





# A Life saving open geodata Warehouse

An application of how an open geodata warehouse can benefit the work of the Dutch Public Order and Safety.

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#### ABSTRACT

Geographically related data and especially information is becoming more and more important to, both for an increasing number of organisations, and also for a wider range of users. The era of using geographically related Information Systems to improve decision making is rapidly advancing. To make this possible, it is necessary to have a solid geographical dataset (map), as recognised by the Directorate of the Public Order And Safety within the Dutch Ministry of the Interior and Kingdom Relations. Therefore the Ministry started a number of projects to find out what it takes to use maps in the most efficient and effective way. The most recent project was called DIGIKAR, which had to produce one national agreement with one or more map suppliers, in order to improve standardisation, co-ordination and communication within the Directorate of the Public Order and Safety. This project became the foundation of this study. When the established project team visited the organisations concerned, they discovered that the use of maps was not the only problem, but there were problems surrounding all data used in relation with their Geographical Information Systems (GIS). This paper presents a solution to these problems based on one of the latest database techniques, known as data warehousing. After an assessment proving that this type of Information System can benefit the Public Order and Safety Directorate effectively, a functional and technical design forms these thoughts into a usable concept, in the form of an Open Geodata Warehouse based on a so called Enterprise Data Mart Architecture (EDMA). This type of data warehouse makes it possible to retrieve information required in a fast and easy manner without the user having to worry where he or she can find this information. The data which is needed to provide this information is previously extracted from the operational systems in a platform-independent manner, and transformed into appropriate databases which can be used according to the information needs. Besides this functionality, it is also possible to begin small and to grow when needed using datamarts. This constitutes an ideal solution for the Public Order and Safety Directorate.

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# DISCLAIMER

The results presented in this thesis are based on my own research in the Department of Regional Economics, Free University of Amsterdam. All assistance received from other individuals and organisations has been acknowledged and full reference is made to all published and unpublished sources used.

This thesis has not been submitted previously for a degree at any Institution.

St. Willebrord, may 2000

Jan Luijkx.

Signed:

#### ACKNOWLEDGEMENTS

In addition to being a professional (Co-ordinator Real Estate Information and Automation) at a Municipality in the south-west of the Netherlands, I am also a volunteer fireman in my home town. This combination was the main reason that I was interested in not only what kind of spatially related data was being used, but also how this data was being used by these types of organisations.

After consulting my tutor Prof. Dr. H. J. Scholten about the choice of the subject for my thesis, we came to the conclusion that it would be very interesting to find out what the geographical information needs would be within the Directorate of the Public Order and Safety within the Dutch Ministry of the Interior and Kingdom Relations. The Ministry heard of this idea and informed me that they also wanted to start a similar project by which a field research could bring more clarity in this particular matter. The objective of this project was to come up with one national agreement with one or more map suppliers to promote standardisation and

uniformity within the organisation of the Public Order and Safety in order to reduce the existing high costs. The project was called DIGIKAR (peiling informatiebehoefte DIGItaal Kaartmateriaal bij de Alarmdiensten en Rampenbestrijding in Nederland, which means in English: investigating of the information need in relation to digital maps within the emergency services and crisis management in The Netherlands) and on the request of the Ministry I became one of the four members of the project-team. This was the beginning for me of a new GIS challenge.

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# **1. ORIENTATION AND PROBLEM DESCRIPTION**

#### **1.1 INTRODUCTION**

Geographical Information Systems (GIS) are becoming more and more available to a growing group of users who have already used spatially related data for quite some time and who are now discovering the advantages of this relatively "new" technology. Within the sector of the Dutch Public Order and Safety (Police, Fire department and Ambulance) where GIS is becoming accepted, this phenomenon of awareness also appears to be happening. But because of the great variety of functions within these organisations a considerable amount of different GIS functionality is present or necessary. The innovations in relation to GIS within these organisations concerned are still young but they are advancing in a rather rapid and mature way. One can observe that GIS is becoming a new trend within these organisations, used to improve the quality of the public services by increasing the efficiency and/or effectivity of the operation of the various resources. The binding factor within all these different GIS's is the location in, on and under the earth's surface of real

and virtual objects, phenomena and processes. A method to accomplish this binding is to join the locations to a cartographic reference file, in our situation also known as a digital map.

The Ministry has therefore done quite some research on the developments of geographical information technology with regard to map use within the field of the Public Order and Safety. A few projects which relate to this thesis will follow next:

In 1994 the Ministry decided to do some research to get more insight in the whole situation with relation to GIS (particularly mapuse) and this resulted in a report called KAR-1 (Kaarten voor Alarmdiensten en Rampen bestrijding deel 1) which means in English: maps for the emergency services and crisis management, part 1. This report tries to gauge the need for analogue as well as digital maps within the emergency rooms of the organisations concerned, recognising that it was important to focus on the financial and personnel resources in relation to obtaining the material, and the status of GIS in the organisations.

This report was followed in 1996 by the report KAR-2 (Kaarten voor Alarmdiensten en Rampen bestrijding deel 2), which means in English: maps for the emergency services and crisis management, part 2, which contained an inventory of all the map providers, including their products and conditions of delivery, to provide more insight into this jungle for the potential map users.

An interim conclusion which can be drawn is that almost every individual organisation uses different kinds of maps and they all do it at their own particular way, and this is an undesirable situation to be avoided at all times, because it reveals shortcomings in standardisation, co-ordination, communication and it promotes redundancy, high costs, etc.

Besides this, the demand for these maps is considerable by which it makes it very difficult to make a wellconsidered choice, because each demand is made from a different perspective. The main issues in map-making therefore are that they are: commercially driven, made for different applications, the suppliers of the GIS applications are not the same, etc.

Therefore the Ministry decided in 1998 to commission one final research step to find out what the functional map information need is among the map users concerned, before the Ministry would actually take action.

The objective of this project is to produce one national agreement with one or more map suppliers, in order to solve the earlier mentioned shortcomings. This project was called DIGIKAR (peiling informatiebehoefte DIGItaal Kaartmateriaal bij de Alarmdiensten en Rampenbestrijding in Nederland) which means in English: investigation of the information need in relation to digital maps within the emergency services and crisis management in The Netherlands, and it will be discussed more clearly in chapter 3 because it is the foundation of this thesis.

#### 1.2 THE OBJECTIVE OF THIS STUDY

The objective of this paper is to improve data sharing of, and easier access to geographically related information within the organisation of the Dutch Public Order and Safety, in order to contribute to improved knowledge and decision making, and at the same time to improve co-ordination, communication and standardisation.

#### 1.3 PROBLEM ASSESSMENT ACCORDING TO THE OPAFIT CONCEPT

When visiting the organisations involved in the DIGIKAR project, it became clear that most of the interviewees had the same kind of problems and that the map use were not the only problem, but in fact all data used in relation with their Geographical Information Systems (if they had one). Each individual organisation spent lots of superfluous time, effort and money making the data readable and understandable for their GIS and almost everything seemed to work in these "naturally" evolved information systems, but nobody knew if the hardware, software, data, procedures, etc. used were actually the most efficient and effective ones. Most of the people were too busy trying to re-invent the wheel that they did not have enough time and energy to fully exploit all the possibilities. The problems that occurred can best be described by the OPAFIT concept [Scholten, 1996], OPAFIT stands for the abbreviation Organisation, People, Agreements, Finances, Information and Technology, which covers all of the important aspects within an information system. Next follows an enumeration of the problems per individual aspect, and how this paper will handle these aspects in detail:

#### **1.3.1 ORGANISATION**

The Public Order and Safety organisation consists out of three different organisations (see also chapter 2) with three different regional divisions, which means that each organisation has autonomy within that region. This has resulted in the fact that every individual organisation built their own independent information system, and this led to a nation wide lack of uniformity, communication and co-ordination. Another important aspect was that there was also a lack of time for building and maintaining a GIS, partly as a result of the earlier mentioned shortcomings, but also because it was not a core business of the organisations concerned.

Although these organisational problems were very important in relation to the upcoming solutions, this paper will mention some issues regarding this subject but will not go into detail concerning them because it is not relevant to this field of study (GIS).

#### 1.3.2 PERSONAL

All three organisations involved have their own tasks to fulfil in connection with their legal obligations, for which the use of GIS is a supporting, rather new technology and not a core business, this results in a lack of specific GIS jobs and GIS knowledge which in its turn results in a lack of awareness and commitment of the personnel.

Although these personnel problems are also very important in relation to the upcoming solutions, this paper will not go into detail because it is not relevant to this field of study (GIS).

#### **1.3.3 AGREEMENTS**

As already mentioned in paragraph 1.3.1 each organisation has autonomy in their own region, which caused every individual organisation to build their own independent information system, and this also led to a nation wide lack of standards covering the needs of all three organisations.

The national standards available were ignored and every individual organisation used their "own" standards. Because standardisation is essential for the "open" concept of this paper, it will receive appropriate attention in paragraph 8.7.

#### 1.3.4 FINANCES

Because all regions have to finance their own information systems (once more a result of the regional autonomy), a range of different information systems are used these days. The people responsible within each individual organisation had their own experiences, knowledge, vendors, etc., through which a system was bought that satisfied their individual needs. And this mixture of different information systems does not improve the possibilities of data communication.

Finances will self-evidently not be handled in this paper because it is clearly not related to this field of study.

#### 1.3.5 INFORMATION

Like a lot of organisations, the Public Order and Safety are also occupied with a migration from data use to information use. This means that a new type of end-user (analysts, managers, etc.) has appeared, needing more and a different kind of information to fulfil their needs, these are not expert users. In this paper a basemap will be the most important geographical data collection because it can provide important information to this new type of user in a easy way. Therefore an extensive explanation will be dedicated to this basemap.

#### 1.3.6 TECHNOLOGY

There is a huge amount of data stored in the operational systems of the Public Order and Safety which are not, or not easily, accessible for the end-users concerned. It is difficult to trace data because it is hidden in a maze of different applications, or certain instructions take up too much capacity so that the overall performance decreases, or the data is traceable but it presents itself in a unreadable format.

This thesis will try to suggest a solution to this problem by using the possibilities of a geodata warehouse.

#### 1.4 STRUCTURE AND LOGICAL DESIGN OF THIS STUDY

This chapter discusses the structure and logical design of the study in order to provide the reader with more insight into the meaning of this paper.

#### 1.4.1 RESEARCH QUESTIONS

During this study the following questions need to be answered:

- What does the user organisation of the Dutch Public Order and Safety look like?
- What are the needs and problems in relation to the use of the geographically related data, both for the DIGIKAR project and in general?
- What can be done to improve the existing problems (lack of data sharing, co-ordination, (data) communication and standardisation) in relation to geographically related data within the organisations involved?
- How can these problems be solved in the most efficient and effective manner?

#### 1.4.2 RESEARCH DESIGN AND QUICK DOCUMENT OVERVIEW

The research design consists of two general aspects:

- What has to be done to solve the named problems.
- And how does this need to happen.

Besides this, the following has also been taken into account:

- Practice: A description of how this project stands in relation to the practice.
- Theory: A description of some theories which are important in relation to the subject of this thesis.
- Reflection: This is a comparison of the practical and the theoretical aspects brought together to find out if they correspond with each other.
- Validation: Evaluation of the findings of this paper.

The research design can be depicted as shown in figure 1





The following document overview will try to clarify the contents of this paper in a nut shell .

- Chapter 1: Gives an introduction of the origin and structure of this thesis in combination with the problem description and a quick overview.
- Chapter 2: Describes the total (GIS) user organisation of the Public Order and Safety in combination with the data that they use and their general data needs.
- Chapter 3: Gives a more detailed explanation of the empirical DIGIKAR project which is the core of this paper and therefore very important.
- Chapter 4: Explains what data warehousing is all about.

Chapter 5: Is an extension of the needs that are mentioned chapter 1, and which are really necessary to

optimise

the use of spatially related data within the concerned organisations.

Chapter 6: Describes a practical approach to assess whether the Public Order and Safety need a data warehouse or not.

Chapter 7: Gives a functional design of a data warehouse which is adapted to the specific situation of the Public

Order and Safety.

- Chapter 8: Gives an example of a technical workout of the functional design of an open geodata warehouse.
- Chapter 9: Describes an actual application of the possible geodata warehouse for the emergency services within the organisation of the Public Order and Safety.
- Chapter 10: Closes this paper with a number of conclusions, recommendations and trends which ought to be taken seriously.

Chapter 11: Glossary.

Chapter 12: Appendix.

Chapter 13: References.

#### 1.5 GIS CONTRIBUTION TO THIS STUDY

Before it is possible to describe the contribution of GIS to this study it is necessary to first consider what it actually means. For a cartographer , GIS may be an efficient map producer, but any spatial analysis capabilities may be beyond his or her remit. For an engineer, dealing with underground sewers, a GIS is a tool which allows him or her to know the location of the different parts of the sewer, or to model flows through the system. As one can see the meaning of GIS depends on how one looks at it, on one hand. Another important factor on the other hand is that it is a fast moving and continuously developing technology so that definitions of a few years ago may no longer be appropriate to the current technology. In Conclusion, it can be said that it is impossible to describe GIS with just one universal definition. Therefore this paper presents a few different definitions by some prominent persons to help appreciate what constitutes GIS and what one can do with it.

"A GIS is a powerful set of tools for collecting, storing, retrieving at will, transforming, and displaying spatial data from the real world" [Burrough, 1986].

"A GIS is a computer system that can hold and use data describing places on the earth's surface." [Rhind, 1989]

"A GIS is a group of procedures that provide data input, storage and retrieval, mapping and spatial analysis for both spatial and attribute data to support the decision making activities of a organisation." [Grimshaw, 1994] Whatever the shortcomings of these definitions, they do provide a starting point for identifying exactly what kind of an animal a GIS is. And to be sure one gets a clear overall picture, all aspects are illustrated in the next figure.



#### INFORMATION

#### figure 2

Aspects shown include those like the contribution of both the geometrical and attribute data to represent the real world, operating within delimited constrained by the system boundary and influenced by the OPAFIT items.

Parallel to an increasing number of different kinds of users there is also an increasing number of questions about the future of GIS, a future which is uncertain on one hand because GIS as we know it might disappear, but on the other hand a future which offers perspective because it reveals new challenges and opportunities.

A few of these questions are:

• How will GIS look in the nearby future?

- What changes will take place?
- Where do we go from here?

One of the latest developments related to GIS is that it appears that it will be absorbed into what has been termed as "Spatial Information Science". It means in fact that a GIS must have the ability to converge with the existing Enterprise Information Systems without operating as an individual specialist system. This is also known as Open GIS, which provides in fact Universal Storage, Access and Delivery [Reeve, 1998] of geographically related data (see paragraph 8.6). And this is where GIS contributes to this study because it forms a perfect tool for approaching the large and most varied kinds of data sets which are stored in an open geodata warehouse (see chapter 4) without needing a specialist user or using specialist software or data structures etc.

