Synchronisation of "Work Processes" vs. "Geo-information", a RWS case

Geo-information needs regarding maintenance of the Highway Network at the "droge" Dienstkring

Version 1.1

June 2004

Master of Science thesis:
M.A. de Rink
Section GIS Technology
Geodetic Engineering
Faculty of Civil Engineering and Geosciences
Delft University of Technology

Colofon
Dit is een uitgave van
de Adviesdienst Geo-informatie en ICT
en de Sectie GIS Technologie

Adviesdienst Geo-informatie en ICT
Bezoekadres: Derde Werelddreef 1, 2622 HA Delft
Postadres: Postbus 5023, 2600 GA Delft
Telefoon: (015) 275 75 75
Fax: (015) 275 75 76
E-mail: agi-info@agi.rws.minvenw.nl
Internet: www.minvenw.nl/rws/agi

Sectie GIS Technologie
Bezoekadres: Jaffalaan 9, 2628 BX Delft
Postadres: Postbus 5030, 2600 GA Delft
Telefoon: (015) 278 45 48
Fax: (015) 278 44 22

Synchronisation of "Work Processes” vs. “Geo-information”, a RWS case

Geo-information needs regarding maintenance of the Highway Network at the “droge” Dienstkring

Version 1.1

Author

Marcel de Rink

Supervisors Delft University of Technology

Prof. dr. ir. P. van Oosterom
Dr. ir. M.J.P.M. Lemmens

Supervisor Geo-Information and ICT Department

A.M. den Boer

June 2004

Master of Science thesis
Section GIS Technology
Geodetic Engineering
Faculty of Civil Engineering and Geosciences
Delft University of Technology

Preface

This thesis is the final part of my study Geodesy at Delft University of Technology. The research was performed at the Geo-Information and ICT Department of the Directorate-General of Public Works and Water Management. This research is focused on investigating the need of information during maintenance of the Highway Network. While performing research to solve the problem, the subjectivity of need of information per person was clear to see. Also the impact of the information supply to the need of information of the user was remarkable. A user states its need of information by referring to existing applications (and data sets). The process to determine the need of information should be suited to deal with these problems.
This research can offer ideas how to control the information supply in an organization and what stages have to be accomplished. This non-technical approach with the use of (technical) modeling techniques was interesting and I enjoyed performing this research.

During the research two supervisors Tjeu Lemmens (TUD) and Adri den Boer (AGI) did assist me. I would like to thank both of them for their guidance and comments. Besides these two supervisors, Jacqueline van Rooij (AGI) also joined all our meetings and supported me during this research. I also would like to thank her for her guidance. This research was performed at GAG, sub department of the AGI. I want to thank my colleagues of GAG for the nice atmosphere. Last but not least I would like to thank the managers and users at the Dienstkringen at Gorinchem, Huis ter Heide and Apeldoorn, who gave me the opportunity to take interviews and the specialists at the Geo-Information and ICT Department.

Marcel de Rink

Delft, August 2004

Abstract

The Directorate-General of Public Works and Water Management is part of the Ministry of Transport, Public Works and Water Management. This Directorate-General is responsible for the main Infrastructures (highway network and main waterways) and water management. A Specialist Department, the Geo-information and ICT department of the Directorate-General, has developed the Digitaal Topografisch Bestand Droog (DTB Droog) [1] . This large-scale (1:1000) geographic data set supports e.g. maintenance at the Highway Network. Besides the use of a large scaled geographic data set also a mid scaled geographic data set has been used: The Nationaal Wegen Bestand (NWB) [2], which is used to add a spatial component to the thematic data. Besides these "custom-made" geographical data sets, other data sets do exist like the nation wide Grootschalige BasisKaart Nederland (GBKN) [3], which is used by Municipalities and Utilities. The accuracy of the GBKN is worse compare with the DTB Droog, but the GBKN is more recent. This thesis will perform research what geographic data sets are needed for maintenance of the Highway Network. The main research question is:

Which geographic data sets can support the need of information regarding the work processes "Maintenance of the Highway Network" at the Dienstkring and what level of quality of the geographic data is necessary

The current situation at the Directorate-General increases the complexity of the research question. Commonly organizations with stable processes (and need of information) are preferred to investigate the need of information. At the Directorate the situation is more dynamic, because of reorganization. Therefore the role of the Dienstkring and their approaches and procedures, regarding maintenance, are changing. Also new instrument, performance contracts (also called innovative contracts), has to be used to control maintenance of the highway network.

The fitness of use of the geographic data sets is focused at the objects (including thematic attributes) stored in the data set and the quality parameters: geometric accuracy and up-to-dateness. The need of information according to the users is presented in Object Models. According to directives from the Head Office, performance contracts have to be used instead of traditional contracts. The need of information will be investigated while using traditional contracts as well as performance contracts.

Using performance contracts require storage of future functionality. The contractor has to make sure the agreed functionality / result regarding the Highway Network should be accomplished. This functionality and vision has to be described in the contract. As a result, some stages of processes used to be performed by the Dienstkring, will be performed by the contractor. Planning for example should be performed by the contractor in stead of the Dienstkring. Also the work processes regarding Technical Maintenance will change, because Technical Maintenance should only support Inspection and development of the performance contracts.

The traditional contract describes the way <u>how</u> maintenance should be performed and won't describe the result. As a result use of traditional contracts requires additional stages of processes. Because the contract describes how maintenance should be performed, the planning process should be added. Also Technical Maintenance has to support three other stages of processes like Inspection, Planning and preparation of Realization.

"Traditional" contract	Performance contract
Description <u>how</u> the contractor should perform maintenance of the Highway Network	Description of <u>the result</u>, the contractor should accomplish
Information storage based on description of statuses of objects	Information storage based on description of functionality of objects
Technical Maintenance is related to: Inspection, Planning and preparation of Realization	Technical Maintenance is related to Inspection and future result

Table 1: Characteristics of traditional contract and performance contract

[1] Digital Topographic Data set "Droog"
[2] National Road Data set
[3] Large scale Standart Chart of the Netherlands

To control and structure the different problems, the Integrated Architecture Framework developed by Cap Gemini has been used. By stating the work processes regarding maintenance of the Highway Network at a detailed level, the need of information should become clear. The need of information is presented by different Object Models separated by the themes: Pavement, Traffic Requirements, Nature and Environment, Exploitation and Civil Infrastructures. Also distinction by traditional contract or performance contract has been made. These Object Models will be used to relate to the data sets (and applications). Besides the desired objects and quality parameters, also the functionality (operations) of the applications has been invested.

The main research question should be answered from the perspective of a Spatial Data Infrastructure (SDI). A SDI consists of four elements:

A. policy and organization
B. geographic data
C. technology to store, communicate and use geo-information
D. standards for description, exchange en relating geo-information

All these elements contain parts of the answer to create an optimal information supply. Only mentioning geographic data sets (with Object Models and quality parameters) wouldn't be useful.

<u>Policy and Organization</u>
Optimalisation of information supply requires clear policy and a structured list of responsibilities of the organization departments. The usage of instruments, such as performance contracts, must be well defined. The change of information needs of statuses to functionalities can be explained, because of the use of this instrument.

<u>Geographic Data</u>
Determination of the characteristics of the geographical data set will be performed while considering the use of performance contracts at the primary processes: Functional Technical Maintenance and Daily Maintenance. Need of information regarding the third primary process: Juridical Maintenance has also been included. The necessary objects during maintenance have been presented in an Object Model in Supplement 19. These objects have been arranged by accuracy. Remarkable is the desired quality parameter: the accuracy of the required objects. In comparison with the Digitaal Topografisch Bestand (DTB) the accuracy can be reduced without consequence. From a similar object model where the required up-to-dateness of the objects has been presented, becomes clear that up-to-dateness should be improved. To improve the up-to-dateness, usage of another large scale geographical data set, the GBKN, will be advised. A list of compulsory objects has to be stored by participants of the GBKN and another list shows the objects which can be stored voluntarily. Usage of the GBKN can improve up-to-dateness. Additional advantage is the extensive use of the GBKN. Exchange of geographical data would be easier. However one remark must be made. The accuracy of "Kant Verharding" and "hectometerpaaltjes" of the GBKN does not comply with the required demands.

<u>Technology</u>
Development of a Corporate Spatial Data Infrastructure can be pushed forward by use of technology. A usable technology has become available by the project "Geo-services". Using "Geo-services" makes data at the source available and guarantees multiple usage of data by communication of the data towards the users. The project "Geo-services" uses OpenGIS standards to perform Web Mapping Services (WMS). In the future, also Web Features Services (WFS) should be available. Therefore "Geo-services" created an excellent opportunity for development of a Corporate Spatial Data Infrastructure (SDI).

<u>Standards</u>
Use of standards is necessary when Web Feature Services (WFS) has to be used. Binding geographical data from different sources requires standards and use of the same Terrain Model. One example of a Terrain Model is the Model developed by NEN (NEN 3610/1878), which can be used to guarantee a good data exchange. Currently an own RWS Terrain Model has been used. Although when several (external) geographical data sets will be added a corresponding Terrain Model will be advisable. Especially when using Web Feature Services. Usage of WFS creates efficient opportunities such as the use of WFS - t (ransaction): Distributed update of a geographical file

It can be concluded that usage of performance contracts require a geographic data set with the characteristics of the Object Model presented in Supplement 19. Although only usage of this data set won't improve the information supply. Long term solutions require the development of a Spatial Data Infrastructure (SDI). Starting with a SDI on RWS level (corporate SDI) and participation at an SDI on national level (National SDI) is recommended.

Besides conclusions about the data sets also conclusions about the used method can be presented. The method used during this research seemed to be useful. Several aspects, which influence the need of information, can be modeled. Also positioning a detailed research in a more general framework is possible. The used method can be used during a preliminary analysis prior to the development of a prototype. The Object Model, found during the research, can be used to create a Data Model for the prototype.

Besides the conclusions, some recommendations will be presented:

1. This research has been framed to “Maintenance” of the Highway Network. When performing research at the work processes regarding “Traffic Management” and “Construction” the total need of information regarding the Highway Network should become clear. Demands regarding the objects and quality parameters, necessary to support the processes of the Directorate-General will became clear.

2. Knowing the necessary spatial objects and quality parameters, makes developing a Corporate Spatial Data Infrastructure easier. Data sets from the National Spatial Data Infrastructure can be invested and maybe used to support the geo-information demand.

3. This research was focused at the need of information at the Dienstkring (Level 4), the need of information at the Regional Direction (Level 3) and Head Office (Level 2) should be investigated and related. A Geographic Object Model should be developed, which has to support the need of geographic data at all Levels.

4. The approach of this research can be used as part of a development method. The used method can recognized as first stage of the development of Information Systems. Strength of this approach is the investigation of need of information. The second stage can be fulfilled by prototyping. The producer has to develop a prototype according to the object model.

Samenvatting

Het Directoraat-Generaal Rijkswaterstaat maakt deel uit van het Ministerie van Verkeer en Waterstaat. Dit Directoraat-Generaal is verantwoordelijk voor de belangrijkste Hoofd-Infrastructuren (Hoofdwegennet en Hoofdwaterwegennet) en de waterbeheersing. Eén van de Specialistische Diensten, de Adviesdienst voor Geo-informatie en ICT (AGI) van het Directoraat-Generaal, heeft het Digitaal Topografisch Bestand Droog (DTB Droog) ontwikkeld. Deze grootschalige data set (1:1.000) voorziet de gebruikers van geografische informatie om bijvoorbeeld onderhoud te plegen aan het Hoofdwegennet. Naast het gebruik van een grootschalige geografische databestand wordt er ook gebruik gemaakt van een midschalig geografisch databestand: het Nationaal Wegen Bestand (NWB). Het belangrijkste doel van de NWB is het toevoegen van een ruimtecomponent aan de thematische gegevens. Naast deze "home-made" geografische data sets, bestaan andere data sets zoals de Grootschalige BasisKaart Nederland (GBKN), die door Gemeenten en Nutsbedrijven wordt gebruikt. De nauwkeurigheid van GBKN objecten is slechter dan de objecten uit de DTB Droog, daarentegen is de GBKN recenter. Deze thesis zal onderzoeken welke geografische data sets het best gebruikt kunnen worden voor Beheer en Onderhoud van het Hoofdwegennet door de Dienstkring. De hoofd onderzoeksvraag luidt:

Welke geografische databestanden voorzien in informatiebehoefte om de werkprocessen "Beheer en Onderhoud" van het Hoofdwegennet te ondersteunen en wat zijn de noodzakelijke kwaliteitseisen van de geografische gegevens

De huidige situatie bij Rijkswaterstaat maakt de omgeving waarin het onderzoek zich afspeelt extra complex. Normaal is het uitvoeren van onderzoek naar informatiebehoefte aan te raden in een organisatie met stabiele processen. Vanwege reorganisatie is de situatie bij Rijkswaterstaat veel dynamischer. Daarnaast is de rol van de Dienstkring met betrekking tot “Beheer en Onderhoud” aan het veranderen. Een nieuw instrument, het prestatiecontract (ook innovatief contract) moet worden gebruikt bij het “Beheer en Onderhoud” van de Rijkswegen.

Het vaststellen van de “fitness for use” van de geografische gegevensbestanden wordt vastgesteld door een Object Model (met inbegrip van thematische gegevens) en de bijbehorende kwaliteitsparameter: precisie. Daarnaast is ook de gewenste actualiteit onderzocht. Volgens richtlijnen van het Hoofdkantoor moet gebruik gemaakt worden van de prestatie contracten en zal het gebruik van traditionele contracten worden verminderd. De informatiebehoefte bij gebruik van zowel traditionele als prestatie contracten zal worden onderzocht.

Het gebruik van prestatiecontracten vereist opslag van toekomstige functionaliteit. De aannemer moet ervoor zorgen dat de overeengekomen functionaliteit (resultaat) wordt bereikt. De functionaliteit en de visie moeten in het contract worden beschreven. Hierdoor zullen sommige soorten processen, die bij gebruik van traditionele contracten werden uitgevoerd door de Dienstkring, moeten worden uitgevoerd door de aannemer. De planning moet bijvoorbeeld door de aannemer worden gemaakt in plaats van door de Dienstkring. Ook veranderen de werkprocessen betreffende Technisch Beheer, omdat slechts “Inspectie” en de voorbereiding van de prestatiecontracten ondersteunt hoeven te worden.

Het traditionele contract beschrijft hoe het onderhoud moet worden uitgevoerd in plaats van het resultaat. Hierdoor vereist het gebruik van traditionele contracten extra stadia van processen. Omdat het contract beschrijft hoe het onderhoud zou moeten worden uitgevoerd, dient het planningsproces bij de Dienstkring worden uitgevoerd. Daarnaast moet het “Technische Beheer” drie andere stadia van processen zoals Inspectie, Planning en voorbereiding van Realisatie ondersteunen.

“Traditioneel” contract	Prestatiecontract
Beschrijft hoe de aannemer “Beheer en Onderhoud” moet uitvoeren	Beschrijft het resultaat wat de aannemer moet bereiken
Informatievoorziening op basis van beschrijving van statussen van objecten	Informatievoorziening op basis van beschrijving van functionaliteit van objecten
Technisch Beheer is gericht op: Inspectie, Planning en voorbereiding uitvoering	Technisch Beheer is vooral gericht op Inspectie en toekomstig resultaat

Table 1: Kenmerken “traditioneel” contract vs. prestatiecontract

Om de verschillende problemen te structureren, wordt het Integrated Achitecture Framework van Cap Gemini gebruikt. Door de werkprocessen betreffende “Beheer en Onderhoud” van de Rijksweg op gedetailleerd niveau te beschrijven, kan de informatiebehoefte duidelijk worden beschreven. Deze behoefte aan informatie zal door de verschillende Object Modellen worden weergegeven afhankelijk van het thema: Verharding, Verkeersvoorzieningen, Landschap en Milieu, Exploitatie en Kunstwerken . Daarnaast wordt tevens onderscheid gemaakt of er sprake is van gebruik van een traditioneel contract of prestatiecontract. Deze Object Modellen worden vergeleken met de opgeslagen objecten en kwaliteitskenmerken van de databestanden. Naast de opgeslagen objecten en kwaliteitsparameters, worden ook de benodigde operaties van de applicatie onderzocht.

De hoofd onderzoeksvraag moet worden beantwoord vanuit het perspectief van een Geo Informatie Infrastructuur. Een dergelijk Geo-Informatie Infrastructuur (GII) bestaat uit vier elementen:

a. beleid en organisatie
b. de geografische gegevens
c. technologie om geo-informatie op te slaan, te communiceren en te gebruiken
d. gebruik van normen voor het beschrijven, uitwisselen en relateren van geo-informatie

Deze elementen samen vormen het antwoord op de vraag om een optimale informatievoorziening te creëren. Het enkel vermelden van de benodigde geografische data sets (met Object Modellen en kwaliteitsparameters) zou een onvolledig antwoord opleveren.

<u>Beleid en Organisatie</u>
Bij optimalisatie van informatievoorziening dient ten eerste het beleid en de verantwoordelijkheden van de organisatieonderdelen duidelijk te zijn. Het gebruik van instrumenten, zoals prestatiecontracten, dient goed omschreven te zijn. De verandering van informatiebehoefte van statussen naar functionaliteiten kan door het gebruik van dit instrument worden verklaard.

<u>Geografische Data</u>
Voor het vaststellen van de karakteristieken van het geografische bestand wordt gekeken naar het gebruik van prestatiecontracten bij de primaire processen: Planmatig Beheer en Dagelijks Beheer. Daarnaast wordt ook rekening gehouden met de informatiebehoefte bij het derde primaire proces: Juridisch Beheer. De inhoud van het benodigde geografische bestand is gepresenteerd in een Object Model in Bijlage 19. De objecten in dit Geografisch Object Model zijn geordend op precisie. Opvallend is de gewenste kwaliteitsparameter: de precisie van de benodigde objecten. In vergelijking met het huidige Digitaal Topografisch Bestand (DTB) Droog kan de precisie zonder gevolg gereduceerd worden. Uit een soortgelijk Object Model waar de benodigde actualiteit van de objecten is weergegeven, blijkt dat de actualiteit echter verbeterd dient te worden. Om de actualiteit te verbeteren wordt gebruik van een ander grootschalig geografisch bestand, de GBKN, aangeraden. De deelnemers in de GBKN moeten een aantal objecten verplicht opslaan en hebben de keuze om een aantal extra objecten vrijwillig toe te voegen. Het gebruik van de GBKN, zou de benodigde actualiteit kunnen verbeteren. Bijkomend voordeel is het omvangrijke gebruik van de GBKN. Uitwisseling van geografische gegevens zou hierdoor verbeterd worden. Eén opmerking moet echter wel gemaakt worden. De precisie van “Kant verharding” en “hectometerpaaltjes” van de GBKN voldoet niet aan de benodigde eisen.

<u>Technologie</u>
De ontwikkeling van een “Corporate” Geo-Informatie Infrastructuur (binnen RWS) kan door middel van nieuwe technologie worden gestimuleerd. Een bruikbare technologie is ontwikkeld tijdens het project "Geo-services". Gebruik van "Geo-services" maakt gebruik van gegevens bij de bron mogelijk en garandeert meervoudig gebruik van gegevens door het verstrekken van de gegevens naar de gebruikers. "Geo-services"maakt gebruik van OpenGIS standaarden. Het gebruik van Web Mapping Services (WMS) is hiermee mogelijk. In de toekomst, ook gebruik gemaakt kunnen worden van Web Feature Services (WFS). Daarom biedt "Geo-services" een uitstekende kans om een GII te ontwikkelen.

<u>Normen en Standaarden</u>
Gebruik van standaarden is noodzakelijk wanneer Web Feature Services moeten worden gebruikt. Om de standaarden van verschillende bronnen te laten aansluiten is gebruik van hetzelfde terrein model gewenst. Het NEN-Terrein Model (NEN 3610/1878) kan bijvoorbeeld gebruikt worden om een goede uitwisseling te garanderen. Momenteel wordt een eigen RWS-norm gebruikt. Indien diverse (externe) geografische databestand samengevoegd worden, is een overeenkomstig Terrein Model aan te raden. Vooral bij gebruik van Web Feature Services. Gebruik van WFS creëert efficiënte toepassingen zoals het gebruik van WFS - T(ransaction): Gedistribueerd updaten van een geografisch bestand

Samenvattend luidt de conclusie dat, bij gebruik van een prestatiecontract, een geografisch bestand met de eigenschappen van het gevonden Object Model gebruikt zou moeten worden. Enkel gebruik van dit bestand, zal de informatievoorziening niet verbeteren. Voor een lange termijn oplossing zal een Geo-Informatie Infrastructuur ontwikkeld moeten worden. Zowel op RWS niveau (Corporate GII) als landelijk niveau (Nationaal GII).

Daarnaast kan worden geconcludeerd dat het gebruik van de gehanteerde methodiek bruikbaar is. Verschillende aspecten die de informatiebehoefte beinvloeden kunnen worden gemodelleerd. Ook de mogelijkheid om een gedetailleerd onderzoek in een algemener kader in te passen en de context uit te leggen is een voordeel. De methodiek kan gebruikt worden als vooronderzoek bij de ontwikkeling van een prototype. Vanuit het Object Model, wat uit dit onderzoek blijkt, kan een datamodel worden ontwikkeld voor het prototype.

Naast de conclusies, worden de volgende aanbevelingen gegeven:

1. Dit onderzoek is afgebakend door alleen processen met betrekking tot "Beheer en Onderhoud" van de Rijkswegen te onderzoeken. Het uitvoeren van een vergelijkbaar onderzoek bij "Verkeersmanagement" en "Aanleg" zou de totale informatiebehoefte in kaart kunnen brengen.

2. Indien de totale informatiebehoefte duidelijk is, zou een Corporate GII moeten worden ontwikkeld. Het wordt aanbevolen om gebruik te maken van de geografische bestanden uit de Nationale GII.

3. Dit onderzoek geeft de informatiebehoefte weer in Dienstkring (Niveau D4), de behoefte van informatie bij de Regionale Directie (Niveau D3) en het Hoofdkantoor (Niveau D2) zou moeten worden onderzocht en kan met elkaar worden gerelateerd. Een Geografisch Model van Objecten zou kunnen worden ontwikkeld, dat de behoefte aan geografische gegevens op alle niveaus zou ondersteunen.

4. De benadering van dit onderzoek kan als deel van een ontwikkelingsmethodiek worden beschouwd: van informatieprobleem naar informatiesysteem. De gebruikte methodiek kan worden ingezet in het eerste stadium van de ontwikkeling van een Informatie Systeem. Het voordeel van deze benadering is het vaststellen van de informatiebehoefte. Het tweede stadium kan door prototyping worden vervuld. De producent zou een prototype volgens het gevonden Object Model moeten ontwikkelen.

Contents

1. Aim of the research

This chapter can be regarded as introduction to the research. Paragraph 1.1 will describe the context of the research. What is the approach to the research? The Enterprise Architecture and Organization of the Directorate-General will be explained in paragraph 1.2. Paragraph 1.3 will be focused on the main research question and will explain what is ment. Finally paragraph 1.4 will describe the objectives of the research.

1.1 Context of the research

Before the use of GIS in organizations, paper maps were made to serve the need of geographical data. Because of the analogous representations of the data, the range of use of geo-information was limited. Creating maps was one of the goals of an organization. Nowadays GIS is becoming more popular and the opportunities of geographic data are increasing. But besides the opportunities of GIS, the use of applications is limited by the fitness for use (quality-parameters) of the data set.

Development of applications is often approached as a single purpose, instead of a mean to reach the objectives of the organization. This thesis will approach Information supply as a mean. Considering this approaching, the question appears what factors will influence the optimal synchronization of information demand (by processes) versus need of information. These dependences should become clear. Nowadays prototyping is a popular method of developing applications. This research in this thesis will investigate the stage prior to prototyping. Should an additional method be introduced before prototyping? Prototyping has a strong relation with a future product, but a weak relation with the objectives. Another method would be approaching the need of information by the “objectives” of the organization. Defining these objectives as part of the subject instead of the context of the model, creates a different point of view at information demand. What modeling techniques should be used to tackle this problem? Does one approach exist as the perfect method to solve information problems in organizations or should different approaches form different scientific areas be used? Does involving goals into the model of Information Management, clarify the model or does it makes the model more difficult?

The Geo-Information and ICT Department (AGI) obtains topographic products from the market. These products will be changed to the customers’ (other departments of the Directorate) demands and the Geo Loket will supply these products of geo-information to the departments of the Directorate-General of Public Works and Water Management. One of these products is the Digitaal Topografisch Bestand (DTB). This topographical database consists of topographical data near infrastructures (highways and main waterways) and is integrated in the application “Kerngis 8”. A different geographic data set about the highway network and main waterways, which the Geo Loket provides is the TOP10vector (creator: TDK [1]), which maintains mid-scale geo-information of the Netherlands. Using the approach, as discussed above, this thesis will discuss the need of information and its relation with the supply of information from the user’s perspective. The question arises if these (or other) mid- or large-scale data sets can contribute to a more optimal information supply, which can be used by Directorate-General of Public Works and Water Management. Creating and maintaining different topographic databases (instead of one authentic database) with financial means from the same government is an undesired situation and will be discussed from the user’s point of view. Regarding the work processes at the Dienstkring an ideal blueprint of a geographic database will be developed and the fitness for use of other existing and innovative data sets will be tested.

[1] Topografische Dienst Kadaster

1.2 Directorate-General of Public Works and Water Management

The Directorate-General of Public Works and Water Management is part of the Ministry of Transport, Public Works and Water Management. This Directorate-General is responsible for the main infrastructures (highways network and main waterways) and water management. The Directorate-General of Public Works and Water Management is responsible for the daily care of four core functions (Bedrijfsmodel Rijkswaterstaat, 2003):

1. protecting the Netherlands against flood,
2. looking after clean and sufficient water for all users,
3. managing maintenance of the highways and main waterways,
4. taking care for smooth and safe traffic flow.

The "Enterprise Architecture Directorate-General of Public Works and Water Management" will show how these activities, concerning these core functions, are realized.

1.2.1 Enterprise Architecture

First a frame has to be defined to indicate the primary processes, which will be included in this thesis. There are different frames used to describe the different primary processes. The perspective of these frames is usually from the management point of view and not from the task point of view. Next paragraph will describe a solution for this problem. The used global frame of primary processes is described in the documents concerning agency shaping. In the Bedrijfsmodel Rijkswaterstaat (2003, 18-28) the primary processes have been again defined according to the Enterprise Architecture of Directorate-General of Public Works and Water Management (table 1.1: "Bedrijfsmodel Rijkswaterstaat".

Network- and Traffic management Main Highway Network	**Network- and Traffic management Main Waterway Network**	**Integral Water control Main water systems**	**Supply of Knowledge and Expertise**
Traffic Management	Traffic Management	Quality Control	
		Quantity Control	
Maintenance and Development	Maintenance and Development	Maintenance and Development	
Construction	Construction	Construction	
Policy support and advisement	Policy support and advisement	Policy support and advisement	Policy support and advisement

Table 1.1: "Bedrijfsmodel Rijkswaterstaat" (2003)

The four columns are the "objects / themes", the Directorate-General has to take care for. The boxes underneath are the areas of attention, which can be recognized. This thesis will focus on the primary processes regarding: Maintenance and Development of the Highway Network.

1.2.2 Departments of the Directorate-General

The Directorate-General of Public Works and Water Management consist of 11.000 employees divided at the Dienstkringen, Regional Departments, Specialist Departments and the Head Office. The Directorate-General is part of the Ministry of Transport, Public Works and Water Management. Figure 1.1 shows the organogram of this Ministry of Transport, Public Works and Water Management (Ondernemingsplan Rijkswaterstaat, 2004). The levels of the different departments are stated on the left side of the figure.

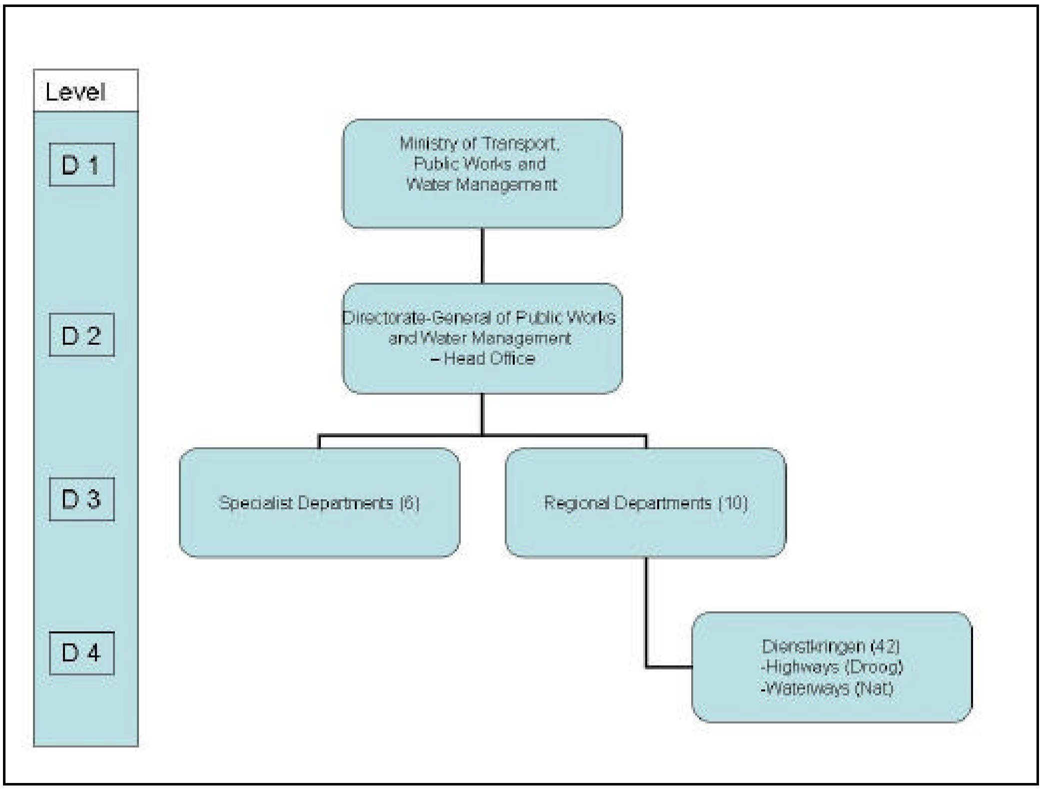


Figure 1.1: Organogram Ministry of Transport, Public Works and Water Management

<u>Head Office</u>
The Head Office of the Directorate-General of Public Works and Water Management is responsible for the management of the organization and the development of strategy and policy of the department. The Director-General of the Department is settled at this Head Office in The Hague.

<u>Specialist Departments</u>
The main responsibility of the specialist departments is the support and development of applications of specialist knowledge for management and operational support. This research has been performed at one of these Specialist Departments, the Geo-Information and ICT Department [1] in Delft.

<u>Regional Departments</u>
The 10 Regional Departments are the backbone of Directorate-General of Public Works and Water Management. They are responsible for the development of the Regionaal Beheerplan [2]. Also the supervision of the Highway and Waterway Network and supervision of the Dienstkringen is their responsibility. Developing the maintenance policy is part of their work processes.

<u>Dienstkringen</u>
The Dienstkring is responsible for the actual availability and reliability of the existing infrastructure (highways and main waterways). These operational work processes are performed in cooperation with other participants.

[1] Dutch: Adviesdienst Geo-Informatie en ICT (AGI)
[2] Regional Plan of Maintenance

Because the Dienstkring is performing this kind of activities, she can be considered as the Front-Office of the Directorate-General of Public Works and Water Management.
Two different types of Dienstkringen can be recognized. The "natte" Dienstkringen (16) and the "droge" Dienstkringen (26). The "natte" Dienstkringen has to perform maintenance of the rivers and canals. The "droge" Dienstkringen has to perform maintenance of the Highways. This thesis will analyze the "droge" Dienstkringen.

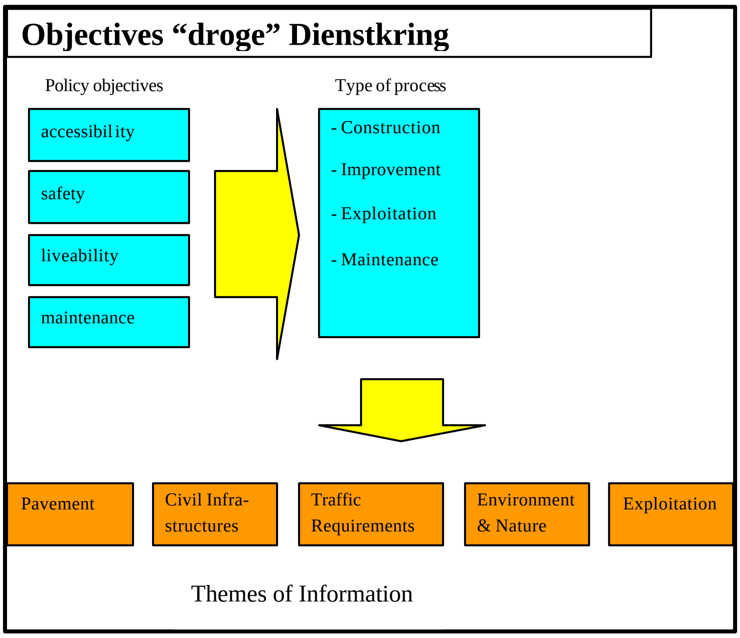


Figure 1.2: Objectives of the "droge" Dienstkring (Luijkx, 2001)

During this research the "droge" Dienstkringen are divided in three different types, dependent on the location of the Dienstkring. The Dienstkringen in the urban areas are indicated as "Randstad" Dienstkringen, in rural areas as "Groen" Dienstkringen and on the edge of the urban district as "Corridor" Dienstkringen. This classification of Dienstkringen has been made by location. The reason for this classification is the difference in number of vehicles using the highway. This classification is recognized by the Directorate-General, but isn't often used. Supplement 2 shows the Dutch highway network with the Dienstkringen, who has to take care of the maintenance.

The Dienstkringen have several policy objectives. The main objectives are accessibility, safety, livability and maintenance of the highways. The types of work, which have to be performed, are: construction, improvement, exploitation and maintenance of the highways (see figure 1.2). These types of work are performed at the themes: Pavement, Civil infrastructures, Traffic Requirements, Environment and Nature and exploitation.

1.2.3 Geo-information and ICT Department

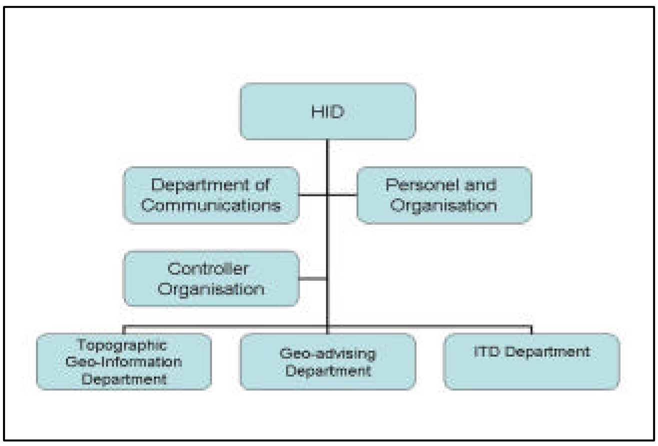


Figure 1.3: Organogram Geo-information and ICT Department

The Geo-Information and ICT Department (AGI) is one of the Specialist Departments of Directorate-General of Public Works and Water Management. The department is directed by the Hoofd Ingenieur Directeur (HID). Three divisions: the Department of Communications, Personnel and Organization and the Controller Organization, perform the secondary processes. The processes regarding the supply of geo-information are performed by the topographic geo-information department, geo-advising department and Information Technology Department (ITD). This research is performed at a sub-department [1] of the geo-advising Department. Figure 1.3 shows the organogram.

[1] GAG: Geo Advisering en GIS

<u>Mission</u>
The mission of the Geo-information and ICT Department (AGI) defines the legitimacy of the organization and gives direction to the daily practice. The mission of the AGI is:

> The Geo-informatie and ICT Department (AGI) is the facilitating and communicating department of the Directorate-General of Public Works and Water Management regarding the area of Geo-Information Management and ICT

The strategy can be characterized by two key terms: concentration of information and ICT-consulting and standardizing the ICT and Geo-Information production and supply to end-users within the Directorate-General of Public Works and Water Management.

1.3 Scope of the main research question

This paragraph will discuss the scope of the research question. The main research question of this research is formulated as:

> *Which geographic data sets can support the need of information regarding the work processes "Maintenance of the Highway Network" at the Dienstkring and what level of geometric and temperal quality of the geographic objects is necessary*

Which geographic data sets……
Geographic data sets, which will be involved, are the currently used data sets at Directorate-General of Public Works and Water Management (like DTB Droog) and innovative data sets (and methods). To define "innovative" the definition of Thether (2001) will be used " Innovation is the capacity to use new knowledge to increase the productivity and create new products and services". This will include data sets and methods, which aren't developed yet (inventions). Besides using these inventions also data sets and methods, which are already used by other parties, but not at the Directorate-General of Public Works and Water Management' can be considered as innovative. Examples of innovative geographic data sets are GBKN, TOP10NL and the data set developed by the VaRi-method (paragraph 4.3.3).

…… the need of information regarding the work processes……
The perspective of the need of information is from the user, which executes the work processes at the Dienstkring. A frame will structure the work processes and the corresponding need of information to be analyzed. Because of the changing role of the Dienstkring regarding maintenance of the Highway Network, this additional aspect causes a changing in need of information. A different way of outsourcing and the use of performance contracts to accomplish the objectives does have impact on the need of information. The effect of outsourcing regarding the demand of information should also be investigated. The methodology and modeling techniques used to cope with this situation will be discussed in Chapter 2.

……"maintenance of Highways"……
The project "Enterprise Architecture" (Middeljans, K et al., 2004) structured and stated all primary processes of the Directorate General of Public Works and Water Management. The maintenance of the Highway Network is one primary process, which is recognized in this Enterprise.

…… at the Dienstkring……
Responsibilities and work processes about maintenance of the Highway Network aren't only performed at the Dienstkring. The "Regionale Directie" and some "Specialist Departments" do have their own responsibilities. These work processes aren't investigated. The work processes at the Dienstkring can be classified as operational maintenance of the highways.

…… and what level of geometric and temporal quality of the geographic objects ……
First the needed geographic objects have to be invested to support the need of information of all work processes. The corresponding quality parameters, which will be invested are:

- Geographic parameters
  - Accuracy
  - Up-to-dateness
- Temporal aspects
- Thematic attributes

Besides the necessary geographic objects, the thematic data about the objects will also be investigated. The geographic quality of the data will be represented by two data characteristics: accuracy and up-to-dateness. These two quality parameters are the only data quality parameters, which can be related to data sets as well as work processes. Besides the reason of focusing the research on these two parameters, the problem in information supply is directed to these parameters and the regarding fitness for use.

1.4 Objectives of the thesis

To answer the main research question, the following objectives have to be realized.

Framework

The first objective is focused on the development of a structured frame of work processes / tasks regarding "Maintenance of the Highways" at the Dienstkring, the most decentralized part the Directorate-General. A clear description and objective of each work process will be gathered. This list will structure the responsibilities of the Dienstkring. The way how the objectives of the Dienstkring should be accomplished shouldn't influence the frame of work processes. How this framework will be created will be discussed in Chapter 2. The framework itself will be presented in Chapter 3.

Need of Information

The second objective is focused on developing an additional scheme regarding the need of information of each work process. The frame of work processes will be used to relate the need of information. The need of information will contain geographic data (spatial objects and attribute data) necessary to perform the tasks including the quality parameters of the data. Performing analysis should be possible with this (digital) scheme. Two situations will be documented and analyzed: Need of information while using (1) traditional contracts and using (2) performance contracts. The need of information will be documented in an excel sheet. Structured overviews will be presented during the analyze.

Analyse

The third objective is creating an object model of all geographic and attributes data (inclusive quality parameters) and required functionalities (operations) necessary to support the work processes. Therefore the work processes have to be grouped, because more than one application at a Dienstkring may be optimal. Considering the different object models, the need of information can be derived. Chapter 5 will present overviews of the object models of the need of information. This need of information will be related to the used data sets and applications. The object models will also be used to analyze the potential need of information caused by the change of policy. Chapter 6 will show more integral analyses.

Conclusion

The forth objective will be a description of the optimal information supply and use. What data sets should be used (according to the object models), what quality parameters are necessary and what functionalities should be available? Also more global conclusions about a Geo-Information Infrastructure will be stated. Chapter 7: Conclusions and Recommendations will contain these final conclusions.

2 Methods of research

This chapter will discuss the methodology and theories, which will be used during this research. The actual results of the research can be found in the chapters and paragraphs concerning the subject.
Paragraph 2.1 will explain the approach of the research: an Architecture Approach. There are different ways of approaching "information problems" in organizations. During this thesis the Integrated Architecture Framework (IAF) developed by Cap Gemini has been chosen. The IAF approaches the "Information Problem" to several components:

- Business component (processes)
- Information component (data)
- Application component

This approach can be used to relate processes with data. After discussing the overall approach some more techniques will be discussed, which can only be used for particular problems.

Paragraph 2.2 will discuss the "Conceptual Models". The "Conceptual Models" will be used to model "information demand" of the user and the "information supply" of the products. Using these "Conceptual Models" creates the possibility to relate need of information with the data sets. Besides investing which objects have to be stored with what thematic data, the most important aspect of the model should be investigated: the necessary geometric data.

Paragraph 2.3 will discuss what geometric quality parameters have to be taken into account. All geometric parameters will be presented. After a discussion of the role and usability of those parameters to support this research. Finally paragraph 2.4 will describe some conditions necessary to establish an optimal information supply.

2.1 Approach: using the Integrated Architecture Framework

The approach to which should be used to determine the need of information of the users is performed by an architecture approach. Two architecture approaches will be discussed. The OpenGIS Reference Model (ORM) and the Integrated Architecture Framework (IAF).

The OpenGIS Reference Model

The OpenGIS Reference Model (ORM) uses the Reference Model of Open Distributed Processing (RM-ODP), which is an international standard (ISO/IEC 10746) and framework for defining architectures. The RM-ODP is build around five relatively orthogonal viewpoints (Buehler, 2004):

- Enterprise Viewpoint
- Information Viewpoint
- Computational Viewpoint
- Engineering Viewpoint
- Technology Viewpoint

Unfortunately this ORM isn't suited to support this approach, because the Framework should be able to cope with the necessary characteristics. The reasons to choose the Integrated Architecture Framework are:

1. A less complex and more transparent approach. Because of the transparency of the architecture approach it is easier to understand how to cope with the problems.
2. The information problem can be approached from the business perspective: To cope with changing business aspects.
3. Establishing a direct and concrete relation between the work processes and need of information by investing the need of information per process.
4. The possibility to model the viewpoints of the ORM into the framework. Analyzing the problem would be easier wit h the IAF then using the ORM. An advantage of the IAF is the possibility of placing the ORM Viewpoints into the framework.

The Integrated Architecture Framework

Two approaches can be used during optimalisation of information supply: The producers' perspective and the users' perspective.

- The producers' perspective: This perspective approaches the information supply from the product. Data concepts and GIS models will be developed and with the product an optimal information supply should be reached. Aspects of the production of the data sets are analyzed like gathering data, data structures, standards and techniques for supplying data. Starting points the Information and Application column.
- The users' perspective: This perspective approaches the problem by trying to state the need of information of the user. What data does the user need to make sure the data can be interpreted as information? Starting point is the Business column

During this thesis, the users' perspective will be chosen, because the process of synchronizing work processes to goals of an organization is dependent on the user (demand of data) and not on the producer (supply of data). The Integrated Architecture Framework (IAF) will be used to structure the research. Besides the use of the IAF during this thesis, the IAF has also been used by the project Enterprise Architecture Rijkwaterstaat (EAR). Because of the compatibility of the approach used in this thesis, this framework will be used to clarify the procedures and activities, which will be performed. A part of the framework is shown in Figure 2.1: Integrated Architecture Framework. The complete IAF is shown in Supplement 3A.

