A cost/benefit analysis for the use of GIS within Dutch water boards

The influence of introducing new technology
to support business processes

Nico Piquer

Zwolle

The Netherlands

Dissertation submitted in part fulfilment of

the requirements for the Degree of

Master of Science in Geographic Information Systems

May 1998

Abstract

Within Dutch water boards there is a growing suspicion towards costly developments in Information Technology. If this point of view becomes generally accepted, it will act as a brake on the introduction of new GIS-applications. In order to counterweight this, an investigation on costs and benefits of new GIS-applications in Dutch water boards is carried out.

Developments are generally determined by environmental circumstances. Information on the relevant influences within water boards, together with information on modern attitudes towards organisation development and IT/GIS, places these developments in the right perspective.

New applications within water boards also emerge because of ongoing technological developments. Without going too much in detail, background information on important developments is provided to be able to conceive how future applications might work.

Water boards employ a manifold of automated and manual systems on facilities information. An overview of all relevant systems, followed by worked-out descriptions of possible new GIS-applications, provides the basis for the research. As expected from the general characteristics of water board’s processes, emphasis is on communication and integration.

Since the decision on new application lies with the water boards, they are invited to give their opinion on benefits and priorities by means of questionnaires and interviews. This phase also provides more in-depth information on their feelings towards the possible new applications.

Since the objective is, to end up with costs and benefits of new applications, the information on priorities and benefits are completed with costs, to provide an overview of applications which the water boards consider to be feasible and necessary.

The intention is, to provide a more or less general overview by gathering information from different water boards. This approach automatically results in limitations because of the limited scope of the information collected. All limitations perceived are addressed, and if possible indications for improvement and future research are provided.

Main chapter headings

Table of Contents

List of Tables and Figures

Disclaimer

The contents of this dissertation and the conclusions herein are the results of my own research and considerations, whilst registered at the Department of Environmental and Geographical Sciences at Manchester Metropolitan University, England.

All assistance received from other individuals and organisations has been acknowledged and full reference is made to all published and unpublished sources used.

This dissertation has not been submitted previously for any degree at any institution.

Signed :

Ing. N. Piquer RI

Dated: may 19, 1998

Zwolle, The Netherlands

1. Introduction

To water boards the most obvious motive for using GIS is to provide solutions for the typical utility mapping problem. Mainly because of the availability of digital maps and the high costs of data conversion and hard-/software, application of GIS has been relatively slow. For some years though these issues have been solved: hard- and software have become cheaper, GIS-tools are better suited for managing the utility's problems and digital maps are available to a large extent now. Nothing seems to stand in the way of a bright "GIS-future".

At this moment almost every water board is engaged in a conversion process, trying to get their facilities data in GIS. Emphasis is on streamlining these -expensive- projects, which distracts the attention from what can be done with the new achievements. Little distraction is necessary though, because to most companies the "GIS-future" is like a black hole; it is supposed to bring all kind of benefits, but no one really knows how or what.

Because of this obscurity management has little faith in GIS-developments. In general, management is more and more questioning the value of money-consuming IT-projects. It still sees GIS as a technical tool, limited to automating the specialised work of the drawing office. The idea that it could be more is strange to them, possibly because no one provides them with the proper information.

A communication problem that has serious consequences, because in water boards as well as other utilities things are changing. Customers and external organisations become more demanding, legislation is getting stronger and catchment areas with clean water become scarce, thus increasing the costs. The unification of Europe can lead to new players in the market and, more likely, there is a constant threat of being overtaken by another water or energy company. To maintain profit for essential investment, for most water boards this results in a renewed interest in three key targets:

- cost reduction;
- quality improvement;
- outstanding customer service.

This implies that new information systems are considered on other merits than just being sophisticated solutions. They are compelled to comply with the revived company targets. New applications based on the conversion data therefore have to compete with other expenditures. If benefits can't be quantified in terms corresponding to the targets, project managers will inevitable become difficulties getting plans approved by their management.

The addressed communication problem will lead to projects being turn down, frustrated project staff who turn their back on GIS-projects and stagnating propagation of GIS. The cumbersome and expensive conversion process will have no follow-up to justify all efforts and expenses, and eventually management may even be proved right:

GIS ***is*** an expensive toy, meant for the drawing office.

1.1 Aims and objectives

If management finally reaches this stage, this may be fatal to new applications in GIS. Developments will experience a serious fallback when the conversion process is finished.

The aim of this Thesis therefore is:

> *to avoid this by proving that the above statement is wrong and that GIS can certainly have a meaningful contribution to the companies' key targets.*

To achieve this, the following questions have to be answered:

- *How can GIS contribute to the companies' targets?*
- *What is this contribution?*

The issue is deliberately separated into two questions. Knowledge in water boards concerning new GIS-applications is limited, so they will have little influence on this part of the thesis. Information will have to be brought in, so they can review the possible benefits. When it comes to specifying benefits they will be approached to provide this information.

A rough description of the objectives therefore may be:

- *to review possible new GIS-applications for water boards*
- *to investigate the benefits of these applications*

This has to be placed in the proper context which explains:

- *why GIS is treated the way it is?*
- *what environment applications will function in?*
- *what developments these new applications are based on?*

This results in the objectives of this thesis to be:

1. *to address organisational constraints by describing the environment*
2. *to investigate technical possibilities and constraints*
3. *to review possible new applications*
4. *to investigate the benefits of these applications*
5. *to combine the information in a way that enables water boards to prioritise developments based on costs and benefits*

Explanation of the objectives:

1. *to address organisational constraints by describing the environment*

The subject of this thesis emerged from developments in the organisations of water boards. Background information may explain why this situation developed like this, but may also provide information on how to handle in the future. New applications must function in this environment, so this will have to be taken into account.

2. to investigate technical possibilities and constraints

Technical developments make new kind of GIS-applications possible. This may be developments in the field of GIS or databases, but also likely this will apply to field work. Datacommunication and field GIS will have an enormous impact on how field work may be organised in the future. Though specifying technical developments is not a necessarily a separate step -it can also be included in the review of new applications- it is believed that treating it separately will result in added clarity when reviewing these applications.

3. to review possible new applications

Reviewing possible new applications is a necessary step to be able to address benefits of extending the use of GIS within water boards. This step has to be done because the companies themselves don't have the knowledge and insight to do so. The fact that they don't makes it inevitable that applications have to be described clearly and in detail. These descriptions form the basis for the quality of the next step, and in fact for the outcome of this thesis.

4. to investigate the benefits of these applications

Information on possible benefits will be gathered by approaching water boards with information based on the review of new applications. In fact this is the first time water boards come in. The complexity of the matter in combination with the limited knowledge will require interviews with employees responsible for GIS-developments. To save valuable time first a questionnaire will be developed, which answers will be evaluated and used to prepare the interviews.

5. *to combine the information in a way that enables water boards to prioritise developments based on costs and benefits*

Information on benefits must be combined with costs. This can be costs of applications, hardware, conversion or manpower. In the end it must be clear what an applications' costs and benefits are and what its development priority is.

1.2 Benefits analysis

Conducting a benefits analysis for GIS-projects is notoriously difficult, for many benefits are abstract of nature. Managers though must feel confident in the benefit estimates if the financial analysis is to have credibility. Lerner claimed a methodology for benefits estimation to consist of the following steps (Lerner, 1994a):

1. Establishing parameters for quantifying productivity gains;
2. Identify all GIS-applications;
3. Prepare an implementation schedule;
4. Identify relevant staff positions and weighed salaries;
5. Calculate the productivity benefits;
6. List other specific benefits for each application;
7. Aggregate the benefits in accordance with the implementation schedule.

The research will be based on this methodology, though not all steps can be handled in depth. Some concern specific company situations, and in this case more than 1 company is involved. This applies especially to steps 1, 3 and 7.

An implementation schedule may follow from the priorities, supplied by the companies. Priorities generally are based on ideas more than on sound proof on how to plan implementation. Prioritising though is crucial if one doesn’t want to end up with applications that don’t fit the organisation’s needs (Lerner, 1994b). This asks for prioritising criteria, that are generally derived from the company’s targets.

GIS-applications will follow from the descriptions; priorities and expected benefits will be an indication of the company’s prioritisation

In case of this research all benefits will be estimated by the interviewees. In this case the estimation comprises steps 1, 4 and 5.

Lerner states that other specific benefits should be investigated and documented also. These benefits generally are more difficult to specify, and especially when intangible benefits are involved it’s not clear how these can be quantified. Part of the cost/benefit analysis will be on investigating these. Since the level of detail is limited (especially on organisational aspects) because more companies are involved, these other benefits won’t be discussed in detail though.

1.3 Research approach

Knowledge in water boards concerning GIS and new applications is limited. Questionnaires therefore will be less suited, considered the nature of the problem area. Developing a questionnaire so detailed, clear and complete will fall outside the scope of this thesis.

The intention is though, to end up with a document which provides insight in new applications and their benefits and can be used in planning and decision making. In order to meet the objectives most of the knowledge has to be brought in by the writer, which may harm objectivity. No preparation though will lead to endless interviews, difficulties in standardising and comparing answers and -probably- less quality.

As a gold mean the following approach will be followed:

Information will be gathered by means of questionnaires, followed by interviews. Technical possibilities and applications will be described in detail, but only a summary of this information will be used in the questionnaire. The questionnaire will have a limited function in the process. It will give the representatives a chance to become familiar with the issues and think it over at their convenience. For the interviewer the outcome is a check on completeness, obscure questioning or questions overlapping. For both sides it will enable a better preparation on the interview to follow.

The interviews will be based on the same questions as the questionnaire. This time though indistinctness will hopefully be largely removed and there will be plenty of room to provide in-depth information on certain issues.

Without taking precautions though there will be many stages in the process where “scientific” research may be hard pressed. Results may become coloured and objectivity may be harmed. To ensure the result to be as objective as possible, all critical points have to be addressed, so proper actions can be taken.

First is to address these points and find out what can be done to ensure a high level objectivity. In the next paragraphs the following stages will be reviewed to address the different points of attention:

1. *Describing the environment*
2. *Investigating technical possibilities*
3. *Describing new applications*
4. *Selecting the water boards*
5. *Developing the questionnaire*
6. *Interpreting the outcome of the questionnaire*
7. *Interviewing the representatives*
8. *Interpreting the outcome of the interviews*
9. *Performing a quick scan*
10. *Combining research data with costs*

1 - Describing the environment

A detailed description of the environment is not especially needed in this thesis. For readers not familiar with the field though it will provide a background on what is going on in Dutch water boards. Some aspects mentioned under “technical possibilities” and “new applications” will be explained by this description. It will be especially helpful in explaining some of the answers from questionnaires and interviews.

2 - Investigating technical possibilities

Developments are going so fast that it’s virtually impossible to describe all possibilities in detail. The impression is that, broadly outlined, most of the technology for the next years is already there, at least the part that is relevant in this context. Changes merely lead to certain processes going faster or easier. On the other hand possibilities that are not yet feasible will be within reasonable time.

The description of technical solutions can be seen as background information. It is meant to provide an impression of the technical environment for new applications, so a limited description will suffice here.

3 - Describing new applications

On basis of technical possibilities, applications have to be thought out to introduce GIS in certain processes. Beneficial applications are manifold and vary per company, depending on how processes are organised. There may be lots of smaller applications that become feasible when other applications are developed. New applications won’t be confined to the drawing office, but will also cover other processes and departments.

To be able to compare answers and get a consistent average, applications must be described at a detailed level, but also clear enough to be understood by the interviewees.

They must understand its impact and be able to apply the information to their own environment.

New applications and their description will be based on knowledge of processes and the present information systems infrastructure within water boards. If during the process apparently applications are missing, this omission will be corrected by adding the application and integrating it in the evaluation.

4 - Selecting the water boards

The decision to work with questionnaires and interviews in fact determines the amount of companies involved. In order to spread the risk of basing results on assumptions or too little information, 4 water boards will be approached. Given the limitations of the thesis this is considered a good balance between time to be spent and the quality desired.

A choice had to be made which companies were to be selected, and the choice was made to select related companies. The employees to be interviewed all have a co-ordinating function in the field of GIS and are willing to spend time on providing the necessary information. All four are involved in a conversion process and have more or less knowledge of problem area. Choosing these companies has several advantages:

- the organisations are familiar, so gross errors or omissions will be detected
- there will be little hesitation in giving information on costs and benefits
- in the future the companies can profit from the information also, which ensures quality
- the existing relationship will probably make them put more effort in it than they would do in an external investigation

The companies are probably not representative for all Dutch water boards, because they use comparable applications and have the same external consultant. The question though is, if and based on what parameters a more representative solution can be found. Knowledge of the organisations and the existing relationship will ensure the quality of the outcome, and it is expected that this positive influence will be greater than another selection of water boards will be.

5 - Developing the questionnaire

One of the objectives of the thesis is, to find out information on priorities and costs/benefits of applications. As already discussed the questionnaire must be seen as a first try to get an impression on what is going on, since there is little knowledge concerned further use of GIS beyond the conversion process. It will give them time to become familiar with the issues and provides the writer with information to improve preparation of the interviews.

The questionnaire will therefore focus on a limited series of -general- questions per application. The description of applications will be limited to a minimum, for it's impossible to provide information on paper sufficient to provide all details. The questionnaire will also contain some general questions on the company, which may provide some extra information when evaluating differences in the outcomes.

The companies will be invited to give as much information as they want. The context may provide extra information on the reliability. Information must not be confined to the questions, for all information may add to the quality of the rest of the process.

6 - Interpreting the outcome of the questionnaire

A lot of guessing will be done, depending on various parameters, e.g. the quality of questions, the descriptions of applications or the level of knowledge. The more unfamiliar companies are with new developments, the higher the “guess-rate” will be.
All answers will be verified in an interview later, but possible inconsistencies have to be filtered out in this phase. Extreme deviations and inconsistencies will be checked by telephone. This way part of the problems can already be solved beforehand, which will improve the quality of the interview. Doing this by telephone will suffice in this phase and also saves the time of visiting the companies.
As a follow-up of this phase it is possible that some companies are asked to perform some investigation by themselves, for especially questions on time spent on present tasks may not be answered easily during the interview.

When all answers have been grossly checked and inconsistencies have been checked, they will be compared with each other. This will probably lead to extra questions, for not all deviations may be explained by differences in e.g. size or organisation. If this is case it is possible to do some extra checking. Normally organisations would probably grow bored of this, but the existing relationship to the interviewees hopefully will prevent this.

This phase will lead to a “worked-up” questionnaire, completed with a set of extra questions. This will form the basis for the interviews to be held.

7 - Interviewing the representatives

Interviews will be based on the product of the previous phase, which will be the guide-line. The companies’ targets also mention “customer satisfaction” and “quality”, which cannot easily be quantified or combined with financial benefits. In the interviews it will be tried to collect information on these so called “intangible benefits”.

Since many problems encountered in the answers occurred from lack of knowledge of the interviewees, a lot of explaining will have to be done here. In this, care must be taken to preserve objectivity, for it is easy (and sometimes even unavoidable) to push through one’s opinion in this phase. Though the fact that four companies are interviewed will prevent gross errors, the complexity of the field in combination with lack of knowledge within the companies will make this phase extremely sensitive to the opinion of the interviewer.

8 - Interpreting the outcome of the interviews

When the interviews have been held, all questions will have been answered and all requested information must be available. Information per company will again be checked against each other to detect omissions or differences that can’t be explained. These can be checked with the companies and if there are corrections these can be worked up in the end product.

This end product in fact consists of 2 or maybe 3 products:

- an overview of all the answers provided by the companies;
- per answer additional information per question;
- (information not related to questions, but relevant in the context).

Normally the next step probably would have been to discuss the outcome per company with the interviewees. Because of the time it costs to do things twice because of the translations this phase is skipped.

9 - Performing a quick scan

A last verification will be carried out by checking the outcome in depth in one of the companies. In this company a "quick scan" will be carried out to get a reference by which the validity of the outcomes can be checked. The scan will also be used to gather extra and more detailed information on related processes and applications.

The "quick scan" will focus on:

- questions from the questionnaire;
- issues concerning relationships with other information systems;
- benefits apart from saving man-hours.

If this investigation is reason to doubt previous answers, these may again be checked and corrected.

10 - Combining research data with costs

The combined outcome of questionnaires, interviews and the "quick scan" will be taken together to 1 overview of benefits and priorities of new GIS-applications. Benefits are of course relevant but, as already mentioned at the beginning of this introduction, it is the combination that management decides on.

At this point benefits will, as far as possible, be combined with costs of:

- hard- and software;
- applications;
- data;
- education.

Information on the items mentioned will be collected from own experience. Since the writer is employed in an organisation that develops turn-key GIS-applications it will be possible to provide information that is detailed enough.

If all data gathered are detailed and reliable enough it may be possible to give an overview of the costs and benefits of applications for e.g. the next five years. At this moment this cannot be said with certainty.

The following page consists of an overview on the research process.

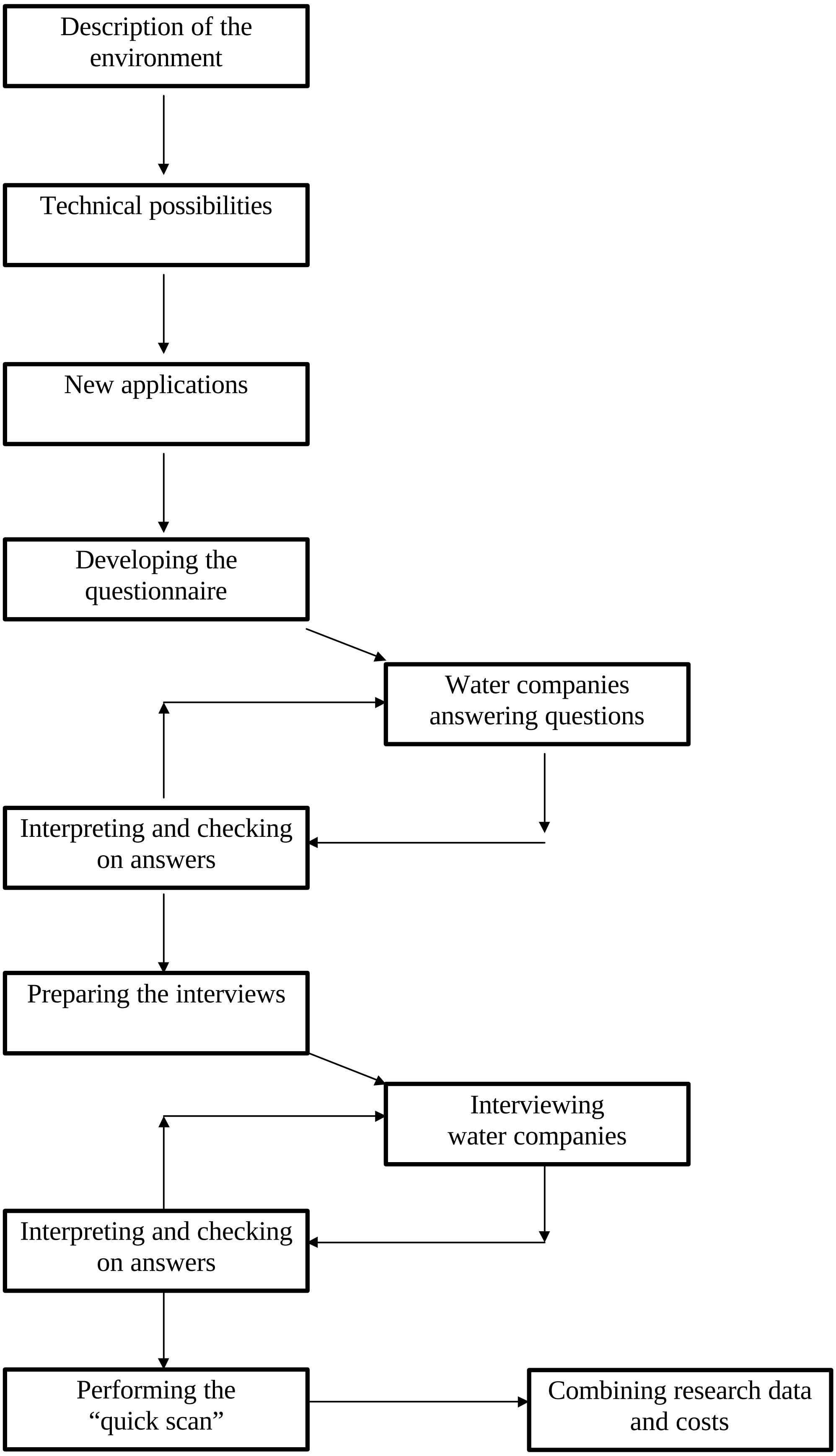

Figure 1 – The Research Process

1.4 Structure of the Thesis

In the preceding paragraph in fact the structure of the Thesis has already be laid down.

The intention is, to end up with a Thesis which provides an insight in costs and benefits of new GIS-applications. In the course of the Thesis though there are many points where a reader may lose grip on the matter, especially when he or she is assumed to have detailed knowledge on the field. This will be avoided by providing extra background information when necessary.

Chapter 2, Background: The present situation

This chapter will provide background information on the environment of GIS within water boards. Some of the information will be relevant to the issues addressed, other will be added to complete the image of the environment where new applications will be functioning.

Chapter 3, New technologies in using GIS/IT

This chapter will provide a brief overview of technical developments that may influence the use and integration of GIS/IT within water boards. It will be set up in a way that makes it easy to read, even for people not familiar with the field. This is hardly relevant for the rest of the Thesis or the possible applications, for on behalf of comprehensibility only little use will be made of technical details.

Chapter 4, The influence of GIS/IT on processes and information systems

The possible new applications are part of a larger conglomerate of information systems and processes. Just providing information on the new applications will blur the overall image, therefore this chapter will consist of the following parts:

- influences on GIS/IT developments;
- an outline of relevant information systems;
- an overview of the larger applications in relation to new GIS-developments.

Chapter 5, The questionnaire

In this chapter the background and motives behind the development of the questionnaire will be described. Since the questionnaire has only a limited function in the research process, this chapter will contain little detail. Clarity and completeness will be the aim here. Changes, omissions and extensions in consequence of the answers will be mentioned in the last part of this paragraph. Since the outcome of the questions will be checked in interviews, this outcome will be part of the next paragraph.

Chapter 6, Benefits of new GIS-applications

After the outcomes of the questionnaires have been checked, the same questions will be used as a basis for the interviews. More will pass in review though than these questions. Especially the information behind the questions will be emphasised. The "quick scan" will provide a check on information already available, but also new information on related issues.

The final result of all inquiries will constitute of:

- the answers on the questions from the (possibly revised) questionnaire;
- additional information on these questions;
- possible information on “intangible benefits”;
- the results of the “quick scan”;
- additional relevant information.

Chapter 7, Costs and benefits

The previous chapter provides the basis for a cost/benefit analysis of new GIS-applications. In this chapter benefits will, if possible, be combined with the costs associated with new applications. Since answers from different companies may vary depending on organisation or the level of GIS/IT-developments, it’s not expected that there will be one outcome. Costs and benefits therefore will be sorted out for one company, probably the one that will approached for the “quick scan” also. The scan may provide useful extra information to use in the analysis.

Chapter 8, Final remarks and conclusions

In this chapter all results from the previous chapters will be taken together, to provide a overview of results and limitations of this Thesis, and to provide indications for improvement and future research.

2. Background: The present situation

The situation within Dutch water boards in relation to IT/GIS can be described by some characteristics. In this chapter important characteristics and influences will be mentioned, thus explaining the way the introduction of IT/GIS is handled in the past.

2.1 Size and finance

Compared to the situation in for instance Great Britain, water boards in The Netherlands are small: companies providing 300.000 customers or more are considered large. Over the years almost all municipal companies were merged with larger ones, leading to provincial companies. This will eventually lead to a few companies covering the country, as is happening to electricity boards. Though this will undoubtedly take several years, it shows the changes that are laying ahead.

Dutch water boards are owned by the Province and municipalities and aren't allowed to make a profit. They are also forced by law to "deliver water of good quality at a reasonable price". Since the base material is getting scarce, the costs of the production of good drinking water are increasing. This is only one of the reasons that forces them to work more efficient.

Compared to especially the electricity boards, water boards have less financial means. They are therefore less inclined to invest in what they see as "uncertain developments" like IT to support their processes.