An example of an open geodata warehouse is the Dutch NCGI (National Clearinghouse of Geographic Information). For further examples see appendix A [Bregt - Crompvoets, 2000].

## 1.6 CONTRIBUTION OF THIS STUDY TO THE GIS COMMUNITY

The application of GIS within a data warehouse is one of the promising new developments of this moment. Although this study will have limited validity, since GIS and its applications are evolving rapidly, it may provide the GIS community enough information about the possibilities of an open geodata warehouse to widen their horizons and to enable them to use this kind of application within their own environment. GIS, as well as data warehouses, can be strong Decision Support Systems (DSS), and combining these two methods results logically in an "ideal" type of spatial DSS by which one method amplifies the other.





Figure 3 gives an abstract illustration by which the GIS (twisted map) is woven around the spatially related data warehouse (cylinder) through which it becomes one whole, and they become indispensable to one another. This emphasises the possibilities of co-operation between two promising decision support techniques, which expresses itself further in this paper.

# 2.0 DESCRIPTION OF THE USER ORGANISATIONS AND THEIR NEEDS

# 2.1 THE OVERALL ORGANISATION OF THE PUBLIC ORDER AND SAFETY DIRECTORATE

In the previous part of this paper the Directorate of the Public Order and Safety has been mentioned more than once. But how these organisations really look, or how many employees there are, or what are their job descriptions are, or what kind of data they use in connection with their Geographical Information Systems, are still obscure. This chapter will try to describe the three different concerning organisations involved who form the actual Public Order and Safety Directorate, namely the Police, the Fire Department and the Ambulance service.



Police

Fire Department

Ambulance service

#### Figure 4

The division of the regions in figure 4 show clearly that the boundaries as well as the number of the regions are deviant. Another thing worth knowing is that all these individual organisations have their own autonomy within these boundaries.

## 2.1.1 POLICE

The total police-force consists out of 25 + 1 regions. This means that there are 25 "normal" regions and 1 national region which is being managed by the KLPD (Korps Landelijke Politie Diensten, which means in English: Corps National Police Services). Two other divisions less important for this thesis are: Railroad Police and Royal Military Police, these are not mentioned again.

The total police-force contains about 60,000 employees, of which 2500 use GIS, and they are hereby the largest and most varied GIS user of all three organisations of the Public Order and Safety Directorate.

The general task of the Police is to maintain the public order and to assist those who need it within statutory legislation and in subordination to the competent authorities.



Figure 5

#### Individual tasks:

#### Corps National Police Services:

- Mobilisation
- Information support
- Guardian of the safety of important people
- Logistics
- Information Technology Organisation.

#### Basic geographical related data used:

- Roads
- Real estate (premises)
- Topography (town area)

Incidents / accidents

Reporting

**Regional corpses:** 

Provide assistance

Trace and record offences

•

•

Maintaining of the public order

- Addresses
- Routes

## 2.1.2 FIRE DEPARTMENT

The fire Department consists out of two different types of corps, the municipal corpses and the regional corps. In fact every municipality has its own Fire Department, because the law states that the municipality is responsible for the basic care in relation to public safety. Next to this there are also the regional corps which are an extension of the local government, and because of their supporting tasks they are in fact the main GIS users. The total Fire Department organisation contains about 22000 volunteer employees and 5000 professional employees, of which 1000 use GIS, and they are hereby the second largest GIS user within the Public Order and Safety Directorate. The general task of the Fire Department is to prevent, limit and fight fire, and to prevent and limit danger to humans and animals.



Figure 6

#### Individual tasks:

- Municipal Fire Department
  - Prevention
  - Preparation
  - Repression
  - Pro-action
  - After-care

#### • Regional Fire Department

• Establishing / maintaining an emergency

room

- Procurement and maintaining of materials
- Placing personal and materials

- Preparing the organisation to act in times of war or other similar situations.
- Warning the population with a siren network.

Basic geographical related data used:

- Roads
- Real estate (premises)
- Topography (town area)
- Vegetation
- Water (hydrological data)

- Surveying dangerous matters.
- Advising municipalities about fire prevention.
- Large scale training exercises.
- Plans of attack
- Railroads
- Fire hydrants
- Addresses
- Routes

## 2.1.3 AMBULANCE

The organisation of the Ambulance services consists out of approximately 30 regions also known as RAV's (Regionale Ambulance Voorziening, which mean in English: Regional Ambulance Provision) and they are generally by one of two organisations which are:

- GGD (Gemeentelijke Geneeskundige Dienst, which means in English: Public health service).

- CPA (Centrale Post Ambulancevervoer, which means in English: Central post of ambulance transportation).

The total organisation contains about 10000 employees, of which 500 use GIS, and they are hereby the smallest GIS user of the Public Order and Safety.

The general task of the Ambulance is to provide transport for the sick and injured in every possible way.



Figure 7

#### Individual tasks:

- Co-ordination of ambulance transport within a certain area.
- Maintaining communication with organisations concerned.
- Stabilising of sick people and victims of accidents.
- Transportation of sick people and victims of accidents.
- Management of transport facilities and remaining materials.

Basic geographical related data used:

- Topography (town area)
- Addresses
- Routes

#### 1.3.4 CRISIS MANAGEMENT

This is in fact a special organisation which not co-ordinates only all previous organisations in case of a disaster, but also a number of other organisations such as municipalities, the environmental office, etc. Each region has a disaster plan in which they prescribe the exact organisation assigned for the specific circumstances. To support the tasks of these organisations, GIS is a helpful tool.

The general task of Crisis Management is to limit and fight disasters, and to prevent and limit danger for humans and animals.



Figure 8

#### Individual tasks:

- Municipalities (Mayor)
  - Internal warning
  - Information provision
  - Collection of infected goods
  - Registration of victims
  - Provision of the necessities of life

- Fire Department (operational leader)
  - Source- and effect fighting
  - Warning population
  - Disinfection of humans, animal, vehicles and infrastructure
  - Mutual communication
  - Providing logistics in relation to operations

- Police
  - Maintaining the public order
  - Evacuation
  - Traffic control
  - Identification of victims

- Ambulance
  - Taking medical and hygienic precautions in relation with public health care
  - Mental care

• Setting up a medical assistance chain

#### • Environmental office

• All aspects in relation to the environment

Basic geographical related data used:

- Roads
- Real estate (premises)
- Topography (town area)
- Incidents / accidents
- Addresses
- Routes
- Vegetation

- Water (hydrological data)
- Plans of attack
- Railroads
- Fire hydrants
- Environmental data
- Meteorological data

Because the composition of a crisis management organisation depends upon the kind and magnitude of the disaster, it also requires a special approach towards the data use for which data exchange is the keyword. This subject offers enough material for at least one other thesis, so that it will be left out of consideration within this paper.

## 2.2 DESCRIPTION OF THE DATA USE

In the previous paragraphs one can see what kind of geographically related data the individual organisations use while performing their tasks. This paragraph has placed these three different data collections into a data table through which one can get a better overview of the whole. It is however good to know that it only concerns general data, because in this stage it is not sensible to go into details. Table 1 gives a clear overview of the spatial related data generally used within the organisations of the Public Order and Safety Directorate. The data in this table is generated from a study performed at the library of the Ministry of the Interior in combination with a study performed by Grothe M. et al. [1994].

data			
Roads	Х	Х	Х
Real estate	Х	Х	
Topography	Х	Х	Х
Incidents/accidents	Х		
Addresses	Х	Х	Х
Routes	Х	Х	Х
Vegetation		Х	
Water		Х	
Plans of attack		Х	
Railroads		Х	
Fire hydrants		X	

organisations Police Fire Dept. Ambulance

table 1

As a result of the clarity of the table a few things immediately attract attention and these are:

- The fire department uses the greatest variety of spatially related data.
- All three organisations use roads, topography, addresses and routes.
- And the police and fire department use real estate.

These findings are very useful to know when analysing the data use, for they give users the opportunity to see where they can find data they need but do not have.

# 2.3 INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) STATUS OF THE EMERGENCY SERVICES

The ICT used within the organisations of the Public Order and Safety Directorate in relation with their geographically related data are just like all the other aspects, dependent on the different regions and the different organisations. In relation with the geographically related data mid-range computer systems are being used, in connection within Local Area Networks (LAN), and the software is characterised by CAD and GIS. For example Autocad and Microstation as CAD software and IMIS, Tensing GIS, Map Info, Map View, Atlas GIS, Arc Info and Arcview as GIS software. And to make the chaos complete, all this software uses different kinds of database management systems such as: oracle, ingres, dbase, foxpro, access, etc. The relatively sporadic data communication between the different organisations takes place with the use of Wide Area Networks (WAN).

Of the total user organisation of the Public Order and Safety Directorate, the police is the biggest and most experienced ICT user, followed by the fire department and then the ambulance service.

A method to represent the technological stages of growth of these organisations was developed by Bemelmans [1991] which introduces the following 4 different growth stages:

• Initiation

A few people begin to experiment with a new technology to find out what the (dis) advantages are. However an organisation does not want to spend too much time and effort with experiments in relation to new technologies because of the high, and in some cases superfluous costs. That is why pronouncements about technology choices are necessary to be able to take direct actions, actions such as hiring professional staff, or giving staff the appropriate education, etc. In this phase, management must stimulate the involved personnel.

• Diffusion

In this phase the technology has proven itself and spreads like an oil spot within the organisation. Management must encourage promotion of this technology to keep the potential users posted.

Consolidation

Attention shifts to the consolidation of the collected experiences and the elimination of existing problems, in order to temper the unbridled growth so that applications of this technology remain manageable. Policy should aim for an efficient use of the technology emphasised by a cost / benefit analysis.

• Integration

After a while the new technology will be integrated into the existing infrastructure and will lose its individual identity. It is important that management appears to be co-ordinated and open to new trends. The time is right to start experimenting with new technologies.

This method is characterised by the fact that ICT is an aggregation of different technologies which are considered as a spiral (see figure 9).



figure 9

This methodology provides a clear insight into the status of growth between the different technologies which is important because every phase carries its own demands and pre-conditions which require in a phased and nuanced policy. Next, a mutual distinction will follow to represent the general status for the three different growth stages of the individual organisations in relation to GIS technology (see figure 10).





The differences between the different growth stages of GIS within the organisations is a result of various aspects such as:

- Knowledge
- Budget
- Applicability
- Management interest

A few GIS related projects are C2000 (digital speech / data communication network) and GMS (Geïntegreerd Meldkamer Systeem, which means in English integrated emergency room system). These systems both offer the opportunity to deal with the locations of emergency units and incidents. Via the C2000 system for instance the location of a vehicle can be transmitted to the GMS, so that GMS can pass it on to a GIS so that it can be visualised on a map.

#### 2.4 WHAT DO THESE ORGANISATIONS NEED?

As one can see in figure 2 a GIS consists out of spatial and attribute data, of which this thesis mainly handles the spatial part. In the first instance these organisations need one usable national basemap extended with specific thematic information tailored to each organisation (see table 1), instead of the haphazard collection of different maps used at present which is growing rapidly. Besides this they also need more knowledge as to how to use this spatial data in an efficient and effective manner, because without knowledge it is impossible to generate the required information through which the former needs mentioned can be satisfied. These are in fact "just" a few simple needs which are on the other hand very comprehensive and important because it appears that it is very difficult, time consuming and expensive to compose such a basemap suitable for all three organisations, especially when there is no central organ that is willing to co-ordinate this and at the same time take the financial consequences, through which every individual organisation has to pay for its own data.

# **3.0 THE EMPIRICAL RESEARCH**

This paper is based on the DIGIKAR project (paragraph 1.1), established as a continuation of the earlier mentioned KAR 1 and KAR 2 projects. The required research was performed under the auspices of the Dutch Ministry of the Interior by the faculty of spatial science of the University of Utrecht in co-operation with the faculty of economic science and econometry of the Free University of Amsterdam.

Next follows a phased description of the project execution, which is extremely important to this paper.

#### 3.1 Project description

Since 1994 the Dutch Ministry of the Interior has been actively involved in the developments of geographical information technology within the Public Order and Safety Directorate. DIGIKAR must be seen as a module within a whole range of other innovative projects like GMS and C2000. These last two projects offer the possibility for handling the locations of units and / or incidents. Via C2000, for example, a location of a vehicle can be transmitted to GMS, which is connected with a GIS, so that it can be visualised on a map. This type of functionality makes the work of an emergency room operator much easier and clearer, because a picture says more then a thousand words. That is, if the map use is of a high quality (standardised, reliable, up to date, etc.). This is something that seems self-evident to a lot of people, but insiders know that the composition and maintenance of a map takes up a lot of time and effort. Former studies like KAR 1 and KAR 2 have highlighted these kinds of problems (chapter 1.1), after which it appeared that more information regarding the actual users was needed. This is when the DIGIKAR project came up for discussion. The DIGIKAR project is an empirical research project by order of the Dutch Ministry of the Interior to find out what the functional map information need is among the concerning map users of the Public Order and Safety Directorate.

The objective of this project is to come up with one national umbrella agreement with one or more map suppliers, in order to improve standardisation, co-ordination and communication within the Directorate of Public Order and Safety.

After assessing the needs of the project, the Ministry composed a project team (see acknowledgements) to start up the DIGIKAR project which consisted out of 6 steps which are shown in figure 11.



figure 11

A further description of these steps will follow next.

# 3.1.1 SELECTION OF THE POTENTIAL USERS

The first step was to select a limited number of prominent regions which were potential users of geographical information technology, in order to obtain a representative image of the functional map information needs within the sector of Public Order and Safety. Based on information obtained from previous projects and experiences, a list of organisations was produced that formed a representative selection.

A survey of these 15 different organisations are:

#### Police of:

- Haaglanden
- Utrecht
- Limburg Noord
- Amsterdam Amstelland
- Brabant Z.O.

Fire department of:

- Haaglanden
- Utrecht
  - Limburg Noord

Amsterdam

- Brabant Z.O.
- Twente

#### table 2

Establishing these organisations was one thing, but to reach the actual person(s) responsible was another interesting challenge. It appeared that the list used by the former projects was aged to such an extent that it was not possible to use it properly. Therefore every individual organisation had to be approached by telephone to update the needed data, such as: name organisation, address, residence, region, name responsible person(s), telephone number, etc. After this it was possible to take the next step.

#### 3.1.2. COMPOSITION OF THE QUESTIONNAIRE

The second step involved the making and distribution of a questionnaire (appendix B) that was able to provide more insight in relation to the present and future map use (digital and / or analogue) within the selected organisations.

The design of the questionnaire was based on the so called supply and demand method (vraag en aanbod methode) developed by the Union of Dutch Municipalities (Vereniging van Nederlandse Gemeenten V.N.G.). This approach is based on investigating what information policy actually means, namely seeking for a qualitative and quantitative balance between the supply of data (technology push) and the demand of data (market pull), [Bos, 1989]. This starting-point corresponded very well with the intentions that were stated for the DIGIKAR project.

