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# ISTANBUL KULTUR UNIVERSITY
## GRADUATED STUDIES INSTITUTE

# Effect of Geographical Information System on Project Management

# MSc Thesis

**Dissertation submitted in part fulfillment for the degree of Master of Project management program**

by
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# ABSTRACT

Recent studies concerning GIS show that it is the fastest growing segment (both hard & software) of the graphical computer market. 70% of private organizations expect to use GIS as a strategic tool within their company.

Like a product, GIS in an organization has a life cycle. According to the model of Nolan this life cycle starts with awareness and ends when full integration with other information systems is achieved. Until recently project management for GIS projects was mainly about projects which were considered to be experimental. The requirements for such projects differ from the requirements for projects which are strategic for a company. Strategic GIS projects require a project manager with thorough understanding of issues such as: planning, knowledge of the objectives of the project, project environment and politics. There is little experience with such GIS projects. However the question " How to manage a GIS project effectively" has to be answered for strategically positioned GIS projects to be succesfull.

It is important for project managers to understand the relationship between the position of GIS in an organisation (Nolan Model) in relationship to the importance of GIS for the organisation (Mc Farlan). The way a GIS project should be handled depends, to a large extend, on these two positionings.

A combination of IT methodologies such as Structured Analysis and Design, project management methodologies such as PRINCE and Hewlett-Packards Customer Project Life Cycle 2 combined with best practices are proposed in order to provide a framework, for project managers, to handle GIS projects which are considered strategic for the organisation.

This framework, based on prior experience and through evaluation of a complex GIS project has been shown, in some respects, to work. There is still some uncertainty since there is little experience in the market with strategic GIS projects so there are not a lot of "best practices" to learn from and to further evaluate the proposed approach available.

# Acknowledgments

Completing a M.s.c is truly a marathon event , and I would not have been able to complete this journey without the aid and support of countless people over the past three years.
First, I would like to thank Project management department, Graduated Studies Institute and Istanbul culture University  for their support and environment.

I would like to express my gratitude to my supervisor,Asst . Prof .Dr. Ali ŞENTÜRK , whose expertise, understanding, and patience, added considerably to my graduate experience.

I am deeply indebted to Dr. Ethem TARHAN Without his guidance, support and good nature, I would never have been able to finished this thesis. At times they may be found on complete opposite ends of the spectrum, but their willingness  helped me through three important years of my life. I would also like to thank all lecturers at project management department.

I would like to thank all my friends who helped me get through three years of graduate school. They are honest friends .
A very special thanks goes out to my  best friend  Deniz who has given me all help and needed happiness . Graduate school isn't the most important thing in life, but good friends, good times and happiness are.

# Dedication

This thesis is dedicated to my parents, without whom none of this would have been even possible.

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# INTRODUCTION

A **geographic information system (GIS)** is a system for capturing, storing, analyzing and managing data and associated attributes which are spatially referenced to the earth. In the strictest sense, it is a computer system capable of integrating, storing, editing, analyzing, sharing, and displaying geographically-referenced information. In a more generic sense, GIS is a tool that allows users to create interactive queries (user created searches), analyze the spatial information, edit data, maps, and present the results of all these operations.Geographic information science is the science underlying the applications and systems, taught as a degree program by several universities.

Geographic information system technology can be used for scientific investigation , resource management , asset management, Environmental Imact Assessment, Urban planning , cartography, criminology, history, sales , marketing_ and route planning. For example, a GIS might allow emergency planners to easily calculate emergency response times in the event of a natural disaster, a GIS might be used to find wetlands that need protection from  pollution, or a GIS can be used by a company to find new potential customers similar to the ones they already have and project sales due to expanding into that market.In the last two decades computer systems which can handle large amounts of "Geographic Information" have become sufficiently powerful and inexpensive to be used on a wide scale. Currently even personal computers are well suited to be used in GIS environments. The field of Geographical or Spatial data is very wide and GIS systems can be used for many different purposes. Some of the more important fields of application are:

- Land & Property Systems :
- Environmental Management :
- Socioeconomic Analysis :
- Telecommunications :
- Health :

More and more data are becoming available in a digital format. Investments in the field of data communication are huge and enable the transfer of large amounts of data all over the world. Internet is increasing the availability of information for large parts of society. And these developments change the way organizations think and act. Well designed GIS systems will enable quick and easy access to these large volumes of data and enable organization to use them to gather information either for their own benefit or for the public benefit in orderto :

- Provide services;
- Increase competitiveness
- Provide information.

Many organizations nowadays recognize that geographic information can serve as an important resource.
GIS however is a complex information technology which requires a lot of planning in order to have a successful implementation.
There is a lack of experience in large GIS project design and implementation and many questions have to be considered when performing a GIS project some of these are:
{ What are the mission, vision and objectives of the project?
{ What has to be achieved by means of this project?
{ How do I build such a GIS system?
{ What are the experiences (best practices) in this field?
This thesis is about the project management aspects of GIS and the way to handle this complexity from a project managers point of view. This is accomplished by providing some theoretical background, a practical approach towards a GIS project.

## Objectives of the thesis
The objectives of the thesis are:
◆  To examine the life cycle of GIS projects;
◆  To explain the importance of the model of McFarlan and the position of GIS in this model;
◆  To look at some methodologies which are useful in GIS projects in relation to the GIS life cycle;
◆  To clarify if there is a difference between project management in general and project management in GIS projects;
◆  To describe the practical implications for approaching and handling a GIS project.

## Problem Statement

The problem which this thesis addresses is:

*How to manage a GIS project effectively?*

At several places in the thesis the following question will be addressed:
*"Is there a difference between a IS project and a GIS project"* in order to clarify if GIS project management differs from IT-project management in general.

## Scope of this thesis

This thesis deals primarily with the "how" question of GIS project management.

What are the generic processes and tools which are available?

Which methodologies are useful?

What are the consequences of the GIS project life cycle and what are the roles and responsibilities of a GIS project manager.

This thesis will not provide a methodology for all GIS projects. It will present only one way to handle a GIS project and share best practices. Methodologies provide unification and prevent common mistakes but training, tools and the exchange of "best practices" are just as important.

## Document Overview

This document overview clarifies the structure of this Master Thesis and the outlines of the chapters that are included.

The *Abstract* contains the main elements and arguments.

The *Introduction* provides information on the changes that are currently happening in the GIS environment and that have influence on the way GIS project management is handled.

Furthermore the objectives, scope and the problem statement are part of the *Introduction.*

*Chapter 1-4* are the core of this document. They each cover an important element necessary for GIS project management.

*In Chapter 5* conclusions are drawn and the developments made from the findings in this thesis are described.

The structure of the Thesis is also be represented graphically (figure 1)

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        p           │     Project life cycle  │        p
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        s           ├─────────────────────────┤   │    s
        i           │       Methodology       │   │    i
        t           │            2            │   │    t
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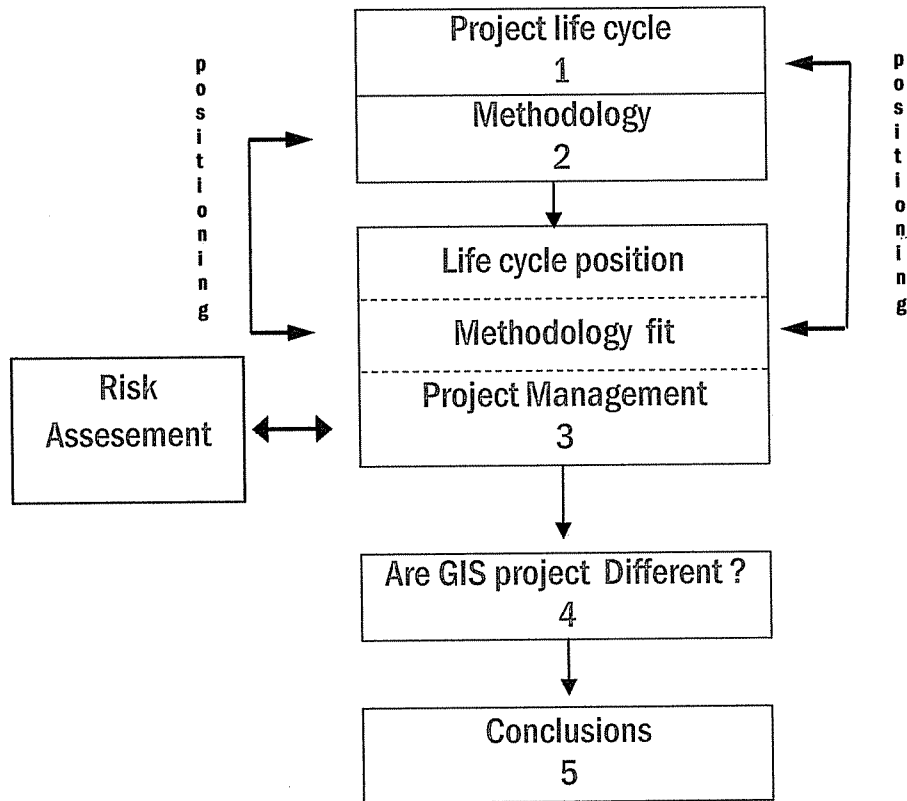
**Figure 1 : Structure of Thesis**

In the Thesis the assumption is made that the GIS project to be managed is either strategic or mission critical. As the graphic representation shows the theoretical chapters are necessary to understand the position in the life-cycle of the project and also to determine which methodology is the most appropriate.

# 1 PROJECT LIFE CYCLE

## 1.1. Introduction

Running out of planned budget, not being ready on time, not providing the expected functionality are the symptoms of failure.

The management of a GIS project has to be aware of changing project requirements and take account of two principle factors:

- The importance of understanding the GIS life cycle( this chapter);
- The methodology which is appropriate (the next chapter).

### 1.1.1 Product life cycle

The life cycle of an information project is always the same.

Initial awareness is the start of every life cycle, maturity the end.

The difficult part is to find out which position GIS has at a particular point in time in a particular organization.Though there is much literature on the life cycle principle there is only very limited information on the influence of the life cycle position of GIS in an organization and the way a GIS project consequently should be handled.

Based on the limited experience of the author in the GIS field and his broader experience with project management within Hewlett-Packard the Relationship between the life cycle position and the way to handle the GIS project is discussed in this chapter. One model of a life cycle of a product is that of Nolan (Davis and Olsen,1987)1  (Figure 2)
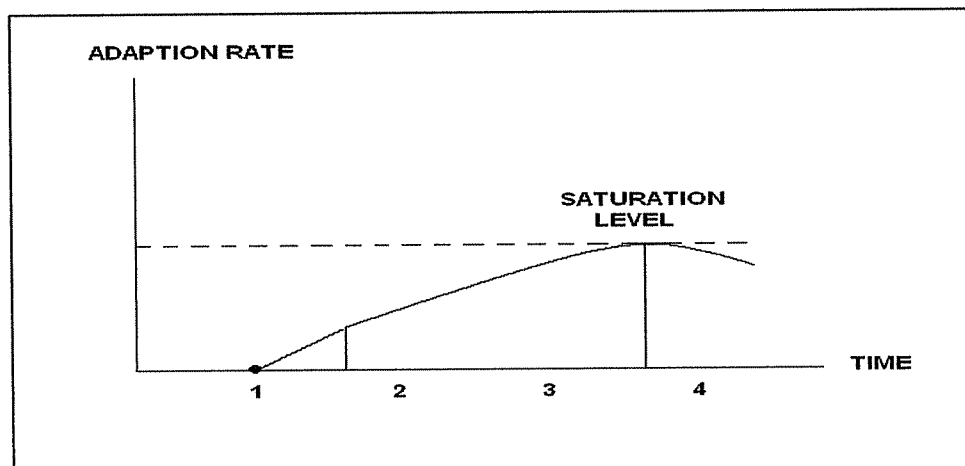


1) Initial a wareness . 2) Accelerated Introduction . 3) Drive to Maturity .  4) Complete Market coverage .

Figuer 2: Nolan's Model of life  cycle

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1) Davis .G. B S & Olsen M.H (1987) Management Informatin System , Academic Service

The life of a product starts after being developed by initial awareness. Customers become aware of the existence of the product mostly because of marketing activities. After this awareness there is a period of accelerated growth and the products reaches it's maturity phase.
The maximum penetration in the market will be reached and finally there will be replacements or more modern products become available and a process of deterioration will start.
For a company, it is of importance to be aware of the life cycle of their products. Research and development should be in line with the life cycle enabling a company to introduce new or improved products before the maximum market coverage is reached. The total life cycle differs considerably between products. A Boeing 747 has a life cycle of several decades whereas a personal computer's life cycle is less then one year. For this reason the time to develop a new plane is considerably longer than to the time to develop a new PC.
To put this into a different perspective; a delay of 6 months due to wrong engineering of a plane is probably acceptable. For a PC producer this will be the differences between success and failure as the competion has had enough time to overtake it's position.

## 1.1.2 Life Cycle of an IT system/IT project.
IT systems have a life cycle similar to products. For this reason the development of any IT systems is limited in time. It is of course, important to know what this model looks like since this describes the period of time available to develop and build a system.
The model of Nolan has been developed by Davis and Olsen (1987)1 into a six phase model (Figure 3)

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1) Davis G.B.S & Olsen M.H (1987) Management Informatin System , Academic Service

USER OF INFORMATION SYSTEM

DEVELOPMENT PHASE

X = Transition from phase
T ▶ T + 1
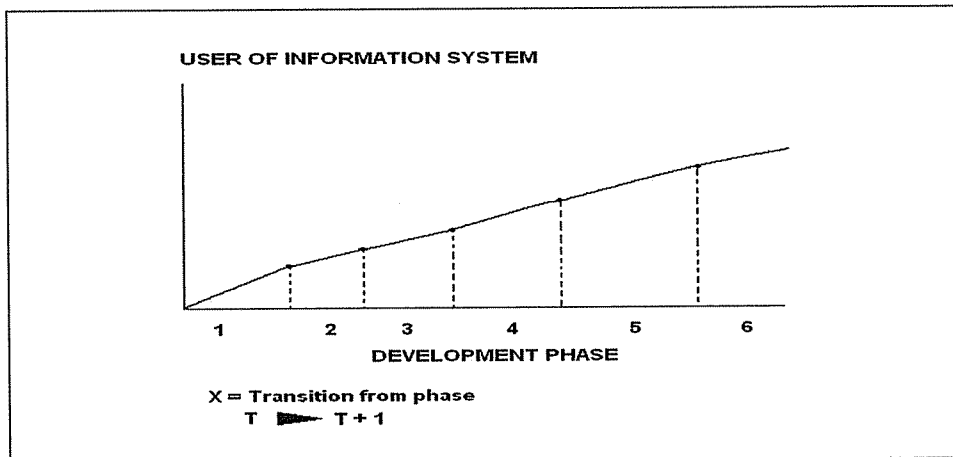
MODEL OF NOLAN WITH 6 PHASE
( DAVIS and OLSEN 1987 )

**Figure 3 : Model of Nolan for project**

1- Start: A small group of people are using the system, limited
and decentralized control, minimum planning.
2- Diffusion: More experimenting, more acceptance, number of users
increases.
3- Management: Organizational steps are taken to ensure
possibilities for intensified use and cost control.
4- Integration: The information system is integrated in the organization.
5- Data Orientation: Integration with other information systems in the
organization.
6- Maturity: System is fully integrated and successfully fulfills expected
tasks.
This 6 phase model is applicable to GIS as well. It is a good way to
determine the position of GIS in an organization. Depending on the
position in the model the demands during a GIS project will differ.
This issue will be examined more fully when looking at the strategic
position of a GIS project later in this chapter. It is important to understand
that it is impossible to skip a phase in project planning since neither the
organization nor the people in the organization are able to do this. The
experiences of every previous phase are needed to step into the next
phase.

### 1.1.3 Strategic position of a Geographic Information System in the Organization.

Information and communications technology (ICT) has become essential to the operations of organisations and communities worldwide, with huge sums of money, resources and user expectations invested in their implementation . Geographical Information Systems (GIS), in a particular type of organisation, namely local government, where GIS usage continues to expand rapidly.

This study focuses on the e-survey undertaken in summer 2006, which aimed to establish the range of GIS training and development delivery methods, attitudes to, and experiences of, training in the local government sector. In order to do this, a questionnaire survey was conducted across county, district, unitary and metropolitan authorities in England, Wales and Scotland. It also sought to establish whether there were any discernible differences in Investors in People organisations.

The survey targeted GIS managers, strategic managers, and 'power users' (users involved in geographical data management and GIS development, and advanced frequent users) in these authorities. The response rate of 52% (253 questionnaires), above average for an self-completion questionnaire (Flowerdew and Martin, 1997)[1], indicates that this is a highly topical issue, and, while the purposive nature of the sample means that the results cannot be considered representative, the response rate, mix of types and geographical spread of responding authorities provide results broadly indicative of local government throughout Great Britain.

The survey revealed that GIS use is widespread, and its adoption as a corporate information tool is steadily increasing. GIS managers and 'power users' are generally a committed, motivated and knowledgeable group. However, the situation is inconsistent, both between and within local authorities, in terms of level of GIS application, senior management commitment, staffing levels, and training.

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1) Flowerdew, R. & Martin, D., (1997), Methods in Human Geography, Harlow: Longman.

The way organisations use GIS in different phases was no part of the survey. In general the importance of the GIS to the organisation is less if the GIS is in a startup phase compared to the integration phase. Management will in pay more attention and give more support to systems which are in a management or integration stage because their relative importance for the company is much greater.