As a result, many water boards are now in a phase of using IT/GIS, several other utilities reached years ago. This is a rather fortunate situation, for during these years many problems have been solved, hard- and software have become cheaper, organisational issues have become clearer and others have built experience. As will become clear in the rest of this chapter, for some reason water boards are slow in catching up with the other utilities.

2.2 The "GIS-image"

Though less than before, GIS still suffers from the image it had several years ago: an expensive toy for specialists and a tool for automating mapping processes. Times have changed though:

- hardware has become cheaper and more powerful;
- modern programming methods cut the time to build applications;
- simultaneous use of raster and vector data enable faster conversion and combination of different sources of data;
- user-friendly interfaces have brought GIS to the office environment;
- use of industry standards enable the integration of GIS within existing information systems infrastructures;
- Developments in GIS-tools, datacommunication and Internet/Intranet facilitate the distribution of GIS throughout the, often spatial distributed, organisations.

The first AM/FM applications were commonly implemented as departmental automated mapping systems. GIS has matured since and has much more potential than that. Promotion therefore must be taken on as a joint action of GIS-professionals and the IT-department, and together they must provide information on which management can decide. The problem one comes across is communication; some way management and technicians speak different languages. In order to level this barrier GIS- and IT-experts must be able to explain the benefits in terms of organisational impact, financial consequences and customer satisfaction (De Groot, 1996).

2.3 Motives for introducing GIS

Some time all utilities were confronted with the shortcomings of their way of registration information on facilities, most of them common to all utilities:

- outdated map sheet data;
- increasing costs of data management;
- deteriorating map sheets;
- impossibility to relate different sources of data;
- increasing information demands;
- difficult and expensive information exchange;
- absence of management information.

Bad quality of map sheets forces organisations to do a manual conversion almost every 20-25 years. The fact that this can be done cheaper and faster by means of GIS is reason enough to start. In most cases the availability of digital basemaps triggered this process. Conversion consists of a well defined amount of work and, since there is plenty of experience nowadays, costs can easily be measured. The introduction of GIS therefore generally starts fast.

Manual conversions generally took ten years or more to complete, almost like operational processes. GIS-conversions can be realised much faster, so costs seem much higher. This explains the emphasis on streamlining conversion and developing tools to speed up the process. Focusing on the “drawing” product only however lead to more or less isolated solutions. Conversion of the map sheets should solve the problems, and in fact it did, at least the ones that could be seen at first sight. It was sufficient if GIS could produce the same drawings as before. Focusing on the conversion process though distracts the attention from other (strategic) aspects, and integration and future applications get little or no attention.

2.4 Present use of GIS

For most water boards the use of GIS for AM/FM systems has started quite recently. Since the introduction in The Netherlands of Smallworld-GIS in 1990, especially utilities have chosen this GIS toolbox. It appeared to be very well suited for the conversion process. The integrated topology capabilities enabled the building of high quality databases. The object-oriented development tools, in later versions combined with a CASE-tool, proved to be an environment for building stable applications. Over the years improvements have been made, especially in connecting to other databases, integration with the Windows environment and added development efficiency.

Although analysis capabilities may not be as extensive as found in other GIS toolboxes, it proves to be very suited for maintaining large utility databases and integrating with already existing information systems. The solutions described in following chapters therefore will focus on IT-technology used in combination with Smallworld-GIS.

The use of GIS is commonplace within departments responsible for R&D in geo-hydraulics. REGIS on Arc/Into is a very well known application for modelling soil composition and groundwater flow. Apart from this a PC-version of REGIS (based on ArcView) and a

Smallworld version (REGIS-PRO) have been developed. Both probably enable better integration capabilities.

2.5 Lack of standardisation

In 1988 VEWIN economists noticed that there was little co-operation in developing GIS-applications (De Haan, 1994). Merges have led to fewer applications, but there is still little standardisation in GIS-applications for utilities. This didn’t just apply GIS-applications; though various companies have comparable information needs and -systems, standardisation is hardly an issue.

In 1990 the PAL-report was completed (VEWIN, 1990). The project, initiated by VEWIN and carried out by representatives from different water boards and CMG, was meant to assist water boards in the introduction and realisation of GIS-applications. Because most companies don’t have Information Plans, a shortcoming perceived by the project participants was the general absence of frameworks GIS had to fit in. The PAL-report so had to cover information planning as well as the definition of future applications, aimed mainly at the development of a Mains Information System (MIS). It also had to comprise reference models to make it workable as a handbook. Unfortunately the project was stopped because of financial problems. Though the report was received with much enthusiasm, no attempts were made to extend it in order to create a standard.

The PAL-approach focuses on existing processes and organisation, distracting the attention from possible changes due to in- or external influences. Having marked out the different information systems (using BSP) it focuses on the MIS system, in fact denying the mutual

influence between IT/GIS and organisation development. BSP is said to “focus on organisations dealing with processes subject to little change. The organisation is the primary input for marking out the information systems” (Cap Volmac, 1995).
This might have been the case, but the opinion on organisations has changed since. PAL therefore should be handled with care, and shortcomings should be neutralised by applying organisation development methodologies better fit for the circumstances.

The reference datamodel for water boards, developed by KEMA, was derived from models developed for gas and electricity boards. Maybe because this model wasn’t a co-operated effort of water boards it didn’t contributed much to standardisation. Most datamodels used are in some way related to the KEMA-model, but every company has developed its own version.

One of the reasons standardisation isn’t commonplace may be that utilities are autonomous in taking decisions, so each company has grown its own tradition in organisation structure and the use of IT/GIS. Differences in organisation, knowledge and level of automation so prevented structural co-operation.
Nowadays, when merges between utilities are fairly common, differences in information systems are sometimes cherished and used as change money in the process of negotiations, an attitude fatal to any intention to improve standardisation.

2.6 Availability of digital data

Though much effort has been spent to speed up its completion, the digital GBKN (a large-scale basemap, supplied by the Dutch Ordnance Survey) still isn’t finished completely.

According to the planning, all maps will be available by the end of 2000. Since utilities require this map for relating mains and cables to digital topography with sufficient accuracy this has been a motive to wait with GIS. Most utilities have subscriptions because they already use the maps, therefore costs constitute little restriction.

Digital data though may present a problem in the future. The GBKN-map can be used as background, but hardly contains any useful information on topography, nor has facilities or structure to let the user add this easily. This will probably be the case until an "object oriented" GBKN becomes available, in which objects can be discriminated and not just points and lines. Relating information to objects will become easier then, and this may stimulate the development of new applications. Investigations show that water boards, municipalities, utilities and the Ordnance Survey don't expect short term benefits of this OO-GBKN, which means that, mainly because of finance, it has to be waited for.

Digital data, for instance cadastral data or data on address locations, are considered to be rather expensive. This may imply that the use of GIS in the Netherlands is being slown down by the availability and costs of digital data.

2.7 Times are changing

2.7.1 A changing environment

Like many other organisations, water boards very much hung on to bureaucratic structures, which hardly stimulated the introduction of modern developments. Contrary to modern technical equipment related to "real" processes like production and distribution, IT was seen as a source of costs and not of benefits.

Responsibility for main processes was distributed over departments, and the use of IT to support (read: automate) these processes often ended in sub-optimisation. Except for large mission-critical systems developments were handled on a departmental level, providing local solutions. Many water boards still don’t maintain Information Plans, thus restricting the integration of developments into a structured and comprehensive framework.

Literature on organisation development state that sometimes rigorous changes are necessary to optimise business processes. These statements apply to organisations which encounter heavy competition, demanding customers and a hostile and constantly changing environment. At first sight this description doesn’t fit water boards however, things are changing there also. Customers and external organisations become more demanding, legislation is getting stronger and catchment areas with clean water become scarce, thus increasing the costs of water. The unification of Europe can lead to new players in the market and, more likely, there is a constant threat of being overtaken. To maintain profit for essential investment a water board must reduce operating costs through the use of advanced technology and innovation while at the same time improving customer service. This not only happens to Dutch water boards though (Finch and Martin, 1993).

Changes in the companies’ environment show that existing structures fail in adapting. Management realises that changes are necessary, but often their hands are tied by existing structures. Due to merging with other organisations, many utilities are restructuring. In this process changes in the environment are often reflected by changes in management: technicians make way for “real” managers, to which technology is just a means to reach the organisations’ goals. If this means the use of IT/GIS, promoters have to evaluate their strategy. Rather than advertising their sophisticated applications they have to emphasise the organisational impact and especially focus on benefits.

For most companies this results in three key targets:

- cost reduction;
- quality improvement;
- outstanding customer service.

Though these targets aren't new, the changing environment leads to renewed interest and efforts.

2.7.2 New concepts on organisational change

Present organisation models have several drawbacks in the current business environment. They have trouble responding quickly to in- as well as external changes. The changing environment asks for a reaction, generally in the form of a restructuring operation. In this paragraph some of the concepts of fashionable methodologies like Business Process Redesign (BPR) and workflow management (WFM) will be discussed. This is done to point out some new insights on the introduction and integration of IT/GIS, not to cover all aspects in depth.

BPR (Business Process Re-design) can be defined as:

> *"the fundamental rethinking and redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service and speed"* (Hammer and Champy, 1993).

Much of what is termed re-engineering operates within an existing framework of attitudes and assumptions, and does not radically change them. Experience in Europe show that the “revolutionary” approach is too radical for most organisations, for BPR is not only about changing processes, but also culture. The “radical approach” therefore applies to formulating new business targets. The re-engineering processes is carried out in a way more suited to European culture.

BPR originated as a reaction to the following problems (De Gooijer, 1996):

- organisation/environment - unable to respond adequate and fast to external changes;
- organisational structure - unable realise changes in the organisation quickly;
- IT infrastructure - use of inefficient and inflexible structure;
- IT technology - use of outdated technology.

The problems point out the close relationship between organisation and IT.
Buitelaar en Groen state, that IT is one of the “enablers” of BPR (Buitelaar and Groen, 1994). BPR-philosophy recognises that valuable tools like IT must be taken into consideration when generating solutions, and not just when implementing them. Also the real value of IT becomes obvious when combined with changes in the supported process.

Some experts on the field are definitely against IT as an initiator for BPR (Coulson-Thomas, *et al*., 1994). The reason is obvious: focusing too much on IT-solutions may distract the attention from the real problem, resulting in task instead of business optimising. This is in fact what is happening when GIS is introduced to solve the mapping problem. Key point of attention must be business processes that cut across the -specialised-corporate structure. Rigorous changes often don't work because the old information systems can't support the new processes. It takes time to change, and sometimes this doesn't work at all because IT is too much fixed at former processes. The "green pasture perspective" too much focuses on the new organisation, underestimating the IT needs to support it (Cramers and Gerrits, 1997). Although expert opinions differ, it seems that organisation- and IT developments must be balanced against each other, trying to reap the benefits from both.

WFA/WFM (Workflow Automation/-Analysis/-Management) are buzzwords, describing a series of methodologies, tools and applications related to process optimisation. While WFM/TQM is more or less a continuous process, BPR is carried out once (or once every x year).

WFM uses technology as a basis for process optimisation, while organisational change is a minor point of attention. It focuses on the layout of processes and the co-ordination of administrative workflow. Benefits are large in organisations suffering from co-ordination problems, mostly administrative organisations who have a good datacommunication infrastructure (Joosten, 1995). Since the introduction of GIS increases communication possibilities, it must be investigated if WFM concepts can be beneficial.

A well known example of a workflow application is a DMS (Document Managing System), in which scanning and imaging are used to automate document flow through the organisation. Many working WFM-applications are in fact DMS's. WFM has resulted in experience and applications that can be used when processes have been reorganised, so complementary to process redesign.

TQM (Total Quality Management) is concerned with continuous improvement within an agreed and existing framework. Many of the tools and techniques of quality can be used in the course of BPR. Quality improvement groups can be set up to examine all sorts of activities, whether or not these form part of a critical process.

In utilities, organisation is a key problem when having to adapt to a changing situation. Introducing new information systems without changing the organisation therefore may result in improving niche tasks instead of processes, ending up in automating existing (and maybe the wrong) processes and building new technology on old foundations. Possible danger of using WFM/TQM is a focus on existing processes, resulting in task improvements, leaving critical processes unharmed.

2.7.3 The corporate approach

Traditional use of IT led to computerised bureaucracy and inflexible information systems that prevented organisational innovation. An organisation using the corporate approach involves all functional areas, including IT, in defining strategy, thus resulting in being able to react on in- and external changes (Spruijt-van der Starre, 1993). Use of GIS can't be treated separate from this developments. Critical to the success of GIS is the integration of systems and the sharing of common data. Integration, ready access to shared corporate data, and the elimination of "private" or departmental databases, are the key to higher productivity and reduced operation costs.

Enterprise system architectures being implemented today require the use and integration of numerous core technologies. In an enterprise-wide data processing environment GIS-technology must be viewed as a core technology that may be integrated into an application for any corporate system. The benefits of GIS technology in support of numerous corporate applications come from its ability to query, analyse and display information that is geographic in nature (Hedges, 1994).

In water boards GIS is still department-oriented, leading to sub-optimising solutions. Responsibility for the conversion process now often lies with the drawing office. Since a strategic approach is required, responsibility for GIS must lie with the management. Support by professionals from the IT-department is necessary to ensure integration.

A corporate approach includes standards on all aspects of corporate data. A way to realise this is to strive for a corporate database. This is nothing like a company-wide information systems, but the concept of a strategic view on corporate data.

The true corporate database is application-independent and provides all applications access to common data. Establishing a corporate database eliminates duplication of data (and the problems it causes) common with application-specific data structures. It is desirable that any AM/FM/GIS technology should use the corporate database for storage of attribute data. Maturing technology is now providing tools for distributing portions of a corporate database at different nodes on a computer network. While the database need not be physically centralised, the concept does imply that standards and procedures for database design, access and update are applied consistently throughout the organisation (Hedges, 1994).

Part of this is the corporate or business data model. Integration of IT and GIS requires agreements on description, structure and meaning of corporate data. GIS as an integrating technology is at its best when implemented in a mature IT environment. In such an environment, the corporate view on information will have been understood. The value of a business data model, applied across the whole organisation is key to effective use of GIS (Martin and Taskis, 1992).

2.7.4 The benefits of IT/GIS

IT-benefits are a popular subject in the professional magazines, which claim that in general IT investments are based on politics and personal arguments, and it is even doubted if IT has any benefits at all. There is little systematic approach and the role of economic argumentation is of minor importance. As a result management is more and more questioning the value of money-consuming IT-projects, which hinders a follow-up of the introduction of GIS.

Project managers and GIS professionals still focus on technical aspects, where modern management demands well supported project plans, containing organisational aspects, project planning and risk- and cost/benefits analysis. GIS can be used as a strategic tool. Only when the value of this approach is fully understood, management will decide in favour of new GIS applications.

It is obvious that performing a good cost/benefit analysis isn’t easy, but when reading articles on IT and GIS projects it seems that carrying out a proper cost/benefit analysis is hardly done at all, not even (or: especially not) afterwards. A cost/benefit analysis though will aid in setting priorities for applications and selecting projects with short payback periods and less risk first. In the end everyone will profit from this approach, because the choice of projects to be carried out will be taken on a more neutral basis.

If benefits of applications are known, maybe it's better to speed up the conversion process, so new developments can be profited from. Even so it can be profitable to develop applications in favour of other because of a better return on investment.

When the use of GIS stays limited to tasks, these individual benefits may not justify payback in the investment. Even though the improvements may be very beneficial, the resultant impact will be improvement in niche tasks. This however means that one has to see beyond the conversion stage and the operational processes of the drawing room.

2.7.5 The use of new technology

One of the consequences of a, more or less company-wide, use of GIS is the introduction of new technology. At the rate new developments are becoming available, almost everything is possible now. The influence of the “technology push”, which has deliberately been denied for a decade, is to be felt more and more.

Benefits depend on the synergetic effect of different technologies, as there are database technology, GIS-capabilities, hard- and software and (wireless-)datacommunication. “What is necessary” must be combined with “what is possible”, offering a cyclic development process in which ideas and solutions are stimulated by the possibilities of new technology. Organisations need to develop an open mind for these opportunities. In order to be able to decide if its use is beneficial it is necessary to have knowledge of the technology available.

New technology can’t be introduced from one day to another. Company-wide use of new technology involves employees who don’t use IT-solutions in their daily work or have little affinity with automation at all.

Field crew for instance are used to get their information from paper maps, and even advanced solutions won’t change this easily. In order to avoid duplication of work the use of modern means can result in a shift in responsibilities from the drawing room to the same field crew, thus burdening them with a change in tasks.

Acceptation depends, beside on technology and application, very much on human factors. Organisational change also invokes changes in culture, attitude and behaviour. This again points out the relationship between organisation development and IT.

2.8 Conclusions from this chapter

From the preceding paragraphs it became clear that, for different reasons, there is a renewed interest in three company targets:

- cost reduction;
- quality improvement;
- outstanding customer service.

The present situation concerning IT/GIS within Dutch water utilities can be taken together in a list of key aspects:

- GIS still has the image of being a technical toy and tool for the drawing office;
- there is little integration of GIS within the information strategy;
- there is little or no standardisation in IT/GIS solutions;
- the use of GIS may be influenced by the availability/costs of digital data;
- the organisational impact of IT/GIS is underestimated;
- the influence of the "technology push" is often denied;
- there is little insight on costs and benefits of new applications.

This results in GIS-developments being slown down. Most aspects originate from lack of knowledge and prejudices against new developments at various levels in the organisation.

3. New technology in using GIS

3.1 Introduction

Though the title looks exiting, most of the “new” technology is already present and used within other companies. In order to show the (potential) benefits of GIS in combination with other developments it must be investigated if this technology can be used to satisfy the demands of water boards,

“In combination with other developments” is a key aspect here. New developments are emerging at an unprecedented rate. Due to the constant flow of technology and change throughout organisations, it becomes increasingly important for those organisations to employ solutions that will coexist and complement installed systems.

When introducing new technology, one has to take into account the present culture within water boards. In the next years water boards will (have to) change into modern and flexible organisations, but at present they are certainly not the first to use newest technology. “Ultimate” solutions must be avoided to improve acceptation; it has to be discriminated which technology can really be used as a solution for business problems.

The intention of this chapter is to give an overview of new technologies related to IT/GIS, not to provide an extended and detailed comparison of technical developments.

3.2 Characteristics of the environment

Tasks related to -geographic- information on facilities can be characterised by:

- much field work;
- poor quality and availability of data;
- much redundant drawing work;
- little strategic approach.

Data quality is improving due to standardisation and extensive controls during conversion, but information is still made available by plotting the requested map. Quality of detailed technical- and environs information is still poor and a strategic approach to e.g. maintenance is often impossible because of the inability to link various data-sources.

New technology can be built into GIS-applications to provide solutions to these problems, so tasks can be supported by:

- more and better quality data;
- integration of data-sources;
- communication;
- tools to support different management levels.

Much emphasis is on communication. Communication though can only succeed if there is agreement on what to communicate. Standardisation therefore is one of the key issues.

3.3 General aspects

Next to specific technological developments that influence the use of IT/GIS there are general aspects and sometimes even conditions that are required to make things work.

The value of GIS functionality

Functionality of GIS-tools has always been the key aspect when choosing a specific toolbox. This Thesis will focus on Smallworld-GIS, being the GIS toolbox used by most Dutch water boards. The specific way water boards use GIS raises the question of the importance of "real GIS functionality". When talking to representatives, questions hardly concern functionality like buffer analysis or difficult overlay techniques. Apart from obvious sufficient GIS functionality, apparently other capabilities are valued at least as high, as there are:

- interfaces to different databases and information systems;
- communication capabilities;
- the use of Internet technology;
- integration with the Office environment.

Obviously the "drawing data" aren't enough to support the company's processes. Focus is now on creating the data-basis and availability of data throughout the organisation. When these are realised "real GIS" functionality becomes a point of attention again.

Standardisation

Most of the processes within water boards involve:

- exchange of information;
- links to other information systems;
- availability of information throughout an organisation.

Standardisation is one of the necessary steps to make this possible. It's no use spending money and effort on information- or communication technology without a general agreement on what and how to communicate.

Utilities exchange data with organisations that use a variety of GIS-tools. The following summary only shows part of the problem, since only the differences in GIS-tools are mentioned:

Organisation	GIS-tool used
Utility	Smallworld-GIS, Intergraph, GDS, ...
Water board	AutoCad, ArcView, ArcInfo, Smallworld
Province	ArcInfo, (Smallworld-GIS)
Municipality	AutoCad, ArcView, GeoCad
Contractor	AutoCad, "total station" software

If this summary would be extended with differences in hardware and information systems GIS may need a link with also, the extent of the problem becomes clear. The same occurs on a large scale, as the following quotation from a document of the EU shows:

> At present, a large number of standards relating to GIS have been, or are being, proposed (Table 2, appendix 1). This multiplicity of standards is confusing to those who wish to use them, while in some cases development effort is being duplicated due to the ad hoc nature of this work. The multiplicity of standards organisations (Table 3, appendix 1) complicates matters and, if the rate of development of official standards does not keep pace with the development of computer systems, de facto standards are likely to arise which are not necessarily suitable for all members of the GIS community. Standards may be ignored by developers if they appear to be inappropriate or irrelevant and this will only compound future interoperability problems (DGIII JRC, 1996).

The strength of GIS within water boards is its ability to combine and analyse data from different sources, information- and computer systems. This makes high demands on the interoperability capabilities within the information infrastructure of an organisation. In OGIS (the Open Geodata Interoperability Specification) the features of interoperability are described as follows:

A general notion of interoperability might incorporate a wide range of attributes including, but not limited to:

- *Access to foreign geodata;*
- *Interaction between network-based applications;*
- *Establishing and maintaining client-server relationships;*
- *Integration of distributed, heterogeneous data;*
- *Integration of distributed, heterogeneous processing resources*

These attributes of interoperability all relate to the notion that access to and sharing of data and process are supported at a number of levels that include hardware architecture, the network environment, the operating system, the data store and the application environment(s) (OGC, 1996).

Many national, European and world-wide initiatives exist to try and develop standards that enhance interoperability. Local initiatives must be in line with these developments.
In the near future most data will be available in GIS(-like) environments, to be exchanged electronically. This will be a leap forward in efficiency, cost reduction and the availability of timely information. Since not many organisations employ an organisation-wide GIS yet, at the moment a lot of work is still manually. Organisations focus on map sheet data now, so information exchange will grow when more data and functionality become available.

When striving for electronic exchange of data, among other the following aspects have to be agreed on:

- use of generally accepted standards;
- meaning and formats;
- type and accuracy of measurement;
- type of basemap used as reference (in case of relative measurement), to enable combination of data;
- internal policies on what data may be exchanged under what terms;
- legal aspects and responsibilities.

In the past every 20-25 years a manual conversion was carried out due to deteriorating material and outdated basemaps. When using GIS this isn't necessary anymore, at least when proper precautions are taken in the conversion process. Organisations have to understand the long-term value of GIS data in this new situation. As already stated in the second chapter, integration requires standardisation and a corporate view on data. (Oogen, 1995). These must be important inputs when planning the conversion process, since that is a unique opportunity to standardise.

Considering the environment and the items mentioned, reaching an agreement on what may or must be exchanged and effectuating this probably will take longer than developing the means to actually do the exchange.

The user interface

In order to avoid acceptation problems one must offer simple solutions when introducing new technology. In the beginning the introduction of new GIS-applications will mainly affect employees who have little experience in using automated applications. This applies to field crew in special.

As a result of continuing reorganisations many companies use job-rotation as a means to increase flexibility. A extra point of attention therefore is the use of similar interfaces in the field and in the office. This way learning time is reduced, while at the same time flexibility increases.

3.4 Electronic data interchange

Since more organisations use computer systems to maintain their spatial data, interest in electronic interchange of these data increases. This requires at least some kind of general agreement on what and how to exchange, as already discussed in the previous paragraph.

Developments in hard- and software and datacommunication have made it possible to realise communication between servers, workstations, information systems and databases. At this moment there are hardly any technical restrictions on datacommunication anymore, though “data-intensive” applications like GIS may still require special attention.

Internet/intranet

Little developments in IT have had such an influence like Internet. Communicating with the rest of the world and world-wide access to data sources are only two features of this phenomenon. Much of the Internet technology will be used in various applications within short.