Ambulance service of:

Limburg Noord

Haaglanden

Utrecht

Twente
The questionnaire itself consists out of 5 different parts, which are:

- A letter enclosed to explain the purpose and the intention of the questionnaire.
- Form A: is a stock-taking form to collect the relevant geographically related data collections (maps) based on a number of activities and applications.
- Form B: is a detailed description of the analogue geographical related data collections used.
- Form C: is a detailed description of the digital geographical related data collections used.
- Form D: contains the future wishes and demands that are important for the coming national agreement.

The intention of the first three forms (A, B, C) was to provide the project team with more insight into the use of different kinds of geographical related data on one hand, but on the other hand to force the organisations to structure their thoughts about their data collections used. It was expected that they would come to the conclusion that one national base map used by the whole Public Order and Safety Directorate would be better than the mixture of maps that they are using now.

#### 3.1.3 INTERVIEWS

The third step of the assignment was to visit the organisations involved and to interview them for the next two reasons:

- Assisting them with answering the questionnaire, if necessary (formal part).
- Observing how these organisations handled their geographically related data and other related issues (informal part).

The visits passed of in a professional and yet relaxed manner so that practically all people approached were more than willing to co-operate with the project interviews. They also endorsed the fact that GIS does not function correctly without a high quality basemap, but in spite of this they were reluctant to commit themselves to any kind of contract. It was interesting to notice that most of the interviewees were so called champions who had evolved in the course of years from a random function to a full or part time self-made GIS expert, trying to promote GIS-related activities in order to obtain more understanding and commitment to GIS from all decision levels within their organisations.

# 3.1.4 RESULTS

Although the people approached were initially more than willing to co-operate, the ultimate response of the questionnaires was approximately 30% which made it difficult to derive detailed conclusions. The most important reasons for this lack of response appeared to be:

- the magnitude of the questionnaire
- composition of the questionnaire
- a lack of time
- a lack of opportunity
- and a lack of knowledge

Despite the poor response it was still possible to form a reasonable picture about the spatial information needs, because almost every organisation produced the same answers. Nevertheless the informal interviews on the other hand brought in enough results to come to a sensible conclusion (see chapter 4 for the real needs). Next follows a table with information regarding the response.

Used	GBKN	Top25	<b>Top250</b>	Top10	Geo	Gemeente	Easy	6 POS.
maps		raster	raster	vector	streets		Travel	Postc.
Organisations								
Pol. Haaglanden	Х			Х	Х			Х
Pol. Utrecht		Х	Х		Х			
Pol. Limburg Noord	Х	Х	Х	Х				
Pol. Brabant ZO		Х	Х			Х		
Pol. Amsterdam-Am.	Х				Х	Х		
Fdept. Roermond				Х				Х
Fdept. Amsterdam						Х		
Fdept. Utrecht		Х	Х		Х			
Fdept. Twente	Х			Х		Х		
Fdept. Haaglanden	Х			Х	Х			Х
Fdept. Eindhoven			Х			Х		
Amb. Twente		Х	Х		Х		Х	
Amb. Utrecht								
Amb. Haaglanden	Х			Х	Х			X
Amb. Roermond				Х				X
Amb. Eindoven			Х			Х		

The different kinds of maps will be further discussed in appendix C.

# 3.1.5 REPORT

The structure of the report consists out of the following chapters:

- 1. Introduction
- 2. Project approach
- 3. Response
- 4. Results of the study
- 5. Conclusions
- 6. Recommendations
- Appendix 1: Experiences of the visits

The used questionnaire

#### 3.2 OUTCOME OF THIS EMPIRICAL RESEARCH

Because of the moderate response to the questionnaires, the objective of the study was only partially achieved. It was therefore not possible to collect enough information to make the right decisions regarding the obligations towards the map suppliers. Nevertheless in combination with the information gathered by the interviews, it was possible to form a fairly clear picture of the user needs and an identification of future trends.

The most important results from this study are:

- As a result of a lack of knowledge within the organisations concerned, files and applications are scattered.
- Innovative projects like GMS and C2000 stimulate awareness in relation to GIS so that a better information requirement and better decision making come into being.
- The increasing centralisation within the organisations of the Public Order and Safety Directorate leads to the implementation of more geographic information technology and to more regional standardisation.
- The big city regions represent a large part of the whole Directorate who are going their own autonomous way.
- It seems that the GBKN (Grootschalige Basis Kaart Nederland, which means in English: a large scale (mostly 1:2500) basic map of The Netherlands) is the only product that has enough potential to fulfil the user needs.
- There is more need for actual maps.

• There is a need for a central umbrella organisation to support the regions concerned.

Some further recommendations are:

- To make a final decision regarding a national GBKN possible, a specific market research stays is necessary.
- Because the TDN (Topografische Dienst Nederland, which means in English: topographical service of The Netherlands) is developing a better alternative for the Top25Raster map, it is better to wait and see what the results of these developments will be.
- It is not sufficient to offer basic data without the proper advice how to use it.
- The big city regions must be stimulated to inter-regional co-operation to promote standardisation.
- The heterogeneous character of the Public Order and Safety Directorate makes it hard to communicate. Information exchange is, however, essential in relation to national geographical data products. It makes sense to use internet technology to improve data communication.

The final version of this report has been distributed among all the organisations belonging to the Public Order and Safety Directorate, so that they have the possibility to make policy and planning guided by the results. If necessary, a member of the project team will give a further explanation by giving a lecture to a specific group of users or managers.

# 4.0 DESCRIPTION OF THE ASSESSED REAL NEEDS

This chapter deals with the needs revealed as a result of the informal part of the interviews which are different from the needs produced in relation to the DIGIKAR project.

# 4.1 WHY REAL NEEDS?

When visiting the organisations of the Public Order and Safety Directorate the interviewees made it clear that the information needs obtained from the DIGIKAR project were different from the general needs of the geographically related information users. While the project limited itself to map use only, the general needs were divided into 3 different types namely:

- Organisational needs
- Technical needs
- Informational needs

As one can see this is much broader than expected. This is why this paragraph is called "Why real needs?". And this was also the motivation for producing to produce this paper.

Next a more detailed description of these needs:

#### 4.1.1 ORGANISATIONAL NEEDS

Despite of the different region divisions in combination with the individual autonomy within the Public Order and Safety Directorate, there is a need for some kind of national co-operation. This type of co-operation can be defined as a national centre which should be capable to provide a number of desired services to the users involved. Services like the provision of knowledge and experience to assist the organisations with the use of their geographically related information so that everyone can use this same data in a more efficient and effective manner. Besides this centre there is also a need for more internal spatial knowledge, specific spatially related functions, more collective use of (inter) national standards, more awareness and more commitment of the personnel.

#### 4.1.2 TECHNICAL NEEDS

According to the interviewees there is also a need for a system which must be able to produce the required information in a fast and simple way and it also has to be accessible to every concerned organisation. Besides this it must also be able to integrate into the present organisations. Summarised this means that there is need for Universal: Storage, Access and Delivery of geographically related information [Reeve, 1998], so that everyone can use this same data in a more efficient and effective manner.

# 4.1.3 INFORMATIONAL NEEDS

As a result of the technological and organisational developments another kind of user arose. And this type of user has grown from a data processor to a full-grown information user [Nolan, 1979]. Operational users are not the only new type of user, but tactical and strategic employees also tend to use spatially related data to improve, for instance, decision making, planning or the production of complicated spatial analyses. A consequence of this different kind of use is that a higher quality of spatial related data is required, of which aspects such as timely, reliable and up-to-date are the most important.

# 4.2 HOW TO COPE WITH THESE NEEDS

Summarising one can say that the stated objective in paragraph 1.2 covers the problems outlined in paragraph 1.3 and the needs of the DIGIKAR project, in combination with the real needs mentioned in this chapter. But to obtain the stated objective it is necessary to try to find a solution to fulfil these needs and to solve the problems named. To accomplish this there are several methods which are all based on the following framework: information-policy, information-planning and the execution of the information-planning these are further explained below.

• Information-policy is laid down at the highest management level, describing which direction the organisation wishes to go, including the consequences regarding the required information system.

• Information-planning fills out the information-policy in terms of planning aspects, planning horizon and planning levels according to the planning hierarchy of Theeuwes, [1986]. This outline describes the general components of different information-planning methods used.





• The execution of the information-planning stage requires a system development method which makes it possible to develop information systems on a phased basis. This is necessary because the development of information systems is very complex and costly. After finishing this last phase, it is the intention that a working system will be developed based on the problems, needs and objectives of an organisation.

This paper has selected two methods namely: Information Strategy Planning (ISP) to determine the strategy and the system development methodology of Vandenbulcke to develop the system concerned, and these

methods are chosen because they correspond best to the situation of this thesis. However this does not mean that it is impossible with another similar methodology to accomplish the same result. Next follows a more detailed description of the methods chosen.

# 4.2.1 INFORMATION STRATEGY PLANNING (ISP)

ISP is one of the few well-known methods for producing information-policy and -planning [Martin, 1990] in a phased procedure, with the distinction that this method is more focused on filling-in the information-policy. Figure 13 gives an idea of the phases of this method in relation to the aspects under consideration.



#### figure 13

The most important objectives of this method are:

- The development of a relation between business strategy, information strategy and IT developments.
- The definition of architectures that form a stable starting-point for future system developments.
- And to assess plans to develop effective and efficient information systems.

And the results of an ISP will be:

- A description of the business strategy in terms of objectives, Critical Success Factors (CSF) and expected developments.
- Information needs and priorities based on the business strategy.
- A blueprint for the future information provision.
- A choice of strategy and a plan of action to carry out the chosen strategy.

In this case, phase 3 (Information needs and priorities) is executed within the framework from the DIGIKAR project. One example of a collection of information needs can be seen in the next table which describes the response of the three organisations in connection with these real needs.

organisations	Police	Fire Dept.	Ambulance
data			
ORGANISATIONAI			
National centre	Y	Y	Y
Spatial knowledge	Y	Y	Y
Specific functions	Y	-	-
Using standards	Y	Y	-
More awareness	Y	Y	Y
More commitment	Y	Y	-
TECHNICAL			
Universal S. A. D.	Y	Y	Y
INFORMATIONAL			

Higher quality Y Y -

Y = yes N = no -= no specific response

table 4

# 4.2.2 VANDENBULCKE (SYSTEM DEVELOPMENT METHODOLOGY)

The development of an information system is a very complex project which requires careful preparation and planning. In the course of years, several methods have been developed for building an information system (SDM, ISAC). Most of them are based on the general method of Vandenbulcke, which also will be used in this paper. The benefit of this choice is that it is independent of one specific method.

The method of Vandenbulcke is based on two principles, namely: a divisibility of the development activities into 9 different phases, and the division of a number of phases into the activities in relation to the processes within the concerned organisation (right side) on one hand and the activities related to the data that is being used (left side) on the other hand, see figure 14.

This paper tries to develop an information system with the emphasis placed on the functional design and technical design which can be seen in the chapters 7 and 8.





Because system development is an unique event, a project organisation has to be set up to accompany this. In this case the project organisation consists out of people of various regions and various levels. Besides operational and tactical management, it is also very important for strategical management to know what is going on in all aspects of this particular project. A method to set up this organisation can be the so-called linking pin principle. This principle is based on three levels of groups, namely: project group, steering group and the policy group, by which the chairman of the lower group sits in the upper group (see figure 15) to link these two.



#### figure 15

The policy group gives general directives about the development. The steering group gives concrete form to these directives with specific goals and tasks. And the project group is taking care of the design, the development, the implementation and the after-care of the system concerned.

In conclusion one can see that developing an information system is not just a case of buying a ready made collection of hard- and software, but that it is something that must be accepted by, and grow into, the organisation concerned. It is however difficult to give one ultimate solution because of the magnitude and complexity of the project. This thesis will try to give a solution for the problems mentioned and to fulfil the defined needs.

# 5.0 THEORY OF DATA WAREHOUSING

Data warehousing is one of the fastest growing client/server applications at this moment. It is an emerging technology that supports non-operational application areas like management information systems, decision support, and data mining. A further explanation of this phenomenon follows.

#### 5.1 EVOLUTION OF DECISION SUPPORT SYSTEMS

In the 1970's virtually all business system development was done on IBM mainframe computers using tools (COBOL, DB2, etc.). The 1980's brought in the new mini-computer platforms (AS/400 and VAX / VMS). The late eighties and early nineties made UNIX a popular server platform with the introduction of client/server architecture. The nineties were characterised by the use of graphical user interfaces (windows, NT, system 7, OS2, etc.).

Despite all the changes in the platforms, architectures, tools, and technologies, a remarkably large number of business applications continue to run in the mainframe environment of the 1970's. By some estimates, more than 70 percent of business data for large corporations still resides in the mainframe environment. There are many reasons for this. The most important reason is that over the years these systems have grown to capture the business knowledge and rules that are incredibly difficult to carry over to a new platform or applications. These systems, generically called legacy systems, continue to be the largest source of data for analysis systems. The data that is stored in DB2, IMS, VSAM, etc. for the transaction systems end up in large tape libraries in remote data centres and are mostly very difficult to retrieve. This is where data warehouses offer a solution.

### 5.1.1 DATA FROM LEGACY SYSTEMS

The primary concept of data warehousing is that the data stored for business analysis can be accessed most effectively by separating it from the data in the operational systems. Many of the reasons for this separation have appeared over the years. In the past, legacy systems archived data onto tapes as it became inactive and many analysis reports ran from these tapes or mirror data sources to minimise the performance impact on the operational systems. These reasons for separating the operational data from the analysis data, have not significantly changed with the evolution of data warehousing systems, except that now they are considered more formally during the data warehouse building process. Advances in technology and changes in the nature of business have made many of the business analysis processes much more complex and sophisticated. In addition to producing standard reports, today's data warehousing systems support very sophisticated on-line analysis including multi-dimensional analysis also known as OLAP (On-Line Analytical Processing).

#### 5.1.2 EXTRACTED INFORMATION ON THE DESKTOP

During the past 15 years, the sharply increasing popularity of the personal computer on business desktops has introduced many new options and compelling opportunities for business analysis. The gap between the programmer and end user has started to close. Advanced users will frequently use desktop database programs that allow them to store and work with the information extracted from the legacy sources. Many desktop reporting and analysis tools are increasingly targeted towards end users and have gained considerable popularity on the desktop. The downside of this model for business analysis is that it leaves the data fragmented and oriented towards very specific needs. Each individual user has obtained only the information that he or she requires. Not being standardised, the extracts are unable to satisfy the requirements of multiple users and uses. The time and cost involved in addressing the requirements of only one user prove prohibitive. This approach to databases. While many of these users may be proficient at data management, most undertake these tasks as a necessity. Given the choice, most users would find it more efficient to focus on the actual analysis and the tools available to them.

#### 5.1.3 DECISION SUPPORT AND EXECUTIVE INFORMATION SYSTEMS

Speed, flexibility and foresight are the primary characteristics that distinguish successful organisations in this information age. Businesses of the 2000's must have management processes in place to monitor and control the organisation while at the same time decentralising decision making in order to react to competitive changes and take advantage of unexpected opportunities. One central element that supports this balance between control and flexibility is shared knowledge. Such knowledge, derived from both internal and external data sources, is converted to information which can be readily interpreted.