An other way to look at GIS in an organization is according to the model of McFarlan and McKenney (1983)1 which describes the strategic position of applications. examined the position of the GIS according to this model (Figure 4)

## Strategic position of GIS

Strategic infuence
New Application

Development
direction

( Little )

( Much )

| 28 %<br>Operation<br>support tool | 49 %<br>Intermediary |
| --- | --- |
| 1 %<br>Vital | 22 %<br>Strategic |
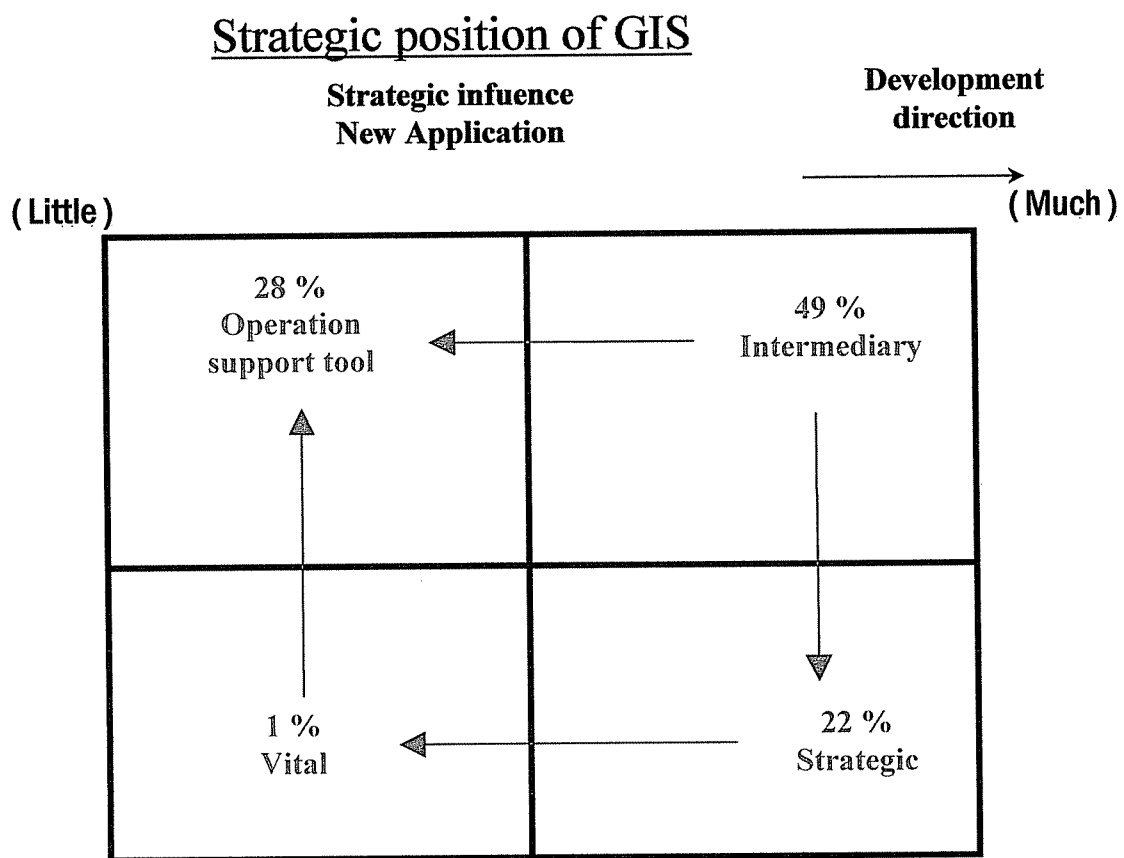
**Figure 4 : Strategic position of GIS, McFarlan
and McKenny Model**

1) Mc Farlan, F.W. and Mc Kenney, J.L.(1983), Corporate Information Systems Management: the issues facing senior executives, Richard Irwin, Homewood..

New GIS applications are first tested and are considered to be in the intermediary or experimental fase.

From this point on two things can happen; either the application is considered to be strategic and might even move on to become a vital application for the organization.

The other possibility is that the application becomes an operation support tool without strategic or vital value.

The same applies of course to GIS applications which are in use. If such an application is either strategic or vital the influence of the application is considerable. The amount of attention from higher levels of management for strategic or vital applications is larger than the amount of attention a operation support tool will get.

It's important to realize that the position in the above model determines the importance of the GIS for the organization.

Companies are willing put a lot of effort (resources & money) into applications (projects) which have a strategic or vital position.

Consequently there are always strict time-constrains in such projects.

A project realizing an intermediary or experimental application will not have the same kind of resources and constraints.

Intermediary applications can become strategic when they are successful or will never be used or will become an operation support tool, which is bound to disappear in case they do not have the potential to move into the strategic stage.

### Table 3:  Basic description of the stages

| Stage | Description |
| --- | --- |
| Support | GIS is usable for support on a operational level, there is no strategic influence of GIS. |
| Strategic | GIS is essential for strategic purposes at present. This influence will either diminish as GIS becomes a *Support* tool or will increase if it becomes *Vital*. |
| Intermediary | GIS is a *Support* tool at present but there is the expectation that it might become *Strategic*. |
| Vital | GIS is essential for the organization at presence and in the near future. |

An other way to look at the model is as shown in figure 5 follows;



STRATEGIC POSITION OF GIS
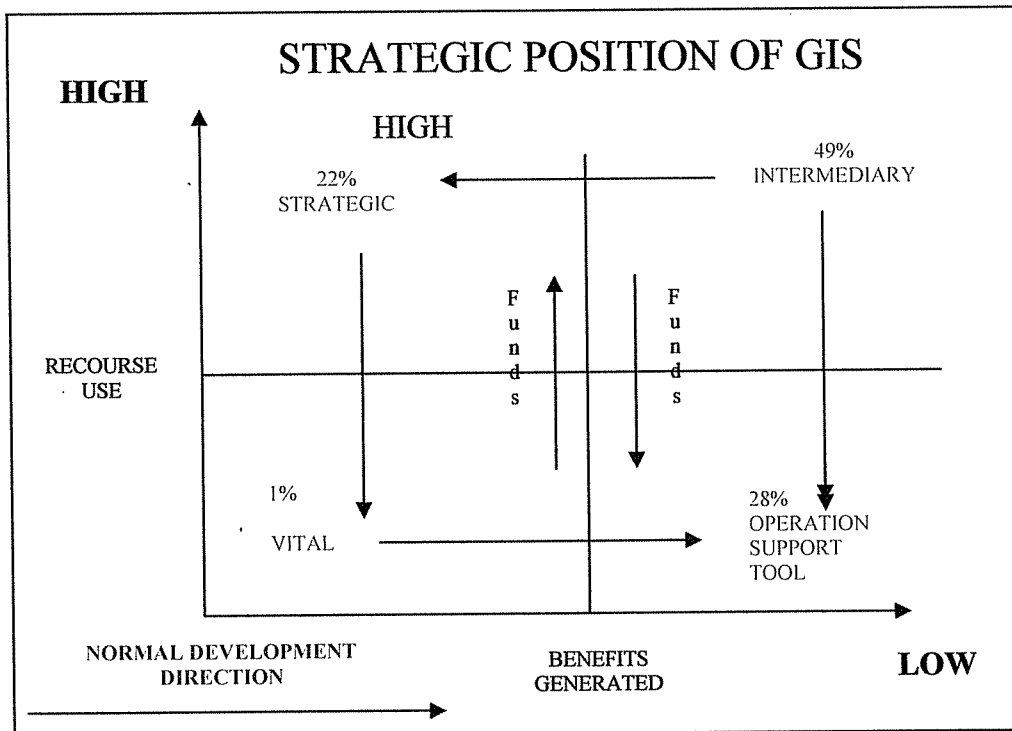
(Mc Farlan, F.W. and Mc Kenney, J.L. 1983)

**Figure 5: Strategic position of GIS
and the effect of funding**

It's important to look at the flow of the funds in this model. Most funds to develop new applications are granted either to replace systems which have become operation support tools.
There are also funds available to add to vital applications. It's not common to invest a lot in operation support tools, this money is often used to invest in intermediary tools which either replace or add to the environment.
There is also a tendency to invest a lot in strategic applications which might become vital applications in time.
Though it goes beyond the scope of this chapter it is important to notice that the demands on the IT system being developed vary in every quadrant. Neglecting this fact will lead to project failure since every quadrant has it's own demands. Vital systems are often also called mission critical and have very strict demands concerning support in case of problems. Sometimes there is even demand for a standby system which can become operational immediately after a system failure.

1)Mc Farlan, F.W. and Mc Kenney, J.L.(1983), Corporate Information Systems Management: the issues facing senior executives, Richard Irwin, Homewood.

This aspect has to be taken into account during the design. The same demand is very unlikely if the system is intermediary or experimental.
A recent KPMG study (Roelofs et al, 1996)1 relates 4 types of IT projects to the Nolan curve:

### Table 4: Types of IT projects to the Nolan curve

| Type of Project | Position in the Nolan Curve |
| --- | --- |
| 1 - IT as a tool | Start/Diffusion |
| 2 - IT as a management instrument | Management |
| 3 - IT as an improvement instrument | Integration |
| 4 - IT as a strategic weapon | Data Orientation/Maturity |

A type 4 project is far more complex than a type 1 project and requires a different way of project management.
A type 1 project could be the installation and configuration of a Mapping system non automated processes.
A type 4 project would link to the strategic goals of the organization and require a high level of involvement of senior management.
Type 4 projects are complex and have, due to their complexity a high failure risk.
Furthermore they are usually very costly. One result of the survey "GIS, noodzaak of luxe?" (Grothe et al.,1994) was that GIS will have a strategic function in an increasing number of companies. GIS will become embedded in the MIS (Management Information System) of companies..
In this thesis the author concentrates on these strategic (type 4) projects these are the kind of GIS projects which are demanded by the customers.
As the study of Grothe et al (1994) shows 49% of GIS applications are in the intermediary quadrant the logical development direction is into the strategic quadrant.
In the past years many intermediary GIS projects have been accomplished the experience with the, far more complex demands, strategic GIS projects is far more limited

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1) Roelofs J.C &La Haye M.W & Schotgerrits A.H.J.B(1996)Management van Complexe IT projecten,

### 1.1.4 Information Needs

An other way to look at information systems by looking at information needs in relation to the position where they will be implemented in the organization. To do this "triangle diagrams" which represent the different levels in the organization are used (Figure 6)

These diagrams do not represent organizational structures they focus on the information need which varies depending on the functions.

**Figure 6: Information Needs in Organizations**

Figure a. shows the different levels in an organization, Executive, Research & Management, Operational.

Figure b. shows that on an operational level there is a need for data and implementation whereas at the executive level there is a need for decision and information.

In figure c. the characteristics of the data involved are low volume, unstructured and external at the executive level and the opposite at the operational level.

Finally figure d. looks at the kind of information systems needed at the different levels.

ranging from executive information systems for the top executives to transaction processing at the operational level.

The information triangle to a GIS environment in Figure 7 :

Spatial Inputs to EIS

Spatial Modelling , Policy

E

R&M

Spatial Decision Support System

O

Operational Information
Processes in GIS

**Geographical
Information
System**
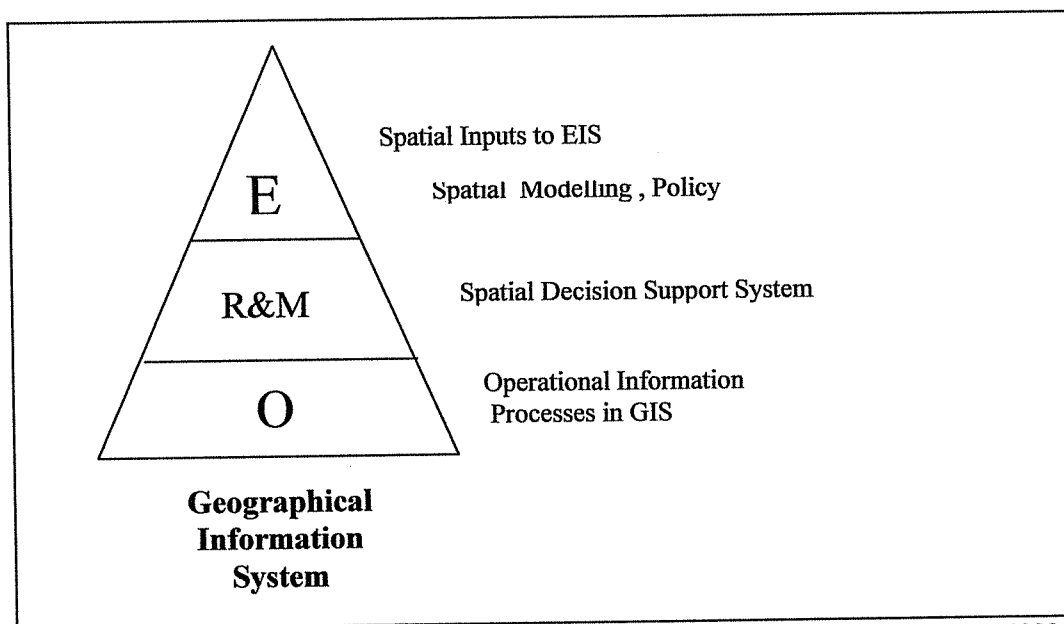
(Source: Reeve and Cornelius, 1993, )

**Figure 7: Information Triangale for GIS**

Depending on the position in the triangle the demands on the GIS will be different.

However it is important to realize that many information systems cover large parts of the triangle and have to fulfill the needs of all levels involv In order to develop an appropriate information system a thorough investigation must be undertaken based on the mission of the organization, on analysis of the information needs at every level and on the translation of all of this into an information strategy and an information architecture

## 1.2. Summary

Understanding the theoretical principles of the life cycle of an (GIS) in an organization is of importance when enrolling in a GIS project.

The position of GIS on the 6 phases model of Nolan determines largely the available funds, demands on the project and the management attention for the project.

A Dutch study (Grothe et al, 1994) shows that within private Organizations 70% of the respondents use or expect to use GIS as an strategic tool. This implies that GIS projects linked to the business goals of the organization will receive a lot of attention.

Every organization ought to have fundamental business objectives which lead to a vision and mission.

These can be translated into a Business /Function strategy.

The IS and IT strategies have to be in line with the Business/Function strategy and, in today's business climate, information technology must deliver tangible results that support the overall business strategy and goals.For a GIS project manager it is important to understand the business strategy in relation to the GIS project which is conducted and he must be able to answer the next important question: *How does my project support the organizations vision and how does it help to achieve it's business goals?*

Once the position of GIS in the organization is clear it is important to handle the project in a structured way.

A project manager has to "build" his project organization keeping this in mind. In order to have a successful project it must be:

- On schedule;
- Within budget;
- Of good quality;
- Complete;
- Accepted by the customer.

Choosing an appropriate methodology to do these things is critical in accomplishing this difficult task..

In the next chapter methodologies for GIS projects are discussed.

# 2 METHODOLOGIES

## 2.1. Introduction

Clients experience project failure due to:
- Inadequate definition of requirements;
- Changing requirements;
- Unrealistic time scale;
- Underestimating project costs;
- Incorrect choice of supplier.

Although project managers are usually intelligent people different project managers make the same mistakes over and over again.

IT projects are getting more complex due to business management and technological developments.

A standard framework or methodology describing the way to perform the project management tasks diminishes at least the chance of "common" mistakes. GIS is in the context of particular interest because:
- It is a new technology and there is relatively little experience of implementing it.
- It is not well understood.
- It has some particular characteristics which affects the choice of methodology.

In the literature on GIS there is only limited reference to the use of methodologies in GIS projects. As described in chapter 1, GIS is moving from the experimental phase in the life cycle to the strategic position. The demands on GIS projects and GIS project managers are changing accordingly and a structured project approach is becoming more important. In this chapter (and the next chapters) the author focuses on GIS projects which are strategic of vital and are complex in the sense that several departments are involved. To determine which methodology to use for such GIS projects is not easy. It could even be a question of how to adapt the "best available" methodology.

Based on literature studies and Rapid Application Development experiences within Hewlett Packard the author discusses the use of methodologies for GIS projects.

Based on the characteristics of GIS projects which are strategic a recommendation which methodology to use is made.

Finally these recommendations are tested by reference to a specific extensive GIS project in which the author was involved.

## 2. 2 General

GIS software applications are often called to solve much more complex problems compare to software applications in other scientific discipline. Developing applications is often one of the most time-consuming and expensive elements of implementing a GIS. It is also one of the keys to a successful GIS.

A GIS application often contains high volume of user interactions, multi-step processes, and multiple ways of performing the same task. The GIS users often desire to have higher level of involvement during the software development. Yet, the detailed functional requirements, scope of works are often hard to define at the beginning of a GIS application development project. Some times, both the GIS users and GIS developers leave the software requirements and functional specifications purposely vague to allow the inevitable changes along the way of software development process. But this kind of practice often cause confusions and contract conflicts later in the project. Developing high quality GIS application on time and within budget has always been very challenging. According to the Standish Report, one of the most comprehensive studies of software development projects, there are only 16% of all software development projects finish on schedule and within budget.

GIS application development often heavily relies on existing GIS software platforms or functional libraries, such as Arc GIS and Arc Objects. Working within these GIS platforms is often one of the major constraints in a GIS application development.