Organisations are investigating its use for business applications, creating universal interfaces. Standard interfaces based on browser technology will simplify computer interaction, thus lowering the threshold to new applications. It is expected that as a result training costs, but also the "costs of ownership" will be reduced.

Internet is already used to access GIS data, available on different sites over the world. In case of Smallworld-GIS, browser technology can be used to access the GIS database for viewing purposes, offering a simple interface. Other GIS-suppliers have similar products. It is a cheap solution for the many "viewers" that will emerge when new applications become available and GIS will become generally used within the organisation.

Functionality is more or less comparable with so-called "screen scrapers", but has less impact on the server workload. This makes it better suitable for general use. Mobile access to GIS data is just one step ahead then.

Many organisations are developing Intranets, bulletinboard-like systems for internal use, based on Internet technology. Municipalities already have their own solutions for the access to and exchange of information, and Water Boards are developing similar activities. When discussing the access to and exchange of data, Internet is a logical step to make data available to others.

3.5 Communication in the field

Exceptional situations, like the large amount of burst and frozen pipes during ‘96/’97 winter’s frost period, show that precious time is lost on driving between the office and the trouble area because of the need for the right maps, work orders and materials. This happens every time a field crew drives to a non-planned job, but there is more to be said on this matter:

- Investigations show that 80% of all field work requires the use of sketches and maps. Not all of this is available in the field, resulting in loss of time or relying on incomplete data. Information from the field is needed in the office for ordering materials and managing work orders;
- Experience shows that working up as-built information is generally months behind. Many problems though develop shortly after mains or equipment have been installed or repaired. Information status is often questionable, because it is uncertain what data are still in the “pipeline”;
- Redundant effort is spent by different departments. Changes are drawn on a copy of the map, and this copy used in the Drawing Office to update the original drawing or the GIS database.

Most water boards now use GSM equipment for voice communication. Mobile fax equipment is sometimes used for sending maps, sketches and materials orders, thus reducing travelling to the office. This only covers part of the problem, since there are more thorough solutions to support these processes.

Field GIS

In water boards hand-held computer equipment is used by meter-readers and service- and maintenance engineers. GIS applications though have still been confined to the desktop or, more specifically, to the drawing office. In the last years portable computers have developed to full grown systems. Memory and storage requirements are not an issue anymore, so portable systems can be used in a GIS environment also.

Mobile GIS started with solutions for viewing data only. Though this was a leap forward in increasing efficiency, still much redundant work was done. Next was the ability to apply changes in the field. Although changes were not made in the original, this resulted in less redundancy because they were available in a digital format.

The key requirement however is the possibility to insert changes in the database on the spot, without having to draw them up again. New and changed data can be uploaded to the GIS database via telephone line or wireless datacommunication. The same time the latest changes can be downloaded, making the system ready for the next job. When both sides are able to send new and changed data only, wireless datacommunication can be used without excessive performance loss.

After been checked data can be merged with the master (Smallworld) database, so timely data can be available to others the next day.

All this has several advantages:

- less or no redundant work;
- “drawings” can be visually checked in the field, thus avoiding large errors (e.g. in measuring);
- increased speed of working up, information is available to others within days;
- no need for visiting the office;
- increased flexibility in field work.

When using Field GIS this way, only part of the work at the office remains. Because all companies have Drawing Offices, this will have a considerable impact on personnel.

Mobile GIS applications, particularly as they apply to utility needs, require specific devices that are suited to harsh operating conditions. When used out in the field the usual portable PC won’t last long because of environmental influences. Other shortcomings of portables are limited battery capacity, weight and restrictions of keyboard/mouse. This will restrict users in their work and possibly endanger acceptation. Experience shows that shortcomings like this are used by users to reject new applications (Mazure, 1996).

A more or less recent solution is the pencomputer, which has developed in a way that allows the use of GIS(-like) applications. They provide the same functionality as PC’s, except for the fact that they are operated by a pen. This make it very well suited for outdoor use.

When questioning water boards, it was found that Field GIS must satisfy the following requirements:

- availability of mapsheets and attribute data;
- changing and adding data;
- extracting changes and merging them in the master database;
- availability of minor GIS functionality to answer questions like:
    - locations on basis of address data;
    - which valves must be closed in case of a leak;
    - which people have to be informed when a watermain is shut down.

A Field GIS solution already available in 1994 (Geolink), already supported the following functions (Elliott, 1994):

- the recording of GPS position, suitable for use in a GIS;
- the editing, verification and co-ordinate transformation of position, time and attribute data collected in the field for use in a GIS.

It is remarkable that it was already in use in 1994, which may prove the utilities' needs and the direction things will be going in Europe also.

On the Dutch market there are several brands of field GIS (SPY, PenMap, LocatorGis). Though all sophisticated applications, none of them suits all requirements yet. In the way the technology is advancing however within short complete solutions will become available. The use of Internet technology will influence these developments, and maybe replace some of the solutions.

Mobile computer systems are also used to support other tasks. Work order planning/-management is an application already used by utilities and service companies. Experience with the Tinoway system on workorder planning /-management show a remarkable payback time of about 7 to 9 months (Wondergem, 1995). In utilities, these applications are closely related to GIS. Because of the expected synergetic effect, implementation of these applications therefore may speed up the introduction of Field GIS.

GPS

GPS's (Global Positioning Systems) are more and more used in field work, sometimes as part of Field GIS. Decreasing costs make it an interesting development for utilities also. Accuracy of standard equipment however isn't good enough for measuring purposes, and more accurate equipment is too specialised and expensive. This must be seen in relation to the way projects are carried out now. In most large projects, measuring is done by contractors or in co-operation with other utilities. The remaining amount of projects is too small to make the purchase of more accurate equipment feasible.

In the future (field-)work has to be done with less people. Reorganisations result in older employees leaving the company, taking experience and knowledge with them. Job-rotation results in loss of detailed field knowledge. Standard GPS-equipment therefore can be a useful help for orientation purposes.

When extending functionality to support maintenance planning and -strategy, much more environment data will be necessary. Field GIS in combination with GPS may prove to be a suited instrument to support acquisition of these data.

Voice input

Voice input and -recognition a fields scientists have been studying on for many years. This resulted in professional solutions for office environments.

For many field workers the idea of working with computer equipment is rather repulsive, which may hinder acceptation of future field applications. Use of pencomputers may be part of the solution, but when combined with voice input, this can become a very powerful solution. In the USA tests with the use of voice input in combination with pencomputers and GPS resulted in increased datacollection speed and accuracy (Bourgeois, 1998). This however concerned environments with much repetitive work. Use is therefore limited to certain field tasks, but for instance in the initial collection of environs conditions voice input can be beneficial. It almost goes without saying that voice input will probably be *the* future way to communicate with the computer, in the field as well as in the office.

3.6 Integration within the office environment

Though not as appealing as the developments mentioned above at first sight, this is an important issue if GIS has to be integrated in the information infrastructure. Applications will become more and more Windows-based and Windows applications are available on every desktop. Applications that cannot communicate with the Windows environment (OLE/COM) will hardly survive. Beside the typical “drawing” information, much of the use of GIS within water boards will be about reports and management information. Being able to integrate these within Windows applications enables users to work up information by means of spreadsheet or wordprocessor, thus enhancing quality as well as presentation. Introducing GIS from within Windows applications, such as viewing maps or performing simple spatial analyses, offers a low-end step in the direction of GIS integration.

3.7 Datawarehousing

Some articles on datawarehousing state that it is just a marketing hype and that benefits are overestimated. Though it's mainly used for marketing purposes, the question is raised if water boards can profit from it also. In utilities the data concerned at first consist of map sheet data. Most other data aren't easily accessible or available and have to be gathered afterwards.

This is different from the systems in which many gigabytes of corporate data from legacy systems is stored to find new relationships. Extra GIS-data are stored because it is almost certain that a relationship exists, though it may not be clear what the mutual influence is. Data acquisition therefore is very much directed by needs and costs/benefits.

The amount of GIS data stored will grow, depending on the applications that are being developed. A full-grown FMS can incorporate many gigabytes of data. Since the use of GIS is just starting, it is possible that future applications result in huge storage requirements. Though GIS may profit from storage and analysis techniques used in the datawarehousing concept, at this moment the relevancy for water boards seems to be limited.

3.8 Conclusions from this chapter

There are many technological developments that may influence the use and integration of information systems beyond the ones mentioned, as there are multimedia and virtual reality. Things that looked futuristic a few years ago are part of today's reality. Since no one can look into the future, it must be assumed that new developments will just consist of better, faster or more sophisticated versions. Though they will add some new functionality, the influence on the applications and benefits will be limited. Remembering the developments of the last years, this assumption will probably be proven wrong.

A conclusion may be, that GIS-functionality is important when developing applications to support processes. This chapter shows that computer- and datacommunication technology is at least as important in the use and integration of GIS.

4. The influence of IT/GIS on processes and information systems

In a recent article it is stated that GIS offers many new possibilities, based in first on the digitised drawings, although it is not clear which applications will be developed (Van der Meer, 1997). Benefits are better accessibility and increased quality of data, but the author is sceptical on the introduction and acceptation of new technology in utilities.

Statements like this lack a corporate approach which, as became clear in the second chapter, is necessary to maximise impact and benefits.

Partly derived from the company's targets, three important developments can be recognised lately:

- An enhanced attention to improving customer service. This even as far as making customer service the main task of water boards, with other processes subservient;
- Many utilities are implementing cost containment initiatives, which often include staff reductions. This forces utilities to streamline essential tasks and implement automated tools which allow employees to work smarter and more efficiently;
- Merges and reorganisations result in employees leaving the company. Job-rotation leads to employees being assigned to other districts. This results in the loss of field knowledge. In order to be independent of these changes, knowledge has to be stored in applications and databases and be made accessible to all users.

This chapter will focus on how applications and processes may be changed as a result of the introduction of GIS/IT. The applications described will be the main input to the research that will be conducted in four water boards.

4.1 Systems concerning facilities information

Systems concerning facilities information are used in several departments. When GIS becomes involved, at first facilities refer to mains and equipment used in the distribution process. When the systems involved mature, the use of GIS extends other departments. In general these applications consist of relative small additions, relationships with other information(systems) and the use of specialised modules.

Every utility has a *Mains Registration System* (MRS), consisting of mainly mapsheets and some small, sometimes automated, information systems.

Most utilities are now in the stage of converting their mapsheets, storing “drawing”-data in GIS. Generally more than just map sheet data are stored: smaller systems may be incorporated into GIS. Since GIS can be queried for information, these systems are generally called *Mains Information Systems* (MIS). Extra functionality is available because this is standard in GIS, but in fact it is still a 1:1 conversion. In all utilities this is the starting point for the use of GIS for facilities management.

When the conversion is completed, GIS is going to be used to support other processes within the Distribution Department, as there are the design, realisation, management and operation of their networks. This leads to a *Distribution Automation System* (DAS), which has relationships with many other information systems. This system is in fact a conglomerate of functionality from almost all main information systems, and covers all information needs from the Distribution Department.

DAS can also be linked with -technical- information systems, which are the responsibility of other departments. This is the so called integrated *Facilities Management System* (FMS), which encompasses the information demand concerning all facilities of a utility.

By careful planning and specification of database attributes and rules, many auxiliary processes can be implemented using the GIS-database. This may require few additional attributes and GIS can often easily be customised to provide other functions.
This chapter will focus on processes within the Distribution Department, so on DAS. If applications within other departments exist that may have a relationship with DAS, these will be mentioned also.
During the initial phase of GIS projects, many decisions concerning the data and functionality needed must be made. Among the many factors which must be considered are the costs associated with obtaining and verifying data, conversion costs and the amount of data collection and/or entry which is economically feasible considering the GIS products being planned for use. In many companies a variety of computer applications exists, and the data used is often also found in or required by GIS. Since all engineering work requires facility information which will exist in the GIS database, there is an opportunity to merge data requirements, so the available data can serve to support more functions.

The main processes concerning technical/administrative information on facilities are the upgrade/design and maintenance of technical infrastructure equipment like mains, outlets, valves, hydrants, etc. Most information systems within the Distribution Department are more or less related to these. The rest of this chapter will focus on the most important processes and (relations with) information systems. An important item which isn't especially part of these processes is the exchange of information. This will be treated separately.

Figure 2 shows the most important systems of a typical water board and their relations with

FMS and DAS (VEWIN, 1990).

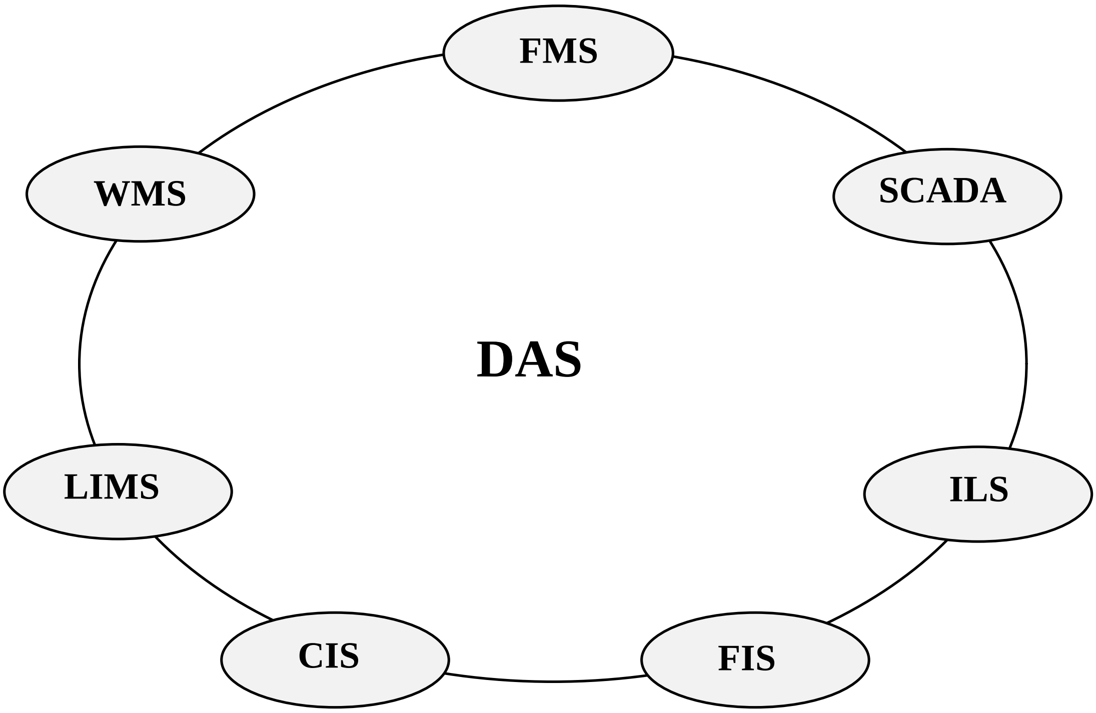

Figure 2 – The most important systems within a typical water board

In order not to create too much confusion, in this chapter generally the term GIS will be used to indicate the use of GIS-functionality, instead of MIS, DAS or FMS.

4.2 Relevant information systems

Within a water board a manifold of information systems concerning facilities information exists. Most of these are related, though hardly by formal or automated relationships. This paragraph will provide an overview of systems relevant to facilities management. Some of the smaller systems are not (yet) automated, or not present at all. The main systems are supplied with some information on in- and outputs, to be able to identify relationships with DAS and FMS.

CIS (*Customer Information System*)

Handling customer information and billing.

Input:	Output:
Customer information	Bills
Addresses	Customer notification
Water use	Water use

Complaints system

Handling complaints on all aspects of the distribution of water. The complaints system is often integrated within the CIS, for most complaints are related to addresses.

Input:	Output:
Complaints	Customer notifications (outage/cut-off)
Address / location	Analysis / cause / correlation
(Cause)	(Repair/sleucing-) actions

LIMS (*Laboratory Information and Management System*)

Analysis of water for different purposes, in order to be able to maintain quality.

Input:	Output:
Water samples	Quality analysis / information
- groundwater (catchment areas)	Protective measurements
- drinking water	
- locations	
Complaints/other signals indicating problem	

ILS (*Inventory and Logistics System*)

Materials management, order processing and materials logistics. Many companies use special software next to ILS to write standard specifications. In most cases this results in an overlap in functionality.

Input:	**Output:**
Materials specifications	Materials order
Suppliers information	Calculation of expenses
Prices	
List of materials	

SCADA (*Supervisory Control And Data Acquisition*)

Collecting process data and controlling equipment on basis of (real-time) information.

Input:	**Output:**
Net layout	Control information
Telemetry information	Water balance
Process (stations)	Input to hydraulic analysis
Pressure / flow (net)	

WMS (*Work/Projects Management System*)

Management of all large projects, especially those related to facilities.

Managing field personnel work programmes.

Input:	**Output:**
Work order	Feedback (planning, finance)
Realised planning	Work order
materials	
personnel	

FIS (*Financial Information System*)

Financial administration, drawing up short and long term budgets.

Input: **Output:**

Facilities information	Budgets Facilities value

Next to these many small, generally standalone, systems exist.

Hydraulic analysis systems (ALEID)

Calculation of flow and pressure on basis of water use, usage models and net structure. In Dutch water boards, ALEID is used.

Leakage monitoring

Often a minor application, sometimes included in the complaints system. The amount of water leakage may be input to SCADA to calculate the water balance.

Geo-hydraulic applications

Application(s) for the modelling of soil and groundwater flow, in order to find and manage catchment areas. These applications use a different GIS (mostly ArcInfo/ArcView) and are responsibility of other departments.

Juridical information and permits

Systems handling all kind of permits on catchment areas, pipes crossing roads or railway lines and pipes on private grounds. Mostly simple database systems, combined with folders of sketch information, stored in archives.

Draught damage

System handling the financial consequences of damage to crops because of lowering groundwater levels or not being allowed to use pesticides. Information is generally kept on drawings. Compensations are generally calculated by hand or sometimes by using ArcView or comparable tools.

Terrains and catchment areas

This information is partly related to the geo-hydraulic applications. Information is therefore managed by that department, and not by the drawing office. Information is often available on drawings only.

Pollution areas

Pollutions can be hazardous to catchment areas, so pollution areas are registered by the Department of Geo-hydraulics. They can permeate or dissolve watermain materials, so registering these areas and relating them to projected and already realised watermains may prevent future problems.

Communication (archives, reception/telephone, mail)

Part of the in- and external communication concerns the concept of the call centre, that will be discussed in one of the next paragraphs.

Management Information Systems

> This consists of all kind of, often especially developed, functions within other applications. Most of them consist of manual gathering of information, followed by an analysis and working-up phase in PC-packages like EXCEL or SPSS. In general this functionality is underdeveloped.

Many systems have some kind of relationship with each other, though little of this is realised in a formal way. Reason for this is that "relational information", the information concerning locations, is still largely maintained on drawings.

4.3 The upgrade/design process

The upgrade process consists of the planning, design and execution of infrastructural works. For clearness of the subject the design part is included here. It will be discussed more extensively though in the paragraph on ILS.

Present situation

The traditional process of designing and building consists of several stages, each of them containing different map products and tasks to be performed. In general the outline of the process is as follows:

- There is always an inducement to an upgrade, like an increase in users because of new wards, complaints on quality/pressure or problems with watermains quality.
- Information from Municipalities or utilities is copied and manually combined with as-built information (by drawing or reproduction).
- This “basemap” is used to design different options. Slight differences lead to drawing new maps.
- Comparing different options is done manually, which is a time-consuming operation. The comparison is on technical as well as financial merits, and includes calculation of materials, work, ground excavations and permits.
- The selected option is redrawn to a construction drawing, fit for a contractor to do his work.
- A final calculation is done (manually) and the materials order is processed;
- When mains and components are worked up, locations are measured and sketched on the drawing.
- The drawings are sent to the main office, where data is once again processed manually on the final AS-built drawings.

Future situation

When GIS is involved and relevant information systems can be accessed, the process can be designed as follows:

- Digital information from municipalities or utilities is combined with -digital- AS-built information, thus forming the base product.
- This map is used in the design stage, options being represented by versions in Smallworld-GIS. Options are copies of each other.
- GIS contains relevant environs data, so comparisons can easily be made. Because of the relationship with ILS, options can be compared on costs also.
- The option chosen is transformed into a construction drawing by just changing information status.
- Materials information is automatically sent to ILS, where the final calculation of costs is done.
- Measurements can be carried out in various ways. When using laptops or pencomputers, measurements can be processed on the spot, using tachymeter or GPS.
- Except for some small changes, the AS-built drawing is an electronic copy of its construction counterpart. Information is supplied by field crew electronically and can be entered in a dedicated part of the database. It only needs a simple check before it is made available to other users.

This outline shows that there is:

- no duplication of data;
- no duplication of work;
- availability of up-to-date information.

4.4 The maintenance process

Information on water boards show an increase in maintenance and replacements of watermains, while expansion of the network is getting less. Formerly maintenance has always been suppositious to new developments. The reason for this is clear: if one doesn't know when equipment has to be replaced, everything is functioning and there is no increase in complaints, money is better spent on other projects. Maintenance was carried out as a reaction on problems or complaints.

A few years ago research showed that in the near future maintenance costs will grow exponentially (KIWA, 1995). Recent research indicates that this giant "bump" will probably be smoothened because "new" materials like PVC seem to hold much longer than expected.

When comparing the loss of water by leakage (6-7% vs. 29% in Great Britain), the general quality of Dutch watermains seems to be good. This doesn't mean that everyone can lean back in his chair:

- National actions have lead to a decreasing water consumption, and maintaining water quality is getting more expensive because of the scarcity of good quality groundwater. Both affect the income and to save expenses water boards have to plan -expensive- maintenance carefully: not too late, but certainly not too early!
- Customer satisfaction is becoming an important issue. Adequate complaints systems will become an important input to the maintenance process, as will water quality information (LIMS).

- Dutch watermains are generally over-dimensioned. Water speed therefore can become too low, especially when water use is decreasing also. This may lead to growth inside the mains, reduced water quality and extra costs for cleaning. Hydraulic analyses therefore will also be an input.

All these require a (predictive) maintenance system, in which all relevant inputs are validated and a more efficient maintenance will be possible. A 1994 article on predictive maintenance mentions descriptive and predictive statistical methods, expert systems and neural networks as part of such a system (Crane, 1994). These may be interesting subjects for research, but when considering the conversion stage most companies are in now, it may be better to focus on pragmatic solutions first.

A preliminary conclusion may be that probably a lot of research has to be done on the various influences on watermains quality, the way they coincide and, most important, what is really going on in Dutch watermains.

This points out the restrictions for a cost/benefits analysis on this application: it will be years or maybe decades before all data and enough experience are available.

Data requirements

Data requirements for a predictive maintenance system go far beyond general contents of a DAS. Most of the network is already in use for many decades, sometimes even more than 100 years, which explains the lack of detailed data.

Conditions of watermains however may not be related to its age only: there are other factors that conspire to damage supply pipes and affect quality standards. Incidents can occur because of weather conditions that may create disruptive ground movements. Building works and excavations may also damage underground assets. An outbreak of localised bursts may indicate deteriorating pipes, changing ground conditions or heavier traffic on roads overlaying pipes. Data on possible influences therefore are manifold:

- technical, like model, material(s), diameter, supplier or age;
- spatial, like soil type, groundwater quality or traffic stress;
- temporal, like historical maintenance records, weather conditions, infrastructural works or groundwater levels.

Most of these data aren't available, not even in paper archives. Designing the functionality of a predictive maintenance system therefore is only part of the solution: data acquisition will be an enormous task to accomplish. When a company wants to handle their maintenance this way though, one way or another necessary data have to be collected.
An investigation on gathering quality data of all pipe materials and diameters per five or ten years of age (by taking out sample parts, endoscopic survey or video monitoring) showed that this project would cost between five and ten million guilders. This would just deliver data on watermains condition; data on possible in- and external influences then still have to be collected. Since it's not clear what this effort will bring, till now no one has undertaken efforts to do so on a large scale.

At the end of 1997 KIWA presented a report on the maintenance of water networks (Rosenthal, 1997). In this report they defined a series of models, to be used to structure maintenance. Filling in the models is a problem they encountered also: they state there is a lack of data on watermains condition in all Dutch water boards. The second problem they encountered is the relative weighing of all aspects on watermain rehabilitation. This report therefore is only the beginning; it may lead to a more scientific approach to data collection.