These types of knowledge systems also known as decision support systems (DSS) and executive information systems (EIS). Decision support systems tend to focus more on detail and are targeted towards lower to midlevel managers. Executive information systems have generally provided a higher level of consolidation and a multidimensional view of the data, as high level executives have more need of the ability to slice and dice the same data than to concentrate on reviewing the data detail. These two similar and overlapping categories are perhaps the closest precursors of data warehousing systems. Yet the high price of their development and the co-ordination required for their production made them an elite product that never entered the mainstream. Today's data warehousing systems provide the analytical tools embodied in their precursors [Gupta, 1997].

#### 5.2 WHAT IS DATA WAREHOUSING

Approximately a decade ago, a set of significant new concepts and tools evolved into a new technology that made it possible to attack the problem of providing all the key people within an enterprise with access to whatever level of information was needed for the enterprise to survive and prosper in an increasingly competitive world. The term that has come to characterise this new technology is "data warehousing". Data warehousing has grown out of the repeated attempts on the part of various researchers and organisations to provide their organisations with a flexible, effective and efficient means of assessing at the sets of data that have come to represent one of the organisations most critical and valuable assets. A data warehouse is in fact a "natural" place for storing the "data space". It is where we store base level data elements that can later be consulted, analysed, etc. to deliver information.

# 5.2.1 DATA WAREHOUSING: A DEFINITION

William Inmon, who coined the term "data warehouse" in 1990, defined a data warehouse as:

A subject oriented, integrated, non-volatile, and time variant collection of data in support of management's decisions.

A further description of the aspects named follows next:

- Subject oriented: There is a shift from application-oriented data to decision-support data. If designed well, subject-oriented data provides a stable image of business processes, independent of legacy systems. In other words, it captures the basic nature of the business environment.
- Integrated: The database consolidates application data from different legacy systems which use different encoding, measurement units, and so on, and eliminates inconsistencies in the data.
- Time-variant: Informational data has a time dimension: each data point is associated with a point in time, and data points can be compared along that time axis, unlike operational data which is valid only at the moment of access capturing, a moment in time.

• Non-volatile: New data is always appended rather than replaced. The database continually absorbs new data, integrating it with the previous data.

The data warehouse is structured as shown in figure 16. This figure shows that there are different levels of detail in the data warehouse.



figure 16

There is data of an older, a current, a lightly summarised and a highly summarised level of detail. Data flows into the data warehouse from the operational environment, also known as legacy applications and data sources. Usually a significant amount of transformation of data occurs at the passage from the operation level to the data warehouse level. Once the data ages, it passes from current detail to older detail. As the data is summarised, it passes from current detail to lightly summarised data, then from lightly summarised data to highly summarised data.

# 5.2.2 DATA WAREHOUSE SCOPE

The scope of a data warehouse may be as broad as all of the informational data for entire enterprise from the beginning of time, or it may be as narrow as a personal data warehouse for a single manager for a single year.

There is nothing that makes one of these more of a data warehouse than another. In practice, the broader the scope, the more value the data warehouse has for the enterprise and the more expensive and time consuming it is to create and maintain it.

Perhaps the most important concepts that have come out of the data warehouse movement is the recognition that there are two fundamentally different types of information systems in all organisations: operational systems and informational systems. Next a description of these two systems:

• Operational systems:

Are just what their name implies, they are the systems that help us operate the enterprise day-to-day. These are the backbone systems of any enterprise and because of their importance to the organisation, operational systems were always the first parts of the enterprise to be computerised. Over the years, these operational systems have been extended and rewritten, enhanced and maintained to the point that they are "naturally" and completly integrated into the organisation. Most large organisations around the world, including the Public Order and Safety Directorate, could not operate today without their operational systems and the data that these systems maintain.

• Informational systems:

On the other hand, there are other functions that proceed within the enterprise that have to do with planning, forecasting and managing the organisation. These functions are also critical to the survival of the organisation, especially in our current fast-paced world. Functions like "marketing planning", "engineering planning", and as in our case "crime analysis", "transportation analysis", routing, localisation and "fire analysis" also require information systems to support them. But these functions are different from operational ones, and the types of systems and information required are also different. These knowledge-based functions are informational systems. And these informational systems have everything to do with analysing data and making decisions now and in the future. And not only do informational systems have a different focus from operational ones, they often have a different scope. Where operational data needs are normally focused upon a single area, informational data needs often span a number of different areas and need large amounts of related operational data.

A good example of an informational system is undoubtedly a data warehouse. And in the last few years, data warehousing has grown rapidly from a set of related ideas into an architecture for data delivery for enterprise end user computing. However, as Inmon himself said in an interview, data warehousing is an evolving concept.

There is no such thing as a complete data warehouse, either in terms of the environment or the tools, and thus by implication, opportunities for developing new tools, products, and opportunities, abound.

# 5.3 WHY DATA WAREHOUSING

If there is a single key to survival in the new century and beyond, it is being able to analyse, plan and react to changing business conditions swiftly. To do this, top managers, analysts and knowledge workers in our enterprises need more and better information. Information Technology itself has made possible revolutions in the way that organisations operate today. But the sad truth in many organisations is that despite the availability of more and more powerful computers on everyone's desks and communication networks that span the globe, large numbers of executives and decision makers can not get their hands on critical information that already exists within the organisation. Every day organisations large and small, create billions of bytes of data about all aspects of their business, millions of individual facts about their customers, products, operations and people. But for the most part, this data is locked up in a myriad of computer systems and is exceedingly difficult to access. This phenomenon has been described as "data in jail" [Orr, 1998].

Experts have estimated that only a small fraction of the data that is captured, processed and stored in an enterprise is actually available to executives and decision makers. While the number of technologies available for the manipulation and presentation of data have literally exploded, it is only recently that those involved in developing IT strategies for large enterprises have concluded that large segments of enterprises are "data poor."

#### 5.4 (DIS) - ADVANTAGES OF DATA WAREHOUSING

First the advantages of data warehousing:

1 Simplicity

2 Better quality data; improved productivity

3 Fast access	10 Enables parallel processing
4 Easy to use	11 Robust processing engines
5 Separate decision-support operation	12 Platform independent
6 Gives competitive advantage	13 Computing infrastructure
7 Ultimate distributed database	14 Down-size facilitation
8 Information flow management	15 Quantitative value
9 Operation cost	16 Security

#### 1. Simplicity:

The most frequently mentioned advantage of data warehousing is summarised as "simplicity." Data warehousing makes business simple because a data warehouse provides a single image of business reality by integrating various data. Data warehouses allow existing legacy systems to continue in operation, they consolidate inconsistent data from various legacy systems into one coherent set, and yield benefits from vital information about current operations [Hackathorn, 1995].

2. Better quality data:

The second advantage is better quality of the data used. Data quality issues like consistency, accuracy, timeliness and reliability are provided by a data warehouse because every data collection is carefully generated from the operational IS with data of the highest quality.

3. Fast access:

Since data warehouses allow users to retrieve necessary data themselves, the work load of an IS can be cut. The necessary data is in one place, so systems response time should be reduced.

4. Easy to use:

Queries from users do not interfere with normal operations, because a data warehouse enables easy access to business data without slowing down the operational database by taking some of the operational data and putting it in a separate database. Data warehouses focus on subjects for fast decision-making as well as regular reporting and they are targeted at end users.

5. Separate decision-support operation from production operation:

Another advantage mentioned is that data warehouses are built in order to separate operational, continually updated transaction data from historical, more static data required for business analysis. By doing so,

managers and analysts can use historical data for their decision-making activities without slowing down the production operation.

6. Gives competitive advantage:

Because data warehouses manage and utilise corporate knowledge better, which in turn helps a business to become more competitive, to understand customers better, and meet market demands more rapidly. Therefore, this benefit can justify the large expense [Barquin, 1997].

7. Ultimate distributed database:

Data warehouses are pulling together information from disparate and potentially incompatible locations throughout the organisation and putting it to good use. Middle-ware, data transfer software and other client/server tools are used to link these disparate data sources. A data warehouse is the ultimate distributed database [Burleson, 1995].

8. Operation cost:

Data warehouses provide fertile ground for building new operational systems. They eliminate paper based files and once the initial investment is covered, the organisation's information-technology group generally requires fewer resources [Barquin, 1997].

9. Information flow management:

The next most important topic is that data warehouses handle a large amount of data from various operational data sources, and data warehouses manage the flow of information rather than just collecting data. To respond to changing business needs, production systems are constantly changing along with their data encoding and structures. Data warehouses, especially the meta data, encourage continuous incremental refinement that must track both production systems and the changing business environment [Barquin, 1997].

10. Enables parallel processing:

Parallel processing helps users perform database tasks more quickly. Users can ask questions that were too process-intensive to answer before, and data warehouses can handle more customers, users, transactions, queries, and messages. They support the higher performance demands arising in a client/server environment, provide unlimited scaleability, and thus, better price/performance.

11. Robust processing engines:

Data warehouses allow users to obtain and refine data directly from different software applications without affecting the operational databases, and to integrate different business tasks into a single, streamlined process supported by real-time information. This provides users with robust processing engines [Goldberg, 1995].

12. Platform independent:

It is also true that data warehouses can be built on everything from a high-end PC to a mainframe, although many are choosing Unix servers and running their warehouses in a client/server environment. IBM and five other data warehouse software vendors formed alliances to clear the cross-platform hurdles inherent in data warehouse implementation. Similar partnerships have been formed by other vendors. It is crucial to have such partnerships which was not easy in the legacy system.

13. Computing infrastructure:

Data warehousing helps the organisation create a computing infrastructure that can support changes in computer systems and business structures.

14. Down-sizing facilitation:

Data warehouses empower employees to make decentralised decisions since they put information closer to the users. They are designed to give end users faster access to the information that is already there, without impacting other systems or resources. Therefore, users do not need to ask IS to get needed data and IS managers can concentrate on other tasks. This potentially eliminates the information middle-man who passes information from one place to another, and suggests down-sizing.

15. Quantitative value:

Another advantage is realistic bench-marking. Data warehouses provide the quantitative metrics necessary to establish business process baselines that are derived from historical data and allow business managers to measure progress.

16. Security:

Last but not least, it is a fact that data warehouses cannot directly query the production databases, thus improving the security of the production databases as well as their productivity. Some warehouses also provide management services for handling security.

Disadvantages of data warehousing

Data warehousing is not without its disadvantages and they are summarised in detail here below.

1 Complexity and anticipation in development	6 Complexity involved in Symmetrical Multi
2 Takes time to build	Processing and Massively Parallel Processing
3 Expensive to build	7 Difficulty in distributed database environment
4 Lack of Application Programming Interfaces	8 Time-lag between data warehouse and operation
5 End-users training	

1. Complexity and anticipation in development:

Enterprises cannot just buy a data warehouse, it has to be built, because each warehouse has a unique architecture and a set of requirements that spring from the individual needs of the organisation. Builders need to pay as much attention to the structure, definitions, and flow of data as they do to choosing hardware and software. In summary, developing such a large database requires an expert.

2. Takes time to build:

To build a data warehouse takes time. In a situation where there is not strong executive sponsorship, IS directors or others wishing to develop a warehouse may spend an inordinate amount of time justifying the need.

3. Expensive to build:

A data warehouse is also expensive to build. One reason data warehouses are so expensive is that data must be moved or copied from existing databases, sometimes manually, and data needs to be translated into a common format.

4. Lack of Application Programming Interfaces:

Data warehousing software still lacks a set of Application Programming Interfaces (API) or other standards that shuttle data smoothly through the entire warehouse process, such as Open Database Connectivity (ODBC) interface (Microsoft Corp.). However, ODBC and API allowing PC's to access data from many different databases, are not everywhere.

5. End-user training:

It is necessary to create a new "mind-set" with all employees, who must be prepared to capitalise upon the innovative data analysis provided by data warehouses; these end users require extensive training. A communication plan is essential to educate all personnel involved [Goldberg, 1995].

- Complexity involved in Symmetrical Multi-Processing and Massively Parallel Processing: The complexity of data warehousing, will be increased if the warehouses incorporate Symmetrical Multi-Processing (SMP) and Massively Parallel Processing (MPP). Synchronisation and shared access are difficult to realise [Burleson, 1995].
- 7. Difficulty in distributed database environment:

Because the data warehouse is a method of bringing disparate data together, it is centralised by its very nature. While many companies are still in the preliminary stages of putting their data warehouses together, this centralisation means that only workers located at the same site as the warehouse have access to the data.

8. Time-lag between data warehouses and operation:

Lastly, it is said that the data in data warehouses are extracted from operational databases that are continuously changing. A real-time data warehouse is an oxymoron because it is impossible to have real-time replication while maintaining a full-scale data warehouse. Data warehouses store only a time slice of corporate data that is steadily drifting backward out of relevance until the warehouses are replenished [Burleson, 1995].



#### figure 17

# 6.0 HOW CAN DATA WAREHOUSING BENEFIT THE ORGANI-SATION OF THE PUBLIC ORDER AND SAFETY DIRECTORATE

#### 6.1 DISCUSSION OF POSSIBILITIES

Before it is possible to determine which solution will meet the stated needs and solve the enumerated problems named, it is necessary to know what the potential options are. As in the case for most ICT projects there is no such thing as one "best" solution but a range of possible solutions from which one search is the best. And this "best" option will be worked out specifically for the Public Order and Safety Directorate. A description of the three possible options follows.

#### 6.1.1 OPTIONS

This paragraph will describe the ins and outs of the three real options:

• Improving existing information systems

This first option is a logical one, because one tends to keep on working with the same familiar information system. The principle of this method is to find out where the bottle-necks of the existing information systems are and then try to fix each bottleneck by enhancing or renewal of this particular part in order to meet the stated requirements. By improving the existing information system it is possible to improve decision making within an organisation, but it is practically impossible to equal the functionality of an actual decision support system. This has to do with the structure and content of the operational databases and the functionality of the matching applications. The principle is represented in figure 18.



# Figure 18

The figure shows the OPATIF system, that needs to be adapted, is improved to an OPAFIT system that fulfils

the operational needs.

## • Renewal of the existing information system

If the existing systems are not adequate there is also the possibility of replacing all existing information systems with new ones that have for example more functionality, more integration, etc. The principle of this option is in fact quite simple because it embodies an implementation of a totally new IS by which the "only" difficulty is to make the right choice. By renewal of the existing IS it is possible to improve decision making within an organisation, but this option also has the same problems as the previous option, in that it is also very difficult to generate management information.



#### Figure 19

This figure shows the PAOTIF system that is not adequate, and therefore needs to be replaced by an OPAFIT system that fulfils the operational needs.

• Data warehouse

This method has already been extensively explained in chapter 5 and needs no further explanation. The principle is represented in figure 20



SITUATION AFTER

#### figure 20

The figure shows that the existing OPAFIT system can operate besides a data warehouse to fulfil not only

the

operational needs but also those from other decision levels.