### 2.3. Choosing the appropriate development methodology for a GIS project.

Choosing the appropriate development methodology depends on the situation. The "one fits all" methodology unfortunately does not exist. Currently, combinations of information engineering and proto typing are used. The basic thought behind information engineering is that data is the most stable factor when developing an information system. This method specially is useful in a project with the following characteristics:

♦ High uncertainty of specifications;

♦ Need of decision support systems;

♦ Low expertise in this field of current users;

♦ High level of uncertainty concerning the exact specifications of GIS.

On the other hand if a current system has to be replaced the best choice of a method is probably SSADM (Structured Analysis and Design) which was produced by CCTA a UK government agency (Reeve and Cornelius, 1993)[1]. SSADM presumes that there is an existing manual or computer system and analyses first the existing system and, on that basis, specifications for the new system are made.

In general, traditional System Analysis takes a lot of time which makes this methodology less and less popular. A project analysis and feasibility study easily takes 0.5 - 1 years of time. Considering the fact that product life cycles are diminishing all the time this is often much too long.

The next table shows traditional versus Rapid Application Development times. Traditional in this case means that, for instance the prototype is a limited program that simulates the required functionality of a very simple application (a mainframe approach).

A client-server pilot is a sophisticated version of the production system that is functional from the beginning but is limited in number of users, speed and functions.

**Table 5: Shown Traditional versus Rapid Application Development times.**

| DEVELOPMENT TIME: TRADITIONAL VERSUS RAPID APPLICATION | | |
|---|---|---|
| *Phase* | *Traditional* | *Client-server* |
| **Feasibility** | prototype 1-6 months | pilot system 1-3 weeks |
| **final user specification** | 1-6 months | Continuous |
| **System design** | 3 months – 1 year | included in the pilot system |
| **Coding** | 6 months – 3 years | production system 9-20 weeks |
| **Testing and revision** | 3 months - 1 year for most changes | continuous, 1 week for most changes |
| **total time** | **1 - 6 years** | **10 - 20 weeks** |

**(Adapted from Donevan, 1994)**

**2.3.1.Rapid Application Development/Joint Application Development**
Rapid Application Development (or RAD) method came to the software development community in the early 1990s (Martin, 1991)[2]. The creation of RAD did not lead to its immediate adoption.

1) Reeve .D & Cornelius.S(1993) GIS Organisations, Manchester Metropolitan University ,Manchester
2) Martin,J.(1991) Rapid Application Development ,Macmillan Publishing Company, New York

But the increasing disenchantment with traditional systems development methods and the long development times associated with them led more and more firms to serious consider RAD. There are many different rapid development approaches. In fact, many consulting firms and corporations have defined their own RAD (Hoffer, et al. 2002)[1]. The general common characteristics of an RAD have always included high level of user involvement in the development process. Although many have pointed out that RAD only works for systems that have to be developed quickly, and other aspects of application development efforts, such as interface consistency, programming standards, scalability, etc. are often overlooked (Gibson and Hughes, 1994; McConnell 1996; Bourne, 1994)[2], the success of RAD in the new business environment of increased costs and competitions is undeniable. Hoffer et al. (2002) has reported some RAD successes ranging from saving 50 percent of costs to nearly cutting more than 60 percent of development time.

The RAD approaches naturally fit the needs of GIS application development, especially in the small to medium size projects that often require accelerated development schedule and fast turn-a-round. There are many success stories of utilizing RAD tools and techniques in GIS projects documented in user conference proceedings and other publications (Cone, et al. 1999; Dennerlein, J. 1997; Kroot et al. 2000)[3]. This paper will focus on discussing a highly adaptive rapid GIS application development approach from a software development methodological point of view.

1) Hoffer,J,George &J.S.Valacich, (2002) Modern System Analysis & Design
2)Gibson M.L &C.T.Hughes,(1994) System Analysis &Design,Danvers,MA Boyd&Fraser Publishing
3)Cone,L.D & Dennerlein, J.(1997) Rapid Application Development & ArcView: A New Horizon for GIS Application Development. Proceedings of the ESRI User Conference

## 2.4.1. Project Planning

Although a GIS application development using rapid development method is generally set to be performed on an accelerated schedule, careful planning in the startup phase of the project is still an essential factor to the success of the project (Figure 8)[1]
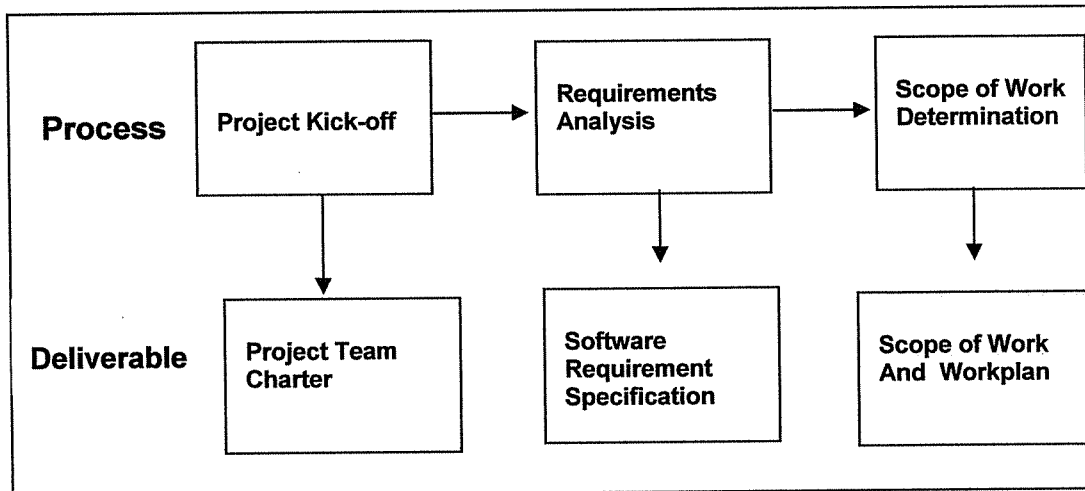


(Source: Kroot, C. M. Smith, S. Rich, and J. Sardano.2000)

## Figure 8 . Project start up and planning

A project kick-off meeting should be called to charter a project team and define the rules and responsibilities of each team members. The project team may include the customers or GIS users, sometimes may be your client. A draft work plan and preliminary schedule may also be determined at this time. In gathering requirements, always ask the GIS users or your clients three questions (1) What do you must have? (2) What do you wish to have? (3) What do you not want to have? The software requirement specification should document the needs in first category as the basic requirements in great detail, list the needs in the second category as optional requirements, and note the third category as being excluded.

The basic requirements will be given thorough consideration throughout the project; whereas, the optional requirement will be considered as the second tier of functionality. In fact the users often have alternative methods to perform the GIS analysis without these functions defined by the optional requirements. In the case of limited funding and development time, they may also choose to delay the development of more complex GIS functions that support certain advanced GIS analyse

1)Kroot, C. M. Smith, S. Rich, and J. Sardano.(2000). Building and Deploying an Enterprise Geographic Information System Using ArcInfo 8.0, Oracle, and Citrix. Proceed ings of theESRI International User Conference.

Sometimes, with the ever improving GIS technology, if you wait, functions that provide better solutions to those needs may come directly from the next release of the underline GIS platform or software upgrade, such as Arc GIS. Meantime, the GIS users may take the time to become more familiar with the basic GIS systems and applications before they can take advantage of more advanced GIS technologies. The third question may be odd, but determining what do not need to be in the development can help further bound the scope of work.

After the software requirement specification has been determined, a detailed scope of work and initial work plan should be developed to document the scope of work, cost proposal and development schedule.

## 2.4.2. Software Design and Build

The second phase of GIS application development in the highly adaptive rapid development process is to design and build the application. Normally, in a rapid application development process, both the developers and GIS users will need to be involved in this design process that may contains several Joint Application Design(JAD) sessions where both the developers and users work together to determine what is the best for the system.

The high level processes of the design and build are shown in Figure 9. The first step of design and build is to quickly design and build the high level GIS interfaces. The greatest flexibility of changes are allowed at this step, A few iterations may be allowed for the developers and users to work together quickly come up with acceptable high level user interfaces and functions. A "prototype" release may be allowed for your client's high level presentations and public outreach activities.

The second step of design and build will actually design and construct all essential functionality of the system which should include all the core functions that satisfy most of the basic requirements. The product will be an essential functional release.

Users should be able to start "test driving" the system by performing some GIS analyses with additional help. Without additional functions that will be built in the next step, the users may have to prepare data or parameters manually before running the analysis using the "basic" system. An iterative development process is also allowed in this step to improve and finalize the major functions of the application.

The third step of design and build is the final step of software construction. The whole system will be built at this time.

All the basic system requirements and some, if not all, of the optional requirements will be satisfied. The software product will be released to the customers or GIS users for deployment in the production environment.



| | Step 1 | Step 2 | Step 3 |
|---|---|---|---|
| **Process** | High-Level User Interface Design and Build | Essential Function Design and Build | Full System Design and Build |
| **Deliverable** | Version 0.1 Release (High-Level Construct) | Version 0.5 Release (Essential Function Construct) | Version 1.0 Release (Full System Construct) |
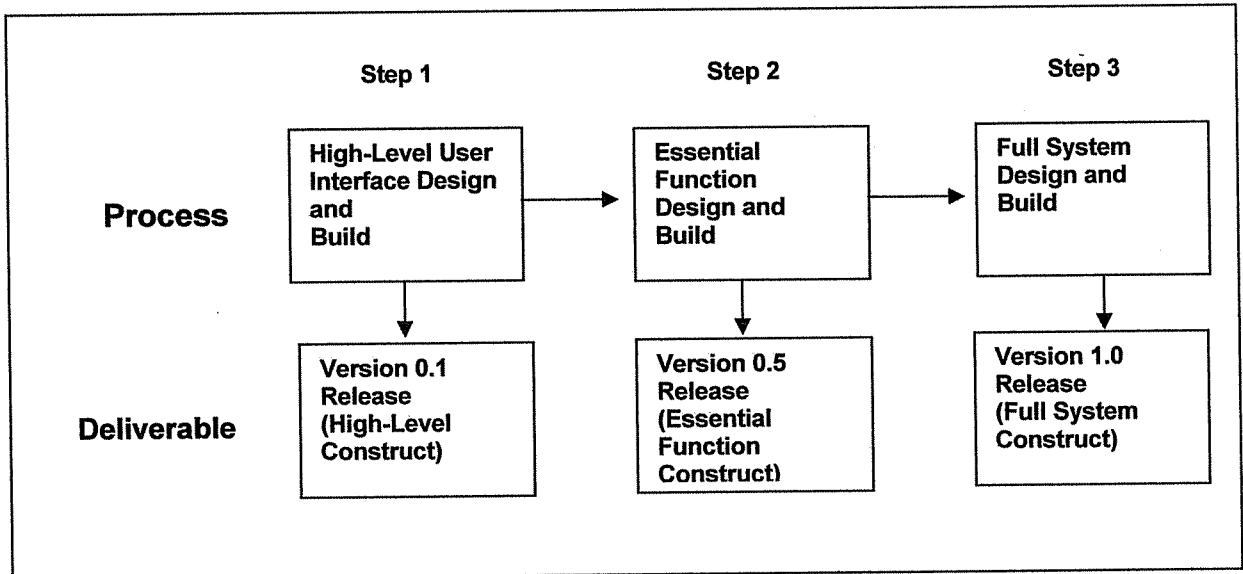
(Source: Gibson M.L &C.T.Hughes,(1994)

**Figure 9 . Design and Build Process**

### 2.4.3. Initial Software Design and Build

The detailed initial design and build process are shown in Figure 10 . While the developers and GIS users may work collaboratively to design and build the high level user interfaces, the developers can work in a parallel process to study and prototype those core functions that do not require user interactions. The users in general do not have great concern on how a low level GIS function should be designed and programmed. The developers may decide alone what the best solutions are. However, the practice of "gold-mining" for the smartest code should also be avoided concerning the cost and development schedule.

Early design and prototyping on non user interface core functions can also help to identify certain "road blocks" in the high level design. For an example, if a proposed user menu item calls a function that is proven to be impossible to be implemented within a given GIS environment, an alternative design has to be given to the menu item.

Early identification of the high level design issues and making
appropriate changes can significantly reduce the cost than changing at a
late development stage.
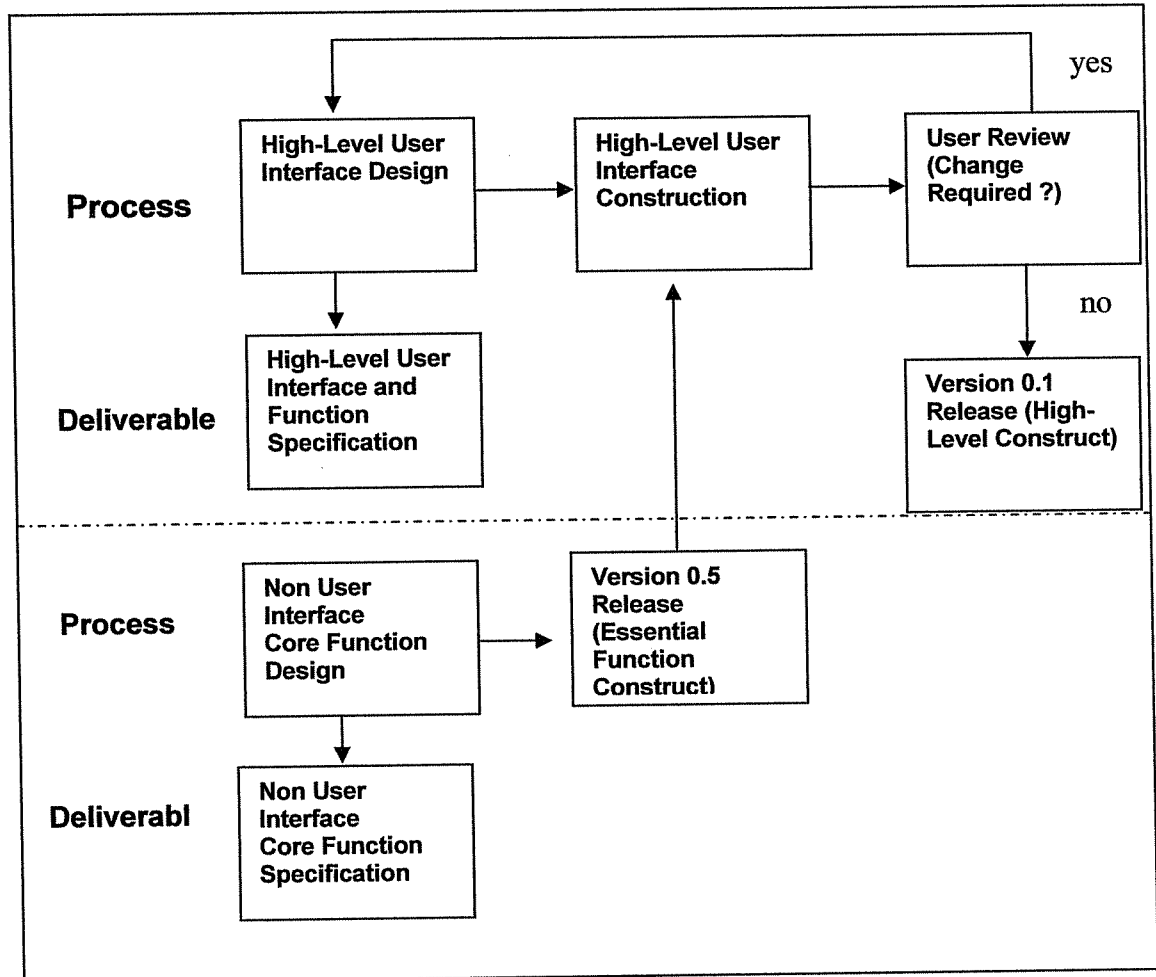


(Source: Gibson M.L &C.T.Hughes,(1994)

**Figure 10 . Initial Design and Build**

### 2.4.4. Essential Function Design and Build

The detailed essential function design and build process are shown in
Figure 11. Similar to the initial design and build, both the developers and
GIS users can work together to create the essential function specification.
Then the developer will start to develop the essential functions of the
application. The constructed essential functions will be review and tested
by the users for acceptance. Necessary changes will be made to the design
and software construct to address user's comments.