Considering the conversion stage much water boards are in now, the report is published rather late. Much of the foreign literature quoted is relatively old, implying that water boards have waited for initiatives too long. The question is if they going to develop initiatives on their own , because the conversion is the basis for new applications.

Short term maintenance

Considering watermains two ways of maintenance can be distinguished:

- short term - cleaning by sluicing on a regular basis;
- long term - aimed at watermain rehabilitation.

For some reason everyone now focuses on long-term maintenance, characterised by uncertainty. Considering the information from the previous paragraph it will take long before there will be a serious contribution from this side.

Though not as interesting as a research subject, investments in short-term maintenance like sluicing are also millions a year. Now sluicing is mainly based on materials used, frequency of complaints and experience. This led to sluicing programs that are automatically scheduled, whether or not problems exist.

Sluicing is a good tool to keep watermains clean and preserve water quality, but to optimise investments, programs should be supported by additional data like:

- materials and quality;
- complaints;
- water use, flow and pressure;

- water quality;
- sluicing preparation by hydraulic analyses.

Quality measurement while sluicing will provide extra information on effectiveness of the process and will result in saving water, manpower and money.

Long term maintenance

Some literature claim that maintenance costs can be cut with 50% when all aspects are taken into account and a fully equipped predictive maintenance system is available. Although it seems worth investigating, this will only be the case when a balanced situation exists, which implies that:

- all overdue maintenance must be carried out;
- all watermains quality data must be available;
- data on all influences must be available.

Collecting quality data is very costly, let alone carrying out all overdue maintenance. As concluded before, no company employs serious activities on collecting all relevant data. The basis for full-grown predictive maintenance systems therefore is missing.

Many projects exist though, where mains are excavated and data can be collected quite easily. This may be supported by an automated system to prevent redundant work afterwards. Even when it is done manually at first though, it is probably the only cheap and easy way to collect data. The same applies to the recording of burst watermains and related incidents. Collecting and analysing these data will provide additional information, and may form the basis for a future maintenance system.

4.5 The repair process

Exceptional situations, like the large amount of burst and frozen watermains and outlets during the winter of ‘96-’97, show that an outburst of small incidents can end up in a nightmare to field crew. Evaluation showed that precious time was lost on driving between office and trouble areas because of orientation/communication problems and the need for the right drawings. Though it isn’t as strikingly, this happens every time a field crew drives to a job.

Unlike regular maintenance, repair works cannot be planned, pointing out some critical issues:

- work has to be done fast, because users can’t be warned beforehand;
- orientation may be a problem;
- a need for detailed information:
  - data on the problem area;
  - locations of valves and other critical equipment;
  - locations of critical users.

The greater the problem, the higher the pressure on field crew. At present there are little automated tools to support them. Availability of information at the right place and time is the most critical aspect of this process.

Present situation

The present repair process can be described by some general characteristics:

- Field crew have sets of small scale maps in their car. These are updated once or twice a year, which implies that maps don't contain timely information. Problems though often occur shortly after works have been completed.

- Low priority workorders are handed out at the office every morning, so field crew has to drive to the office almost every day.
- High priority workorders are transmitted by phone, which lacks the possibility of giving detailed technical information.
- Field crew don't have information on critical users or exact locations of valves that have to be closed.
- When the situation isn't clear, mains have to be excavated or detailed and timely information has to be obtained from the office.
- Materials are ordered by phone, and fed into ILS manually.
- After the repair is completed data are sketched on a copy drawing, like described for the present upgrade process, and processed on the AS-built drawings afterwards.

Future situation

When GIS and modern communication technology are involved, the process can be designed as follows:

- Workorders are handed out by WMS, which fills the “order book” of every crew periodically.
- The dispatcher can see on his console where crew are and what order they are working on. In case of a high priority workorder he can notify the right crew.
- Crew use Field GIS with detailed and timely information on watermains.
- Using a link to CIS they are able to assess critical users. By using GIS-functionality they analyse which valves must be closed. GIS will provide them with alternatives in case some might not work or cannot be reached.
- Materials are ordered from ILS by wireless datacommunication. ILS creates a workorder to transport the materials ordered to the location.
- Measurements and materials information are processed on the spot. Data are uploaded into the database and are available to all users within days.

There is already a strong tendency to work from home, rather than from the office. The process described so probably will become reality soon for most water boards.

4.6 Inventory and logistics (ILS) - the design process

On midrange systems records pertaining to material inventories, technical details and prices are available. Relationships with information systems are manifold, but at present most of them are realised manually. The design process is already discussed cursory in the paragraph on upgrading. In this case the emphasis will be on standardisation and the relation with ILS.

Present situation

The design process presently proceeds as follows:

- A new plan is designed, using mains and components based on experience.
- When the construction is complete a list of materials is made manually, which is fed into ILS.
- The list is manually completed with fixing materials, also based on experience.
- The list is the basis for a materials order. This order though can differ depending on the employee who has been working on it.

A shortcoming is, that standardisation is hardly possible. Material choice is based on experience, which may lead to:

- different constructions, which may hinder future maintenance;
- large stocks of all kind of different materials;
- a design process which quality depends on persons;
- increased costs in design, realisation and maintenance.

Future solution

Using a GIS design application and information from other systems accessible, the process can be designed as follows:

- Designed is based on components that are standardised and in stock.

- Instead of single components “macros” of multiple components are used, which enables a faster and more standardised design process.
- When the construction is complete, GIS automatically produces a list of materials.
- This list is automatically completed by ILS, using standard components and fixing materials.
- In fact this is the materials order, independent of who has been working on it.
- Prices are added automatically, for up to date information is available in ILS.

Estimated quantity requirements will be passed back to the inventory control and forecasting system. As this process is refined, delays due to material shortages should be more predictable and less frequent.

The ability to optimise materials planning will turn out beneficial for the size of stocks, while at the same time GIS is used to standardise materials by using carefully selected pick-lists. An additional aspect on cost reduction, though a non-GIS one, concerns the contracts with materials suppliers. Improved planning and standardisation can be used to realise better contract terms.

Functionality can be increased when historical data concerning labour costs and time requirements for specified units of work is available. These can be used to provide an initial labour, transportation and equipment estimate, based upon the materials to be installed.

Experience with a GIS design-application in a US electricity board showed an increase in productivity by more than twenty times. It also provided a 10% cost reduction through better design, installation and use of equipment (Pistorese, 1994).

Although this is just example, it shows clearly what GIS-support is the design process can achieve.

4.7 Customer Information/billing System (CIS)

The Customer Information System (CIS) is the control centre for all billing programs, and thus the central source of all utility revenues. It is also *the* source of timely address data. Many applications use address data as a means for relating information to a location, as there are for instance ALEID and the complaints system.

When information is related to an address, this doesn't automatically mean that it also related to one certain watermain. For calculations on water use this may not be a problem, but when complaints are concerned it's essential to know what main and outlet a customer is on.
This functionality requires the exact location on the watermain where this join can be made. Creating these points is one action; maintaining its integrity is another, which asks for regularly confrontation between GIS and CIS.
This join enables links with many other systems, for it is the one location where GIS and address data come together. A relationship with CIS enables geo-referencing water use and complaints. Also generation of supply interruption notices can be achieved more accurate and in less time.

Municipal taxes and taxes of water boards are more and more collected on the bills of utilities. Borders of water board areas generally don't coincide with the utilities operating area. Storing these borders in GIS enables a more controlled situation and a better response to changes. Creating a solution for one purpose so generates possibilities for many other.

Advances in technology, datacommunication and the need to have immediate knowledge on water usage will eventually lead to a direct metering system. This will not only save the costs of manpower by replacing the cumbersome work of the meter-reader, but will also enable faster and more accurate response to deviations from normal use.

4.8 Work/project Management System

Work- or project management systems are used for managing projects, but also for managing field crew working programmes.

Since the availability of timely information is improved through the use of GIS, project planning capabilities have improved also. Since this improvement concerns all tasks and processes related to GIS-data, it is implicitly present in this chapter and won't be discussed separately.

Work management consists of managing field crew on performing service activations, routine maintenance and necessary repairs. Experience with the Tinoway system show that the use of mobile computer systems and -communication has a considerable impact. (Wondergem, 1995). Benefits are about the same as mentioned in the chapter on Field-GIS.

Developments within water boards show that mobile solutions like this will be used on a large scale within short, though not always in combination with GIS. Also without the combination these systems will generate considerable benefits.

4.9 SCADA

SCADA-systems (Supervisory Control And Data Acquisition) are a family of telemetry-related systems to:

- collect and evaluate process data;
- monitor and manage processes.

SCADA systems are used to monitor and operate processes from a distance. The amount of switches and relays, the ease of manipulating these from a distance and the need to react on fluctuations make that these tools are very well developed within electricity boards.

Compared to this a watermains network is rather static: there are few pumping stations and reservoirs, and all equipment in between is more or less a fact given. Most stations function almost autonomously, and only few functions can be influenced from a remote (central) location. Main function is acquisition of data, which is analysed and by which adjustments can be made. This however is based on trend analysis and is therefore not realised real-time. Most companies use pressure and flow meters in the field, but only few have an interface to the control system.

Considering network stability, the underdeveloped control and operating capabilities are explainable. Most networks are divided into areas with stable pressure. On borders there is little flow, resulting in sedimentation and oxidation. Fluctuations therefore would lead to these deteriorations coming off, so to prevent complaints on quality control is aimed at keeping a stable situation.

SCADA is part of the FMS and could possibly use, or be related to, GIS. This idea comes automatically when comparing SCADA infrastructure schematics with the GIS representation of the network. Even electricity companies though doubt the need for an integrated SCADA/GIS, considered the differences in functionality. For them, an integrated solution lies in the future. The idea is, to develop environments in which systems can "consult" each other (Berkel-Coumans, 1996).

Developments in water boards ask for more efficiency, which will result in doing more work with less people. Merges lead to larger areas to be controlled. This may result in installing more equipment that can be operated from a distance. It is unlikely though that water boards will adapt the concept of an integrated solution on a short term.

There are however some short term possibilities for using SCADA-data in other applications:

- use of pressure and flow data as input to ALEID;
- use of differences in pressure (-areas) and flow as input for the complaints system, to be able to assess cause and effect of deviations.

For these, no direct link between SCADA and GIS is necessary.

4.10 Laboratory Information and Management System (LIMS)

Most water boards have laboratory systems or use external organisations to collect the necessary data. Legislation forces them to perform a certain amount of quality measurements to ensure that the water they deliver is within a specified quality range. These data have always been related to locations manually. It was virtually impossible though to track down all causes of less quality water, because the data needed for assessing cause and effect couldn't easily be referenced spatially.

Storing the locations in GIS enables analysis of the relationships between water quality and other aspects of the distribution process. Summarising the possible causes of affected water quality leads to the data necessary to be recorded in or accessible via GIS:

- quality of, and materials used;
- burst pipes and leaks;
- maintenance works and sluicing;
- pollution of environs - type and location;
- flow - direction, amount and changes;
- water use;
- quality data from pumping stations and reservoirs;
- complaints.

Most data eventually will be geographically referenced, and when this is realised, GIS will provide the functionality to perform the necessary analyses.

Which system will incorporate all this functionality isn't clear yet, but it is possible that LIMS will expand or will become part of a Quality Management System.

Like information from the complaints system, less quality drinking water may be an early indication that something is wrong. Water use is getting less, watermains networks are over-dimensioned, and as a result reduced flow may lead to deterioration of water quality. Quality data from LIMS may therefore prove to be a valuable information input to the maintenance process.

4.11 Hydraulic modelling

Dutch water boards mostly use ALEID for performing hydraulic modelling and analysis operations. At present preparing input sets for ALEID is very time-consuming.

Present situation

Preparing the input for ALEID consists of:

- digitising the watermains network;
- adding data on diameters, lengths and frictions;
- adding water use by means of querying the CIS for water use on a basis of postcode areas;
- assigning summed use to nodes, based on experience;
- completing the input with locations and data on reservoirs, pumps, watermains height, etc.

Preparing input this way costs weeks of cutting drawings, marking up areas and assigning usage to nodes. Though this sounds like kindergarten work, it is based on experience and knowledge of the network. Maintaining these models is difficult, time consuming and fault sensitive.

Future situation

Most of the required input for ALEID can be found in the GIS database. Watermain types and sizes are available in virtually all GIS datasets and friction factors can be derived from these attributes. Lengths can be calculated with great accuracy and part of the nodes can be generated automatically on basis of net layout. Since GIS is a model of the real world this will yield an accurate, up-to-date hydraulic model of the network (McLeroy, 1994).

Additional attributes must be added at reservoirs, pumps and other model nodes, because these are generally not available in GIS. Since these data seldom change and can be stored in the model, additional data entry is limited.

Availability of customer address locations in GIS will be a matter of time. PAP and ACN (combinations of address and location) provide a means for realising such a relationship. For dealing with water use these are accurate enough. Other applications may ask for a 1:1 relationship between watermain and customer. Some companies generate these points themselves, based on detailed information on outlets.

When customer locations are available, water use can easily be related to watermains. As next step recent information on water use from CIS will be extracted. Together this makes up the input file for ALEID. When the modelling and analysis process is finished, information can be put back into GIS for different purposes:

- presentation of results;
- input for planning and development;
- storage of the model.

The first purpose is clear, for now presentations can be generated based on the real net-layout. The second one is more interesting. When proposed changes are available in GIS, financial consequences can be calculated and weighed against other options. Storing the model ensures that ALEID keeps up with future changes in the watermains network.

A mentioned before watermains are generally over-dimensioned. When striving for an optimum in costs of realisation and maintenance, the role of applications like ALEID will become more important in the future.

4.12 Documentary information / sketches

Documentary information systems (DIS) were already mentioned as a way to streamline processes. Next to the “real” DIS, some companies use systems for storing sketches of outlets consisting of databases with outlet data and scanned sketches. Known solutions for this problem are Diasys and SchetsView. New sketches can be scanned, drawn in a simple CAD-package or chosen from a pick-list with standard solutions.

On first sight these data are more at place with the rest of information on facilities. Sketches though are mostly used apart from GIS, which doesn’t make it necessary to store them there. Tests in the past also revealed that conversion would cost far more. Storing the data in GIS also implies that access must occur through more expensive hard- and software. The solution chosen uses low-cost software on standard PC’s, which makes distribute of the application less costly.

Several companies already use these applications in the field, which has the same advantages as discussed in the chapter on Field GIS. Solutions exist, in which the sketches are related to the location of the outlet in GIS, and both systems can be accessed from within the other. This way information on both sources can easily be retrieved, which increases efficiency especially when providing information to external organisations.

4.13 Fire hydrants/valves systems

Most water boards use some kind of automated system on fire hydrants and valves. They have to, because they own many tenthousands of them. Main purposes of these systems are maintenance and to provide information to fire-departments and municipalities. Most applications use midrange systems; often functionality is included in CIS. Information on locations however is kept on map sheets in the drawing office, resulting in two departments maintaining it. This makes it difficult to relate tabular information to locations, which leads to discrepancies in case of changes in municipality borders and removal, movement or renumbering of valves and hydrants.

The drawings don’t contain technical and maintenance information, which prevents integration of the maintenance with that of watermains. Fire hydrants are also used for sluicing purposes, but since there is no relation to addresses it is difficult and time-consuming to notify the customers affected.

Fire hydrants and valves already have a location on the map, so they are automatically converted into GIS. The next step may be, to store existing data there also or make it accessible via GIS. For some companies the ease of having all data in one system is reason enough to build a new maintenance system for hydrants and valves in GIS.

4.14 Complaints system/call centre

Utilities get many thousands of complaints a year on all kind of subjects. Since customer satisfaction has become one of the main points of attention there is a increased interest in improving the handling of complaints.

Present situation

Complaints come in by telephone and, depending on the kind of complaint, the complainer is connected to an employee of the department concerned. Complaints can have several origins, e.g. outage because of a burst main, brown water because of a section of the network being cleared or questions on billing. Because of the variety handling the complaint often results in someone writing it down. Some action is undertaken and (hopefully) the complainer is called back later.

Complaints systems are generally part of the CIS, for complaints are mostly related to addresses. In most cases CIS cannot access information from other systems, which limits it capabilities to support the handling process. When facilities are involved, most of the necessary information is available, but not “real time”. It is scattered over different departments, systems and employees. Timely information on recent works or problems in the watermains infrastructure is generally only available through the employees directly involved. At present information is combined through a number of phone calls, which is:

- slow and cumbersome;
- expensive;
- customer unfriendly.

The need for cost reduction and improved customer service call for a different approach, using GIS/IT as well as reconsidering the process of handling complaints.

Future situation

If the receptionist would have the information at hand, it is expected that 90% of the questions could be answered directly, thus resulting in satisfied customers and financial benefits because of less telephone calls and time spent by the different departments. The system also keeps track of complaints and sees that they are handled correctly and within a reasonable time.

Complaints on e.g. water quality may be a first indication that something is wrong, which may change the attitude. Using this might be a cheap control on network-/water quality and an important input to the maintenance process.

Functionality like can't be realised overnight, because it needs to access all kinds of data:

- watermains status, infrastructural works, outages;
- water use, pressure and flow;
- water quality;
- other complaints, to find out clusters and relationships;
- ....

A newcomer and hot item in the communication with customers is the Call Centre, a central facility where all telephone calls come in and are handled. Much attention is on technical (telecommunication) equipment and automated solutions for reducing human involvement (voice response, automatic call distribution).

An investigation shows the distribution of investments in such centres:

network (Telecom)	20%
overhead	12%
equipment	8%
salary	60%

Source: Automatisering Gids 1996/43

Though these percentages may not be representative for Call Centres in utilities, they show that effective dialogue management and data navigation facilities will have an enormous impact because the reduction of handling time. To consult other applications relationships must be established, most of them using GIS to be able to geo-reference aspects concerning the watermains network. GIS therefore may be one of the important facilitators of an integrated Call Centre. An working example of an application in a Smallworld-GIS environment is HP's Customer Contact Manager (Quarmby and Leinemann, 1996).

4.15 Information exchange / KLIC

Since The Netherlands are the most densely populated country in Western Europe, there is a growing need for information on underground infrastructure to support planning and building activities. Utilities get in- as well as external questions on their facilities. Part of the external questions are handled by KLIC. In this paragraph the present and possible future working methods of KLIC are discussed. The outcome though is applicable to all information exchange.

In The Netherlands, KLIC (Cables and Mains Information Centre) is an intermediate between anyone who employs activities involving any digging and organisations managing cables and mains. KLIC was founded to reduce maintenance costs by preventing damage to cables and mains by structuring the provision of information. KLIC therefore is paid by the managing organisations.

Present situation

At present anyone who wants to employ underground activities informs KLIC on name/organisation, date and place. KLIC has information on utilities per map quadrant. The utilities are supplied with the necessary information, so they can provide the requester with locations of cables and mains.

Utilities secure themselves against claims by stating that any information on locations has to be checked. According to recent articles, there is a tendency to let companies pay part of the financial consequences of an outage. If this becomes standard procedure, more attention must be paid to the KLIC process.

Although much effort is spent on providing information, direct costs of damage are estimated at about Dfl. 150 million per year (Zevenbergen, 1994). It is guessed that some contractors use KLIC-information as a carte blanche to tear cables and mains, which is easier then taking care of underground infrastructure. Notifying KLIC frees them from repair costs, which will be paid by their insurance companies. Being able to provide better information can result in a different attitude concerning this problem. When the quality of information can be guaranteed escaping responsibility won’t be as easy anymore.

The present situation has a number of shortcomings:

- many different sources of information;
- bad quality maps, e.g. copies of a copy;
- information can't be combined (different map sheets (or parts of it) and scales);
- information may be drawn on a map sheet with pen or colour marker;
- information is not confined to the location; often complete wards are supplied;
- anyone can get information; there is no means of control;
- information is sent directly to the customer, so there is no control on quality or completeness;
- the process is very time-consuming, especially on the side of utilities:

An inquiry, carried out in 1995, revealed that utilities spent an average of Dfl. 100,- on finding, copying and sending the information for one request. Per requester, an average of 7.8 utilities were approached for information. For the whole country 64.363 requests were counted in that year, summed up to about 50 million for all utilities. KLIC registers an increase in requests of 10% per year.

In the new system, that is about to be accepted by KLIC, locations can be found on basis of street names, house numbers and postal codes or by pinpointing on the screen. This however only covers the accuracy problem of the previous system and reduces working pressure on KLIC-personnel.

At this moment this is the best KLIC can do, for only few utilities employ a fully operational GIS. Most organisations however are converting their map sheets or have plans to do so within the next few years, so now is the time to consider the use of modern technology to improve the process.

Future situation

When all organisations have finished converting their data the most simple solution would probably be to make it available via Internet. For e.g. contractors this will do, but not all private persons will not get to the information easily. Other problems may be process control and legal aspects concerning responsibilities.

There is also the aspect of combining data from all utilities; it’s not acceptable if one has to visit 8 websites to get the required information.

Formerly utilities were against information to become public, resulting in specialised personnel handling the requests. At the moment though information is often provided by non-specialist personnel already, so automated solutions may not be so far away. Since it’s not always possible to discriminate exact locations automatically, some human involvement (from the utilities or KLIC) will still sometimes be required.

The present process can and must be improved, and if KLIC will survive is the question then. Improvements can be reached by:

- better information, so calamities and financial claims can be avoided;
- cost reduction by:
- providing only the information needed;
- combining information to one product;
- cut down human involvement on both sides;
- better means of control.

At present the information provided is based on quadrants instead of exact location, which may lead to superfluous information. The future KLIC-database contains the exact regions utilities are responsible for. KLIC "looks" into the utility's database and queries it for the correct information.

Profits will especially be gained within the utilities, for the only thing they have to do is to make their data available to KLIC, e.g. by means of a restricted user account. KLIC doesn't need to access the database itself; it is sufficient if a facility exists which accepts co-ordinates and provides information on that area.

A simple solution would be using something similar like a plotting mechanism which copies data to KLIC, based on area information. KLIC checks the information for quality and completeness, combines it on a base map and sends it to the requester, a process that can be automated to a large extend.

It is clear that combining information and providing a better product has everything to do with agreements on standards, and will depend on the conversion processes to complete.

The process of requesting information will also be influenced by new technology. In the application that is about to be introduced a requester, using the same application like KLIC, can file his own request. KLIC then will be relieved of filing the requests, resulting in a decrease in required manpower. This though is merely a temporary solution; different examples show that Internet can perfectly be used to access geographic information. KLIC can enable requesters to define the area of interest themselves by making an application available via Internet. The effect on KLIC manpower will probably be the same, but it saves contractors of buying applications that will be superfluous in a few years.

When considering the 50 million spent on provision of information KLIC-processes will certainly change. It is even possible that KLIC in its present form will cease to exist. The solution described above isn't an "ultimate" one; when keeping in mind the developments in Internet technology more sophisticated solutions will become available in short.

4.16 Management Information

Literature on information systems mentions MIS, EIS and other systems for years already now. The purpose of these systems is, to create high-level information which will support managers at different levels in the organisation in decisionmaking. The intention has always been to let managers themselves filter the necessary information out of the data available. For some environments this has been successful; in other situations information is still produced by anyone but the manager. Reason stated is often lack of time, which is probably an excuse for not understanding the technology. People often can't be blamed for this; differences in systems, interfaces, menus, operating systems and data descriptions don't make it easy for a casual user.

The way data on facilities were stored has always been the main reason why these were difficult to access. The preceding chapter pointed out the importance of communication and relationships between information systems. These are base prerequisites for accessing and creating the information needed. GIS is a powerful interface to this information, since the visual and intuitive way of operating an application is much more related to the human way of perception.

Examples of different applications are provided in the preceding paragraphs. Much of the information isn't strategic, but is in fact "management information". Through GIS data can be accessed and visualised much better than before. The possibilities of GIS will enable organisations to get hold of the information they desire. Eventually the interface will become that sophisticated that even managers will be able to operate it, leading to real "management information".

4.17 Conclusions from this chapter

The processes and information concerning facilities are manifold and complex, at least the way they are handled now. Data are stored in various systems that have no formal or automated relationship. From the different descriptions it becomes clear that GIS can contribute to cost reduction and more efficient working procedures. More important though is, that most of the benefits are realised by improving communication. Communication meant here is between information systems, between the office and field crew and with external organisations. GIS, or more concrete the digitisation of facilities information, is the facilitator these exchanges and relationships. When coming down to the benefits, only part of it is a contribution solely of GIS.