# 6.2 (DIS) - ADVANTAGES OF THE NAMED POSSIBILITIES

Method 1 (improving existing information system)

Advantages:

- Familiar use
- Less education needed

• Relative moderate expensive

#### Disadvantages:

- Time consuming
- Practically impossible to retrieve direct management information
- Difficult to improve
- Difficult to keep the system in the air while adjusting it

#### Method 2 (renewal of the existing information system)

#### Advantages:

- Possibility of developing a new system without hindering the existing system
- Freedom of choice

#### Disadvantages:

- Time consuming
- Very expensive
- Practically impossible to retrieve direct management information from operational systems
- Committed to the functionality of the operational information system

Method 3 (Data Warehouse)

The (dis) advantages were already extensively explored in paragraph 5.4

# 6.3 S.W.O.T. ANALYSIS

SWOT stands for Strengths, Weaknesses, Opportunities and Threats analysis, which is a tool to enhance strategic thinking in order to find out how these aspects relate to the internal and current issues. Like what is the company good at? What are the weaknesses in the present situation? Opportunities and Threats have primarily to do with the external and future issues. What are other regions doing? Will emerging technology strengthen or weaken our services? An example of a SWOT analysis in relation to the present use of GIS within the Public Order and Safety Directorate is given in table 5

STRENGTHS	WEAKNESSES
- Large amounts of useful data present	- Various regions with own autonomy
- Organisations are used to procedures	- Lack of national standardisation
-	- Lack of co-ordination and communication
-	- Lack of knowledge
-	- Data is not always accessible for the general
user	
OPPORTUNITIES	THREATS
OPPORTUNITIES - Growing awareness	THREATS - Not sure all regions will co-operate the same
OPPORTUNITIES - Growing awareness way	THREATS - Not sure all regions will co-operate the same
OPPORTUNITIES - Growing awareness way - Growing commitment	THREATS - Not sure all regions will co-operate the same - There is no map which fulfils the information
OPPORTUNITIES - Growing awareness way - Growing commitment needs	THREATS - Not sure all regions will co-operate the same - There is no map which fulfils the information
OPPORTUNITIES - Growing awareness way - Growing commitment needs - Technology is ready	THREATS         - Not sure all regions will co-operate the same         - There is no map which fulfils the information         - Growth of individual independent IS's is
OPPORTUNITIES - Growing awareness way - Growing commitment needs - Technology is ready increasing	THREATS         • Not sure all regions will co-operate the same         • There is no map which fulfils the information         • Growth of individual independent IS's is

#### table 5

# 6.4 MAKING CHOICES

Before one is able to work out a solution on behalf of the specific situation of the Dutch of Public Order and Safety Directorate, it is necessary to know what the "best" solution is. Therefore it was necessary to enumerate the three preceding possibilities in combination with the SWOT analysis to determine what the eventual choice should be. The first two methods are based on (partly) adjusting the operational information systems. Because these IS's have a certain purpose, like for example processing and viewing operational data, it is unlikely that these systems are also capable of generating management information or something similar. Data warehouses were invented to solve this problem. This type of IS was developed to operate in parallel with the operational systems to process management information out of the operational databases, and to offer this in an easy, fast and standardised way to all kinds of non-operational users (see chapter 4).

This solution has therefore been selected as the "best" or, better said, as the least worse choice and it will therefore be more extensively handled in the next few chapters, which present a functional and a technical design of a possible solution.

# 7.0 FUNCTIONAL DESIGN OF THE OPEN GEODATA WAREHOUSE

One of the phases of the system development methodology of Vandenbulcke in paragraph 5.2.2 is functional design. This phase describes the functional specifications in a more detailed and problem-centred manner, in combination with a global description of the way that these functional specifications have to be executed within the IS concerned and it tries to state WHAT has to be done to deliver the information wanted, and also under which conditions this has to be done (functional demands). This chapter will provide more clarity regarding this subject.

# 7.1 FUNCTIONAL SPECIFICATIONS

The system that has to be developed must be able to retrieve, process and deliver the geographically (related) data of all three organisations of the Public Order and Safety Directorate, individually as well as collectively according to certain functional specifications to solve the problems defined and to fulfil the stated needs and objectives (chapters 1 and 5). The functional specifications of the data flow within the IS that has to be developed consists out of three different phases, and these are:

Input

The system needs input of "raw" data in order to be able to produce the required information. Input in this particular case consists out of a range of different types of maps and spatially related data. Universal access [Reeve, 1998] can be obtained by uniformity and standardisation so that the data can "automatically" be extracted from the original distributed data sources, and be made ready for use in the IS. The quality of the data has to be monitored at all times.

• Processing

Processing in the context of this subject means storage of the data that has entered the IS. This means that the transformed data in placed in universal storage [Reeve, 1998] defined by a pre-defined and structured geodata model which also must be platform independent. It is important to mention that it must be possible to start small and to be able to keep on growing at all times without the system becoming unmanageable. An example of the functional Geodata model in the text to be considered as one of the many different models that can be applied within this type of IS. According to Haines - Young and Petch [1986] a spatial data model is an idealised or simplified representation of reality (real world), which is often presented as a map. This will therefore be worked out further. Before a spatial data model can be designed, a number of steps must be taken. This is also known as the transformation process [Peuquet, 1990]. This transformation process arranges the transition to get from the real world to a GIS environment, by means of abstraction which is called data modelling. This data modelling process can be summarised as a series of four stages of data abstraction.

# REAL WORLD

• LEVEL 1 abstraction (real world model).

- Points, lines, areas, networks and surfaces.

• LEVEL 2 abstraction (spatial data models).

- Raster or vector.

- LEVEL 3 abstraction (data structure).
  - Grid data structures (quadtree).
  - Vector data structures (topology).
- LEVEL 4 abstraction (file structure).

- Physical storage (harddisk, cd-rom, tape, etc.).

COMPUTER VIEW

The first two levels of this data abstraction represent the functional design, and will therefore be further discussed in this paragraph. The other two levels are respectively technical design and the actual building of the file structure of the database, for which the technical design will be discussed in chapter 8; the last level is not relevant for this paper. A further description of the first and second level follows.

• Level 1 is necessary to identify those spatial entities from the real world in which you are interested in, and to decide how you intend to represent them in your model.

An example of such a basemap is given here below.



Figure 21

The map must content the next features:

Points:

• Tree

- Electric lamppost
   Premises
   Lines:

   Networks
   Roads
   Routes
   waterways
   Surfaces
   Areas:
   Regional divisions
- Houses (addresses)

The geographical data must be usable for all three organisations of the Public Order and Safety Directorate individually as well as collectively, see table 1.

• In Level 2 a choice must be made between the two spatial data models (raster or vector) which the computer is able to use to display, analyse and store the entity representation of the real world features.

Given the need for topology (routing, position-finding, etc.) it is apparent that a vector is preferable for this type of basemap.

• Output

When the data is stored in a proper manner, the next step is to enable the users to retrieve this data. In this case it means that all users of all three organisations of the Public Order and Safety Directorate must be able to retrieve the information needed in an uniform, easy universal delivery [Reeve, 1998] and fast manner. This must be made possible with standard applications which are already on the market and which are able to retrieve attribute as well as geographically data in a user-friendly manner and to present the data in a form the user understands.

## 7.2 FUNCTIONAL DEMANDS

Besides defining functional specifications to achieve a certain goal, it is also very important to state under which conditions this has to be done. These conditions are called functional demands (also known as performance demands) which are in fact a composition of effectivity, durability, user-friendliness, integration and efficiency and which also include quality and standard aspects [Poly Automatiserings zakboekje, 1999].

• Effectivity -Time criteria

-The response of the data must be within an acceptable time, satisfying the users.

-The system must contain up-to data extended with the possibility of storing older data.

-The data must be accessible at all times of the day and night, also in the weekends.

-Size

-The size of the data collection must be able to grow "indefinitely".

-The applications that operate this data must be applicable on a modern pc.

#### -Integrity

-The IS has to be available at all times of the day and night.

-The data within the system must be correct (complete, right and accurate).

-Security

-Protection against (un-) aware abuse of hardware, software and data must be guaranteed.

Durability -Flexibility

-The system must be adaptable to be resistant against certain exceptional situations.

-Maintainability

-The IS has to contain the possibility of being audited.

-Compatibility

-The data and applications must have the ability to be processed in a platform

independent manner, also known as an open system..

• User-friendliness -Control comfort

-The system must satisfy the most important rules of ergonomics.

-Audibility

-The use of the system must be predictable.

# -Learn ability

-The effort to learn the system must be kept to a minimum.

• Integration -Uniformity

-The IS must be adjusted to other systems by synchronising definitions, codes, documentation, etc. according to agreed standards (ISO, CEN, OGC, etc.).

• Efficiency -Costs

-The costs of developing, implementation and maintenance must be reduced to a minimum, without loss of quality.

-Efficiency

-The elapsed time for developing the system must also be reduced to a minimum, without loss of quality.

# 8.0 TECHNICAL DESIGN OF THE OPEN GEODATA WAREHOUSE

After the functional design the next phase of the system development methodology of Vandenbulcke in paragraph 5.2.2 is technical design. This phase transforms the functional design, that answers the question HOW the functional aspects need to be executed within the concerned IS. This chapter elucidates the subject of technical design.

# 8.1 TECHNICAL SOLUTION

The most important characteristic of the IS that has to be developed, must have the ability to access, store and deliver the required data in an easy, fast and reliable manner. Given the previously mentioned objectives, problems and wishes in combination with the results of chapter 6 regarding the intention of the functional design, a data warehouse principle (see chapter 5) was chosen. An adjusted data warehouse to be precise, because this type of IS best satisfies the stated requirements the best. What this means exactly, will be worked out further in this chapter.

# 8.2 WHY SHOULD THE GENERAL DATA WAREHOUSE MODEL BE ADJUSTED?

This paragraph will elaborate on the reason why this particular concept is different from others. The general data warehouse model (figure 16) represents an ensemble of co-operative systems for processing data in a data warehouse as it is usually understood. This model serves as a starting-point for a further extension of the data warehouse concept, adjusted to the specific organisational environment of the Public Order and Safety Directorate in combination with the geographically related data used, which resulted, in our case, in an open geodata warehouse as a solution.

This means an open geodata warehouse for which the emphasis lies on the geodata model of the basic map. This will therefore be the only paragraph that will be worked out as a technical design, because this is a very important subject in relation to a geodata warehouse on one hand and to GIS on the other. The other paragraphs will be limited to a description of the specific subjects.

## 8.3 WHAT DOES AN OPEN GEODATA WAREHOUSE MEAN

To clarify the concept of an open geodata warehouse it is necessary to divide the name into open, geodata and warehouse, to be able to explain what these individual parts mean, and after this to explain what the eventual combined term stands for.

• Open:

Refers to interoperable processing, which means that it has the ability to freely exchange all kinds of data, over networks, platform independent and running software capable of manipulating such information.

• Geodata:

Means that it involves spatially related data about the earth and about objects, and phenomena on, above, and below the earth's surface also known as real estate data.

• Warehouse:

This is in fact nothing more then a large collection of data that is organised in a specific manner and is easily accessible to the users.

• Open geodata warehouse

The term open geodata warehouse stands for a large collection of geographically related data that can be processed in an interoperable manner.
The main goals of an open geodata warehouse are:

- Organising and documenting data storage for geographically related data.
- Easy access to geodata.
- Fast access to geodata.
- Controlling the access to geodata.
- Logical links between geodata of different sources (data integration).
- Simplification and automation of complex spatial analysis.

### 8.4 THE EDMA CONCEPT

The chosen concept of data warehouse technology is called Enterprise Data Mart Architecture (EDMA) [Firestone, 1998], because of the following reasons:

- It encompasses the entire enterprise of the Public Order and Safety Directorate.
- It facilitates the retrieval of data per specific subject (data mart) or a mixture of subjects (data warehouse).
- It can be built in a phased manner.
- And it is based on a Multi Tier Architecture (Applications, Middle ware and Data servers).

Besides this it supports an incremental approach to the data warehouse through data mart development by creating a shared framework for development. The EDMA framework includes enterprise subject areas, common dimensions, metrics, business rules, and similar kinds of data sources [Firestone, 1998]. Central to the architecture also, is a data staging area called Dynamic Data Store (DDS) for extraction, transformation, and migration from operational systems (see paragraph 8.4.1), and it also prepares the data for loading into the data marts (see paragraph 8.4.2 and 8.4.3) after which it receives a place in the actual data warehouse (see paragraph 8.4.4). Owing to this it is possible to retrieve the stored data from the data marts and data warehouse in an easy, structured and standardised manner by using a Shared Metadata Repository (see paragraph 8.4.5

and 8.4.6) by the application servers (see paragraph 8.4.7). An explanation of the individual parts of an EDMA follows.

# 8.4.1 DYNAMIC DATA STORE STAGING AREA

The Dynamic Data Store (DDS) is similar to, but goes beyond, the traditional role of an Operational Data Store (ODS) [Inmon, 1996], which is used to extract and hold operational data that would be sent to a data mart or data warehouse. The primary focus of the DDS is in providing a clean consistent set of operational data for creating and refreshing the data marts concerned. Within an Enterprise Data Mart Architecture, the DDS can consolidate data from disparate systems. The transformation of data removes the application bias of data and re-creates the data in a corporate mould. The transformation can include activities such as:

- Converting
- Deciding which data is the best
- Summarising data
- Decoding / encoding data

- Altering key structures
- Reformatting data
- Internally representing data
- Recalculating data

The DDS may apply fundamental transformations to some database tables in order to reconcile common definitions, but it is important to note that the DDS is not intended to be a transformation processor. Its role is to consolidate detailed data within common formats. That way, users can create wide varieties of analytical reports, and be assured that those reports will be based on the same detailed data, using common definitions and formats.

The next figure gives an illustration of the DDS as a part of an EDMA [Firestone, 1998].





# 8.4.2 DATA MARTS

A data mart is a DSS incorporating a subset of the enterprise's data focused on specific functions or activities of the enterprise. Each Data Mart is guided by the enterprise data model developed for the data warehouse, and is developed in a manner consistent with this data model. Here Data Marts are seen as developing in parallel with the data warehouse. The next figure gives an illustration of the data marts as a part of an EDMA [Firestone, 1998].



figure 23

In our case a few examples of data marts can be:

- Basemap
- Crime analysis
- Fire prevention
- Routing
- etc.

# 8.4.3 GEODATAMODEL OF BASIC MAP

Level 3 of the transformation process as mentioned in paragraph 7.1 encloses the technical design of the geodata model. Next follows a data structure for the basemap that can be used within the Public Order and Safety Directorate.