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Note that non interactive core functions can be designed and developed by the developers in parallel to the joint design and build of essential functions. These core functions will be incorporated into the essential software construct. Once accepted, the essential function construct will become the "basic" system of the application that contains all the essential functionality. For the developers, it is a good to baseline the system at this time.
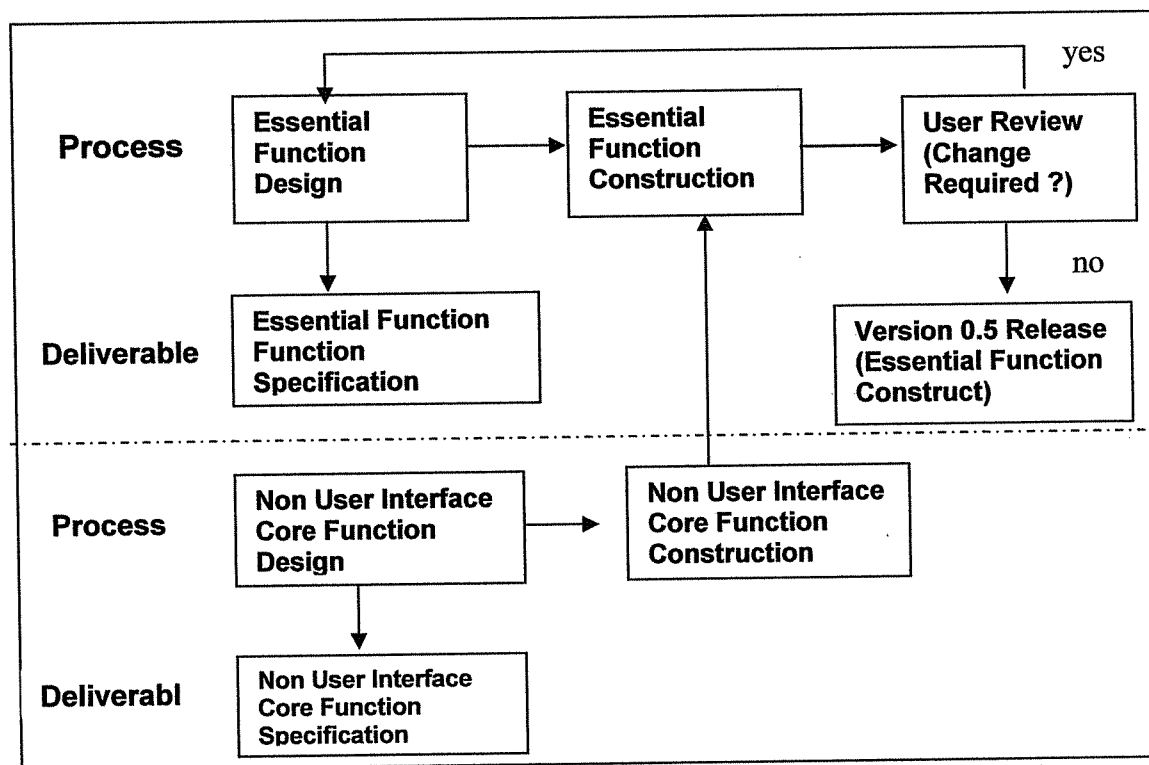


(Source: Gibson M.L &C.T.Hughes,(1994)

**Figure 11 . Essential Function Design and Build**

### 2.4.5. Full System Design and Build
The final system design and build process are shown in Figure 12. All of the additional system functions will be designed and constructed at this step. The developers and GIS users will work together to create specification for additional functions that required by the system. Then, the developer may begin to develop these additional functions to finish the full system construct. Note that additional non interactive low level functions may be designed and developed by the developer at the same time.

These non interactive low level functions will be incorporated into the final system. An iterative process may also be allowed to address user's comments and concerns to improve the functionality and system performance. At this time, the developers and users also assess the available funding and development time. If both the time and budget allow, some or all optional requirements may be considered to further enhance the software application.

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│              ┌───────┴────────┐    ┌──────────────┐    ┌─────▼──────┐  │
│              │ Full System    │───▶│ Full System  │───▶│ User Review│  │
│   Process    │ Design         │    │ Construction │    │ (Change    │  │
│              │                │    │              │    │ Required ? │  │
│              └───────┬────────┘    └──────────────┘    └─────┬──────┘  │
│                      │                     ▲                 │ no      │
│              ┌───────▼────────┐            │          ┌──────▼───────┐ │
│              │ Full System    │            │          │ Version 1.0  │ │
│  Deliverable │ Specification  │            │          │ Release      │ │
│              │                │            │          │ (Full System │ │
│              └────────────────┘            │          │ Construct)   │ │
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│              │ Function Design│    │ Construction     │                │
│              └───────┬────────┘    └──────────────────┘                │
│              ┌───────▼────────┐                                        │
│              │ Non Interactive│                                        │
│  Deliverable │ Low-Level      │                                        │
│              │ Function       │                                        │
│              │ Specification  │                                        │
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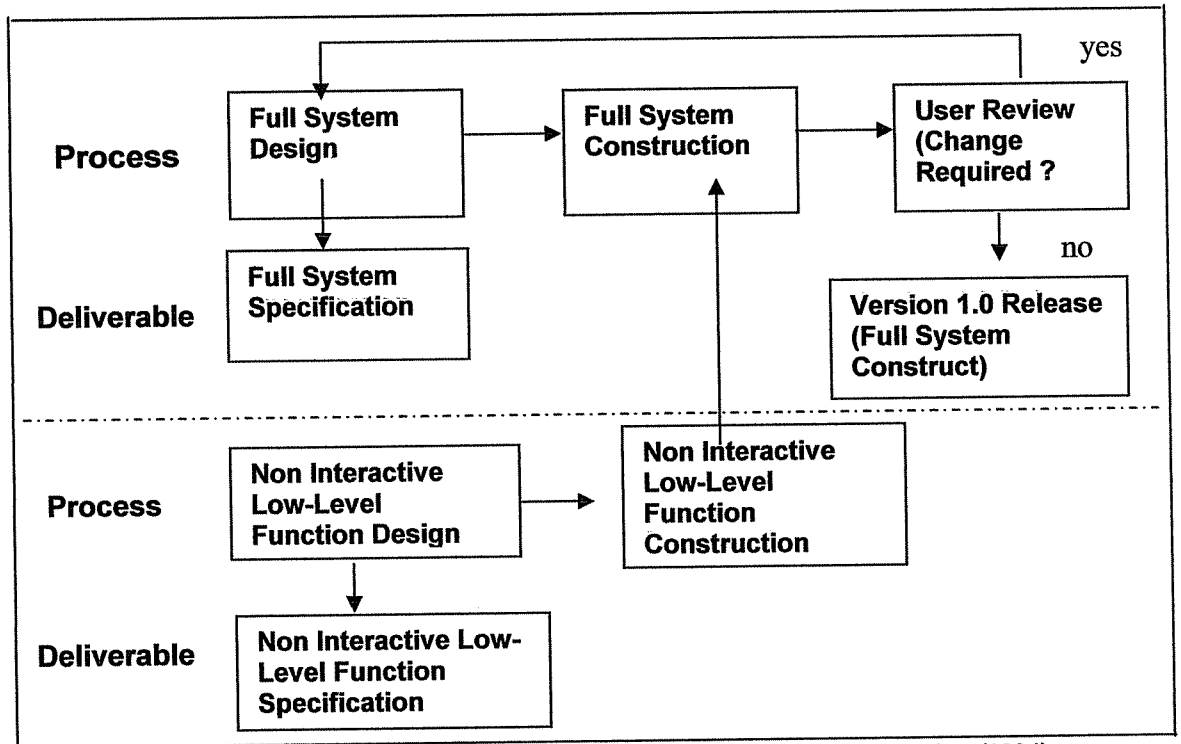
(Source: Gibson M.L &C.T.Hughes,(1994)

**Figure 12 . Full Design and Build**

## 2.5. Project Close-out

After the final delivery of the software application, the current development project will be closed out. All project materials, including requirements and software design documents as well as programming source codes and object codes will need to be archived. The developers should always consider certain level of customer support for all GIS applications delivered to the clients or GIS users. With the rapid changes and ever improving GIS technology, there may be opportunities for additional works in the future to further improve the functionally of the software application or realign it with newer GIS technology.
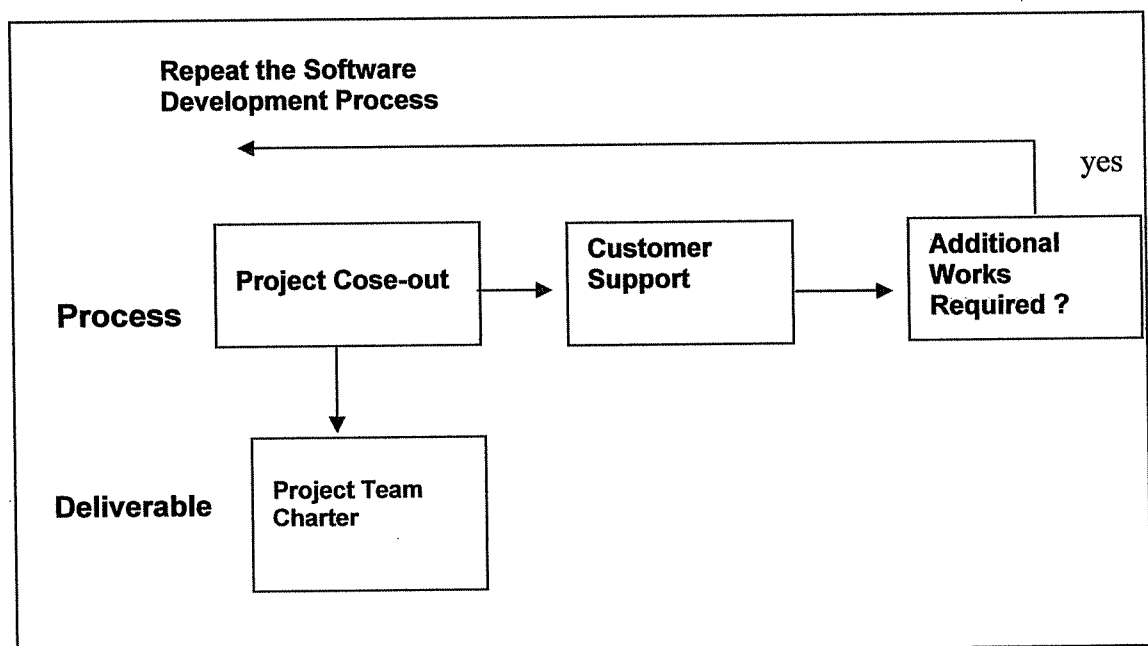


(Source: Gibson M.L &C.T.Hughes,(1994)

**Figure 13 . Project close-out and customer support**

## 2.6 Summary

The highly adaptive rapid GIS application development method described in the paper can be applied to many complex GIS applications that are developed in a dynamic environment. It will significantly shorten the development time while allow many iterations of software construct to be built with great level of flexibility.

Significant user involvement right from the beginning allows more design issues to be addressed early in the process and thus reduce the amount of re-work to the minimum. Being able to prioritize the functional

requirements and design and build the application in different phases allows the development to start small and more adaptive to change. Focusing on adding the "must have" functions next will keep the development concentrated on major requirements of the system while leaving enough room for growth and being adaptive to changes in the middle of the project.

As long as the budget and time allow, more additional functions will be added, and some or all optional requirements may be considered. The final software product will be a high quality software application with maximum optimized functionality allowed by a given budget and development time. The software requirements and design specifications are always living documents throughout the process that allows reasonable changes and updates.

# 3 PROJECT MANAGEMENT FOR GIS

## 3.1. Introduction
The previous chapters describe the life cycle of GIS projects and the methodologies which are useful. But how to apply this knowledge when doing an actual project ?

Based on the life cycle and methodology principles outlined above in this chapter an approach towards an actual project is proposed.

The assumption is made that the GIS project is of a strategic nature and involves several departments of an organization.

Finding the appropriate guidelines is not easy. Not many GIS projects of this magnitude of complexity have been conducted and even fewer have been documented.

The approach in this chapter is based primarily upon the PRINCE handbook (Bradley, 1993)[1] for project management which is primarily meant for Government projects. PRINCE is an abbreviation of **PR**ojects **IN** Controled Environments and is the standard project management method for Government (in the UK) IT departments approved by the CCTA. Basically PRINCE is the definition of the products to be produced by a project. When using the Structured Systems Analysis Design Methodology (SSADM) PRINCE is the project management methodology to be used. SSADM however is, as argued in chapter 2, not always applicable to GIS projects.

Methodologies like RAD/JAD have to be used. By extension PRINCE is not always applicable. The argument here is that a specificific management approach for strategic GIS needs to be developed.

This involved combining PRINCE with "The Customer Project Life Cycle"(Hewlett-Packard, 1995)[2] which is the mandatory project management approach of Hewlett-Packard and taking account of the issues described in "Managing Geographic Information Systems Projects (Huxhold et al, 1995)[3], and Management van Complexe IT projecten (Roelofs et al, 1996)[4].

Additionally the authors own experiences is used to genereate a set of guidelines to handle GIS projects.

Issues like Project Initiation, Deliverables, Monitoring and Risk management are discussed.

1)Bradley,K.(1993)Prince:A practical Handbook,Butterworth-Heinemann Ltd. Linacre House Jordan Hill Oxford.
2)Hewlett-Packard(1995)Customer Project life cycle2, Mountain View.
3)Huxhold, W.E. &Levinsohn A.G(1995)Managing GIS Projects 1st ed ,Oxford University Press.
4) 1) Roelofs J.C &La Haye M.W & Schotgerrits A.H.J.B(1996)Management van Complexe IT projecten,

## 3.2. General

In this chapter a practical approach towards GIS project management is described. The importance of a Project Initiation Document, Quality Control Procedures and Monitoring of the project is clarified.

*What is a project: A unique set of activities with a defined time frame, with a well defined goal, with acceptance criteria, with known risks which are all established at the beginning of the project.*

Huxhold et al. (1995)1 mentions some interesting facts about IT projects by referring to a 1989 study by Croswell who found that relatively few GIS installations in the USA and Canada are fully successful.

Some other statistics show the same:

♦ 25% of all major IT projects are not completed (Jones, 1981).

♦ 15% of major IT projects deliver products which are never used (De Marco and Lister, 1987).

The reasons for this, which they all mention, are mostly not technological but institutional (sociological). Starting a project is easy, ending it successfully isn't. Project management is *not* an easy job and the difficulty of most projects is underestimated.

When a GIS project manager is being told that "this is an easy project to do" he always has to think of the knowledge base:
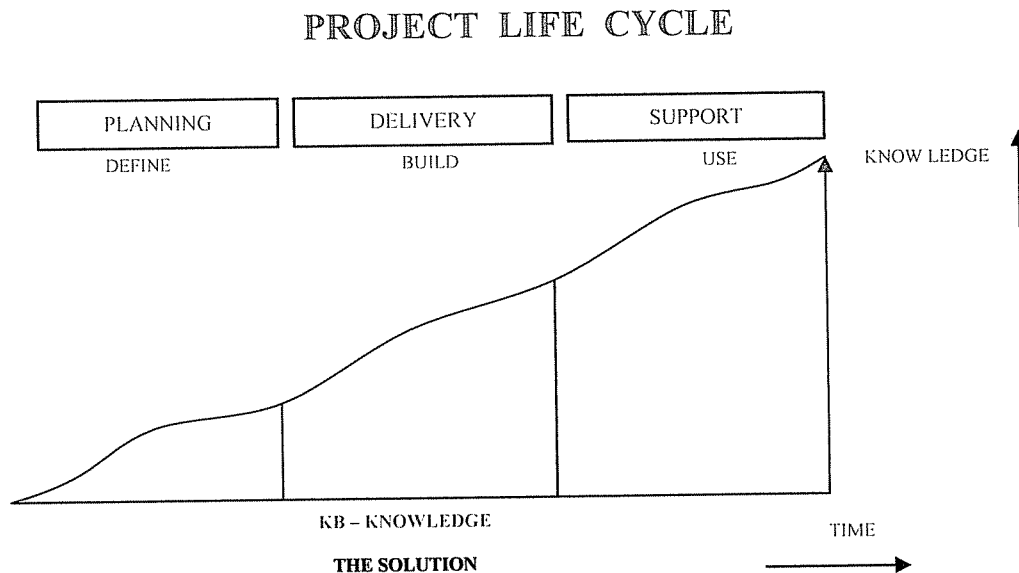


**Figure 14: The Project Life Cycle**

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As Figure 14 shows at the very beginning of the project, when the specifications have to be defined the knowledge base is the smallest. How about the knowledge base of the customer? His/her knowledge base is not much different because all the work still has to be done and the sum of the work often looks less complex than the parts. Yet specifying the parts in an appropriate manner is of paramount importance. Many customers ask for project management but also would like to have some process management as well. It is important to know the difference between a process and a project. A process (Figure 15) has the following sequence:

## Process Management



### Project Management
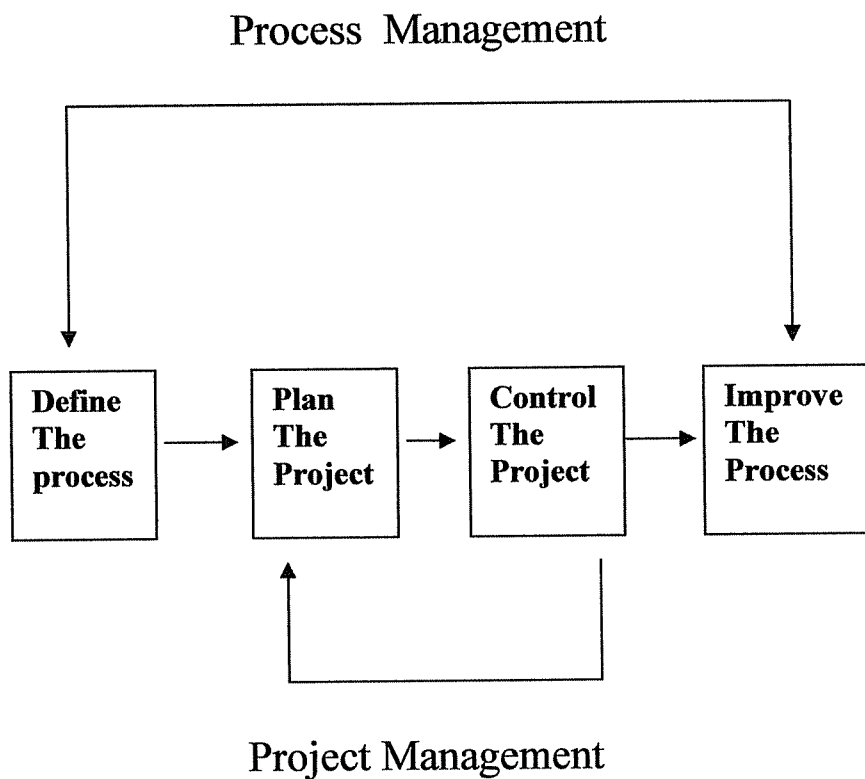
(Source :Huxhold, W.E. &Levinsohn A.G(1995))

**Figure 15: Process Management & Project Management**

Many projects don't start with a clearly defined requirement specification. Often there is a need to look at the process as well. If the process is not working properly there might be a need to improve it. Without doing this the project might be endangered.