5. The questionnaire

5.1 Objectives

As already stated in the introduction interviews will be required to be able to obtain information on benefits and priorities of possible new applications. Because of the complexity of the matter and the limited knowledge within the companies proper preparation is key to this process. The choice is made first to develop a questionnaire. This has several advantages:

- time is saved, because there is no need for ample explanation beforehand. The interviewees become familiar with the field and answer questions at the same time;
- many answers won't be available directly during an interview, especially not those on man-hours spent on certain tasks. This way time between answering the questionnaire and the actual interview can be used for doing necessary inquiries;
- answers can be used to improve preparation of the interviews;
- the questionnaire can be used as a guide-line for the interviews.

Part of the questionnaire has a limited function in the process, because all answers will checked anyway in the interviews. It will give the representatives a chance though to become familiar with the issues and think it over at their convenience. For the interviewer the outcome is a check on the quality of the questions.

Except for changes due to omissions or errors, the questionnaire will act as a leading thread in the process.

5.2 General contents and approach

Technical possibilities and applications are described in the previous chapters in detail. Translating these in a way that representatives fully understand is hardly feasible and also largely superfluous because the explanation part probably has to be done over again when performing the interviews. Therefore only a summary will be used in the questionnaire. All technical detail will be removed, so questions will be in conformity with their way of thinking. The questionnaire focuses on:

- priorities;
- the costs in the present situation;
- the benefits by using GIS/IT.

This results in a limited amount questions per application/relationship. The questionnaire will also contain some general questions on the company's size and the experience with GIS till now, which may provide some extra information when evaluating differences in the outcomes.

The companies will be invited to give as much information as they want, for this may explain more about the answers given. The context may provide extra information on reliability. Information must not be confined to the questions, for all information may add to the quality of the rest of the process.

The questionnaires will be sent by E-mail in MS/Word-format. This has several advantages:

- representatives can add as many comment as necessary;
- answering the questions this way (behind the PC) probably leads to more serious/structured answers, but this is from own experience;
- most important: it is much more easier to read afterwards.

Since the company's targets also mention "customer satisfaction" and "quality", questions on these issues will also be present in the process. Information on these intangible benefits though will be obtained in the interviews. Answering questions on these issues is defined by subjectivity, which makes them better at place there.

5.3 Outline of the questionnaire

In this paragraph the inducements to the questions will be explained. An example of the actual questionnaire can be found in the next chapter.

In general questions can't be treated apart from each other. As the descriptions on the different applications showed also, there are many relationships between the various systems and data sources. Relations can be beneficial for one or more applications. This is something that has to be kept in mind when evaluating costs and benefits.

1 - Size of the company

Some distinctive numbers on the size of the company will give information that might explain differences in man-hours spent or tasks that are whether or not carried out. It can be used as an extra check on certain proportions.

2 - Experience with GIS (time)

In order to be able to have some reference on the reliability of the information provided, some questions on the experience with GIS are added. Even though many answers are more or less based on general ideas, there still is a difference between a hunch and a idea, based on some experience.

On all the next items a series of questions has to be answered. These can be found in the questionnaire example in the next paragraph.

At first there were more questions, but it was concluded that they did not add extra information. One question was, if certain developments were meaningful. This however can easily be deduced from the question on priorities. A second question was on the amount of working spots where the application was to be used. For one company this was the amount of licenses (floating licenses!), for another the amount of employees that were going to use the application and for yet another the amount of workstations. The obscurity created was reason enough to skip this question. The amount of licenses can be deduced from the man-hours spent in the new situation.

3 - Information exchange to KLIC and others

The previous paragraph showed the amount of money spent on information exchange via KLIC and the means to improve this process. Since this concerned only part of the total exchange and substantial benefits are expected it is a necessary subject to investigate. Companies don't keep records on the different in- and external requests for information, therefore the process of information exchange is treated as one.

4 - Integration of small systems

Water boards have multiple small systems in which they keep information on facilities and related objects. At present these systems function standalone, whether or not they are automated. Information can be kept on a midrange system (valves and hydrants), on PC's (permits) or on sketches (cable network). This often results in maintaining data at different places, because generally part of the data (locations) is kept on drawings also.

Benefits of an integration with GIS won't be enormous and probably can't be specified exactly. Because costs of integration are minimal when a GIS-environment is available, it is interesting to know which applications have priority and if there are other benefits. The systems that come up for discussion are:

- Valves and fire hydrants;
- Permits;
- Terrains;
- Pollution areas;
- Cable network.

5 - Relationships with other information systems

5a - Hydraulic modelling

Since preparing the input for ALEID is taking much valuable time and a large part of the input can be derived from GIS this seems a very beneficial relationship. Therefor e it is important to know how much time is spent on this work now. The general idea is that in the future the use of ALEID will increase, but at the moment it's not clear what the company's policies are.

The Dutch branch of Smallworld is working on an in- and export function to realise the relationship between GIS and ALEID. It's not clear what it will cost, but it is meaningful to know the benefits of such a tool beforehand. Benefits of a simple tool for one of the companies turned out to be very beneficial, so expectations are high.

5b - SCADA

From the description in the previous paragraph it can be concluded that a relationship probably isn't considered to be necessary or beneficial. A question will be added though to check this and, more important, to get information on the way SCADA works within water boards.

5c - REGIS

REGIS is an application on a different GIS-platform ("island") within the Department of Geo-hydraulics, as most information systems used there. There may be relationships between GIS and REGIS, though it is questioned what this will bring. The questions therefore focus of the necessity of such a relationship and a possible migration to the Smallworld-GIS platform, more than on financial benefits.

5d - Engineering

Engineering drawings are used mainly in the Production Department. At present the Production and Distribution department use separate (drawing-) systems for maintaining the information on facilities. Developments show a tendency to have the Distribution Department handle information on Production mains also. For them this concerns little extra work because of the small amount of mains. The Production Department maintains many drawings on pumping stations, reservoirs and special equipment also. A relationship would enable access to this extra information as if it concerned detail drawings. There may be some efficiency benefits because a better access to data, but large financial benefits aren't expected.

5e - Drought damage

Systems concerning drought damage at present don't use much GIS-functionality. Mostly a presentation tool is used to make pictures. Since drought damage has everything to do with overlaying catchment areas with parcels and land-use, a GIS seems to be the perfect tool to solve the problem. The questions here are, why is GIS used so little? Is it because drought damage itself gets little attention or is it concerned with presumed costs of data and GIS-applications?

5f - Laboratory Information and Management System (LIMS)

Maintaining drinking water quality is one of the targets of water boards. Quality problems at present can only be related to causes with great difficulty. If a GIS with data on watermains and addresses is available, little extra functionality (=costs) is needed to expand the capabilities concerning the assessment of quality problems.

5g - Customer Information System (CIS)

The CIS is *the* source of accurate address data and therefore one of the systems that must be related to GIS in order to reap the benefits of other applications like the complaints system, ALEID or LIMS. Realising the relationship is fairly easy, depending on ones requirements. Relationships with addresses are contained in other applications also, so this question will focus on mailings and notifications to customers. Because the relationship will probably be necessary for other applications, the extra costs for this addition will be minimal.

5h - Inventory and Logistics System (ILS)

When standardising by the use of a GIS design-application it seems reasonable that, beside benefits in the design process itself, there are benefits like reduced and standardised stock. The question is, if this standardisation is the result of GIS or the implementation of ILS itself. Financial benefits will be very hard to define.

6 - The design process

6a - Using GIS/IT in all stages of the preparation and design process

The design is one of the main processes involving facilities data, and may not be absent in this questionnaire. Present costs can easily be tackled because it is clear how many people work at the drawing office. Since the companies have built up experience in the conversion, they can also exactly specify the benefits. This makes it a very well outlined process to calculate costs and benefits.

Though in general the process is clearly outlined, only overall man-hours are known. This became clear after the first questionnaire session. At first this process was divided over different questions. From the answers it seemed that it wasn't clear what exactly was meant. The true reason though was the fact that the companies didn't have information detailed enough to answer these questions. The choice therefore was made to put all in one question and add sub-questions on detailed subjects.

6b - Use of electronic data exchange in the design process

Part of the design involves the use of external maps. A lot of manual work is done, which is guessed to be a substantial part of the whole process. This part can easily be discriminated, which will deliver accurate information on benefits. Since most of this work will be superfluous when GIS is used and maps can be supplied in digital format, it may be one of the most simple beneficial applications.

6c - Use of external data to support the design process

When designing plans for new mains, generally external data are used to be able to find out the best option. Mostly little external data are gathered in the field, when the plan is nearly finished. Companies are looking forward for an object-oriented basemap, which they think will provide them with the necessary information. This question must make clear to what extent the companies are in need of these data.

7 - Revision process

The question on the revision process also emerged after the first questionnaire session. Since revision of data is part of more than one process, it wasn't clear how to divide the amount of man-hours over these processes. The choice was simple, because data on the costs of the revision process, at least when office work is concerned, can easily be derived from the amount of employees in the drawing-office.

The process also involves working up the revised data in the field, using modern equipment like Field GIS and GPS. This will be less easily to tackle. Question 10c will also address this issue, aimed at more general aspects.

8 - Preventive maintenance system

It is said that these systems will save enormous amounts of money on rehabilitation of mains. Since investigations in The Netherlands are continuing and no definite statements on benefits are available, it is not to be expected that water boards have anything definite to say on costs and benefits. This question however is added especially to get an idea on how companies plan their maintenance now and how they think GIS can help in the future. Since companies generally don't use planning mechanisms, based on aspects discussed in the previous chapter, information on costs and benefits will be no more than hunches. More important though is, how they think preventive maintenance could function in the future.

9 - Customer complaints / Call Centre

Customer satisfaction is one of the main targets of water boards, and Call Centres are a hot item in most organisations also. These therefore will be common property within short, which is reason enough to try and get some information. Since there is hardly any comparison with existing tasks, focus is on the present system. This part must provide information on the costs of this situation. Another important issue here is customer satisfaction, for this is the most important system to improve this.

10 - Miscellaneous

10a - Generating special map products

This question is added because it’s a task that fits nowhere in the previous questions, though it is simple and can easily be inquired. Companies use different map products, and using GIS part of this can be automated. Special attention will be paid to the question if the benefits aren’t overestimated, especially because Smallworld-GIS is used, which isn’t known for its well-developed mapmaking capabilities.

10b - Management information

GIS is known for its analysis capabilities and ability to combine various sources of data. This would make it a perfect tool for generating management information. Generating this information surely won’t be the problem; more important is, what is spent at the moment to generate this information. Probably there won’t be much information on this issue.

10c - Field GIS

though most of them have already visited some workshops, Field GIS is relatively new to all companies. The intention of this question is, to get an idea on the opinion on these new developments. Within short some of the companies will start pilot projects, so it’s interesting to know what the expectations are.

5.4 Example questionnaire

Contrary to earlier remarks on changes, these changes are already contained in the questionnaire. Placing them at the end of the chapter was considered to be obscure, also when considering the results that are discussed in the next chapter. The items that are changed and the reasons for these changes are mentioned in the previous paragraph on the outline.

The following example questionnaire is a translation of the original, which was of course in Dutch. Some changes were made along the way, but it is tried to keep the translation as authentic as possible.

Introduction

As you all know I'm trying to get my M.Sc., and in order to do so I'm writing a Thesis on costs and benefits of new GIS/IT applications. It would have been possible to write it based on articles and information from companies that are already heavy involved into GIS. Since water boards are somewhat special though it seems better to try and collect the data myself. Therefore I have developed a questionnaire, which must give an impression on:

- priorities;
- costs in the present situation (man-hours);
- expected benefits by using GIS/IT.

Some answers can easily be obtained because it concerns an acceleration in relation to the "old" tasks. Other questions may be more difficult, because it concerns tasks that aren't performed now. It will be difficult to define benefits here, but maybe an estimate can be given. If possible, indicate what this estimate is based on (read in an article, heard from colleagues from other companies).

If it isn't possible to give information on the expected benefits, please give the costs in the present situation. Maybe it's possible to derive the necessary information from the other answers.
At every question there is room for remarks and amplification, because it's impossible to develop a questionnaire fit for everybody.

It's very well possible that an application or relation has slipped my mind. These can be added at the end of the document. Be free to give as many comment as you want!

If there are questions I can be reached at the office or at home (...). To complete this stage possibly some consultation by phone will be necessary. All answers will be checked during an interview, for which I will visit all representatives.

I'm aware of the fact that answering these questions is one hell of a job. You have to keep in mind though that especially concerning the benefits an order of magnitude is enough. It's not important to know if the benefits are 8% or 12%, however it's important to know if it's 10% or 50%. Also the man-hours spent now may be rounded up to a hundred. If answers are guessed it's better to place an "X" or to state clearly that it concerns a guess.

For the sake of good order, names of companies will not be mentioned in relation to the information provided.

1 - Size of the company

1. total length of mains;
2. total length of outlets;
3. number of customers;
4. service area;
5. number of employees;
6. expenditure on new projects;
7. expenditure on management/maintenance.

2 - Experience with GIS (in terms of time)

1. pilot project
2. conversion
3. other

The questions asked on every application are:

1. is the task carried out (manually) in the present situation;
2. what is the amount of man-hours spent per year;
3. what is the (relative) priority of the application and at what term will it be realised;
4. what are the savings when using the application in a percentage or in man-hours;
5. other benefits and comments.

Priorities are rated from 1-4, in which 1 equals high priority and 4 equals low priority.

Next to these questions, some other have been added to get extra information on certain subjects.

3 - Information exchange to KLIC and others

Information on mains and outlets to KLIC and other in- and external users is now produced by copying drawings and sketches. Information concerns watermains as well as outlets. Outlets will generally be available in a DIS and watermains will be stored in GIS. By using these systems, information can be made to measure, which will result in benefits in time as well as materials (drawings, copies, plots). When GIS and DIS are linked benefits will even be larger. In the near future information exchange will be done by e-mail or other electronic services. Data can also be made available via Internet. When this is realised, the manual process of providing information becomes due, realising the optimal benefits of technology.

4 - Integration of small systems

4a - Valves and fire hydrants

Most water boards have some kind of automated administration on valves and fire hydrants. Next to this, locations and numbers/status are recorded on drawings, resulting in difficulties in keeping the information consistent and up-to-date. When both sources are combined into or through GIS, timeliness can be guaranteed and provision of information to e.g. fire-departments and municipalities is made easier.

4b - Permits

Water boards manage permits for different kind of activities, as there are catchment areas and mains/cables on private property. Most data stored are on administrative issues. When storing at least the spatial part of these data in GIS, management of permits will become easier.

4c - Terrains

Water boards own terrains around catchment areas and pumping stations. Management of these terrains can be done using GIS.

4d - Pollution areas

Pollutions can be hazardous to catchment areas, so pollution areas are registered by the Department of Geo-Hydraulics. Certain pollutions can permeate or dissolve watermain materials, so registering these areas and relating them to projected and already realised watermains may prevent problems in the future.

4e - Cable network

Water boards often manage own networks of cables for data acquisition and operating equipment from a distance. Data are generally kept on drawings (which are often copies of the drawings containing watermains). When GIS functionality is available, this application will cost little extra. It enables integration of cables and mains, which facilitates maintenance and the provision of information.

5 - Relationships with other information systems

5a - Hydraulic modelling - ALEID

GIS-applications can be coupled with ALEID, a program for hydraulic modelling.

Much of the data needed by ALEID is already available in GIS, as there are a schematic network, lengths and diameters. This will reduce the time needed for input. Information on water use can be obtained by a relation with CIS, which delivers addresses and water use. When ALEID returns different solutions, information can be merged back into GIS/Smallworld, where they can be compared on costs.

5b - SCADA

In literature we can read articles on SCADA (Supervisory Control And Data Acquisition) systems, mostly related to Electricity companies. SCADA is aimed at monitoring and managing equipment from a distance. Within short data from SCADA can be used in relation to the complaints system or ALEID. Full integration with GIS will probably not be realised within the next years. Would this be a meaningful application for water boards?

5c - REGIS

Some water boards use REGIS (REgionaal Geohydrologisch InformatieSysteem) for geo-hydraulic processes concerning their catchment areas. REGIS was developed on the Arc/Info platform, but nowadays a version on Smallworld is available also. The questions are focused on a possible integration of DAS and REGIS:

- is it realistic to strive for integration if REGIS is still an Arc/Info application?
- are the expected benefits that large that a migration to Smallworld is realistic?
- is it necessary to integrate the applications, because there is a difference in use(rs)?
- when integration in not an issue, maybe benefits can be achieved by enabling

possibilities for easy exchange of information and use of the same basemaps.

5d - Engineering

For architectural and mechanical engineering CAD-solutions are used. It is possible to approach and view these drawings, thus offering a complete environment. Would this be a meaningful functionality?

5e - drought damage

Farmers who live inside or near catchment areas have settlements by which they can get money for the loss of proceeds of crops because of the dropping groundwater level. There are also settlements for not using harmful pesticides. Most companies use PC-based systems for managing these settlements. When catchment areas are stored in GIS and are combined with cadastral data, the process can be better controlled, adaptation to changes is faster and handling costs will be reduced.

5f - Laboratory Information and Management System (LIMS)

Most companies use a laboratory information system to measure water quality on different locations in the net as well as in reservoirs. The outcomes include a spatial component however, this isn't used extensively to track down causes of disturbances in quality. Locations can be managed in GIS just as a standalone application, but it can also be seen as part of the quality and maintenance system.

5g - Customer Information System (CIS)

Address information is available in the UIS, together with information on water use. In case of outage or cleaning of watermains, mailings have to be sent to the people concerned. When a relation between address and location exists, addresses concerned can automatically be detected. It is also possible to check if vulnerable users, like dialysis patients, dentists or laundries are involved.

5h - Inventory and Logistics System (ILS)

In the GIS, a relation can be made with the materials/logistics system. When this is realised, it is possible to:

- standardise;
- reduce stocks by better planning;
- get better contracts with suppliers because of better process control.

Eventually this will lead to a reduction of materials costs.

6 - The design process

6a - Using GIS/IT in all stages of the preparation and design process

Within GIS a design system can be realised, which makes an optimal use of GIS/IT possibilities:

- standardisation of materials;
- easy comparison of options;
- automated materials lists;
- relation with stock management for timely prices and stocks;
- relation with logistics and planning;
- different map products (plan, construction, as-built) use the same base information, avoiding duplication of work;
- all field workers use laptops for accessing information;
- measurements are carried out by electronic equipment and can easily be translated into GIS;

- all “drawing” is carried out in the field; the only task of the main office will be a last check on data quality before these are merged with the master database.

The questions concern all functions mentioned.

6b - Use of electronic data exchange in the design process

This moment external data (drawings) are used in planning extensions. These drawings are traced or copied, and combined to form a “basemap”. When GIS is introduced, exchanging and combining data can be done digitally, thus avoiding manual work. When planning new mains, this is often combined with other utilities that use the same strip. Here also the exchange of data can occur digitally.

6c - Use of external data to support the design process

By storing data on:

- cadastral parcels;
- soil type;
- groundwater level;
- land use;
- metalling

it will be possible to automate part of the planning, calculation and specification. Buying and maintaining these data however will cost also, but part of the data can be used by other applications. Is this solution beneficial?

7 - Revision process

The revision of changed data can be done much faster and more efficient when GIS is used. Revision merely exists of changing the status of the design information. When equipment is available in the field, changes and measurements can be fed into the portable system directly. Office personnel only have to check the information before making it available to the rest of the organisation.

8 - Preventive maintenance system

Professional magazines regularly publish articles on the costs and benefits of maintenance and the overdue in watermains maintenance. Not only water boards suffer from this; sewer systems seem to be even worse.

The message is, that preventive maintenance is more beneficial than corrective maintenance, the repair of damages. It is stated that preventive maintenance will reduce the costs of maintenance by 50%.

Benefits are the avoidance of outages and better planning of work. Reducing outage can also be seen as customer service. To achieve this, water boards have to catch up in data acquisition because much of the data needed to carry out maintenance like this aren't available. Also the overdue in maintenance has to be caught up, resulting in an increased investment which will counterbalance the benefits at first. For this application many relations with other systems have to be realised and much data have to be gathered, much of these can be used by other applications also.

Part of the questions will be hard to answer. The intention of this question is to get an impression on the possible benefits on maintenance by using an optimal (preventive?) maintenance system.

9 - Customer complaints / Call Centre

GIS is generally seen as an integrator of different sources of data. When the relationships are present, the registration and handling of complaints will become easier. In the present solution a receptionist accepts the call and tries to put it through to the department responsible. When an integrated solution (Call Centre) is available, complaints are accepted and handled by one person having all the information necessary at hand. Via a map interface and address/postal code locations the complainer can easily be located. Because all information on the net status is available, cause and effect can be traced within only a fraction of the time needed before.

10 - Miscellaneous

10a - Generating special map products

Generating all kinds of special map products is a very time-consuming task, most of which is carried out manually now. GIS can easily produce maps with different scales, symbology and contents.

10b - Management information

GIS offers different possibilities for providing all kinds of information, including management information, that weren’t possible before. Please note the different kinds of information, together with the benefits (in relation to the “old” method or because things can be done more efficient now).

10c - Field GIS

Technology offers possibilities to take GIS data in the field on a laptop or pencomputer. These data can be used for orientation purposes, but also for data acquisition, in which case part of the work of the drawing office won’t be necessary.

Using this kind of equipment and application has several advantages:

- timeliness of information, which makes copy sets of drawings superfluous;
- no more travelling to the office to get the right information;
- orientation purposes, especially when used in combination with GPS;
- changes and measurements can be fed into the portable system directly.

1. Considering the present activities and level of knowledge, do you see possibilities for the use of this kind of equipment?
2. Will field crew use laptops or other mobile equipment with normal input devices or will the introduction of this kind of equipment depend on the availability of cheaper pencomputers?
3. Is the laptop/pencomputer going to be used for orientation purposes and marking up changes (to be handled at the office) or is it preferred that revision is done in the field, and is merged with the master database almost without human involvement?

6. Benefits of new GIS-applications

In the previous chapter the realisation of the questionnaire was discussed. It was sent to the four companies, and after that the answers were put together and checked. This check led to new questions, which were checked by telephone. The resulting questions were handled in the interviews. In one company a quick scan was carried out to verify the answers in detail and to gather extra information. This chapter contains results of the process outlined:

- general remarks on the questionnaire and interview process;
- a summary of the results of questionnaires and interviews;
- additional information on questions;
- results of the quick scan.

An overview of all verified answers can be found in appendix 2.

6.1 General remarks on the inquiry process

Given a limited amount of time, the chosen approach was probably the only way of getting information. The process though revealed some more or less remarkable information:

- From the answers it becomes clear that water boards, at least the ones interviewed, aren’t commercial organisations. Detailed information on daily work isn’t available and, since the Drawing Office also works for other departments, at first errors in the answers were unavoidable.
- When the use of GIS/IT for performing new tasks is involved, this appears to be extremely difficult. The descriptions in the preceding chapter proved to be helpful and necessary here.

- Certain questions couldn’t be answered because information wasn’t detailed enough. Some questions appeared to overlap. During the interviews some questions therefore were altered, added, combined with other ones or removed.
- During the interviews a lot of information emerged that didn’t fall under certain questions. All relevant information will be stated in paragraph 6.4.
- The interviewees are very liable to adopt proposed answers, so questions were often answered with “what do you think?”. This made it sometimes difficult to give examples and explanations and at the same time keep ones objectivity.
- Altogether quality of the information gathered in the first session was less than expected. If it hadn’t been checked with data from other companies, a large part of the information on time spent on tasks would have been false.
- After all information was written down and could be compared the “misses” were checked again. The way these were handled (answers were changed remarkable easy sometimes) strengthened the opinion that companies have little insight on the time spent on present tasks.
- It was recognised later that insiders can relate the answers to the actual company name. Since financial information is available in annual reports also this is not considered to be a problem. Financial information though will be removed from the overview.

A conclusion is, that information gathered in the inquiry process must be handled with care. Though big misses probably have been corrected because of the comparison of four companies, the spread in some answers asks for additional inquiry if the outcome is going to be used in practice.