FEATURES	ENTITY	DATA MODEL	DATA	FILE
			STRUCTURE	

Trees	Point	Vector	Spaghetti	Tree
Lightpost	Point	Vector	Spaghetti	Lpost
Roads	Line	Vector	Spaghetti	Road
Waterways	Line	Vector	Spaghetti	Wway
Houses	Area	Vector	Spaghetti	House
Parcels	Area	Vector	Spaghetti	Parcel
Routes	Network	Vector	Topology	Route
Regions	Surface	Vector	Spaghetti	Region

Table 6

# 8.4.4 DATA WAREHOUSE

The data warehouse integrates all data in a common format and a common software environment. In theory all of an organisation's data resources are consolidated in the data warehouse construct (including historical data). All data necessary for decision support are resident in the data warehouse. After the data warehouse is implemented, there is no further need for consolidation. It only remains to distribute the data on demand to information consumers and to present it so that it does constitute information for them. The data warehouse provides the granular foundation for all of the data found in all of the data marts. Because of the singular data warehouse foundation that all data

marts have, all of the data marts have a common heritage and are able to be reconciled at the most basic level. Figure 24 provides an illustration of the data warehouse as a part of an EDMA [Firestone, 1998].





#### 8.4.5 SHARED METADATA REPOSITORY LAYER

The role of the Shared Meta Data Mart Repository layer is to maintain and promote access to metadata that is authorised to be "public." This begins with metadata (see paragraph 8.4.6) about the operational systems and the DDS. Through metadata management the enterprise can capture and put in place a growing repertoire of best-in-class transformation components, and can make those components available to users throughout the enterprise.

By promoting this kind of component re-use, the enterprise can build a portfolio of best-in-class components over time. These would be made up of transformation logic that is too user-specific for the DDS, but that depends on principles commonly used across all applications. This figure illustrates the shared metadata repository layer as a part of an EDMA [Firestone, 1998].



#### 8.4.6 METADATA

Metadata (data about data) is the warehouse repository that defines the rules and content of the warehouse and maps this data to the query user on one end and to the operational sources of data on the other. As an abstraction layer, metadata masks the technical aspects of data access, making information resources access-friendly. Ideally, end users access data from the data warehouse using application servers (see paragraph 8.4.7) without knowing where the data reside, the format, or any other physical attributes. Metadata is the nerve centre of a data warehouse and is essential to all levels of the data warehouse, but exists and functions in a different dimension from other warehouse data. Metadata used to manage and control data warehouse creation and maintenance resides outside the data warehouse, in our case in a shared repository layer. Metadata for data warehouse users is part of the data warehouse itself and is available to control access and analysis of the data

warehouse. To a data warehouse user, metadata is like a "card catalogue" to the subjects contained in the data warehouse.

## 8.4.7 APPLICATION SERVERS

Application Servers (also known as middle-ware) are the primary place where business rules live in the data warehouse, and they provide services to other components by executing business logic and data logic on data accessed from database servers. This is the place where information can be retrieved by so called Business Process Engines (BPS), which may be classified by the processes they support. Some examples are: collaborative planning servers, data mining servers, knowledge publication and delivery servers, query and report creation, and (as in our case) geographical viewers like arcview, mapinfo, idrisi, etc. These viewers can be connected to the data warehouse in a number of ways using application layers like Common Object Request Broker (CORBA), Object Linking and Embedding/Common Object Model (OLE/COM) and Java (see paragraph 8.6) also known as Distributed Computing Platforms (DCP's). Next figure illustrates the application server in combination with the DCP's as a part of an EDMA [Firestone, 1998].



figure 26

# 8.5 FINAL MODEL OF THE LIFE SAVING OPEN GEODATA WAREHOUSE

Finally when all the different parts are merged to an EDMA, the ultimate life saving open geodata warehouse appears, just as in the picture here below.



#### Figure 27

Important in this figure are the data flows between the different parts of the EDMA, the input at the dynamic data store staging area at the left side, the processing in the data marts and the data warehouse in the centre and the output by the application servers, in combination with the shared metadata repository layer at the top [Firestone, 1998].

#### 8.6 WHAT MAKES IT OPEN

As already mentioned earlier, an open IS must be able to provide Universal Storage, Access and Delivery of data [Reeve, 1998], also known as "OpenGIS" (registered trademark of Open GIS Consortium (OGC)). This refers to the ability of digital systems to freely exchange all kinds of spatial information about the Earth and about objects and phenomena on, above, and below the Earth's surface, and co-operatively, over networks, platform independent to run software capable of manipulating such information [The OpenGIS Guide, 1999]. Geodata formats tend to be complex, more complex than other kinds of digital data formats, because of the range of information they must be able to represent. Integrating geodata from various sources is increasingly

important because of growing environmental concerns, pressures on governments and businesses to perform more efficiently, and simply because of the existence of a rapidly growing body of useful geodata and geoprocessing tools. Data sharing makes sense for the simple reason that there is only one Earth, and we share it. When this vision is compared with the spoken open geodata warehouse under discussion, it becomes clear that this also applies to this case.

Next a general explanation of the three issues which can make an IS "open".

#### • Universal Storage

Universal Storage can be enabled by using new DBMS structures which can accommodate novel data types (including spatial data).

A few well known examples of these new types of DBMS's are:

- SDE by ESRI
- SDO by Oracle
- Spatial Data Blades by Informix
- Spatial Extender by IBM
- Universal Access

Universal Access to allow seamless integration of heterogeneous data platforms can be done with the so called Distributed Computing Platforms (DCP's). A few examples of this phenomenon, are:

- Common Object Request Broker (CORBA) by the Object Management Group
- Object Linking and Embedding/Common Object Model (OLE/COM) by Microsoft;
- Java by SunSoft

These DCP's are essential for seamless integration also known as Interoperability.

Interoperability gives machines, data and processes the freedom to interact with one another, without the danger of misinterpretation.

Universal Delivery

Universal Delivery can be accomplished using a so called Client/server model. In this particular architecture, so called "thin" clients located at the PC's of the different users retrieve information from a

server somewhere in the country. This means that the processing of the data happens on the server, and the clients only need a so called spatial viewer to view the information.

- A few examples of spatial viewers are:
- Arcview
- Sirius 7
- Geomedia

It is important to say that these three aspects must be supported by the already earlier mentioned Multi-Tier Architecture mentioned earlier.

### 8.7 STANDARDISATION

The four basic categories of information engineering standards are: data, processes, organisations, and technology, which are aspects of the earlier mentioned OPAFIT [Scholten, 1996] concept. One standard may contain several categories of standards.

More detailed description of these four categories follows.

• Data

Data are the most widely recognised and documented component of standards and information technology. Data modelling describes how the bits of information are defined and structured so they can be applied in a meaningful way. Most standards will be of this type. Data standards describe objects, features or items that are collected, automated, or affected by the activities or functions of agencies. Data are organised and managed by institutions. Data standards are in fact semantic definitions that are structured in a model. An example of standards, in relation to data, which can be used within an open geodata warehouse are:

- Geodata standards according to RAVI (RAad voor Vastgoed Informatie, which means in English: council for real estate information).
- Metadata standards according to ISO/TC 211 standards which will replace the CEN/TC 287 in time.
- For exchanging data the NPR 3611 can be used, which in its turn uses NEN 3610 and NEN 1878 standards.

Ultimately all these standards must evolve in agreement with the ISO standards.

#### Processes

Processes or functions describe tasks and how information and technology are used to accomplish organisational goals. Process standards may also be called service standards. They describe how to do something, procedures to follow, methodologies to apply, procedures for presenting information, or business process rules to follow in order to implement other standards. These are important but not within the scope of this paper.

# • Organisations

The organisational component of information engineering consists of the rules for assigning responsibilities and authority to the people who perform tasks and use technology. These include things like who does which tasks, what data do they need, and what are the attendant skill requirements. Organisational or institutional standards are the specifications for communication among communities. These are the human and institutional interactions necessary to carry out data, activity, and technology standards. Ways to organise, communicate, identify responsible parties, and co-ordinate roles are examples of organisational standards. This is also an important issue, but not within the scope of this paper.

Technology

Technology includes things like software, hardware, and system protocols. In system design, the technology may be specifically described in terms of known application solutions such as computer aided mass appraisal, topologic processing, or co-ordinate geometry computations. Technology standards relate to the tools, environment, and interfaces among systems, and are often called information technology specifications. They are the tools to producing, manipulating, managing, organising, disseminating, or otherwise implementing activities or data standards. This is also an important issue, but not within the scope of this paper.

# 8.8 HOW TO IMPLEMENT (CENTRAL OR DISTRIBUTED)

Before making a choice about how implementation can be achieved, it is necessary to know what "central" or "distributed" actual means, therefore an explanation follows.

#### Distributed Data Warehouses

Distributed data warehouses are just what their name implies, they are data warehouses in which certain components of the data warehouse are distributed across a number of different physical data bases. Increasingly, large organisations are pushing decision-making down to lower levels of the organisation and in turn pushing the data needed for decision making down (or out) to the LAN or local computer serving the local decision-maker. Distributed data warehouses usually involve the most redundant data, and as a consequence the most complex loading and updating processes.

#### • Central Data Warehouses

Central data warehouses are what most people think of when they are introduced first to the concept of a data warehouse. The central data warehouse is one physical data base that contains all the data for a specific functional area, department, division or enterprise. Central data warehouses are often selected where there is a common need for informational data and there are large numbers of end-users already connected to a central computer or network. Usually, central data warehouses contain data from multiple operational systems. The data stored in the data warehouse is accessible from one place and must be loaded and maintained on a regular basis. Normally, data warehouses are built around advanced RDBM's or some form of multi-dimensional informational data base server.

Given the situation of the Public Order and Safety Directorate (bad communication and co-ordination, lack of knowledge and experience, much classified information, etc.) it is preferable to use a central data warehouse where all authorised users can retrieve their information, based on a Client/server architecture which is also discussed in paragraph 8.6. A perfect location for the server would be within an organisation which has enough experience and knowledge both of the subject concerned and of the procedures of the Directorate in order to fulfil this difficult task in a satisfactory manner.

# 9.0 AN APPLICATION OF THE LIFE SAVING OPEN GEODATA WAREHOUSE

# 9.1 GENERAL DESCRIPTION OF THE APPLICATION

On Sunday April the 1<sup>st</sup> of the year 2001, a plain crashes on a shopping mall in a city called Imagine Town. Given the extent of the accident one can say that it is a big disaster, and therefore Crisis Management is enlisted. An extra difficulty is that the shopping mall is located near by several region boundaries. What needs to be done to limit expansion of this disaster and to prevent that more people (or animals) from being killed or wounded? To be able to answer this question a large amount of reliable information is needed within a short period of time presented in an understandable format. Information such as:

• What is the status of the situation?

- Where is the shopping mall located?
- Which emergence services (police, fire dept., ambulance, etc.) in the area nearby need to be alerted?
- What area needs to be evacuated because of dangerous matter?
- How many people need to be evacuated?
- Which hospitals in the area can be reached within a reasonable time?
- What roads need to be blocked?
- What route can be taken by the emergency services?
- Which water hydrants can be used?
- And so on.

The given example is just one of the many different situations that can occur, but something that immediately attracts the attention is that most of these questions are spatially related. The information required is archived at the different emergency services for that particular area, using different computer platforms and / or hard-and software, which makes data-communication decline laborious, especially with corps from out of the region like in this situation.

This is where the Open Geodata Warehouse becomes very useful! Why? Because this type of IS offers each individual emergency service the option to retrieve the data they want, in an easy and fast manner regardless of the location of the original data.

An example of how this can be achieved in the Dutch situation can best be explained on the basis of the earlier mentioned OPAFIT [Scholten, 1996] aspects of an IS, in order to obtain a complete picture of the whole. Next follows a detailed description of these aspects in relation to a hypothetical practical application within the Public Order and Safety Directorate:

# 9.2 ORGANISATION

Implementation and maintenance of an Open Geodata Warehouse is a rather difficult and time consuming task, which is important and therefore must be assigned specifically to a specific group of people. Given the present situation within the Public Order and Safety Directorate, it is not easy to fulfil this task. A few reasons are:

- Lack of finances.
- Lack of time.
- Different regions and disciplines must perform the same task.

- Lack of knowledge.
- Lack of experience.

The main reason that these issues are significant is that this task is not a core business for the Directorate, so this kind of activity has no future within these Directorate itself. It is therefore preferable that this task should be performed by one national organisation. An ideal solution would be to assign this task to the IT Organisation (ITO) of the Ministry of the Interior, which is located in the centre of the country and has enough expertise and experience with different types of IS's regard to this types of organisations. From this location, all related tasks could be performed on a solid basis and the Open Geodata Warehouse would have a future.

#### 9.3 PERSONNEL

The potential users do not have to worry any more where they can find certain data. The data is stored in a structured and standardised manner and is retrievable in a fast and easy manner in which data sharing are the key words. The "only" condition that has to be satisfied, in relation with the personnel, is how to operate the viewer used in order to retrieve the information required. This can be done by a solid education provided by a selected special division of the ITO, through which continuity is guaranteed.

#### 9.4 AGREEMENTS

Agreements between all organisations concerned about a seamless co-operation in relation with the data warehouse are necessary in order to promote uniformity, co-ordination and communication within the total organisation of the of Public Order and Safety Directorate. Agreements like placing the required data at one's disposal, or using the same basemap, etc., are necessary. To make sure that all parties concerned within the Directorate do what they have to do it is necessary that they use Service Level Agreements (SLA). SLA's are a tool for specifying the rights and obligations between the supplier and the user, to promote co-operation and prevent wrong interpretation [Fry, 1989]. This way every organisation knows what to do, not only about their own tasks, but also about the tasks of other organisations involved. Another aspect of agreements within an organisation are the standards used which are of major importance. Standardisation covers mainly data, processes, organisations, and technology. The data part is discussed in more detail, see paragraph 8.7. Standards to be used in relation to the geodata are in compliance with RAVI standards, which are assessed in co-operation with the members of RAVI such as NNI, CEN, ISO and De Nederlandse Commissie voor

Geodesie (Dutch committee for geodesy). This way data can be used in an "open" manner and can benefit the organisation of the Public Order and Safety Directorate in a comprehensive way.

# 9.5 FINANCES

This aspect has been a problem for many years, because the individual organisations owned their own budget and therefore had to pay for their own IS's. This, in combination with their autonomy, are the cause of a great deal of the earlier problems mentioned, because each organisation did what they considered right within their own budget. In this new situation it is much better that the Ministry of the Interior pays for all costs in relation to the Open Geodata Warehouse, to avoid disagreements and to promote co-operation. However one condition must be that all regions are obliged to contribute data to the data warehouse, and (more important) to use the data warehouse. Another stimulant to join is that it saves time and money so that employees can spend more time doing their actual task, rather then spending lots of time searching for the right information. The money saved can be used to finance other important projects. This way a big contribution can be made to improve quality, and to improve efficiency and effectivity on the one hand and to achieve cost saving aspects for the individual organisations on the other.