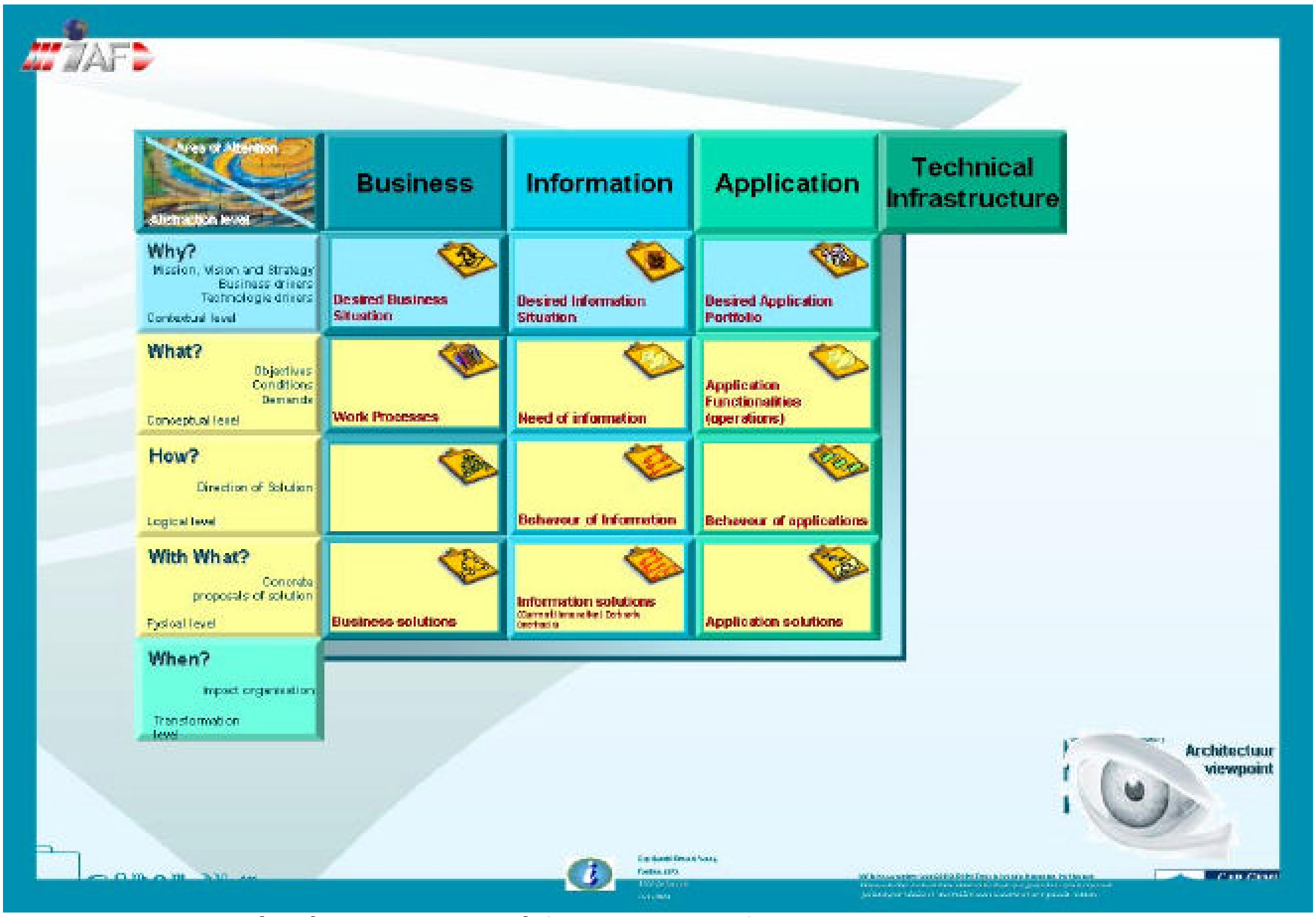


Figure 2.1: Integrated Architecture Framework (Cap Gemini, 2001)

2.1.1 IAF: Business – Why

An organization does have its core-business and has a strategy to reach its objectives. Achieving those objectives is the purpose of the organization. Often information supply is considered as an objective, but it should be considered as a supplying functionality to reach the objectives of the organization. The purpose of information supply is supplying a user with the necessary data / information to perform work processes.

A list of goals of the Dienstkringen regarding maintenance of the highways, which are related to my research, are listed below (Middeljans K et al., 2004). The functions do have two typical conditions. The first condition is the focus on the maintenance function of the goals. The second condition is the operational level of the goals. Both are typical conditions of objectives, which should be accomplished by the Dienstkring, according to table 1.1: “Bedrijfsmodel Rijkswaterstaat”(Table 1.1)

FUNCTION 1.2.2.1: DETERMING THE NECESSARY RESOURCES FOR MAINTENANCE OF MAIN INFRASTRUCTURE NETWORK

Goal: Decide what resources are necessary to maintain and improve the main infrastructure network.
Description: A budget will be made, which finally can be included in the Rijksbegroting.

FUNCTION 1.2.2.2: AVAILABILITY MEANS FOR MAINTENANCE OF MAIN INFRASTRUCTURE NETWORK

Goal: Making resources available to maintain and develop the main infrastructure network.
Description: After granting the requested resources to maintain and develop the main infrastructure network, proceedings can take place.

FUNCTION 1.2.3.1.1.1.1: AVAILABILITY OF MAIN INFRASTRUCTURE NETWORK

Goal: Taking care of the availability of the main infrastructure network
Description: This function concerns the part of the main infrastructure, which is concerning traffic. For example: Making sure the highway network is often available and not all the time in maintenance.

FUNCTION 1.2.3.1.2.1.1: TAKING CARE OF FUNCTIONALITY OF MAIN INFRASTRUCTURE NETWORK

Goal: A main infrastructure network with an optimal functionality.
Description: This goal is regarding the functionality of the main infrastructure network to guarantee mobility and accessibility. For example: Are additional lanes necessary?

FUNCTION 1.2.3.2: TAKING CARE OF CIVIL INFRASTRUCTURES

Goal: Taking care of available civil infrastructures
Description: This goal is concerning the mobility and accessibility goals as well as the safety- and environmental goals. Within this function is included the maintenance of the Civil Infrastructures. Example : The usage of a newer and wider bridge as part of the Highway.

Considering the level of abstraction of these goals, it’s impossible to perform a structured analyze to determine the need of information. The main reason is the vagueness of the objective, because the level of abstraction is too wide. The need of information can’t be related by these objectives. Optimalisation of information can’t be accomplished by using the objectives of the Directorate, because the framework isn’t suited to relate “objectives” to “information”. For a structured analyze of the need of information, a different approach should be performed. Before presenting the overall approach the two most important parts of the IAF will be discussed.

2.1.2 IAF: Business – What

This box “Business - What” will focus on the framework of work processes and give a description of the work process itself. This framework of work processes will be used to relate the work process and objects needed to support the work process. The work processes will be described and integrated into the frame. After defining the model, the aggregation level has to be defined. To create a useful perspective of processes, following aspects have to be included:

- Different in- and output of geo-information;
- Themes of subjects which can be recognized;
- Level of abstraction.

Different in- and output of geo-information

Different in- and output of geo-information has to be related to the (stages of) work processes. To develop a frame of work processes, a overall approach will be used to start and some important process aspects will be used for a more detailed framework. The Directorate-General of Public Works and Water Management recognizes three primary processes at the Dienstkringen (Bedrijfsmodel Rijkswaterstaat, 2003). Those three primary processes are:

- (Strategic) Functional Technical Maintenance
- Daily Maintenance
- Juridical Maintenance

All processes of maintenance and its objectives can be addressed to one of the primary processes. Example of work processes are mowing, taking care of cables / civil infrastructures / pavement and traffic requirements. A characteristic of the work processes of the same primary process are the corresponding stages. Following stages of the work processes have been recognized:

- Planning
- Technical Maintenance
- Inspections
- Realization
- Granting/maintaining permits
- Incident Management

These stages require geo-information with different characteristics. The objects can be the same, but the quality parameters can be different. The quality parameters invested in this research are accuracy and up-to-dateness. The frame of processes should be able to store and analyze the need of information per work process and stage.

Themes of subjects, which can be recognized

The themes / categories of the Beheerplannen used to make a difference by goal are another differentiation made by the Directorate-General of Public Works and Water Management. The “Beheerplan Droog” describes the activities of maintenance and is the base for financial support from the “Head Office”. The following differentiation regarding to the Beheerplannen can be made (Wegwijzer Wegbeheer, 2003):

- Pavement
- Traffic Requirements
- Exploitation
- Civil infrastructures
- Environment and Nature

Level of abstraction

When comparing need of information with data-supply (current or innovative products), the corresponding level of abstraction should match. The level of abstraction is determined by abstraction rules (Uitermark et al., 1999). These abstraction rules describe the transformation process from topographic objects (Real World objects) to geographic data set objects. In other words, abstraction rules define what topographic objects and how topographic objects are represented. Abstraction rules include:

- Inclusion rules: what objects and attributes are selected;
- Representation rules: how objects are represented;
- Simplification rules: how objects are simplified;
- Aggregation rules: how objects are merged.

The abstraction rules, necessary to determine the need of information, consist mainly of inclusion rules. This is because the first stage has to be focused on the need of information of the users. When users need thematic data of an object, this object will be considered as needed. The accuracy and up-to-dateness will indicate the need of information regarding the geographical component. Because of the different themes and perspectives, which can be recognized, aggregation rules could also be made. Maybe some entities should be merged to create an object of interest.

One of the main requirements of the model, which should model the work processes, is the compatibility of the need of information regarding the work processes versus the object model (with attributes and quality parameters) of the data sets. For modeling the data sets the “object model” (with attributes) will be chosen and when using the inclusion rules, a relation can be established between the need of information of the work process and data supply. When, for example, the characteristics of the data supply do have a high level of detail and during the interview the level of detail isn’t equal, the results will seem to be matching, but are in fact faked (de Boer and Hisschemoller, 2001, p7).

2.1.3 IAF: Information – What

The box "Information – What" will investigate the need of information. What is ment by "need of information"? The term "need of information" can be interpreted as the information needed by the user as support to perform a work process. The next question, which should be asked, is: "What is information?" According to Bemelmans (1987): "*Information consists of related interpreted data*". Derksen and Crins (1992) define the term information as more semantic "*data, which is meaningful to the receiver of the data*". A difference with the definition of Bemelmans isn't the data isn't only related and interpreted, but has a meaning to the user to answer his question. The data should only be numbers to the user, but the user knows what those numbers mean. Starreveld et al. (1985) define information even more strict: "*information is that which reaches the conscience of people and contributes to its knowledge*". According to Starreveld and de Mare information should increase the knowledge of the receiver. (Verschuren, 2000, p27).

In this research, the definition of Derksen and Crins will be chosen. The definition of Bemelmans is too narrow. When providing the users with the necessary data, the user shouldn't only interpret the data, but also have a meaning to the user. In this thesis the definition of data will consist of the following axioms:

Information;
σ1) Information consists of more than one entity (n) of data ($n \geq 2$);
σ2) Information has to support the user by reaching his purpose;
σ3) Data is true;
σ4) Data is related;
σ5) Data is received by a user;
σ6) Data has a meaning according to the user.

Figure 2.2: Information Engineering and its relations

Concretization of need of information
Data are numbers, which are collected, according to fixed procedures and can be used for all kind of aims (de Boer and Hisschemoller, 2001, p6). Data also hasn't been interpreted and can be classified as objective. On the contrary, as discussed above, information concerns a combination of data (related). Because of the combination of data (by a user), information is subjective. Concretization of information is therefore much more difficult. To clarify the method used for concretization of information, a philosophical approach will be used. According to Mahler "*Information can only be defined within the scenario, it is not just out there* (Mahler 1996, 117)". The question which data will be used is depended on the scenario. To concretize the need of information, objectives of the work processes should be used as departing constraints. Information will be "assembled" out of data to reach the objective. The scenario isn't the only aspect of interest to concretize information. According to Floridi "information is the product of received data interpreted by a network of definitions". The network of definitions is the user's reference system (knowledge). The problem is that all reference systems of the users are different. The need of information of each user is therefore also different (and therefore subjective). Stating formal semantics can be used as tool to match the reference systems of the different users. The way these two elements "scenario and reference" should influence the analysis will be performed by displacement in the role of the user. According to de Boer and Hisschemoller (2001) this can be done with a work scheme as presented in figure 2.3.

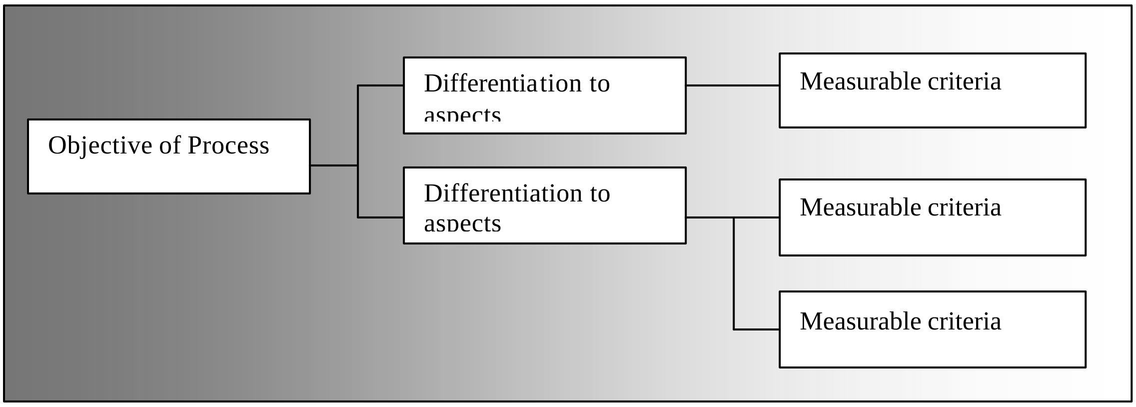


Figure 2.3: Systematic differentiation of processes (de Boer and Hisschemoller, 2001)

Explanation: systematic differentiation of objectives
The original method of this scheme is displacement in the user. The first approach is performed by a top-down questioning technique. Checking of the gathered data will be summarizing the answers by a bottom-up questioning technique. Secondly, the objective of the work process has to be made clear. What does the user want to achieve? All the objectives of the work processes should be related to the objectives of the function model (Business – Why). When focusing on the objective of the work process, a list of aspects, which are important during the decision to perform maintenance. The list of aspects, important to support the work processes, will be different per person. All necessary aspects, users will mention during all interviews, will be collected and classified as aspects.
After making a list of aspects, a list of measurable criteria will be gathered. While structuring information about these measurable criteria, a differentiation will be made by thematic criteria and geometric criteria (see figure 2.4). Concretization of these criteria will be most difficult. The conceptual model, which has to be chosen, has to relate the need of information with the data sets and has to make sense. The entities should be comparable and of the same aggregation level. During this process the Universe of Discourse is investigated per work process. This Universe of Discourse will be modeled by Object Models to a Conceptual Domain Model.

2.1.4 Stages: from information problem to solution

Besides a description of the areas of attention, this paragraph will focus on the stages, which have to be performed. During the research multiple problems have to be investigated. The following fases can be distinguished.

The first fase will define a framework of work process: This stage has been described in the Business – What (see figure 2.1) of the IAF. The purpose of this framework of work processes is limiting the subject, which would be investigated. After interviewing the users about the work processes they have to perform, the necessary aspects have to be determined. The goals according to the users and the description of the work process will be investigated. Interviews will take place at three Dienstkringen. All Dienstkringen have different procedures how to manage geo-information. To understand the procedures regarding geo-information, the procedures in one Dienstkring (Waarden) will be presented by UML use-case diagrams (Supplement 2). The work processes and the model, which has to be used during the analysis, should be familiar or recognizable by the users. This is important because the users have to recognize the work process and state the need of information. The developed frame of work processes will be necessary to go to the second stage

The second fase will collect the need of information and relate the need of information to work processes. This fase can be recognized in the Information – What (see figure 2.1) of the IAF. The purpose is a structured and detailed investigation of need of information and the possibility to perform analysis on the data (concerning need of information). Because this research will focus on geo-information, the objects with the quality parameters (accuracy and up-to-dateness) will be investigated. Because multiple interpretations of the objects are possible, also some necessary thematic data will be collected. An Object Model will be created to store the need of information. The Object Model will be used because of two reasons. The first reason is the focus of the research on objects and its quality parameters. Therefore an object model would be easy to store characteristics about data. The second reason is the usability. The Object Model should be understandable by the users (for checking) and should show the necessary characteristics of the data. A necessary condition to keep the Object Model interpretable for the users is defining objects by itself. The Object Model won't consist of relations between the mentioned objects, because the research is focuses on the quality parameters. Arranging the objects by quality parameter creates a kind of Conceptual Domain Model. This Conceptual Domain Model can be regarded as the necessary "Real World" in the system. This model of the "Real World" is called the Universe of Discourse. During the interviews to develop the Object Model, the necessary operations on the data have also been investigated. This functionality can be regarded as part of the Application – What (see figure 2.1). In fact this information should be modeled according to the Conceptual Application Model.

The third fase will check the completeness of the listed work processes. This will be performed by using the objectives stated in the Business – Why (see figure 2.1) of the organization. Concretization of the objectives into work processes is a very difficult task. Because the prime research of this research is more focused on the relation between "process" and "information" and less to the relationship "objective" and "process", a detailed approach to this problem shouldn't be very useful. The approach to check this problem will be performed bottom-up. The following proposition will be used: The work processes should realize the objectives. Therefore the work processes are analyzed by the criteria if they do support the objectives. According to the approach of the Boer and Hirschemoller (2001) the aspects and measurable criteria are obtained. Afterward would be determined if the objectives would be accomplished by the work processes. This proposition was positive. An independent check was performed by using a guideline (Vusse, 2002). The overlap of processes with the guidelines from this report with the work processes, which were mentioned during the interviews, was about 90% so the list of work processes could be considered as reliable.

The forth fase will focus on the supply of current data sets and current applications. These data sets have to be investigated and are related to the IAF in the box “Information – With What” and the applications have to be related to the box “Application – With What” (see figure 2.1). The purpose of the forth stage is to establish a relation between the need of information (Information – What) with the current data sets (Information – With What). Comparing the Universe of Discourse and the Conceptual Domain Model (by Object Models) with the used Object Models of the Data sets. By comparing these Object Models the fitness for use of the data sets can be determined. Besides the data-oriented analysis the operation-oriented analysis are also considered. The need of functionalities during the work process and the functionalities of the applications are also compared, because the existence of the data doesn’t mean a functional use of the data. Functionality of the application should be investigated to determine this part of the analysis.
Innovative data sets (and methods) and applications are also considered. These are also part of box “Information – With What” and “Application – With What”. Determination of the fitness for use of these innovative data sets (and methods) and innovative applications will be performed in the same way. These four different stages will be performed.

The next fase would be developing a desired Conceptual Application Model. This model could be used to develop the data model of the application. This stage isn’t investigated during this research. The Conceptual Application Model should be developed by UML-schemes. UML is specially designed technique for implementation of data models. In the earlier stages, the Conceptual Application Model wasn’t useful, because of the global aggregation level.

2.2 Conceptual models

After discussing the more overall approach and methods structured by the IAF, some modeling techniques regarding the research will be discussed. The models will be used to describe and understand the interpretation of the “Real World” and perform analysis to predict the optimal way to act.

2.2.1 Conceptual Domain Model: the approach to the users

While interviewing the users, the data from the users has to be gathered in a uniform way and the considered entities should be structured to make clear what data is necessary to draw conclusions. Considering the demarcation of the problem and the need of information of the users, the needed entities of the conceptual domain model presented in figure 2.4 has been developed. This model gives an impression of the needed information during the interviews and check if all data has been gathered. The collected data will be stored in Microsoft Excel, which will be used as spreadsheet to store and analyze the collected data. The excel sheet used to store and analyze the data is enclosed to this thesis.

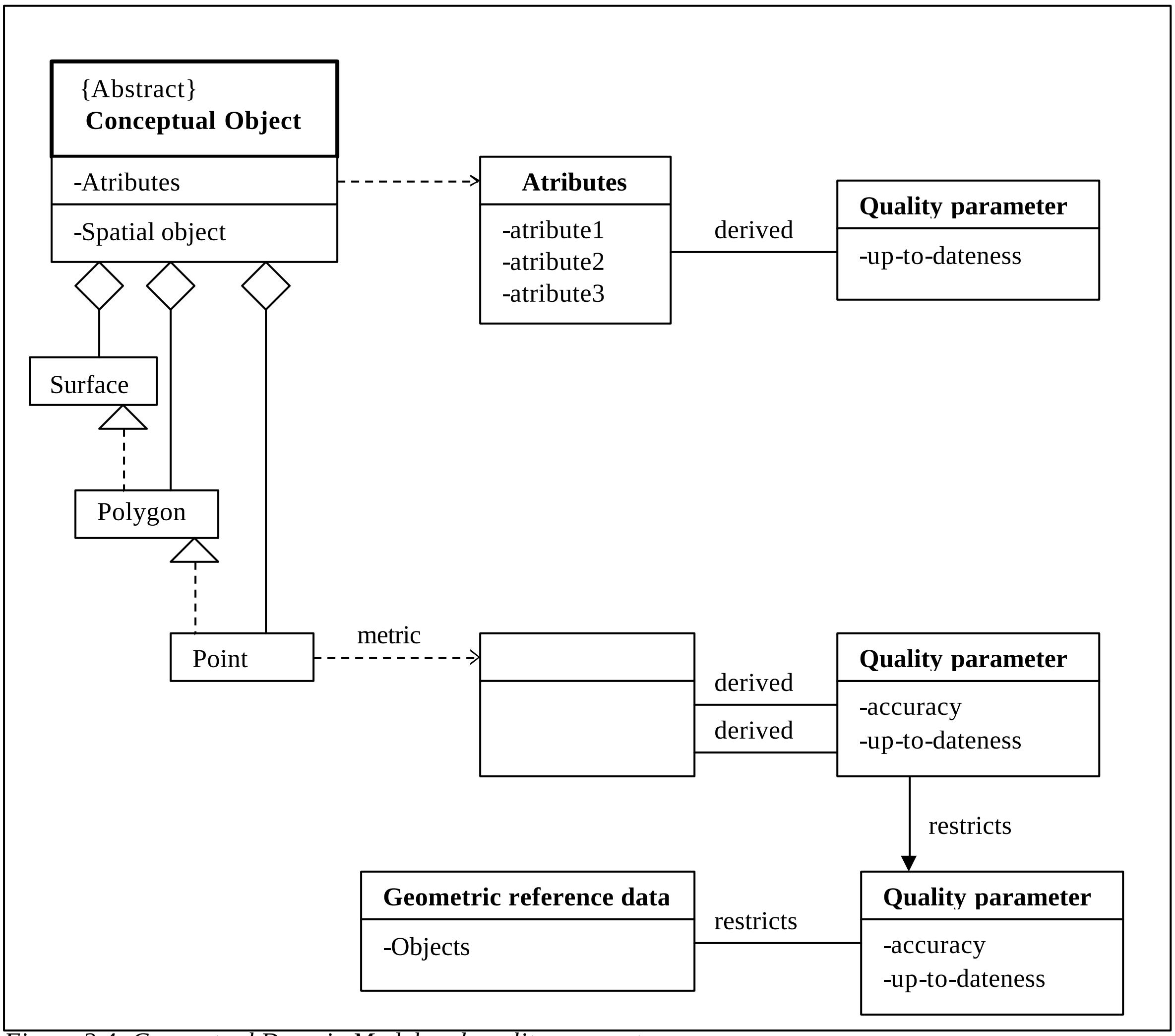


Figure 2.4: Conceptual Domain Model and quality parameters

Explanation: Conceptual Domain Model and quality parameters
While gathering information to support the execution of a work process, the necessary ‘conceptual objects’ will first be selected. Those ‘Conceptual Objects’ do have thematic data, which the user needs to support the work process. These attributes are the ‘entities’. The up-to-dateness of the ‘thematic data’ is the only quality parameter, which will be gathered. The list of ‘thematic data’ represents the completeness of the data. Because of the difference in necessary data ‘completeness’ will only be represented in the list of ‘thematic Data’ (already discussed in 2.2.2). Besides the ‘Attribute Data’ the user also needs a certain quality about the geometric component of the object. The geometric component of the ‘Conceptual Object’ is described in the ‘Spatial Object’. This ‘Spatial Object’ consists of points, lines and/or surfaces. The ‘Accuracy’ and ‘Up-to-dateness’ of points will be gathered. The relative distance between points is important and not distance between lines or surfaces of objects, which would exclude some of the geographic relations of spatial objects. The two parameters, accuracy and up-to-dateness will define the necessary geometric resolution of the data set. The accuracy and up-to-dateness of the ‘Geometric reference data’ should at least have the same quality parameters. Besides the needed objects also the ‘Reference objects’ will be gathered. This description is also derivable from the UML diagram in Figure 2.4: Conceptual domain model and quality parameters.

2.2.2 Conceptual Model: the approach to the geographic data sets

After discussing the conceptual model of the need of information to support the work processes in the previous paragraph, this chapter will focus on the conceptual model of the data sets. First the perspective and modeling technique of the data sets has to be determined. Secondly the role of geographic reference data sets will be discussed.

Perspective of data set

The perspective of the data set has to be synchronized with entities gathered by interviews, which determine the need of information. The different characteristics used to determine the fitness for use of the data sets, will be stored. These characteristics have to serve two objectives: (1) modeling the (thematic and geometric) entities, which will be provided by the data set and (2) determination of the quality parameters of the data set. The possible operations on the data set, which can be performed by the application, will be presented in the paragraph concerning the applications. This thesis does separate the data (data set) and the functionality (operations of application).

Modeling the (thematic and geometric) entities has to be done at a certain abstraction level. The abstraction level, which will be chosen, is based on the object model, which will be discussed in next paragraph (par. 2.3.2). In Supplement 18 and 19 a scheme of objects (entities) will be presented with the geometric quality parameters and its attributes. Which quality parameters have to be chosen will be discussed in paragraph 2.3.

Different modeling techniques of data set

The design of an Information System can be performed according to different components, with its own characteristics. Sol (Mantelaers, 1995, p53) describes four types of models, which can be used to handle a problem. Each different type of model has its own characteristics of information, which can be expressed. According to Brussaard (Mantelaers, 1995, p53) following aspects can be expressed which these models:

Model	**Information characteristic**
Object model	Pragmatic - Information
Information model	Semantic - Data
Data model	Syntactic - Structure of data
Media model	Empiric - Media

Table 2.1: Models and its characteristics (Mantelaers, 1995)

The method of modeling will be based on the Object model and the Information model. The Data model isn't suited because its characteristic doesn't have anything in common with the need of information of the users. The data model can only be interesting, when a data set has to be created and an application should be filled. The media model can only be used when a media for data must be optimized.

The Information model

The information model can be used because this model will deal with the semantic characteristics of the data stored in the Information System. To relate certain data sets to work processes, the necessary entities (and its characteristics) have to be gathered. When using the necessary entities, information can be created. The data (thematic and geometric) will obtain its own semantics.

The Object model

The object model will be the most important model. This model will discuss the objects of interest, which are necessary to support the work processes with information.
The first reason to use the object model is the corresponding abstraction levels of the data gathered from the users regarding their "need of information" and the data gathered regarding "the characteristics of the data sets". While using the object model, the user can be questioned about the need of information (of objects), which the user should know to perform its work processes. Also the necessary quality parameters about these objects can be obtained. The level of detail of the "need of information", gathered during interviews is quite global.

The first reason is the amount of data, which should be gathered from the user by the interviewer. It's almost impossible to gather all detailed (thematic) data about the need of information from the user. This is because of temporal and structuring incapability's of the human brains. The second reason is the sufficient data capture when using a more global level of detail. A higher level of detail would only be necessary when the technique prototyping would be used. This technique won't be used during this research so a higher level isn't necessary.

2.2.3 Conceptual Model: the analyse tool

The data collection method is based on the CEN Metadata Model (Figure 2.5). The way of storing this data in Excel will be discussed in this part of the paragraph. The conceptual model of the work processes and the conceptual model of the data set have to match to perform analysis. The contents of the sheet are split in to different parts.

The first part does classify the subject, cluster of processes, theme description and objective. Besides these entities also the use of performance contracts is stated. The data stored in this part is concerning the column "Business" in the IAF. Table 2.2a shows the different columns.

Subject	Cluster	Theme	Description Process	Objective	Trigger	Performance contact
						yes / no

Table 2.2a: Entity scheme application tool

Explanation entities scheme application tool

Subject: A short description of the object, which has to be maintained.
Cluster: The classification of the process according to the 'conceptual model' of processes at the Dienstkring
Theme: The classification of the process in one of the five themes.
Id. nr.: Unique number to identify the process.
Description Process: A global description of the process.
Objective: The objective, what purpose should be achieved?
Trigger: How does the process start? After a certain period or inspection?
Performance Contract: Is the maintenance arranged by traditional or performance contacts

The second part does store data about the need of information (Information – What) and the necessary functionality of the application (Application – What). Data about the spatial objects, attributes, quality parameters and operations have been stored in this part of the tool. The conceptual model will be stored according table 2.2b:

Subject	Thematic Data		Spatial Objects			Geo. Ref. System				Operations
	Entities	up-to-dateness (months)	Objects (geometric)	Accuracy (meter)	Up-to-dateness (months)	Reference objects	Accuracy (meter)	Up-to-dateness (months)	Dimensions	1. view 2. store attribute 3. store geometry 4. analyse attributes 5. analyse geometry 6. spatial calculation

Table 2.2b: Entity scheme application tool

Explanation entities scheme application tool

Subject: A short description of the object, which has to be maintained.
Thematic Data: Thematic data about object, necessary to support process
Spatial Objects: The necessary object, necessary to support process
Geo. Ref. System Currently used geometric Reference System.
Operations: Required operations on data

2.3 Quality parameters of work processes and data sets

The choice of quality parameters is dependent on the chosen perspective(s). The first perspective is from the user's point of view to determine the fitness for use of the data to support the execution of work processes. The methods, which will be used, must describe the quality parameters of the need of information, which correspond with the fitness for use of the user.

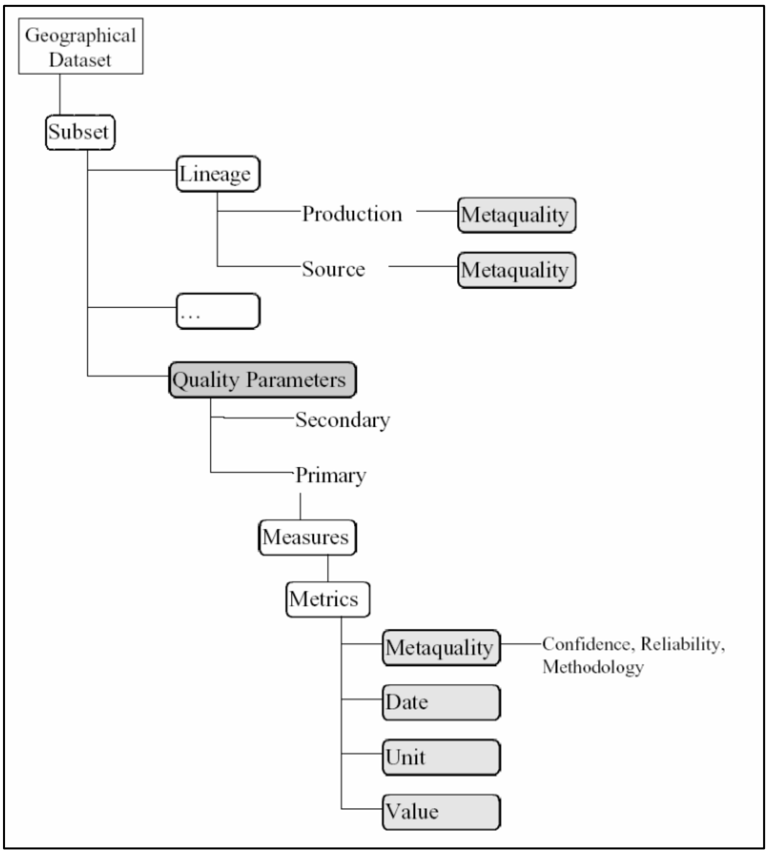


Figure 2.5: CEN Metadata Model (CEN, 1998)

The second perspective is determining the quality of the (potential) data sets. From this point of view a relation can be established between the need of information and the data sets.

Timpf developed a general model to store metadata to a data set. To focus the quality parameters to work processes and data sets, a more detailed approach should be made to the primary quality parameters because these metadata parameters can determine the fitness for use.

The CEN (1998) has released a European prestandard (ENV 12656), that defines the following primary quality parameters;

- *Positional accuracy*, a quality parameter describing accuracy of geographic position within a geographic data set;
- *Semantic accuracy*, a quality parameter describing accuracy of semantic aspects within a geographic data set;
- *Temporal accuracy*, a quality parameter describing accuracy of temporal aspects within a geographic data set;
- *Completeness*, a quality parameter describing the presence and absence of entity instances, relationship instances and attribute instances;
- *Logical consistency*, the degree of conformance of a geographic data set with respect to the internal structure given in its specification;
- *Homogeneity*, textual and qualitative description of expected or tested uniformity of quality parameters in a geographic data set.

These six parameters can be considered as sufficient to describe the quality occurring in most of the existing GIS. According to Veregin (1998) geographical data quality can be defined by the dimensions space-theme-time. The first three parameters cover these dimensions of geographic data. The last three parameters indicate if the data set is complete in terms of the queries someone wants to answer with the help of this data set and on the other hand if the representation of the data is consistent within itself.

These quality parameters can be used for describing the quality of data within a data set. Besides the perspective of the data set, the perspective from the process should also be considered; a relation has to be created. Some quality parameters which can describe the data sets will be chosen to define need of information

Positional accuracy
Positional accuracy of the data, needed to perform a work process is necessary. A user can define the positional accuracy needed to perform a work process and the problems, which would appear when less accurate data will be used.

Some remarks concerning the determination of positional accuracy can be made. From the perspective of defining the positional accuracy of the data set, as well as defining the needed positional accuracy to support the work process, determining ? would be very difficult. The ? of the data set won’t be stated, because the producer of the data set isn’t able to define ? or don’t want to define ?, so his product can be criticized. The same problem appears when determining the ? from the user. The user can give an indication, but isn’t able to define an optimal ?, according to the definition of ?. To cope with this problem, certain intervals of estimated ? will be introduced. These intervals will be chosen to match the characteristics of some products.

Semantic accuracy
In this case determining the semantic accuracy of data is useless. First of all this aspect will focus on the content of data and its meaning. The model which should be used to investigate semantic accuracy is the data model and information model (par 3.3.2). This level of gathering data is too detailed to reach the purpose of this thesis. Secondly the work processes at the Dienstkringen will be performed with different perspectives: different need of information.

Temporal accuracy / up-to-dateness
Temporal accuracy can be considered as up-to-dateness or update frequency. This aspect is necessary to investigate, because different processes will have different up-to-dateness of the needed data. Data is useless to support processes, when up-to-dateness of the data is necessary.

Completeness
The information and object model used during this research, do investigate the objects, which are necessary to gather. All mentioned objects will be stored, so the completeness will be secured by the mentioned “need of information” of objects by the users at the Dienstkringen

Logical consistency
Logical consistency won’t be investigated, because consistency isn’t necessary to answer the research question. The level of detail can’t be reached by the information and object model.

Homogeneity
The Homogeneity of parameters of the data set will be taken into account. While gathering the need of data according to the object model, several different types of data will be gathered. These different objects will have their own quality parameters. During the analysis clusters of data, with the same quality parameters could be created.

2.4 Conditions for a optimal supply of information

After modeling the work processes, the need of information and the data sets, the conditions of a healthy supply of information should be defined. Regarding these models, some scenarios will be discussed. Afterwards conditions for a healthy supply of information will be stated.

Following scenarios will be discussed:
1. Self supporting Information Management
2. Implicite Information Management
3. Explicit Information Management

<u>Self supporting Information Management</u>
The scenario, regarding self supporting Information Management, hasn't any policy and coordination about multiple use and updating of data. The data sets, which support the work processes, are stored at the departments, which need the data to support their work processes. This scenario can be stated as the poorest in Information Management.

<u>Implicit Information Management</u>
Implicit Information Management scenario is a scenario where different departments do store and maintain their own operational data. Although, geometric reference data is created and maintained by one department and is used by every departments, which need the data. The operational data at the departments can be stored at the department and be related to the geometric data. This scenario is visualized in figure 2.6: Implicit Information Management

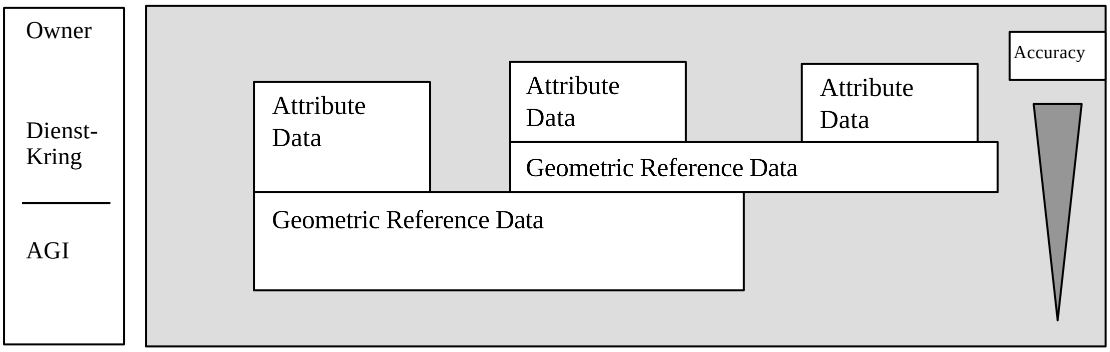


Figure 2.6: Implicite Information Management

<u>Explicit Information Management</u>
Explicit Information Management scenario has the same characteristics as the implicit information Management scenario, but has also other characteristics added. Besides the data sets described, there is also an additional application, which can perform operations at the data. This data sets and operations are determined by a work process. Figure 2.6 shows "Work Process 1". An inventory will be made about the data needed and operations to the data to accomplish the work process. An explicit Information Management scenario will be reached when each work process will be supported by the needed data sets in an application (with the needed operations).

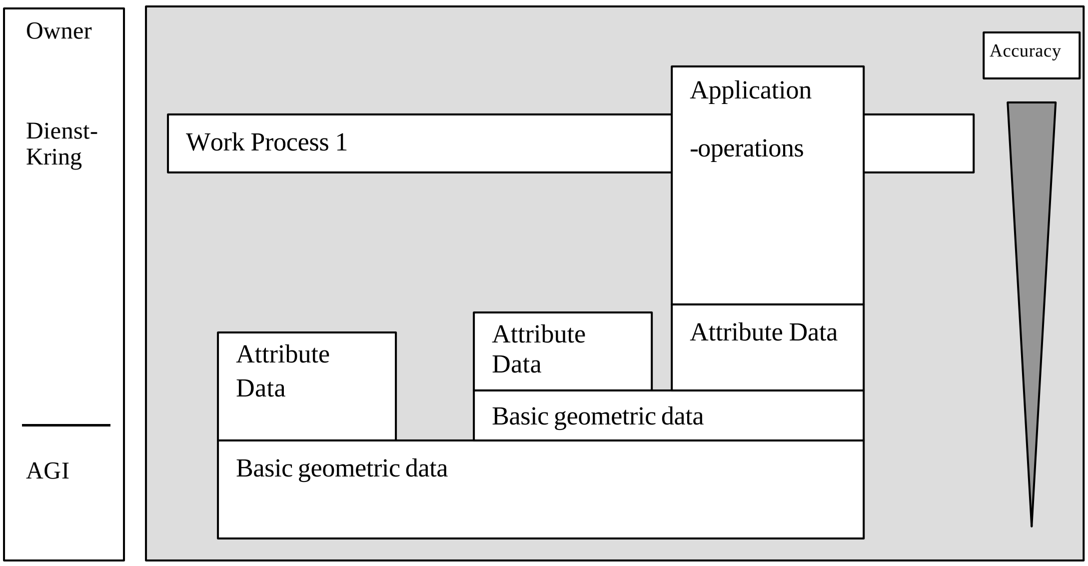


Figure 2.7: Explicit Information Management

The work processes at the Dienstkringen will be structured per theme (Pavement, Traffic Requirements, etcetera). One possible scenario of explicit information can be created by theme. The characteristics of the system will be analyzed. After analyzing per theme, an explicit Information Management scenario will be analyzed by all work processes at the Dienstkring. Each of these "Universe of Discourse" will be presented.

3 Processes at the Dienstkring

Paragraph 3.1 till paragraph 3.3 will describe the development of the conceptual models of working processes. Paragraph 3.1 describes the different primary processes. Paragraph 3.2 recognizes different stages during the primary processes. These stages are recognized because of difference in need of information. Also a differentiation by theme will be explained. Finally paragraphs 3.3.will describe the conceptual model of processes. Which stages of work processes have to be performed is based on the way outsourcing has been realized. Paragraph 3.4 will discuss the influence and difference, while using traditional contracts and performance contracts. Finally paragraph 3.5 will present all work processes regarding maintenance of the Highway Network structured by theme.

3.1 Primary processes at the Dienstkring

The work processes investigated in this thesis are performed at the Dienstkring. The Regionale Directies do also have their work processes but these work processes won't be included. The primary processes at the Dienstkringen are further differentiated to (Directie Oost-Nederland, 2003):

1. Strategic Functional Technical Maintenance
2. Daily Maintenance
3. Juridical Maintenance

3.1.1 Strategic Functional Technical Maintenance

The purpose of Strategic Functional Technical Maintenance is to ensure a durable availability of the objects. Functionality and safety regarding the objects have to be sustained for a durable performance. To accomplish this objective, inspections have to be performed and activities have to be planned and executed. Malfunctions of these objects, which impede the users, have to be avoided. The procedures can be modeled by the use of a traditional contract (Figure 3.1a) and by the use of a performance contract (Figure 3.1b).

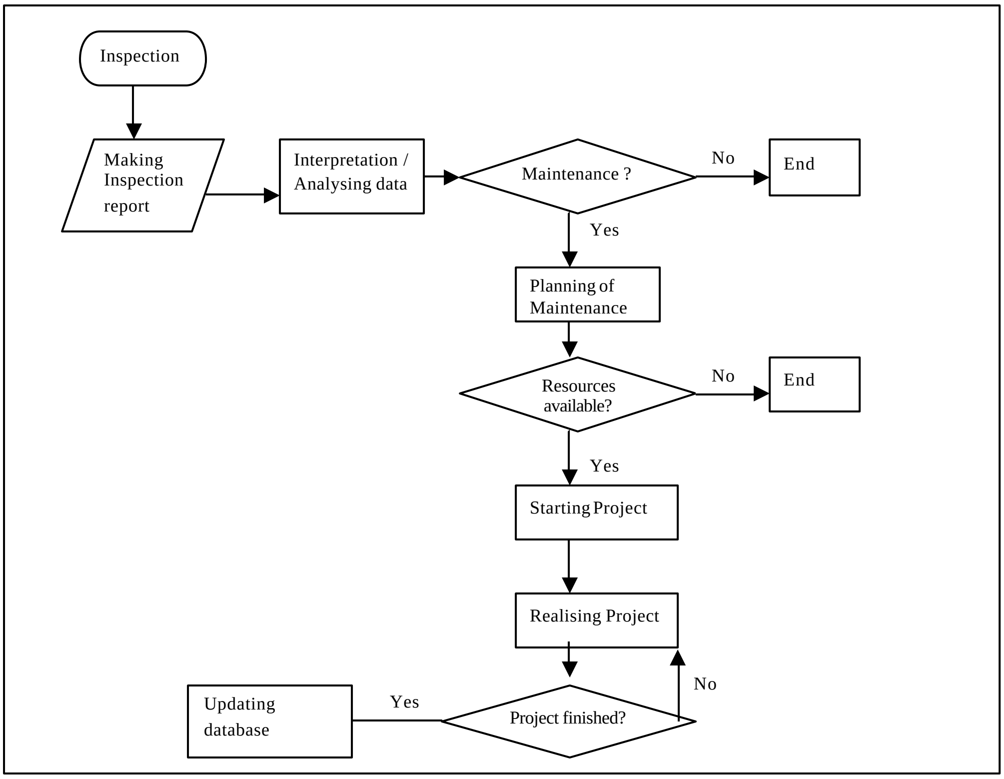


Figure 3.1a: Procedure Strategic Functional Maintenance (use of traditional contract)

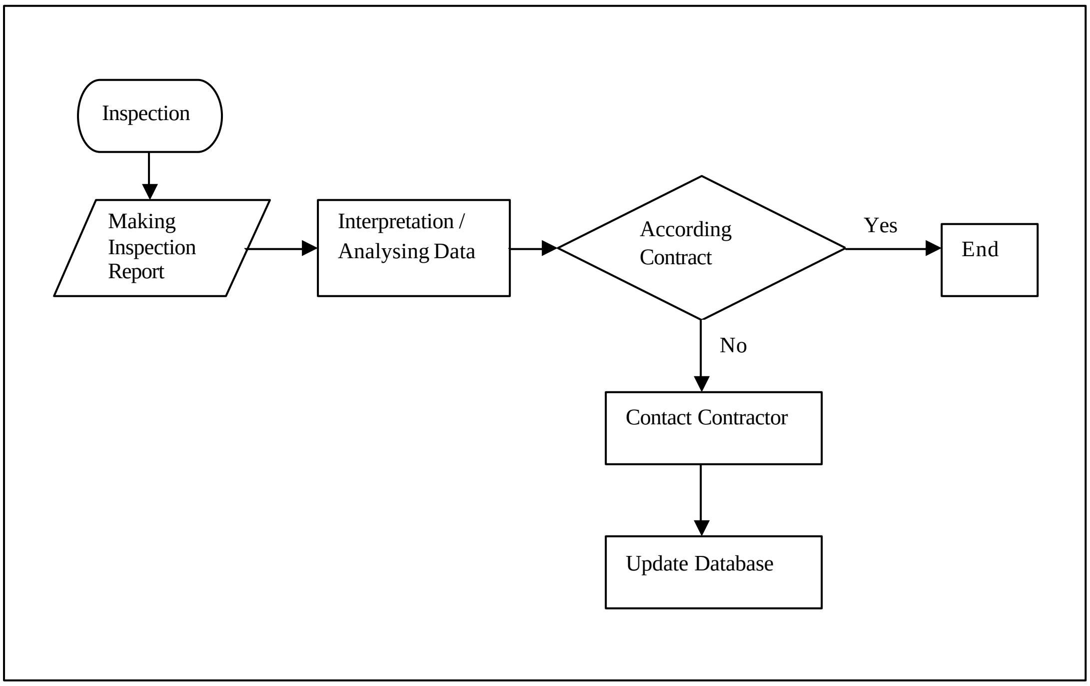


Figure 3.1b: Procedure Strategic Functional Maintenance (use of performance contract)

3.1.2 Daily Maintenance

The objective of Daily Maintenance is the daily care for the availability and safety of the road and flow of traffic. Taking care of the road during incidents, making sure vehicles can travel safely at the Highway, removing damaged vehicles and make sure the highways won't become icy. The performance contract is the only used contract. According to the contracts, contractor has to reach a certain performance

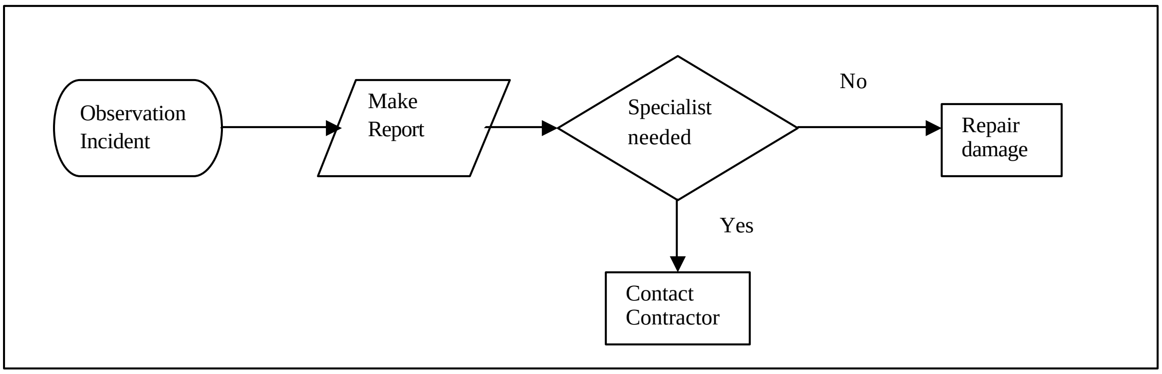


Figure 3.2: Daily Maintenance

3.1.3 Juridical Maintenance

Juridical maintenance contains the work processes concerning permits. When a cable has to cross the Highway, a GSM-receiver/transmitter has to be placed or other objects near the Highway, a permit is compulsory. Figure 3.3 describes the process of Juridical Maintenance.