6.2 Evaluation of the time spent

Considering the complexity of the field and the knowledge/experience of water boards an interview seemed the best solution for obtaining the necessary information. The questionnaire was used for preparation purposes, to save time during the interviews. Though this was a well-thought choice, the process eventually took longer than expected. It has to be said though that everyone kept their promise on providing the data required, so little time was lost on that part.

The first evaluation of the questionnaire took about half a day per company, mainly spent on answers that weren't there or were obviously wrong. Comparing answers often lead to more obscurity, and about 50% of the answers had to be checked by telephone.

Preparing the interviews and formulating the right questions also took some hours per company. The actual interviews took about 3 hours per company; travelling time an extra 6 hours. Checking all answers afterwards and comparing them with other answers still took another half day per company. Translating and working up all the data to a preliminary outcome took about 2 days, as did the quick scan.

Total amount of time spent:

- first evaluation 16 h.
- preparing interviews 10 h.
- interviews 18 h.
- second evaluation 16 h.
- preliminary outcome 16 h.
- quick scan 16 h.

When evaluating the total amount of time spent this seems much, but most of it would have been spent also when another approach had been chosen. Though at first part of the answers was rubbish, for the companies the questionnaire proved to be a good means for preparation and saved a lot of time in the rest of the process.

At first it was uncertain what level of detail of the questionnaire should be. It was thought that more detail might have saved time during the interviews. From the results it became obvious that the level of detail sometimes even was too high, so the effort needed to develop a more extensive questionnaire wouldn't have weighed against the benefits.

Though not based on hard evidence it can be said that it was a fortunate choice to follow this approach.

6.3 Priorities and savings of new applications

Table 1 shows a summary of the results of questionnaires and interviews. An overview of all questions and answers can be found in appendix 2.

Application	Priority	Qual/Cust. Sat.	Expected savings
3 - Information exchange to KLIC and others	1-2	4 / 2	60-95%
4 - Integration of small systems			
4a - Valves and fire hydrants	1-4	3 / 2	20-75%
4b - Permits	3-4	1 / -	25-50%
4c - Terrains	2-4	2 / -	0-50%
4d - Pollution areas	2-4	2 / -	0-75%
4e - Cable network	2-4	3 / -	0-50%
5 - Relationships with other information systems			
5a - ALEID	2-3	4 / -	60-90%
5b - SCADA	na	1 / -	na
5c - REGIS	4	- / -	na
5d - Engineering (installations/buildings)	na	- / -	na
5e - Draught damage	3-4	3 / 3	na
5f - Laboratory Information and Management System (LIMS)	3-4	3 / 2	na
5g - Customer Information System (CIS)	2-4	3 / 4	50-75%
5h - Inventory and logistics (ILS)	1-4	- / -	na
6 - The design process			
6a - Using GIS/IT in all stages of the preparation / design process	1-2	4 / -	30-70%
6b - Use of electronic data exchange in the design process	1-2	4 / -	50-90%
6c - Use of external data as part of the design process	3-4	3 / -	0-50%
7 - Revision process	1-2	3 / -	50-90%
8 - Preventive maintenance system	2-4	3 / 2	30-40%
9 - Customer complaints / Call centre	2-3	4 / 4	50%
10 - Miscellaneous			
10a - Generating special mapping products	1-2	4 / -	50-90%
10b - Management information	2-3	3 / -	0-80%

Table 1 - Summary of the results from questionnaires and interviews

6.4 Additional information

The questionnaire-session has in fact been carried out twice: first in the beginning of 1997. Because of lack of time work on the Thesis was stopped just after the first evaluation. At the end of 1997 the session was done once again. It was surprising to see that there were little differences in the answers, despite the one year in between. Differences concerned priorities, some higher benefits of new applications and an increased interest in new developments like GPS and pencomputers. Three companies were involved in conversion at the beginning of 1997 and the fourth company started in march 1997. New developments though were hardly initiated, mainly because of reorganisations and merges.

Apart from the answers on the questions from the questionnaire, much additional information was gathered. Though it doesn't explain everything, it provides a comprehensive background on the answers.

3 - Information exchange (KLIC and others)

Information exchange on mains and outlets appeared to be in the proportion of 30% to 70%. A main part of the benefits though is already realised by automating the information on outlets by means of DIS or by storing them in the GIS (company 1). Especially the availability of timely information and the possibility of printing/faxing information from behind the PC, without having to search for sketches and copying them, already saves halve of the time. Information on watermains will benefit from the use of GIS but, since this is a minor part, benefits will be smaller. The eventual benefits though will be substantial, because when a relation between DIS and GIS data exists, information on watermains and connected outlets can be handled as one. Two companies already use this functionality.

Digital exchange of information still isn't used much, so it will take some time before the maximum benefits can be realised. Considering the way KLIC is working now and the status of various conversion projects it will probably take several years before maximal benefits can be realised. Part of these benefits consist of disappearing costs of paper and copying.

4 - Integration of small systems

4a - Valves and fire hydrants

Use of information(systems) on valves and fire hydrants differ per company. None of them though uses an extended maintenance program. This seems strange, for water boards have many tenthousands of them and it concerns two important components in the network.

Additional data on addresses are used to provide information for fire departments and municipalities. Storing locations in GIS, in fact automation of the present drawings, will add extra functionality against very little costs. All companies have chosen to do so, but benefits will only be realised when data can be used by a maintenance program. Since the companies don't work that way yet, at first this will result in an increase in costs because the necessary data aren't available.

There are technological developments on equipment that can measure the quality of valves and fire hydrants (Acmovator, Visser & Smit Hanab). This equipment can measure up to 200 parameters, which may be used in a condition-dependent maintenance program. It is obvious that this is impossible without using automated systems.

4b - Permits

Data on permits related to watermains are static and mainly used in the design process. When a project is realised and compensations are paid, permits are archived. They are very seldom retrieved, so storing them (the location) in GIS may only be useful for having an overview on all permits. Water boards have many thousands of permits registered, which makes conversion expensive. Storing them in GIS will only be beneficial when retrieval demands change.

Permits can be used in combination with watermain locations, cadastral parcels and ownership. Permits necessary for projects then can easily be determined and stored in GIS automatically.

Because of the financial consequences, permits on catchment areas are used frequently. These permits are handled by other departments in other systems, in relation to cadastral parcels and land use. At this moment there are no intentions to integrate this functionality, though it may be beneficial to use the same cadastral information and basemaps for other applications also.

The costs of digital cadastral information momentarily prevent extensive use of GIS for permits, so only when the handling of permits changes, e.g. because of new legislation, "real" GIS-solutions will be feasible. If necessary data is purchased for other applications also, sharing costs may speed up this one.

4c - Terrains

Information on terrains is often handled by other departments. On these terrains cables and mains of the Production Department are located. Data are available on different map products, as there are P&ID’s, PFD’s and PA’s (Piping and Instrumentation, Process Flow and Piping Arrangement). The PA-diagrams consist of information comparable with information in the MIS. In the near future PA’s will be integrated within the FMS when the Distribution Department gets the responsibility for all mains. PA information consists of a limited amount of mains, so conversion is mostly scheduled at the end of the “distribution-conversion”. Information is sometimes stored in CAD-systems, which may ease this process because part of the conversion can be automated. Keeping all data on mains in one system will add to standardisation and efficiency. Because of the relatively small amount of pipes financial benefits will be small.

Information on the terrains themselves concern buildings, woods, roads and paths , etc. that need maintenance also. This maintenance is now carried out ad-hoc, and information is generally kept on drawings. The amount of information is limited, as is the complexity, so it can easily be included in GIS.

4d - Pollution areas

Pollutions can be hazardous to watermains as well as catchment areas. Information on pollutions in or near catchment areas is kept on drawings, and only in specific situations this information is used in groundwater flow models to calculate the risk of pollution. Information on locations, water quality and probes is kept on drawings and in paper archives. All these data are maintained by the Department of Geo-hydraulics.

Certain organic pollutions can permeate or dissolve watermain materials, so registering these areas and relating them to projected and already realised watermains will prevent future problems. Information on pollutions though is registered at will, and only on outlet sketches. This made it impossible to e.g. relate pollutions and quality problems (water or mains).

Although information on pollution areas can be obtained in digital form now from the Province or municipalities, there is still little interest in integrating this information in GIS. Reason for this is probably that the concept of preventive actions is new, and there are no direct benefits. All companies though state that it is necessary information when developing a preventive maintenance system.

4e Cable network

Water boards generally own cable networks for monitoring and operating pumping stations. Information on these networks is kept on special drawings, but sometimes also on drawings on watermains for purposes of information exchange. Data on these networks almost don’t change, so there are no large benefits to be gained here. Benefits of storing it in GIS will be that data are stored only once, the same basemaps can be used and increased efficiency in information exchange.

Benefits will be small, but so are the costs of integrating this functionality in GIS.

5 - Relationships with other information systems

5a - ALEID

A relation between ALEID and GIS will result in substantial benefits and therefore has a high priority. As explained earlier, preparing the input takes a lot of time. Most of this time can be saved by using GIS-data as input. This is proven by a minor GIS application developed to facilitate the input, which saved half of the time normally needed for preparing the input. Since models can be stored, the process will be less liable to errors.

An aspect that also plays a role here is the fact that water boards are being pushed by KIWA to use ALEID more. A critical approach to sluicing activities and the over-dimensioned watermains network are also motives for using it more.

At this moment Smallworld Benelux is realising a link between GIS and ALEID. The costs of this application will probably be no more than Dfl. 15 - 20.000,-. Considering the savings this is one of the applications that must be introduced as soon an possible.

5b - SCADA

As mentioned before, most data aren't used real-time and there are little or no fluctuations in flow or pressure. To all the companies a relationship with SCADA therefore has little or no priority. At some critical locations measuring is done, part of which are used in other systems. The only reason water boards might need a link for is better and faster exchange of data. The little data necessary for other applications, e.g. ALEID, can also easily be obtained without this link. When a complaints system is realised, especially data on fluctuations from SCADA can be useful then.

5c - REGIS

The water boards expect no direct benefits from a relationship between GIS and REGIS, probably also because REGIS is used by a different department and there is little knowledge on how such a relationship would be effectuated. If this can be realised they prefer REGIS on the Smallworld-GIS platform. Benefits mentioned are:

- use of the same basemaps;
- information exchange (terrains, wells);
- standards in software and user interface;
- savings on system maintenance.

So far none of the companies uses REGIS on Smallworld-GIS and at this moment functionality of the Smallworld-GIS application is still less than the Arc/Info version. Water boards will investigate this relationship further when terrains and catchment areas are stored in GIS. Considering the fact that the Departments of Geo-hydraulics use many specialised software packages and are very autonomous in purchasing these, it is guessed that for the next years the “link” will consist of exchanging information via floppy disk or the internal network.

5d - Engineering (installations / buildings)

Departments responsible for installations and buildings are generally not the same as the one responsible for watermains. In most cases there is a “barrier” between these departments when it comes to maintenance of data.

Concerning the design of watermains the companies aren’t using full-grown design applications yet. Especially when designing technical constructions GIS may not have the functionality needed. On the other hand AutoCad is used in the design of installations. This may in some cases may be used for special details on watermains also. When AutoCad details can be viewed from the GIS environment, this may be an opportunity to do the same with installation details for overview purposes. The interviewees expect no benefits of this relationship because it concerns different subjects and responsibilities.

5e - Draught damage

Draught damage is very much related to catchment areas and therefore responsibility of the Departments of Geo-hydraulics. Drawings concerning catchment areas and cadastral parcels though are generally made by the Distribution Department, so integration in GIS would be obvious.

The applications handling this information are rather simple, very much depending on information from the farmers involved. The little GIS functionality necessary would be used to make drawings and overviews themselves, using e.g. ArcView. The costs of cadastral information restricts use of GIS-functionality, but companies see opportunities when this information is needed by other applications and costs can be shared. An integration with GIS though isn’t supposed to be necessary.

Here also possible benefits come from the use of the same basemaps. Savings, in this case less compensation that has to be paid, will be used to do more with the same staff. Overall benefits therefore will be little.

5f - Laboratory Information and Management System (LIMS)

Only one of the companies considers a relationship between GIS and LIMS not to be meaningful, for the reason that they have very little problems with water quality. Soil quality/stability and low groundwater levels would explain this. The other ones consider it not to be the first application to be realised, but state that it will support maintenance and can function as a means for tracking the cause of quality complaints.

Here also a reviewed interest in the sluicing process, clearly something that is under heavy discussion nowadays. Water quality at measuring points can be used to measure sluicing activities and quality. In the future more functionality must be developed to support the maintenance process. Most probes are taken from the customers's tap, so these measuring points can easily be related to locations on the watermains network.

Historical data on water quality could be combined with watermains quality (deterioration, internal growth) to investigate relationships. These relationships could be extrapolated to other watermains used in areas with the same water quality in the past. This might be a rather cheap way to collect/generate data on mains quality.

5g - Customer Information System (CIS)

Except for one, all the water boards see this as a meaningful and beneficial application, that will save a substantial part of the time spent now on customer notification. Most time spent now is on customer notification due to sleucing and works on the network.

Part of the functionality needed is used in other functions also. The key problem is, that information from other systems must be related to a location on a watermain. For a GIS this is not a problem, but in the administrative environment this question could not be solved. For other applications this “location-relation” has to be established also, as there are DIS (sketches), the complaints system and LIMS.

Next to the financial benefits the improved customer satisfaction is at least as important. This though is a remark that was heard in every interview; the customer is getting more and more important.

5h - Inventory and logistics (ILS)

The conclusion from the interviews is, that substantial benefits can be generated by using GIS in the design process. The general idea is, that benefits in standardising materials and reducing stocks are created by using GIS as a means of standardising design, based on standards within ILS. Standardisation of stock is realised by the ILS; GIS is used for implementing these standards. Though information to quantify the benefits of GIS in this process doesn’t exist, it is believed that it plays an important part. Without using GIS in the design one of the organisations already has realised small stocks, proving that benefits can be realised by only using ILS.

Some of the companies are in the middle of a reorganisation process, and as part of that investigations are done after new logistic concepts. For one of the companies benefits of a new logistic concept were estimated at Dfl. 3 million a year. Logistic experts claim that GIS will have a large influence in this process.

Opinions on priorities differ, but this link will become available as part of the design functionality almost automatically. At that moment the companies must decide if and how they want to standardise.

6 - The design process

6a - Using GIS/IT in all stages of the preparation and design process

Two of the companies have plans to develop such an application within the next year and think it will have substantial benefits. One already uses a conversion-application for designing. Without having all the functionality mentioned they are able to work much faster already.

Some of the possibilities mentioned have already been tested in pilot projects, so the people interviewed know what they are talking about. Saving 30% seems to be on the safe side, but this may have something to do with not worrying the employees. To all companies it is clear that the design process will undergo great changes.

Compared to the other functionalities mentioned this one is especially attractive because of the large amount of hours that can be saved.

6b - Use of electronic data exchange in the design process

This part of the design process has high priority and generates substantial benefits. Also the technical aspects are rather easy to realise. Most important is the agreement on what to exchange and what format is to be used. Some companies let their benefits depend on how data are delivered. For all organisations this is something that has to be worked out in the near future, because all parties in the process can profit from it.

Utilities in The Netherlands are highly co-operative in planning and realising projects, in order to reduce the costs of excavations and contractors. Electronic data exchange will play a large part in this co-operation.

6c - Environs data

Most companies use part of these data in their design process. Use in the GIS is considered to be meaningful, though not extensively. Data are collected mostly by fieldwork, but to limit expenses often only detailed topographical data and heights are collected. In fact there are many more data that may influence the locations of watermains.

Most companies think the object oriented GBKN to be the solution to this problem, because it is supposed to deliver all information necessary. The O-GBKN surely won't comprise all the information needed, and at the moment it isn't clear if it will be realised within the next years.

The companies are concerned about the costs of data, since most of them have experience with cadastral information. On the other hand they aren't interested in collecting these data themselves, but seek organisations that can supply it keep it up-to-date.

7 - The revision process

The revision of changed data can be done much faster and more efficient when GIS is used. Revision merely exists of changing the status of the design information. When equipment is available in the field, changes and measurements can be fed into the portable system directly. Office personnel only have to check the information before making it available to the rest of the organisation.

Though all companies see the benefits of the new technology, most of them have their doubts on how this technology is going to be used, especially in the field. Present field crew isn't used to this, but it is recognised that developments can't be stopped. Some think that the benefits of new technology on short term are overestimated. Nevertheless the priority as well as the benefits are high, which puts this application high on the list.

8 - Preventive maintenance system

Except for the one which policy is aimed at corrective maintenance, all companies think this application may yield large benefits. On the other hand they recognise that it asks for detailed information that isn't available yet. Costs of collecting the necessary data will be a bottleneck in realising this application.

Most companies are planning maintenance applications, at first aiming at data already available, like complaints and watermains problems. If ever an optimum will be reached is not clear, costs and efforts to reach that situation will be large, without proof on the benefits. More information though will lead to a more optimal situation of maintenance and rehabilitation, since at this moment maintenance and rehabilitation are based on leakage problems and age only.

The KIWA-report may give a new impulse to developing this kind of systems. The general idea is though, that this action should have been undertaken ten years ago.

9 - Customer complaints / Call Centre

All companies consider the idea of GIS being a helpful aid in handling complaints. Customer satisfaction is becoming a key item, so there are many changes in processes involving customers. Some of the companies are already working on the idea of a Call Centre. GIS doesn’t play a big part yet; ideas on call centres are aimed at the CIS, in combination with a complaints system and technical means like voice input. This view is aimed at the complaint: how to handle the phone call and store the complaint. Solving the complaint is of lesser interest. The people interviewed think GIS to be beneficial in solving part of the complaints by determining relationships between complaints and causes.

Though it doesn't seem wise to claim too high benefits here, handling customer complaints will ask for more information than CIS can deliver now.

10 - Miscellaneous

10a - Generating special mapping products

Generating special mapping has a high priority because most of it can be done using standard functionality. If field workers are going to use field GIS, benefits will grow because paper products won't be necessary anymore. An additional benefit is the timeliness of information, since products can be derived from the master database at will.

Some companies have their specialist work (including DTP) done by external bureaus, which won't be necessary anymore then.

10b - Management Information

Management information is now produced at different places in the organisation, so benefits may be much larger than perceived. The general idea is, that management makes little use of real management information concerning facilities; information produced is mostly aimed at the operational level. Information now consists of total lengths of mains and outlets, amounts of valves and fire hydrants or amount of disturbances. Management of facilities seems to be based on costs: when the costs grow too high there will be less maintenance next year.

Better information will lead to better decisions, but it is stated that it is difficult to quantify benefits. Quality and timeliness of information will increase, which will automatically lead to a need for more information.

10c - Field GIS

Though some companies are sceptic about the maximal benefits that can be realised using Field GIS, all see it as a development that will have a large impact on field work. They prefer the easy to use pencomputer, but only if it's possible to make changes in the field. On the other hand they perceive that the present field crew aren't used to this kind of equipment, which may lead to serious acceptation problems. For the present the solution will probably be the use of semi-portable equipment that is mounted inside the car.

Modern WMS-systems, e.g. Tinoway, also use this kind of hardware, in combination with wireless communication. Most companies are investigating mobile applications, trying to find integrated solutions that use the same hardware and communication technology.

There in an increased interest in leaving part of the field work to contractors or specialised organisations. Especially when specialised equipment is involved (total stations, DGPS) this is considered an efficient alternative.

6.5 Intangible benefits

The key targets of water boards nowadays are:

- cost reduction;
- quality improvement;
- outstanding customer service.

The inquiry so far mainly focused on the first target, the financial benefits. Though this chapter sometimes proves otherwise, these often can be tackled fairly easy. This explains why the other, the so-called “intangibles” are getting less attention. When using all kind of automated systems e.g. electronic means for the exchange of information, systems that check data quality and tools that standardise procedures, these new developments must be beneficial to the latter two targets also.

Questions concerning these subject weren’t asked directly. The answers probably would have been positive for all questions, which would make them useless as a selection tool.

From the extra information in the questionnaire forms and the interview sessions information on these items was derived. Though this doesn’t provide quantitative information, the fact that more companies mention it may be an indication of its relative value.

Information on these benefits are comprised in table 1. Except for the two mentioned there is more to say on intangible benefits. Evaluation of these kind of benefits will be discussed in the next chapter.

6.6 Results of the quick scan

In one of the companies (C) a quick scan has been carried out, intended to check the results of the questionnaire and the interview, but also to get more information on possible benefits. Some of the answers changed because more and better information became available.

Changes though were minor.

The information is also used to do the “ultimate check” on the quality of all answers. All answers showing unexplainable deviations were checked again. During the scan several employees have been approached with detailed questions on the questionnaire. Some had to answer questions for which they had to perform interviews or do some inquiries in paper archives.

Information exchange (KLIC, other)

Based on the following starting points:

- 13.000 copies per year;
- better area selection will result in 10% less plots/prints;
- because one is not bound to standard formats, 25% can be saved on paper costs;
- 25% can be printed on a printer instead of a plotter,

per year a saving of ca. Dfl. 25.000,-- (35%) on printing materials can be realised when information is still sent by mail. As a result postage costs will be reduced by 50% or Dfl. 12.000,--.

When all information is sent electronically, total savings will add up to Dfl. 75.000,--

Copy facilities

All companies have central copy facilities. When eventually most of the drawings are available in digital format, this central facility will disappear and make way for laserplotters and coupled scanning devices. For the central copy facility this implies saving at least 1 man-year (Dfl. 80.000,--) per year. Technical equipment will change also, but because it wasn't clear how this will function in the future organisation there was no explicit information on benefits.

Materials and logistics

It was found that relationships between GIS and ILS are not so easy to realise. The systems use different coding and material/component names. When considering international standards there is no system that fully complies to these. Especially when exchanging information with contractors or suppliers (European Tender) it is necessary that general accepted standards are used. Differences in coding systems also occur when systems of other departments are involved (Production, Geo-hydraulics).

(Preventive) Maintenance

The company has already started with collecting watermains quality data and detailed technical data on components, using a paper system. A proposal on starting data collection using pencomputers, a project that would also act as a pilot on the use of field equipment, was cancelled because of the ongoing investigation on a total "field-concept". This way though no time is lost during this investigation stage.

Some investigation on maintenance information is done. Though this may not apply to all companies, it is an indication of what the collection and maintenance of this information costs. Input of "maintenance information", specific technical data and that part of quality data that can easily be collected, is considered to cost 7200 hours Keeping this data up-to-date will cost another 4800 hours(Dfl. 240.000,--), 1 man per region per year.

It is the impression that much of the functionality needed for a maintenance-application is already available in Smallworld-GIS. This will be used to experiment with, so preventing unnecessary costs for application building. Based on this information a maintenance-application will be very low-cost.

6.7 Conclusions from this chapter

Though the inquiry was aimed at new GIS-applications the “real-GIS” aspects got little attention. Much emphasis was on communication and the use of GIS to support present processes like design and revision. This reflects the conclusion from chapter 5, which stated that only part of the benefits is a contribution of GIS, and communication is one of the most important aspect of integration.

From the answers it becomes clear that GIS can contribute to cost reduction and more efficient working procedures for part of the applications. Communication is stated as being important, but standardisation and quality of existing data are generally not seen as a problem. Experience in conversion processes and the results of the quick scan though prove the opposite.

The interviewees generally aren't interested in tasks that aren't carried out at present. The same applies to applications from which no direct benefits are expected, even applications that can be added with very little extra costs. The impression is, that the development of ideas on new applications is very much restricted because of the difficulty to change the existing thinking pattern. Thinking obviously is still aimed at the present way of working.

Emphasis is also still on the conversion, which will take some years for all four companies to complete. One gets the impression that they want to wait with more new applications till this conversion is largely completed.

Much is expected of the OO-GBKN and cadastral- and other external information. The possibilities and availability of these information is generally over-estimated. Considering costs of external information the general idea is: expensive and a possible barrier for GIS.

There was much interest in the preventive maintenance application. Though this will be one of the latest applications to be developed it has a certain technical "attractiveness".

Though they are changing also, water boards still are "social" organisations. As mentioned earlier, many employees aren't used to working with high-tech equipment. The companies realise that this might become a problem when new technology is introduced too fast. In order to avoid acceptation problems they allow the organisation to "grow" gradually. This implies that the introduction of new technology may be slown down.