# 9.6 INFORMATION

Besides "normal" spatially related information (the location of the nearest hospitals or fire hydrants, or the location of a vehicle), an Open Geodata Warehouse can also deliver spatially related management information for the improvement of decision making (which hospitals have admitted the most patients as a result of an accident, which fire hydrants do not have enough capacity, or what areas do not have enough surveillance). By using carefully collected and transformed data in combination with the functionality of an Open Geodata Warehouse, it is possible to produce just the right information required by a user or an organisation. But in order to produce reliable output, it is necessary to use reliable data as input to avoid the GIGO (Garbage In Garbage Out) syndrome. The quality of information retrieved from the Open Geodata Warehouse must be therefore be the number one priority.

#### 9.7 TECHNOLOGY

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The technology that is required for the distribution of data across the country is based on a client/server architecture, with the server located at a location. The ITO mentioned earlier is prefered, because of physical security, the knowledge of the organisations concerned and maintenance considerations. Besides storage of the data, it is also necessary to execute all processes on this server. This means that the clients can stay "light" to lower the threshold for connecting with the server. It is sufficient to have a so-called viewer at the client's location to retrieve the information required. The most advanced client / server technology at the moment is known as the World Wide Web (WWW). That can certainly be used, possible in combination with the so-called WAP (Wireless Application Protocol). This way it becomes possible to retrieve data from all over the country (or world), and not just from one office. Special attention has to be given to the security of data, because most data within the data warehouse are classified. A good method is called encryption, this scrambles the data when it is transported on the network, so that it cannot be read if it is intercepted. Besides this, a so-called fire wall is also necessary to keep uninvited visitors or software (virus) outside the data warehouse.

The technology of the actual EDMA itself is diverse. Informatica [2000] is a company who is specialised in EDMA engineering which supplies a range of products for this type of data warehouse.

A few examples are:

- "Powercenter" is an example of a data mart preparation product that supports most of the requirements needed to support next-generation data marts. It provides a global metadata repository that helps users integrate multiple data marts into an enterprise decision-support architecture. It also provides a systems management application that enables administrators to monitor and control multiple data marts from a central console. It is also extensible, providing open API's for integrating third-party tools and embedding custom transformations into the PowerCenter engine.
- "PowerMart" is a patented feature called incremental aggregation and helps users to avoid performance penalties by requiring that only newly changed data be loaded into changing aggregate tables. Data loading and processing cycles are cut substantially; in many cases, all processing is performed in the PowerMart server's main memory. To optimise aggregation performance, PowerMart combines powerful aggregation algorithms with an ability to maintain aggregation histories across multiple load sessions.

• "PowerCapture" is able to monitor changes in source databases, then, at the time of refresh, apply only the changed data to the new target load.

This is just one of many concepts related to data warehousing, which provides a small supply of possible software to build and maintain an EDMA.

## 9.8 CRITICAL SUCCESS FACTORS

Data Warehouse engineering is a huge and complex project but not impossible. Nevertheless there are some so called Critical Success Factors (CSF) as mentioned in the ISP (paragraph 4.2.1) that have to be taken into account to prevent failure.

A few important CSF's are [Perkings, 1999]:

Sponsorship and involvement

Not only users, but also executives and managers must both sponsor data warehouse development, and also be involved in data warehouse engineering.

• Data Warehouse Architecture and Design

The key to success in scaleable data warehouse development and the single factor that contributes most to data warehousing success is a data warehouse architecture (EDMA).

Engineering a data warehouse is like engineering a physical warehouse. Both involve a rigorous development cycle and require the right tools. That is why data warehouses are built a from architectural models (blueprints) of enterprise infrastructure (policies, goals, measures, critical success factors, etc.). The architecture and design of an enterprise's data warehouse should reflect the performance measurement and business requirements of the enterprise.

• Information Quality

Data in the data warehouse must be of the highest possible quality. It must be accurate, relevant, complete, and concise. It must be timely and current. It must be presented in a way that is clear and understandable. A data warehouse that contains trusted, strategic information, becomes a valuable enterprise resource for decision makers at all organisational levels. If its users discover that it contains bad data, the data warehouse will be ignored and will fail. Worse, if it contains bad data, but its users never find out and make decisions based upon the data, it is possible that the whole enterprise will fail.

Data warehouse engineering is not like normal application development. Its scope is broader, its visibility is greater, its user community is larger, and it is more prone to failure. Before beginning a data warehouse project, an enterprise should evaluate whether it has adequately addressed the critical success factors for data warehouse engineering.

# **10.0 CONCLUSION, TRENDS AND RECOMMENDATIONS**

The objective of this study was to find a solution to improve data sharing of, and easier access to geographically related information within the Dutch Public Order and Safety Directorate, further objectives were to contribute to improved knowledge and decision making and at the same time to improve co-ordination, communication and standardisation. This objective was formed on the basis of observations and findings obtained from fieldwork as a part of the DIGIKAR project. After analysing the needs, problems and wishes in relation to the stated objective, a possible solution was found and worked out. In this paper it is called a Life Saving Open Geodata Warehouse. This chapter will provide conclusions, new developments and recommendations according to the highlights of this study.

# **10.1 THE USER ORGANISATION**

The organisation of the Public Order and Safety Directorate suffer from the fact that the government has already chosen an organisation structure in which every region has it's own autonomy and budget. As a result, almost every individual organisation has built there own IS, with their own money, based on different technologies and starting-points. This led to a diversity of IS's and an even greater range of different data used, which can operate quite well on a local level, but when it exceeds boundaries or it involves assistance of more then one emergency service, data sharing, and easy access to data (also from other regions) become of essential importance. To make this possible, it is not only a matter of implementing a supersonic IS, but it is also very important to prepare the organisations concerned, for the changes that will come. Preparations including creating awareness and commitment (also within management), creating specific jobs, education, improving co-ordination, improving (data) communication, etc. This is however easier said then done. The best way to do this is by re-organising the total organisation of the Directorate, including the regional boundaries, but this is almost impossible to do within a reasonable amount of time, effort, and money, and it is also unlikely to happen.

Therefore this paper has chosen for a different solution so that the organisation structure can stay unaltered, and by which the user organisations can still obtain the spatially related information needed. It is supposed to set up one national centre, specialised in the use and management of spatially related data, in this case an Open Geodata Warehouse, which is located in the centre of The Netherlands (ITO) and to serve as an intermediary between all the organisations concerned. This is a long term solution which would satisfy the stated needs and wishes, and which could very well solve the problems specified.

#### **10.2 DIGIKAR PROJECT**

The DIGIKAR project was not only a very fascinating project but was also of essential importance for this study, because it forms the foundation of this paper. As a result of the interviews within the scope of this project, it became clear what the problems, bottlenecks and wishes were in relation to the geographically data within the total organisation of the Public Order and Safety Directorate. The objective of this project was therefore to come up with one national umbrella agreement with one or more map suppliers in order to improve standardisation, co-ordination and communication, and to lower the operational costs. The final report has been distributed among all organisations concerned and, where necessary, elucidated by a member of the project team, in the hope that a majority of these organisations would co-operate in order to achieve the stated

objective, in which individual interests are also being served. According to the last opinion poll it seems that there is a vast majority in favour, so this is a step in the right direction. It is now time to start negotiations with the map suppliers; this project is on its way to being a great success.

#### **10.3 DATA WAREHOUSING**

Data warehousing is a technology of potentially enormous worth to an enterprise. It is, however, fragile. If IS's, for example, have too much input, the user will be deterred. If the facilities are not linked to business requirements, the system will fall into disuse.

Over the next few years, the growth of data warehousing is going to be enormous with new products and technologies coming out frequently. In order to get the most out of this period, it is going to be important that data warehouse planners and developers have a clear idea of what they are looking for and then choose strategies and methods that will provide them with performance today and flexibility for tomorrow. Moving forward, it is apparent that no single architecture is right for every application. Based on its information needs, its data source structures, its timelines and requirements, some organisations will choose to select the enterprise data warehouse, and some will select smaller data mart solutions. Many will come to the conclusion that a Multi Tiered Architecture will bring the best results and the most flexibility for the future. The EDMA solution uses a mixture of these methods in order to obtain the best results.

The shortest, quickest solution may be to build from the bottom up, creating data marts to meet specific departmental needs, but with the forethought to remain in line with the corporate information strategy. This will allow for some early, quick successes to provide departmental information to end users without derailing the enterprise-wide information effort. An organisation can now deliver better information to its end users and enable informed decisions based on accurate, timely and precise corporate data, and may grow freely. But although a data warehouse can be of enormous value in the decision making environment of an organisation, it is a fallacy to think that all problems are solved automatically when using such an IS. There is always a need for a solid management to interpret the obtained information in a right way, and to make the ultimate decisions which only "some" managers can do. Technology can never replace good management. Whether a data warehouse will be a valuable strategic tool or an expensive toy, depends therefore on the enterprise itself.

#### 10.4 A LIFE SAVING OPEN GEODATA WAREHOUSE

Besides the conclusion in favour of a general data warehouse there are some specific things that distinguish the Open Geodata Warehouse and which have to be taken into account separately.

Because of the rapidly growing need of spatially related information within the Public Order and Safety Directorate, it is necessary to respond to this with a solid IS capable of providing the necessary information, any time anywhere, with a minimum of time and energy wasted. Such a system is extensively discussed in this paper. There are however some things that must be take into account before it is possible to make the geographically related information generally available.

First it is important to use reliable sources for extracting the geographical data. This forms the basis for this type of data warehouse and without this basis the system cannot operate correctly. The ultimate map(s) chosen in the DIGIKAR project satisfy to this condition.

Second, it is necessary to have good facilities for transforming the geographical data from legacy systems into the data warehouse. This has to done in an open manner. But to make a system open is not such an easy job because there are no turn key solutions. The OGC, in co-operation with many different organisations, are trying to bring Open GIS to everyone's attention, but they are in fact still in their infancy. Therefore this process has to be done with extreme caution.

Thirdly, the data marts and the data warehouse are established in such a way that it is possible to retrieve not only one particular map from a data mart, but also a range of different maps from different data marts or the data warehouse to use them as layers for example the execution of spatially analysis.

Fourthly, the metadata that is used is standardised and may only be adjusted to the specific needs of the users concerned. Where necessary, this has to be done with the co-operation of the standardisation organisations concerned.

And fifthly, this system makes it possible to produce information in map form by using so-called viewers. This is a big advantage when processing geographically related data, because otherwise it is very difficult to describe how, for example, the topography of a map looks, or to perform spatial analysis.

#### **10.5 FUTURE DEVELOPMENTS**

Within the scope of this study there are two kinds of trends that can be perceived, namely the general future developments that can have consequences for all users of geodata warehouses, and the specific developments within the Public Order and Safety Directorate. This will be further explained below.

## **10.5.1 GENERAL FUTURE DEVELOPMENTS**

The geodata warehouse is a big step forward in the integration of GIS with the general Information Technology. Particularly it helps to elevate the value of geographic data by passing it through a quality control, by providing logical links and by providing universal access, storage and delivery. Future developments may go in several directions, such as:

- Integrating geographically data into the Internet framework of XML.
- Further standardisation of geographical functions to build the foundation for automated, data driven application development and "intelligent" applications.
- Simplification of data modelling to allow end users to structure their own geographical data.
- Extension of current application server technology to include specific geographical functionality.
- Development of parallel data base servers with improved query engines to enhance the performance.
- And data warehouses that allow for the mixing of traditional numbers, text and multi-media, and the availability of improved tools for data visualisation (including 3D).

# 10.5.2 FUTURE DEVELOPMENTS WITHIN THE PUBLIC ORDER AND SAFETY

# DIRECTORATE

Besides the general future developments, there are also a number of interesting developments coming up within the Public Order and Safety Directorate itself. This is an overview.

- New types of users are still emerging.
- Data quality continues to move to the forefront.
- Awareness and commitment will keep on growing, as a result of the increasing information need.
- The use of geographically related data will increase.
- More collective initiatives in relation to data warehousing will arise when the Open Geodata Warehouse becomes successful.
- A new data communication network is under construction that is usable for all kinds of data.

• The number of emergency rooms are decreasing further, which means that bigger areas must be monitored.

The organisation of the Directorate must not only take these specific developments into account but is also obliged to follow general future developments.

## **10.6 RECOMMENDATIONS**

In order to take care of the present and future developments some recommendations have to be followed up, in order to guarantee success in the future.

- It is necessary to keep on influencing the individual organisations of Public Order and Safety Directorate to consider co-operation in connection with the DIGIKAR project.
- Try to rearrange the regional boundaries in order to make them compatible, if not physically then administratively.
- Make sufficient and well-considered agreements between both sides (supplier and user) in order to prevent different interpretations.
- Establish a crew at ITO with enough experience and know how to guide the organisations involved on to establish a firm basis.
- Permanent education of the users and their management concerned, is of great importance.
- Think big and start small, because several projects that tried to build a large data warehouse at once, have failed because the data warehouse became too big too fast. Owing to this, the system became unmanageable and too expensive to maintain, and the users became confused by the great amounts of, (at that time) superfluous data causing the system to be insufficiently used.

# 11.0 GLOSSARY

• Address

•	Analogue	A medium or mode in which data is represented by continuously variable quantities
	such	
		as amplitude, frequency or position. Hard copy or screen displays of maps, drawings,
		recorded, and photographs are analogue images.
•	Area	A bounded continuous two dimensional object which may or may not include its

A means of referencing an object for the purpose of unique identification and location.

- boundary. Usually defined in terms of an external polygon or in terms of a set of grid cells.
- Attribute A descriptive characteristic of a feature. An attribute asks a question about it: what, where, how big, how many, etc. The answers to the questions are the values stored in a

		data base. Cartographic attributes describe how to display map information, while non-
		graphics data describe the mapped feature.
•	Base map	Fundamental map information, either as one layer or as a combination of layers, which
	is	
		used as a standard framework upon which additional data of specific nature are
	OV	erlaid.
•	C2000	Digital speech and data communication network in behalf of the Dutch Public Order
	and	
		Safety Directorate, managed by ITO.
•	CEN	Comité Européen de Normalisation is a regional standards group for Europe. It is not a
		recognised standards development organisation, and so cannot contribute directly to
		ISO. It functions broadly as a European equivalent of ISSSO and its key goal is to
		harmonise standards produced by the standard bodies of its member countries.
•	CAD	Computer Aided Design is a computer graphics system to create, modify, manipulate,
		and display digital drawings.
•	Client / server	Is an architecture that processes data in a co-operative manner, which means that it
	is	
		possible to use different parts of an application by different kinds of computers (clients)
		in a distributed network. Connected to LAN servers and / or mainframe servers.
•	COBOL	A high programming language mainly used in a mainframe environment.
•	Co-ordinate	Position of an addressable point with respect to the origin of a specified co-ordinate
		system.
•	СРА	Centrale Post Ambulancevervoer which means in English Central post of ambulance
		transportation, and they are responsible for the transport of sick people in The
		Netherlands.

- Data mining A decision support process in which we search for patterns of information in data.
- Data modelling Is a method for designing computerised information systems based upon the data that

must be available in a data base and can be available for computer programs to retrieve,

manipulate, update, store, and display in order to satisfy the information requirements of

one of more functions of the organisation.