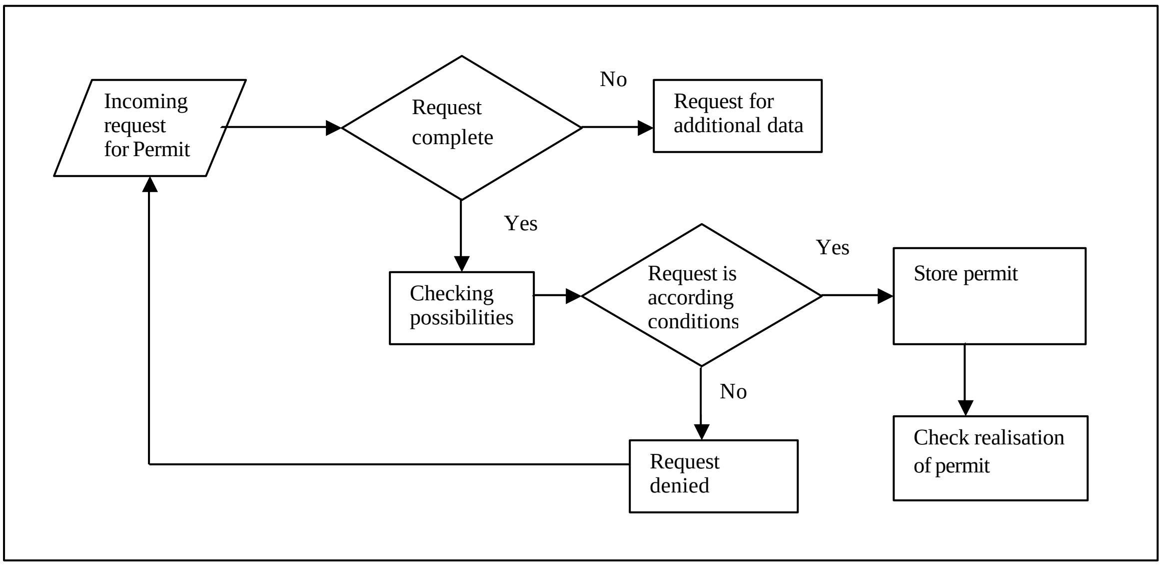


Figure 3.3: Juridical maintenance

3.2 Different input and output of geo-information

Besides the difference in primary processes, two aspects which concern work processes have to be taken into account, before investigation of need of information. The two aspects are:

- Stages of the work processes (discussed in paragraph 3.2.1)
- Different themes (discussed in paragraph 3.2.2)

3.2.1 Stages of the work processes

The three primary processes, mentioned in previous paragraph, can be used to classify the work processes. Although different and more detailed stages have to be defined for creating a structure of processes needed to relate and store the need of information per process. These stages will be sorted by different input and output of geo-information. A model of the stages of processes recognized at the “natte” Dienstkringen will be used as starting point (van der Graaf, 2003). These stages will be adapted to the processes performed at the “droge” Dienstkring. The recognized stages are:

<u>Planning of Maintenance</u>
Planning will be defined as the actual planning process of maintenance. Geo-information like location and surface are necessary to explain why maintenance should be performed. For example data about the status of functionality and safety of an object will be necessary to get money to perform maintenance.

<u>Technical Maintenance</u>
The cluster of processes regarding “Technical Maintenance” includes the work processes which take care of a durable and qualitative technical good condition of the areal-objects at the Office. The purpose of this data is supporting the actual maintenance outside by analyzing data. After “grounding” and “programming”, analyzing is a work process which will be performed at “Technical maintenance”. When the realization of maintenance is

performed, the preparation and evaluation of the work process is part of the technical maintenance (for example calculating the areas of objects).

Supervision, inspection and observation

The process of “Supervision, inspection and observation” are three activities to support the “Technical Maintenance”. The activities are:

a. Supervision of activities
b. Inspecting of objects
c. Observation of monitoring programs

These activities are performed in co-operation with the Rayon. Inspectors check outside the different areal objects and classify the condition. When maintenance of an object is necessary, the inspectors will give their reports to “Technical Maintenance”. The inspectors are the “eyes” of the Dienstkring.

Granting permits

Executing activities and placing objects require a permit. The work processes at the office of documenting these permits are the work processes “Granting permits”. Most important is legislation about “Wet Beheer Rijkswaterstaatswerken (WBR)” and the “Wet Verontreiniging Oppervlaktewateren (WVO)”, which contain most important procedures. The first fase is checking is the completeness of the forms. The second fase is an observation of the inspectors if the proposal is suited to the situation and if a better proposal is possible. When the employee at the Dienstkring and the applicant of the permit have an agreement, the permit will be granted and registered.

Checking permits

To make sure the permits will be preserved, inspections have to be performed. Two types of processes can be distinguished. First the inspectors will check the permits when the objects are placed or activities will be performed. The second process is observing if there are any irregularities. This process is a part of the global inspection.

Incident Management

Incident management consists of the work processes, which are executed when an accident happens on the Highway. These work processes are performed by the Rayon-employees / Inspectors. Incident management needs for example information of the area of control by the Dienstkring and what responsibilities are included.

Besides these stages of work process, performed by the Dienstkring, one other stage, performed by the contractor, has influence at the processes at the Dienstkring: Realization.

Realization

The processes “realization” are the work processes outside regarding performing maintenance. Nowadays changes appear regarding this category of processes. All activities concerning realization are performed by a contractor. The kind of contract the Dienstkring uses to make sure the contractor will perform maintenance is changing. The traditional contracts describe how the contractor should perform maintenance, while the performance contract describes the result the contractor should accomplish. The new type of using contracts is called “innovative contracting”. The contractor gets an offer to take care of the hardening of the highway. The contractor himself has to investigate what he has to do and makes an offer. Information which is needed includes inventories to check if the offer is realistic. How the contractor takes care of the maintenance isn’t important, only the purpose will be tested.

The above list of processes at the Dienstkring is changing. Policy of Directorate-General of Public Works and Water Management is changing the “targets of execution”. For example “outsourcing” with the contractor changes the need of information. “Array of entities” is a key word in this need of information. Innovative contracting reduces the need of information at the Dienstkring. The contractor has to make an offer to perform maintenance. From the objective “maintenance of nature” at the highways only a global indication of area, which should be maintained is necessary. Together with the “Beheerplannen” and “landschapsplannen” a contract can be made. The reality shows an additional indirect “need of information”. Dienstkringen do make these contracts, but at they also want to know their array of entities. They want to register the current situation to have enough control. What type of storing and maintaining data is necessary? An aggregation level has to be set. Because of the subjectivity of information, this could lead to different need of information per person. Objectification of information will be performed by determining objectives.

3.2.2 Different themes

The categories used by the beheerplannen “maintenance” are another (financial) differentiation made by Rijkswaterstaat. The “Beheerplan Droog” describes the activities of maintenance and is the base for financial support from the “Head Office”. The following differentiation regarding to the Beheerplannen can be made (Wegwijzer Wegbeheer, 2003):

- Pavement: The Pavement consists of all work processes which are necessary to maintain the road itself. Maintenance of the concrete (e.g. ZOAB) and road marks are part of this cluster of processes. Maintenance of this category is called “grey” maintenance.
- Traffic Requirements: This cluster of processes is related to the safety of the road (e.g. with signs) and placement of objects near the road.
- Exploitation: This cluster of work processes is related to cables underground and permits. These processes can be considered to the primary process: juridical maintenance. According to the law (WBR), when putting a cable in the ground, a permit is required. Commonly this cluster has more tasks, but because this thesis is framed to the process of “Maintenance of the Highways” some of the other processes are neglected.
- Civil infrastructures: This cluster of processes contains all processes regarding infrastructural objects like bridges, tunnels, portals and viaducts. Because of the complexity of these objects, these infrastructural objects require specialistic maintenance and inspection by specialists.
- Environment and Nature: This cluster of work processes is related to the activities to maintain the landscape and nature besides the road. Taking care of this area is also called “green” maintenance.

Each cluster is related to the maintenance of objects which have different characteristics. Therefore the reference data has also different requirements. These five categories contain all objects the Dienstkring has to maintain.

3.3 Conceptual model of the processes

The perspective of the work processes used in the two previous paragraphs of this Chapter contains the following characteristics:

1. Primary processes, which types of processes have to be performed (par 3.1);
2. Stage of work process with different in- and output of geo-information (par 3.2.1);
3. Themes of subjects which can be recognized (par 3.2.2).

When combining this information a model can be created to show the entities and relationships between those entities. Processes can be defined in only one cluster of processes. The objective, which should be reached, can be accomplished by a procedure performed by more then one process. Estimated is the difference in needed quality parameters of the data. After the inventory, conclusions may be drawn about the quality parameters from the different processes. *Figure 3.4: Conceptual model: Primary processes at the Dienstkring* shows the model, which shall be used during this thesis. The procedures regarding responsibility and data flow are investigated by van der Spek (2003) and used to develop figure 3.4. The five themes can be are part of every stage of work process.

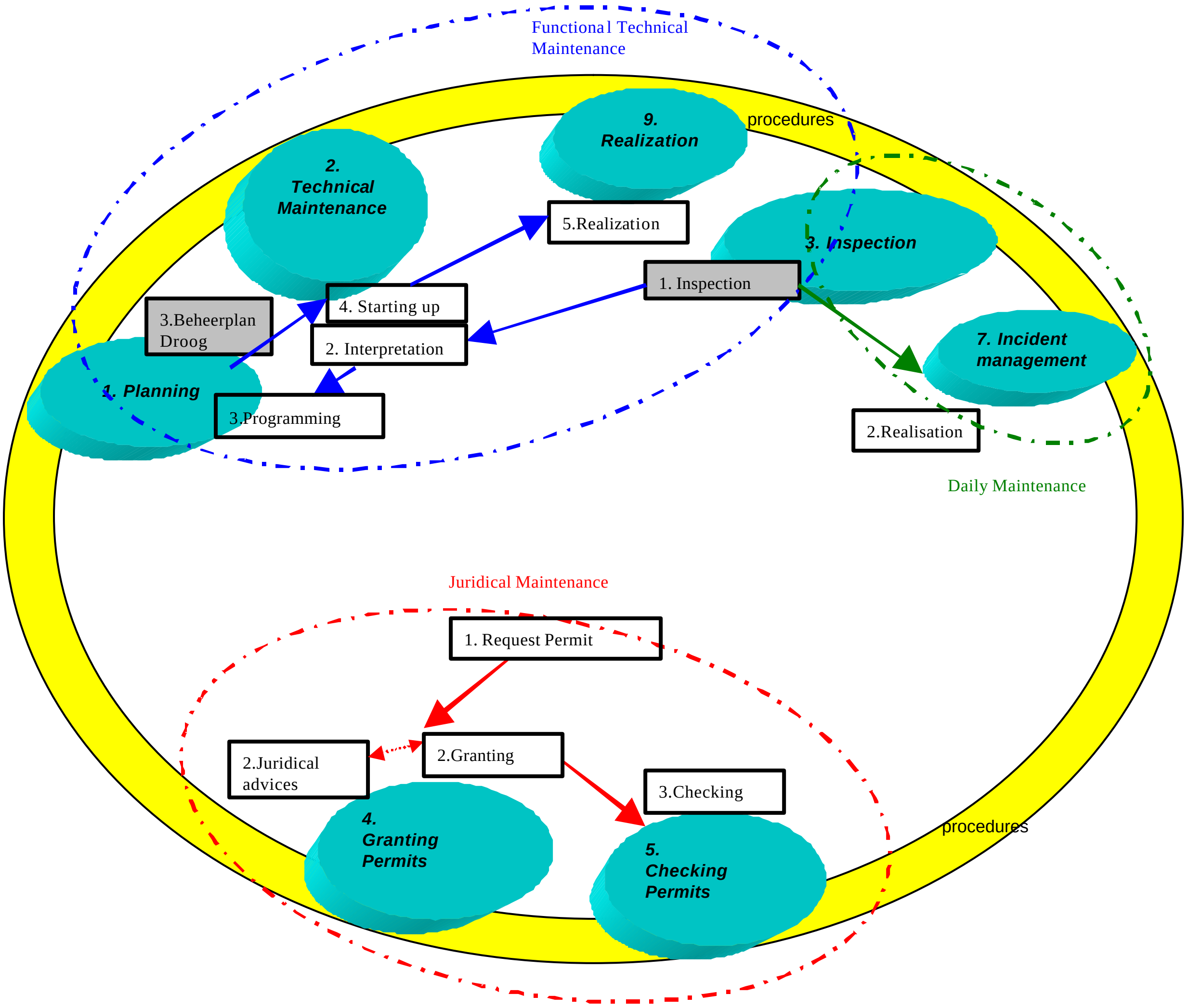
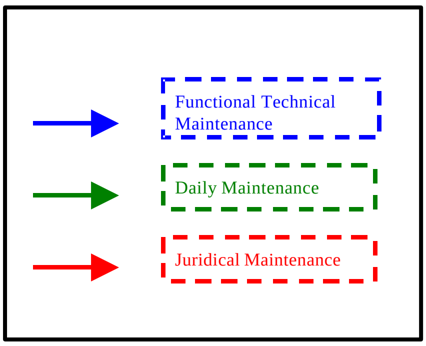


Figure 3.4: Conceptual model: Primary processes at the Dienstkring



Themes

- Pavement
- Infrastructures
- Traffic Requirements
- Environment and Nature
- Exploitation

3.4 Traditional Contracting vs. Performance contracting

The Head Office has introduced a new instrument to perform maintenance: Outsourcing by performance contracts. A performance contract states the objectives, which has to be achieved by the contractor. Before performance contracts, the traditional contracts stated what activities has to take place and how and when maintenance has to be performed. These restrictions won't be included in the performance contracts.

The introduction of the performance contracts causes a significant change in information demand. This change will be explained by analyzing the stages of processes. The situation in figure 5.1: stages of work processes, shows the data flow between the different processes. The supervision of all processes is performed by the Dienstkring and the information supply should support the stages:

- Inspection
- Technical Maintenance
- Planning
- Preparation of Realization

Performance contracts can delegate the execution / responsibility of some stages of the work processes. Outsourcing can be modeled by ignoring the need of information of the stages of processes in the outsourced clusters. The question appears which stages of processes have to be outsourced. According to the policy of the Head Office, outsourcing has to be realized at the clusters "Realization" and "Planning". The result is a change in need of information per stage and difference in dataflow between the different stages. Technical Maintenance has to store areal data to support the "Inspection" and the data flows should be related. The only planning processes, which have to be supported by technical maintenance, are the development of the Landschapsplannen and Groenbeheerplannen. To determine the need of information of Functional Technical Maintenance by the instrument "Performance Contracting" the need of information of "Planning" and "Realization" will be neglected. Figure 3.5 shows the stages of work processes and its coherence of data flow.

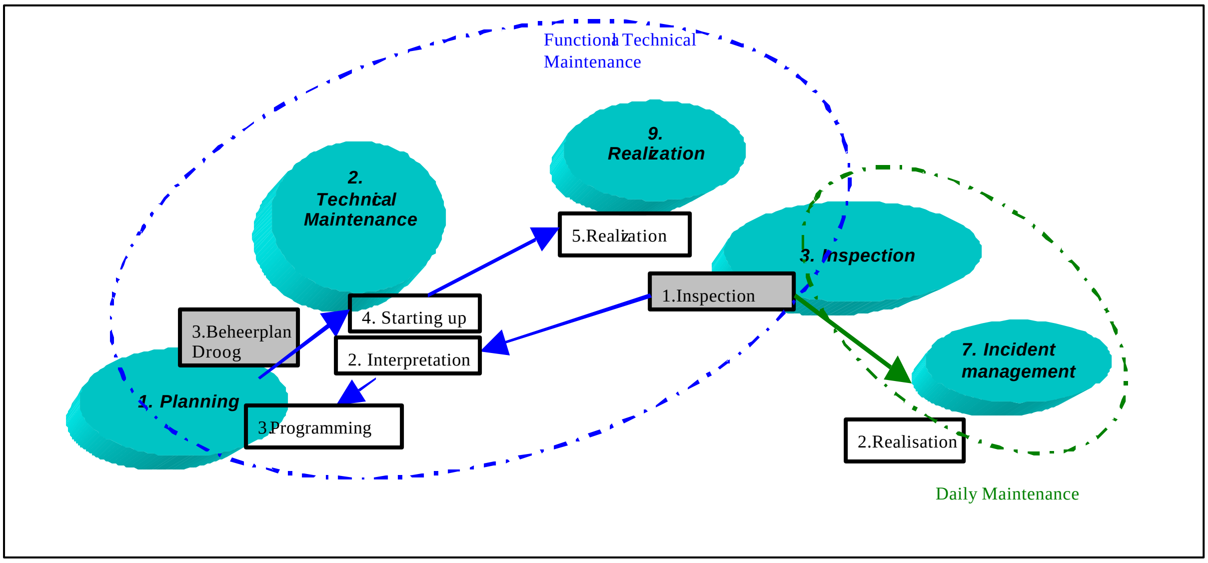


Figure 3.5: Stages of work processes

3.5 Work processes per theme

This paragraph will explain the structure of the different work processes by theme.
First will be described, which primary processes are involved per theme. Secondly the relation with the different clusters of processes will be described. Finally the contracts which have been and will be used will be described. After stating these relations the work processes itself will be mentioned including the goal of the work processes.

3.5.1 Exploitation

The work processes regarding the theme “Exploitation” are part of the primary process “Juridical Maintenance”. Two different clusters of processes can be recognized by primary process “Juridical Maintenance”. The first cluster of processes is “Granting Permits”, which includes the processes at the Office (inside) regarding “Granting Permits”. The second cluster of processes is “Checking Permits”, which includes the processes outside to check if the permit applicant sticks to the permit. The inspectors will perform processes regarding “Checking Permits”. Only one of the processes, Global Inspection (E10) can be classified as “Daily Maintenance”. One of the goals of Global Inspection is checking permits to make sure activities are performed with a permit.

The criteria of selecting work processes regarding “Exploitation” is performed by the work processes with granting and checking permits of objects in the neighborhood of the Highway. The permits granted to an applicant can be divided into two categories:

- Objects at government property
    - Cables and pipelines
    - Visible objects
- Activities performed at government property

Normally processes like monitoring the energy supply of the traffic requirements and buildings, are included with other secondary (supporting) processes at the theme “Exploitation” (Wegwijzer wegbeheer, 2003). These aren’t taken into account during this research. The processes regarding this theme are focused on granting permits.

These work processes support Juridical Maintenance. Juridical Maintenance will always be performed by the Dienstkring itself and no contractors are involved. Therefore the need of information isn’t influenced by the introduction of performance contracts.

ID nr.	Subject	Goal
E1	Cables and pipelines	Registration of permits "Cables en Pipelines"
E2	Electricity supply	Maintaining energy supply to support the electrical systems
E3	Tubes (drilling)	Registration drilling tubes
E4	Environmental Permit	Registration and checking environmental activities near the Highway
E5	Ground use Permit (pachtvergunning)	Exploitation of real estate (land) near the Highway
E6	Hunting Permit	Maintaining animal population, without reducing safety at the Highway
E7	Permit of activities	Registration of activities near the Highways
E8	Permit to place objects	Registration of activities and objects near the Highways
E10	Global Inspection	Global Inspection to ensure safety en functionality of the Highway
E11	Permit of selling fuel	Registration and control of fuel station near the Highway
E12	Permit of exploiting a restaurant	Registration and control of restaurants near the Highway

Table 3.1: Work processes “Exploitation”

3.5.2 Civil Infrastructures

The work processes regarding the theme “Civil Infrastructures” have a strong relation with the primary process “Functional Technical Maintenance”. Three clusters of processes can be recognized.
During “Inspection”, inspectors will check if maintenance at the Civil Infrastructures is necessary. When necessary, specialists from the Bouwdienst will inspect the Civil Infrastructures and will determine what kind of maintenance is necessary. The inspections will be used to be interpreted at the second cluster of processes: Technical Maintenance.
Technical Maintenance includes analyses, which are performed to decide how to improve the Civil Infrastructure. This information will be used to support the third cluster of processes: Planning.
Planning is necessary to structure the longterm activities and get financial means. Without the planning, the Dienstkring won’t get any financial means to perform maintenance. When the Planning has been approved and financial means have been gathered, a contract will be made at Technical Maintenance.
Maintenance at Civil Infrastructures is performed by the Bouwdienst and a traditional contract will be made to support the “Realization” of the maintenance.

The processes in Table 3.2: Work processes “Civil Infrastructures” will be recognized.

ID nr.	Subject	Goal
K1	Civil Infrastructures	Maintenance to ensure the functionality and safety of Civil Infrastructures
K1a	Cellar and water systems	Maintenance to ensure the functionality and durability of Cellar and water systems
K2	Fauna supplies	Maintenance of fauna suppliers to ensure a safe passage between habitats
K3	Sound reducing barriers	Maintenance to ensure the functionality and safety of Sound reducing barriers
K4	Portals	Maintenance to ensure the functionality and safety of Portals

Table 3.2: Work processes “Civil Infrastructures”

3.5.3 Environment and Nature

The work processes regarding the theme “Environment and Nature” have a strong relation with the primary process “Functional Technical Maintenance”. Three clusters of processes can be recognized. The first process concerns “Inspection”. During “Inspection”, inspectors will check the Environment and Nature near the Highway at check if maintenance is necessary. This is only performed during some work processes. Most maintenance of Nature en Environment is performed after certain periods of time. Also the inspection of the result of contractors will be performed. This data will be processed and interpreted at the second cluster of processes: Technical Maintenance. If the vision of maintenance of “Environment and Nature” changes, new plannings should be made to get financial means. Without the planning, the Dienstkring won’t get any financial means to perform maintenance. When the Planning has been approved and financial means will be available, a contract will be made at Technical Maintenance. The “Realization” of the maintenance will be performed by the contractor.

Two types of contracts are used. The normal contracts, which include activities, should be performed by the contractor. The second type of contract is the performance contract. This contract includes the performance which should be accomplished. The policy of the Directorate is to use this type of contracts in the future to outsource some of the activities of Dienstkring.

The different processes and goals regarding “Environment and Nature” are presented in table 3.3: Work processes “Environment and Nature”.

ID nr.	Subject	Goals
L1	Developing Groenbeheerplan / Landschapsplan	Developing the vision of the Environment and Nature close to the Highway.
L2	Mitigating requirements	Maintenance to support Nature according the Environmental Law
L3	Public areas (parking/carpool areas)	Maintenance of verzorgingsplaatsen to facilitate the road user
L4	Waterways	Maintenance of waterways to ensure safety of the Highway
L5	Trees	Maintenance of trees to ensure safety of the Highway
L6	Road sides: mowing (also taluds)	Maintenance of Environment to ensure safety of the Highway
L7	Road sides: Suppression of weeds	Maintenance of Environment to ensure safety of the Highway
L8	Road sides: Removal of environmental waste	Maintenance of Environment to ensure safety of the Highway
L9	Evacuation of garbage	Removal of objects near or on the Highway to ensure safety
L10	Checking of ground poisoning	Maintaining healthy environmental conditions according the Environmental Law
L11	Sound Barriers	Maintaining Geluidswallen to ensure sound reduction according the Environmental Law and guarantee the safety of road users

Table 3.3: Work processes "Environment and Nature"

3.5.4 Pavement

The work processes regarding the theme "Pavement" are part of the primary processes "Daily Maintenance" and "Functional Technical Maintenance".

"Daily Maintenance" is concerned about Incident Management and quick repairs (within a day) of the pavement. When the pavement is burned the pavement should be replaced. Incident Management is arranged by performance contracts.

"Functional Technical Maintenance" of pavement is performed by traditional contracts as well as performance contract. In the future the performance contracts should be used as contract. Four stages of work processes can be recognized.

Inspection is the first stage: The Road and Hydraulic Engineering Institute (DWW) annually inspects the Highways according several criteria and makes a planning for the maintenance of pavement. Besides the inspections of the DWW the inspectors also perform "Inspections" and check if maintenance at the pavement is necessary. The proposal of the DWW and inspections will be used decide the need of maintenance.

Technical Maintenance is the second stage. The inspection reports and the planning of the DWW will be interpreted.

Planning is the third stage: The planning will be presented and has to be approved to get financial means. These new proposal of maintenance of the Highway may only differ with one year of the proposed planning from the DWW. When the Planning has been approved and financial means will be established, a contract will be made at Technical Maintenance.

Starting the project will be performed at Technical Maintenance, the forth stage: A contract will be made to be used during the Realization of maintenance. The processes regarding "Realization" aren't taken into account, because maintenance is never performed at the Dienstkring but by a contractor.

The list of processes in Table 3.4: Work processes "Pavement" will be recognized regarding "Functional Technical Maintenance".

ID nr.	Subject	Goal
V1	Grijs Onderhoud	Maintenance to ensure a quick and safe use of the Highways
V1a	Variable Onderhoud Highway (Asfalteren / Freezen)	Maintenance to ensure a durable and safe use of the Highways
V2	Vast Onderhoud – Other pavement	Maintenance to ensure a durable and safe use of roads in control by the Dienstkring
V3	Cleaning of pavement	Maintenance on the Pavement to ensure a durable use of the highway and removal of dirt of the Highways
V4	Road sides: Endeepening road sides of Highways	Maintenance on the site of the Highway to ensure a safe water removal on the Highway
V5	Water Systems (removal of water)	Maintenance on the Water system to guarantee a durable removal of water on the Highway

Table 3.4: Work processes "Pavement"

3.5.5 Traffic Requirements

The work processes regarding the theme "Traffic Requirements" are part of the primary processes "Functional Technical Maintenance". Just like the other themes, the different stages, which have to be performed, are Inspection, Technical Maintenance and Planning. These processes are performed in cooperation with the Transport Research Centre.

Maintenance of Traffic Requirements is performed by two types of contracts are used. The traditional contracts, which include activities, should be performed by the contractor. The second type of contract is the performance contract. This contract includes the performance which should be accomplished. The policy of the Directorate is to use this type of contracts in the future to outsource some of the activities of Dienstkring.

The different processes regarding "Traffic Requirements" are presented in table 3.5: Work processes "Traffic Requirements". The goals are the maintenance of the object, which is mentioned at the column "Subject".

ID nr.	Subject
Vk1	Public illumination
Vk2	Road marks
Vk3	Road site securing (geleiderail)
Vk4	Road signs RWS
Vk4b	Road signs ANWB
Vk5	Traffic and Indication signs
Vk6	Highway detection systems
Vk7	Traffic- and detection systems
Vk8	Lamps of Traffic Systems
Vk9	Dynamic Route Information Panel (DRIP)
Vk10	Highway Accessibility System (TDI)
Vk11	Cameras
Vk12	Mist detection systems
Vk13	Road-side electrical systems
Vk14	Incident management
Vk15	Icing protection (Gladheidsbestrijding)

Table 3.5: Work processes "Traffic Requirements"

4 Geographic Information supply

This chapter makes a difference between current geographic data sets (paragraph 4.1) and current applications (paragraph 4.2). This is necessary, because data sets contain the data, which should be used. Applications contain the necessary operations, which can be performed at a data set. Paragraph 4.3 will describe the aspects regarding the Spatial Data Infrastructure (SDI). Paragraph 4.4 will investigate innovative data sets and methods. Innovative means not only existing data sets and methods are taken into account, but also data sets, which aren't currently used by the Directorate-General of Public Works and Water Management (Zegveld, 2003). Innovative applications won't be mentioned. The reason is the variety of existing applications by the market. The purpose of this thesis isn't giving a list of current applications, which aren't used.

4.1 Current geographic data sets

However nationwide large and middle scale geographic data sets are available like the Grootschalige BasisKaart Nederland (GBKN) and the TOP10 data sets (by the "Topografische Dienst Kadaster"), two specialist departments of the Directorate-General produce the dedicated data sets DTB Droog (by the "Geo-information and ICT Department") and NWB (by the "Transport Research Centre").

4.1.1 DTB Droog

The DTB Droog is a geographic database created by the AGI of the highways of the Netherlands at a working scale of 1:1.000 with approximately 300 types of topographical elements with the possibility of thematic storage. Because the DTB is used in a GIS, the data set is regarded without a scale, although the photo scale is 1:4.000.
The DTB Droog doesn't exist as a separate data set. The data is directly implemented in the application Kerngis. The domain boundaries are about 50 meters away from the Highway. The database has been constructed by photogrammetry, completed by terrestrial surveys. The DTB is updated every five years. To visualize the DTB Droog a partition of this data set will be shown in Figure 4.1: DTB Droog

The DTB Droog is the only database with all the areal objects of the highways included. Therefore this data set is the backbone of the information supply to support the processes regarding Maintenance. This data set is also the only large-scale topographic database at the Directorate-General of Public Works and Water Management to support maintenance of the Highway Network.

Figure 4.1: DTB Droog (K+V, 2002)

The data set “Digitaal Topografisch Bestand” (DTB) is implemented in the application Kerngis. Therefore the DTB consists of different coverages. The entities stored in those coverages can contain administrative data. Figure 4.2: Current data model DTB/Kerngis, is the representation of the entities. The numbers at the entities indicates a multiple storage of those entities (will be presented in paragraph 4.2.6). Supplement 9: DTB Droog contains more detailed information about the DTB Droog.

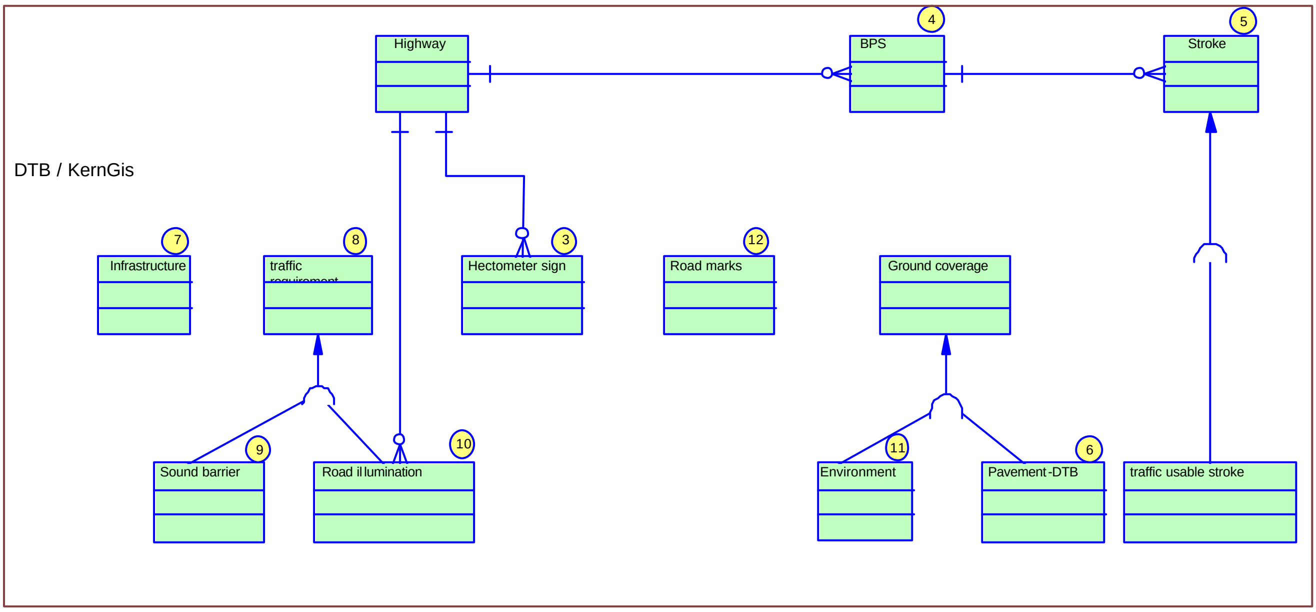


Figure 4.2: Current data model DTB/Kergis (van Hengstum, 2003)

4.1.2 Nationaal Wegen Bestand

The Nationaal Wegen Bestand - Wegen (NWB-W) is a digital geographical data set of all public accessible roads and supplied by the AVV. The NWB-W is part of the NWB, which contain data about all public accessible roads, waterways and railways in the Netherlands. This mid-scaled (1:10.000) geographical data set presents the roads as line segments. These line segments represent the mid axis of the roads. Each modality (roads, waterways and railway tracks) has a coherent network with geometry, topology and attribute information. An example of the NWB Wegen is presented in figure 4.3: Nationaal Wegen Bestand - Wegen. Because of the possibility to address attribute information to line segments, the NWB is suited to integrate information. During this thesis only the modality “roads” will be considered. The NWB is created by means of the TOP10 Wegen has an up-to-dateness of six months. Every three months the AVV releases a new version of the NWB – Wegen (Productcatalogus 2004).

Figure 4.3: Nationaal Wegen Bestand – Wegen (Productcatalogus 2004)

The NWB is updated by received mutations from the municipalities. Actuality can also be accomplished by using SPOT-images (Dierikx-Platschorre Y, 1999). Because of these characteristics, this data set is the standard network of mid-scaled (1:10.000) geographic data sets at the Ministry of Transport, Public Works and Water Management.

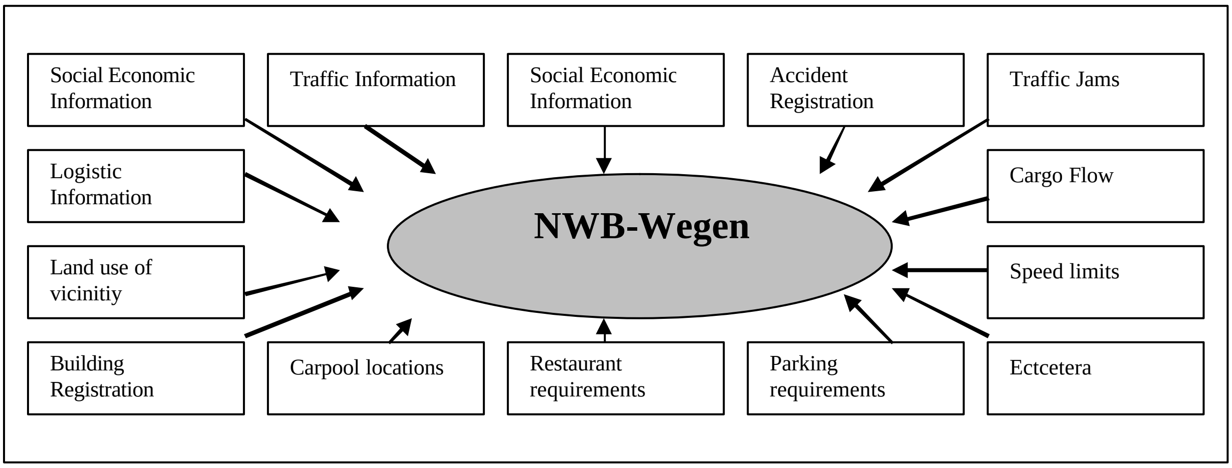


Figure 4.4: NWB and possible use of attribute data (Handleiding NWB, 2003)

Integration of different attribute data is one of the NWB's main advantages. An example of possible use of attribute data supported by the NWB is shown in Figure 4.4. Some registrations are already related to the NWB. The purpose of the NWB is relating different attribute data to roads. Precise allocation of the data shouldn't be an obligation. Up-to-dateness is one of the main advantages of the NWB.

4.1.3 Top10 data sets

The Top10 data set is a product of the Topografisch Dienst Nederland (TDN). Originally the TDN had to supply the military department of detailed maps and was under supervision of the Ministry of Defense. Nowadays the TDN is a department of the Cadastre, a "Zelfstandig Bestuurs Orgaan", which takes care of the registration of (juridical) right of real estate. The Top10 data sets are nationwide geographic database and have been created by photogrammetry and addition inspection and terrestrial measurements. The database is updated every four years. Because of the integration of the TDN with the Cadastre data sets, the products have a juridical use. According to the 'Kadasterwet' the up-to-dateness has to be improved to two years. The data set has been developed to be used at a working scale of 1:10.000. Three different aspects can be recognized:

<u>Top10 Vector:</u>

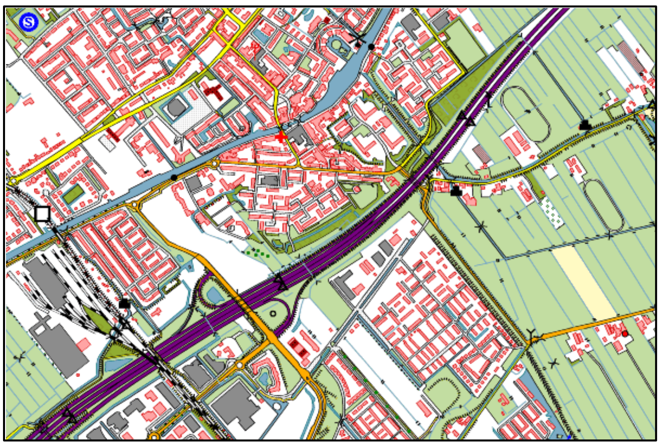


Figure 4.5: Top10 Vector (www.tdn.nl)

The vectors of the Top10 Vector represent the edges of the roads and true area features. Figure 4.5 shows a part of the Top10 Vector. Each type of object has its own assigned color.

Top10 Wegen:
The vectors of the Top10 Wegen represent the mid axis of the roads. The Top10 Wegen is the source of many other geographic databases like the NWB. The NWB looks equal to the NWB presented in Figure 4.3: Nationaal Wegen Bestand – Wegen.

Figure 4.6: Top10 Wegen (www.tdn.nl)

Top10 Raster:
Besides the vector data sets, the TDN also develops the Top10 Raster. The Top10 Raster can be considered as a gridded visualization. This data set can only be used as reference data set (e.g. Kerngis uses the Top10 Raster). Updating and addressing attribute data to geographic objects is impossible, because the Top10 Raster is just visualization and doesn't contain objects only pixels. Therefore the Top10 Raster won't be mentioned any more.

The TDK is developing the TOP10NL, which has to replace the existing Top10 products. The TOP10NL will be described in paragraph 4.3.2.

4.2 Current applications

The applications described in this paragraph are just a few of the total amount of applications. The main characteristic of these applications is the nationwide use of the applications.

4.2.1 Kerngis

Kerngis has been developed by the AGI to be used as a GIS-tool to support the operational processes concerning Maintenance of the Highways. The application Kerngis has been developed in ArcGis and is used as interface to present data, for example, the DTB Droog. Besides using data sets like the DTB Droog, Kerngis should be used to store and manage the contracts and permits at the Dienstkringen. The ideas of Kerngis started in 1990. The current commonly used version is Kerngis 8 although the latest version is Kerngis 9. During this thesis Kerngis 9 will be considered. The two most important reasons are:

1. Trying to relate the information supply in the present and future. Kerngis 8 at the Dienstkringen will be converted to Kerngis 9. In the beginning of 2005 Kerngis 9 should be operational at all Dienstkringen.
2. During the testing of the products, the latest version of Kerngis should be considered otherwise a more historic testing will be performed.

At the end of 2000, Kerngis has been assigned as the standard application to support the processes "Maintenance" of the area objects of the Highways. The main characteristic of an application are the operations, which can be performed. Kerngis 9 can perform the following operations:

a) mutate geographical data,
b) mutate attribute data,
c) visualization of graphical data,
d) address administrative data to geographical objects,
e) perform selections at attributes
f) perform geographic overlays and analysis according to BPS[1] reference system (e.g. data from Weggeg),

[1] BPS example see Supplement 20: BPS example

g) uploading web featured databases and performing queries at different data sets simultaneously by use of Open GIS standards.

Data which will be stored in the data structure of Kerngis are presented in table 4.1: Objects in Kerngis (Productcatalogus 2004). These objects are stored when they have an overlay with the domain boundary of the DTB Droog. The implementation of Kerngis with the objects will be finished in the beginning of 2005.

- Civil infrastructures
- Cadastral, province, municipal and section boundaries
- Properties of the government
- Traffic requirements
- Area of maintenance
- Environmental maintenance
- Arial Photos
- Permits
- Height data
- Contracts
- Cables and pipelines
- Road marks
- Hectometer signs
- Measure points AGI

Table 4.1: Data in Kerngis

4.2.2 Kerngis Viewer

The Kerngis Viewer can be considered as a web based application and easy usable version of Kerngis. The Kerngis Viewer can perform some simple queries by web browser at Kerngis data. The main advantages of using a web server are easy accessibility, performing queries at Kerngis data and lower licenses costs (because fewer licenses are necessary). The operations of the Kerngis Viewer have been simplified to make sure the data is more accessible. Figure 4.7 is an example of the Kerngis Viewer available at the intranet of the Directorate.

Figure 4.7: Kerngis Viewer

4.2.3 Weggeg

Weggeg is an application using a database with more then 100 different types of features of the 3.200 kilometers of highways in the Netherlands. The geographical data in Weggeg is derived from the NWB - Wegen, which is derived by the TOP10 Wegen and is updated every three months. The attribute data is implemented in Weggeg by the AVV and the user has no possibility to store or mutate data. This means Weggeg can only be used for making inquiries about highway features and has possibilities to present the data graphical. The reference system is the BPS location assignment. More information about Weggeg can be found in Supplement 5: Weggeg (Productcatalogus 2004).

4.2.4 Winfrabase

Winfrabase is an application maintained by the Dienst Weg- en Waterbouw. The application is web based and there accessible by an Internet browser. The NWB Wegen is used as geometric reference system and the attribute data can be presented graphically. After questioning the application, the data (shape files) can be downloaded. Winfrabase does inform the user about:

- Road pressure
- Environmental features
- Composition of the road
- Quality pavement top-layer
- Type of pavement

The information can be presented in two ways. In figure 4.8: Winfrabase the data is presented graphically. The web based application can also present this data in tables. More information about the quality parameters is presented in Supplement 6: Winfrabase.

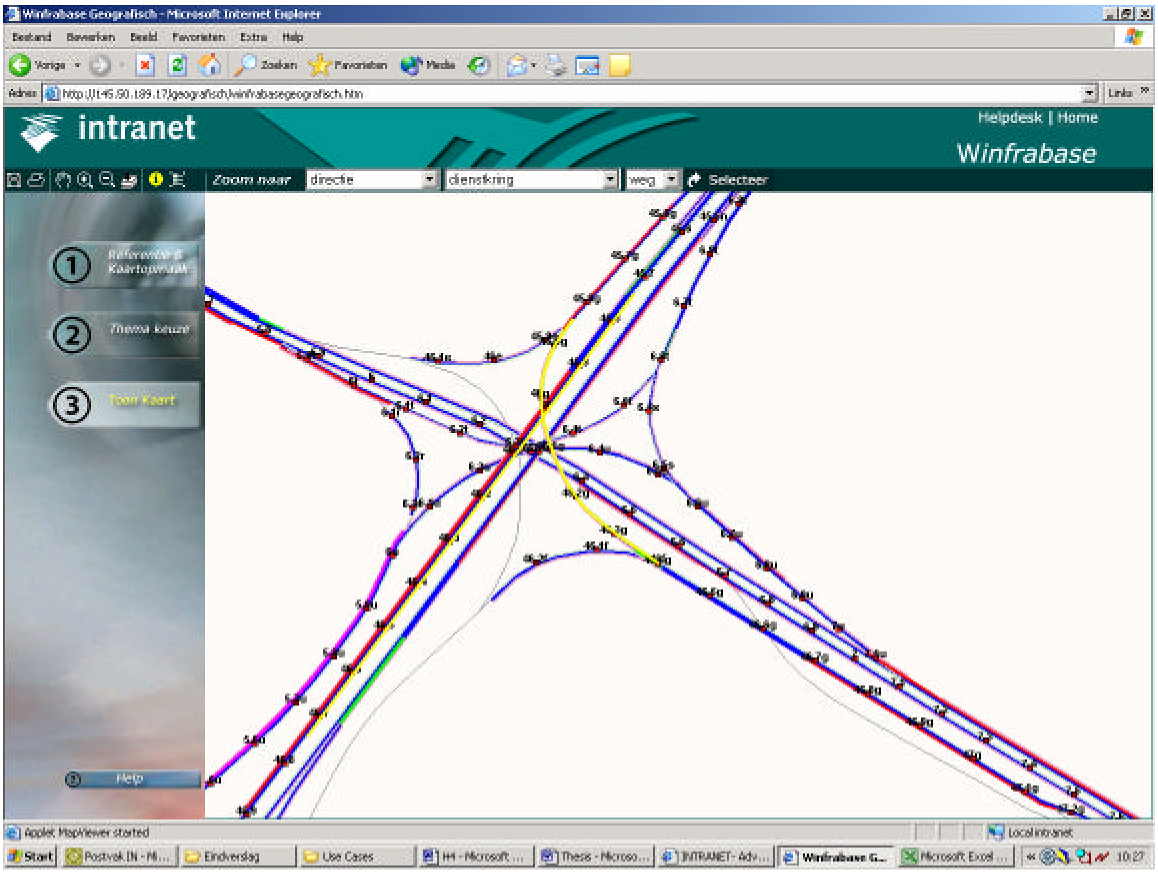


Figure 4.8: Winfrabase (www.rws-avv.nl)

4.2.5 TISBO / DISK

TISBO is the abbreviation for “Technische Informatie Systemen Beheer en Onderhoud”. The application and its data is managed by the Bouwdienst. The application consists of two modules, which support the users at the Dienstkringen (and WED’s) to motivate the decisions about maintenance at Infrastructures. One of these models supports the maintenance of the Infrastructures near the highways (Droge Dienstkringen). The other module supports the information supply of Infrastructures near rivers (Natte Dienstkringen) The structure of the application has been adapted to the commonly used maintenance cycles. TISBO stores data about Infrastructures at a uniform and easy accessible. This can reduce time for creating “Regionale Beheerplannen”.