"Customer orientation" and "quality" are very much heard, but it is uncertain how these aspects are treated when it's going to cost. In new management environments this terminology is rather fashionable. Time will learn if GIS-applications will be judged by these criteria.

7. Costs and benefits

In the last years there has been a considerable change in attitude towards the approval of GIS/IT projects. Mainly because management has little trust in IT-related projects, long payback periods were seen as potential risks. When a payback period of 8 years was acceptable before, nowadays 3 to 4 years is the standard. Anything beyond 5 years is nearly unacceptable. This puts a considerable strain on the manager trying to get a new project approved.

As the previous chapter revealed there are many benefits of the use of GIS and IT within a water board. The “hard” benefits can be derived from the expected savings in man-hours. An example on the preferred applications will provide an impression of the costs and benefits.
Much benefits though are described in terms like ‘better” or ”higher quality”. Valuing applications on these criteria will be discussed in the last part of this chapter.

7.1 Standardisation and quality

An important aspect of GIS relates to the ability to integrate data from different sources. The former chapters showed the applications and their many relationships with other information systems. The paragraph on the quick scan however showed that even within a company different codes and names are used. Relationships and electronic exchange of data require agreements on standards and quality of data, which again stresses the importance of the “corporate view” when planning new applications. This implies that for every new application it has to be checked if extra costs for standardisation and quality improvement have to be taken into account. Experience shows that quality of data is generally over-estimated. Unfortunately this is mostly discovered after the conversion.

It almost goes without saying that standardisation issues also applies to the use of hard- and software. Here also the corporate view is of key importance when integration and communication are required.

Standardisation limits the amount of specialised links, converters and communication programs. Restricting the various products to a set of standard products will enhance integration and co-operation capabilities. Costs will be reduced because less tailor-made solutions are used. Next to this benefit, costs of system and application management will be less.

7.2 Costs and benefits of new applications

In this paragraph an example of costs and benefits will be provided, based on the applications described and the results from the questionnaire. It's not the intention to provide a detailed analysis, but to give an indication on the costs and benefits of the applications most likely to be realised. Therefore only those applications will be valued, the companies were more or less unanimous on in the answers.

General assumptions on costs

In order to be able to develop an overview on costs and benefits, some general assumptions have to be made. Assumptions concern the costs of hard- and software, maintenance, application development and education, and are based on recent information and own experience. Data on write-offs are based on company information.

Education (edit tasks)

1 week course	Dfl. 3.000,--
man-hours (40 * Dfl. 50,--)	Dfl. 2.000,--
3 week experience (120 * Dfl. 50,--)	Dfl. 6.000,--

Education (view tasks)

1 week course in-house (40 * Dfl. 50,--)	Dfl. 2.000,--

Smallworld licenses

Edit license	Dfl. 29.500,-- (Dfl. 28.000,-- incl. discount)
View license	Dfl. 11.500,-- (Dfl. 11.000,-- incl. discount)
Maintenance	15% p.a.

Applications

Costs	per application
Maintenance	10% p.a.

Hardware

Server systems	Dfl. 35.000,--
Workstations	Dfl. 3.500,--

(only costs of extending PC's generally available)

Write-offs

Interest percentage	6,5 %
Education	3 years
Hardware (server)	5 years
Hardware (workstations)	3 years
Smallworld licenses	5 years
Applications	3 years
Data conversion	3 years

Personnel costs

System maintenance (10% * Dfl. 80.000,--)	Dfl. 8.000,-- p.a.
Application maintenance (25% * Dfl. 80.000,--)	Dfl. 20.000,-- p.a.
"Super-users"(20% * Dfl. 80.000,--)	Dfl. 16.000,-- p.a.
Man-hour	Dfl. 50,--

New applications are introduced in the beginning of 1998, when companies are still involved in conversion for about 2 years. Benefits in the first year are fixed at 1/3, because only part of the data is converted then. In the second year they are fixed at 2/3 and the full 100% will be reached in 2000, when the conversion is finished. This implies that benefits will be achieved relatively earlier if applications are developed later (after the conversion is finished).

Valuing the conversion

The conversion process has to be carried out to be able to introduce the applications mentioned. As already stated before, most companies have stopped or postponed their manual conversion as became clear that the digital era was coming near. Result of the GIS-conversion is, that it is done once instead of every 20 or 25 year. In fact money is saved by doing the conversion this way; it can be seen as a long-term investment. Experience and calculations afterwards show that conversion speed is about twice as fast as in a manual conversion. An average conversion speed of 200 m/h and 10.000 km of watermains even results in a benefit of Dfl. 2 million, compared to the manual conversion. Conversion costs don't consist of conversion time only; the process includes much preparation and checking, which takes almost as long as actually performing the conversion. This part also has to be carried out when doing a manual conversion.

Though the financial managers probably won't agree there is little reason to include conversion costs in a cost/benefit analysis of new applications.

Most companies do the conversion in-house, where the actual conversion work is mostly carried out by contractors. This implies that the starting point is a situation in which certain facilities like hard- and software are already available. Most applications mentioned will be introduced when the conversion isn't finished yet, which implies that some overlap occurs. In order to create a plain example all this will be left out. This is certainly not beneficial for the outcome, but therefore it can easily be adapted to a specific environment.

Costs and benefits of applications

A detailed overview of costs and benefits for main applications can be found in appendix 3. Results from the quick scan are not taken into account since they represent the benefits within one specific company.

3 - Information exchange to KLIC and others

Electronic data exchange, the eventual solution described in chapter 4, is not yet taken into account here. Reason for this is, that it will probably take several years to reach that stage. Stating benefits already based on that situation may raise unfounded expectations. Since part of the benefits is already achieved by using a DIS for sketches on outlets, extra benefits are determined at 25% of 4800 man-hours.

Priority: 1-2
Payback time: 2 years

4a - Valves and fire hydrants

Costs of the application for valves and fire hydrants (4a) are estimated at Dfl. 10.000,--. Standard functionality will probably be enough, but since companies want to improve maintenance capabilities some extra costs are taken into account here. Since an average can hardly be established, benefits are determined at 50% of 400 man-hours.

Priority: 1-4
Payback time: 4 years

5a - ALEID

Benefits on the use of GIS as provider of most of ALEID's input is generally considered highly beneficial. Benefits are determined at a safe 75% of 800 man-hours. The costs of application development are not clear, but keeping in mind the cost-structure of other Smallworld-GIS converters this will probably be in the range of Dfl. 15.000 - 20.000 for in- and output converters. An extra Dfl. 10.000,-- is added for additional application changes.

Priority: 1-3
Payback time: 3 years

6 - Using GIS/IT in all stages of the preparation / design process

This application the companies were unanimous on, so a mean value for benefits can be adopted. Since the application involves a relationship with ILS and various standardisation aspects, application costs are fixed at Dfl. 40.000,--. An extra Dfl. 20.000,-- is added for data conversion due to this standardisation.

Priority: 1-2
Payback time: 3 years

6a - Use of electronic data exchange in the design process

This application is added because it almost doesn't need extra application building. When there is agreement on what and how to exchange, this can be done almost using standard functionality only. It also can be totally separated from the design functionality to be designed. The benefits are determined at 75% of 1000 man-hours.

Priority: 1-2
Payback time: 2 years

7 - The revision process

The use of field equipment has not yet been taken into account. At first people must get acquainted with the new situation, so the process will stabilise. After that it's the time to start automating field work, but then many more aspects must be taken into account. Benefits are therefore established at a low average of 50% of 6000 man-hours. Most of the functionality probably will be standard, but to be on the safe side Dfl. 20.000,-- is taken into account for developing extra functionality.

Priority: 1-2
Payback time: 2 years

9 - Customer complaints / Call centre

The Call Centre is supposed to achieve considerable benefits (50%). The application is considered complex because of the many relationships and the special interface that must be developed. Application costs therefore are determined at Dfl. 100.000,--. Special Call Centre hard- and software probably will be available by then, but to be safe another Dfl. 100.000,-- is added. Though one of the companies though seems to spend much less time than the other, benefits are determined at 50% of 4000 man-hours.

Priority: 2-3
Payback time: 6 years

10a - Generating special mapping products

Generating special mapping products is almost standard functionality and therefore available from the beginning. In case some special plotting functions have to be developed, application costs are fixed at Dfl. 10.000,--. Benefits are determined at 75% of 500 man-hours.

Priority: 1-2

Payback time: 3 years

7.3 Remarks on the previous paragraphs

Though the assumptions on which costs and benefits are based can be criticised on many points, the outcome gives a useful overview on costs and benefits concerned with the introduction of GIS-applications.

Some remarks on the analysis:

- Because Smallworld-GIS uses floating licenses, mean costs of licenses will become less when more are used. This is not taken into account in the overview;
- Applications may have opportunities to share costs, so that the benefit of two applications taken together may be greater than the sum of two standalone applications;
- Although application costs don’t have a large influence, they are rough guesses. If they are going to be used in practice, analysis of the necessary functionality is required.

Preliminary conclusions:

- The applications preferred by the water boards generally have short payback times, which confirms their ideas on benefits;
- Payback times of single applications are generally very short, which can be a motive to start as soon as possible, especially when the GIS-environment is already available;
- when the standard functionality available is nearly sufficient for a certain application, payback time generally is short (special mapping products). This should be an inducement to investigate these applications more thoroughly.

When all related costs (server hardware, maintenance personnel) are taken into account, the payback time of the applications mentioned together will be about 7 years. This is without taking into account the costs of conversion. Since (luckily) all companies have already started their conversion, this won't be the way GIS is going to be valued.

Calculating this way one forgets the changes companies experience nowadays. All benefits are compared to the way water boards worked in the past. If they want to function as modern, flexible organisations in a dynamic environment, they can't do this without support of modern Information Technology. Going back to the "stone age" of facilities information will cost far more.

Considering the previous remarks one can say that benefits will be more that calculated, because:

- there are more applications to be developed, which will generate additional benefits;
- the applications mentioned are valued rather safe;
- preventive maintenance is expected to generate large benefits, though not at first;
- mean costs will decrease when more applications are used because sharing of sources and synergetic effects.

When considering costs and benefits this way only, management may be right when they consider GIS to be an expensive toy. This chapter so far was on direct and financial benefits, based mainly on savings by automating (parts of) processes. There are more benefits though, that haven't been valued yet. This is a shortcoming of the methodology followed in this Thesis, and a consequence of the choice to investigate more companies.

It is stated that tangible benefits account for only 28% of the value of an AM/FM/GIS-project, and that the remainder are benefits where the value is too elusive to quantify with reasonable time and effort (Donaldson, 1994). The next chapter will investigate these remaining benefits, in order to find out if these can be valued also.

7.4 Intangible benefits

In a traditional cost/benefit analysis the following types of benefits are considered (Ferguson, 1996):

- Type 1 Productivity;
- Type 2 Capability;
- Type 3 Response to unanticipated events;
- Type 4 Intangibles;
- Type 5 Revenue generation.

Ferguson states that the only the first two are quantifiable, and the latter three are real intangibles and can't be (easily) defined in terms of money. When remembering the benefits stated in the questionnaire, most of them were direct -productivity- benefits, aimed at saving man-hours. The latter four got little or no attention, except for the valuation of "quality" and "customer satisfaction".

Also on other aspects a cost/benefit analysis is said not to be sufficient to decide on complex applications like GIS. It's use is said to be confined to compare the economic value of two mutually exclusive plans (Donaldson, 1994). Because of the depth of the investigation and the focus on technology and applications though, only superficial information was provided. If a more thorough analysis would have been the aim, research would have focused much more in detail on one company.

Investment Analysis /Appraisal (IA) comprises more than the CBA used, like company mission, risks, intangibles, project synergy and benefit realisation. Though it’s not the intention to explain here what IA is, part of the method refers to the intangibles and the way to handle them.

The introduction showed that water boards have three key targets:

- cost reduction;
- quality improvement;
- outstanding customer service.

Benefits will be rated by the way they contribute to these targets, at least the last two.

IA provides a way to make “intangibles” measurable, first by investigating their contribution to:

- maintain sales;
- sell more;
- charge a higher price;
- save money;
- create new business.

The aspects mentioned can’t easily be projected on water boards because of their special status:

- maintaining sales is hardly an issue for water boards. Customers aren’t able to go to the “company next door”;
- since national actions are aimed at saving water, “selling more” is no criterion;

- charging a higher price is only allowed within certain limits. Generally this is only accepted when there is no other solution;
- the difficulty to translate intangibles into saving money was the reason to start this in the first place;
- Since most water boards still aren't allowed to make a profit, the result of new business is generally marginal. Delivering other quality water is something that is done to save money on the purification process, and so belongs to the previous category.

In fact this implies that part of the valuing of intangibles must be done by translating them to savings.

This process is only a small part of IA. Since measuring intangible benefits is extremely difficult and can't be done without extensive case studies and market surveys (Hare and Royle, 1994), there is no reason to continue the process. A few applications though will be used to provide an example on how intangibles can be translated to possible financial benefits, without quantification though.

3 - Information exchange to KLIC and others

Better information quality will lead to less damage by contractors. Better information may also lead to a changing attitude of contractors, which also may lead to less damage. Quality and standardisation of data may result in agreements on electronic exchange sooner, implying that companies can profit sooner also.

5e - Draught damage

GIS-support of the handling of draught damage may save time, but may also save money because information on regulations, cadastral parcels, crops and groundwater levels can be combined much better. The opposite may be possible also.

5h - Inventory and logistics (ILS)

An example of possible benefits has already been mentioned before. When timely information on projects and materials orders is available and standards are maintained, it may be possible to realise better contract terms with suppliers.

9 - Customer complaints / Call centre

The ability to relate different sources of data enables faster reaction on problems in the network. An early discrimination of a problem will generally lead to reduced costs of solving it. This applies also to the improved and faster handling of complaints.

The status of customers of water boards in The Netherlands is different from customers on the free market, because they have no real financial influence. As a result probably the percentage of tangible benefits will be larger than the 28% mentioned in the previous paragraph, though this would need more investigating.

Because of this different status valuing part of the intangibles is difficult. The example on information exchange, where the customer (contractor) has a different role, show the -possible- result of improving customer satisfaction.

If they strive for valuing all benefits, water boards will have to find “translations’ for their intangibles. Since only part of the benefits concerning “quality improvement” and “customer service” can be quantified, a common denominator must be established to be able to compare these intangibles with real financial benefits.

7.5 Conclusions from this chapter

Analysis of costs and benefits, based on general assumptions, leads (for the applications preferred by the water boards) to considerable benefits. Short payback times could be a motive for starting with certain developments as soon as possible. When considering all related costs though, GIS-developments are hardly feasible. This is a result of the limitations of the questionnaires and interviews, which prevent an overview on all applications and benefits.

Only the direct financial benefits of increased productivity and capabilities have been taken into account in detail. Other benefits, the intangibles, can be measured also, though this is much more difficult. GIS must be seen as a long-term investment, and maximal benefits are generated when solutions are integrated and conform with the corporate view.

Especially when intangible benefits are concerned, valuation very much depends on the organisation’s key targets.

If GIS/IT are really considered to be strategic and mission-critical, a cost/benefit analysis won’t suffice if all relevant aspects have to be taken into account. The cost/benefit analysis then just reveals the top of the iceberg when striving for a thorough evaluation of investments in new developments.

8. Final remarks and conclusions

The aim of this Thesis is, to prove that GIS can have a meaningful contribution to the key targets of a water board, in order to counterweight the idea that management has on GIS: an expensive toy, meant for the drawing office.

In the introduction a research approach is chosen. Part of this concerned the of using a questionnaire and interviews. First the questionnaire, so the interviewees could get familiar with the field. In interviews all questions would be reviewed again. In fact the choice of doing this part of the research like this puts a stamp on the rest of this Thesis.

The introduction and growth of GIS in Dutch water boards has been slow. As chapter 2 shows, finance, unavailable digital basemaps and outdated organisational structures prevented a fast development. There has also been little stimulation from professional organisations, which resulted in lack of standardisation. Merges, reorganisations and changes in the environment result in water boards re-emphasising their key targets:

- cost reduction;
- quality improvement;
- outstanding customer service.

There is also a change in insight on GIS; instead of developing standalone applications, GIS/IT must be part of a corporate approach, to be able to fully profit from the benefits.

Processes within water boards can be characterised by much field work and much

redundancy in work concerning facilities. These processes can be supported by tools that support integration and communication. As chapter 3 shows, the “new” technologies that can be used in GIS-applications therefore very much concern of non-GIS aspects. New technology is relative in this case because, considering the organisations at present, ultimate solutions must be avoided to prevent acceptation problems.
Though standardisation isn’t an important issue at present, when striving for communication and integration, standardisation must be a key point of attention.

The Thesis is on the costs and benefits of GIS. The applications described in chapter 4 revealed the relatively minor importance of “real GIS” functionality and the large influence of communication capabilities. Most of the benefits are realised by improving communication between information systems, between office and field crew and with external organisations. This is characteristic for the use of GIS within water boards at present and in the near future.

Designing a questionnaire is notoriously difficult. Since water boards are not the first to adopt new technology, the questions were very much aimed at the present situation. During the process different alterations have been made, mainly because of still too much detail. Because of the two phases though, problems though could be solved in the interviews.

Companies are still too much focused on the way present tasks are organised. Detailed knowledge though, especially on how time is spent on tasks, is generally not available. All this was painfully revealed when evaluating the results from questionnaires and interviews. Paragraph 6.1 provides a summary of conclusions on this part of the research process.

Though on the other hand useful information was provided, even the interviews didn't reveal all information required.

The present way of thinking explains why only part of the applications described were considered to be beneficial; these were the ones that could easily be translated.
Though there are few that have been claimed not to be beneficial at all, only part of the applications are considered to be beneficial within short. Information on the obscure group in between isn't reliable enough to taken them into account also.

In order to identify benefits, an organisation must first identify all GIS-applications that it will develop (Lerner, 1994a). When a GIS-environment is present, most of the overhead costs have already been made (conversion, hardware, licenses, maintenance personnel) and can be shared. To provide a more sound analysis, the less "interesting" applications have to be investigated also. The fact that this wasn't part of the research approach seriously limits the value of the outcome.
Overcoming this limitation asks for a more thorough approach and investigation. Also slowing down GIS-developments because of management decisions and -opinion may not result in employees losing interest. This implies that new GIS-applications have to be promoted and investigated by:

- doing pilot projects;
- demonstrations of GIS for different departments;
- promotional activities to inform management;
- gathering information from companies that already use them;
- co-operation between organisations (water boards, other utilities).

As became clear from chapter 7, many applications are supposed to be very beneficial.

When all related costs are taken into account (hardware, maintenance, licenses, conversion(?)), GIS is really a costly tool though. This outcome can be explained though:

- there are more applications to be developed, which will generate additional benefits;
- the applications mentioned are valued rather safe;
- preventive maintenance is expected to generate large benefits, though not at first;
- mean costs will decrease when more applications are used because sharing of sources and synergetic effects.

More and more thorough investigation must deliver the information to value GIS as a whole, instead of treating applications as standalone developments.

Although there are still options to prove different, it has not yet been possible to prove that management is wrong in their opinion on GIS/IT.

This doesn't have to hinder GIS-developments though, because the question that management must ask itself is, if a water board can do without advanced technology? In the preceding chapters the following changes have been widely discussed:

- reorganisations and merges lead to organisations with less people which have to work more efficiently;
- job-rotation and the need for increased flexibility ask for support by adequate systems that store part of the expert's knowledge;
- employees are stimulated to work from home;
- information demands (amount and quality) from external organisations are increasing.

To be honest:

- part of the demands just can't be satisfied without the support of GIS and Information Technology;
- part of the demands can, but the costs would be enormous.

Though they seems rather clear, management generally don't accept these statements. For the time being therefore a cost/benefit analysis is probably the only way.

The cost/benefit analysis revealed some impressive benefits. It revealed direct benefits only though, resulting from increased productivity and extra capabilities. This is a limitation of the approach, since these are only part of the benefits. More benefits exist, but these are inherently more difficult to quantify (Donaldson, 1994).

Tackling these asks for different tools, but also for much more thorough investigation.

Applications are treated as standalone, while maximal benefits are generated when solutions are integrated and fit in -again- the corporate view. Especially when intangible benefits are concerned, valuation very much depends on the organisation's key targets. Research therefore must be aimed at one company then.

One of the methods which are said to be better fit to this approach is Investment Analysis.

This Thesis showed an approach to the analysis of costs and benefits. It also revealed several limitations of this approach.

Part of the conclusion is, that several applications exist where the use of GIS can be beneficial. It is expected that other applications may also yield benefits, but without thorough investigation nothing definite can be said on this subject.

The research focused on direct financial benefits. These appeared to be only part of all benefits perceivable. Valuing the remaining benefits though is a difficult and time-consuming task. Since these benefits constitute the largest part though, investigating them may be an option when striving for insight in all benefits.

Though this Thesis didn't gain it's object, it proved that certain GIS-applications can be beneficial. It also provided information on how to overcome the limitations perceived, in order tot be able to perform a more thorough cost/benefit analysis of new GIS-applications in water boards. Without further proof it is expected that an approach, aimed at avoiding the shortcomings perceived, will be promising.

List of abbreviations

ACN	Adres Coördinaten Nederland (Dutch address co-ordinates)
ALEID	Dutch program for calculation of flow and pressure, based on water use, usage models and net structure
BPR	Business Process Redesign
BSP	Business System Processes
CIS	Customer Information System
CBA	Cost/Benefit Analysis
CMG	The Computer Management Group
COM	Common Object Model
DAS	Distribution Automation System
DBMS	DataBase Management System
DMS	Document Managing System
FIS	Financial Information System
FMS	Facility Management System
GPS	Global Positioning System
IA	Investment Analysis/-Appraisal
ILS	Inventory and Logistics System
IT	Information Technology
KEMA	International organisation on electric energy systems and environmental technology/-management
KIWA	Dutch organisation for research and certification, aimed at water and environment
KLIC	Kabels en Leiding Informatie Centrum (Cables and mains Information Centre)
LIMS	Laboratory Information and Management System
OGC	The Open GIS Consortium
OGIS	Open Geodata Interoperability Specification
OII	Open Information Interchange Initiative
OLE	Object Linking and Embedding
PA	Piping Arrangement

PAL	ProjectAanpak Leidingenregistratie (project approach to watermains information)
PAP	Postcode, Adres, Plaats (Postal code, Address, Place)
PFD	Process Flow Diagram
P&ID	Process & Instrumentation Diagram
REGIS	Regionaal Geohydrologisch Informatie Systeem (Regional Geo-hydrologic Information System), a system for monitoring and analysing groundwater flow
SCADA	Supervisory Control And Data Acquisition system
TQM	Total Quality Management
VEWIN	Association of owners of water boards in The Netherlands
WFM	WorkFlow Management
WMS	Work Management System

References

Berkel-Coumans, F., 1996, Operational and integrated SCADA far off yet, (Operationeel, geï ntegreerd GIS/SCADA nog ver weg), *VI-Matrix*, 1996/3, pp. 26-27.

Bourgeois, S., 1998, Voice recognition accelerates data collection, in ESRI ARC News vol.19, no. 4, pp. 20.

Buitelaar, M. and Groen, U., 1994, Business Process Redesign, a new view on automation? (Business Process redesign, een nieuwe kijk op automatisering ?), *Informatie* 1994/6, pp. 388-397.

Cap Volmac bv., 1995, Information modelling (Informatiemodellering).

Coulson-Thomas et al, C., 1994, *Business Process Re-engineering: myth & reality*, Kogan Page Limited, London, pp. 69-72&116-117.

Cramers, M. and Gerrits, H., 1997, Financial world keeps process redesign at a distance (Financiële wereld houdt procesontwerp op afstand), *Automatisering Gids* 1997/13, p. 13.

Crane, A.I., 1994, Incorporating GIS and predictive modelling into facilities management, *AM/FM*, pp. 589-598.

DGIII JRC, 1996, EC GIS Strategic Research and Development In Europe, A strategic view of GIS research and technology development for Europe, Report of the Expert Panel Convened at the Joint Research Centre, Ispra, 19-20 November 1996, URL http://ams/emap/sai/jrc/it/dg3gis/

Donaldson, W.R., 1994, Why Cash Flow Analysis Stifles Innovation And Unfairly Penalizes AM/FM/GIS, *AM/FM*, pp. 483-492.

Elliott, B., 1994, Moving AM/FM to the field: technology, trends & success stories(1), *AM/FM*, pp. 845-857.