This is especially the case if the project also requires organizational changes (different job, different responsibilities). In practice many project managers also manage processes that will enable the project to succeed. Nowadays not many projects start with a full set of functional specifications and it is increasingly important to be aware of the underlying processes.

### 3.3. The project stages
Many inexperienced project managers make the mistake of starting a project by taking a piece of paper and filling in the blanks. This is **not** project management!
Looking at a project the following stages can always be recognized:
1. Planning;
2. Delivery;
3. Support.
The main focus of this thesis is on planning and delivery though support will be discussed briefly later on.
The urge to jump the delivery phase is only human but needs to be avoided if the project is to be successful. Specially the planning stage where the objectives of the project are clearly stated and are agreed upon is of paramount importance.
How does a project start? Some examples are:
♦ Champion; somebody in the organization who is very enthusiastic about the possibilities of GIS will start a decision making process;
♦ Management; on the basis of their strategic planning process, contacts with other organizations management recognizes the need for a GIS;
♦ Customer demand; customers of the organization ask questions which can only be handled if a GIS is used;
♦ External consultant; an external party which has been invited to give advice proposes a GIS to solve certain problems / questions in the organization.

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## 3.4 Project Initiation

In the GIS Project Management Handbook British Columbia Ministry of Forest (date unknown) a Project Sponsor is mentioned: "This person is the promoter of the project. His role is to "represent" the project to management, and secure priority and recourses for the project. He also acts as the supervisor for the project manager." It is obvious that such a person is needed in projects but in large complicated projects it is better to have a project board.

According to the PRINCE-handbook (Bradley, 1993)[1] the ideal project organization looks as follows (Figure 16):

## PROJECT ORGANIZATION
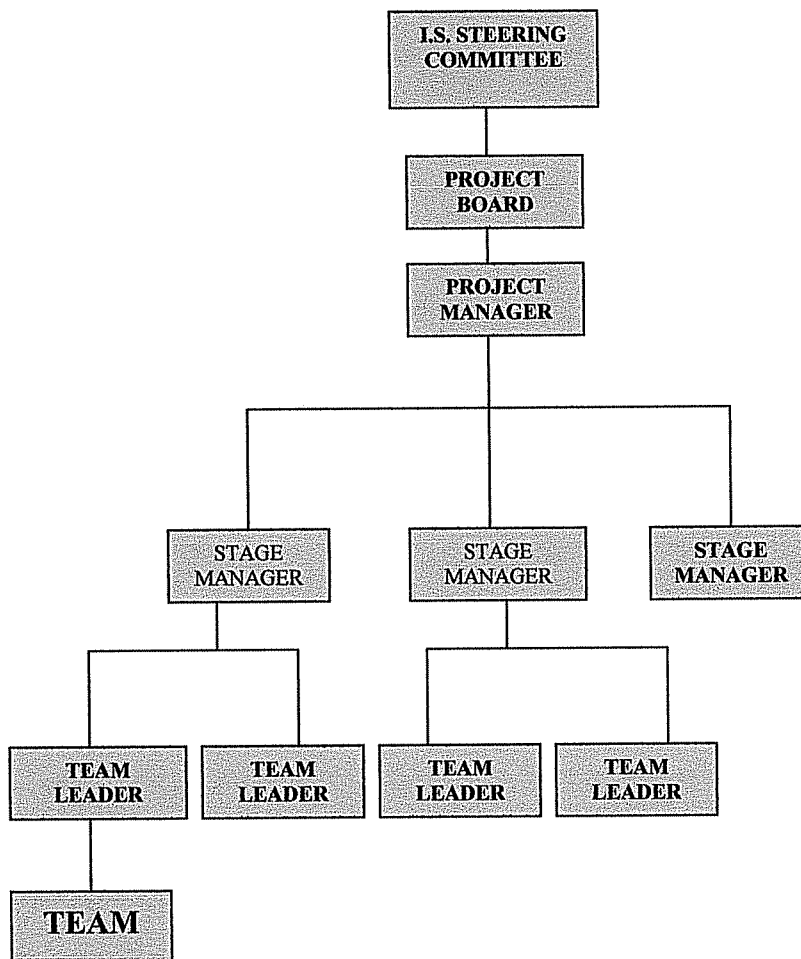


**Figure 16: The Project Organization**

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1)Bradley,K.(1993)Prince:A practical Handbook,Butterworth-Heinemann Ltd. Linacre House Jordan Hill Oxford.

If the project is highly visible, risky and of strategic or mission critical importance to the organization, it is very important to establish an IS steering committee. This committee is responsible for the overall objective's of the organizations business and keeping the project in line. Subjects such as :
Hardware strategy .
Software strategy .
Application strategy .
Staff strategy (hire or freelance).
will be covered by the IS-steering committee.
They however are not involved in the day to day business of the project. For this purpose the project board is established. This board should consist of people at the management level as they have to make decisions on recourses, budget etc. The project board should have the following managers:
1. Executive : he/she is the link with the steering committee and has the role of project sponsor;
2. Senior User : representing the users of the system ensuring support for the project at the users level;
3. Senior Technician : representing the parts of the organization which will take care of the technical implementations. The project manager reports to the project board.

### 3.4.1 Responsibilities of the Project manager

To get a good idea about the responsibility of a project manager take a look at the job advertisements in some magazines:
{Translate customer demands into realizable and manageable product specifications;
{Give advice in the field of product improvement;
{Meet with other involved departments and suppliers;
{Guard budget and time lines;
{Make detailed project plans; Lead one or more projects;
{Give verbal and written reports to the management;
{Look at details without forgetting the big picture;
{Meet predefined project objectives;
It is the responsibility of the project manager to define the roles and ensure the availability of internal and external recourses so the proposed solution can be delivered.

There are 2-kinds of project managers:
{ Internal : somebody appointed from the own organization;
{ External : somebody hired from the outside on a temporal assignment.
Sometimes a combination with an internal and external project manager
is chosen.
One problem Internal project managers fase is the risk of becoming a "if
you have a spare minute" project manager who still has their own
previous job to fulfill as well. Don't be fooled, managing a project is
almost never a part-time job. A second common mistake internal project
managers make, which is not uncommon to external project managers as
well, is to forget demanding senior management involvement in the
project.
In a good project organization is a big part of the work. In order to define
the required organization one has to look at the work which has to be
accomplished. It is very tempting at this point to go into details but there
is no need for this yet. The work which has to be done in the project must
be split into major phases, activities, sub activities and tasks.
Depending on the level of complexity it might be worthwhile to appoint
one or more stage managers which are responsible for parts of the project.
A stage manager is technically responsible to deliver the products of one
or more stages. Often the project manager also has the role of stage
manager.(Figure 17)



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┌──────────────┐        ┌──────────────┐        ┌──────────────┐
│   Project    │ ─ ─ ─> │    Stage     │ ─ ─ ─> │    Steps     │
│              │        │              │        │              │
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```

Project  manager          Stage manager                Teams
                               Or
                          Project manager

( Source:Bradley ,K. Prince:A practical Handbook 1993)

**Figure 17: Project->Stage->Steps**

So on a macro level the project is divided into stages which are divided
into steps. Steps are carried out by teams (which, depending on the
complexity of the work, might be only one man or a team with a team
leader). It is likely also that internal recourses are needed.

In the Project Initiation Document, which is mentioned later on in this chapter, there should be a list of needed recourses mentioning the required skills and, appropriate, the names of specific individuals if they are essential for the success of the project.

It is important to seek agreement on the organizational structure which is being used for the project since it is a representation of the resources needed in the project.

Being a project manager is **not** a part-time job unless it is an unimportant project. There is a tendency to underestimate the importance of good project management which in general is regarded as being a overhead and very costly.

A good project manager will however ensure that a project is completed according to plan, within budget, within time and will create an acceptance level for the project in the organization.

Get the appropriate management involved! For this reason the very first thing a project manager has to do is to establish a Project Initiation Document.

## 3.5 The Project Initiation Document (PID)

A carefully structured project initiation phase should ensure that the project is clearly defined and specified from the start. The project owner should appoint the project manager and direct them to produce a detailed project initiation document (PID). This document has various components, which together will quantify the risks and benefits associated with the project. The project manager appointed to produce the project initiation document will normally be retained to manage the project. One or more sub-project managers and staff from the project office may also be appointed to assist in its production. The project office is the generic term given to a central resource of dedicated project staff. Project Office staff are likely to include estimators and planners, whose services can be very useful in the creation of a detailed PID. The precise composition of the PID will be influenced by such considerations as management attitudes and the perceived complexity of the Project .

### 3.5.1 Components of the PID

Project, It is used to define the financial and other benefits which the project is expected to deliver. It also details the cost, timescale and other constraints within which the project is required to operate and against which its performance will be evaluated. The configuration management plan should detail The business case details the justification for undertaking, and for continuing, a the configuration management procedures to be used throughout the project. It should be produced as part of the project initiation document. A project does not normally exist in isolation. There are various relationships and areas of common interests with other projects, or other activities in the same department, organization, or even externally. The project boundary must therefore be defined in a way which makes it clear how related projects interact, and where the output from one project forms the input to another project, or related area of work. A project plan will normally consist of a project technical plan and a project resource plan. The project technical plan is produced at the beginning of the project and shows the products required and the corresponding schedule of major activities that will occur throughout the project. This is produced in conjunction with a project resource plan, which details the resources required. Quality policy, where it is applied, is the documented standard for the application of quality assurance and quality control procedures to the running of projects within an organization. The terms of reference provide a definition of the objectives for a project, including any relevant background information.

### 3.5.2 Project Initiation - Owners Duties.

Upon receipt of the project initiation document, the project owner should ensure that it is checked against the business objectives and the project boundary - as defined by the project sponsor. The project owner will need to review and approve the project plans. At this time the plans will need to contain detailed information relating to the first recognized stage of the project, including plans for those sub-projects that reside in the first stage. In addition to appointing the overall project manager the project owner should appoint the sub-project managers required to deliver the first agreed stage. The resources required should be agreed by the project owner, in consultation with the project and sub-project managers.

### 3.5.3 Ongoing Project Management.

The use of formal organizational processes throughout the project activities phase should ensure that the project is properly managed and controlled. The control framework required to enable the project owner to monitor progress and exercise control should be detailed at project initiation. The project owner should relate a high level summary of the information they receive to the project sponsor, to keep them informed of progress. Through regular communication with the project managers, the project owner should satisfy themselves that the agreed project management approach is followed - that is, that the structures and control framework put in place are being adhered to. The project owner should monitor the project against its business case and ensure that it remains viable. The business case details the commercial or business benefits justification for the project. The project owner should review and approve forthcoming sub-project plans as the project progresses. This also applies to any remedial plans that may be produced to address a project that is going seriously off-course. It is quite common for sufficient information to produce sub-project plans only to become available immediately prior to the intended start point of the sub-project.

### 3.5.4 Reviews & Reports.

The project manager should be responsible for ensuring product delivery and for the management and motivation of staff working on the project. They should analyze and collate the progress reports and summarize this information in regular highlight reports which should be presented to the project owner. Highlight reports should be produced at regular intervals, for example monthly, and may also be produced in response to exceptional circumstances. Where a project office is being used, the project manager should assess the results of all project and quality reviews and liaise with the project office staff to maintain the integrity and direction of the project. Decisions which effect the strategic direction of a project will almost certainly need to be referred to a senior management body or individual, but it is the project manager who will have to make the recommendations and then put into effect the decisions made. The project manager should be aware that disagreements have the potential to arise at all levels. The intensity of any particular conflict may be affected by a variety of factors including approaching deadlines, a squeeze on resources or the individual characteristics of those involved.

### 3.5.5 Formal Project Closure.

A carefully structured project closure phase should ensure that the project is brought to a controlled end. The project manager should prepare the end project report, which details the main findings and outcome of the project and represents a formal review of the projects degree of success. The project manager should organize the project closure meeting and draw up a list of who should attend. This meeting is concerned with reviewing the project and ensuring the completeness of all of the major project deliverables. It is the final formal control point - apart from the post implementation review; and should be attended by the project owner and the overall project manager. The basic question facing the attendees is: 'Did the project deliver its intended end-product within the time and budgetary limits set?'

### 3.5.6 End Project Report.

The project manager should present the end project report to the project owner at the project closure meeting. The project owner will need to study this report in detail and should ensure that the project has successfully delivered its objectives, as detailed in the project initiation document, before they formally close the project. The project owner should schedule a future review of the overall outcome of the project. This post implementation review is an analysis of the operational effectiveness of the projects end-product some time, typically six months, after it has been delivered. This process enables valuable lessons to be learned and applied to future project based work.

### 3.6 Detailed Plans/Work Structure Breakdown

In the PID there is a work structure breakdown and a resource list. Depending on the complexity of the stages more detailed plans can be made describing each step. The principles are just the same as those used in the PID. The level of detail depends on several factors such as the complexity of the work, the size of the engagement and the experience of the staff involved.

After getting an overview of the activities and tasks involved, two of the most important and difficult assignments of the project manager are to:
- Quantify the resources needed;
- Estimate time & costs.

There is software available on the market which enable a project manager to do this in a very structured way.

Basically there are two "charts" which are the basis for estimates:
- ♦ Gantt Chart; a representation of all tasks and their time relationships;
- ♦ PERT (Program Evaluation and Review Technique) Chart; a representation of beginning, end, duration and resources needed to accomplish tasks. A PERT Chart shows the relationship between the tasks whereas the Gantt Chart shows the time constrains. In the following example data has been used from "The Project Management Handbook" of the British Columbia Ministry of Forest (date unknown) on a project in which there is a need for reports and maps showing the "waste" potential (the acceptable amount of waste) in a certain area. The list of activities/recourses is used as input for MS-Project, a planning tool. The following diagrams (figure 18 & 19) show :
- ♦ Basic Input;[1]           ♦ List of relationships.

| ID | Task Name | Duration | May 19 96 | | | | | | | May 26 96 | | | | | | | Ju | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | S | M | T | W | T | F | S | S | M | T | W | T | F | S | S | M | T |
| 1 | Download files | 3h | | | GO | | | | | | | | | | | | | | |
| 2 | Contact Pedologist | 2h | | | GO | | | | | | | | | | | | | | |
| | Get terrain maps | 4h | | | PM | | | | | | | | | | | | | | |
| 4 | Get programming Information | 4h | | | PM | | | | | | | | | | | | | | |
| 5 | Define Terrain database | 6h | | | RP, PP | | | | | | | | | | | | | | |
| 6 | Design terrain attribute list | 1h | | | RP, PP | | | | | | | | | | | | | | |
| 7 | Assign GIS levels | 4h | | | RP , PP | | | | | | | | | | | | | | |
| 8 | Translate forrest data | 4h | | | GO | | | | | | | | | | | | | | |
| 9 | Digitize terrain maps | 10d | | | | | | | | | | | | | | | | | | G |
| 10 | Enter terrain attributes | 2d | | | | GO | | | | | | | | | | | | | | |
| 11 | Produce update maps | 2d | | | | GO | | | | | | | | | | | | | | |
| 12 | Digitize update map | 2d | | | | GO | | | | | | | | | | | | | | |
| 13 | Mass-wasting program | 2d | | | | GO | | | | | | | | | | | | | | |

**GO= GIS Operator, RP = Regional Pedologist, PP= Project Programmer, PM= Projectmanager..**

## Figure 18: Basic Input

1) INPUT ,(1994), Managing Risks in System Development Contracts, INPUT – an independent market intelligence organization.

| ID | Task Name | Duration | May 19 96 | | | | | | | May 26 96 | | | | | | | | | Ju |
|----|-----------|----------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|----|
| | | | S | M | T | W | T | F | S | S | M | T | W | T | F | S | S | M | T |
| 1 | Download files | 8h | | | | | GO | | | | | | | | | | | | |
| 2 | Contact Pedologist | 8h | | | | | GO | | | | | | | | | | | | |
| 3 | Get terrain maps | 8h | | | | | PM | | | | | | | | | | | | |
| 4 | Get programming Information | 8h | | | | | PM | | | | | | | | | | | | |
| 5 | Define Terrain database | 8h | | | | | | RP,PP | | | | | | | | | | | |
| 6 | Design terrain attribute list | 8h | | | | | | | | RP,PP | | | | | | | | | |
| 7 | Assign GIS levels | 16h | | | | | | | | | RP,PP | | | | | | | | |
| 8 | Translate forrest data | 16h | | | | | | | | | | | | | | | | | |
| 9 | Digitize terrain maps | 11d | | | | | | | | | | | | | | | | | |
| 10 | Enter terrain attributes | 3d | | | | | | | | | | | | | | | | | |
| 11 | Produce update maps | 3d | | | | | | | | | | | | | | | | | |
| 12 | Digitize update map | 3d | | | | | | | | | | | | | | | | | |
| 13 | Mass-wasting program | 3d | | | | | | | | | | | | | | | | | |

( INPUT ,(1994), Managing Risks in System Development Contracts)

**Figure 19 : List of Relationships**

Unfortunately tools have no knowledge about the data. Even in this time of sophisticated IT systems the project manager has to provide information. This requires a lot off skill and experience. It is a major problem to estimate the time taken to complete tasks. Experience elsewhere often is of little value but everybody seems to be an expert. Though tempting to listen to such "experts" it is important to remember that the total in general looks more simple than the separate parts. This point is well made in

"The Mythical Man-Month" (Brooks, 1995)1 which compares the difference in effort to create a:

1. Program, ready to run by the author on the system on which it was developed;

2. Programming product, a program that can be run, is tested, repaired and can by extended by anybody and which can be used in many operating environments and is well documented;

---

1) Brooks Jr,F.P.(1995),The Mythical Man-Month,Essays on Software Engineering Anniversary Edition, Addison-Wesley Publishing Company Inc , Amsterdam

3. Programming system; a collection of interacting programs coordinated in function and duplicated in format;

4. Programming systems product, a programming systems which is truly useful object, tested, repaired, and documented and which can be used in many operating environments.