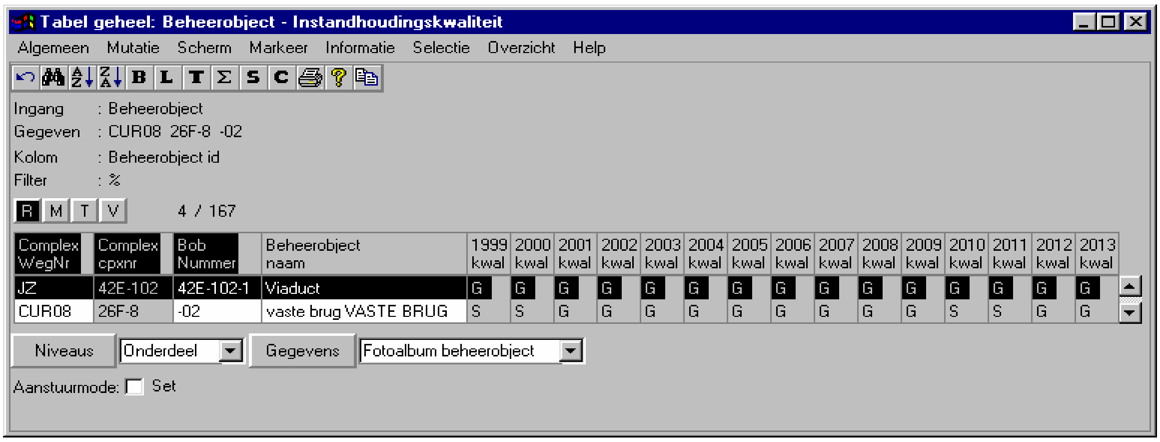


Figure 4.9: Status of Maintenance Tisbo (Handleidng TISBO)

4.2.6 Current information model highway network

After discussing each application apart, the relation between the data used in the applications will be discussed.

All Specialist Departments has to inform users (e.g. at the Dienstkring) about thematic data concerning the highway network. To ensure the information supply, applications have been build to store the geographic and thematic data. Table 4.2 shows the relation between the Specialist Department, the theme of support and its developed application.

Department	*Kind of data*	*by application*
Department of Geo-information and ICT	Large-scale Geographical data – All objects	Kerngis
Road and Hydraulic Engineering Institute (DWW)	Thematic data – Pavement	Winfrabase
Civil Engineering Division (BD)	Thematic data – Civil Infrastructures	TISBO
Transport Research Centre (AVV)	Thematic data – Traffic Requirements	WEGGEG / NWB
Dienstkring	Thematic data – Status / Vision	WEGGEG / NWB

Table 4.2: Department – Kind of data - Application

Because all applications are created by another Specialistic Department, the spatial objects of registration used in the applications aren’t related. Table 4.2: Problem fields vs. information systems, shows a scheme which entities are stored in what application. The (P)-numbers are the objects of “multiple” registration.

Nr	Object of Registration	NWB	Weggeg	Winfra-Base	DTB/ Kerngis	Tisbo/ Disk
P1	Junction / Knot	x		x		
P2	Road Part	x		x		
P3	Hectometer sign	x		x	x	
P4	BPS-lane	x		x	x	
P5	Stroke		x	x	x	
P6	Pavement		x	x	x	x
P7	Civil Infrastructure		x		x	x
P8	Portal		x		x	x
P9	Sound Barrier Construction		x	x	x	x
P10	Illumination		x		x	x
P11	Environment		x		x	
P12	Road marks		x	x	x	x

Table 4.3: Problem fields vs. information systems (van Hengstum, 2003)

Although table 4.3 indicates usage of the same objects of registration, the conceptual model of the highway network differs because of two reasons.

The first reason is de difference in definition of the objects of registration. The data support of work processes regarding the theme "Pavement" uses a conceptual model of the highway network, which focuses on the pavement (concrete), its layers and different lanes (road marks). On the other hand the work processes regarding the theme "Nature and Environment" are focused on the surroundings of the highway network and uses a totally different conceptual model of the highway network. The conceptual model of the highway network regarding Civil Infrastructures is focused on the Civil Infrastructures itself (objects). These different views of the highway network are the cause of this multiple storage of entities.

The second reason is the different level of detail of the spatial objects. Some work processes require high accuracy and other work processes can be performed while using less accurate spatial data. When storing the location of underground objects, (like cables) a higher accuracy could be required then storage of visible objects.

Van Hengstum (2003) recognizes the problem of the different conceptual models and defines the current geographic conceptual model of the highway network (Figure 4.10). The report Information Model of the Highway Network (IHWN) by van Hengstum (2003), also describes an ideal conceptual information model of the highway network with definition library (of the spatial objects), which has been accepted by the AdviesGroep Beheer & Onderhoud & Ontwikkeling Droog (AGGBOOD).

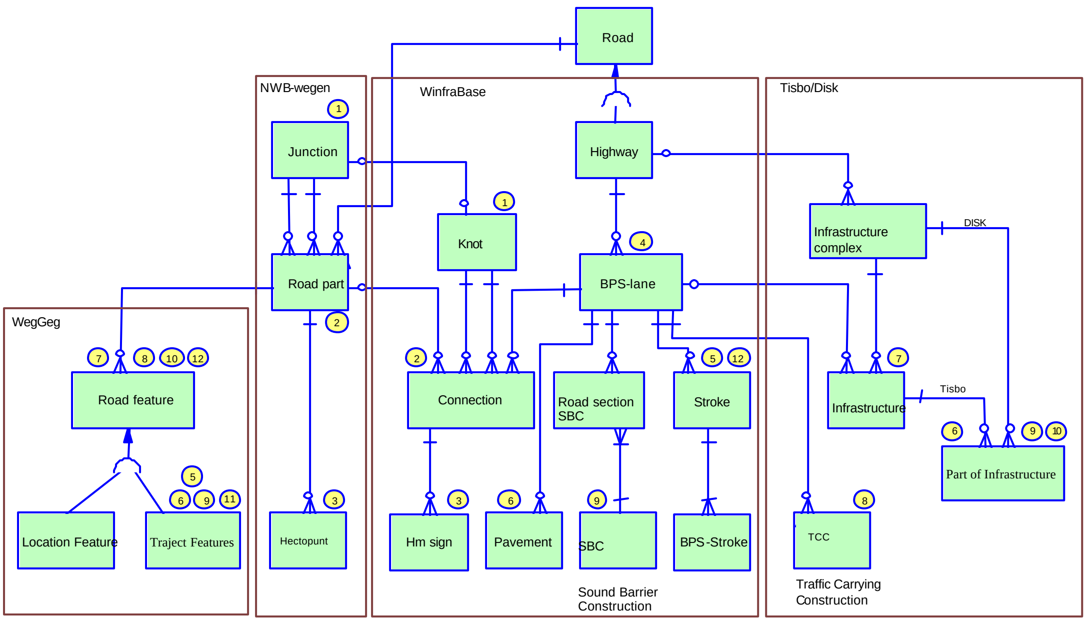


Figure 4.10: Administrative model of the highway network (van Hengstum, 2003)

4.3 Spatial Data Infrastructure

Previous paragraphs described the geographic data sets and applications. Optimalisation of use of geographic information isn't only determed by these two resources. A Spatial Data Infrastructure (also: Geographic Information Infrastructure) concerns all other conditions necessary for an optimal use of information.

4.3.1 What is a "Spatial Data Infrastructure"?

A definition of a Geographic Information Infrastructure (GII) (or Spatial Data Infrastructure (SDI)) is "A Spatial Data Infrastructure is one that encompasses the policies, organizational remits, data, technologies, standards, delivery mechanisms and financial and human resources necessary to ensure that those working at the appropriate (global, regional, national, local) scale are not impeded in meeting their objectives" (GSDI). A GII promotes the minimization of duplicate data collection. By facilitating data sharing and to allow for data integration, the use of existing data resources is maximized.

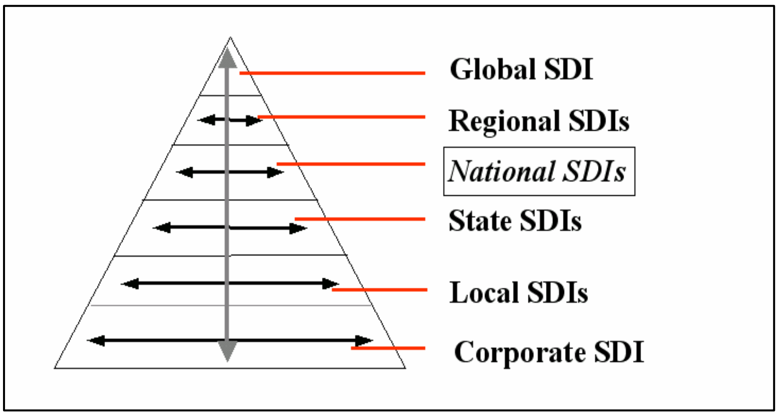


Figure 4.11: Relations in SDI (Rajabifard, A et al., 2002)

Spatial Data Infrastructures exists on all levels. From corporate SDI's, which are used in organizations, till global SDI's, which consist of a world wide Spatial Data Infrastructure.

An important remark is the inclusion of policies, organizational remits, data, technologies, standards, delivery mechanisms and financial and human resources in an SDI. Next paragraph will invest the role of the SDI at the Department of Traffic and Public Works.

4.3.2 Spatial Data Infrastructure at the Department of Traffic and Public Works

At the Department of Traffic and Public Works the SDI is included in four elements (den Boer, 2004):

- technology to store, communicate and use geo-information
- policy and organization
- standards for description, exchange en relating geo-information
- geographic data

Policy of the Department of Geo-information and ICT is (SBP AGI) joining on the National Geo Information Infrastructure (NGII). At the Department of Geo-information and ICT these the four components are realized (den Boer, 2004) according table 4.4: Realization of SDI components.

SDI Component	Realization
Technology	The technology concerns innovation policy and catalogizing of applications. Example is the project "Geoservices". This project invests the use of Web Mapping Services (WMS) and Web Feature Services (WFS).
Policy and organization	Participation in several Geo Gremia. Examples are: - the sponsoring of research (universities) - participation in Dutch Council for Geo-Information (RAVI) - publishing Geo-information magazine (GeoNieuws)
Standards	Participation in organizations concerning standardization (NEN) and

	directorate-wide approach of geo-information and ICT (GIS-coordinatoren overleg and ICT-standaardisatieboard RWS)
Geographic Data	Geographic data will be distributed at the GeoLoket. The Geo Loket takes care of the availability of the geographic data sets.

Table 4.4: Realization of SDI components

Supporting a National Spatial Data Infrastructure concerning maintenance of the Highway Network is a secondary objective. The first objective is creating a usable application (Kerngis 9) to support the processes. Creation of a SDI was a secondary objective, because of the following policy:

1. Use of own Terrain Model (Corporate SDI) instead of NEN3610 (National SDI)
2. Use of DTB – Droog (Corporate SDI) instead of GBKN (National SDI)

The current Corporate SDI of the Directorate-General regarding maintenance of the highway network (by the Dienstkring) is presented in Figure 4.12: Communication of geo-information (van der Zee and Iseger, 2003)

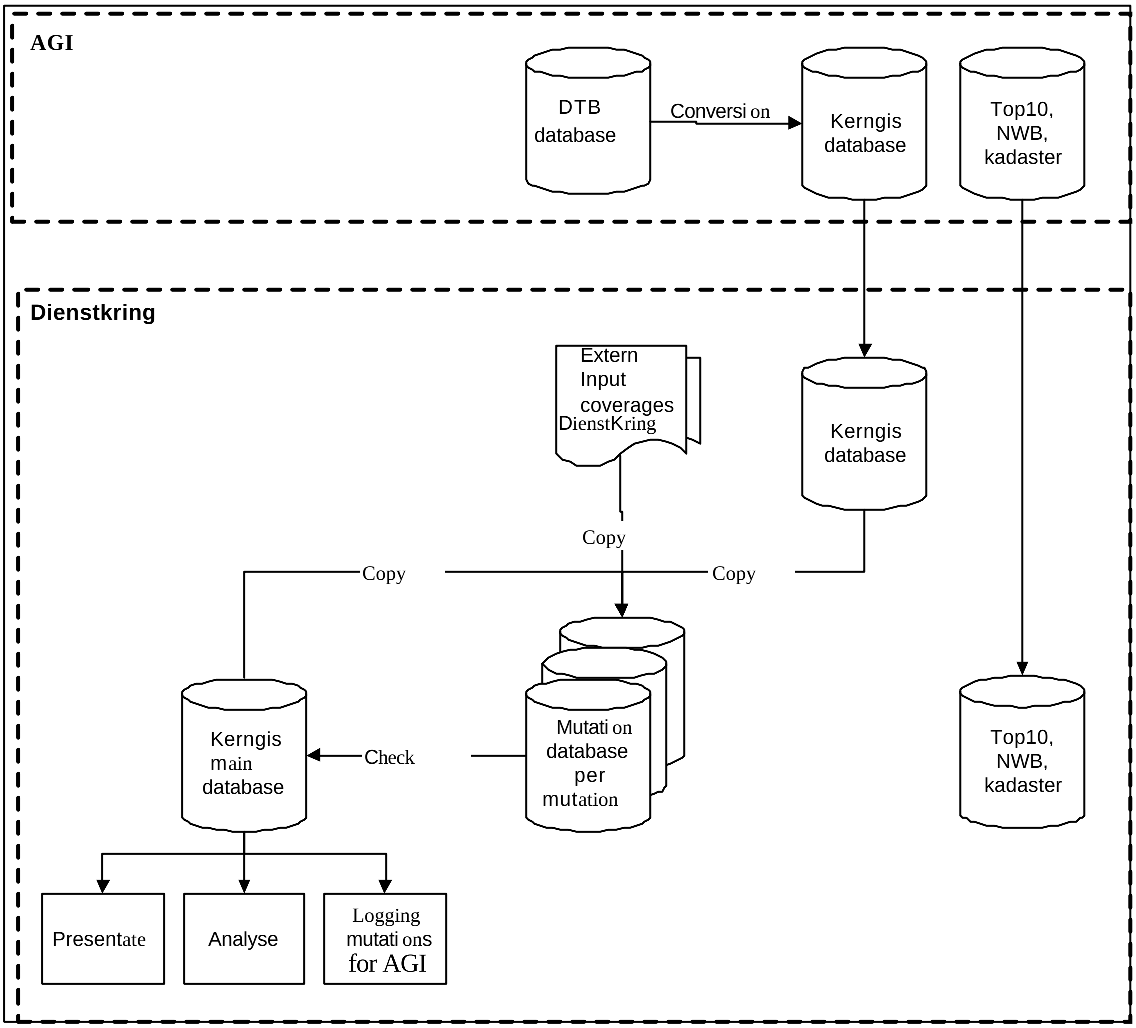


Figure 4.12: Communication of geo-information (van der Zee and Iseger, 2003)

Nevertheless since the beginning of 2004, the Geo-Information and ICT Department is increasing its efforts to join a National SDI. This can be concluded according to the following efforts:

1. Investigation of possible use of GBKN to support the work processes of the Directorate-General
2. Leading position in the Netherlands concerning use of Web Mapping Services (WMS) and Web Feature Services (WFS) to support the users

4.4 Innovative data sets and methods

This paragraph will discuss de innovative data sets and methods. According to Zegveld (2003) innovation is "initial and actual use of a new product, service production process, (organization typology, market, distribution) customers are willing to pay for". Often the definition of invention (which is new technical artifact, which can be useful or can be useless (Zegveld, 2003) is exchanged with innovation. The difference between an innovative data set and an new data set (invention) is the willingness to pay.

The data sets and methods discussed in this paragraph aren't in use at the Directorate-General at the moment. Development of new techniques makes considerations of introducing these new data sets and methods advisable.

4.4.1 Grootschalige BasisKaart Nederland

The Grootschalige BasisKaart Nederland (GBKN) is a product coordinated by the Landelijk Samenwerkings Verband (LSV GBKN). This foundation is founded by members of the municipalities, Cadastre, Utilities (like Nuon, KPN and Gasunie). All participants have in common, that they needed a large-scale data set to support their work processes. The result is a country covered large-scale geographical data set with approximately 100 objects types (more information in Supplement 11). In rural areas the scale is approximately 1:1,000 and in urban areas the scale is approximately 1:2,000. Its up-to-dateness is around one year. The accuracy of the data set is dependent per geographic object type (www.gbkn.nl).

The GBKN is almost totally geographical integrated with the cadastral data sets. An example of the GBKN is presented in figure 4.13: Grootschalige BasisKaart Nederland. This map fragment has also been stored in another large-scale data set: the Digitaal Topografisch Bestand - Wegen. To compare the DTB Droog with the GBKN, figure 4.1: DTB Droog is a presentation of the same area.

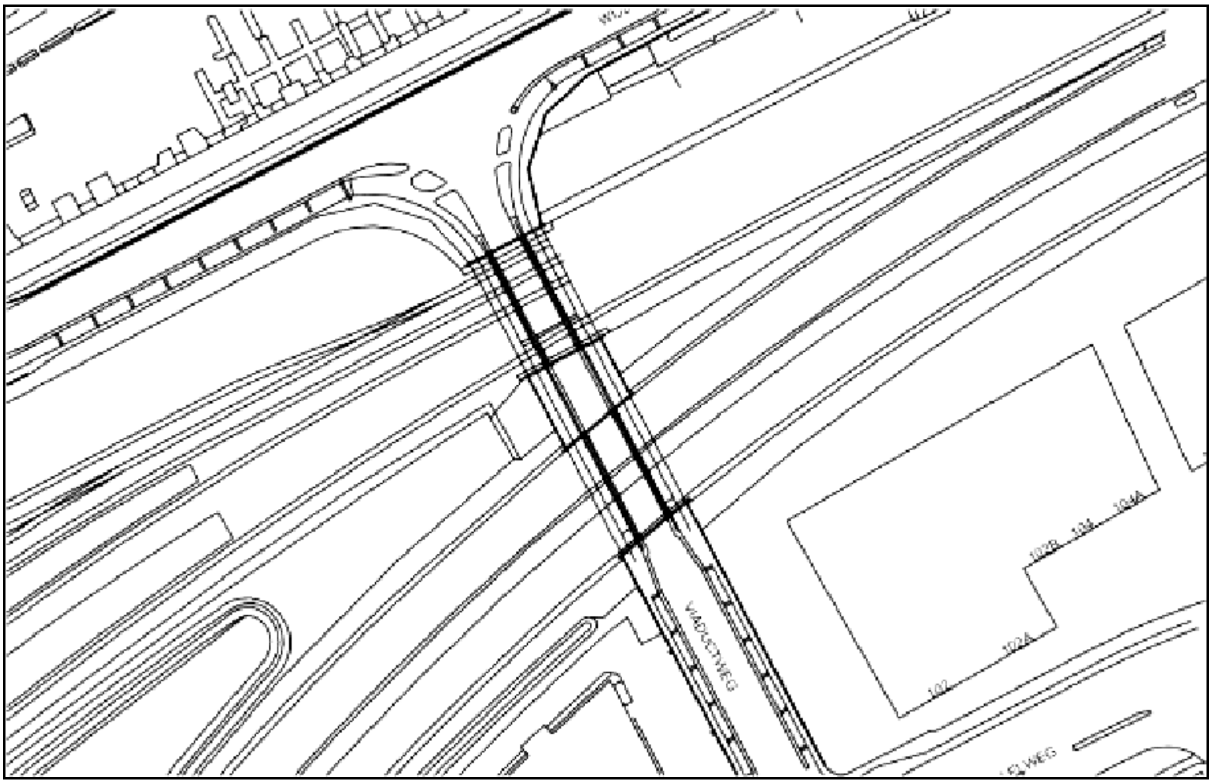


Figure 4.13: GBKN (K+V, 2002)

4.4.2 Top10NL

The Top10NL is a future data set, which will be available in the beginning of 2006. The Top10NL will be derived from the Top10vector by making the Top10 - Vector object-oriented. Therefore some geometry of the Top10vector should be altered. During the development of the Top10NL special attention should be addressed to the parturition of roads. The roads should be divided in separate surfaces. Most important characteristics of the Top10NL will be:

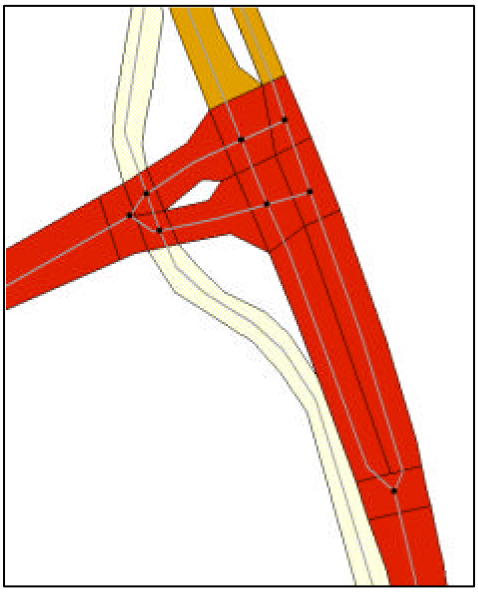


Figure 4.14: Top10NL (http://kartoweb.itc.nl)

- Object Based data set (unique object ID's)
- No distortion of geometry and storage of edges of roads (from Top10 - Vector)
- Additional of mid axis of roads to relate other data set (from Top10 – Wegen)
- ISO / OpenGIS standards (GML exchange format)
- Meta-data on object level
- Usable terrain objects (NEN3610)
- Nationwide data set without chart borders

One of the most important characteristics is the use to relate data to the data set. Because of the use of the centre line, which have already been used by lots of registrations. Also the Object Based characteristic makes it easier to use the Top10NL.
(sources: Knippers and Kraak / kartoweb.itc.nl/top10nl)

4.4.3 VARI method (DTB Droog/Kerngis)

At Highway 15 between Vaanplein and Ridderster (km 60,5-63,5) no DTB has been available. The reason is a frequent change of the highway because of reconstruction. Because DTB production is performed by fotogrammetry, creating a DTB at such an area isn't suited, because of the worse up-to-dateness of the fotogrammetry process. The temporal component of the spatial data is needed. To handle this problem, the VaRi (Vaanplein Ridderkerk) method has been developed to increase the up-to-dateness. The VaRi-method involves a terrestrial measurement of all DTB objects in a certain area instead of photogrammetric measurement of the DTB objects. The terrestrial measurement is performed with the same quality parameters of accuracy (? = 6 cm) of the VaRi-method are equal to the quality parameters of the DTB.

The potential data set created by terrestrial measurement will be considered as innovative. The main advantage of the VaRi-method is the improvement of the up-to-dateness. The VaRi-method is suited to update the DTB Droog/Kerngis in reconstruction areas. The future expectations are that the current Highway Infrastructure will be maintained and only incidentally separate highways will be build. Widening highways by additional lanes would be the future perspective of the construction of roads. The VaRi-method is suited for a quick update of the geographic data of the Highway. The financial aspects regarding terrestrial measurement should also be considered. Compared to the photogrammetric DTB development, terrestrial measurement is more expensive.

4.4.4 Performance Contracting Module

This paragraph will discuss a global approach which additional features should be implemented to support the information supply regarding performance contracting. The coordination of maintenance has to be performed by the Dienstkring. As a result, processes regarding Technical Maintenance, which provides data to develop contracts, will change and so the need of information will change. The problem arises that none of the existing applications or data sets are fully equipped to create or monitor “performance contracts”. The main characteristic of a “performance contract” is a description of the highway function at future vision, instead of detailed descriptions how to maintain the road. The major changes in need of information are presented in table 4.5: Traditional Contracts vs. Performance Contracts: changing conditions in need of information

Traditional Contract	**Performance Contract**
Temporal component only important for updating. History of highway data is not important.	Temporal component important to: communicate “vision” of the highway check the contractor (inspection)
Uses registrative data to develop contract and perform inspections to check contractor	Uses functional data (how can the highway function?) to check contractor
Uses accurate data about surfaces and how to perform maintenance	Uses less accurate data to describe the demanded result in 10 years

Table 4.5: Traditional Contracts vs. Performance Contracts: changing conditions in need of information

Logical information model

Supply of functionalities should be performed by applications. To visualize a future scenario, the geographic data from the GIS (Kerngis) should be presented in a 2,5 D visualization. A landscape architecture application could be used to present the highway. Besides the highway the objects of maintenance should be added to the landscape model for example trees. Also temporal components should be integrated in the application to show for example the growth of trees. The assignment of values / statuses to the objects, which are necessary to accomplish the future scenario, makes checking the contractor possible.

To accomplish these functionalities van Oosterom et al. (2004) describe two conditions, which have to be arranged:

1. Relating the formal semantics of CAD and GIS: The Geographic Object Model of Kerngis should be related to the Landscape Model of the landscape architecture application.
2. Integrated data management: Users has to use the same model (with different views to representate).

Regarding the work processes maintenance of the highway network the first condition is most important, because the Dienstkring will store all its data necessary for maintenance in Kerngis. A landscape architecture application is only necessary to develop the performance contracts. The planning and construction of the Highway Network isn’t the responsibility of the Dienstkring. Development of an landscape architecture application with the same object model as Kerngis is therefore recommended. Some of the functionalities this application has to execute are:

- Storage of temporal data to objects e.g. growth of trees
- Generalization (= from large-scale (detailed) to small-scale (overview)

Louwsma (2004) describes the use and input of constrains in the geo information model of SALIX-2, a landscape architecture application, which can be used to create VR Pictures. Louwsma also uses an Oracle Database with ArcGIS just like Kerngis.

4.4.5 Geo-services

Geoservices is a new method of Information Supply. In September 2003 the AGI has started the development of a central Internet GIS infrastructure. This infrastructure is based on OpenGIS standards (web services architecture of the OpenGIS Consortium). This infrastructure will be stated as Geo-services infrastructure.

This Geo-services infrastructure has already been used for the development of four applications: The basic packet of geo-information of the AGI, WADI-lodingen, Zeegras and Zulte (Grothe, 2003). These applications can be accessed by the geo-services infrastructure and has the specification of Web Mapping Services (WMS). OpenGIS WMS supports the decentralized integration of geographic data sets of different suppliers. Geo-services offers users the possibility to question the data, mutating data isn't possible with OpenGIS WMS. The next stage is to adopt the geo-services according to Web Feature Services. One of the main characteristics of Web Feature Services is the possibility of changing geometry. The OpenGIS application Architecture is presented in figure 4.15: OpenGIS application architecture

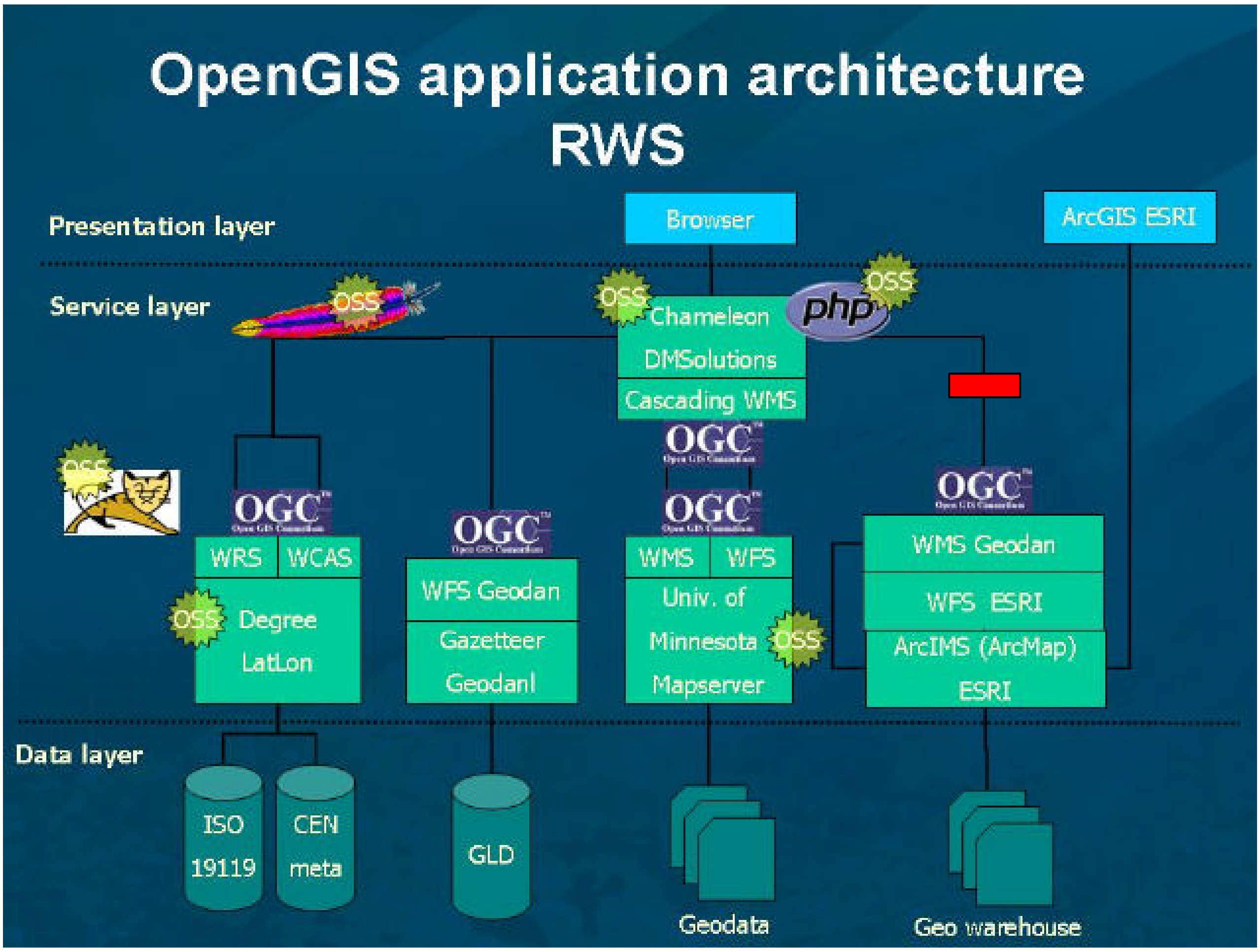


Figure 4.15: OpenGIS application architecture (Grothe, 2004 (adapted))

How does Geoservices work? Geoservices is based on the Publish - Find – Bind principle. The data owner has to publish his data as a map server in a register. The user has an application to search for data in the register of map servers to find his data. Finally the user can collect / bind the data by a web based application.

The software architecture consists of three layers:

1. A data layer
2. A service layer
3. A presentation layer.

The data layer contains different sources of data. The standard geographic data sets are included and also other geographic data sets can be included (see figure 4.15)

The service layer contains the core of the architecture. The parts of the architecture included in this layer are:

- The OpenGIS product Degree: includes Catalog Service (WCAS) and Register Service (WRS)
- The Minnesota Map Server (MS4W) owned by the university of Minnesota
- Standard geo-information data set distributed by WFS and WMS.
- Geocoder by Geodan: zooming to location by address or postal code.

Finally client software from Chameleon makes sure the data is questioned in the right way and presented in the correct way.

The presentation layer could therefore be very simple. A common browser is enough to use Geo-services. ArcGIS has also functionality to use the Geo-services architecture so Kerngis can use data of different sources, with the functionalities of the application ArcGIS (Grothe, 2004).

The mayor advantage of Geo-services is opportunity to use open standards-based services that can be used for editing geo-information, while keeping the data at the source. The owner of the data can maintain its data and register the data in the catalog application. This technique simplifies multiple usage of (actual) data. The only demand to the data sets is interoperatibility with OpenGIS standards. Besides questioning, also mutating geographic data at another geospatial database is a possibility. Brentjes (2004) describes the use of Web Feature Services for editing cadastral data. His conclusion is that WFS are a suitable and powerful interoperatible GIS Web Services, although further development is necessary.

5 Need of information per theme

This chapter discusses the analysis. The need of information will be presented in paragraph 5.1 and will each paragraph will focus on a theme. The object model will be used for the presentation of the need of information. The functionality of the application (operations), which should be performed on the data, will be discussed in paragraph 5.2. The characteristics of these analyses are the level of detail. More general analyses from a higher abstraction level will be presented in Chapter 6.

5.1 *Data related analysis*

Each paragraph will discuss a data-related analyse per theme. It's recommended to keep *paragraph 3.5: Work processes* in mind. All analysis are based on the model and relations between the primary processes, work processes and themes described in that paragraph. The analyses are performed with the analyse tool. This analyse tool is an Excel sheet can be used to analyse the need of information during the work processes.
The object models used in this paragraph show the need of information. An object model is never complete without a definition library. The definition library, which should be used to add the semantics of the objects, is presented in Supplement 12: Definition Library of Information Model. The objects in the Definition Library are the objects, which the users indicated as necessary geographic objects with needed thematic data.

To manage the data during the analysis the need of information at Planning is neglected. The analyse-sheet shows the geographical objects (and thematic attributes) needed at Planning are always less then necessary at Technical Maintenance. The quality parameters are in all situations equal or less qualitative then the parameters of Technical Maintenance. Because one information model per theme is desired, combining these clusters won't change the outcomes of these analysis.

Clustering quality parameters
To simplify the analysis, eight clusters concerning accuracy and up-to-dateness have been created. The intervals of the clusters are presented in table 5.1. These intervals are chosen, because of the answers of the users and quality characteristics of data sets.

Intervals	**Accuracy (meter)**
Cluster 1	15 <
Cluster 2	5 < **10** < 15
Cluster 3	1.50 < **3** < 5
Cluster 4	0.70 < **1.00** < 1.50
Cluster 5	0.40 < **0.50** < 0.70
Cluster 6	0.20 < **0.30** < 0.40
Cluster 7	0.10 < **0.15** < 0.20
Cluster 8	0.00 < **0.06** < 0.10

Intervals	**Up-to-dateness**
Cluster 1	36 Month <
Cluster 2	12 - 36 Month
Cluster 3	6 - 12 Month
Cluster 4	1 - 6 Month
Cluster 5	1 Month
Cluster 6	Week
Cluster 7	Day
Cluster 8	Hour

Table 5.1: Clusters of quality parameters

The cluster, chosen per object in the information model, is the most strict quality parameter. This choice has been made, because the information model should represent the optimal information model, which can be used to support all processes. The Supplements contain more specific tables, which presents more detailed information about the quality parameters.

5.1.1 Exploitation

Primary Processes and Clusters of Processes
The need of information, concerning the theme "Exploitation", has a strong relation with the primary process: Juridical Maintenance. Juridical Maintenance consists of two different clusters of processes: Granting permits and Checking permits. The necessary data is acquired by the permits, the juridical instrument to register information about spatial objects at Juridical Maintenance. Some of the data concerning the theme "Exploitation" requires multiple usage by another primary process: Functional Technical Maintenance. Three

work processes like the registration of cables and pipelines (E1), persen van buizen (E3) and registration of objects (E8) needs geographical data from Juridical Maintenance. This multiple usage can be explained by the need to register spatial objects to support Technical Maintenance. When this data wouldn't be used at Functional Technical Maintenance, spatial data of objects (which need a permit) were only stored in the permits, which would just create an archive. Performing geographic queries and visualizing analysis wouldn't be possible, which creates an undesirable information supply. To avoid the archive function, objects have to be registered at Technical Maintenance. Supplement 13 shows a table with the criteria of the information supply regarding the theme "Exploitation".

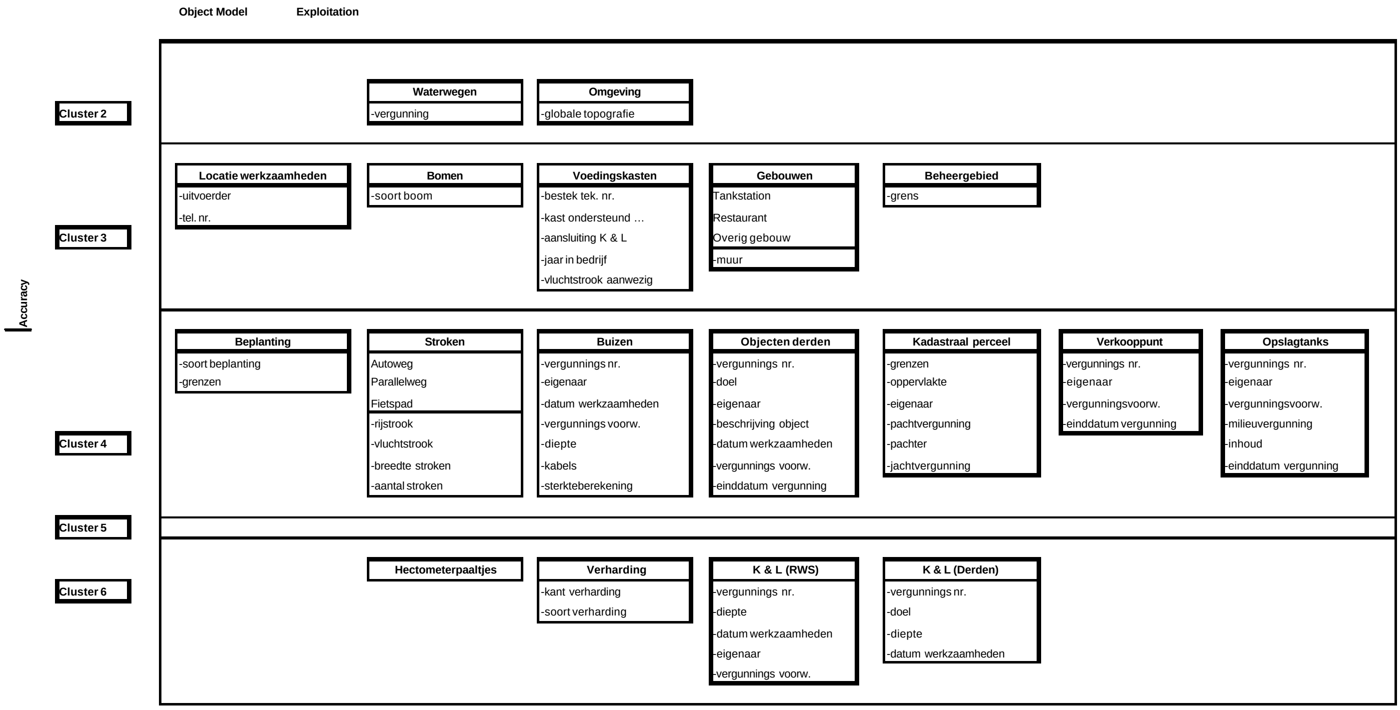


Figure 5.1: Needed Object Model"Exploitation" and required accuracy

Discussion

The processes regarding exploitation have a juridical accent. Every object near the road should be known and therefore the instrument "permit" has been introduced. The main function of the permit is registration and therefore permits should always be granted when the proposal isn't in violation with the restrictions. To judge the proposal of the permit the characteristics of the spatial objects in figure 5.1 should be known. For a better insight in the situation, inspectors will check the proposal and check if there's a better suggestion. Considering the need of information, the high quality parameter for up-to-dateness and relative low quality parameter for accuracy are remarkable. Nevertheless the high quality demand of the parameter "up-to-dateness" is an important characteristic of Juridical Maintenance. Data about the cables and pipelines and parcels also should be quite accurate. Although two remarks should be made.

The first remark concerns the storage of cables and pipelines. When activities will be performed, which need information about cables and pipelines, a KLIC-report will be made. A KLIC-report is a request for information about cables and pipelines in a certain area. All Utilities participate in a KLIC-report. Therefore central registration of cables and pipelines of Utilities isn't necessary and even undesirable, because the reliability would be poor. The registration of cables of the Directorate on the contrary would be important, because the owner of the cable/pipeline is responsible for an accurate map of the location of its cables. The reference system outside is created by the "hectometerbordjes" and "Kant verharding". The quality parameters of these reference objects should be equal to the quality parameters of cables and pipelines.

The second remark concerns the storage of real estate rights. The Dutch Cadastre does supply information about the boundaries and owners of Parcels. This information should be accessed by internet. A monthly cadastral data delivery could be used to register the Gebruik-, Jacht- and Pachtvergunningen.

5.1.2 Civil Infrastructures

Primary Processes and Clusters of Processes
The need of information concerning the theme "Civil Infrastructures" is entirely included in the primary process: Functional Technical Maintenance. This primary process consists of the work processes: Inspection and Technical Maintenance. Two departments of the Directorate perform maintenance processes at Civil Infrastructures: the Dienstkring and the Bouwdienst. The Dienstkring, who's responsible for the planning of maintenance at Civil Infrastructures, performs global inspections to determine if maintenance on the Civil Infrastructures is necessary. When maintenance is necessary, a description and financial overview have to be added to the "Beheerplan Droog". In cooperation with the Bouwdienst, a final planning and detailed motivation will be made to get financial means to perform maintenance. The Bouwdienst has to perform a more technical inspection to motivate the maintenance on the Civil Infrastructure. These work processes won't be performed by performance contracts, because the specialized knowledge is available at the Bouwdienst. Supplement 14 shows the criteria of the information supply regarding the theme "Civil Infrastructures".

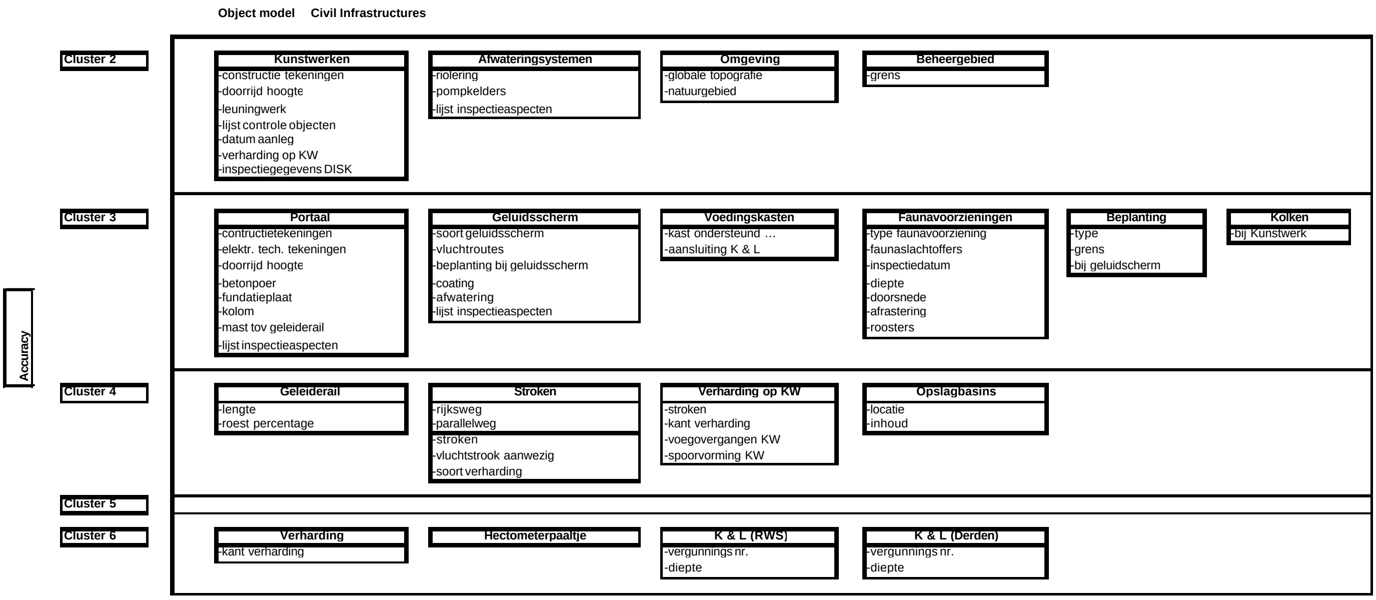


Figure 5.2: Needed Object Model "Civil Infrastructures" and required accuracy

Discussion
One of the most remarkable results in the Information Model is the amount of types of objects. The relevance of geometry of objects isn't a prime issue, but the relevance of attribute data is. When accurate information about the Civil Infrastructure is necessary, construction drawings will be used. Each Civil Infrastructure has an identification number related to a number of the TOP10-grid of its location. Most Dienstkringen don't have that many Civil Infrastructures and data about maintenance of the Civil Infrastructures is stored together. Besides this ID-number, the reference system used to determine the location of the Civil Infrastructure is based on the hectometerpaaltjes (one dimension). Some general information about the Civil Infrastructure is stored in Kerngis. The wide variety of features of the Civil Infrastructure, which have to be inspected, makes an administrative database more suited for Functional Technical Maintenance. The accuracy of the spatial object is almost neglectable. Maintenance of Civil Infrastructures can be obtained as a maintenance process, which needs mostly administrative data, instead of geographical data. Therefore the application TISBO is suitable to control maintenance of Civil Infrastructures.

5.1.3 Nature and Environment

Primary Processes and Clusters of Processes

The need of information concerning the theme “Nature and Environment” is entirely included in the primary process: Functional Technical Maintenance. This primary process consists of the clusters of processes: Inspection, Planning and Technical Maintenance. The creation of the object model will include the clusters of processes regarding Inspection and Technical Maintenance. The planning processes: Development of the Groenbeheerplan (L1) and Policy about Mitigating Requirements (L2) are also included, because of the complexity of need of information. The need of information of the other planning processes is included in the need of information at Technical Maintenance. Maintenance of this theme can be performed in a different ways. Usage of traditional and performance contracts. To show the difference in need of information by using performance contracts and normal contracts, different object models has been created.

Traditional Contract

The amount of objects regarding this theme is quite large. Data about all objects with current status (last inspection / maintenance) and characteristics (geographic / thematic) are necessary to support maintenance. The objects of interest are all located besides the Highway and a complete and easy-to-use data set is required. Global geographical data can be used, because during inspection and realization require global data. At public areas, like parking site or carpool sites, more accurate geographic information is necessary, because a higher standard of maintenance is necessary at public areas compared to areas besides the Highway. To establish a functional support of data, the application should be easy usable and readable maps should be presented. The necessary objects and level of accuracy is presented in *Figure 5.6: Object Model “Nature and Environment” (traditional contract)*. A table with all objects and necessary accuracy and up-to-dateness can be found in Supplement 15: Need of information: “Nature and Environment”.

