	R 68.75 / hour	R 103.13 / hour	R 0.00
Laptop Computer	R 20.00 / hour	R 20.00 / hour	R 100.00