Most projects require programming systems products whereas most people think that they only require a program. As the following picture (Figure 20) shows a programming systems product requires at least 9x the effort building compared to a complex program.

<u>Evolution of the Programming Systems roduct</u>
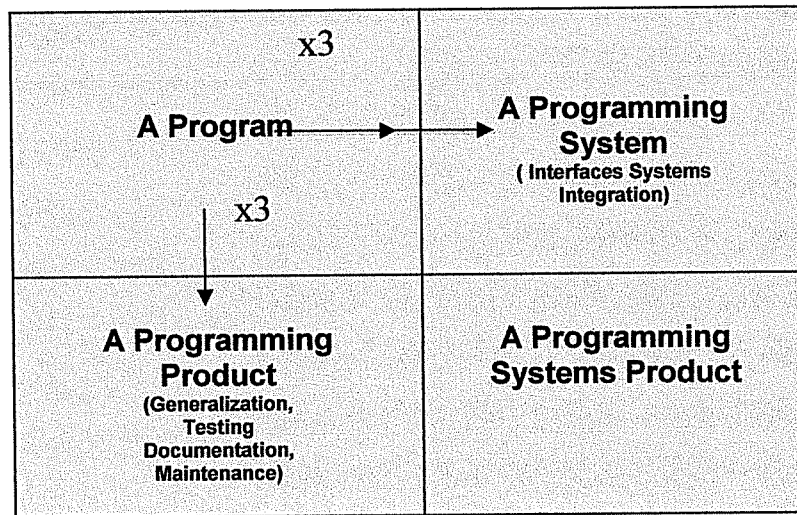


(Source: Brooks, 1994)

**Figure 20: Evolution of the programming systems product**

Brooks does not compare the effort involved in turning A Programming Product of A Programming System into A Programming Systems Product in the figure. However he writes that this will take 9 times the effort of writing a program.

An experienced project manager uses some "rules of the thumb" if they have to give an estimation on the duration of a task which he understands but has no actual experience with:

Take the time you believe it will cost, multiply this with factor 3 and in general this will reflect the actual time needed to do the task.

It is very important to discuss with the customer what his "documentation standards" are; what has to be documented and to what extent.

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Making documentation is a profession as well and many projects fail either financially or totally because the documentation didn't get enough attention. The size of this work should not be underestimated. Additionally if resources from the customer are needed it is important to agree this with the customer.

Also it might be necessary to give training to personal of the customer either to get them involved in the project or to give them the necessary background to work with the system.

It is important to clarify what the project will **not** attempt to do. As John Tuman jr. the president of Management Technology Groups Inc.put it being able to say: "No we don't intend to address this particular problem" is critical when clarifying roles and responsibilities. In the work structure breakdown every identified task should have a recourse and a cost estimate

### Table 6: Task , Resource and Costs

| TASK | RESOURCE | DURATION | COSTS |
|------|----------|----------|-------|
| Define Data Model | Senior Programmer | 100 hours | 120$/hours 12000 |
| Discuss with Modelers | GIS Specialist | 60 hours | 150$/hour 9000 |
| Build Data Model | Senior Programmer | 250 hours | 125$/hour 31000 |
| Coordination | Project Manager | 40 hours | 200$/hour 8000 |

The required skill set of the resource needed has to be defined so there can be no misunderstanding about this. For instance a senior GIS programmer is somebody with at least 5 years experience with Arc/Info and not somebody of 60 years or older. Similar specifications are needed for needed recourses from within the organization.

After defining the input to the analysis the next step is to specify the interdependencies of the tasks. Like building a house; it is unrealistic to place the roof before the walls are ready.

However it is possible to make the necessary preparations, or even start building in case of a prefab-roof, during the creation of the walls.

The next example shows what good planning can do:

## Table 6: Good Planning and Duration

| Activity | Duration | Total |
|---|---|---|
| Creating the walls | 12 weeks | week 1 – 12 |
| building & placing the roof | 4 weeks | week 12-16 |
| total time needed | 6 weeks | 1 **16 weeks** |

| Activity | Duration | Total |
|---|---|---|
| Creating the walls | 12 weeks | Week 1-12 |
| roof preparation | 2 weeks | Week 10-12 |
| roof placement | 2 weeks | Week 12-14 |
| total time needed | 16 weeks | **14 weeks** |

By knowing the interdependencies of the tasks it is possible to make a planning in which certain activities go in parallel thus diminishing the total time needed for the completion of the project. The best way to do this is to work backwards from the point that the project is completed. It has to become clear what are the predecessors of certain tasks, what are their duration and earliest starting and latest acceptable starting dates. By means of this input it becomes clear what the total duration of the project is and how the critical path looks.
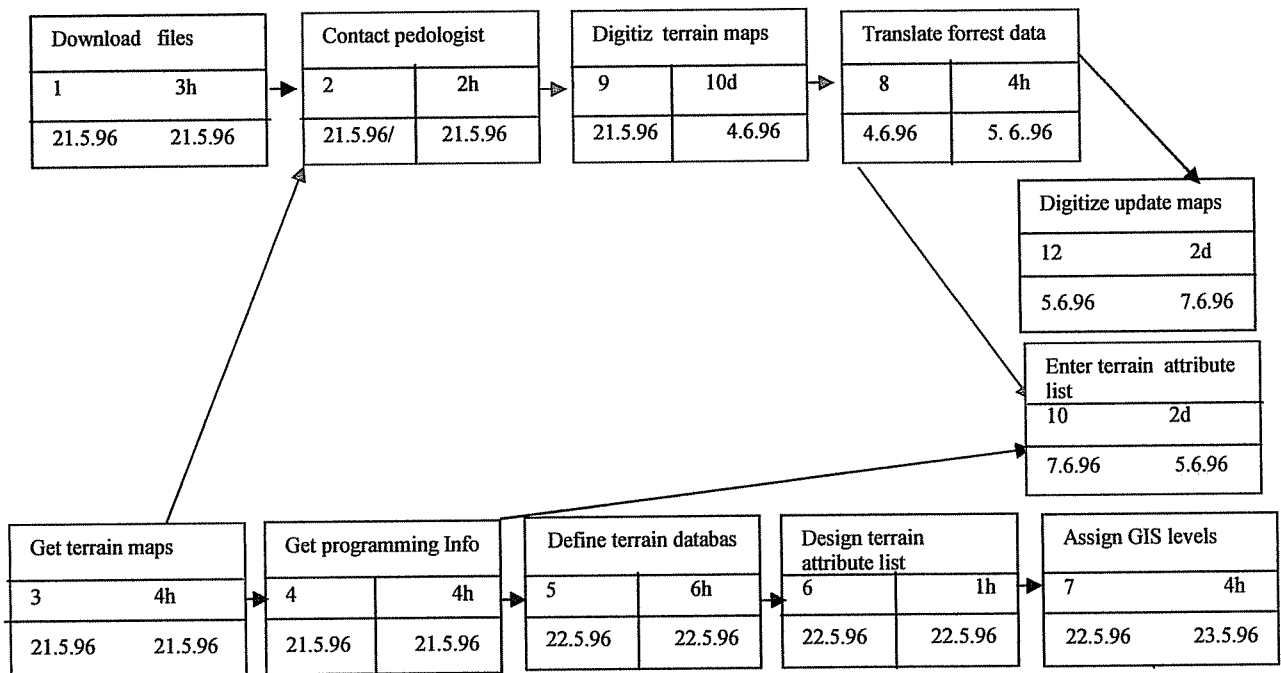


( INPUT ,(1994), Managing Risks in System Development Contracts)

**Figure 21: Critical Path**

As this PERT chart (figure 21) shows activity nr 2 can only start after
the completion of activity number 3. Activity 10 can start after
the completion of 8, 9, 2,3,and 4.
Imagine doing this on a sheet of paper specially if changes must be made
in the planning!
There is a tendency to believe that by adding resources it is possible to
shorten the needed time for a project. This sometimes is valid but it
depends greatly on the nature of the project. Getting a baby will take
something like 9 months but even when putting 9 women to work it will
not become 1 month! Or how about 9 dentist trying to pull 1 tooth
The next graphs (figure 22,23,24) show the effect of increasing resources,
the effect depends on the kind of task:
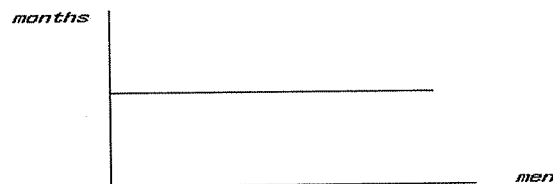
months

men

Figure 22: Perfectly Partitional Task

months

men

Figure 23: Unpartitional Task

months

men
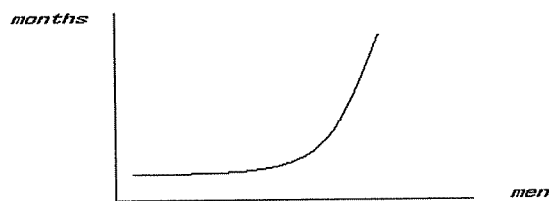
Figure 24: Task with Complex
             Interreelationships

1) Brooks Jr,F.P.(1995),The Mythical Man-Month,Essays on Software Engineering Anniversary
Edition, Addison-Wesley Publishing Company Inc , Amsterdam

As the graphs (Brooks, 1995)1 show, increasing resources do not always mean that the total time needed will be shorter.
In certain cases the duration of a project will increase when the number of people working on it grows (and so will the costs).
On the basis of the work structure breakdown and it's related costs, recourses and time constrains a discussion with the project board or sponsor can be held about the project and it's milestones . By doing this the customer stays involved in the project.
Whenever a discussion starts about the duration, costs etc. remember there is a firm relationship between quality, costs/budget and time
Finding the right combination of technical performance, financial performance and working within a given time schedule to provide the necessary quality easy.
The customer has to be made aware of "quick and dirty" principles if he starts pushing to the limits. Also keep this picture in mind if requests for changes are made. Make sure they are de-scoped from the original project

## 3.7 Monitoring

### 3.7.1 General

After spending 90% of the available time and 80% of the available money only 15% of the work is done. Though this seems ridiculous these things happen all the time.
Without a mechanism for adequate monitoring and reporting it is very difficult to keep track of a project.
Most GIS projects are costly, complex and last over a long period of time. Furthermore there is relatively little experience in the field of GIS projects as it is a new field compared to other IS projects such as financial applications. Without a well established plan to control the progress of a GIS project problems will occur. It is not enough to have only the normal project reporting of the project team members. It is also necessary to have formal meetings progress meetings to ensure that it is given enough and regularly attention.

### 3.7.2 Progress Meeting

The objective of the progress meeting is to measure the actual progress against the project plan and to address eventual problems. Progress meetings should be held at regular intervals (e.g. weekly) and both the project manager and stage managers should be present.

1) Brooks Jr,F.P.(1995),The Mythical Man-Month,Essays on Software Engineering Anniversary Edition, Addison-Wesley Publishing Company Inc , Amsterdam

During the meeting at least the following issues have to be covered
- ◆ Progress of each activity against the project plan;
- ◆ Review of the total engagement against schedule, costs, open issues, quality review status, known problems;
- ◆ Customer relationship

The end result of the meeting should be a progress report containing the results of the meeting, any alternative plans and (if necessary) a new schedule.

Furthermore a brief overview should be sent to the project board to inform them on the progress.

## 3.8 Risk Management

### 3.8.1 General

"Project Risk is the cumulative effect of the changes of uncertain occurrences adversely affecting objectives " (Project Management Institute, 1992).1

The goal of risk management is to identify project risks and develop strategies to reduce or to enable steps to avoid risks.

Risk management is a part of everyday life and it is something which is done on a every day basis. Think of driving a car through rush-hour traffic when you are late for an appointment, most people drive at a different speed and take more risks compared with the Sunday afternoon trip with the family to visit relatives. The benefits of the higher speed to reach the appointment in time are seen as making the extra risk acceptable.

INPUT, an independent market intelligence organization studied project success factors, by means of questionnaires and interviews, in Europe and the USA. Their study revealed 4 major factors why projects fail:
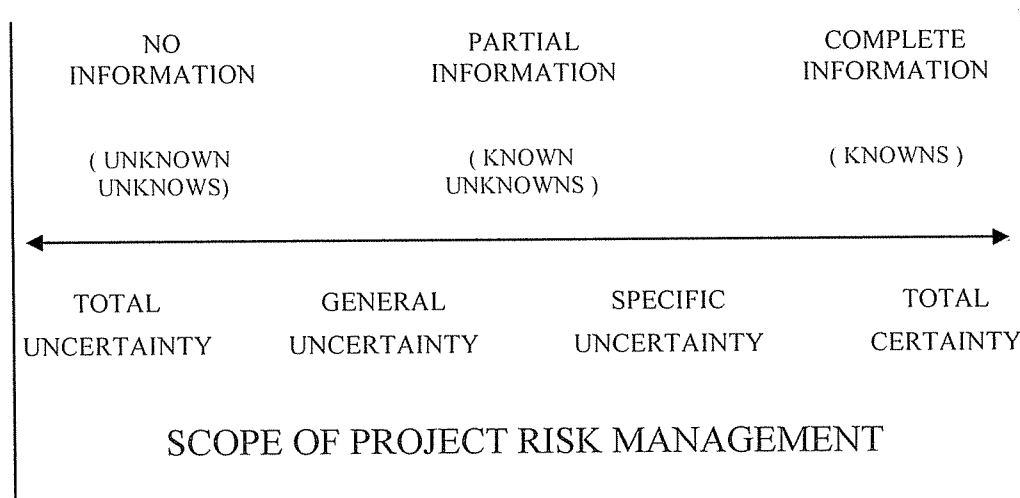
1. Initial requirements are inadequately defined;
2. Poor management by vendor;
3. Inadequate risk evaluation at the start of the project;
4. Lack of user involvement during the course of the project.

In chapter 1 of this thesis the principle of de-scoping and the principle of the known unknowns was mentioned. Risk management tries to quantify the risks associated with this.

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1) Project Management Instituta (1992), Project & Program Risk Management , Preliminary Edition, Upper Darby.

The Scope of Risk Management is shown in figure 25.

| NO INFORMATION | PARTIAL INFORMATION | COMPLETE INFORMATION |
|---|---|---|
| ( UNKNOWN UNKNOWS) | ( KNOWN UNKNOWNS ) | ( KNOWNS ) |

$\longleftrightarrow$

| TOTAL UNCERTAINTY | GENERAL UNCERTAINTY | SPECIFIC UNCERTAINTY | TOTAL CERTAINTY |
|---|---|---|---|

SCOPE OF PROJECT RISK MANAGEMENT

(Source: Project Management Institute, 1992)

**Figure 25: Scope of Risk Management**

Realize that risk management does not eliminate the risk but anticipates it and enables managers to take decisions beforehand; *risk management isn't crisis management.*
Risk can be handled in a proactive and a reactive manner.
Proactive means taking steps to avoid the risk; reactive means defining actions to take if the risks actually emerges.
Imagine building a system with the following objective:
'Keeping a fleet of trucks on the road and making sure vehicles arrive as quickly and a safely as possible at their destination'. A powerful combination of GIS and GPS can accomplish this task.
Though there is undoubtedly a lot of pressure involved in putting such a system in place the results of a malfunction could be enormous. For this reason there should be a proactive approach:
The software will be tested up front. This probably will be done by means of a live-test where the systems and the "old" planning mechanism will work simultaneously for some time looking for faults in the new software and thus diminishing the risks.
A reactive approach to this same problem would be an action plan which comes in place if there is a problem with the software. In this case probably both strategies will be necessary since testing is never 100% .

In fact the approach which is taken depends much more on the impact of the risk then on the chances it will actually occur; for a piece of software used to control a nuclear power plant it is not acceptable to test only 95% of the code, for a Internet Web browser one might wonder if even 60% of the code was tested.

### 3.8.2 The four phase approach
Basically there are 4 phases in Risk management:
1. Identification;
2. Assessment;
3. Response;
4. Documentation.

**Identification:**
How does a project manager know if there is a risk?
There are some general project risk situations which are good signals:
 ♦ The project sponsor/board does not recognize that every project is an exercise in risk;
 ♦ The project is very different from the last one;
 ♦ There is a feeling of uneasiness;
 ♦ The project scope, objectives and deliverables are not clearly defined or understood;
 ♦ There are a large number of possible alternatives;
 ♦ Some, or all technical data is lacking;
 ♦ Standards for performance are unrealistic or absent;
 ♦ Costs, schedules and performance are not expressed in ranges;
 ♦ The future timing of events is vague;
 ♦ Prototype of a key element is missing;
 ♦ High R&D component;
 ♦ Similar projects are delayed or have failed;
 ♦ Wide variations of bids were received;
 ♦ No appropriate contingency planning;
 ♦ Someone starts "heading for the best" without any plan.
(Source: Project Management Institute, 1992)[1]
In order to get a good idea of the project risks a brainstorm session is a good tool. In such a session a group of experts using the available information look at both the vulnerability and potential risks.