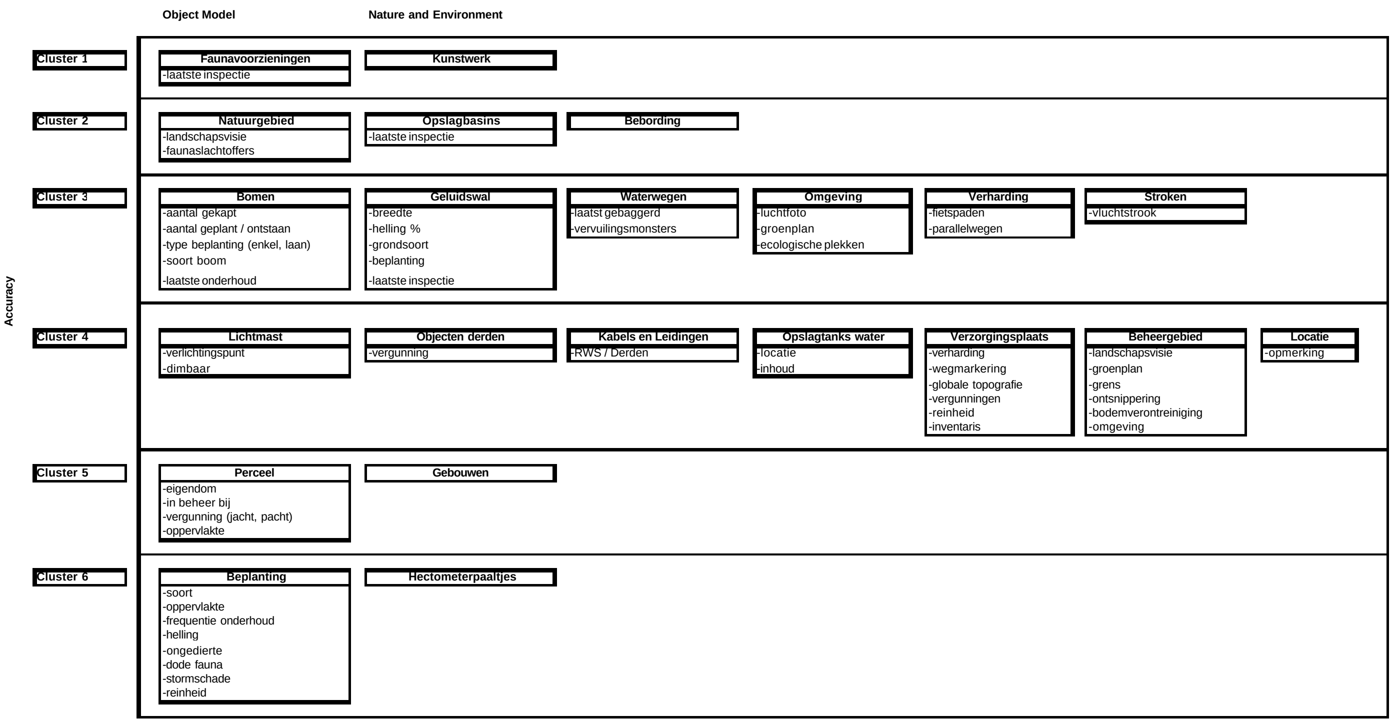


Figure 5.3: Needed Object Model “Nature and Environment” and required accuracy (traditional contract)

Performance Contract

Besides using traditional contracts, the use of performance contracts is increasing within the theme “Nature and Environment”. Figure 5.4 presents the influence of the performance contracts. The first remarkable change shown by the object model is the decreasing amount of objects. A second remarkable change is the difference in accuracy. This can be explained by the different use of data during the processes. Regarding performance contracts, the geographic objects are mostly necessary to support the “Inspection”. Regarding the traditional contracts, the geographic objects have to support besides Inspection en Technical Maintenance, also Developing

Contracts (additional part of Technical Maintenance), Planning and Realization. The support of data to these different clusters of processes requires a stricter data supply, because the data has to support all clusters of processes. A work process which requires data about a large amount of objects is the development of the Groenbeheerplan / Landschapsplan. While developing such a plan, more geographical data is needed to investigate the current situation and state a future vision of the Highway. Nevertheless this work process is very important, because it would be the base of the performance contract.

A remarkable aspect is the necessary accuracy of the geographical objects to support the work processes. Clusters 6, 7 and 8 aren't necessary. The necessarity of an accurate surface of "beplanting" can be questioned. According to the principle of outsourcing, an accurate surface wouldn't be necessary, but the user indicated that need of information. The surfaces areas used in the current contracts are defined years. Normally a contractor never protests against the suggested surfaces, because it will cost more money to calculate the accurate surface. The area, which has to be maintained, is quite clear so the contractor has no need to know the precise surface, just the boundaries outside are important. The up-to-dateness of most geographical objects should be between one month and six months.

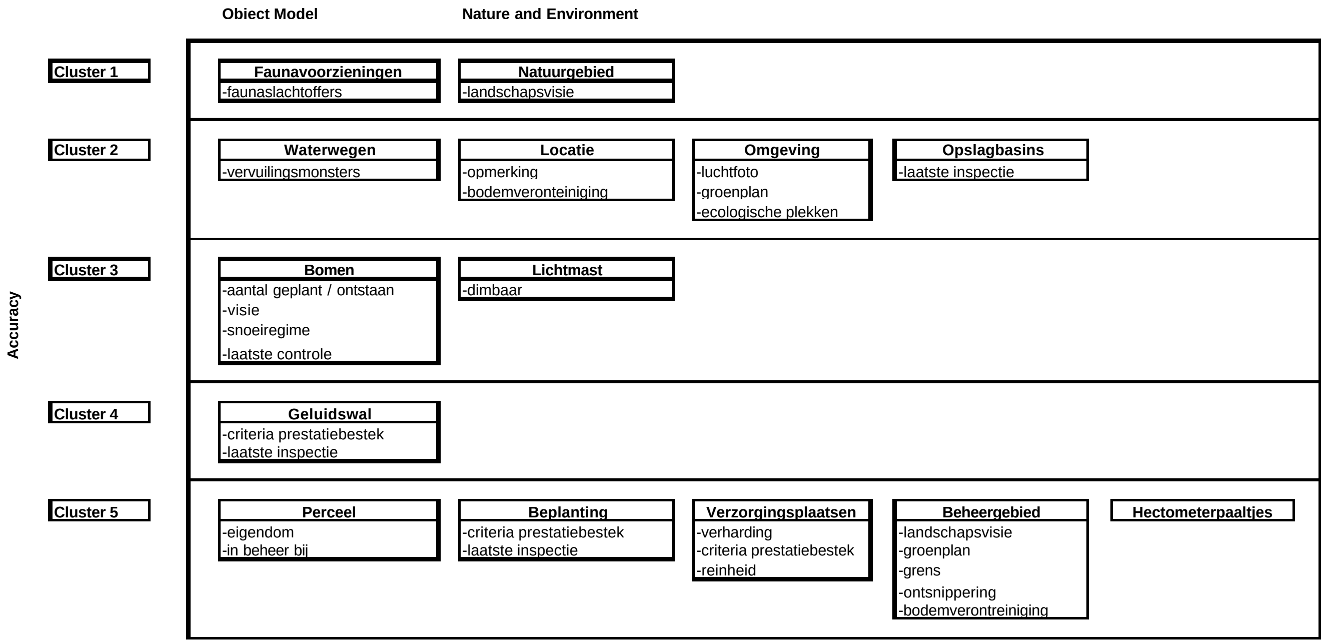


Figure 5.4: Needed Object Model "Nature and Environment" and required accuracy (performance contract)

5.1.4 Pavement

Primary Processes and Clusters of Processes

The need of information concerning the theme “Pavement” is included in the primary processes: Functional Technical Maintenance and Daily Maintenance.

This first primary process “Functional Technical Maintenance” consists of the stages: Inspection and Technical Maintenance. Pavement has to be maintained in a durable way. Maintenance on pavement has its limits, because it will decrease the amount of vehicles, which has to use the Highway.

The primary process “Daily Maintenance” consists of the stage: Incident Management. This process is regarding Grijs Onderhoud. When an incident has happened and the pavement has been damaged, the pavement has to be repaired as soon as possible. Safety of the Highway users is the prime objective, so the repairs have to take place as fast as possible.

Traditional contract

Maintenance of pavement has been performed by traditional and performance contract. The need of information concerning performance contracts will be discussed later in this paragraph.

The geographical objects of the object model have the highest demands on accuracy of all themes. The reason of this high demand on accuracy is the costs of pavement. The surface of the Highway should be known very accurately. Remarkable enough the used surfaces of pavement at the Dienstkring are surface calculation, which are used every year or the as-design specifications. The as-design specifications are the surfaces as mentioned in the contract and not the realized surfaces. For example: A Highway has three stokes (3,60 m) for traffic and 2 emergency strokes (3,20 meter). The road marks are 30 cm wide so the width of the Highway lane is (3 x 3,60 + 2 x 3,20 + 4 x 0,30 =) 18,4 meter. When this part has to be maintained for a distance of 1.300 meter the surface is 18,4 x 1,300 = 23,920 m2. The mentioned surface is often 24,000 m2. The used geometry isn’t the as-build geometric data but the as-design data. At the Dienstkring they want to know the as-build geometry. The mentioned surface of the Highway is always accepted by the contractor, because measuring the Highway to prove the surface is larger will only cost additional money.

The up-to-dateness has an average quality. Because all changes on pavement of the Highways are well known at the Dienstkring, the up-to-dateness decreases. Although the new situation should be registered in the system in six months. The project leader of a pavement renewal project does know the exact geometric data and he is responsible for the up-to-dateness of the data of his project. The object model, which represents the need of information regarding this theme is presented in Figure 5.5.

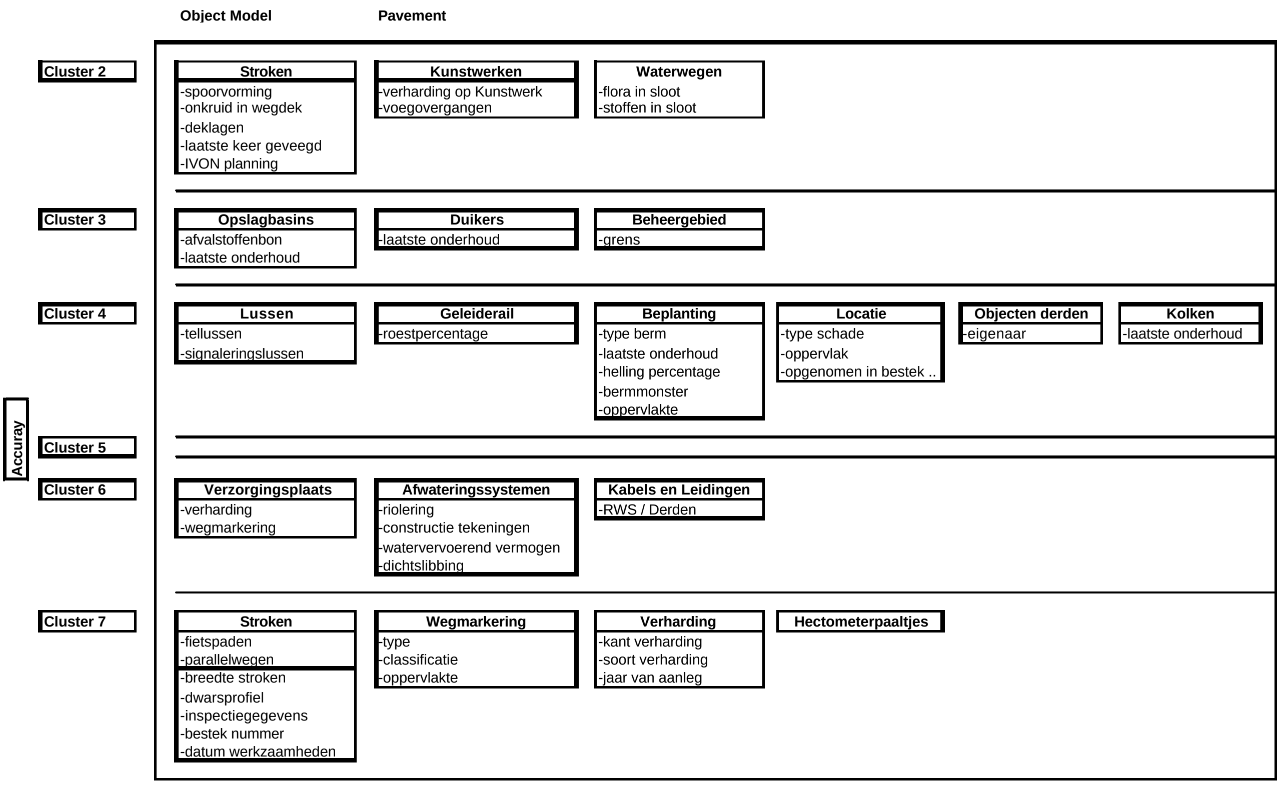


Figure 5.5: Needed Object Model “Pavement” and required accuracy (traditional contract)

Performance Contract

The development of performance contracts does change this demand of information. The contractor has the responsibility of the functionality, safety and availability of the Highway. The information supply at the Dienstkring should support the inspections and make sure the contractor accomplishes the necessary performance. Therefore Technical Maintenance should support the Inspections like a monitoring system. The monitoring objects could be obtained by the “Program of Demands”. To make sure the Dienstkring won’t be too dependent on the contractor, standard regulations about data delivery should be made. The clustering of objects by accuracy is highly dependable on the contract. The location for example should by known exactly (the surface), but this wouldn’t be necessary, when the appointments would be different. The needed objects are presented in Figure 5.6. More detailed information can be found in Supplement 16: Need of information: Pavement.

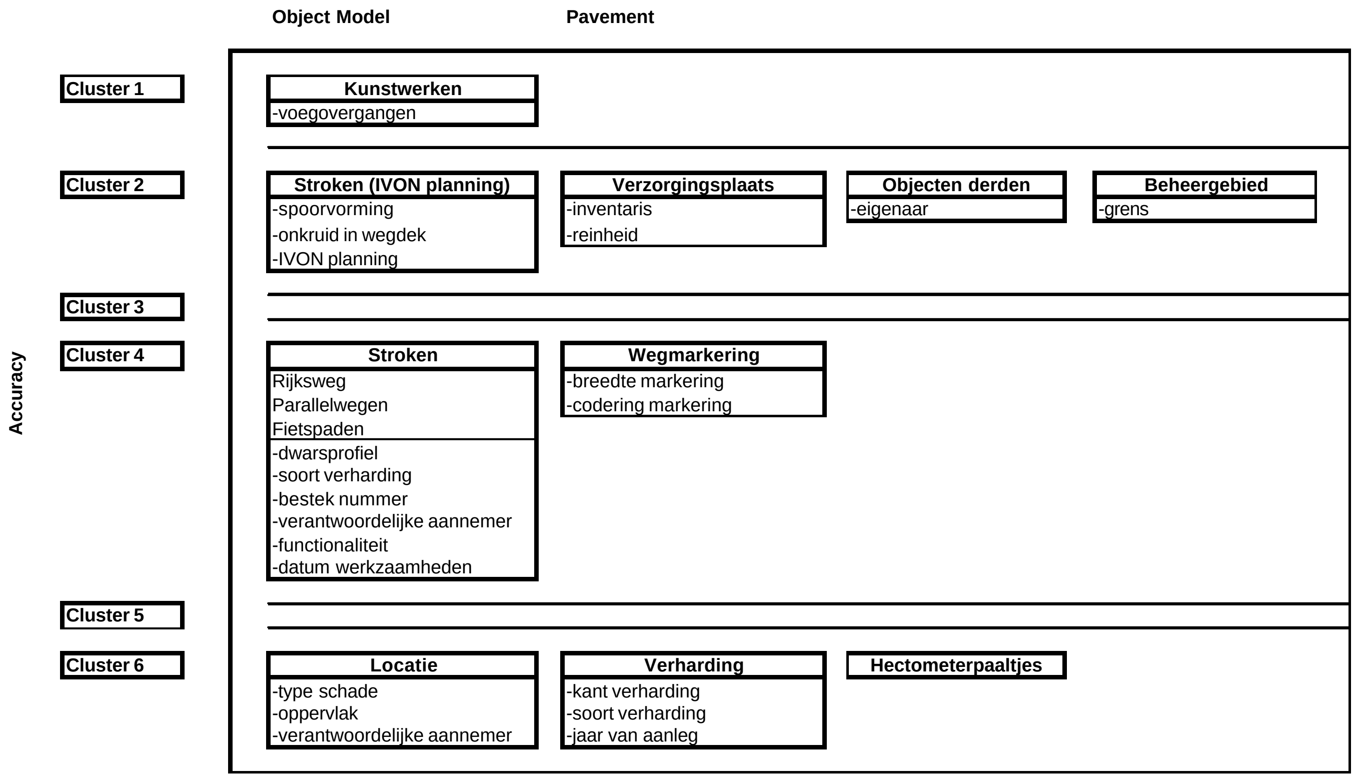


Figure 5.6: Needed Object Model “Pavement” and required accuracy (performance contact)

5.1.5 Traffic Requirements

Primary Processes and Clusters of Processes
The need of information concerning the theme “Traffic Requirements” is included in the primary processes: Functional Technical Maintenance and Daily Maintenance. Functional Technical Maintenance consists of the cluster is processes: Inspection and Technical Maintenance (both regarding Functional Technical Maintenance) Daily Maintenance consists of Incident Management. The processes classified as Daily Maintenance are Incident Management – Wegslepen, Gladheidbestrijding and Bijzondere Transporten. When an incident has happened and the pavement has been damaged, the pavement has to be repaired as soon as possible. Daily Maintenance has a strong relation with the processes regarding Pavement. Considering the results of last paragraphs, the primary process “Daily Maintenance” doesn’t have a recognizable separation by theme. The processes are all classified as Incident Management and Global Inspection.

Traditional Contract
The need of information about the objects has a relatively high up-to-dateness (see Supplement 17). This can be explained by the directive of safe usage of the Highway. The most important objective is to function correctly to ensure the safety of the road user. Because of the large variety and amount of objects near the road to guarantee the safety, the up-to-dateness should be considerably high. The geometric accuracy of these objects is a secondary aspect. The most important questions, which can be recognized according this theme is the availability of the requirements in a specified area. At the Dienstkring the processes concerning Traffic Requirements is split in two different clusters. The electric and non-electric Traffic Requirements. Processes regarding non-electric requirements need quite global geographic data. The processes regarding electric requirements need more accurate geographic data, because, for example cables, aren’t visible. The need of information regarding those cables has as result that the location of the reference objects should also be quite accurate. Figure 5.7 shows the object model.

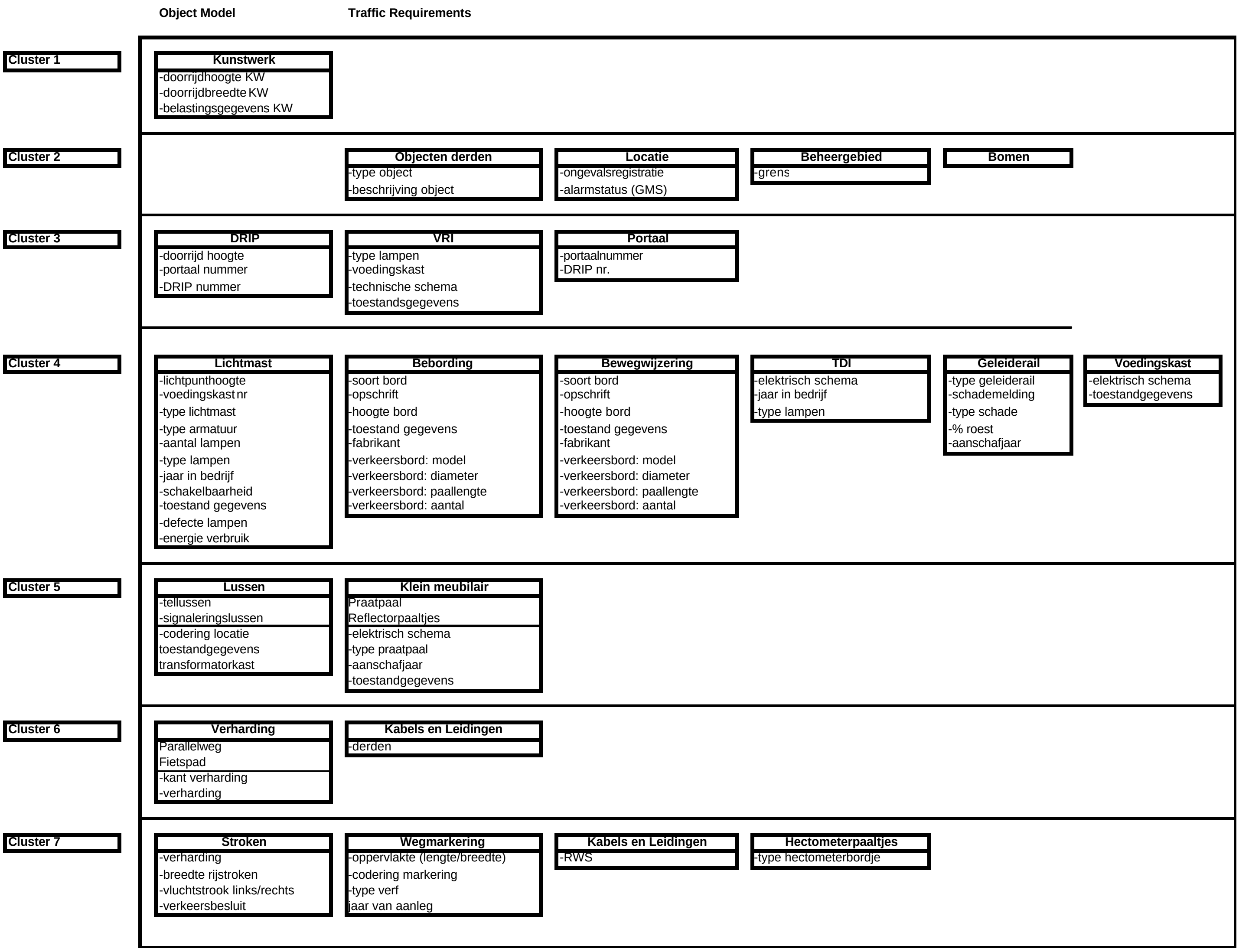


Figure 5.7: Needed Object Model "Traffic Requirements" and required accuracy (traditional contract)

Performance Contracts

Besides using traditional contracts, the maintenance of the objects, regarding "Traffic Requirements" is also performed by performance contracts. The non-electric requirements are maintained by a contractor coordinated by the Dienstkring. The electric-mechanical requirements are maintained by the WED (Mechanical and Electrical Department). In the future the electrical-mechanical systems will also be maintained according performance contracts. In the investigated situation maintenance was performed by the WED's themselves. Although maintenance of traffic requirements can be outsourced, the Dienstkring has to know their areal of traffic requirements. Existence has to be known, accuracy is subordinate. Because the Directorate has to register their cables, the location of these objects should be known quite accurate. The position of road marks should be known quite accurate, because when a large trailer (Bijzonder Transport) has to make use of the Highway, the width of the Highway should be known. Constructions and temporary road marks (and width of the Highway) should be known quite accurate and recent. The Object Model is shown in Figure 5.8. More detailed information can be found in Supplement 17: Need of information: Traffic Requirements.

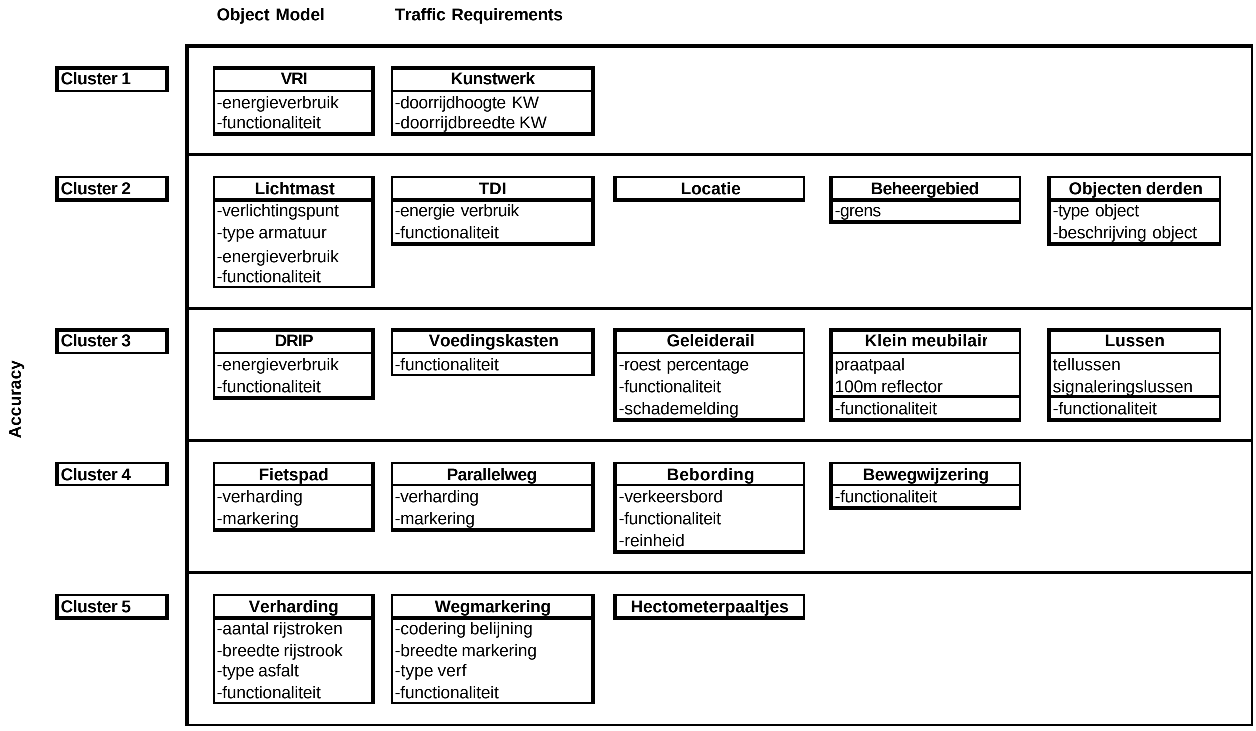


Figure 5.8: Needed Object Model "Traffic Requirements" and required accuracy (performance contract)

5.1.6 Inspections

Last five paragraphs did discuss the need of information per theme with the necessary quality parameter per object. To make sure sufficient data is available, the Dienstkring gathers additional data. Collecting data is performed by Inspections. The different types of Inspection are:

Spatial Object	Accuracy (Cluster)	Up-to-dateness (Cluster)
Hectometerbordjes	1	7
Kant Verharding	1	7
Verharding	1	7
Parallelwegen	1	7
Voegovergangen	1	7
Wegmarkering	1	7
Geleiderail	1	7
Bebording	1	7
Bewegwijzering	1	7
Verlichtingspunt	1	7
DRIP	1	7
VRI	1	7
TDI	1	7
Bomen	1	7
Natuurgebied	1	7
Verzorgingsplaatsen	3	7
Verkooppunt	1	7
Opslagtanks	1	7
Kunstwerk	1	7
Geluidscherm	1	7
Objecten van derden	1	7
Locatie	1	7

Table 5.2: Global Inspection

Global Inspection

Global Inspection is the inspection process regarding the primary process "Daily Maintenance". The purpose of global inspection is a safe usage of the Highway and the improvement of the up-to-dateness of the data by inspection. Objects, which need maintenance and changes near the road, can be noted in an early stage. The data gathered during the inspections has the quality parameter level of table 5.2: Global Inspection. Not all objects are inspected. According to the "Handleiding Technische Inspectie", the objects in Table 5.2 will be inspected during global inspection. At Dienstkring Apeldoorn a test has been performed to use palm computers during the Global Inspection. The evaluation report (Groenenstein, 2003) indicated a positive result regarding the use of Mobile ICT. One of the functional requirements was the use of pull down menus. The inspector has to classify his inspection and wouldn't write a report what isn't normalized and couldn't be compared.

Technical Inspection

The Technical Inspection is a more detailed inspection. After periods the areal objects are systematically inspected. The inspected objects are included in the object models per theme. The supplements per theme indicate the frequency of the Technical Inspections. Conditions how to inspect the objects are described in Wegwijzer Wegbeheer (2003). Different aspects, which require attention, are noted and the responsible employee will be informed. The data shown in the analyse tool (excel sheet) regarding the different clusters are about Technical Inspection.

Inspection by a Specialist Department

Inspection by a Specialist Department is a quite specific inspection. Some objects are too complex and therefore some inspections aren’t performed by the Dienstkring, but by specialists from a Specialist Department. Those specialists motivate if maintenance is necessary. Different characteristics of the Pavement and the inspection of Civil Infrastructures are examples of Inspections performed by specialists.

Reference system during inspection

The BPS reference system (1989) will be used during the inspection and maintenance of the Highway. The final accuracy is depended on the “strength” of this reference system. During the interviews, it appears the objects of reference are the hectometerpaaltjes and the Kant Verharding by all users. The use of these objects is easy to understand, because these objects are always available and are easy to use. Although this local reference system seems logical, the use of this reference system will appear to be a problem, when a high accuracy is necessary. The following problems can be recognized

The first problem is the geometry of the reference system. An accurate reference system should have a geometric system as a frame. This isn’t a characteristic of the used reference objects. For example, the appearance of a curve in the Highway will bound the “coordinate-lines”. Therefore an accurate transformation to the RD-system of the Netherlands is hard to accomplish, with a high accuracy.

The second problem is the level of fixation of the reference system. The reference system, used during inspection and realization of maintenance at the Highways, is based on the objects “hectometerpaaltjes” and “Kant verharding”. The problem appears that these reference objects aren’t fixed. The hectometerpaaltjes can be accidentally removed when, for example, a mowing machine hits the sign. The hectometerpaal will be put back, but this won’t be done by an accuracy of a centimeter. A geographic database with a ‘high’ accuracy, while using the hectometerpaaltjes as reference objects, will suggest a false idea of high accuracy. The Kant Verharding has the same problem. When pavement has to be replaced, a new Kant Verharding will appear and this will be the new reference object.

When high accuracy should be necessary, the reference system of the users wouldn’t be sufficient. Because the users indicated, the accuracy doesn’t have to be that accurate, these “dynamic” reference objects can accomplish the needed to be used as reference system.

5.1.7 Multiple use of Geographical Objects

Spatial Object	Exploitation	Civil Infrastructures	Nature and Environment	Pavement	Traffic Requirements
Hectometerbordjes	0	0	0	5	1
Kant Verharding	6	3	5	6	4
Stroken	1	4	3	8	21
Verharding	1	2	6	8	4
Fietspaden	3	0	2	3	1
Parallelwegen	3	1	3	3	2
Voegovergangen	1	1	0	2	0
Wegmarkering	1	0	2	4	2
Tellussen	0	0	0	1	3
Signaleringslussen	0	0	0	1	4
Geleiderail	0	1	0	2	5
Bebording	1	0	2	0	3
Bewegwijzering	1	0	0	0	2
Klein meubilair	0	0	0	0	2
Lichtmast	0	0	2	0	2
Verlichtingspunt	1	0	3	0	2
DRIP	1	0	0	0	6
VRI	1	0	0	0	4
TDI	1	0	0	0	2
K en L (KLIC)	6	1	1	1	2
K en L (RWS)	5	1	1	1	5
Perceel	6	0	2	1	0
Voedingskasten	2	2	0	0	9
Beplanting	5	3	9	4	0
Bomen	3	0	7	0	1
Kolken	0	2	0	5	0
Waterwegen	2	0	4	2	0
Opvangbasins	0	0	0	1	0
Natuurgebied	1	1	4	0	0
Verzorgingsplaatsen	1	0	8	1	0
Gebouwen	4	0	2	0	0
Verkooppunt	3	0	0	0	0
Opslagtanks	3	2	1	0	0
Kunstwerk	1	4	1	3	1
Geluidscherm	1	2	1	0	0
Geluidswal	0	0	3	0	0
Portaal	0	2	0	0	5
Duikers	0	0	0	3	0
Riolering	0	2	0	4	0
Buizen	3	0	0	0	0
Faunavoorziening	0	2	2	0	0
Objecten van derden	6	0	2	1	1
Omgeving	3	2	5	1	0
Locatie	3	0	4	8	3
Beheergebied	23	10	17	12	28

Table 5.3: Multiple use of objects

After discussing the need of information per theme, this paragraph will show multiple usage of the geographical objects by theme. Table 5.6 shows the frequency of use of a geographical object in a work process per theme.

Some of the objects are only used at processes in one or two themes. Although most objects are used in processes at multiple themes. This indicates, an integral approach of the geographical object is necessary. The quality parameter: accuracy will be discussed while first using traditional contracts and secondly using performance contracts.

Traditional contract
The perspective to the spatial component of most objects differs a lot. This is because of the different need of accuracy regarding the different clusters of processes. Global geographic data about the objects is sufficient for the planning processes. Making inventories is most important. More accurate geographic data is necessary to support the Realization of maintenance. Locations of objects are more important to make sure maintenance is performed at the specified location. Supplement 18: Objects Model: Traditional Contract shows the total object model while using traditional contracts.

Performance contract
While using performance contracts the need of accuracy of objects is less, because of the dominant Inspection support. Performance contracts will always demand geographical data. Although the data at Technical Maintenance doesn't have to support the processes at Realization, there are aspects, why accurate geospatial data is necessary. Being the owner of cables, these cables have to be stored. The quality parameter, necessary to locate the cables have to be determined. Because Utilities also have to store their cables, using these parameters would be sufficient. Supplement 19: Object Model: Performance Contract shows the integral objects models while using performance contracts.

5.2 Operation related analysis

In paragraph 5.1 data related analysis have been performed. This paragraph will analyse the necessary functionality: the elementary operation analysis. Six different types of operations have been defined. Table 5.4: Classification basic operations, shows these basic operations. The main characteristics of this classification of operations is the corresponding aggregation level with the data related analysis and the inclusions of all possible operations on data. The operations aren't split by traditional and performance contract, because no significant differences were found regarding the operations on the data.

Operation	Sub-operation	Classification	Description
Observe	View	A	Application will only be viewed
Store	Mutate attributes	B	Application will be viewed and mutating attributes is possible
Store	Mutate geometry	C	Application will be viewed and mutating geometry is possible
Analyse	Selection	D	Application can perform selections at attributes
Analyse	Overlay (in 1 data set)	E	Application can perform selections at geometry
Analyse	Surface calculations	F	Application can perform calculations at geometry and attributes

Table 5.4: Classification basic operations

Table 5.4: Classification basic operations identify three main operations: observing, storing and analyzing.

- Observing is the less demanding operation. Data should only be presented.
- Storing is a more demanding operation. Besides viewing also additional data should be stored.
- Analyzing is the most demanding operation. Not only the data should be viewed also making queries to the data should be possible

The operation-based analyse will also be approached by theme. A table will present the characteristics of the operations regarding the work processes and clusters of processes. The goals of the tables used to present the operation-based analysis can be analyzed with different perspectives. The horizontal axis presents the different classifications of operations as described in table 5.4. The upper part of the table shows the relation between the work processes (y-as) and needed operations (x-as). The purpose is to show the impact of the required operations per work process.
The relation between the different stages of work processes and operations will be presented in the lower part of the table (below the x-as). The relation between the clusters of processes and operations is described by the amount of work processes, which need the functionality. The cumulative amount of mentioned operations per theme indicates which operations are important to process the data at a certain theme.

5.2.1 Exploitation

Theme = Exploitation							
Work processes	Cables and pipelines		x	x		x	
	Electricity supply		x	x	x	x	
	Tubes (drilling)		x	x		x	
	Environmental Permit		x	x		x	
	Ground use Permit (pachtvergunning)		x	x	x	x	
	Hunting Permit		x	x	x	x	
	Permit of activities		x			x	
	Permit to place objects		x	x		x	
	Global Inspection		x		x	x	
	Permit of selling fuel		x	x	x		
	Permit of exploiting a restaurant		x	x	x		
Operations		A	B	C	D	E	F
Stages	Planning						
	Technical Maintenance		4	4	1	4	
	Inspection		1		1	1	
	Granting permits		9	9	3	7	
	Checking permits		9				
	Incident Management						

Table 5.5: Need of functionalities: Exploitation

Clusters

The first point of discussion is the need of functionalities inside and outside the Office. Inspection, Checking permits and Incident Management are performed outside. Planning, Technical Maintenance and Granting permits are performed inside. Storing attribute data is functionality necessary inside as well as outside. During inspections, storing the status should be possible. An important remark is keeping the application outside stupid and simple. After Inspection the data gathered outside, should be uploaded in the system at the Office to perform more complex operations. Storing geometry and analyzing attributes and geometry are important demands.

Variety of operations

Just viewing data isn't enough to support the inspection. Nowadays the inspectors don't use any computers to store attributes. Inspection forms are used and afterwards the data is stored in an application. After storing the data, the inspector gets a print to check if the input in the application is correct. When handhelds will be used during the inspection, storing different attributes should be possible outside and the used procedure can change so the data doesn't have to be checked. This will improve the Data Management at the Dienstkring. Uploading from the Handheld to the application will also increase the up-to-dateness, which can be used at the Office. At Technical Maintenance the geometric and attribute analysis could be performed.

Juridical perspective

According to the law (Wet Beheer Rijkswaterstaatwerken), all objects, which aren't property of the Government and are situated near the Highway, should have a permit. A registration of these objects is obligatorily. The responsibility of the Directorate about these objects is limited. The Dienstkring may not directly (digging) or indirectly (by trees) damage these objects. All cables and pipelines of the Utilities are for example also stored in the archive for juridical purposes. The need of that information is pure juridical. To obtain the geographical data a KLIC announcement should be made to know where all cables and pipelines of all participants are. These geographic data doesn't have to be available at the Dienstkring. A more reliable and used method is obtaining the data from the owner himself. Applications, which can perform an overlay of all registrations of all Utilities, can be very useful to present reliable and recent data about the current cables and pipelines.

5.2.2 Civil Infrastructures

Theme = Civil Infrastructures							
Work processes	Civil Infrastructures		x				
	Cellar and water systems		x				
	Fauna supplies		x	x		x	x
	Sound reducing barriers		x		x		
	Portals		x	x	x	x	
Operations		A	B	C	D	E	F
Cluster	Planning		5	1	2		1
	Technical Maintenance		5	1	1	2	
	Inspection		5				
	Granting permits						
	Checking permits						
	Incident Management						

Table 5.6: Need of functionalities: Civil Infrastructures

Clusters

Regarding Clusters of processes just three stages of work processes should be analyzed. The required operations Outside (Inspection) are limited to the storage of attributes. Because the Civil Infrastructures can be regarded as objects, geographical presentation isn't extra useful. Construction drawings are used per object (Civil Infrastructure) to prepare and execute maintenance. Thematic (administrative) data plays a more important role.
Regarding the processes at the Office, the necessary operations are still quite simple. The only need of processing geographical information is regarding policy about Fauna requirements (necessary) and location of Portals.

Variety of operations

The operations have a plain focus on administrative processing of data. Just storing data and performing simple analysis like predicting future statuses are sufficient for Maintenance of Civil Infrastructures.

Innovative ICT

New ICT means can be used to upload the inspection data to the system at the Office. Extra functionalities at the application aren't really necessary. If constructions have to be inspected, the analogue construction drawings will be used.

5.2.3 Nature and Environment

Theme = Nature and Environment							
Work processes	Developing Groenbeheerplan / Landschapsplan		x	x			x
	Mitigating requirements		x	x	x	x	
	Public areas (parking/carpool areas)		x	x	x	x	x
	Waterways		x	x	x		
	Trees		x		x		
	Road sides: mowing (also taluds)		x	x			x
	Road sides: Suppression of weeds		x	x			x
	Road sides: Evacuation of environmental waste	x					
	Evacuation of garbage		x				
	Checking of ground poisoning		x	x	x	x	
	Sound Barriers		x	x	x	x	x
Operations		A	B	C	D	E	F
Cluster	Planning		8	4	5	3	3
	Technical Maintenance		7	6	3	1	4
	Inspection	1	6				
	Granting permits						
	Checking permits						
	Incident Management						

Table 5.7: Need of functionalities: Nature and Environment

Clusters
Regarding clusters of processes just three stages of processes should be analyzed. The most required operations during Inspection (outside) is the storage of attributes. Regarding the processes at the Office, more variety of necessary operations is needed. During inspections there is a need of changing the attributes. This can be interpreted as giving a status to certain surface or tree. The more complex operations only exist at the Office. The development of the Groenbeheerplannen requires inventories of objects, which are necessary to clarify the vision. The spatial analysis are used to give insight in a realistic prize for maintenance. Geographic information is important to state the intentions.

Variety of operations
All types of operations will be used. Because of the changing roles and method from making normal maintenance contracts to performance contracts the functionalities there's a large shift in functionalities. Just storing data and performing simple analysis isn't the way to manage and check performance contracts.

Performance Contract
Performance contracts differ in many ways from the normal contracts. One of the most important characteristics is storing the future functionality as a vision. All current systems can only store data from the past. These systems could support the traditional contracts.
The introduction of the performance contracts requires storing data about the future (temporal component). To support information supply in an efficient way three functionalities have to be considered. Storing the vision of the future regarding Nature to support Inspection, using this vision to communicate the purpose to the contractor and check the maintenance of the contractor. More characteristics about functionalities necessary to support Performance Contracts can be found in Paragraph 4.4.4: Performance Contract Module.

Innovative ICT
There's a large shift in the need of information regarding the theme "Nature and Environment". New ICT means can be used to support the processes. First of all the business should be defined and the corresponding functionalities.

5.2.4 Pavement

Theme = Pavement							
Work processes	Incident Management – Repair pavement	x	x	x			x
	Variable Onderhoud Highway (Asfalteren / Freezen)		x	x			x
	Vast Onderhoud – Other pavement		x	x			x
	Cleaning of pavement		x		x		
	Road sides: Endeepening road sides of Highways		x		x		x
	Water Systems (removal of water)		x	x	x	x	
	Grijs Onderhoud		x	x	x	x	
Operations		A	B	C	D	E	F
Cluster	Planning		7	5	4	2	3
	Technical Maintenance		7	5	3	2	4
	Inspection		6				
	Granting permits						
	Checking permits						
	Incident Management	1					1

Table 5.8: Need of functionalities: Pavement

Clusters

Four clusters of processes should be analyzed: Planning and Technical Maintenance at the Office and Inspection and Incident Management outside. The required operations Outside (Inspection) are the storage of attributes, but also viewing data and geometric functions regarding Incident Management. In the current situation the operation isn't necessary, because an experienced inspector, with the knowledge to analyse the situation, performs the process. When this process will be included in performance contracts, these operations won't be necessary.

Variety of operations

All types of operations are necessary on the data. Because maintaining Pavement is expensive, the necessary operations should be available to support the work processes. The Performance Contracts will also change the needed operations. The need of operations has to be derived of the Business goals of the organization. What are the specific responsibilities of the Dienstkring and what procedure has to be used to start and check a performance contract?

Performance Contract

Performance contracts differ in many ways from the traditional contracts. One of the characteristics regarding pavement are the functional demands and durability. Although the Dienstkring doesn't need very accurate data, this data can be useful to support processes in other themes (for example: information supply of bijzondere transporten). Besides the maintenance of Pavement the data about the Pavement and operations can be necessary to support other processes. Ensuring information supply of pavement to the Dienstkring should be ensured to know what the Dienstkring is responsible for and making the Dienstkring less depended of the contractor. Also durability of the Highway needs attention.

Innovative ICT

New technology can be used when the responsibilities of all actors are clear. Also the kosten/baten policy should be clear to define necessary functionalities on the data.

5.2.5 Traffic Requirements

Theme = Traffic Requirements							
Work processes	Public illumination		x		x		
	Road marks	x	x	x			x
	Road site securing (geleiderail)	x	x	x	x	x	
	Road signs RWS	x				x	
	Road signs ANWB		x	x	x	x	
	Traffic and Indication signs	x	x	x	x	x	
	Highway detection systems		x		x	x	
	Traffic- and detection systems		x		x		
	Lights of Traffic Systems	x	x		x	x	
	Dynamic Route Information Panel (DRIP)		x		x		
	Highway Accessibility System (TDI)		x		x	x	
	Cameras		x		x	x	
	Mist detection systems						
	Road-side electrical systems	x	x				
	Incident management	x					x
Operations		A	B	C	D	E	F
Cluster	Planning	1	10	3	5	5	1
	Technical Maintenance	2	17	8	15	11	2
	Inspection		12				
	Granting permits						
	Checking permits						
	Incident Management	4					1

Table 5.9: Need of functionalities: Traffic Requirements

Clusters

Four clusters of processes should be analyzed: Planning, Technical Maintenance and Incident Management at the Office and Inspection and Incident Management outside. Incident Management is performed outside as well as inside. The required operations Outside (Inspection) are limited to the storage of attributes. Incident Management outside doesn't need any geographic data. Only Incident Management at the Office.
At the office a large variety of operations should be available. Storing attribute data as well as geographic data and analysis should be made. The main focus of the analysis is making inventories about the areal, which should be maintained. Selections by geometry and attributes are an often-used operation.

Variety of operations

As mentioned before a large variety of operations should be available at the Office. This is because lots of data about all objects should be stored. These data are available in different applications. Reasons of storage in different applications are the different perspectives, which can be considered like: Maintenance perspective (Kerngis), Traffic Management perspective (Signview) and the electric mechanic perspective (AutoCAD). This thesis will focus only on the maintenance perspective but there's multiple use of data from the different perspectives.