Ferguson, C. Warren, 1996, Valuing your AM/FM/GIS investment, *Smallworld conference proceedings 1996*, pp. 163-168.

Finch, S., and Martin, J., 1993, Introduction, GIS in the infrastructure, *Geographic Information 1994*, pp. 169-172, Taylor & Francis.

Gooijer, J. de, 1996, The end justifies the means (Doel heiligt de middelen), *Computable*, 1996/11, pp 33-37.

Groot, R. de, 1996, Management doesn't understand anything about GIS (Management begrijpt niets van GIS) *VI matrix,* June 1996, pp. 36-37

Haan, A.J. de, 1994, Utilities: so many men, so many minds (Nutsbedrijven: zoveel hoofden, zoveel zinnen) *Automatisering Gids*, 1994, pp. 11-15.

Hammer, M. and Champy, J., Re-engineering the corporation: A manifesto for business revolution, London, Nicholas Brealey.

Hares, J.S., and Royle, D., 1994, Measuring the Value of Information Technology, John Wiley & Sons Ltd., pp. 205-216.

Hedges, E.T.,1994, Supporting process re-engineering through incremental AM/FM implementation, *AM/FM*, pp. 269-278.

Joosten, S.S.M., 1995, Workflow: a review (Werkstromen: een overzicht), *Informatie* 1995/9, pp. 518-527.

Kiwa/VWN, 1995, Colloquium "Distribution: quality against what costs?", (Distributie: kwaliteit tegen welke prijs?).

Lerner, N.B., 1994a, Quantifying GIS benefits: a bottom-up approach that builds management confidence, *AM/FM*, pp. 53-59.

Lerner, N.B., 1994b, Prioritizing application development in an interdepartmental AM/FM system, *AM/FM*, pp. 419-429.

Martin, J. and Taskis, D., 1992, Use of GIS in the water industry, *Geographic Information* 1992/93, pp. 153-164, Taylor & Francis.

Mazure, R., 1996, AM/FM/GIS-field creates basis for portable PC's (AM/FM/GIS-veld ontwikkelt draagvlak voor draagbare PC's), *VI-matrix*, Oct. 1996, pp. 10-12.

McLeroy, R.J., 1994, Linking AM/FM/GIS with work order management and hydraulic analysis models, *AM/FM*, pp. 381-382.

Meer, A. J. van der, 1997, Dimensions of surveying in the utility world, (Landmeetkundige dimensies van de nutswereld), *Geodesia*, 1997/1, pp.19-25.

OGC, 1996, The OGIS Testbed, OGIS Project Document 94-010R1.

Oogen, J.H. van, 1995, Standardisation: foundation for the support of business processes, (Standaardisatie, het fundament voor ondersteuning van bedrijfsprocessen), Proceedings of the 7th AM/FM Conference, 1995.

Pistorese, T.A., 1994, Actual benefits realized through implementation of a GIS, *AM/FM*, pp. 409-417.

Quarmby, M., and Leinemann, U., 1996, Smallworld Integration with HP's Customer Contact Manager, *Smallworld conference proceedings 1996*, pp. 27-32.

Rosenthal, L.P.M., 1997, Maintenance of watermains networks, (Leidingnetbeheer), 1997, KIWA.

Spruijt-van der Starre, M.E.J., 1993, IT: Part of a strategic whole ? (IT: Onderdeel van een strategisch geheel ?), *Informatie* 1993/1, pp. 59-63.

VEWIN, Projectgroep PAL,1990, Handbook on project approach to watermains information (Handboek Projectaanpak Automatisering Leidingeninformatie).

Wondergem, J., 1995, Less irritation because of better communication (Minder irritatie door betere communicatie), *Installatie*, 1995/12, pp. 38-39.

Zevenbergen, J.A., 1994, Preventing damage by better information on mains, (Betere leidingeninformatie ter voorkoming van graafschade, *VI-Matrix*, 1994/8, p. 29.

Appendix 1 - Geographical Information standards and organisations

Amtliches Topographisch-Kartographisches Informationssystem (ATKIS)
BS 7666 - Spatial Data Sets for Geographical Referencing
CEN TC287 - European Norms for Geographic Information
Data Interchange Standard for Cadastral Mapping (DFT)
Digital and Electronic Maps Transfer Standard (DEMTS)
Digital Geographic Information Exchange Standards (DIGEST)
Echange de Données Informatisées Géographiques (EDIGéO
FGDC - Metadata standard
Geographic Data File (GDF)
Geographic Tag Image File Format (GeoTIFF)
IHO Transfer Standard for Digital Hydrographic Data (IHO DX-90)
INTERLIS - Data Exchange Mechanism for LIS
International Terrestrial Reference Frame (ITRF)
ISO 6709 - Standard representation of latitude longitude and altitude
ISO 8211 - Specification for a data descriptive file for information interchange
ISO 15046 - Geographic information
Israel Exchange Format (IEF91)
JHS 117-119 - EDI-based information services for geographic data
National Standard for the Exchange of Digital Geo-referenced Information (NES)
Netherlands Transfer Standard for Geographic Information (NEN 1878)
Neutral Transfer Format (NTF)
Norma de Intercambio de Cartografia Catastral (NICCa)
Norma de Transferencia de Informacion Geografica (NOTIGEO)
Open Geodata Interoperability Specification (OGIS)
ON-A2260/1 - Interface for Digital Exchange of Geographic-Geometric Data
Receiver Independent Exchange Format (RINEX)
Samordnet Opplegg for Stedfestet Informasjon (SOSI)
Spatial Archive and Interchange Format (SAIF)
Spatial Data Transfer Standard (SDTS)
Standard Procedure and Data Format for Digital Mapping (SPDFDM)

Table 2 - Current Geographical Information standards

ISO/IEC JTC1/SC21 - ISO/IEC Joint Technical Committee on Information Technology. SC21 is the subcommittee of JTC1 for open systems interconnection, data management and open distributed processing.

ISO/IEC TC211 - ISO/IEC Technical Committee for Geographic Information and Geomatics (TC211).

CEN TC287 - European standardization organisation for geographic information.

CEN TC278 - European standardization organisation for road transport and traffic telematics.

CERCO - Comité Européen des Responsables de la Cartographie Officielle

DGIWG - Digital Geographic Information Working Group, whose work defines the standards used within European military applications.

EUROGI - European Umbrella Organization for Geographic Information

EUROSTAT - Responsible for developing standards for the dissemination of geo-statistical data within the European Commission.

ADV - Arbeitsgemeinschaft der Vermessungsverwaltungen der Lander der Bundesrepublik Deutschland

AFNOR - Association Française de Normalisation

AGI - Association for Geographic Information

ANSI X3L1 - US standard committee for Spatial Data Transfer: responsible for turning the Spatial Data Transfer Standard (STDS) into a US standard. Working Group 2 of this committee is working on GIS extensions to SQL in conjunction with the Open GIS Foundation.

BSI - British Standards Institute

CSSITR - Committee on Standard of Spatial Information Transfer (Russia), Russia GIS-Association

FOMI - Hungarian Institute of Geodesy, Cartography and Remote Sensing Japanese Geographical Survey Institute

NNI - Netherlands Normalisation Institute

NMA - Norwegian Mapping Authority

OGC - Open GIS Consortium

ON - Austrian Standards Institute

SFS - Finnish Standards Association

South African National Land Information Services

Spanish Instituto Geografica Nacional

USGS - US Geological Service

IHO - International Hydrographic Organization

IGS - International GPS Service for Geodynamics

ICA - International Cartographic Association.

Table 3 - Standards development organisations

Appendix 2 - Results from the questionnaire

1 - General properties of the company

		A	B	C	D
1		4500 km1 > 32 mm	5000 km1	10.000 km1	3.850 km1
2		2000 km1	190.000x	450.000x	4000 km1
3		168.000	190.000	450.000	165.000
4		2250 km2	1745 km2	3855 km2	2700 km2
5		210	200	450	195
6					
7					

2 - Experience in using GIS

1		na	1 year	3 months	2 year
2		since mid 1995	since October 1994	since September 1997	since February 1997

B - extensive research on GIS-capabilities for 1 year
C - spent 1 year for realising an extensive report on the future use of GIS
D - uses GIS for the design of watermains for 1.5 years already

3 - Information exchange to KLIC and others

1		y	y	y	y
2		4800	8000	4600	6400
3		1	2	1	1
4		95%	60%	(50%) 95%	(50%) 85%

A - stores outlet data in GIS also. Part of the benefits is realised by storing less detailed information.
B - main part of the benefits is a result of storage of outlet sketches in a DIS.

4 - Integration of small systems
4a - Valves and fire hydrants

1		PC-application	AS/400 application	AS/400 application	PC-application
2		800	100	800	1600
3		4	3	2 (after conversion)	1
4		50%	50%	20%	75%

B - though it will become more in the future, little is done with these data.
D - already in use, though not for all valves and hydrants.

4b - Permits

1		PC-application	paper archive	paper archive	PC-application
2		320	200	minimal	1600
3		4	3	4 (see comments)	3
4		hardly	25%	na	25-50%

B - 25% savings on hours, 50% on paper.
C - information on permits (related to watermains) are rather static.
D - After design is completed static information, GIS may add extra functionality. Reference to drawings.

4c - Terrains

1		y	y	y, manual	y, manual
2		800	800	?	800
3		4	3	3	2
4		0%	25%	na	50%

A - in combination with other applications, which use the same basemaps.
D - all catchment areas are owned, which yields much administrative work.

4d - Pollution areas

1		y	n	y (see comments)	y
2		200	minimal	1600	2400 (see comments)
3		4	4	4	2
4		0%	na	na	75%

A - has been much more, but is stabilised now. No plans to store the areas in the GIS.
B - minimal use, not yet in the design process.
C - mainly for catchment areas. Integrating these areas would stimulate analyses in relation to watermains.
D - aimed mainly at catchment areas.

4e - Cable network

1		y, separate drawings	y	sep.drawings + dbase	manual on drawings
2		200	50	100	160 (but growing)
3		4	3	2	3
4		0%	25%	0%	50%

A - data almost doesn't change. Technical equipment is stored in other systems.
B - network doesn't change, except when e.g. new pumping stations are build.
C - can easily be integrated into FMS.

5 - Relationships with other information systems
5a - ALEID

1		ALEID	ALEID	ALEID	ALEID
2		800	1600	500	800
3		3	2	2 (see comments)	2
4		90%	90%	90%	60%

A - no integrated solution.
B - application of "ALEID-dumper" software in Smallworld already lead to 75% savings.
C - immediately after conversion of a region has been completed.

5b - SCADA

1		y	y, PRODIS	y	y
2		see comments	see comments	see comments	see comments
3		eventually	na	na	na
4		na	na	na	na

A - data isn't used real-time, measuring at critical locations, little or no fluctuations.
B - relationship for better and faster exchange of data, no integration necessary.
C - data necessary for other applications can easily be obtained without integration.
D - stable network, little benefits. Use of data in e.g. complaints system.

5c - REGIS

1		Dawaco	REGIS-PC	REGIS	Dawaco
2		1600	?	1600	1600
3		4	4	4 (see comments)	4 (see comments)
4		no direct benefits	no direct benefits	no direct benefits	no direct benefits

B - when applications for terrains are realised relationships will be investigated further.
C - information exchange (terrains, wells), same user interface, basemaps
D - no integration of applications, use of the same basemaps, easier information exchange.

5d - Engineering (installations/buildings)

1		manual / CAD	CAD	manual / CAD	manual / CAD
2		na	na	na	na (see comments)
3		na	3	na	na
4		na	na	na	na

A - no need for an integrated solution, relation with scanned data or external file.
B - relation, by which external drawings can be viewed.
C - different departments, resulting in "hard" separation of responsibilities.
D - responsibility of different departments. Integration will have no significant benefits.

5e - Draught damage

1		PC-application	PC / ArcView	progress application	spreadsheet
2		400	400	800	800
3		4	4	na	3
4		50%	see comments	na (see comments)	see comments

A - costs of cadastral information will influence extensive use.
B - possibilities when cadastral information is available for other applications also.
C - Need for GIS-functionality (e.g. ArcView), but no integration with FMS.
D - little use, because understaffed. Savings will be used to do more with the same staff.

5f - Laboratory information (LIMS)

1		n / ad-hoc	minimal (see comments)	n / ad-hoc	n (see comments)
2		na	?	na	na
3		4	3	3	na
4		na	na	na	na

A - can be part of an integrated quality/maintenance system
B - measuring points in relation to sluicing. In future more functionality to support the maintenance process.
C - meaningful application, especially for tracking the cause of complaints on drinking water quality.
D - little complaints, so little need for establishing this relationship.

5g - Customer Information System (CIS)

1		y - AS/400	y - AS/400	y - AS/400	y - AS/400
2		800	800	4800	na (see comments)
3		4	3	2	na
4		80%	75%	50%	na

C - most time spent on customer notification due to sleucing activities. Improved customer satisfaction.
D - at present the organisation doesn't work this way. May lead to improved customer satisfaction.

5h - Inventory and logistics (ILS)

	1	y, manual	y, manual	y, manual	y, use of GIS

	2	see comments	see comments	see comments	see comments
	3	4	3	1	4
	4	na	na	na	na

A - development in combination with design application.
B - benefits of new logistic concept are estimated at 3 million a year, but not as result of GIS only.
C - very high priority, application(s) will be realised shortly. No information on possible benefits.
D - organisation already has small stocks. Benefits are realised using other information systems.

6 - The design process

6a - Using GIS/IT in all stages of the preparation and design process

1		y, manual	y, manual	y, manual	y, use of GIS
2		4800	6400	4200	6400
3		2	2	2	1
4		50%	30%	70%	50%

6b - Use of electronic data exchange in the design process

1		y, manual	y, manual	y, manual	y, use of GIS
2		1600	1600	800	1600
3		1	2	1	2
4		80%	50%	90%	50-75%

B - 50% + 50% on costs of paper and copies.
D - depends on how the information is supplied.

6c - Use of external data as part of the design process

1		limited (see comments)	limited	limited	y
2		na	na	na	400
3		4	4	3	3
4		na	na	na	50%

A - most of this work is put out to contract.
B - benefits must be found in the use of existing information, or in the use of the object oriented GBKN.
C - costs of data may be high, metalling may be meaningful, other questionable.
D - improved quality in preparation. Data may be used for other GEO-applications also.

7 - Revision process

1		y, part digital	y, part digital	y, manual	y, part digital
2		6400	4000	8000	8000
3		2	1	1	1
4		80%	80%	90% / 40%	50%

A - experience shows that updating speed has increased enormously.
B - this is already experienced during the conversion process.
C - 90% when newly designed, 40% when maintenance.

8 - Preventive maintenance system

1		n	limited	limited	limited

2		na	?	?	?
3		2	3	4	4
4		na	30%	40%	"gigantic"

A - at present policy is aimed at corrective maintenance only.
B - part of future "maintenance and info" application. Other information (complaints) can already be used.
C - can be used to find an optimum, asks for detailed information that isn't available yet.
D - complaints and watermains problems are the first input to this functionality.

9 - Customer complaints / call centre

1		y, part of CIS	y	y	y
2		3200	4000	4200	1200
3		3	3	2	2
4		50%	50%	50%	50%

C - (geo)graphic interface, ability to access different sources of data.
D - very little complaints, in future a more preventive approach to failures.

10 - Miscellaneous
10a - Generating special mapping products

1		manual	manual	1:100.000 / 1:25.000	manual
2		1600	200	200/800 (see comments)	1600
3		2	1	2	2
4		80%	50%	90% (of 200)	75%

2- most of he specialist work (including DTP) is done by an external bureau.
C - 600 hours are spent annually on making products for other departments.
- 75% savings on paper if the end product is used "digitally" (laptop, pencomputer).

10b - Management information

1		y, limited	y, manual	y, manual	y, manual
2		?	?	200 (?)	?
3		2	3	2	3
4		80%	na	80%	na

A - management must first see the benefits of GIS.
B - difficult to quantify benefits, increased efficiency and quality.
C - benefits may be much larger, for this information is now produced at various places in the organisation.
D - all kind of counts that are very time consuming now.

Appendix 3 - Costs and benefits of new applications

General		**1998**	**1999**	**2000**	**2001**	**2002**	**2004**	**2005**
Hw/sw (1 server per district)		34.000	34.000	34.000	34.000	34.000	34.000	34.000
System management		8.000	8.000	8.000	8.000	8.000	8.000	8.000
Application management		20.000	20.000	20.000	20.000	20.000	20.000	20.000
"Super-user" (1 per district, 3 districts)		48.000	48.000	48.000	48.000	48.000	48.000	48.000
	Net cash fl.	110.000	110.000	110.000	110.000	110.000	110.000	110.000
	Tot. cash fl.	110.000	220.000	330.000	440.000	550.000	660.000	770.000

3 - Information to KLIC and others (without electronic exchange)

Application	10.000	4.000	4.000	4.000	-	-	-	-
maintenance	10%	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Licenses	3*view (33.000)	8.000	8.000	8.000	8.000	8.000	-	-
Maintenance	15% over 34.500	5.000	5.000	5.000	5.000	5.000	5.000	5.000
Education	3*view (6.000)	2.000	2.000	2.000				
Hardware	3 workstations (11.500)	4.000	4.000	4.000	4.000	4.000	4.000	4.000
Benefits	25% * 4800h	20.000-	40.000-	60.000-	60.000-	60.000-	60.000-	60.000-
	Net cash fl.	4.000	16.000-	36.000-	42.000-	42.000-	50.000-	50.000-
	Tot. cash fl.	4.000	**12.000-**	**48.000-**	**90.000-**	**132.000-**	**182.000-**	**232.000-**

4a - Valves and fire-hydrants

Application	10.000	4.000	4.000	4.000	-	-	-	-
maintenance	10%	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Licenses	x	-	-	-	-	-	-	-
Maintenance	x	-	-	-	-	-	-	-
Education	1*view(2.000)	1.000	1.000	1.000				
Hardware	1 workstation (3.500)	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Benefits	50% * 400h	3.000-	7.000-	10.000-	10.000-	10.000-	10.000-	10.000-

	Net cash fl.	4.000	-	3.000-	8.000-	8.000-	8.000-	8.000-
	Tot. cash fl.	4.000	4.000	1.000	**7.000-**	**15.000-**	**23.000-**	**31.000-**

5a - ALEID

Application	10.000	4.000	4.000	4.000	-	-	-	-
Maintenance	10%	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Licenses	in- + output (20.000)	5.000	5.000	5.000	5.000	5.000	-	-
Maintenance	15% over 20.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000
Education	1*edit (12.000)	5.000	5.000	5.000				
Hardware	1 workstation (3.500)	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Benefits	75% * 800h	10.000-	20.000-	30.000-	30.000-	30.000-	30.000-	30.000-

	Net cash fl.	9.000	1.000-	11.000-	20.000-	20.000-	25.000-	25.000-
	Tot. cash fl.	9.000	8.000	**3.000-**	**23.000-**	**43.000-**	**68.000-**	**93.000-**

6a - Using GIS/IT in all stages of the preparation / design process

Application	40.000	15.000	15.000	15.000	-	-	-	-
Maintenance	10%	4.000	4.000	4.000	4.000	4.000	4.000	4.000
Licenses	2*edit (56.000)	13.000	13.000	13.000	13.000	13.000	-	-
Maintenance	15% over 59.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000
Data conversion	20.000	8.000	8.000	8.000				
Education	2*edit (24.000)	9.000	9.000	9.000				
Hardware	2 workstations (7.000)	3.000	3.000	3.000	3.000	3.000	3.000	3.000
Benefits	50% * 4000h	33.000-	67.000-	100.000-	100.000-	100.000-	100.000-	100.000-

	Net cash fl.	28.000	6.000-	39.000-	71.000-	71.000-	84.000-	84.000-
	Tot. cash fl.	28.000	22.000	**17.000-**	**88.000-**	**159.000-**	**243.000-**	**327.000-**

6b - Use of electronic data exchange in the design process

Application	x	-	-	-	-	-	-	-
Maintenance	x	-	-	-	-	-	-	-
Licenses	1*edit (28.000)	7.000	7.000	7.000	7.000	7.000	-	-
Maintenance	15% over 29.500	4.000	4.000	4.000	4.000	4.000	4.000	4.000
Education	1*edit (12.000)	5.000	5.000	5.000				
Hardware	1 workstation (3.500)	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Benefits	75% * 1000h	13.000-	26.000-	38.000-	38.000-	38.000-	38.000-	38.000-

Net cash fl.	4.000	9.000-	21.000-	26.000-	26.000-	33.000-	33.000-
Tot. cash fl.	4.000	**5.000-**	**26.000-**	**52.000-**	**78.000-**	**111.000-**	**144.000-**

7 - The revision process (not based on the use of field equipment yet)

Application	20.000	8.000	8.000	8.000	-	-	-	-
Maintenance	10%	2.000	2.000	2.000	2.000	2.000	2.000	2.000
Licenses	3*edit (84.000)	20.000	20.000	20.000	20.000	20.000	-	-
Maintenance	15% over 88.500	13.000	13.000	13.000	13.000	13.000	13.000	13.000
Education	3*edit (36.000)	14.000	14.000	14.000				
Hardware	3 workstations (11.500)	4.000	4.000	4.000	4.000	4.000	4.000	4.000
Benefits	50% * 6000h	50.000-	100.000-	150.000-	150.000-	150.000-	150.000-	150.000-

Net cash fl.	11.000	39.000-	89.000-	111.000-	111.000-	131.000-	131.000-
Tot. cash fl.	11.000	**28.000-**	**117.000-**	**228.000-**	**339.000-**	**470.000-**	**601.000-**

9 - Customer complaints / Call centre

Application	100.000	38.000	38.000	38.000	-	-	-	-
Maintenance	10%	10.000	10.000	10.000	10.000	10.000	10.000	10.000
Licenses	3*view (33.000)	8.000	8.000	8.000	8.000	8.000	-	-
Maintenance	15% over 34.500	5.000	5.000	5.000	5.000	5.000	5.000	5.000
Extra hw/sw	100.000	38.000	38.000	38.000				
Maintenance	10%	10.000	10.000	10.000	10.000	10.000	10.000	10.000
Education	3*view (6.000)	2.000	2.000	2.000				
Hardware	3 workstations (11.500)	4.000	4.000	4.000	4.000	4.000	4.000	4.000
Benefits	50% * 4000h	33.000-	67.000-	100.000-	100.000-	100.000-	100.000-	100.000-

Net cash fl.	82.000	48.000	15.000	63.000-	63.000-	71.000-	71.000-
Tot. cash fl.	82.000	130.000	145.000	82.000	19.000	**52.000-**	**123.000-**

10a - Generating special mapping products

Application	10.000	4.000	4.000	4.000	-	-	-	-
Maintenance	10%	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Licenses	1*view (11.000)	3.000	3.000	3.000	3.000	3.000	-	-
Maintenance	15% over 11.500	2.000	2.000	2.000	2.000	2.000	2.000	2.000
Education	1*view (2.000)	1.000	1.000	1.000				
Hardware	1 workstation (3.500)	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Benefits	75% * 500h	7.000-	13.000-	19.000-	19.000-	19.000-	19.000-	19.000-

Net cash fl.	5.000	1.000-	7.000-	12.000-	12.000-	15.000-	15.000-
Tot. cash fl.	5.000	4.000	**3.000-**	**15.000-**	**27.000-**	**42.000-**	**57.000-**

Acknowledgements

After finishing this Thesis I realise that many people have contributed to this piece of work one way or another.

First I would like to thank Professor Henk Scholten and Doctor Ian Heywood for their support and advice. Their enthusiasm and useful/structured tips proved to be a welcome help when looking at the deadline.

I also would like to express my special thanks to:

Koos Bijlsma, KLIC Noord,
Henk Haverkamp, Waterbedrijf Gelderland,
Simon Gjaltema, Waterleidingmaatschappij Overijssel,
Gerrit Gruis, Waterbedrijf Groningen,
Arthur van Dijk, Waterleiding Drente,

for spending time on questionnaires, interviews and boring questions and for their interested support,

Willem Aleva,

for trying to improve my English,

Henk Klein Nienhuis,

for sharing with us his knowledge on watermains maintenance, and finally

Wim van de Belt,

for letting me attend this course, for his sometimes un-stimulating support and for not complaining about my frequent absence.

Nico