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1) Project Management Instituta (1992), Project & Program Risk Management , Preliminary Edition, Upper Darby.

For vulnerability risks the confidence level of the experts can be used. Vulnerability addresses questions such as; Is it possible to access an Oracle Database with Arc View and can we build the desired program? Depending on their experience experts should be able to tell about such risks.

For potential risks a "What if" analysis is the appropriate way to do an assessment.

The following probability and impact matrix can be used:

## Taple 7 :Probability &matrix Impact

| Probability | | | | |
|---|---|---|---|---|
| High | HL | HM | HH | |
| Medium | ML | MM | MH | |
| Low | LL | LM | LH | |
| | Low | Medium | High | Impact |

**HH**

| | |
|---|---|
| You can manage the cause | -> Pro-active plan |
| You can't manage the cause | -> Contingency plan |

**MM**

Mostly contingency plan

**LL**

Don't worry

**LH**

| Do the utmost if it occurs | ( e.g. World war III) |
|---|---|
| A preventive action plan will: | Reduce the potential of the risk. |
| A contingency plan will: | Reduce the impact of the risk. |

The problem is of course selecting the right approach. It is basically very simple , all project risks are characterized by the following three risk factors:

| 1 Risk event: | What might happen to the project; |
|---|---|
| 2 Risk probability | How likely is the event to occur; |
| 3 Amount at stake | The severity of the consequences. |

The formula is: Risk event = Risk Probability * Amount at Stake.

On the basis of the outcome of this formula a decision must be made whether a preventive action or a contingency plan is appropriate.

During the assessment more information on all the mentioned factors is gathered.

### 3.8.3 Assessment

Remember: *An unidentified risk is a threat, a defined risk is an opportunity.*

Risk is natural; there is **no** way to diminish all the risks but the consequences of the risks can be accessed. A simple assessment is shown in Figure 26:

## IMPACT ANALYSIS MATRIX SEQUENCE
### PROCESS
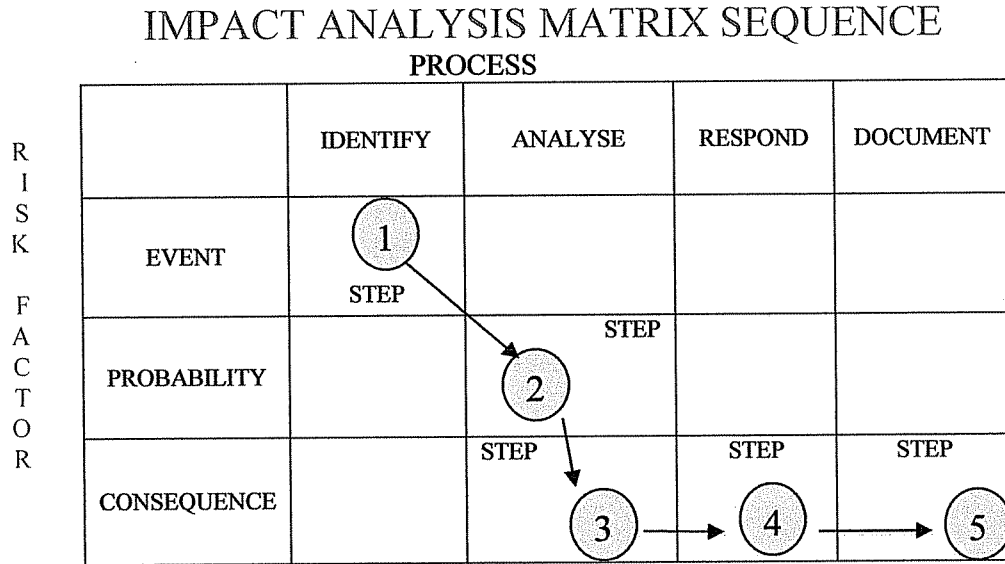


(Source: Project Management Institute, 1992)

**Figure 26: Impact Analysis**

**Step 1:** Select events to be examined by organizing a brainstorm session;
**Step 2:** Analyze the probability based on the methodology described before.

Imagine the situation were final planning may start after the scope is defined and there is a final approval: If there is a probability of 80% that the scope of the GIS project is defined by next month and the chance of final approval is 70% the chance that both events will occurs is: Pr(event1)*Pr(event2)=Pr(both events)

0.8 * 0.7= 0.56 = 56%

So the chance that the scope will be defined and the project will be approved is only 56%.

If only scope or approval is needed to start the project planning the picture looks quite different:

Pr(no scope) * Pr(no approval) = Pr(no planning)

0.2 * 0.3 = 0.06 (6%)

Based on these kind of calculations (which in practice are often a bit more complex) it is possible to look at probability and associated costs.

**Step 4:** Defining a response.

Knowing the consequences of a risk makes it possible to develop a suitable response. Such a response could be e.g.: gather more info, find additional funds, find assurance company to assure certain risks.

**Step 5:** Conclusions & recommendations.

In the last step conclusions and recommendations are made to clarify the risks involved.

This results should be taken into the project planning and communicated with the project board. Based on the outcome of this communication the decision to run or even stop the project can be made.

## 3.9 Change requests, expectations and deviations

### 3.9.1 General

That change is the only certainty in this uncertain world is a popular statement. Though this
is undoubtedly true it is not acceptable for a project or for the project manager.

After the PID is made and agreed upon all changes have to happen in a controlled environment. Not so long ago organizations in charge of project management refused to accept request for change from their principals or they charged ridiculous prices to implement changes. For GIS projects the situation is very different.

Remember most GIS projects, until a few years ago, could be found in the 'experimental' square of the McFarlan Model. Changes were not a big issue since everybody recognized that this was necessary.

As GIS projects move into the strategical or mission critical square it becomes very important to control the requested changes by the customer. Even with techniques like "Rapid Application Design" at a certain moment in time everybody has to agree upon the functional and technical design and all changes have to be examined.

### 3.9.2 Change Control

The customer, for whom the GIS system is made, is of course in control of the change.

After all his organization has to work with the system and get the necessary results out of it.

Asking for changes is very tempting:

1. Could you add this functionality as well?
2. I'd like to have a push button over here;
3. Could you present this data as well?
4. etc.

Many of the requests at first glance seem to be easy to realize. For reasons of customer satisfaction, often without further analysis, the changes are made.

This is very dangerous, looking at the examples above the following questions are relevant:

1 How will this affect the other parts of the application?
2 Maintenance could become more complex;
3 Performance of the system might diminish;
4 etc.

If change occurs the following questions have to be addressed:

- ◆ What is the impact of the change (time/costs)?
- ◆ What are the risks involved with this change for the entire project?
- ◆ Is this an essential change?
- ◆ What additions are necessary and who is responsible for the result?

Every change should be properly documented on a change request form (see addendum) and be signed off for approval by the project board.


### 3.10 Exceptions

Even it the planning is suburb, everybody agrees, and the project looks like a dream-case exceptions will happen. Nobody can foresee the unforeseen but if the unexpected happens action has to be taken to resolve the problem.

Basically the steps are simple:

1 Identify the problem;
2 Describe the reasons how the problem started;
3 Access the impact on the project (time/costs/quality/etc.);
4 Make a recommendation how to solve the problem;
5 Access the impact of the recommendation on the project;
6 Describe any other options (if appropriate);

7 Access the impact of the other options on the project;
8 Inform and involve the project board;
9 Gain approval for the solution proposed;
10 Incorporate solution in the project plan.
Exceptions should be very well documented.
In a GIS project the digitizing will be done by the digitizing department of the organization.
It will take 3 persons four months.
Another project however slipped dramatically and due to the penalty clauses in this project it is necessary to put all resources on this project.

**Problem:**
Due to unavailability of Digitizing Department digitizing will start in July instead of March.
**Reason:**
Other priorities set by company management.
**Impact:**
6 months delay in the project as other resources have to be rescheduled as well.
Financial impact is an additional costs of..............
**Recommendation.:**
Have an external company do the digitizing.
**Impact:**
Project costs will increase with.............
**Option:**
Hire free lance digitizing staff.
**Impact:**
Difficult to find and often of low quality
**Recommendation:**
Not a good alternative.

## 3.11 Threats in a project

In the article "Software Engineering in GIS Development" Williams and Bury make the following two statements:

◆ Modern GIS systems are as complex as the problems they're intended to solve;

◆ The implementation of a GIS system should be engineered just like any large software system.

GIS, MIS or any other large project within a company or within government is a risky endeavor and unless carefully planned doomed to fail in one way or another.

A few of the risks involved in projects are:

◆ Unclear Business Objectives, the objective of a project should be clear otherwise the expectation level isn't in line with reality;

◆ Unclear Requirements, if it is not clear what a system is expected to do the results will be poor. A system for financial planning for one person might mean a multimillion dollar SAP system and for others a Lotus spreadsheet;

◆ Unrealistic Objectives, often companies expect projects to solve problems which actually require organizational or process changes;

◆ Poor Planning, large projects tend to be very complex both from an organizational and from a financial point of view. A planning methodology and lots of experience are required to get good and realistic planning in place;

◆ Unclear Deliverables, Depending on the point of view the deliverables might be looked upon in different ways causing wrong expectations.

◆ Lack of ownership, unless there is involvement of all parts of the organization involved they won't feel any responsibility towards the project or might even feel threatened by the project;

◆ Ineffective Tracking, a formal tracking method is needed to avoid situations where 95% of the time and money is spent and only 15% of the project is done;

◆ Creeping Elegance, though tempting it is very dangerous to change the functional specifications during the process to improve the end result.

This phenomena called creeping elegance might complicate the entire project and give major future support problems.

As GIS matures the expectations of customers change and they will expect the same from a GIS project manager as from any other project manager.

There are two way to tackle this challenge:

- ♦ On intuition;
- ♦ With a structured method / methodology.

Companies quickly find out that intuition alone isn't enough so there is a preference to handle projects through a methodology.

However always remember that a methodology can never be an excuse not to think! As De Marco and Lister (1987)1 say: "Methodologies encourage people to start thinking in a paranoid defensive way. The last project which had 1 ton of documentation was a mess so this project has to produce 2 ton's of documentation. Voluminous documentation is often part of the problem and not the solution".

The answers lies in a combination of methodology, responsibility and motivation.

Basically there are only 2 questions for a project manager:

- ♦ What do I have to build?
- ♦ How do I build it?

A project manager who has a clear view and can answer these questions will succeed.

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1) DeMarco.T. & Lister.T.(1987), Peopleware:Prpduktieve Projecten Teams, Educare B.V. Drachten

## 3.12 Project Closure

### 3.12.1 General
It is difficult to come to a formal end of a GIS project. There are several reason for this including:
- ◆ No acceptance criteria defined at the beginning of the project;
- ◆ Arguments about the objectives, scope and deliverables between project manager and organization;
- ◆ Extra functionality (changes) introduced during the project with no proper risk/cost/time assessment;
- ◆ No formal procedure for project-ending was agreed upon.

If possible every project plan should have deliverables and milestones. The project manager and the project board agree upon milestones and deliverables. If necessary the project manager negotiates with the project board which actions are necessary before a deliverable is accepted. Quality management will be very helpful to ensure that criteria are met. At the end of the project the entire solution has to be delivered and accepted formally.

### 3.12.2 Acceptance testing
If the acceptance test is not agreed upon at the beginning of the project a project manager can be in trouble. For this reason a test plan has to be established and agreed upon at the beginning of the project.
Such a plan should at least contain:
- { What aspects of the solution will be measured;
- { What are the conditions of the test;
- { When will the solution be accepted, denied or partly denied;
- { Who will sign for agreement;
- { What will be the procedure if the parties don't agree;

As user expectations change during the project the acceptance plan is a good development guide line. A successful acceptance test should be signed off.

### 3.12.3 Project Closure Meeting

Though a successful acceptance test often is sufficient to end the project a formal project closure meeting should be conducted.

During such a meeting the following actions have to be conducted:
- Confirm completion of all deliverables;
- Close all open issues;
- Make sure that the solution can move into a support mode;
- Sign a formal acceptance letter with the principal.

During this meeting the project manager, stage managers and the project board and executive steering committee have to be present.


### 3.13 Quality Review

it is important to take care about quality assurance throughout the project. In " Assessment and Control of Software Risks" Jones (1994)[1] says: " Costly and late projects invest most of the extra work and time in finding and repairing errors in specifications, in design, in implementation". The data he uses shows a strong correlation between lack of systematic quality control and schedule disasters.

For this reason a quality plan must contain at least the following:
- Quality assurance procedures and measures;
- Major deliverables to be tested and reviewed;
- Time plan;
- Review team members must be in place.

The quality criteria or measures should be documented in the technical specifications of the product. Sometimes the client has specified quality matters such as MTBF (Mean Time Between Failure) of MTBR (Mean Time Between Repair) figures as a quality measure.

The quality review team should look at the product they are reviewing and not the errors they find based upon:

1. Their understanding of what the product should be;
2. Quality criteria as stated in the product plan.

The review has to be a formal process done in a methodological way resulting in a list containing the errors the team found and agreed upon so they can be corrected in a later stage.

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1) Jones ,C. (1994) Assessment Market & Control of Software Risk, Prentice Hall, Engelwood Cliffs.

The end result of the review can be 3-fold:
- ◆ Completed; the deliverable will be formally accepted;
- ◆ Follow-up required; a time-limit and the actions to be taken must be agreed upon;
- ◆ Rescheduled, a new quality review will be done for this deliverable as it did not meet specifications and needs major rework

In the addendum there is an example quality review form which can be used in projects.

Quality reviews are no threat to a project manager. Junior project managers tend to postpone quality reviews until the end of the project and find out, often very late or even too late, what went wrong. It is worthwhile, if possible, to do a quality review as early as possible for instance over the specification or the design.

The idea behind this is that it proves to be cheaper to repair failures in a early stage of the project.(Figure 25)

ERROR CORRECTION COSTS
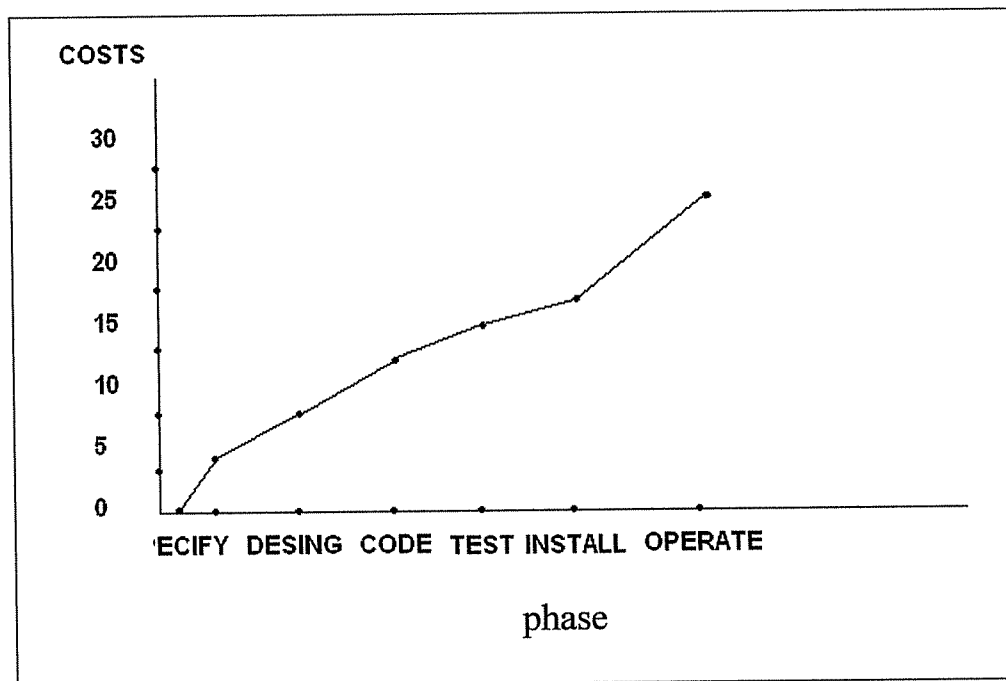


( Source: B.Boehm, "Software Engineering economics, 1981)

**Figure 25: Error Correction Costs**

This picture shows that a failure which is noticed in the operating phase is 5 times more expensive to repair compared to a failure noticed in the specification phase. Quality reviews are a way to ensure that mistakes are noticed as soon as possible thus diminishing costs.

## 3.14 Training

The importance of training people is often underestimated. Training and education should be in line with the activities in the project plan. Though it seems to be very inexpensive to do, "training on the job", which in reality often means working via a trial and error approach, can never replace the benefits of formal training.Adequate training will enable those who receive the training to do their job more effectively.