Performance Contract

Performance contracts can decrease the complexity of the Maintenance of Traffic Requirements. When all maintenance is included in a performance contract, the need of information regarding the Traffic Requirements is limited to geographic storage with a status. The status will be defined during inspections of the Traffic Requirements.
A point of attention is the dependency of the Dienstkring by the contractor, which performs maintenance. Clear appointments have to be made to arrange the information supply. The first reason is dependency of information about the traffic requirements to support policy and other work processes, which need data about Traffic Requirements. The second reason is in case of ending the contract. The Dienstkring should be depended and should be able to finish the contract without consequences for the information supply

Innovative ICT

When performance contracts will be used, geo-services are a mean to integrate data from the different users. Also the Inspection can be improved by using handheld computers during inspection and upload the data to the system at Technical Maintenance.

6 Analysis

After discussing the results at a detailed level in Chapter 5, a more global level (higher abstraction level) will be used in this Chapter. During this research the changing policy about using performance contracts instead of traditional contracts appeared to be a very important aspect, because the need of information in both situations is different. Paragraph 6.1 describes the influence concerning the use of tradional and preformence contracts. Paragraph 6.2 will describe if a relation or difference was found between the need of information of the three different types of Dienstkringen. Paragraph 6.3 will discuss the fitness of use of the different currently used products. A more integral analysis will be presented in paragraph 6.4. While using the Integrated Architecture Framework, analyses per box of this frame will be presented.

6.1 Accuracy of spatial objects: traditional contracts vs. performance contracts

One of the most important conditions regarding need of information is caused by the use of the contract. This paragraph presents two graphics, which represent the need of information, while using a traditional contract and while using a performance contract. These graphics have been made by Excel, while using all interview data from the analysis tool.

The x-as shows the spatial objects mentioned by the users. The same objects are used in the object models in Chapter 5. The y-axis shows the cluster of accuracy. Cluster 1 is very global (accuracy of more than 15 meter) and Cluster 8 is very accurate (approximate 0.06 meter). The specifications of the clusters are defined in paragraph 5.1. The height of the columns (z-as) shows the total number of work processes, which requires geographical data about the corresponding spatial object within the specified cluster of accuracy.

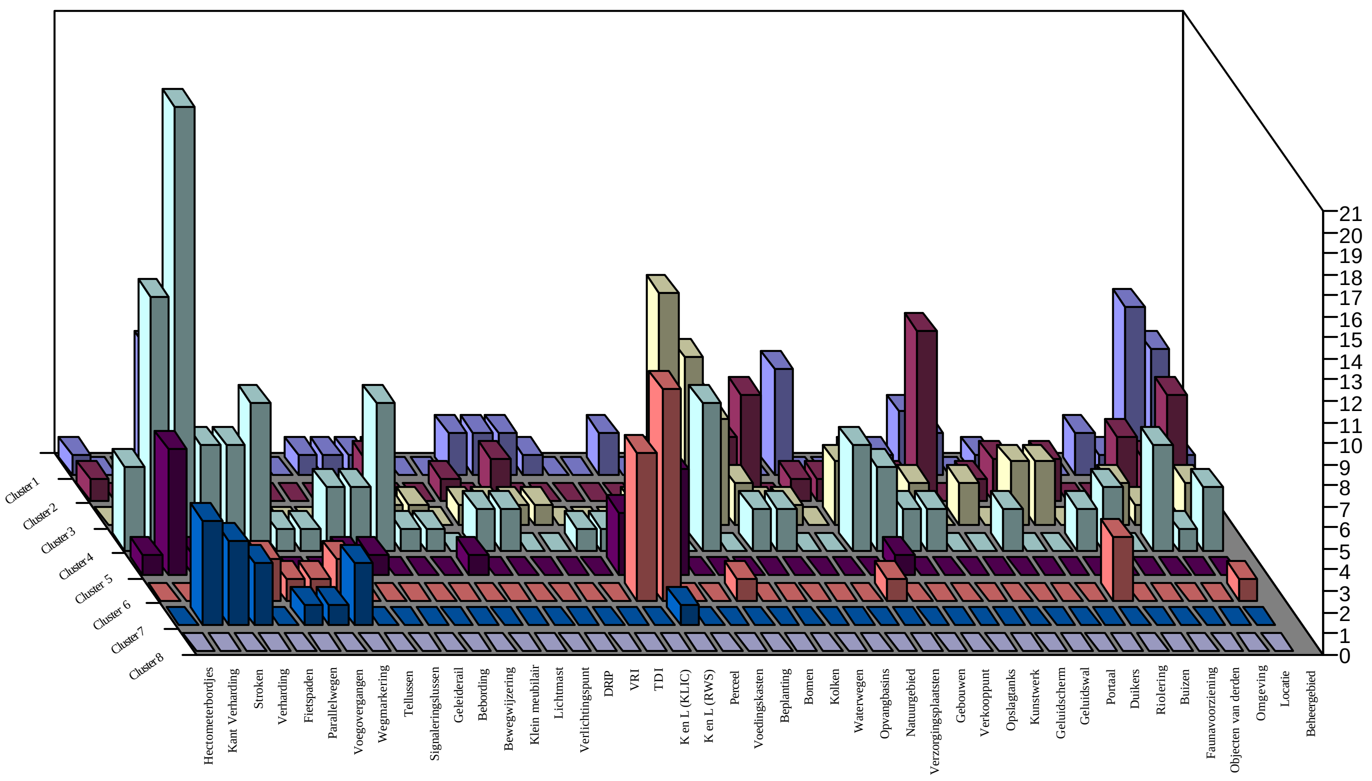


Figure 6.1: Accuracy of spatial objects needed with traditional contract

Figure 6.1 shows the need of information while using a traditional contract. All need of all spatial objects in all stage of the work processes including every theme is presented. The spatial objects, which require high accuracy, are about pavement and cables. Pavement can be explained, because pavement is very expensive and the Dienstkring (and Head-Office) want to know how many square meters pavement have to be maintained. The cables of the Directorate also need high accuracy, because the Dienstkring has a juridical obligation to store their cables in a registration.
On the other hand figure 6.2 shows the accuracy of spatial objects while using a performance contract. This model has been created by summarizing:

- the spatial objects with accuracy parameter while creating performance contracts
- the spatial objects with accuracy parameters necessary to support Inspection (monitoring)
- the spatial objects with accuracy parameter to support exploitation

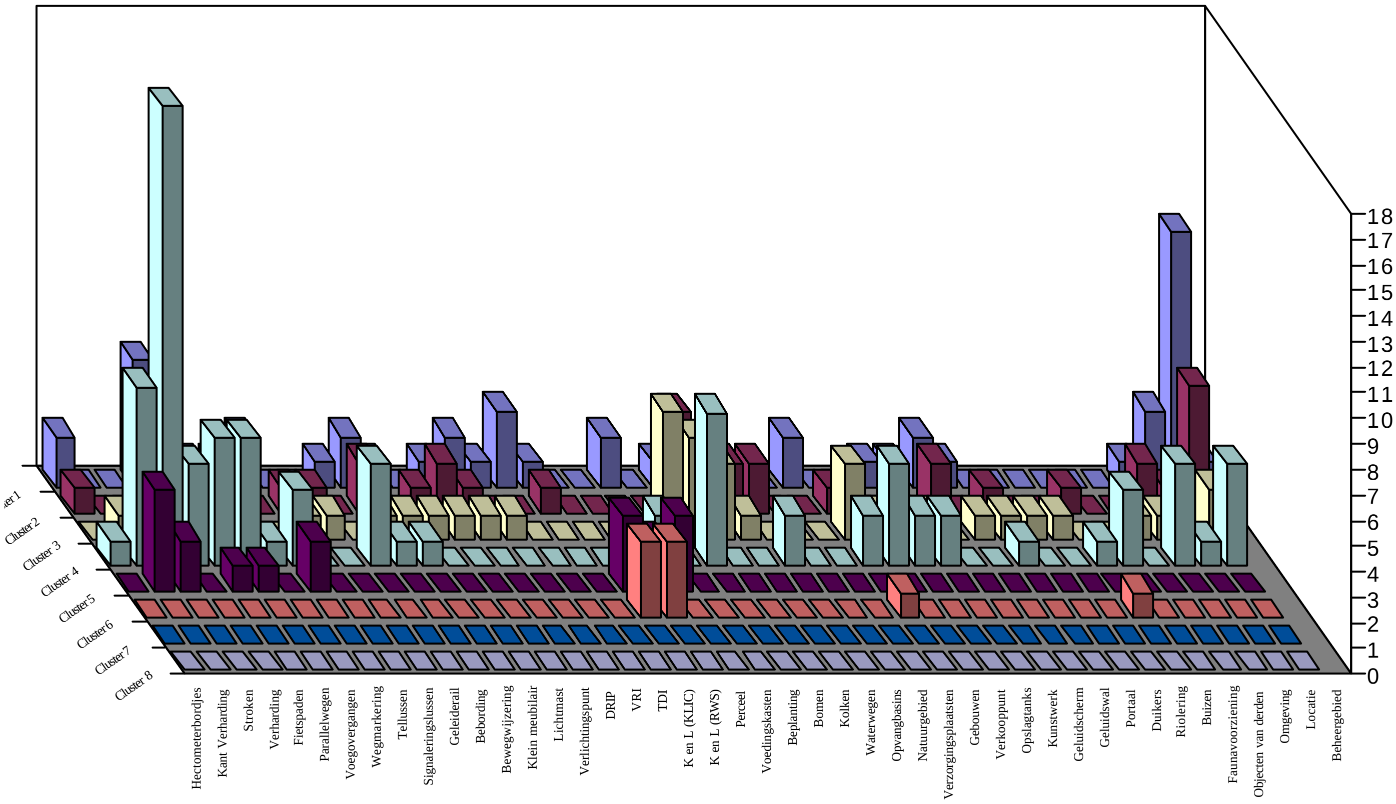


Figure 6.2: Accuracy of spatial objects needed with performance contract

The influence of using performance contracts is plain to see. The percentage of cluster 1 till cluster 4 objects is increasing, which means a decreasing need of accuracy of geographical objects. An important characteristic is the use of the same geographic objects. This characteristic is although quite logical. The objectives (business - why) of the organization aren't changing, but the way (business – how) the objectives should be performed will. In other words, the objects of maintenance aren't changing so these objects still have to be checked during Inspection. A remark should be made that Business – How has a strong effect on the Business – What (processes), because Business – How can assign an instrument, what has to be used. As a result the procedures of the processes will change and so the information demand will change.

More detailed information about data-related analysis has been presented in paragraph 5.1, while detailed information about the demanded operations on the data can be found in paragraph 5.2.

6.2 Location of the Dienstkring

One of the points of attention was to determine the difference in need of information at the different locations in the Netherlands. Because of the difference in traffic-intensity of the Highways, a difference in need of information could be possible. The Directorate-General of Public Works and Water Management recognizes three types of Dienstkringen:
Randstad, Corridor and Groen Dienstkringen (paragraph 1.2.2). Interviews have taken place at these types of Dienstkringen (Zuid Hollandse Waarden, Huis ter Heide and DAS Apeldoorn).

In the analyse tool the results are presented. No correlation could be found between the need of information between the different Dienstkringen. It seems impossible to find a difference in need of information at the different dienstkringen. This is due to the following aspects:

1. Use of Performance Contracts	The conditions at the different Dienstkringen were different. Some of the Dienstkringen were using performance contracts, which did change the need of information. Because of the impact outsourcing, the “possible” difference in need of information couldn’t be detected, because the influence of the location was inferior compared to the use of performance contracts.
2. Ability of defining “Need of information”	Because of the complexity of functionalities of applications and lack of awareness of existence of data, a user has difficulties to state its need of information. By replacement in the user (de Boer and Hisschemoller, 2001) and structuring need of information per process during the interviews this lack of stating “need of information” can be reduced. This improves the reliability of the data gathered about the need of information. Finding differences in need of information, the impact of using Performance Contracts was more significant
3. Subjectivity of “Need of information”	The difference in experience between the users (and their knowledge) was also an important aspect. Because of relating need of information to the goals, which have to be achieved, also knowledge, the user knows without being stored in an Information System was gathered. Although a 100 % guarantee is almost impossible

6.3 Fitness for use of currently used products

This paragraph will evaluate the fitness for use of the currently used geographic data sets DTB / Kerngis, NWB and the Algemeen Hoogtebestand Nederland (AHN). Evaluating the fitness for use of those data sets will be done by data-oriented analysis and operation-oriented analysis (regarding the functionalities of the supporting application). These analysis will be performed considering the need of information to support traditional contracts and also by performance contracts when possible.

6.3.1 Fitness for use of DTB / Kerngis

This paragraph will determine the fitness for use of the data set DTB Droog with the supporting application Kerngis. The data oriented analyse of Kerngis will be performed by comparing the scheme of the spatial objects per layer (Supplement 10C) with the scheme which represents the object model regarding the total need of information of the all maintenance processes at the “Droge” Dienstkring (Supplement 18/19). The operation-oriented analyse will be performed by comparing the different demands of operations to the functional characteristics of Kerngis.

Traditional contracts

Data oriented analysis

Kerngis can present two dimensional geographic data about the Highways. The Algemeen Hoogtebestand Nederland (AHN) has been implemented with height measurements so the used data set can be considered with a dimension of 2.5. The geographical data about objects stored in Kerngis has a very high accuracy (Cluster 8). On the contrary the up-to-dateness is very poor (Cluster 1/2) and more recent data is necessary. The uniformity of the high quality level regarding accuracy is impressive, but according to the object model, such a uniform quality, isn’t really necessary to support the processes. Some objects should have high accuracy and other objects can have lower level of accuracy. Which objects need a higher accuracy, can be found in the object models in the paragraph 5.3. Besides the needed global accuracy, it’s recommended to assign some objects as reference objects. During interviews it seems the objects “Kant Verharding” and “Hectometerpaaltjes” are the objects, which are used as reference objects. The most significant problem is that these objects don’t have a static location. Hectometerpaaltjes can be moved and this sometimes happens accidentally during mowing. Also the Kant Verharding can move when new pavement will be laid. The problem with the changing “Kant Verharding” can be solved by adding a spatial temporal component to the data set. The past position of “Kant Verharding” can be stored as well as the current position of “Kant Verharding”.
The object models, presented in paragraph 5.3, do show a lot of spatial objects. These objects can be stored in Kerngis, but because of the variety of possible objects and prioritizing the implementation of data, these objects aren’t always stored. Also not all cables are stored, but Kerngis 9 has a layer, which could consist the cables owned by the Directorate-General. Also the possibility of binding (uploading) cables from Utilities is a feature possible in Kerngis (by use of Geo-services). The accent of this group of objects is focused in spatial position. The objects stored in Cluster 1 till 3 are more focused on the attribute data then the precise geographic position. The functionality of the geographic component is to make an inventory of the amount of objects in a certain area.

The logical data model of Kerngis can be considered as a combination of six parts, which have their own relations:

- A group of DTB Droog objects
- A group of objects the Dienstkring wants to use
- A mid-scale group like TOP10 objects, NWB objects,
- A large-scale group of Cadastral data (bulk output)
- Boundaries of provinces, municipalities, area of maintenance.
- A raster data set with digital aerial photo’s

Because of this classification, some of the spatial relations between the objects are hard to model. Although most important objects are stored in Kerngis, the accent is mainly focused on the geographical components instead of the attribute component. Kerngis can be considered as the application with most focus of storing geographical data and has a two-dimensional perspective of the Highway. For the support of work processes regarding maintenance processes two dimension data is sufficient.

Operation oriented analysis
Paragraph 3.4 showed the need of functionality (operations), which is required to support the processes. Six different types of operations are considered. It seemed viewing-only data is a rare operation. This operation is often used in combination with editing data. Often selection or overlay operations are performed on the data. Changing geometry and storage is a functionality required at the Office, but for some objects this functionality is needed outside.
Kerngis is the only large scale geographical application used by the Directorate. Large-scale geographical data is required by processes at the office like Technical Maintenance and Granting Permits and has to support the realization. While performing maintenance outside accurate data about the location of (for example underground) objects is necessary. The Directorate is also responsible for its cables and making clear to third parties, where those cables are located. Changing geometry (with storing) and making selections are important functionalities, which should be performed by Kerngis. Also the possibility of changing attributes (and sometimes changing geometry of certain objects) outside is a desired functionality.

Performance contracts

Data oriented analysis
While using performance contracts the accuracy of the data may decrease, but the up-to-dateness should remain the same, compared to the need of information without performance contracts. Also the amount of objects will remain the same. This can be explained, because maintenance has to be monitored. The Inspection will appear to be a dominant process and the Information supply should be adapted to serve this type of process. Besides the description of functionality is a new way of storing data. The current storage of data in Kerngis isn't sufficient to cope with storing these functionalities. Creating of 2.5 D features should be possible

Operation oriented analysis
Visualizing the future vision of the highway isn't possible by Kerngis. Integration of CAD data with GIS data can be considered as a bridge to far. Using an additional landscape architecture application with a corresponding Geographic Object Model (related to Kerngis), can help to create "landscape pictures/visions".

Regarding the other needed functionalities, Kerngis can execute the necessary operations to support the work processes. Also the development of additional parts of Kerngis creates a better fitness for use like:

- Development of the Kerngis Viewer is a new mean to the less experienced user for an easy analyse of the data. The people who would work with Kerngis itself can be considered as the experienced users, because some experience with GIS is necessary.
- Mobile GIS can be used to diminish the Inspection procedure and have more accurate and recent inspection data. Especially when Inspection will become the focus of information support. Simple storage of inspection rapports should be possible. Uploading of inspection data into Kerngis can also improve the up-to-dateness

Spatial Data Infrastructure
Unfortunately a useful Spatial Data Infrastructure hasn't been developed. Also the development of a Corporate SDI for maintenance of the Highway Network hasn't been realized.

Some features indicate the start of creating a Corporate SDI. Projects like:
- Development a general Geographic Object Model: Data sets created by the Directorate-General can only be related in a useful way by use of a related Geographic Object Model.
- Development of "Geo-services": Future use of Geo-services and development of WFS – Transaction are highly recommended. Current problems in using other geographic data sets are caused because of unrelated Geographic Object Models.

Besides development of a Corporate SDI also use of National SDI's are developing. Investigations about the possible use of the GBKN has been started. A well defined Corporate SDI can be used, when participating in a National SDI.

Conclusion

Use of DTB / Kerngis isn't suited because of the following characteristics:

1. Absence of a useful Corporate SDI. Stating the "need of information" is a difficult task
2. Mismatch in quality parameters of the spatial objects: Accuracy at a too high level and Up-to-dateness at a too low level
3. Objects of registration in DTB / Kerngis contain the necessary spatial objects (see paragraph 5.1)
4. Data set "DTB Droog" and application Kerngis has been integrated at the Dienstkring. Data can't be separately uploaded
5. Own Directorate-General Terrain Model is used in DTB Droog. NEN 3610 won't be used, but Terrain Model can be transformed to NEN3610

6.3.2 Fitness for use of NWB - Wegen

<u>Data oriented analysis</u>
The NWB - Wegen can be considered as a one-dimensional representation of the road (vectors are centre lines of highway). The geographical data about objects stored in the NWB has a high up-to-dateness (Cluster 4). On the other hand the accuracy is very low (Cluster 2/3). The quality parameters seem to have the opposite characteristics of Kerngis. Therefore the NWB is most suited to store thematic data and addressing this data to road segments. This is also the main purpose of the NWB. Thematic data, which doesn't have to be stored at a precise location, can be stored in the NWB (e.g. status of pavement, accident registration, etcetera) and many administrative data sets use the NWB as reference system. Exchangeability between different systems should be easily performed by using the NWB. This is the most important characteristic of the NWB. Point of attention is the interchangeability with Kerngis. A binding function in Kerngis is available to link attribute data from the NWB – Wegen into Kerngis / DTB data.

<u>Operation oriented analysis</u>
The need of operations is significant different then in Kerngis. Although the NWB is a data set and therefore can't perform operations the NWB is used in several applications as a reference system. Added with a BPS coding, thematic data can be addressed to certain road segments. The applications, which use the NWB as reference system are Tisbo, Disk, Winfrabase and Weggeg. The NWB is distributed every 3 months by the AVV and they are the only ones, who can change geometry. Because the main purpose of the NWB is addressing attribute data to the NWB, storage of attributes is a must. Also performing analyzing is necessary for the information supply. Performing overlay analyse with data in Kerngis is also desirable.

<u>Spatial Data Infrastructure</u>
The NWB – Wegen is part of the National SDI. The Topografische Dienst Kadaster is a mayor participant in Geo-information and supports the development of an National SDI (the data set aspect). NWB - Wegen data set is related to the TOP10 vector data set. Thematic data in other geographic data sets, which are also related to TOP10 Vector can be linked. OpenGIS standards can create the possibility to use the spatial temporal characteristics of the NWB / TOP10 Vector for updating the NWB – Wegen.

6.3.3 Fitness for use of AHN

<u>Data oriented analysis</u>
While interviewing the users to determine the need of information, necessary to support the work processes regarding maintenance of the Highway Network, all users indicated height data isn't necessary. At the work processes regarding construction the height data play an important role, but not during maintenance of the highway network.

6.4 Integral Analysis

This paragraph will present the integral analysis. The detailed results from Chapter 5 will be used to state more global analysis. The IAF (see also supplement 3A) will be used to structure these analysis. The first part of the paragraph will discuss the dependency of the Business column. What is the influence of this part of the IAF?
The second part will discuss the focus of this thesis: the Information analysis. What information is needed to support maintenance of the Highway Network and what are the results of the used approach?

6.4.1 Business Dependency

Stating the optimal information model and functionalities isn't possible without knowing the Business conditions. These factors won't be analyzed, but it's important to understand these conditions. Need of information (Information – What) is more or less dependent to all aspects mentioned in the Business column. The aspects are discussed by box of the column Business followed by the global approach of the Business column.

Why:
First of all the Mission and Vision should be clear. The problem of this box is the abstract level of the vision. A more specific and detailed representation of the vision is necessary to determine the need of information. Also the transparency of the Business Strategy: How should the objectives of the organization be reached should be clear. This means to realize the Business Strategy is discussed at a more specific level at the "With What"-box. The parameters will still be the same in both situations. These objectives, regarding maintenance of the Highway Network, are stated in paragraph 2.1.1. These objectives has to be realized by the work processes (What) with certain means (With What).

What:
This box is the most specific and usable box of the "Business"-column. The most important features of this box are the work processes (already derived from the primary processes), which have to be performed. Defining a framework of work processes is most complex task and the approach and result has been discussed in chapter 3. The purpose is the development of a concrete frame of processes, which can be used to investigate the need of information (Information – What) and establish a direct and concrete link to the column "Information". These work processes will be the same in both situations. Comparing the need of information regarding the processes can only be performed when these variables will be the same. The processes are listed in paragraph 3.4.

With What:
This box is derived from the Business Strategy and presents a direction by stating which means should be used to accomplish the objectives. The change of policy does in fact influence this box. The policy change regarding outsourcing (Business – Why) changes the kind of contract (Business – With What). The use of traditional contract will be diminished and the new mean, performance contract, will be used. The use of these means has an impact on the processes, which should be performed and the corresponding need of information.

Global approach:
The dependency of need of information is stated in the Business column. The Why-box is the most abstract box and can't be used as frame to invest need of information, but should be used as checking box. This box should be used to check the accomplishment of all objectives. The With What-box shows the instruments, which should be used to realize the objectives. These instruments (like performance contracts) may have impact in the procedures. Therefore the need of information is dependent of the used instrument. Relating the Business column with the Information column should performed as concrete and detailed as possible. Only the "What"-box is concrete enough to relate the Business with the Information. The developed model of processes should be capable to relate to the aspects mentioned in Information – What (Supplement 3a):

- Demands and desires of the information,
- Used information objects,
- Distinction of stages in the working processes,
- Quality parameters,
- Information characteristics

6.4.2 Information Analysis

The Information column is the most important column of my research. The analysis, which will be performed, are focused on this column. The analysis about the need of information will be performed at the box "What". The need of information is compared with the current and innovative data sets. These data sets will be analyzed in the With What-box. Besides the data sets, also new information technological opportunities (Geo-services / Open GIS) and methods which can increase quality parameters of certain data sets (VaRi-method) will be discussed and related to the need of information. One of the most important analysis, which will also be discussed is the relation between Business – What and Information – What. The different aspects from the IAF (Supplement 3A) are used to structure these analysis.

Information - Why

No analysis will be performed in this box. The Why-box is focused on the information policy and strategy. Some assumptions of a desired information strategy will be defined:

Explicit Information supply: The explicit Information supply will be regarded as an optimal scenario. The explicit Information supply is based on the users' perspective. This scenario and conditions are discussed in paragraph 2.4

Use of available databases: The use of available geographic databases is allowed, when a better information supply can be guaranteed. Especially when an external geographic database is more suited to support the work processes.

Multiple use of data: A multiple use of data would be advisable. Of course the geographical data used per theme would be stored in the same data set. One large scale data set should be used to store data and one mid-scale data set could be used to store data about less accurate needed attributes. Dependent on the fitness for use, one of these data sets should be used. An Information Architecture can support a structured use of spatial data. Creation of information islands should be avoided by using an Information Architecture.

Information – What

This part of the paragraph will focus on the realization of relating Business – What with Information – What. The five aspects of the Integrated Architecture Framework indicated in the box Business – What (see paragraph 6.4.1) will be approached from the Information – What box.

A Information Objects and Quality Parameters

To determine the geographical data necessary to support the processes, an overview of the needed objects with quality parameters has to be created. Paragraph 5.1 presents the need of information by object model per theme. Because geographical data should be used to support all processes, an overview regarding need of information has to be made of all themes regarding maintenance. The need of information regarding the use of traditional and performance contracts have been presented in two object models. Supplement 18 shows the object model regarding need of information to support maintenance using a traditional contract. Supplement 19 shows the object model regarding need of information to support maintenance using a performance contract. This thesis has to determine a difference in need of information while using the performance contract (instead of traditional contracts) and performing analysis to describe an optimal information supply (in the future).

The first quality parameter is the global accuracy. The main reason for this decrease of accuracy is the focus of the contracts to performance instead of a detailed description of what the contractor should do. While developing traditional contracts surface calculations and detailed information was stated about the maintenance what should be performed. Performance contracts will only describe the functionality and purpose, what should be achieved by the contractor: How should the Highway and surroundings look like. This change in need of information, created a devaluation of the accuracy of the geographical component.
Some of the objects do still need a high accuracy (approximate 30 cm). The reason this level of accuracy is necessary is the need to register the cables (including reference objects: Kant verharding and hectometerpaaltjes) of the Directorate.

The second quality parameter is the necessary up-to-dateness. An overview of the necessary up-to-dateness is shown in Supplement 19: Need of information – Performance contact. The needed level of up-to-dateness is high. The reason is the support of geographical data to their processes when the geographical changes are made. The most important problem is the storage of data will cause problems to store inspection statuses / reports. The Dienstkring itself is responsible for maintenance of the Highway and when change took place, although the Dienstkring is aware of the changes. Appointments should be made with the contractor to deliver a geographic mutation data set to keep the geographic data of the Highway Network up-to-date. This mutation data set should be integrated in a Corporate SDI (at Directorate-General level).

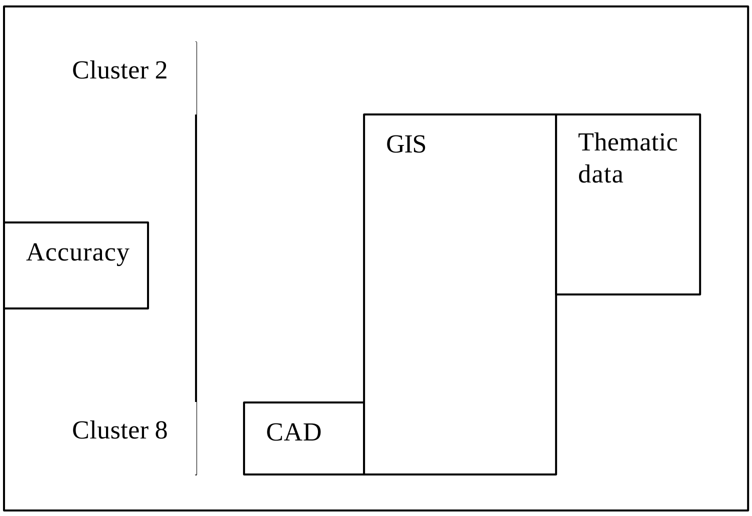


Figure 6.3: Use of geographic data (by accuracy)

A remark is the difference in use of the geographic data. The different use can be distinguished by accuracy. Two main perspectives can be distinguished. First the CAD-applications, which need the most accurate data. The purpose of CAD usage is mutating and drawing geographical data (vectors).
Secondly GIS, which needs less accurate data. The purpose of GIS usage is analyzing geographical data (thematic data + spatial component). Because of outsourcing, processes at the Dienstkring will change. Storing inspection data and developing a maintenance vision will become more important. Supporting the planning and realization process will disappear. Integration of CAD and GIS data will become necessary.

A potential opportunity to increase the up-to-dateness of geographic data set, would be the use of the as-build designs (CAD drawings) of the Highway. Van Oosterom et al. (2004) discusses the problem between Computer Aided Design (CAD) and Geographic Information Systems (GIS) and states the interoperability problem between CAD and GIS can only be solved by examining it at the right level of abstraction and by studying the different semantics used in both worlds. Two crucial steps can be recognized. The first step is stating a formal description of the semantics used in both domains. During the next step a design has to be created with one central formal semantic that is compliant with both GIS and CAD semantics. This formal semantic can be used in the factual integration of GIS and CAD, which should be implemented in an integrated data management structure based on the multi-view model. This structure should be well defined in a DBMS environment (Oosterom et al., 2004).

B Information Characteristics: Status vs. Functionality

While using traditional contracts, inspection results were used to up-date attribute data and signal changes in the geographic data. The attribute data can be considered as different statuses regarding objects of maintenance. When an object has a low status, an object requires maintenance and a planning would be developed. After planning maintenance, a contract would be made to perform the necessary maintenance. The data used to support these clusters of processes would be geographical data and inspection data. This used data has been measured and described a historical situation.

The use of a performance contract will demand different data storage. The developer of the contract has to store his subjective (but clear) vision into the application. This vision should be shared (and communicated) with the contractor, because the contractor has to accomplish the vision. Besides communicating the vision to the contractor, the inspectors have to monitor the situation and should check maintenance: Is maintenance at the Highway (and surroundings) performed according to the described vision? The data used to support maintenance has to describe a future scenario. Besides the progress should be monitored.

The mentioned characteristics of the data regarding the use of performance contracts, demand a significant change of storage of data. One of the characteristic is the demand to the data set to store more semantic data. Just storing statuses, like the current situation, wouldn't be sufficient. Storing and presenting the data would be best if the participants would have the same reference to interpret the data. Virtual Reality pictures have to communicate a clear vision towards another person. Those VR pictures can be interpreted in one way, while numbers can be interpreted in different ways. A major disadvantage of pictures is the complex storage of objects in these pictures. The contractor and inspectors has to store data about the objects in the pictures. The system should be able to present a picture of the necessary characteristics. Figure 6.4 and Figure 6.5 shows two different examples of visions of maintenance of Nature and Environment along the Highway. A way of storing data with the possibility to create those pictures and store inspection data has been described in paragraph 4.4.4: Pe

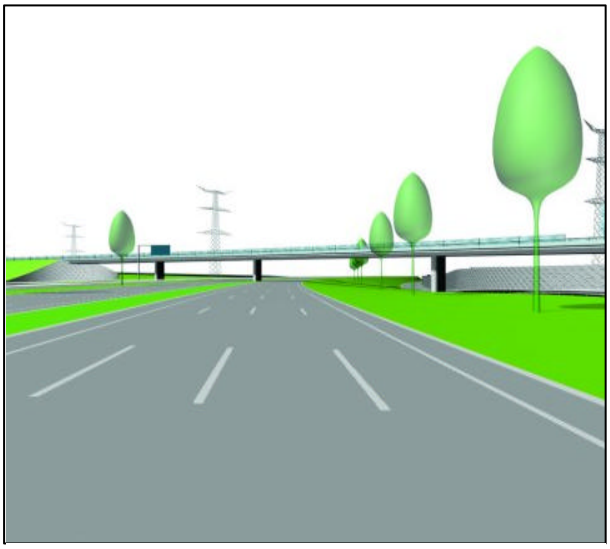


Figure 6.4: Vision of Maintenance: Scenario A

Figure 6.5: Vision of Maintenance: Scenario B

Only by using images, the (functional) vision of performance contracts can become clear. This VR pictures contain lots of semantical data, which are easily communicated to the receiver (contractor) and can be interpreted in one way. The supporting landscape architecture application should use the same Geometric Object Model with the same formal semantics compliant with Kerngis. A possible solution is presented in paragraph 4.4.4: the performance contract module. This module / application should be used to create VR pictures by using Kerngis data. A point of attention is keeping the geographical data up-to-date. When a contractor performs maintenance, clear regulations should be made, what data will be supplied to the Dienstkring. Without these regulations, the Dienstkring will be dependent on the data of the contractor. Geoservice can offer the solution. When the contractor would like to keep its data (at the source), the geographic data set of the contractor can be registered in the application used at the Dienstkring.

C Distinction need of information by stages of processes

Determination of the need of information by process isn't detailed enough. The inspectors outside does have a different need of geographical information compared to an employees at the Office, who has to develop Landschapsplannen. The difference in need of information can also be recognized at the Office. Employees, who are analyzing inspection data to develop contracts, does have a different need of geographical information, compared to a planner. The model of processes (Figure 3.4: Conceptual model: Primary processes at the Dienstkring) does show a distinction in processes. Using this clustering of processes, the analysis regarding objects and functionalities will be presented. These analysis will present the analysis considering outsourcing of maintenance. The procedures how the primary processes are performed are presented in paragraph 3.1: Primary processes at the Dienstkring.

Primary Process: Technical Functional Maintenance

<u>Inspections</u>
Besides the need of information at the Office, the inspectors outside do also have a need of information / functionality. The data necessary to support their processes is focused on Inspection. These inspection results have to be related to a certain object / location. This need of information can be presented by a small, easy to use palm computer with a location device (e.g. GPS). The palm can show the current position at a map. Inspectors do need the same geographical data as at the Office, remarking that changing some of the attribute data is their main purpose. The presented geography has to be used as object to store and mutate attribute data. The use of mobile computers by the inspectors has another advantage. Import of the inspection reports and checking inspection data, usually does cost a lot of time. The use of Mobile ICT can improve data distribution by uploading the data in Kerngis (part of Spatial Data Infrastructure).

<u>Technical Maintenance</u>
At Technical Maintenance two main responsibilities can be distinguished: (1) the vision of maintenance has to be developed and (2) the inspection results have to be processed and analyzed. The object model regarding the need of information and corresponding accuracy is presented in Supplement 19: Need of Information – Performance Contract. Geographical data about these objects should be available. Because precise directives aren't formulated to perform Technical Maintenance using performance contracts, the invested scenario of outsourcing of approximately 70% of the areaal-objects will be formulated. Storing and mutating the geometry, as well as the attribute data, should be possible. Also the necessary analysis like selection of attributes in a certain area and just selecting a certain area should be possible. These spatial operations should be available to support the themes: Nature and Environment, Pavement and Traffic Requirements. The need of information regarding the theme Civil Infrastructures has a dominant administrative aspect. The use of an attribute database and the Construction Aided Design (CAD) drawings are more needed then implementing the data in a central geographic database. Although some geographical data regarding the Civil Infrastructures is necessary. These data is stated in the object model. The analysis performed will be focused on processing inspection data.

<u>(Planning)</u>
When performance contracts will be used, the planning doesn't have to be performed, because the contractor is responsible for the planning of maintenance.

<u>(Realization)</u>
Realization is performed by the contractor. The Dienstkring doesn't have to support the need of information regarding Realization. Because at the Dienstkring there is a need of information and dependency of the up-to-

dateness, regulations should be defined to make sure the contractor does supply the changes to the geographical data sets. The up-to-dateness and accuracy of the geographic data (and format) delivery should be regulated in the performance contracts. The advice according this research is a data supply corresponding the object model (with the format, which can be integrated in the application).

Primary Process: Daily Maintenance

(Global) Inspections
The Inspections performed regarding this Primary Process are the Global Inspections. These inspections require the storage of attribute data. Storage by palm computer (same as used by Inspections regarding Functional Technical Maintenance) would be preferable. The only functionality is the storage of attribute data and the supply of that data to Technical Maintenance. The needed accuracy of the geographic data is low. Because these inspections are performed on a daily base, the inspectors should have the ability to store some geometric changes. These changes can check the up-to-dateness of the used geographical data set at the Office.

Incident Management
Nowadays outsourcing of Incident Management is quite usual. The basic activities are performed by the inspectors. When necessary a contractor will be called and has to repair the damage caused by the Incident. Also the process: Gladheidsbestrijding is performed by a contractor. The only need of information by the inspectors is the request to call a contractor (view attribute data) and register the incident (store attribute data).

Primary Process: Juridical Maintenance

Granting Permits
The processes regarding Granting permits are all included in the theme “Exploitation”. Granting a permit requires registration of the permit. The procedure of granting the permit has been described in paragraph 3.2.1. The need of information to support this process won’t change. Because granting of permits won’t be outsourced, the necessary information should be the same. The inspectors will check the proposal so this data doesn’t have to be presented at the Dienstkring. Although the Dienstkring has to register the permit. An accurate registration of the permit (objects) is obligatory by law and needed by (for example) the contractor. Storing, mutating and analyzing geometry and attribute data is necessary at the registration of permits.

Checking Permits
The processes regarding Checking permits are all included in the theme “Exploitation”. The inspectors need the permit itself (text and drawings) and check if the applicant sticks to the permit restrictions. After the activities the inspector should store the applicant performed the permit according to the permit. Using a copy of the permit would be useful. When a palm computer is available it could be used. A paper representation of the permit should also be sufficient.

Information - With What

The Information – With What box includes the data sets. The currently used data sets (DTB Droog and NWB) have already been discussed in paragraph 6.3. This part will discuss the innovative data sets en methods.

A Fitness for use of GBKN

The GBKN is a nationwide large-scale geographic data set. This geographic data set hasn’t been used to support the maintenance of Highways. The accuracy of the GBKN in rural areas is classified in Cluster 4 and in urban areas in Cluster 5. The objects included in the GKBN are mentioned in Supplement 11. The up-to-dateness is four months (Cluster 4) (www.gbkn.nl). Because the GBKN isn’t used in the current situation, the data oriented analysis will focus on the future use (outsourcing).

Data oriented analysis
The objects which should be registered compulsory (by municipalities) can support the work processes regarding maintenance of the Highways. Comparing these quality parameters with the information model of *Supplement 19: Need of information - using performance contract* the accuracy of most objects is sufficient. Besides storing the compulsory objects, some objects can be stored voluntarily. Therefore a hundred percent completeness of

some objects near the Highway can't be guaranteed. Two spatial reference objects "Kant Verharding" and "Hectometerpaaltjes, should be measured according to a more accurate way. Most of the other required objects are defined in de GBKN definition library. The used Terrain Model is according NEN 3610 and the exchange format (NEN3610) is a common used format (GML-based) so interchangeability is possible with other data sets. This makes interoperatibility, with for example Utilities or other users, easier.

Operation oriented analysis

The GBKN is a data set and not an application. So testing the operation-oriented characteristics isn't logical. The GBKN is currently line-based, although the data structure is suited to make the data set object based. One of the purposes of the LSV GBKN is making the GBKN object based. Making the GBKN object based can support the information model, which can be used to support working with performance contracts. Using OpenGIS (Geo-services) the GBKN can be used as part of the Spatial Data Infrastructure.

B Fitness for use of Top10NL

The description of the Top10NL has been presented in paragraph 4.3.2. This data set is suited to support registrations with a spatial component. The Top10NL is a product what can replace the NWB in the future. The Top10NL has all advantages of the NWB and presents the solutions to the disadvantages of the NWB. Exchange of spatial data and attributes with other departments is possible by using GML. The Top10NL has to replace the use of the Top10 - Vector and Top10 – Wegen, because all data characteristics of both data sets will be combined. The exchange of data sets and attributes is based on mid-scale data sets (1:10.000).

C Fitness for use of VaRi Method

The VaRi Method is an innovative method for increasing the up-to-dateness of the DTB Droog with the same objects and quality parameters of the DTB Droog by terrestrial measurement. Not taking into account the need of the DTB Droog, the VaRi method does provide an alternative solution for the development of DTB. Also the possibility of performing additional measurements to increase the up-to-dateness will contribute to a better product. The disadvantage is the bad fitness for use of the DTB itself. Some of its quality parameters are too high, but the accuracy may be suited. The result may be a geographic product, which can support the processes at the Dienstkring. The fitness of use is dependant on how Kerngis can cope with storing functionalities.

D Fitness for use of Performance Contract Module

The Performance Contract Module is an example of an object model what can be used to store visions / functionalities. The DTB data can be used to store the inspection results and the extra Module can be used to support the performance contracts. It's important the Performance Contract Module uses existing data. The usage of other existing geographical data with a suited information model and quality characteristics would be useful too (like GBKN adapted with features from the DTB).

E Fitness for use of Geo-services

Geo-services has been described in paragraph 4.4.5. Using this technological opportunity improve an Corporate Spatial Data Infrastructure. Geo-services is very suited to support the work processes, because it makes geographic data accessible. Some potential advantages of Geo-services are:

- Using a new Architecture to develop a Corporate (or even National) Spatial Data Infrastructure
- Data sets can be maintained at the source at distributed by Geo-services, which improves the up-to-dateness
- Possibility of distributed updating: When using Web Feature Services – T(ransaction) data sets at different locations can be updated.
- No need to run heavy applications at local computers. Servers can be used to run the application. A browser at the client is sufficient

7 Conclusions and recommendations

In previous chapters the research regarding the Optimalisation of Information Supply has been discussed. This chapter will present the final conclusions and recommendations.

7.1 Conclusions

The conclusion will start with discussing the approach used to answer the main research question. Afterwards an answer will be presented to the main research question.

Approach of Optimalisation of Information Supply

To answer this research question, many aspects have to be taken into account and be modeled. The following aspects were identified as crucial to find the answer:
1. Changing policy to use “Performance Contracts” instead of “Traditional Contracts”
2. Starting point to analyse need of information would be the working processes and differentiations

1. <u>Changing policy to use “Performance Contracts” instead of “Traditional Contracts”</u>
While performing interviews, the users indicated the use of “Performance Contracts” causes a mayor shift in need of information, because the processes and responsibilities were changing. Some of the Dienstkringen used traditional contracts and some did already use performance contracts. During the interviews, the need of information of both situations were analyzed and there was a mayor change in need of geo-information and use of geo-information. One of the objectives of the research was stating the difference in need of information.

2. <u>Starting point to analyse need of information would be the working processes and differentiations</u>
Need of information should be investigated at a detailed level. Just asking what data a user needs, can’t be used to store and analyse need of information. A list of work processes should be made. As a result three different differentiations were made. The first differentiation was made by the three primary process:
   - Functional Technical Maintenance
   - Daily Maintenance
   - Juridical Maintenance

   Besides these three primary processes, different stages of work processes can be recognized. The reason is the different need of information (regarding the quality parameters) during the different stages of the work processes. A conceptual model of work processes has been developed to cope with the different need of quality. The second differentiation was made by the different stages:
   - Planning
   - Technical Maintenance (includes preparation of Realization)
   - Inspection (global and technical)
   - Incident Management
   - Granting Permits
   - Checking Permits

   The need of information to support maintenance of the Highway Network has been stored in the developed model. The use of performance contracts did show a difference in stages of the work processes. Stages like “Planning”, “Incident Management” and parts of “Technical Maintenance” (preparation of realization) disappeared. The usage of performance contract developed a “Technical Maintenance” highly related to “Inspection”-data processing “.

   The third differentiation was made by the themes:
   - Exploitation
   - Pavement
   - Civil Infrastructures
   - Traffic Requirements

- Nature and Environment

After these differentiations, a model has been created with these differentiations and a list of working processes was used as base to invest the need of information.

These three aspects have to be integrated and a suitable approach should structure the aspects. The Integrated Architecture Framework (IAF) by Cap Gemini is a Framework (Supplement 3A), which can be used to integrate the mentioned aspects. The work processes (of the Business column) can be related with the need of information (of the Information column). A detailed model of work processes has been necessary to link these two columns. The detailed model of work processes could be mirrored into a detailed scheme, which represents the need of information. This scheme will be used to perform further analyses in the "Information"-column.

The IAF has also been used to structure some aspects in the "Information"-column. Following aspects has to be solved:

1. Model of need of information has to be related with Model of Data Set
2. What has elements has to be stated for a suitable support of geo-information
3. Potential data sets could be existing or non-existing

1. Model of need of information has to be related with Model of Data Set

   The need of information has been stored by spatial objects (with quality parameters) and thematic data per object. The objects will be ordered by accuracy. This representation is the Object Model. A Definition Library will contain the definitions of the spatial objects. This representation will be compared the Object Model of the data set. When an Object Model isn't available, an Data Model can be used.

2. What entities should be considered for a useful support of geo-information

   The entity stated by the main research question is the data set. It seems the answer would contain an Object Model (including accuracy parameters) with thematic data. That wouldn't be sufficient. Following entities should be considered:
   - Data Set: Define the Object Model (including accuracy parameter) with thematic data
   - Functionality: The IAF indicates an Application (- What) aspect. What functionalities (operations) should be performed by the application.
   - Spatial Data Infrastructure (SDI): At Department level also technology to communicate, procedures for exchange, policy and standards for description, exchange en relating geo-information has to be created. These elements are part of a SDI.

3. Potential data sets could be existing or non-existing

   The need of information should be represented in a suitable way. The first aspect was stating the spatial objects, which have to be stored in the data set. The second aspect was stating the necessary quality parameters (accuracy and up-to-dateness). The representation of need of information is presented in Object Models. The Objects (with thematic data) were ordered by needed accuracy.

Conclusion

This new approach can relate Business elements (of the IAF) into the "Information"-column. Object Models can be used to present the need of information. The used approach even can be used to investigate need of information in changing environments. This investigation can be performed by a structured approach. In Application Development this approach can be used as pre-fase before "Prototyping".