- Data quality Indications of the degree to which data satisfies stated or implied needs. This includes information about lineage, completeness, currency, logical consistency, and accuracy of the data.
- Data warehouse Is a subject oriented, integrated, non-volatile, and time variant collection of data in support of management's decisions.
- DBMS Data Base Management System is a collection of computer programs used to organise and use data stored in a data base. Typical functions of a DBMS include the logical and

physical linkage of related data elements, the retrieval and verification of data values, and

other data management functions such as; security, archiving, and updating.

- DCP Distributed Computing Platform allows seamless integration of heterogeneous data platforms, by connecting viewers to the data warehouse using application layers.
- Digital map The representation of cartographic features in a form that allows the values of their attributes to be stored, manipulated, and output by a computer system.
- DIGIKAR peiling informatiebehoefte DIGItaal Kaartmateriaal bij de Alarmdiensten en Rampenbestrijding in Nederland, which means in English: bearing of the information need in relation with digital maps within the emergency services and crisis

#### management

in The Netherlands.

• EIS Executive Information Systems have generally a higher level of consolidation then a DSS

and a multidimensional view of the data, as high level executives need more the ability

to

slice and dice the same data than to drill down to review the data detail.

- GGD Gemeentelijke Geneeskundige Dienst what means in English Public health service.
- GMS Geïntegreerd Meldkamer Systeem which means in English integrated emergency room system, and is generally used in the emergency rooms to manage the emergency calls.
- Interoperability Is the ability for a system or components of a system to provide information portability, inter-application and co-operative process control.
- ISAC Is a system development methodology that distinguish itself by a preceded analysis and by using information and activity diagrams.
- ITO This is the Information Technology Organisation of the Dutch Ministry of the Interior and Kingdom Relations that is located in Driebergen in the centre of the country.
- KAR-1 Kaarten voor Alarmdiensten en Rampen bestrijding, deel 1, which means in English: maps in behalf of emergency services and crisis management part 1, which contains an inventory of the map use at the emergency rooms within the Directorate of Public

Order

and safety.

• KAR-2 Kaarten voor Alarmdiensten en Rampen bestrijding, part 2 which contains an inventory

of all the map providers, including their products and conditions of delivery.

- KLPD Korps Landelijke Politie Diensten what means Corps National Police Services and this
  - a division of the total Dutch police force.
- LAN Local Area Network, is a network that is limited to one or a few buildings and consists out of one or more mini- and / or microcomputers.
- Legacy systems This are the systems that help us run the enterprise operate day-to-day, also known as operational systems
- Line An one dimensional object that forms a direct connection between two points.
- Map A graphic representation of features of the earth's surface or other geographically distributed phenomena.
- Meta data Information about data, such as: data quality or feature classification information.

is

• Middle-ware Also known as application servers are the primary place where business rules live in the

data warehouse, and they provide services to other components by executing business logic and data logic on data accessed from database servers.

NCGI National Clearinghouse of Geographic Information), which is an example of an existing

geodata warehouse in The Netherlands.

- NNI Nederlands Normalisatie Instituut, which means in English: Dutch Normalisation Institute, and this organisation is responsible for the Dutch standardisation (NEN).
- NPR Nederlandse Praktijk Richtlijnen, which means in English: Dutch Practice Directives.
- NT New Technology is a graphical user interface for PC environment and mid-range systems, designed by Micosoft.
- OGC Open GIS Consortium that exists generally out of GIS suppliers and users, was launched

in 1994 with the mission of improving the interoperability of GIS.

- Plans of attack This is a plan (map), used by the fire department which encloses the routes that have to be taken in and around an object to be able to put out a fire in a most efficient and effective manner.
- Point A zero-dimensional abstraction of an object, with location specified by a set of coordinates.
- OLAP On-Line Analytical Processing which support very sophisticated on-line analysis including multi-dimensional analysis.
- OPAFIT stands for the abbreviation Organisation, People, Agreements, Finances, Information and

Technology which covers all of the important aspects within an information system.

- OS2 Is a graphical user interface for a PC environment
- PowerCapture Trademark to monitor changes in source databases made by Informatica.
- PowerCenter Trademark of a data mart preparation product made by Informatica.
- PowerMart Trademark of a feature called incremental aggregation made by Informatica.

- Raster A method for displaying or storing graphic data that uses individual points for processing. On displaying the data, each point is either displayed or not displayed, depending upon whether it is a part of the image or not. On storing and manipulating raster data, each point contains attribute values.
- RAV Regionale Ambulance Voorziening which means in English Regional Ambulance provision, and who are responsible for the transport of sick people in The Netherlands.
- RAVI RAad voor Vastgoed Informatie which means in English: council for real estate information.
- RDBMS Relational Data Base Management System that supports the relational model.
- Routing A spatial analysis function that uses network analysis to identify a path along a network,

usually for moving a vehicle from one point to another point.

- SDM System Development Methodology is a set of techniques and methods for effective and efficient planning, analysis, design, construction, implementation and support of computer systems.
- SLA Service Level Agreement is a tool to assess the rights and obligations between the supplier and user.
- Spaghetti map Vector data composed of line segments which are not topologically structured or organised into object and which may not even be geometrically tidy.
- Spatial analysis Analytical techniques associated with the study of locations of geographic phenomena together with their spatial dimensions.
- Spatial data model Is an idealised or simplified representation of reality (real world).
- TDN Topografische Dienst Nederland, which means in English: topographical service of

The

Netherlands, a former map making division of the Ministry of Defence. Now responsible

for many different commercial geographical data collections.

• Topology The relative location of geographic phenomena independent of their exact position. In

digital data, topological relationships such as connectivity and relative position are usually expressed as relationships between nodes, links and polygons.

• UNIX Is a server platform for mini and micro computers which uses multi programming and is

popular in a client/server environment.

- VAX / VMS) Is a mini-computer platform designed by Digital Equipment Company (DEC).
- Vector A format for processing and displaying graphic data. Vector data are represented by strings of co-ordinates representing the true position of features represented by points, lines and areas. Vector data define polygons, objects, and other complex entities that
  - can

be manipulated on the basis of attributes.

- V.N.G Vereniging van Nederlandse Gemeenten which means in English Union of Dutch Municipalities, which is the representative of all Dutch municipalities.
- WAN Wide Area Network is a network that extends across cities using one or more mainframe

computers.

- WAP Wireless Application Protocol, used to integrate Internet facilities in combination with wireless communication.
- Windows Is a graphical user interface for a PC environment, designed by Microsoft.
- XML eXtensible Mark-up Language (extensible because it is not a fixed format like HTML) is

designed to enable the use of SGML (the international standard meta language for mark-up) on the World Wide Web. A meta language, is a language for describing other

languages, which lets you design your own mark-up.

# **12.0 APPENDIX**

# APPENDIX A: EXAMPLES OF GEODATA WAREHOUSES

	Web-nage	Phase	Year of	Standard
Country			implementation	
Denmark	http://www.geodata-info.dk/	Under	1997	CEN/TC287
		development		
Germany	http://www.ddgi.de/	Under	1997	CEN/TC287
		development		
France	http://www.cnig.fr/	Under	1995	NF52000
		development		
Portugal	http://www.cnig.pt	Full-grown	1994	CEN/TC287
United	http://www.ngdf.org.uk/	Under	1999	ISO TC/211
Kingdom		development		
Qatar	http://www.gisqatar.org.qa/	Full-grown	1997	n.g.
Singapore	http://www.inlis.gov.sg/index.h	Full-grown	n.g.	FGDC
Australia	http://www.auslig.gov.au/asdi/fclghse.ht	Full-grown	1998	AS/NZS
	m			4270
Canada	http://ceonet.ccrs.nrcan.gc.ca/	Full-grown	1995	n.g.
Costa Rica	http://www.gemlab.ukans.edu/cr/metadat	Full-grown	1998	FGDC
	a/abtcgis.htm			
Honduras	http://sdnhon.org.hn/metadatos/	Under	1999	FGDC
		development		
Mexico	http://isite.ciceana.org.mx/	Under	1999	FGDC
		development		

United States of	http:///www.fgdc.gov/clearinghouse/clear	Full-grown	1994	FGDC
America	inghouse.html			

Attention: These are highlights of the total survey executed by Arnold Bregt and Joep Crompvoets who work at

the Centre of Geo-information, located in Wageningen, The Netherlands.

APPENDIX B: DIGIKAR questionnaire

# A: Stock-taking form

# Use of spatial data collections

The meaning of this form (A) is to make an inventory of what data is being used in your business processes that contain a spatial component. Examples are: digital or analogous maps, files with addresses on street or zip code level, positioning-finding data, files with administrative boundaries (municipalities, districts and neighbourhoods).

If you have completed the stock-taking you need to fill up:

- Form **B** per analogous data file
- Form C per digital data file

There are 3 extra copies added of form B and C. If you need more samples you can copy them at will.

The last Form (D) is of a general character and serves to give you the opportunity to make a pronunciation regarding the national agreement with one or more map suppliers proposed by the Ministry of the Interior and Kingdom Relations in relation with the purchase of spatial basic files in behalf of the Public Order and Safety Directorate.

Form D gives you the opportunity to influence the decision-making regarding the file-acquisition.

# a.1. Description of the organisation

a.1.1 Name of the organisation:	
a.1.2 Division	
a.1.3 Address	
a.1.4 Zip-code and residence	
a.1.5 Telephone	
a.1.6 Fax	
a.1.7 E-mail	
a.1.8 Name of the inquirer	
a.1.9 Function of the inquirer	

a.1.10 (Exclusively for the fire department) Do you have a regional plan of Y / N organisation according to the "Reference cadre business management and support"

# a.2 Overview of relevant activities and data collections

Name Activity	Data collection	Name Application

**Remarks:** 

# **B:** Analogous detail form:

# b.1. Use of analogous spatial data collections / maps

It is the intention to fill up data explicit about existing and / or future data collections on paper.

This can be maps but also address files, plans of attack etc.

**b.1.1 Name data collection:** 

.....

**b.1.2** Purpose of use of the data collection:

.....

**b.1.3** Is the file:

**administrative oriented**?

**geographical oriented**?

**b.1.4 Description of the contents of the file** 

..... b.1.5 How is it recorded? □ map □ remaining namely ..... **b.1.6** Do you have an indication of the size of the data collection: ..... b.1.7 Did your organisation built the file? Y/N b.1.8 Does your organisation manage the file? Y / N b.1.9 Does your organisation own this file? Y/N b.1.10 How many users, use this data collection: ..... **b.1.11** How often is this file being used:

..... times per
□ day
u week
□ month
🛛 year

## b.1.12 What is de quality of the data file

Actuality, reliability, unambiguously, etc.

.....

# **b.2** Need for change

In this part you need to indicate what your plans are with your traditional (analogous) data files.

b.2.1 Are you planning to digitise this file within 2 years from now	Y / N
--	-------

#### **Remarks / comments:**

b.2.2 Which amount did you have estimated to maintain this data file?

.....

b.2.3 Will this amount change in the future? If yes, how and why?

.....

b.2.4 How much time does it take to manage and mutate this file?

.....

b.2.5 Will a national agreement as mentioned, make you decide faster to apply a digital version of this

file?

.....

# **C: Digital Detail form**

# c.1 Use of digital spatial data collection

c.1.1 Name data collection:

.....

c.1.2 Purpose of use of the data collection:

.....

c.1.3 Is the file:

 $\Box$  administrative oriented?

□ geographical oriented?

### c.1.4 How is it recorded

🗆 map

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□ remaining namely	••••••		
c.1.5 Description of the contents of the file:			
c.1.6 Do you have an indication of the size of the data collection:			
c.1.7 Did your organisation built th If not, to whom is it boarded o	e file? out?	Y / N	
c.1.8 Does your organisation manag If not, who is the manager?	ge the file?	Y / N	
c.1.9 Does your organisation own th If not, who is the owner?	iis file? 	Y / N	
c.1.10 How many users use this dat	a collection:		
c.1.11 Do you exchange digital data form this file with other parties, if yes with who?			

c.1.12 How often is this file being used:

..... times per

□ day

□ week

□ month

□ year

### c.1.14 What is de quality of the data file

Actuality, reliability, unambiguously, etc.

.....

c.1.15 Are you satisfied with this file Y / N

If not, which improvements are necessary according to you

.....

# c.2 Contracts and finances

In this part you need to describe what your plans are with your digital data collections and their applications in relation with your agreement with your supplier and the amounts on your budget(s).

c.2.1 Are you planning to change this data file within 2 years from now, if yes, what:

Remarks:

------

c.2.2. Do you have an agreement with a supplier regarding delivery and maintenance of this file?

If yes, under which conditions and in what kind of form?

Kind of contract (mantle, lease, property etc.): .....

Currency: Eventual contract partners.....

Remaining conditions:....

c.2.3 Is the purchasing and maintenance of this file included in your budget as a separate item?

.....

If, yes. What is the amount?

.....

c.2.4 Will this amount change in the future? If yes, how and why?

.....

# **D:** Demands and wishes

Of this form you will only have to fill in 1 sample. It is preferenced to consult your management to get some backbone from your organisation in order to obtain a more complete answer.

d.1.1 What kind of spatial basic files will you purchase within 2 years from now?

.....

d.1.2 Are these files meant for existing or new activities.

.....

d.1.3 If there is a new central data portfolio going to be composed, based on mantle agreements are you prepared to adjust your specifications according to this.

.....

..... d.1.4 Will the existence of a central mantle agreement accelerate this acquisition? Please explain \_\_\_\_\_ d.1.5 Are you prepared to enter into a formal commit when you decide to join the mantle agreement? Y / N d.1.6 How do you think you can get money available to purchase and maintain these files. ..... d.1.7 Do you have concrete ideas regarding the form of the maintenance contract? **Please explain!** ..... d.1.8 Is purchase and maintenance of this file admitted in your budget as a separate item? ..... d.1.9 Do you have any special demands and / or wishes? ..... .....

## APPENDIX C: Different used maps within the Public Order and Safety

• 6 POS. Postc.

produced by

- Easy travel planner with the
- GBKN
   which means in



A Raster map detailed at address level, Kdata, a division of the Dutch office of land registry. Is a timely, small scaled raster oriented route topography of The Netherlands on street level and produced by Suurland/Falkplan. Grootschalige Basis Kaart van Nederland, English: a great scale (mostly 1:2500) basic map of The Netherlands, which is vector based and produced by different

companies, by which the Dutch office of land registry plays a central role.

- Gemeentekaart A collection of different maps produced by individual Dutch municipalities.
- Geostreets A raster oriented map produced by Geodan which contain 6 geographical aggregation levels, namely from street level to country level.

Level 1

Level 6

• Top10vector A vector oriented topography (scale

1:10000) of The Netherlands produced by the TDN.





• Top25vector A vector oriented topography (scale 1:25000) of The Netherlands produced by the TDN.

• Top250vector A vector oriented topography (scale 1:250000) of The Netherlands produced by the TDN.



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