Huxhold and Levinsohn (1995)[1] provide a sample education and training program which can be of help deciding what training is required:

### Table 8: Sample Education & Training Program

| Sample Education and Training Program | | | | |
|---|---|---|---|---|
| **Who** | **Topics** | **Purpose** | **Forum** | **When** |
| Senior management process | GIS orientation and Implementation | Benefits and implications of GIS implementation | Half-day seminar (GIS demonstration) | At start of GIS planning and implementation |
| Business Unit Managers | GIS orientation Implementation process<br><br>GIS fundamentals / application | Familiarization<br><br><br><br>Allocation of resources | In-house seminars GIS conference attendance In-house seminar | At start of GIS planning Prior to GIS implementation<br><br>During Implementation |
| Non technical end users training | GIS orientation<br><br><br>Applications limitations | Familiarization<br><br><br><br>Capabilities | GIS concepts course In-house seminar Vendor training during installation | At start of GIS planning<br><br><br>Prior to Needs Analysis |
| Operations staff | GIS orientation Task and technology specific training | Task of technology competence for GIS operation | GIS concept course Vendor training On-the-job training installation | Prior to Needs Analysis/ Functional Specs Technology |
| Systems staff | GIS orientation Analyses and design GIS development tools | GIS design techniques competence Software customization | GIS concepts course Vendor training Systems course | Prior to analysis and design tasks. Prior to system installation and testing |
| Project team | GIS orientation<br><br>GIS project design and management | GIS concepts<br><br>GIS management competence | GIS courses<br><br>Mentoring program facilitated by a GIS expert | Prior to project start Prior to GIS implementation |

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1)Huxhold,W.E.& Levinsohn,A.G.(1995),Managing GIS Projects,1st ed., Oxford University Press.Inc.,New York

## 3.15 Support

The final step in the project is to make sure that the solution will be supported and procedures are in place for changes. Also the appropriate contracts for hard-, software and application support have to be in place. The support plan must address the customers stated requirements.
Detailed approach plans for specific situations must be in place. Typical parts of a support plan could be:

- Warranty criteria;
- Maintenance plan;
- Hard/Software support plan;
- Reliability (Mean time between failure/Mean time to repair);
- Contingency plans;
- Software changes/improvement plan.

In the support plan also the costs of labor by contractors on the developed product for maintenance or change requests can be included. The content of the support plan, as stated, depends on the customer requirements.
If the system has to be functional for 100% during weekdays between 0.800 - 17.00 hours it might be necessary to have a fall-back system.
In the support plan the necessary actions, such as be the purchase of a fall-back system should, be mentioned.


## 3.16 Summary

In this chapter a practical approach to handle GIS projects is introduced. When the position of GIS on the life cycle is determend and
a methodology is chosen the question "in what way has the project to be conducted" remains. By putting a lot of emphasis on the project initiation, the involvement of the appropriate levels of the principals senior management, by clearly defining the milestones and deliverables and by doing risk management it is possible to create a controlled GIS project environment.
A GIS project conducted in this way has a good change of being:

- On time;
- Within budget;
- On specification;
- Useful to the customer.

Yet two important questions remain:
1. Are GIS projects different from other IT projects?;
2. Will the proposed approach actually work?
In the next two chapters these questions will be discussed.

# 4 THE SPATIAL COMPONENT
## ARE GIS PROJECTS DIFFERENT?

## 4.1. Introduction

This thesis explores the best ways to handle a GIS project. It is important to understand if GIS projects differ from other IT projects in order to determine the best way to handle a GIS project. In this chapter, through literature study and from own experience of the author a comparison between GIS projects and other complex IT projects is made.

GIS projects are considered "special" because of several reasons such as:
{ GIS is a new technology;
{ The term GIS can mean a lot of different things, it is not well defined;
{ GIS is considered to be difficult.

Based on the above assumptions the questions "Are GIS projects different?" is approached and answered.

## 4.2. The main components of GIS

Geographic Information Systems have three major components: computer hardware, sets of software, and the human resources and organization that make the system work.

## 4.2.1. GIS computer hardware

The hardware components of a GIS include units that are common to any computerized data base management system - a general purpose computer, several disk drive units for storing data and programs, tape drives for back up copies of data, colour graphic display units, and other general purpose computer peripherals. The GIS has, in addition, several specialized hardware components, including: a digitizer or scanner, which is used to convert the geographical information from maps into digital form and send it to the computer; a plotter, which prints out the maps and other graphic outputs of the system; and a visual colour graphics workstation on which spatial data editing and display can be performed by the user.

## 4.2.2. GIS software

The main GIS software components are designed to perform the following functions, where data implies both cartographic and/or attribute data:

- data input: digitizing or scanning the lines on the maps and entering the attribute information from a keyboard
- data base management
- data analysis and processing
- interaction with the user (map editing)
-
- data output and presentation (plotting)

***Data input*** involves the conversion of data from maps, field observations, processed satellite images and aerial photographs into compatible digital form.

Many GISs today utilize a manual digitizing approach to input maps. This means that someone must sit down with the map at a large, flat, digitizing table, and using a small cursor pad, follow the thousands of lines that make up the map, carefully keeping the cursor (cross hairs) on the lines, ensuring that lines are not double digitized or left out, and that intersections are accurately closed and no gaps are left in lines.However, large cartographic data inputs are generally made using automated digitizing systems such as scanners. These eliminate the manual work of following the lines and ensure consistent, repeatable results each time a map is scanned. Although scanning is quicker than digitizing, only good quality maps can be scanned, and even then the quality of the products is generally not as high. However, as in most areas of computerization, the technology is continually being improved. Furthermore, once a map has been digitized, it can be reproduced and transformed at will (much as a written document can be quickly edited or corrected once it has been entered into a word processor).The quality of input data will affect the quality of GIS products regardless of the sophistication of its hardware and software. In many cases, inventories of natural resources are often not completed or up to date and information in maps may have to be revised before digitizing.

***Data base management*** operations mainly consist of the following functions: structure, query, analysis and reporting of the attribute data linked to the features on the maps.

*Data processing* covers two types of operation: firstly, preparing data by removing errors or updating, and secondly, analyzing data to provide answers to the questions the user puts to the GIS. Processing can operate on the spatial and non-spatial aspects of the data, or on both. Typical operations include overlaying different thematic maps, computing areas and distances, acquiring statistical information about the attributes, changing the legend, scale and projection of maps, and making three-dimensional perspective view plots using elevation data, as shown in the figure at right.

*Data output and presentation* deals with the way the information is displayed to the user. This can either be as a visual display (soft copy) or hard copy drawn by a plotter, or as magnetically recorded or printed information in digital form. The plotter is to the GIS what a printer is to the standard word processor: it produces a copy of map on paper.

### 4.2.3. Human resources and organization
When describing a GIS one tends to think in terms of hardware and software as the entire system, which overlooks perhaps the most important component: the people needed to make the whole system function effectively. It may seem that GIS is the resource planner's crystal ball, but - as with any computer system - the information produced is only as good as the information that is put in. Incorrect or inadequate information fed into the GIS will produce incorrect or inadequate answers, no matter how refined or "user-friendly" the computer technology may be. As in any map-making operation, data collection and data input operations require high standards of design and work, intensive training and frequent monitoring for quality control. In other words, in addition to having the right hardware and software to do the job, effective utilization of a GIS requires adequate staff training as well as planning, organization and supervision in order to maintain the quality of the data and the integrity of the final product. Another essential element of successful GIS operation is the need for data input and processing to be a joint effort involving the computer specialist and the subject matter specialist (e.g. crop production, forest management, aquaculture). This ensures that the necessary specialized subject matter expertise is applied in the interpretation and evaluation of data. Specialists in remote sensing and cartography may also be involved.

In many developing countries, resource information collection and processing systems are still relatively undeveloped. This means that application of GIS at the country and subcountry level will, in many cases, need to be accompanied by the improvement of existing information collection systems and the introduction of new ones. This provides an opportunity for international assistance, and imposes on FAO and other technical assistance agencies an added reason to develop their own capabilities in GIS and related technologies in order to provide technical expertise at the national level

## 4.3. The GIS

*"Geographic Information" is information which can be related to specific locations on the Earth. It covers an enormous range including the distribution of natural resources, the influence of pollution's, description of infrastructures such as buildings, utility and transport services, patterns of land-use and the health, wealth, employment, housing and voting habits of people.*
*Most human activity depends on geographic information: on knowing where things are and understanding how they relate to each other.*
( Handling Geographic Information, Report of the Committee of Inquiry chaired by Lord Chorley, Departement of the Environment, 1987)[1].
Many Information Systems in use by companies and organizations deal with information which has a spatial component. Any database containing addresses or location codes has some of these characteristics yet we don't call such a system a Geographic Information System.

◆ Until only a few years ago systems capable of doing GIS tasks like spatial analysys were not available or extraordinary expensive. The recent price decreases of computer systems and the tremendous performance improvements have changed this situation dramatically in the last decade and made GIS affordable. Applications which were considered to require mainframe capacity nowadays run smoothly on a Pentium PC.
Suddenly it is possible for any organization to have an information system with a spatial component; a GIS.

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1)Department of the Environment.(1987),Handling Geographic Information . Report of the Committee of Lnquiry Chaired by Lrod Chorley ,H.M.S.O. London

## 4.4. The IS in GIS

Information Systems can have different roles in an organization, they can
be:

♦ Operational Support of processes; getting the data needed in the
process. Or to put it in a more simple way; automating the day to day
processes like a database of clients or in case of a GIS the catalog of a
collection of maps;

♦ Documentation of records, documenting the available records of an
organization;

♦ External information; providing information about activities and
records of an organization for marketing or sales purposes;

♦ MIS ; Management Information Systems; supporting management in
providing information.

Most IS  systems can be put in one of these 4 categories.
The position of an IS system in the organization depends on the category
in which it is placed and can be either:

♦ Central; for the entire organization or a large part of the organization
e.g. a customer DBMS;

♦ Departmental; only used in a specific department e.g. a marketing
DBMS;

♦ Specialist Group; only used for a very specific purpose e.g. a CAD
system;

♦ IT infrastructure; the basic infrastructure of the entire IT operation
e.g. a network management system;

♦ Outsourced; considered to be a non-core operation of the
organization and placed in external hands e.g. a salary payment system.
When looking at GIS on basis of these categories it is not so difficult to
understand why GIS is considered to be different from "normal" IS
systems.
Most IT managers haven't got the faintest idea what a GIS system is.
What they know is that it has to do with maps or drawings. For this
reason GIS and CAD are often placed in the same category: difficult and
only useful for the specialist but no part of the central IS environment.
This positioning of GIS is both an advantage and a disadvantage.

## Why an advantage?

*"Many of the first GIS projects were undertaken by departments without the involvement of a central IT/IS department. A lot of freewheeling was done by GIS enthusiasts who had knowledge and idea's about Spatial Information but not so much knowledge about IT and IS strategies and practices. Nor did they see GIS as a part of the Corporate Information Strategy "* (Grimshaw, 1991)1.

The projects they did however turned out to be successful and enabled organizations to do things, like complex spatial analysis, which were almost impossible in the past and often of strategic importance to the organizations.

## Why a disadvantage?

"More than with other sectors of automation in GIS there is a tendency to abandon the IT profession, somebody who has had a small course in programming should be able to build a system". (Corsten, 1996, Manager of Urbidata interviewed by Mom of VI Matrix magazine).

GIS implementations that are ad hoc developments primarily designed to improve the operations of the organization are potentially under utilizing the benefits of GIS. Managers need to see GIS among a range of management support tools, in a way that other information systems might be viewed (Grimshaw, 1991).

After the successes in the 1980's the expectation levels of an organization on GIS are increasing.

they show that GIS is moving from being experimental to being strategic or even mission-critical. In this process the demands put on a GIS project become higher and higher. IT specialists are needed (as well) to make such projects successful even though they might have been a burden in the past.

Without the involvement of IT and IS specialist it is not possible to integrate GIS with the other IS systems in the organization as for this the cooperation of the IS and IT department is needed

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1) Grimshaw,D.J.,(1991),GIS a strategic business tool, GIS Europe Magazine.

## 4.5. What is so special about GIS?

There are several descriptions of GIS.:

♦ "A GIS is a powerful set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real word. (Burrough, 1986)".

♦ "A System for capturing, checking, manipulating, analyzing and displaying data which are spatially referenced to the Earth (Departement of the Environment,1987)2."

♦ " A Geographic Information System is a decision support system that integrates spatially referenced data in a problem-solving environment (i.e. application). (Grupp, 1990)3."

♦ " The total of actions and tools that will lead in doing task and taking decisions in relation to spatial questions to the supply of relevant information.

## 4.6. Are GIS projects different?

GIS projects are new in the sense that there is only limited experience with them. The field of GIS is very broad and the possibilities seem to be nearly limitless. It is not yet so clear however what is feasible to do with a GIS and what is not.

GIS projects are generally complex and often very expensive. There is a tendency among professionals (both GIS and non GIS) to focus strongly on the visual (graphical) aspects of these systems. For the GIS specialist this is fairly logical as this what he understands best.

The non GIS-IT professional compares GIS with CAD as he also only understands the graphical parts of the system.

GIS projects have kept out of the mainstream of IS projects until now since they are considered to be "different and complex" but this is the fate of every new technology.

Due to the very rapid technology development and the increasing interest in GIS suddenly there are difficult multi departmental or even multi organization GIS projects which have become feasible but there is little or no experience in how to handle such projects.

As a matter fact there isn't that much experience with other non-GIS projects with comparable magnitude and complexity as well.

A conclusion is that GIS projects are not all that different from other projects without a spatial component.

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1) Burrough, P.A(1986), Principles of geographical information systems for land resource assessement, Claredon Press, Oxford.

2) Department of the Environment,(1987), Handling Geographic Information, Report of the Committee of Inquiry Chaired by Lord Chorley, H.M.S.O. London.

3) Grupp, F.H.(1990), Geographic Information systems, an emerging component of decision support, Journal of Information Systems Management.

However there is yet little project management experience in doing GIS projects which are strategic and developments enabling new solutions are advancing rapidly. This problem is further compounded by the tendency of GIS and non-GIS specialist to trade GIS as something "special" which prevents an exchange of general project management experiences and knowledge. GIS projects are different in the sense that spatial data enables specialized types of analysis which can be performed with them. Forthinham (1996)1 says:

*"The defining characteristic of spatial data - the thing that makes it special- is that it is tied to locations. This means that each piece of data has a unique set of relationships with all other pieces of data".*

## 4.7. Conclusion

GIS projects are complex IT projects. Their magnitude of complexity is so high that there is little project management experience available. In this sense they are different but this is not because of the spatial component but because of the complexity level.

The spatial component, which gives a unique relationship of each piece of data to every other piece of data is not found in other IT environments. In this way GIS projects are different because of the things which can be accomplished by using a GIS due to this unique data linkage

1) Fortheringham,S.,(1991) the ties that bind, GIS Europe Magazine, Labute Limited, Cambridge

# 5. CONCLUSIONS

## 5.1. Introduction

The management of GIS projects is not an easy job. Although GIS is being considered as a strategic application or a future strategic application by many organizations it is perceived as being complex and inaccessible. Project-managers involved in strategic GIS projects have the difficult task to "establish a good working GIS that is integrated into the organization".

The objective of this study is to address the project issues of a strategic GIS project. This is done by addressing the overall problem statement which is "How to manage a GIS project effectively?".

## 5.2. The importance of Life Cycle and Methodologies

Two of the unknowns at the beginning of this thesis were; if life cycle principles had any influence on GIS projects and if the position in the life cycle had any influence on the methodology to be used.

A study called "GIS, noodzaak of luxe?" (Grothe et al, 1994) investigated where GIS is located in the Mc Farlan raster whereas "Management van complexe IT projecten" (Roelofs et al, 1996) places the Mc Farlan raster into the Nolan curve. The conclusion is that GIS projects are moving into the strategic quadrant of the Mc Farlan grid. At present most GIS projects for organizations are experimental. The major difference between experimental and strategic projects are the emphasis in strategic projects on being:

♦ On schedule;
♦ Within budget;
♦ Good Quality;
♦ Complete;
♦ Accepted by the customer.

In order to accomplish this, strategic projects need a much more structured approach compared to experimental projects. Methodologies are often used to handle such environments because they provide a general framework for entire projects.

There is not a lot of experience with strategic GIS projects and no specific GIS methodology is known.

## 5.3. Project management for GIS

The assumption is that the position on the life cycle of GIS within the organization is of influence on the way the GIS project should be handled. The question is how this affects GIS projects which are considered by the organization to be strategic.

By combining existing methodologies for IT projects, project management and best practices, a framework for strategic GIS projects was established. This framework was used to evaluate a existing GIS project.

Conclusions are that strategic GIS projects can be managed through a methodology based upon the same principals as other IT projects however GIS projects have some specifics which have to be taken into consideration.

Contrary to belief in some parts of the GIS society GIS projects are not special however they are very complex and GIS knowledge is necessary to understand the environment.

The proposed framework seems to work but there are still many unknowns specially where it concerns best practices in the specific field of strategic GIS projects.

## 5.4. Area for further research

An important aspect of GIS project management for strategic projects is the sharing of information. In general, all the information on a project is held in 3-ring project binders which are being distributed to the project members.

This results in documents becomming lost and out of sequence and there are often major problems concerning the latest revision of certain documents. New technologies like the Internet provide a possibility to address this problem of project documentation in a different way.

By placing all project information on the Internet and the use of pull (user has to take action) and push (user does not have to take action) techniques it is possible to ensure that every project member has the most recent information at all times. Furthermore by defining "user profiles" it might also be possible to distribute information on the progress of the project to those involved in the project in a very structured manner on a "needs to know" basis. Some preliminary work in this field by Hewlett-Packard on a concept called "The WebNoteBook" (1997) showed a cost reduction in software development projects of several millions!

For the first time in history technology enables different users (PC and Workstation) to use a common interface (Webbrowser) and the Internet to access information without the worries of compatibility of programs. The potential of a "webified" project file could be quite substantial and further research is needed.

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