In the next fase (which isn't performed during this research), the presented Object Models should be transformed into Data Models. This Data Model can be used to create a prototype. The prototype can be used to check the need of information at a larger user-group to determine the reliability of the presented need of information. The information support to perform work processes should be guaranteed. Changes can be made after "Prototyping". Finally the created application should be able to support the users in their need of information.

Conclusions about geographic information supply

The main research question has been stated as:

"Which geographic data sets can support the need of information regarding the work processes Maintenance of the Highway Network at the Dienstkring and what level of quality of the geographic data is necessary?"

The main question will be answered from a Spatial Data Infrastructure's point of view. Just mentioning a geographic data set or its specification won't present the solution to this question. The solution will be presented by the four elements of a Spatial Data Infrastructure (SDI):

A. policy and organization
B. geographic data
C. technology to store, communicate and use geo-information
D. standards for description, exchange en relating geo-information

A. Policy and Organization

The elements regarding "policy and organization" can be considered as conditions for the information supply. The new directive, regarding outsourcing of maintenance of the Highway Network by the instrument "performance contract", is the cause of a major change in need of information at the Dienstkring. Storing, analyzing and presenting former statuses of areaal objects seemed to be insufficient to support the work processes. Performance contract has to describe the functionalities and future vision of the Highway Network. The spatial-temporal component of the data will be introduced to support the development of future visions. How a contractor performs maintenance isn't important anymore. Only realization of the functionalities should be fulfilled. The first conclusion of this research concerning "policy and organization" is the mayor change in need of information while using performance contracts instead of traditional contracts. The differences in need of information are:

1. Changing quality parameters. Level of accuracy of the spatial objects is decreasing. Level of up-to-dateness remained the same, but should be improved considering the current data supply
2. Increasing demand of storing functionality of objects instead of storing statuses of objects
3. Objects in the Object Model won't change. The areal objects, which require maintenance isn't changing. Only the level of accuracy is decreasing

B. Geographic Data

According to the conditions of "Policy and Organization" only the need of information using performance contracts will be investigated. The model of work processes indicated five different themes. The possibility of significant differences in need of information at the different themes could exist. Except the theme "Civil Infrastructures" the other themes do have a difference in need of information, but the difference isn't significant enough to recommend use of different geographical data sets. Using a single large scale geographic data set would be recommended. The need of information (of all five themes) has been presented in an object model (Supplement 19: Need of information - Performance Contract).

Comparing the need of information with the currently used geographical data set with application DTB/Kerngis [1] shows some remarkable aspects. The necessary objects are included in the DTB [2] and could even exist of fewer spatial objects. Most remarkable are the quality parameters. The level of accuracy of the DTB is very high. Even too high, because its level of accuracy isn't necessary to support the work processes. On the other hand, the level of up-to-dateness is too low. The DTB doesn't match with the necessary quality parameters. Two solutions can be chosen.

> The first solution will be adaption of the DTB. The most important task should be the improvement of the up-to-dateness. The VaRi-method has been developed to cope with the up-to-dateness, but is expensive.

[1] Digitaal Topografisch Bestand / Kerngis
[2] Digitaal Topografisch Bestand

The second solution is the use of another existing geographic database with the necessary quality characteristics. The GBKN [1] does have the corresponding quality parameters. A disadvantage of the GBKN is the small amount of objects, which have to be stored. Therefore the completeness of the areaal objects can't be guaranteed.

Considering these solutions, the use of GBKN as geographical data set, would be a preferable solution.
The first reason is the necessary up-to-dateness. Keeping the DTB up-to-date with a normal budget would be impossible, considering a geographic data set with the same quality parameters and the existing measurement techniques. Using the GBKN would include more participants of the geographic data. The costs for the development of the data set can be split. Regulations about measurements near the Highway should be made.
The second reason is the need of interchangeability of the data. The GBKN is a commonly used geographical data set. Other Departments of Ministries do already use the GBKN. Usage is also quite realistic, the contractor would use the GBKN, because it's the only nationwide large-scale geographic database in the Netherlands.
One remark should be made. The object model of the need of information does indicate a higher accuracy of the reference objects. An addition of the "Hectometerpaaltjes" and "Kant verharding" in the GBKN with a higher level of accuracy would be preferable. Also a possibility of storing centre lines (of NWB [2]) in the data set would be preferable for addressing thematic data to certain road segments.

Besides the use of DTB/Kerngis, the NWB is another geographical data set used in applications. Weggeg and Winfrabase do use the NWB to present the attribute data and TISBO uses the NWB as a spatial reference system. The main advantage of using the NWB is storing attribute data to road segments. An important difference is the mid-scaled geographical data, used in this data set. The use of the NWB is sufficient, when the accuracy isn't important. The global storage of thematic data can be easily performed by using the NWB. The reference system BPS (1989) can be used for a more detailed positioning of the data. The TOP10NL will be finished in 2006 and this data set will have all necessary characteristics to address data to a certain location.

C. Technology to store, communicate and use geo-information

The same geographic data sets have to be used in different locations. Also thematic data, available at the Dienstkring or a Specialist Department. Most preferable would be storage of data at the source. Using "Geo-services" makes sure data is stored at the source and guarantees multiple usage of data by communication of the data towards the users. Table 7.1: Department - Data owner, shows the Specialist Departments supplying data to the Dienstkring.

Department	***Kind of data***		***by application***
Department of Geo-information and ICT	Geographical data	– All objects	Kerngis
Road and Hydraulic Engineering Institute (DWW)	Thematic data	– Pavement	Winfrabase
Civil Engineering Division (BD)	Thematic data	– Civil Infrastructures	TISBO
Transport Research Centre (AVV)	Thematic data	– Traffic Requirements	WEGGEG
Dienstkring	Thematic data	– Status / Vision	WEGGEG

Table 7.1: Department - Data owner

The project "Geo-services" is supported by the OpenGIS standards of Web Mapping Services (WMS). In the future, also Web Features Services (WFS) should be available. Geo-services creates an excellent opportunity for development of a Corporate Spatial Data Infrastructure (SDI).

Using one large scaled geographical data set and one mid-scale geographical data set would be preferable. Supplement 19 describes the Object Model with the necessary accuracy. On the other hand, the use of geo-information during the different stages differ. The need of functionalities by the different stages of processes are:

[1] Grootschalige BasisKaart Nederland
[2] Nationaal Wegen Bestand

Inspection: The inspector indicated the need of digital storage of statuses. A pilot project at Dienstkring Apeldoorn also indicated this need of functionality. Inspection of objects by assigning different statuses is the main functionality. An additional advantage of storing the attribute data digital is the increasing up-to-dateness and possibility of shortening the procedure.

Technical Maintenance: The need of operations by the employee at the Office, can be addressed by two major tasks: (1) Processing and analyzing inspection reports and (2) development of performance contracts. Processing and analyzing inspection results require functionalities like, viewing, updating and analyzing (selection by attribute and geometry). Development of performance contracts requires to store functionalities. Integration of CAD en GIS data would be useful. Paragraph 4.4.4. describes a possible solution by relating formal semantics of their Geographic Object Models.

Incident Management: Incident Management will be outsourced. There will be no need of geographic information, besides an accident registration. When necessary the inspector has to call the contractor.

Granting Permits: Legislation demands storage of the cables of the Directorate. Viewing and storing geographical and thematic data is necessary. Also participating in a KLIC-calling is necessary, which require an overlay operation. Analyzing by geometry is also required.

Checking Permits: The inspector requires digitally stored statuses. Also the data in the permit has to be available to check the applicant. Permit data like CAD-drawings doesn't have to be stored digitally. A copy of the permit would even be more useful. The same requirements are needed as at the stage "Inspection"

Summarized, all functional requirements of the current systems are necessary. Because the incomplete implementation of Kerngis some operations aren't functional yet, but be soon. Use of a landscape architecture application for developing performance contracts (at Technical Maintenance) and Mobile ICT(during Inspection) is advisable.

D. Standards for description, exchange en relating geo-information

Description of geo-information is performed by Geo-services in a catalogue application. This catalogue application can search in a register to certain metadata so the desired data could be found. A data set has to be published at the register of "Geo-services" to be listed and create a possibility for exchange. The web based application of Geo-services can bind (relate) different data sets (sources) with geo-information, so analyses can be performed. These binded sources are transferred by use of WMS. These features are currently available in Geo-services.

The usage of OpenGIS standards is a condition for data exchange by WFS. WFS can exchange features. An example of using WFS – T(ransaction) is distributed update possibilities of a data set. Unfortunately the AGI currently decided to use its own Terrain Model instead of NEN3610/1878 (Terrain Model).

7.2 Recommendations

This paragraph will suggest some recommendations regarding this research.

Recommendations

1. This research has been framed to “Maintenance” of the Highway Network. When performing research according the same approach at “Traffic Management” and “Construction”, the total need of information regarding the Highway Network should become clear.

2. After investigation of need of information at the Dienstkring (Level 4), the need of information at the Regional Direction (Level 3) and Head Office (Level 2) should be investigated and related. A Geographic Object Model should be developed, which has to support the need of geographic data at all Levels.

3. Storage of geographic data is realized in the application (DTB/Kerngis). Using data from this application in a Corporate Spatial Data Infrastructure requires separation of data set and application. Development of a Corporate Spatial Data Infrastructure is recommended. Also participation in the National Spatial Data Infrastructure can be useful to reduce costs.

4. The approach of this research can be used as part of a development method. The used method can be recognized as first stage of the development of Information Systems. Strength of this approach is the investigation of need of information. The second stage can be fulfilled by prototyping. The producer has to develop a prototype according to the object model.

5. Build a Corporate Spatial Data Infrastructure. Keep in mind useful data sets from the National Spatial Data Infrastructure. Recommendation regarding the data set is storage at the source. Table 7.1 shows an overview of types of data with sources

Interview list

Gebruikers		
Dienstkring	**Functie / Aandachtsgebied**	**Persoon**
DK Waarden	Hoofd Beheer	Steven van Hese
DK Waarden	projectleider	Evert van Tweel
DK Waarden	Verkeersvoorzieningen / Verharding	Bram Venema
DK Waarden	Verkeersvoorzieningen / Verharding	Vincent Prins
DK Waarden	Exploitatie	Rachel Nooij
DK Waarden	Landschap en Milieu	Ruben Plazier
DK Waarden	Areaalbeheerder	Sjaak Boganen
DK Waarden	Rayoncoordinator	Martin Versluis
DK Huis ter Heide	Hoofd Beheer	Caspar Voorburg
DK Huis ter Heide	Landschap en Milieu	Eric Nieuwerf
DK Huis ter Heide	Verharding	Rudy van Bemmel
DK Huis ter Heide	Verkeersvoorziening (WED)	Rob te Koppele
DK Huis ter Heide	Exploitatie	Bouke de Jong
DK Huis ter Heide	Verkeersvoorziening	Ruud van den Broek
DK Huis ter Heide	Kunstwerken	Ruud van den Broek
DK Huis ter Heide	Inspecteur	Arris Hardeman
DK Huis ter Heide	Inspecteur	Evert van Essen
DK Apeldoorn	Hoofd Beheer (pres. con.)	Jan Oonk
DK Apeldoorn	Coordinator Beheer	Friso Klapwijk
DK Apeldoorn	Juridisch medewerker	Marieke Top
DK Apeldoorn	vice-rayoncoordinator	Jeroen Homburg
DK Apeldoorn	Areaalbeheerder	Floor van Nes

Specialisten	
Onderwerp / Functie	**Persoon**
Senior-adviseur / productverantwoordelijke GII standaarden/generiek	Adri den Boer
Senior adviseur en accountverantwoordelijke droge sector	Jacqueline van Rooij
Senior Adviseur (mbt tot IAF)	Ardy Siegert
Adviseur en Productverantwoordelijke Geo-informatie infrastructuur-advies/specifiek (IAF)	Pieter Meijer
Adviseur (o.a. Planmatig Beheer)	Albert Driesprong
Adviseur GIS (Kerngis 9)	Merijn Hansler
Kerngis specialist	Piet ten Haaf
Systeem specialist	Ted Stevens
Technische adviseur GBKN	Hans van Eekelen
IT consultant GIV-BOO-Nat	Kees van der Graaf

References

Adviesdienst Verkeer en Vervoer, Handleiding NWB, 2003, Rijkwswaterstaat, www.rws-avv.nl

Adviesdienst Verkeer en Vervoer, 2004, Productcatalogus 2004, Rijkswaterstaat,

AGI, Strategisch Bedrijfsplan AGI

Ahonen P, Metadata of geographic information, 5.9.2002, LIBER 2002 conference, Helsinki, http://www.kb.nl/infolev/liber/articles/13ahonen.pdf

Bedrijfsmodel Rijkswaterstaat versie 2.2, 2003

Bemelmans, T.M.A., 1987, Bestuurlijke informatiesystemen en automatisering

Boer de J, Hisschemoller M, 2001, Handvatten voor het concretiseren van de informatiebehoefte

Boer den A.M., 2004, Productplan Geo-Informatie Infrastructuur Standaarden/generiek 2004-2005

Bouwdienst Rijkswaterstaat, 2002, Handleiding TISBO

Brentjes T.J., 2004, OpenGIS Web Feature Services for editing cadastral data

Brevé N.W.P., Productspecificatie DTB-Droog, 2000

Buehler K, Open GIS Consortium, Geospatial Interoperability by Design, GITA 2004 Conference, Seattle

Cap Gemini / Ernst & Young, 2001, Business & Information Architecture Concepts

CEN, 1998, European Prestandard ENV 12656 – Geographic information – Data description – Quality, CEN Central Secretariat, Brussels, ICS 07.040;35240.70.

Derksen, Th.J.G. Crins, H.W, 1992, Automatisering van de informatieverzorging

Dienst Weg- en Waterbouwkunde, 1989, Beschrijvende Plaatsaanduiding Systematiek, http://www.minvenw.nl/rws/dww/home/richtlijnen/bps/

Dienst Weg- en Waterbouw, Handleiding Technische Inspectie, 2^{e} editie,1997

Dienst Weg- en Waterbouw, 2003, Wegwijzer Wegbeheer, blz 7-16:

Dienst Weg- en Waterbouw, 2004, Winfrabase, http://145.50.189.17/winfrabase/winfrabase_keuze.htm

Dierikx-Platschorre Y., 1999, SPOT-beelden houden het Nationaal Wegenbestand actueel, Beleidscommissie Remote Sensing, http://www.neonet.nl/providers/bcrs/folders/nederlands/pdf/42nlpdf.pdf

Directie Oost-Nederland, 2003, Planmatig Beheer, Rijkswaterstaat, Droge Dienstkringen, Afdeling Planmatig Beheer

Eindrapport: Haalbaarheidsstudie Nationaal Wegen Bestand als Authentieke Registratie, fase II, 2004

ESRI® Redlands, 2004, Geodatabase Designer, scheme developed by The Applications Prototype Lab

Fowler M and Scott K, 2000, UML beknopt

Geographic Information Science, URL: http://www.ncgia.ucsb.edu /giscc/units/u100/u100_f.html

Graaf, M.C. van der, 2003, Architectuurverkenning GIV-BOO-Nat

Graafland A., 1993, Informatie analyse

Groenenstein S, 2004, Evaluatie rapport demo “Mobiele Globale Schouw” bij de dienstkring Apeldoorn, Logica CMG Geo-ICT

Groenenstein S, 2002, Resultaten “Onderzoek basisset beheerobjecten Kerngis”, AGI

Grothe M, 2003, Rijkswaterstaat start met implementatie OpenGIS, GeoNieuws 2003-4, www.geonieuws.nl

Grothe M, 2004, Geoservices: RWS realiseert centrale InternetGIS infrastructuur, GeoNieuws 2004-1, www.geonieuws.nl

GSDI, www.gsdi.org

Hengstum M van, Eindrapportage (v0.8) Informatiemodel Hoofdwegennet, 2003, registratie nummer P4304-R01

Heres L., Hartog-Sprockel J. den, Plomp P., Basisbestand Netwerken, NWB-Wegen, -Vaarwegen en – Spoorwegen, , ,

ISO, 2004, Metainformatie conform ISO 19115, V & W Richtlijnen

K+V Organisatie Bureau en Stuurgroep, 2002, Een grootschalige topografische kaart van Nederland

Knippers R., Kraak M J, 2002, Top10vector objectgericht, http://kartoweb.itc.nl/top10nl/download/pdf/ONTWERP.pdf

Louwsma, J.H., 2004, Contraints in geo-information models, applied to geo-VR in landscape architecture

Lemmens M.J.P.M., An European Perspective on Geo-Information Infrastructure (GII) Issues, http://www.gisdevelopment.net/policy/gii/gii0007pf.htm

LSV GBKN, referentie inhoud GBKN, www.gbkn.nl

Luijkx J.A, 2001, Organisatie Gegevensbeheer Dienstkringen, 2001, document nr. MD-TGA-2001-33

Mahler G, 1996, Quantum Information. In K. Kornwachs & K. Jacoby (Eds.), Information. New questions to a multidisciplinary concept (p. 103-118). Berlin, Germany: Akademie Verlag

Middeljans, K et al., 2004, Enterprise Architectuur RWS versie 10.7

Mantelaers, P, 1995, Organisatie-ontwerp van de informatievoorziening

Ministerie van Verkeer en Waterstaat, Ondernemingsplan Rijkswaterstaat, een nieuw perspectief voor Rijkswaterstaat, 2004, http://www.rijkswaterstaat.nl/Images/2_2398.pdf

Oosterom P. van, Stoter J., Jansen E., 2004, Bridging the worlds of CAD and GIS, CRC Press

Rajabifard, A et al., 2002, Future directions for SDI Development, Int. Journal of Applied Earth Observation and Geoinformation 2002, 4 (1), 11-22

Spek J van der, 2003, Implementatieplan Kerngis bij dienstkring Zuid-Hollandse Waarden, Brown Paper Company

Starreveld, R.W., Mare, H.B. de, Joëls, E.J., 1985, Bestuurlijke informatieverzorging: deel 1: Algemene Grondslagen

Tether, B. ,2001, Identifying Innovation, Innovators And Innovative Behaviours: A Critical Assessment Of The Community Innovation Survey (CIS), CRIC Discussion Paper No 48, December, Manchester: University Of Manchester – Centre For Research On Innovation & Competition.

Uitermark, H, Oosterom P van, Mars N, Molenaar M, 1999, Ontology-based Geographic Data Set Integration, Paper presented at the STDBM'99 Workshop

Veregin, H., 1998, Unit 100 - *Data Quality Measurement and Assessment* NCGIA Core Curriculum in

Verschuren F.J.M., 2000, Het ManagementKompasSysteem: integratie van ondernemingsplanning en informatievoorziening in het MKB, http://www.ub.rug.nl/eldoc/dis/eco/f.j.m.verschuren/h1.pdf

Vusse, C. van der, 2002, Handboek vast onderhoud droge infrastructuur, Expertise centrum Beheer en Onderhoud

Zee E. van der and Iseger, O, Adviesrapport Toekomstige Ontwikkeling Kerngis, 2003, Geodan IT

Zegveld M., 2003, sheets: The role of knowledge and innovation, Strategic Management of Organisations

List of Tables

List of Figures

Supplement 1: Definitions

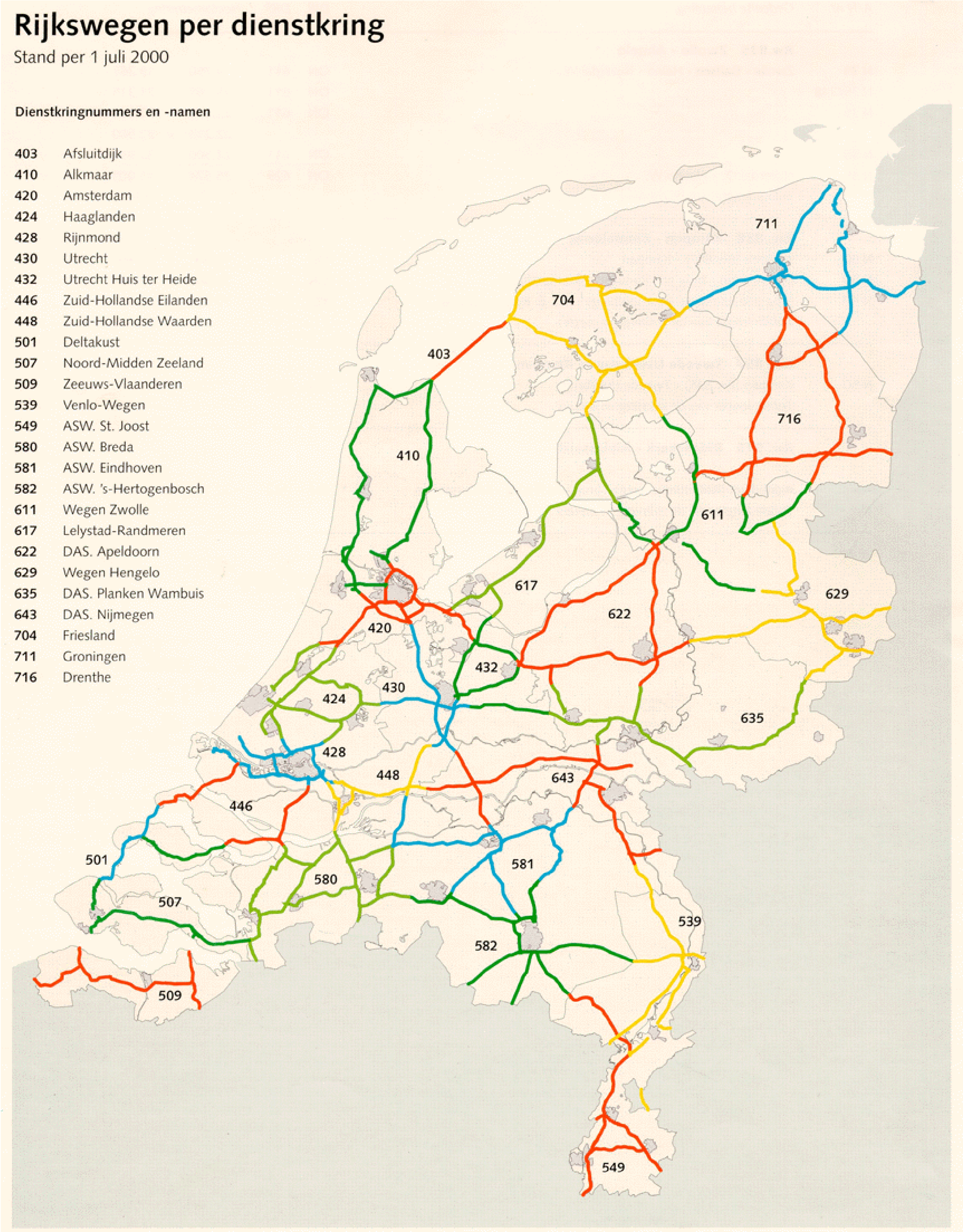
This thesis is written in English, but is performed in Dutch. Lots of terms used at the Directorate-General of Public Works and Water Management are translated into English. The purpose of this list of definitions is scoping of a certain term and showing the Dutch translation.

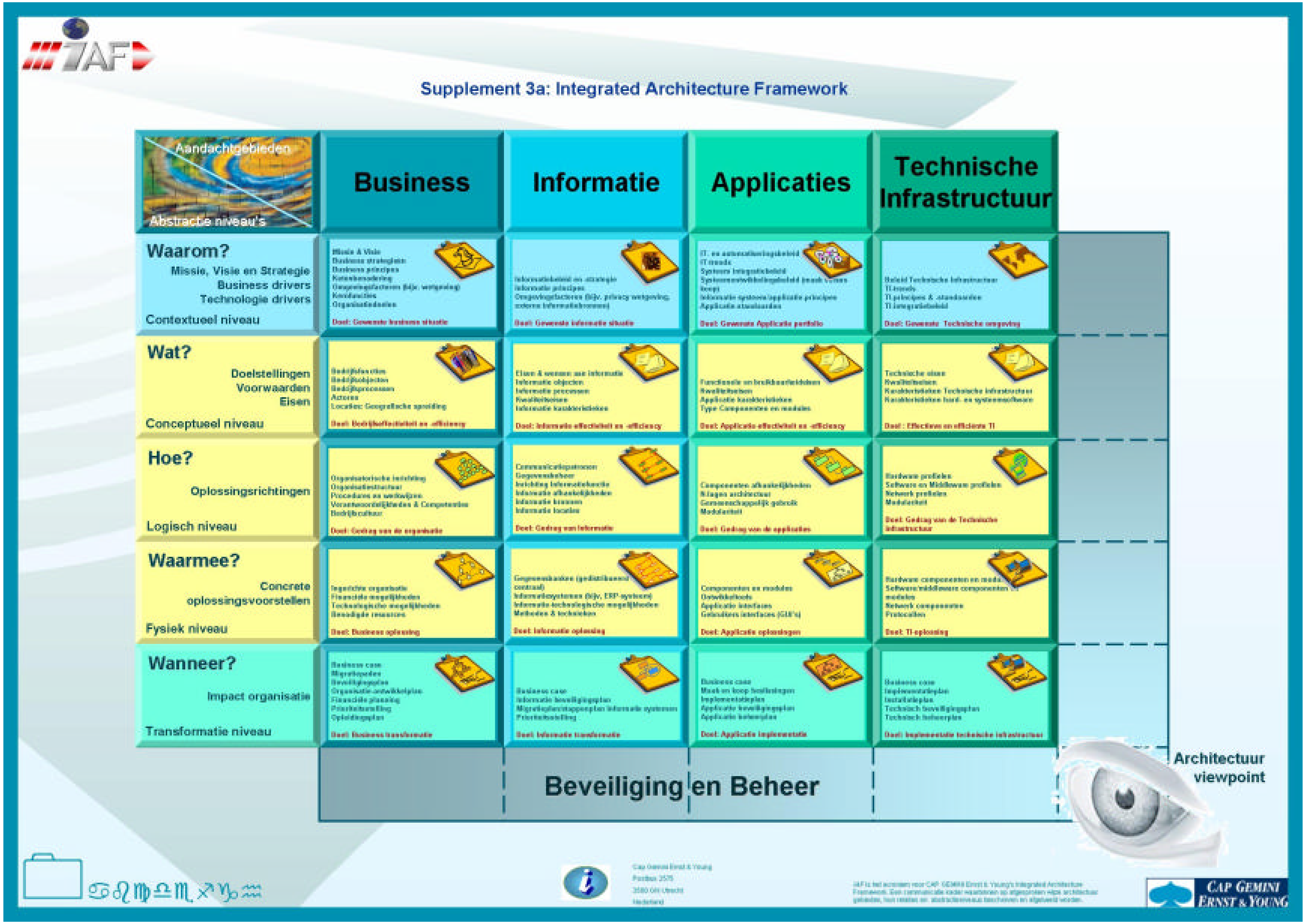
Term (English)	Term (Dutch)	Definition
BPS	Beschrijving Plaatsbepalings Systematiek	Virtual one dimensional reference system, which is often used as reference system to find objects. Notation is Highway / Hectometre sign / Road side / Lane.
Daily Maintenance	Dagelijks Beheer	Maintenance / Inspection performed at a Daily base
Directorate-General of Public Works and Water Management	Rijkswaterstaat (RWS)	Part of the organisation of Ministry of Transport, Public Works and Water Management
Environment and Nature	Landschap en Milieu	Theme recognized by Maintenance.
Fitness for use	Geschiktheid voor gebruik	Suited for use.
Fixed Maintenance	Vast Onderhoud	Maintenance, which take place after certain periods
Geometric Accuracy	Geometrische precisie	Dutch: De spreiding van een stochastische grootheid ten opzichte van haar gemiddelde. Een maat voor precisie van een enkele grootheid is de standaardafwijking; een maat voor de precisie van een aantal grootheden is de variantiematrix
Geographic data	Geografische Data	= attribute data + positional data (related to the surface of the Earth)
Geo-information and ICT Department	Adviesdienst voor Geo-informatie en ICT (AGI)	Specialist Department of the Directore-General, which has to take care of collection and distribution of knowledge regarding geo-information and ICT
Information Architecture	Informatie Architectuur	Een information-architecture is a coherent vision of an organisation on its current and desired information supply. An information Architecture can be developped by a wide supported process of vision and negotiations of all participants.
Information Management	Informatie Voorziening	The discipline that analyzes information as an organizational resource. It covers the definitions, uses, value and distribution of all data and information within an organization whether processed by computer or not. It evaluates the kinds of data/information an organization requires in order to function and progress effectively.
Information Supply	Informatie Aanbod	The discipline that analyzes information as an organizational resource. It covers the definitions, uses, value and distribution of all data and information within an organization whether processed by computer or not. It evaluates the kinds of data/information an organization requires in order to function and progress effectively.
Innovative	Innovatief	initial and actual use of a new product, service production process, (organisation typology, market, distribution)

		customers are willing to pay for
Juridical Maintenance	Juridisch Beheer	Maintenance regarding Juridical control
Maintenance	Beheer, Onderhoud en Verbetering	Maintenance has to take care of increasing durability of objects after Contruction
Quality parameter	Kwaliteits parameter	Quantifiable quality element describing the performance of a geographic data set compared with its Universe of Discourse
Primary process	Primaire proces	This proces delivers results to the (external) client. These import processes are the core business
Process	Proces	Een proces is het geheel van samenhangende of elkaar beïnvloedende activiteiten dat input omzet in output (ISO 9000:2000)
Universe of Discourse	Universe of Discourse	The Universe of Discourse states the model of the real world.
Up-to-dateness / Currency	Actualiteit	The Currency represents the date at which the data was introduced or modified in the database. This date of entry is used as a proof of modification for a single datum, permits statistical interpretation of several data and supports localization of defective data.
UML	Unified Modeling Language	Dutch: Dit is een nog in ontwikkeling zijnde modelmatige taal die door Grady Booch, James Rumbaugh en Ivar Jacobson is ontworpen om object-georiënteerde analysis en ontwerpen te kunnen maken.
WED	Werktuigkundige en Elektrotechnische Dienst	Supporting Department of the Regionale Directie, which have to support the Dienstkring regarding maintenance of electronic traffic requirements
Work process	Werkproces	Is a process concerning one specific and concrete task

Supplement 2: Highway Network and its Dienstkringen

(source: van der Zee and Iseger, 2003)




IAF
Supplement 3a: Integrated Architecture Framework
Aandachtgebieden
Abstractie niveau's
Business
Informatie
Applicaties
Technische Infrastructuur
Waarom?
Missie, Visie en Strategie
Business drivers
Technologie drivers
Contextueel niveau
Wat?
Doelstellingen
Voorwaarden
Eisen
Conceptueel niveau
Hoe?
Oplossingsrichtingen
Logisch niveau
Waarmee?
Concrete oplossingsvoorstellen
Fysiek niveau
Wanneer?
Impact organisatie
Transformatie niveau
Beveiliging en Beheer
Architectuur viewpoint
Cap Gemini Ernst & Young

Supplement 3b: Positionering onderzoeksaspecten in IAF

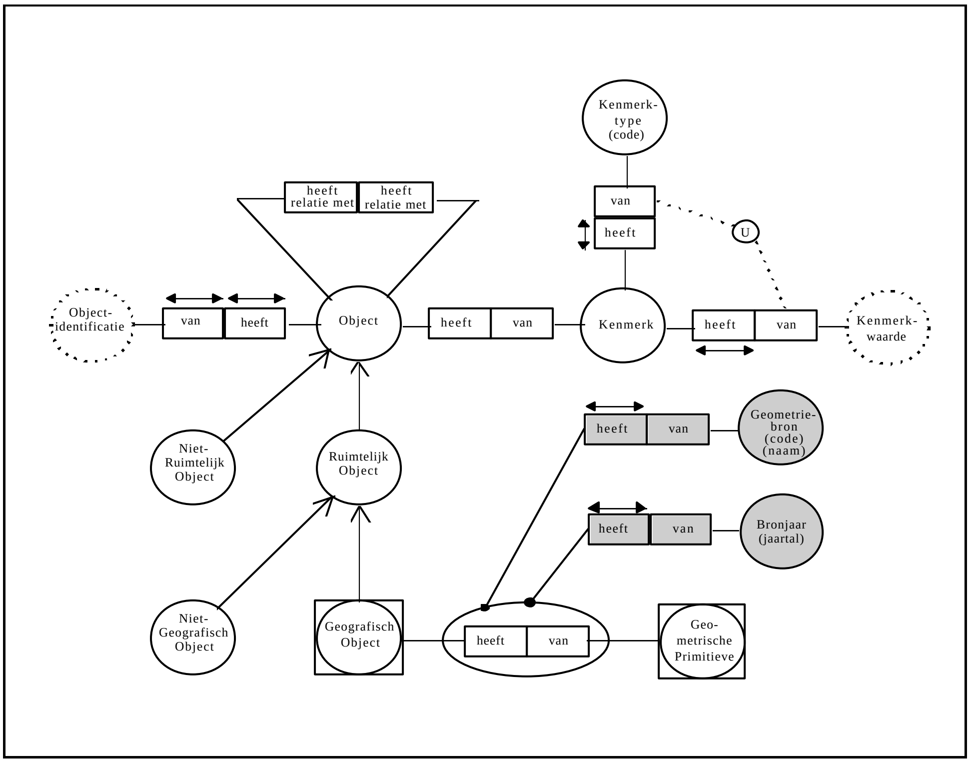
	Business	Informatie	Applicaties
Waarom?	- Organisatiedoelstellingen - Verantwoordelijkheden !!		
Wat?	- Framework van bedrijfsprocessen - Beschrijving werkprocessen	- Informatiebehoefte bij werkprocessen (objectmodel)	-Gewenste operaties bij werkprocessen
Hoe?	- Dienstkring van de Toekomst - Prestatiebestekken	- Meervoudig gebruik data ->AR? (bekeken op niveau van RWS en landelijk)	
Waarmee?		Innovatie in data sets - Inwinningsmethodiek	Innovatie - ICT kansen - Geoservices) - Mobielglobaleschouw

schema 3: Positionering van onderzoeksapecten in IAF

Supplement 4: NWB Vector / Wegen

Huidige situatie t.a.v. de dekkingsgraad, actualiteit en nauwkeurigheid locatiegegevens		
		Systeemproces
Objecttypen		Inwinning gegevens
Geografische objecten	Dekking	Rijks-, provinciale, gemeentelijke en waterschapswegen (minimaal 98% van het hele Nederlandse verharde wegennet)
	Actualiteit	3 maanden
	Bron	Wijzigingen aangeleverd door wegbeheerders en gebruikers van het NWB-Wegen, zoals dienstkringen en gemeentes; Top10Wegenbestand van het TDN; Hectopunten uit DTB-Droog. Ongevalsverwerking heeft triggerfunctie voor wijzigingen wegennet.
Weg	Dekking	Rijks-, provinciale, gemeentelijke en waterschapswegen.
	Nauwkeurigheid	N.v.t.
Juncties	Dekking	Rijks-, provinciale, gemeentelijke en waterschapswegen.
	Geografisch plaatsbepaling	RDX en RDY uit Top10Wegenbestand.
	Nauwkeurigheid	Standaardafwijking in TDN is 3m uitgaande van een normaal-verdeling; dus 95% heeft een afwijking van 10 meter of minder t.o.v. de werkelijkheid.
Wegvak	Dekking	Rijks-, provinciale, gemeentelijke en waterschapswegen.
	Geografisch plaatsbepaling	Aan de hand van Juncties
	Nauwkeurigheid	95% heeft een afwijking van 10 meter of minder t.o.v. de werkelijkheid.
Hectopunten	Dekking	Rijks- en provinciale wegen.
	Nauwkeurigheid	95% heeft een afwijking van 10 meter of minder t.o.v. de werkelijkheid.

Toelichting:
Een geografisch object is een ruimtelijk object waarvan de positie ten opzichte van de aarde gefixeerd is in de tijd. Geografische objecten kunnen zich niet of nauwelijks verplaatsen. Voorbeelden: een gebouw, een boom, een straat, een lantaarnpaal. Visuele wegkenmerken, zoals verharding, geluidbeperkende voorzieningen, etc. zijn ook geografische objecten. (source: van Hengstum, 2004)



Bron: Basisbestand Netwerken, NWB-Wegen, -Vaarwegen en –Spoorwegen, L. Heres, J. den Hartog-Sprockel, P. Plomp

Supplement 5: Weggeg

Huidige situatie t.a.v. de dekkingsgraad, actualiteit en nauwkeurigheid locatiegegevens		
Objecttypen		Inwinning gegevens
Visuele kenmerken van de weg	Dekking	Rijkswegen en enkele aanvullende SVV-wegen
	Actualiteit	Om de 3 maanden n.a.v. onderhoudswerkzaamheden; rest van de locaties wordt eens in de drie jaar geïnventariseerd.
	Bron	Inventarisatie in het terrein door extern adviesbureau; communicatie over beheers grenzen met regionale directies en dienstkringen.
Weg	Dekking	zie NWB-Wegen
	Actualiteit	zie NWB-Wegen
	Nauwkeurigheid	zie NWB-Wegen
Juncties	Dekking	zie NWB-Wegen
	Actualiteit	zie NWB-Wegen
	Nauwkeurigheid	zie NWB-Wegen
Wegvak	Dekking	zie NWB-Wegen
	Actualiteit	zie NWB-Wegen
	Nauwkeurigheid	zie NWB-Wegen
Stroken	Dekking	Strooksoort en aantallen rij- en bijzondere stroken op Wegvakken van SVV-Wegen
	Nauwkeurigheid	Aantal stuks
Verharding	Dekking	Op SVV-wegen
	Nauwkeurigheid	N.v.t., alleen soort geregistreerd
Bermen/Groen-stroken	Dekking	Langs SVV-wegen
	Nauwkeurigheid	10 meter
Kunstwerk	Dekking	SVV-wegen
	Nauwkeurigheid	10 meter
Geluidbeperkende voorziening	Dekking	SVV-wegen
	Nauwkeurigheid	10 meter
Verkeerskundige DraagConstructie	Dekking	SVV-wegen
	Nauwkeurigheid	10 meter
Verlichting	Dekking	SVV-wegen
	Nauwkeurigheid	10 meter

De registratienauwkeurigheid van de wegkenmerken is 1 m. Echter door de projectie van de locatie van deze wegkenmerken op de *Wegvakken* heeft 95% van de wegkenmerken een afwijking van 10 meter of minder t.o.v. de werkelijkheid. Dit is namelijk ook de afwijking van de *Wegvakken* zelf.
SVV-wegen: Wegen uit het **S**tructuurplan **V**erkeer en **V**ervoer (source: van Hengstum, 2004)

Supplement 6: Winfrabase

Huidige situatie t.a.v. de dekkingsgraad, actualiteit en nauwkeurigheid locatiegegevens		
Objecttypen		Inspectie en Aanleg
Geografische objecten	Dekking	Rijkswegen
	Actualiteit	Bij aanleg en inspecties om de 2 jaar
	Bron	Videobeelden ARAN; wijzigingen verharding door visuele inspecties van DWW en door enquêtes van de dienstkringen.
Weg	Dekking	Rijkswegen
	Nauwkeurigheid	5 à 10 meter
BPS-Baan	Dekking	Rijkswegen
	Nauwkeurigheid	5 à 10 meter
Strook	Dekking	Rijkswegen
	Nauwkeurigheid	5 à 10 meter
Knoop	Dekking	Rijkswegen
	Nauwkeurigheid	nvt
Verbinding	Dekking	nvt
	Nauwkeurigheid	5 à 10 meter
Wegmarkering	Dekking	speciale strook
	Nauwkeurigheid	5 à 10 meter
Hectometerborden	Dekking	Rijkswegen
	Nauwkeurigheid	Niet ingewonnen, standaard 100-meter vakken
Verharding	Dekking	Rijkswegen
	Actualiteit	1x per 3 maanden door dienstkring van veranderingen van de verharding. Geheel om 2 jaar
	Nauwkeurigheid	5 à 10 meter, breedte en dikte
Geluidbeperkende voorziening	Dekking	Rijkswegen
	Nauwkeurigheid	5 à 10 meter

Toelichting:
De Wegbermen zijn wel opgenomen in het logische gegevensmodel van Winfrabase, maar deze zijn niet geïnplementeerd.

De positie van de hectometerborden wordt niet ingewonnen. Er wordt uitgegaan van standaard 100-meter hectometervakken. In enkele gevallen wijkt de lengte van de hectometervakken af van deze standaard 100 meter. In het verleden hebben sommige dienstkringen namelijk de werkelijke afstand tussen hectometerbordjes geregistreerd.

In Winfrabase wordt het begin- en eindpunt van de wegen, banen en stroken en de visuele wegkenmerken geregistreerd als het werkelijke aantal meters t.o.v. het dichtsbijzijnde hectometerbordje. Bij een aantal wegkenmerken, zoals de rijspoordiepte, wordt de begin- en eindhectometrering van deze gegevens omgerekend naar de theoretische 100-meter vakken. (source: van Hengstum, 2004)

Supplement 7: Disk

Huidige situatie t.a.v. de dekkingsgraad, actualiteit en nauwkeurigheid locatiegegevens			
		Systeemproces	BOO-proces
Objecttypen		Inwinning gegevens	Inspectie
Geografische objecten	Dekking	objecten op rijkswegen	objecten op rijkswegen
	Actualiteit	bij aanleg en inspectie	0 tot 5 jaar
	Bron	Inspectie-resultaten	Inspectie-resultaten
Verkeerskundige DraagConstructie	Dekking	op rijkswegen; ook doorrijhoogten	op rijkswegen
	Actualiteit	tot aan 2002 bij aanleg en inspectie	geen inspecties vanaf 2002
	Nauwkeurigheid	kilometrering	nvt
Kunstwerk	Dekking	bij aanleg	op rijkswegen
	Nauwkeurigheid	in het zwaartepunt	kilometrering
Verharding	Dekking	op kunstwerken van rijkswegen	op kunstwerken van rijkswegen
	Nauwkeurigheid	n.v.t., alleen soort geregistreerd	n.v.t., alleen soort geregistreerd
Bermen/Groenstroken	Dekking	alleen taluds langs kunstwerken	alleen taluds langs kunstwerken
	Nauwkeurigheid	registratie aanwezigheid	registratie aanwezigheid
Geluidbeperkende voorziening	Dekking	langs rijkswegen	langs rijkswegen
	Nauwkeurigheid	kilometrering	kilometrering
Verlichting	Dekking	alleen langs kunstwerken	alleen langs kunstwerken
	Nauwkeurigheid	registratie aanwezigheid	registratie aanwezigheid

Toelichting:

Een geografisch object is een ruimtelijk object waarvan de positie ten opzichte van de aarde gefixeerd is in de tijd. Geografische objecten kunnen zich niet of nauwelijks verplaatsen. Voorbeelden: een gebouw, een boom, een straat, een lantaarnpaal. Visuele wegkenmerken, zoals verharding, geluidbeperkende voorzieningen, etc. zijn ook geografische objecten.

Kilometrering is berekend aan de hand van aantal meters tot dichtsbijzijnde hectometerbord.

(source: van Hengstum, 2004)

Supplement 8: Tisbo

Huidige situatie t.a.v. de dekkingsgraad, actualiteit en nauwkeurigheid locatiegegevens			
		BOO-proces	
Objecttypen		Onderbouwing maatregelen	Programmering maatregelen
Geografische objecten	Dekking	kunstwerken op rijkswegen	kunstwerken op rijkswegen
	Actualiteit	1 jaar	1 jaar
	Bron	beheerder	beheerder
Verkeerskundige DraagConstructie	Dekking	nvt	nvt
	Nauwkeurigheid	hm-bord plusmeters	hm-bord plusmeters
Kunstwerk	Dekking	op rijkswegen	op rijkswegen
	Nauwkeurigheid	kilometrering	kilometrering
Hectometeraanduiding van het kunstwerk	Dekking	bij kunstwerken van rijkswegen	bij kunstwerken van rijkswegen
	Nauwkeurigheid	hm-bord plusmeters	hm-bord plusmeters
Verharding	Dekking	op kunstwerken van rijkswegen	op kunstwerken van rijkswegen
	Nauwkeurigheid	n.v.t., alleen soort geregistreerd	n.v.t., alleen soort geregistreerd
Bermen/Groenstroken	Dekking	alleen taluds langs kunstwerken	alleen taluds langs kunstwerken
	Nauwkeurigheid	registratie aanwezigheid	registratie aanwezigheid
Geluidbeperkende voorziening	Dekking	alleen langs kunstwerken	alleen langs kunstwerken
	Nauwkeurigheid	registratie aanwezigheid	registratie aanwezigheid
Verlichting	Dekking	alleen langs kunstwerken	alleen langs kunstwerken
	Nauwkeurigheid	registratie aanwezigheid	registratie aanwezigheid

Toelichting:
Een geografisch object is een ruimtelijk object waarvan de positie ten opzichte van de aarde gefixeerd is in de tijd. Geografische objecten kunnen zich niet of nauwelijks verplaatsen. Voorbeelden: een gebouw, een boom, een straat, een lantaarnpaal. Visuele wegkenmerken, zoals verharding, geluidbeperkende voorzieningen, etc. zijn ook geografische objecten.

Kilometrering is berekend aan de hand van aantal meters tot dichtstbijzijnde hectometerbord.
(source: van Hengstum, 2004)

Supplement 9: DTB Droog

Source (Brevé, 2000)

Huidige situatie t.a.v. de dekkingsgraad, actualiteit en nauwkeurigheid locatiegegevens		
Objecttypen		Inwinning gegevens
Geografische objecten	Dekking	Rijkswegen en directe omgeving
	Actualiteit	0 tot 5 jaar
	Bron	Fotogrammetrie en veldmetingen
Weg	Dekking	Rijkswegen
	Nauwkeurigheid	6 cm
Wegmarkering	Dekking	Op rijkswegen
	Nauwkeurigheid	6 cm
Hectometerbord	Dekking	Naast rijkswegen
	Nauwkeurigheid	6 cm
Verharding	Dekking	Op rijkswegen
	Nauwkeurigheid	6 cm
Bermen/Groenstroken	Dekking	Langs rijkswegen
	Nauwkeurigheid	6 cm
Kunstwerk	Dekking	In rijkswegen
	Nauwkeurigheid	6 cm
Geluidbeperkende voorziening	Dekking	Langs rijkswegen
	Nauwkeurigheid	6 cm
Verkeerskundige DraagConstructie	Dekking	Op rijkswegen
	Nauwkeurigheid	6 cm
Verlichting	Dekking	Op rijkswegen
	Nauwkeurigheid	6 cm

Toelichting:

Een geografisch object is een ruimtelijk object waarvan de positie ten opzichte van de aarde gefixeerd is in de tijd. Geografische objecten kunnen zich niet of nauwelijks verplaatsen. Voorbeelden: een gebouw, een boom, een straat, een lantaarnpaal. Visuele wegkenmerken, zoals verharding, geluidbeperkende voorzieningen, etc. zijn ook geografische objecten.

(source: van Hengstum, 2004)

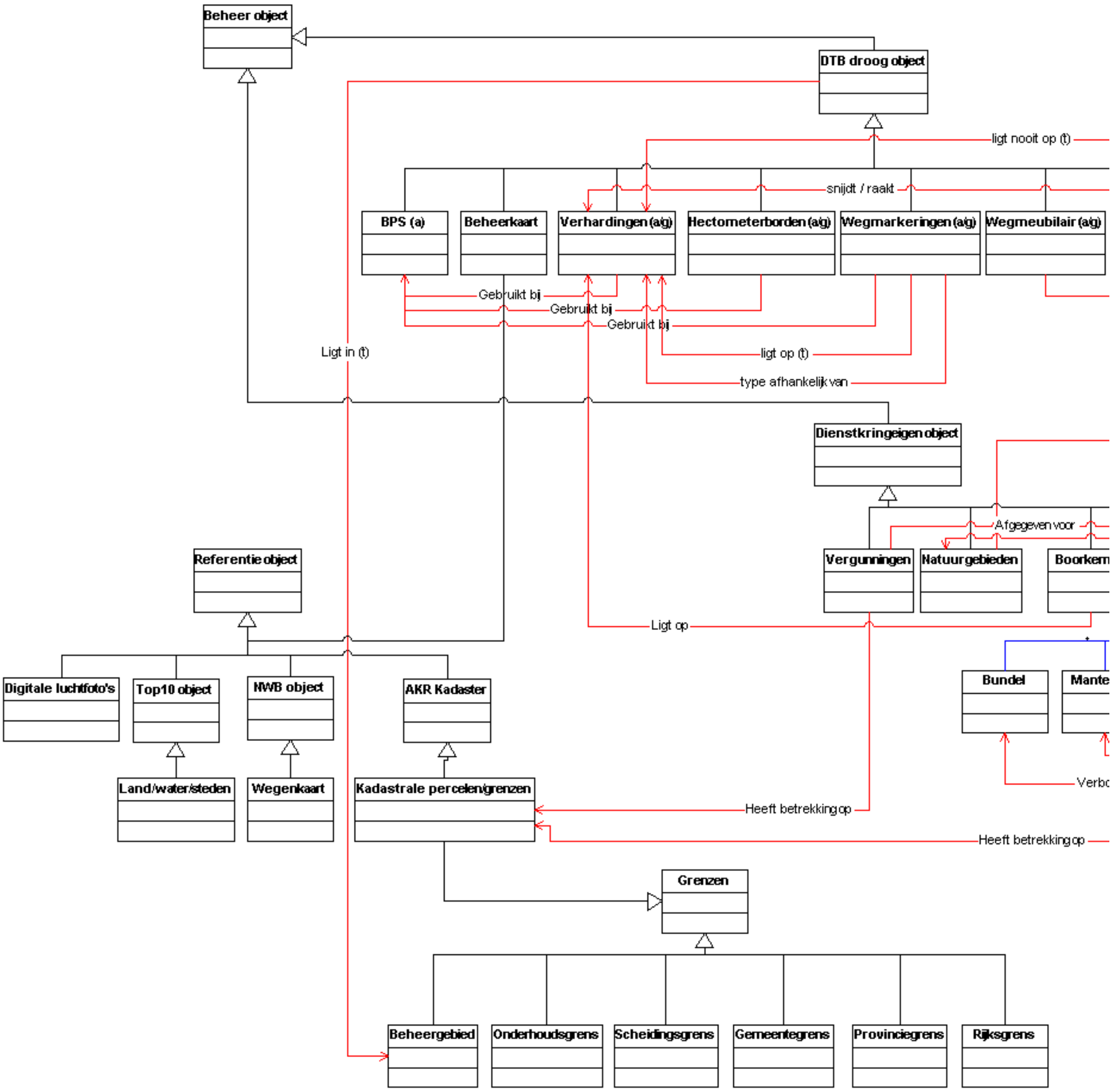
Supplement 10a: Kerngis- Quality parameters

Huidige situatie t.a.v. de dekkingsgraad, actualiteit en nauwkeurigheid locatiegegevens			
Objecttypen		Inwinning gegevens	Inspectie
Geografische objecten	Dekking	Rijkswegen en directe omgeving	Rijkswegen en directe omgeving
	Actualiteit	continue bijwerkproces	continue bijwerkproces
	Bron	DTB en beheerder	DTB en beheerder
Weg	Dekking	Rijkswegen	Rijkswegen
	Nauwkeurigheid	nauwkeurige weergave bij schaal 1:1000	nauwkeurige weergave bij schaal 1:1000
BPS-Baan	Dekking	Rijkswegen	Rijkswegen
	Nauwkeurigheid	nauwkeurige weergave bij schaal 1:1000	nauwkeurige weergave bij schaal 1:1000
BPS-Strook	Dekking	Rijkswegen	Rijkswegen
	Nauwkeurigheid	nauwkeurige weergave bij schaal 1:1000	nauwkeurige weergave bij schaal 1:1000
Wegmarkering	Dekking	Op rijkswegen	Op rijkswegen
	Nauwkeurigheid	nauwkeurige weergave bij schaal 1:1000	nauwkeurige weergave bij schaal 1:1000
Hectometerbord	Dekking	Naast rijkswegen	Naast rijkswegen
	Nauwkeurigheid	nauwkeurige weergave bij schaal 1:1000	nauwkeurige weergave bij schaal 1:1000
Verharding	Dekking	Op rijkswegen	Op rijkswegen
	Nauwkeurigheid	nauwkeurige weergave bij schaal 1:1000	nauwkeurige weergave bij schaal 1:1000
Bermen/Groenstroken	Dekking	Langs rijkswegen	Langs rijkswegen
	Nauwkeurigheid	nauwkeurige weergave bij schaal 1:1000	nauwkeurige weergave bij schaal 1:1000
Kunstwerk	Dekking	In rijkswegen	In rijkswegen
	Nauwkeurigheid	nauwkeurige weergave bij schaal 1:1000 (als vlak)	nauwkeurige weergave bij schaal 1:1000 (als vlak)
Geluidbeperkende voorziening	Dekking	Langs rijkswegen	Langs rijkswegen
	Nauwkeurigheid	nauwkeurige weergave bij schaal 1:1000	nauwkeurige weergave bij schaal 1:1000
Verkeerskundige DraagConstructie	Dekking	Op rijkswegen	Op rijkswegen
	Nauwkeurigheid	nauwkeurige weergave bij schaal 1:1000	nauwkeurige weergave bij schaal 1:1000
Verlichting	Dekking	Op rijkswegen	Op rijkswegen
	Nauwkeurigheid	nauwkeurige weergave bij schaal 1:1000	nauwkeurige weergave bij schaal 1:1000

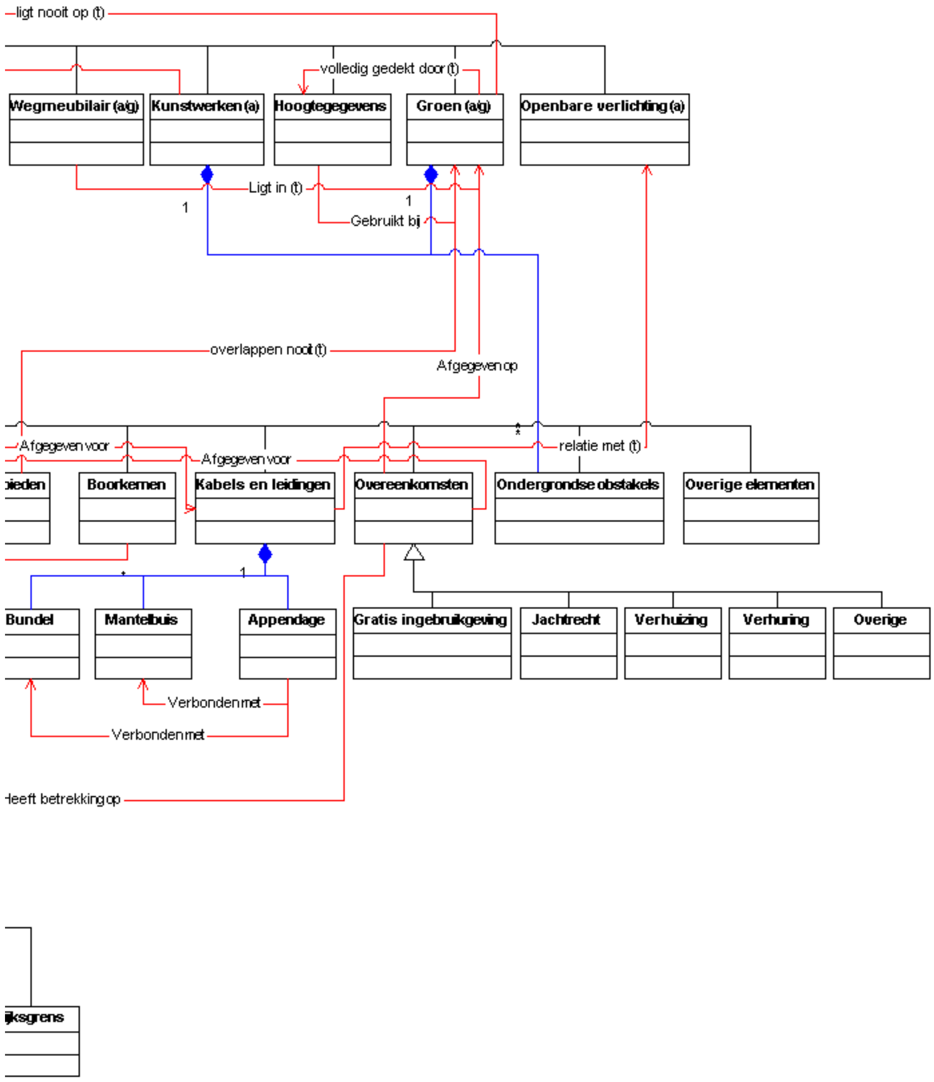
(source: van Hengstum, 2004)

Supplement 10b: Kerngis- Logical Datamodel

(source: van der Zee and Iseger, 2003)



<Vervolg>


ligt nooit op (t)
volledig gedekt door (t)
Wegmeubilair (a/g)
Kunstwerken (a)
Hoogtegegevens
Groen (a/g)
Openbare verlichting (a)
Ligt in (t)
1
1
Gebruikt bij
overlappen nooit (t)
Afgegeven op
Afgegeven voor
Afgegeven voor
relatie met (t)
Boorkernen
Kabels en leidingen
Overeenkomsten
Ondergrondse obstakels
Overige elementen
1
Bundel
Mantelbuis
Appendage
Gratis ingebruikgeving
Jachtrecht
Verhuizing
Verhuring
Overige
Verbonden met
Verbonden met
Heeft betrekking op

Supplement 11a: GBKN – compulsory objects

(source: www.gbkn.nl - referentie inhoud GBKN, bijlage 1)

Tabel met GBKN classificatiecodes voor topografie die, wanneer ze in de werkelijkheid voorkomt, tot de referentie inhoud van de GBKN behoort. Ze kan in de verschillende aangegeven verschijnings-vormen in het GBKN-bestand voorkomen.

l = lijnvormig element
p1 = puntvormig element (éénpunts-symbool)
p2 = puntvormig element (tweepunts-symbool)
g = grondslagpunt
t = tekst element

hoofdgebouw	l	B01
bijgebouw	l	B02
overig opstal	l	B03
kunstwerk	l	B04
tussenmuur	l	B07
dakrand	l	B11
hoogspanningsleiding/mast	l	L01
windturbine	p1	L58
spoorrail	l	Q01
as spoor	l	Q02
as weg	l	Q03
wegmarkering	l	Q04
walbescherming	l	Q06
kademuur	l	Q07
steiger	l	Q10
talud (overig lijnvormig object)	l	Q19
taludlijn	l	T13
overig puntvormig object	p1	Q39
symbool gesloten verharding klein	p2	S01-2
symbool gesloten verharding groot	p2	S01-4
symbool gesloten verharding middel	p2	S01-6
symbool open verharding middel	p2	S02-2
symbool open verharding groot	p2	S02-4
symbool open verharding klein	p2	S02-6
symbool talud	p2	S04
symbool water	p2	S05
symbool hoogspanningsmast	p2	S07
terreinafscheiding	l	T00
muur	l	T01
raster	l	T02

hek	l	T03
heg	l	T04
schutting	l	T05
houtwal	l	T06
sloot / greppel (midden)	l	T07
insteek sloot	l	T09
geluidswal	l	T11
geluidswering	l	T12
afsluitende lijn (overige afscheiding)	l	T20
kant verharding algemeen	l	V00
kant gesloten verharding	l	V01
kant open verharding	l	V02
kant onverhard	l	V06
kant water	l	W00
kant sloot	l	W01
kant beek	l	W02
kant kanaal	l	W03
kant gracht	l	W04
kant rivier	l	W05
kant vijver	l	W06
overig water	l	W09
tekst	t	Z00
huisnummer	t	Z02
cultuuraanduiding	t	Z05
straatnaam	t	Z06
waterloopnaam	t	Z07
functieaanduiding	t	Z09
overige tekst	t	Z19

Supplement 11b: GBKN – extra objects

(www.gbkn.nl - referentie inhoud GBKN, bijlage 4)

verlaten boorput	p1	A60
dakrand (rechthoekig)	l	B12
dakrand (voorgevel)	l	B13
dakrand (bijgebouw)	l	B14
dakrand (bijgebouw rechthoekig)	l	B15
luifel	l	B16
overbouw	l	B17
woonboot	l	B18
woonwagen	l	B19
steunpilaar gebouw	p1	B50
steunpilaar viaduct	p1	B51
grens ondergronds bouwwerk	l	G30
hoogte kenmerk	p1	H00
hoogtepunt	p1	H01
leiding	l	L00
straalzender	l	L02
communicatieleiding	l	L03
elektriciteitsleiding	l	L04
gasleiding	l	L05
rioolleiding	l	L06
waterleiding	l	L07
laagspanningsleiding	l	L08
drainage-leiding	l	L09
stadsverwarmingsleiding	l	L10
benzine- / olieput	p1	L50
waterleidingput	p1	L51
gasput	p1	L52
laagspanningsmast	p1	L53
drainageput	p1	L54
filterbuis	p1	L55
peilbuis	p1	L56
boorgat	p1	L57
grondslagpunt	g	M00
verzekerd grondslagpunt	g	M01
natuurlijk grondslagpunt	g	M02
meetlijn	l	M03
reconstructiepunt	g	M04
punt SD'76	g	M05
overige grondslag	g	M09
topografisch object	l	Q00
bomenrij/groep	l	Q05
remmingswerk	l	Q08
geleiderail	l	Q09
steiger	l	Q10
abri	l	Q11
afvalplaats	l	Q12
speelwerktuig	l	Q13
zitbank	l	Q14
portaal bovenleiding	l	Q15
portaal verkeer	l	Q16
parkeervak	l	Q17
strekdam / golfbreker	l	Q18
straatmeubilair	p1	Q20
lichtmast	p1	Q21
paal/steen	p1	Q22
kolk	p1	Q23
putdeksel	p1	Q24
CAI-kast/trafo	p1	Q25
boom	p1	Q26
telefooncel	p1	Q27
rioolput	p1	Q28
verkeerslicht	p1	Q29
verkeersbord	p1	Q30
verklikker transportleiding	p1	Q31
dukdalf	p1	Q32
meerpaal	p1	Q33
speelwerktuig	p1	Q34
drinkbak	p1	Q35
praatpaal	p1	Q40
vlaggenmast	p1	Q41
schakelkast openbare verlichting	p1	Q42
verkeersinstallatiekast	p2	Q43
KPN kast	p2	Q44
electrakast	p2	Q45
gaskast	p2	Q46
rioolkast	p2	Q47
haltepaal	p1	Q48
afvalbak	p1	Q49
planten- / bloembak	p1	Q50
fietsenrek	p1	Q51
informatiebord	p1	Q52
kunstobject	p1	Q53
parkeerautomaat	p1	Q54
parkeermeter	p1	Q55
plaatsnaambord	p1	Q56
afsluitpaal	p1	Q57
seinpaal	p1	Q58
slagboom	p1	Q59
straatnaambord	p1	Q60
verkeerszuil	p1	Q61

Supplement 12: Definition Library of Object Model

Ruimtelijk object	Geometrie	Definitie
Hectometerbordjes	punt	Paal of bord, geplaatst langs de weg, waarop een hectometerwaarde is vermeld, eventueel gevolgt door letter
Kant Verharding	lijn	Rand van Verharding - geen element uit de BOCO classificatie
Stroken	vlak	Gedeelte van de verharding ingesloten door wegmarkering
Verharding	vlak	Aaneengesloten continue verharding van asfalt
Fietspaden	vlak	Aaneengesloten continue verharding van asfalt met als doel gebruik door fietsers
Parallelwegen	vlak	Aaneengesloten continue verharding van asfalt (geen Rijksweg)
Voegovergangen	lijn	Overgang tussen verschillende platen beton aanwezig op Kunstwerken
Wegmarkering	vlak	Belijning op het asfalt om stroken aan te geven
Tellussen	lijn	Lussen in het asfalt met als doel het tellen van voertuigen
Signaleringslussen	lijn	Lussen in het asfalt met als doel het signaleren van een voertuig en de bijbehorende snelheid
Geleiderail	lijn	Lintvormige beveiligingscontructie, samengesteld uit metalen planken, afstandhouders en palen of stijlen
Bebording	punt	Verkeersbord
Bewegwijzering	punt	Bord met bewegwijzerings tekst
Klein meubilair	punt	Wegmeubilair zoals reflectorbordjes, praatpaal, ect
Lichtmast	punt	Hoge paal die wordt gebruikt ter ondersteuning van een kabel, waaraan lampen zijn bevestigd
Verlichtingspunt	punt	Paal, waaraan openbare verlichting is bevestigd
DRIP	punt	Dynamisch Route Informatie Paneel, geeft verkeersinformatie weer en is bevestigd aan een (half)portaal
VRI	punt	Verkeers Regel Installatie is een paal met verkeerslichten
TDI	punt	Toerit Doseer Installatie, verkeerslicht om te toevoer van voertuigen op de oprit van een Rijksweg te doseren
K en L (KLIC)	lijn	Kabels en Leidingen in eigendom van derden
K en L (RWS)	lijn	Kabels en Leidingen in eigendom van Rijkswaterstaat
Perceel	vlak	Afgebakend stuk grond (kavel) waarop eigendomsrechten zijn vastgelegd
Voedingskasten	punt	Electriciteitskasten ter ondersteuning van de elektrische systemen langs de Rijksweg
Beplanting	vlak	Vlak met zelfde begroeiing
Boom / Bomen	punt of vlak	Vrij staande boom / Bomengroep als zelfstandig element geregistreerd
Kolken	punt	Afvoerpunt gelegen in de goot van de Rijksweg voor de afvoer van hemelwater
Waterwegen	lijn of vlak	Sloot met als doel het reguleren van de waterhuishouding
Opvangbasins	vlak	Basin met als doel het verzamelen van hemelwater
Natuurgebied	vlak	Gebied, aangewezen met bestemming natuur
Verzorgingsplaatsten	vlak	Parkeer- rustplaats gelegen langs de Rijksweg
Gebouwen	lijn	verzameling zijmuren van gebouw
Verkooppunt	punt	Punt in gebouw, waar goederen (meestal brandstof) verkocht worden
Opslagtanks	lijnen	Opslagtanks die een gevaarlijke, brandbare of explosieve stof kunnen bevatten
Kunstwerk	vlak	Brug, viaduct of tunnel
Geluidscherm	lijn	Scherm met als doel het keren van geluid
Geluidswal	lijn	Verhoging van aarde met als doel het keren van geluid
Portaal	lijn	Tot een constructie verbonden geheel van 1 draagpaal en een dwarsbalk, bedoeld voor het aanbrengen van leidingen of verkeersaanwijzingen
Duikers	lijn	Doorstroomopening onder een weg die een functie vervult in de waterhuishouding
Riolering	lijn	Ondergrondse leiding voor afvoer van hemelwater in een watergang of rioolput
Buizen	lijn	Buis gelegen onder de Rijksweg
Faunavoorziening	lijn	Grote buis onder de weg, met als doel habitat uitbreiding aan de andere kant van Rijksweg
Objecten van derden	punt	Object bij de Rijksweg met als eigenaar niet Rijkswaterstaat zoals GSMmast, reclamebord, ect
Omgeving	vlak	Vlak ingedeeld volgens terrein model (meestal NEN3610) welke informatie geeft over gebruik
Locatie	punt	Punt waarbij thematisch data moet worden toegevoegd
Beheergebied	vlak	Gebied waarover de Dienstkring beheer moet uitvoeren

Supplement 13: Need of information- Exploitation

		Accuracy (normal)								Up-to-dateness							
		Cluster								Cluster							
Spatial Object	total	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Hectometerbordjes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kant Verharding	6	0	0	0	5	1	0	0	0	0	0	2	1	2	0	0	0
Stroken	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
Verharding	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
Fietspaden	2	0	0	0	2	0	0	0	0	0	0	2	0	0	0	0	0
Parallelwegen	2	0	0	0	2	0	0	0	0	0	0	2	0	0	0	0	0
Voegovergangen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wegmarkering	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tellussen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Signaleringslussen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geleiderail	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bebording	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bewegwijzering	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Klein meubilair	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lichtmast	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Verlichtingspunt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DRIP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VRI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TDI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K en L (KLIC)	6	0	0	0	0	3	3	0	0	0	0	0	0	0	1	3	0
K en L (RWS)	5	0	0	0	0	2	3	0	0	0	0	0	0	0	2	3	0
Perceel	6	2	0	0	1	1	2	0	0	0	0	2	1	0	2	0	0
Voedingskasten	2	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	0
Beplanting	4	0	0	1	3	0	0	0	0	0	0	2	1	1	0	0	0
Bomen	2	0	0	2	0	0	0	0	0	0	0	1	1	0	0	0	0
Kolken	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Waterwegen	2	0	0	0	2	0	0	0	0	0	0	2	0	0	0	0	0
Opvangbasins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natuurgebied	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Verzorgingsplaatsten	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gebouwen	4	0	0	0	4	0	0	0	0	0	0	0	2	0	0	2	0
Verkooppunt	2	0	0	0	2	0	0	0	0	0	0	0	1	0	0	1	0
Opslagtanks	2	0	0	0	2	0	0	0	0	0	0	0	1	0	0	1	0
Kunstwerk	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geluidscherm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geluidswal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Portaal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Duikers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Riolering	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Buizen	3	0	0	0	3	0	0	0	0	0	0	0	0	3	0	0	0
Faunavoorziening	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Objecten van derden	5	0	2	0	3	0	0	0	0	0	0	0	2	0	1	1	0
Omgeving	3	3	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0
Locatie	2	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Beheergebied	22	0	22	0	0	0	0	0	0	0	0	0	0	22	0	0	0

Supplement 14: Need of information- Civil Infrastructures

Spatial Object	total	Accuracy Cluster								Up-to-dateness Cluster							
		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Hectometerbordjes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kant Verharding	6	0	0	0	1	2	0	0	0	0	0	1	2	0	0	0	0
Stroken	1	0	0	3	1	0	0	0	0	0	0	2	2	0	0	0	0
Verharding	1	0	1	0	1	0	0	0	0	0	0	0	2	0	0	0	0
Fietspaden	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parallelwegen	2	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
Voegovergangen	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Wegmarkering	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tellussen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Signaleringslussen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geleiderail	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
Bebording	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bewegwijzering	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Klein meubilair	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lichtmast	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Verlichtingspunt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DRIP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VRI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TDI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K en L (KLIC)	6	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
K en L (RWS)	5	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
Perceel	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Voedingskasten	2	0	0	2	0	0	0	0	0	0	0	0	2	0	0	0	0
Beplanting	4	1	0	2	0	0	0	0	0	0	0	1	2	0	0	0	0
Bomen	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kolken	0	0	1	1	0	0	0	0	0	0	0	2	0	0	0	0	0
Waterwegen	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Opvangbasins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natuurgebied	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Verzorgingsplaatsten	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gebouwen	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Verkooppunt	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Opslagtanks	2	0	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0
Kunstwerk	0	0	4	0	0	0	0	0	0	0	1	3	0	0	0	0	0
Geluidscherm	0	0	0	2	0	0	0	0	0	0	0	1	1	0	0	0	0
Geluidswal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Portaal	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	0	0
Duikers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Riolering	0	0	2	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Buizen	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Faunavoorziening	0	0	0	2	0	0	0	0	0	0	0	1	1	0	0	0	0
Objecten van derden	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Omgeving	3	2	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Locatie	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beheergebied	22	0	10	0	0	0	0	0	0	0	0	0	0	10	0	0	0

Table 5.2

Supplement 15: Need of information- Nature and Envirronment

		Accuracy (normal) Cluster								Up-to-dateness Cluster									Accuracy (innovative) Cluster							
Spatial Object	total	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	total	1	2	3	4	5	6	7	8
Hectometerbordjes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kant Verharding	5	0	0	1	1	3	0	0	0	0	2	2	1	0	0	0	0	2	0	0	1	0	1	0	0	0
Stroken	3	0	0	3	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0
Verharding	6	0	2	2	2	0	0	0	0	0	2	1	2	0	0	0	0	3	0	1	1	1	0	0	0	0
Fietspaden	2	0	0	1	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Parallelwegen	3	0	1	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Voegovergangen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wegmarkering	2	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	1	1	0	0	0	0
Tellussen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Signaleringslussen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geleiderail	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bebording	2	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	2	0	0	0	0	0	0
Bewegwijzering	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Klein meubilair	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lichtmast	2	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	2	1	0	1	0	0	0	0	0
Verlichtingspunt	3	1	0	1	1	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0
DRIP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VRI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TDI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K en L (KLIC)	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
K en L (RWS)	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Perceel	2	0	0	1	0	1	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0
Voedingskasten	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beplanting	9	0	2	4	1	1	1	0	0	0	2	3	1	0	0	0	0	8	0	4	2	0	2	0	0	0
Bomen	7	0	4	3	0	0	0	0	0	0	3	1	1	0	0	0	0	6	1	4	1	0	0	0	0	0
Kolken	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Waterwegen	4	0	3	1	0	0	0	0	0	0	2	1	0	0	0	0	0	2	0	2	0	0	0	0	0	0
Opvangbasins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natuurgebied	4	3	1	0	0	0	0	0	0	1	2	0	1	0	0	0	0	2	2	0	0	0	0	0	0	0
Verzorgingsplaatsten	8	0	1	2	4	1	0	0	0	0	3	0	3	0	0	1	0	6	0	1	2	2	1	0	0	0
Gebouwen	2	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0
Verkooppunt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Opslagtanks	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kunstwerk	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geluidscherm	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geluidswal	3	0	1	0	2	0	0	0	0	0	0	2	0	0	0	0	0	3	0	1	1	1	0	0	0	0
Portaal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Duikers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Riolering	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Buizen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Faunavoorziening	2	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Objecten van derden	2	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
Omgeving	5	3	1	0	1	0	0	0	0	1	1	2	1	0	0	0	0	1	0	1	0	0	0	0	0	0
Locatie	4	2	2	0	0	0	0	0	0	0	1	0	0	0	0	1	0	3	2	1	0	0	0	0	0	0
Beheergebied	17	0	#	3	0	4	0	0	0	0	0	0	0	#	0	0	0	#	0	8	3	0	4	0	0	0

Supplement 16: Need of information- Pavement

		Accuracy (normal) Cluster								Up-to-dateness Cluster									Accuracy (innovative) Cluster							
Spatial Object	total	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	total	1	2	3	4	5	6	7	8
Hectometerbordjes	5	1	1	0	2	1	0	0	0	0	2	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Kant Verharding	6	0	0	1	2	0	0	3	0	0	3	2	0	1	0	0	0	1	0	1	0	0	0	0	0	0
Stroken	8	0	0	0	5	0	0	3	0	0	3	1	3	1	0	0	0	5	1	1	0	3	0	0	0	0
Verharding	8	3	1	0	2	0	0	2	0	0	3	1	4	0	0	0	0	5	0	1	0	4	0	0	0	0
Fietspaden	3	0	0	0	2	0	1	0	0	0	1	0	1	1	0	0	0	3	0	1	0	1	1	0	0	0
Parallelwegen	3	0	0	0	2	0	1	0	0	0	2	0	1	0	0	0	0	3	1	1	0	1	0	0	0	0
Voegovergangen	2	0	0	0	1	0	0	1	0	0	1	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0
Wegmarkering	4	0	0	0	1	0	1	2	0	0	2	0	1	1	0	0	0	2	0	1	0	1	0	0	0	0
Tellussen	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Signaleringslussen	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geleiderail	2	0	0	0	2	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Bebording	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bewegwijzering	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Klein meubilair	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lichtmast	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Verlichtingspunt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DRIP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VRI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TDI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K en L (KLIC)	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K en L (RWS)	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Perceel	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Voedingskasten	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beplanting	4	0	1	1	2	0	0	0	0	1	0	2	1	0	0	0	0	1	0	0	0	1	0	0	0	0
Bomen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kolken	5	0	2	1	2	0	0	0	0	0	2	1	2	0	0	0	0	2	0	0	0	2	0	0	0	0
Waterwegen	2	0	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Opvangbasins	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natuurgebied	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Verzorgingsplaatsten	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Gebouwen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Verkooppunt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Opslagtanks	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kunstwerk	3	0	3	0	0	0	0	0	0	0	2	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0
Geluidscherm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geluidswal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Portaal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Duikers	3	0	0	3	0	0	0	0	0	0	0	3	0	0	0	0	0	1	0	0	1	0	0	0	0	0
Riolering	4	0	0	0	2	0	2	0	0	0	2	2	0	0	0	0	0	2	0	1	1	0	0	0	0	0
Buizen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Faunavoorziening	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Objecten van derden	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Omgeving	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Locatie	8	3	0	2	3	0	0	0	0	0	2	0	5	0	1	0	0	7	0	1	0	5	0	1	0	0
Beheergebied	12	1	#	1	0	0	0	0	0	0	0	0	0	#	0	0	0	7	0	0	0	0	7	0	0	0

Supplement 17: Need of information- Traffic Requirements

		Accuracy (normal)								Up-to-dateness									Accuracy (innovative)							
		Cluster								Cluster									Cluster							
Spatial Object	total	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	total	1	2	3	4	5	6	7	8
Hectometerbordjes	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	2	1	1	0	0	0	0	0	0
Kant Verharding	4	0	0	0	3	0	0	1	0	0	0	1	1	2	0	0	0	2	0	0	0	2	0	0	0	0
Stroken	15	0	0	0	13	1	0	1	0	0	0	3	9	6	0	2	1	#	0	0	0	12	0	0	0	0
Verharding	4	2	1	0	0	1	0	0	0	0	0	0	1	3	0	0	0	1	1	0	0	0	0	0	0	0
Fietspaden	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0
Parallelwegen	2	0	0	0	1	0	0	1	0	0	0	0	0	2	0	0	0	1	0	0	0	1	0	0	0	0
Voegovergangen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wegmarkering	1	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	2	1	0	0	0	0	1	0	0
Tellussen	2	0	0	0	1	1	0	0	0	0	0	0	2	1	0	0	0	2	0	1	1	0	0	0	0	0
Signaleringslussen	3	1	0	0	1	1	0	0	0	0	0	0	2	1	0	1	0	2	0	1	1	0	0	0	0	0
Geleiderail	4	0	0	0	4	0	0	0	0	0	0	1	1	2	1	0	0	3	0	0	0	3	0	0	0	0
Bebording	2	0	0	1	1	0	0	0	0	0	0	0	2	0	1	0	0	3	1	0	1	1	0	0	0	0
Bewegwijzering	2	0	0	1	1	0	0	0	0	0	0	0	1	0	1	0	0	2	0	0	1	1	0	0	0	0
Klein meubilair	1	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	2	0	1	1	0	0	0	0	0
Lichtmast	2	0	1	0	1	0	0	0	0	0	0	0	1	0	1	0	0	1	0	2	0	0	0	0	0	0
Verlichtingspunt	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	2	1	1	0	0	0	0	0	0
DRIP	4	1	2	1	0	0	0	0	0	0	0	0	2	1	1	2	0	2	0	0	1	0	0	0	0	0
VRI	2	1	0	1	0	0	0	0	0	0	0	0	3	1	0	0	0	2	2	0	0	0	0	0	0	0
TDI	1	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	1	0	1	0	0	0	0	0	0
K en L (KLIC)	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
K en L (RWS)	6	0	0	0	0	0	2	4	0	0	0	0	0	1	0	4	0	0	0	0	0	0	0	0	0	0
Perceel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Voedingskasten	8	0	1	2	5	0	0	0	0	0	0	0	6	3	0	0	0	2	0	0	1	0	1	0	0	0
Beplanting	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bomen	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kolken	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Waterwegen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Opvangbasins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natuurgebied	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Verzorgingsplaatsten	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gebouwen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Verkooppunt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Opslagtanks	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kunstwerk	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Geluidscherm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geluidswal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Portaal	4	1	2	1	0	0	0	0	0	0	0	1	0	2	1	1	0	1	0	0	0	0	0	0	0	0
Duikers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Riolering	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Buizen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Faunavoorziening	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Objecten van derden	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Omgeving	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Locatie	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	3	2	0	0	0	0	0	0
Beheergebied	17	0	17	0	0	0	0	0	0	0	0	0	0	#	0	0	0	#	0	17	0	0	0	0	0	0

Supplement 18A: Object Model - Traditional Contract

Supplement 18B: Need of information- Traditional Contract

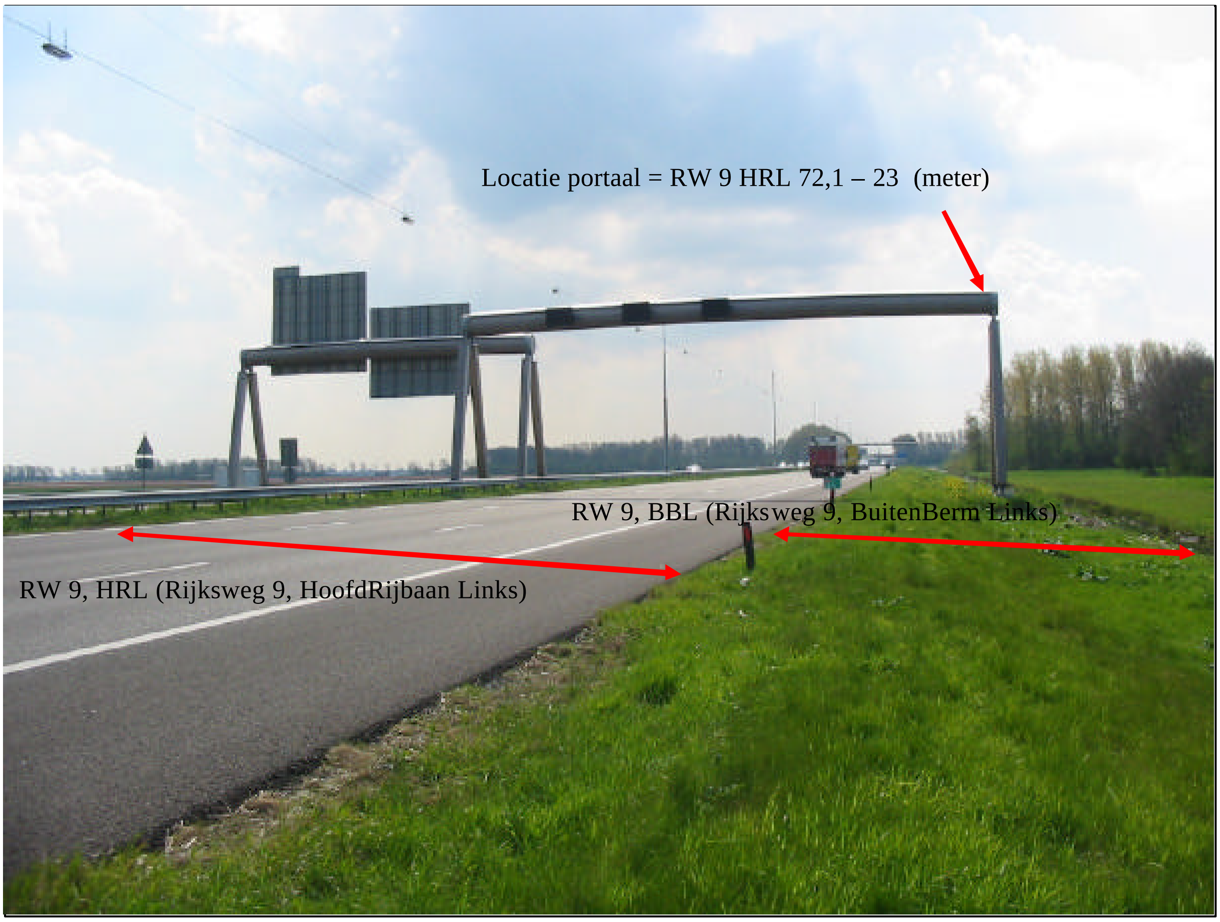
		Accuracy (traditional contract)									Up-to-dateness							
		Cluster									Cluster							
Spatial Object	total	1	2	3	4	5	6	7	8	total	1	2	3	4	5	6	7	8
Hectometerbordjes	8	1	2	0	4	1	0	0	0	7	0	2	2	2	1	0	0	0
Kant Verharding	25	0	0	2	12	6	0	5	0	24	0	5	8	5	5	0	0	0
Stroken	38	0	0	6	27	1	0	4	0	25	0	4	4	9	6	0	2	0
Verharding	21	6	5	1	5	1	0	3	0	17	0	5	2	6	4	0	0	0
Fietspaden	9	0	0	1	5	0	2	0	0	6	0	2	2	1	1	0	0	0
Parallelwegen	12	1	1	1	7	0	1	1	0	10	0	3	4	1	2	0	0	0
Voegovergangen	5	1	1	0	1	0	1	1	0	3	0	1	0	2	0	0	0	0
Wegmarkering	8	2	0	0	1	0	2	3	0	6	0	2	0	2	1	1	0	0
Tellussen	5	0	0	1	3	1	0	0	0	4	0	1	0	2	1	0	0	0
Signaleringslussen	6	1	0	1	3	1	0	0	0	5	0	1	0	2	1	0	1	0
Geleiderail	9	1	0	0	8	0	0	0	0	6	0	1	0	1	3	1	0	0
Bebording	6	2	2	1	1	0	0	0	0	3	0	0	1	1	0	1	0	0
Bewegwijzering	3	1	0	1	1	0	0	0	0	2	0	0	0	1	0	1	0	0
Klein meubilair	2	0	0	1	0	1	0	0	0	1	0	0	0	1	0	0	0	0
Lichtmast	5	0	2	1	2	0	0	0	0	3	0	0	0	2	0	1	0	0
Verlichtingspunt	7	3	1	1	2	0	0	0	0	3	0	1	0	2	0	0	0	0
DRIP	6	2	2	2	0	0	0	0	0	4	0	0	0	1	0	1	2	0
VRI	5	4	0	1	0	0	0	0	0	2	0	0	0	1	1	0	0	0
TDI	3	1	1	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0
K en L (KLIC)	11	0	0	0	1	3	7	0	0	11	0	0	1	0	1	2	5	0
K en L (RWS)	14	0	0	0	1	2	10	1	0	14	0	0	1	1	2	3	7	0
Perceel	9	2	0	1	1	5	0	0	0	9	0	1	4	1	0	2	0	0
Voedingskasten	14	0	1	13	0	0	0	0	0	11	0	0	0	8	3	0	0	0
Beplanting	20	1	3	8	7	0	1	0	0	15	1	2	8	3	1	0	0	0
Bomen	11	1	5	5	0	0	0	0	0	8	0	3	3	2	0	0	0	0
Kolken	7	0	3	2	2	0	0	0	0	4	0	2	2	0	0	0	0	0
Waterwegen	8	0	5	1	2	0	0	0	0	7	0	2	5	0	0	0	0	0
Opvangbasins	1	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0
Natuurgebied	6	5	1	0	0	0	0	0	0	5	1	2	1	1	0	0	0	0
Verzorgingsplaatsten	10	0	1	3	5	0	1	0	0	7	0	4	0	3	0	0	0	0
Gebouwen	6	0	0	1	4	1	0	0	0	5	0	0	0	3	0	0	2	0
Verkooppunt	3	1	0	0	2	0	0	0	0	2	0	0	0	1	0	0	1	0
Opslagtanks	6	1	1	2	2	0	0	0	0	4	0	1	1	1	0	0	1	0
Kunstwerk	11	3	8	0	0	0	0	0	0	8	0	5	1	0	1	0	1	0
Geluidscherm	4	2	0	2	0	0	0	0	0	2	0	1	0	1	0	0	0	0
Geluidswal	3	0	1	0	2	0	0	0	0	2	0	0	2	0	0	0	0	0
Portaal	6	1	2	3	0	0	0	0	0	5	0	0	1	1	1	1	1	0
Duikers	3	0	0	3	0	0	0	0	0	2	0	0	2	0	0	0	0	0
Riolering	7	0	2	0	2	0	3	0	0	5	0	2	2	1	0	0	0	0
Buizen	3	0	0	0	3	0	0	0	0	3	0	0	0	0	3	0	0	0
Faunavoorziening	4	2	0	2	0	0	0	0	0	3	0	2	1	0	0	0	0	0
Objecten van derden	10	1	3	1	5	0	0	0	0	7	0	0	0	3	1	1	1	0
Omgeving	11	8	2	0	1	0	0	0	0	11	1	3	5	1	0	1	0	0
Locatie	19	7	6	2	3	0	1	0	0	8	0	3	0	3	0	0	0	1
Beheergebied	90	1	81	4	0	4	0	0	0	60	0	0	0	0	60	0	0	0

Supplement 19A: Object Model - Performance Contract

Supplement 19B: Need of information - Performance Contract

	Accuracy (performance)									Up-to-dateness								
		Cluster									Cluster							
Spatial Object	total	1	2	3	4	5	6	7	8	total	1	2	3	4	5	6	7	8
Hectometerbordjes	4	2	1	0	1	0	0	0	0	7	0	2	2	2	1	0	0	0
Kant Verharding	5	0	0	1	2	2	0	0	0	24	0	5	8	5	5	0	0	0
Stroken	16	0	0	0	14	2	0	0	0	25	0	4	4	9	6	0	2	0
Verharding	6	3	2	0	1	0	0	0	0	17	0	5	2	6	4	0	0	0
Fietspaden	2	0	0	0	1	1	0	0	0	6	0	2	2	1	1	0	0	0
Parallelwegen	3	0	0	0	2	1	0	0	0	10	0	3	4	1	2	0	0	0
Voegovergangen	0	0	0	0	0	0	0	0	0	3	0	1	0	2	0	0	0	0
Wegmarkering	5	1	0	0	2	2	0	0	0	6	0	2	0	2	1	1	0	0
Tellussen	2	0	1	1	0	0	0	0	0	4	0	1	0	2	1	0	0	0
Signaleringslussen	2	0	1	1	0	0	0	0	0	5	0	1	0	2	1	0	1	0
Geleiderail	3	0	0	0	3	0	0	0	0	6	0	1	0	1	3	1	0	0
Bebording	4	1	1	1	1	0	0	0	0	3	0	0	1	1	0	1	0	0
Bewegwijzering	2	0	0	1	1	0	0	0	0	2	0	0	0	1	0	1	0	0
Klein meubilair	2	0	1	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0
Lichtmast	3	1	2	0	0	0	0	0	0	3	0	0	0	2	0	1	0	0
Verlichtingspunt	2	1	1	0	0	0	0	0	0	3	0	1	0	2	0	0	0	0
DRIP	1	0	0	1	0	0	0	0	0	4	0	0	0	1	0	1	2	0
VRI	2	2	0	0	0	0	0	0	0	2	0	0	0	1	1	0	0	0
TDI	1	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
K en L (KLIC)	0	0	0	0	0	0	0	0	0	11	0	0	1	0	1	2	5	0
K en L (RWS)	0	0	0	0	0	0	0	0	0	14	0	0	1	1	2	3	7	0
Perceel	1	0	0	0	1	0	0	0	0	9	0	1	4	1	0	2	0	0
Voedingskasten	2	0	0	2	0	0	0	0	0	11	0	0	0	8	3	0	0	0
Beplanting	6	1	2	1	2	0	0	0	0	15	1	2	8	3	1	0	0	0
Bomen	2	1	1	0	0	0	0	0	0	8	0	3	3	2	0	0	0	0
Kolken	0	0	0	0	0	0	0	0	0	4	0	2	2	0	0	0	0	0
Waterwegen	1	0	1	0	0	0	0	0	0	7	0	2	5	0	0	0	0	0
Opvangbasins	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
Natuurgebied	1	1	0	0	0	0	0	0	0	5	1	2	1	1	0	0	0	0
Verzorgingsplaatsten	4	0	0	1	2	0	1	0	0	7	0	4	0	3	0	0	0	0
Gebouwen	0	0	0	0	0	0	0	0	0	5	0	0	0	3	0	0	2	0
Verkooppunt	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	1	0
Opslagtanks	0	0	0	0	0	0	0	0	0	4	0	1	1	1	0	0	1	0
Kunstwerk	1	1	0	0	0	0	0	0	0	8	0	5	1	0	1	0	1	0
Geluidscherm	0	0	0	0	0	0	0	0	0	2	0	1	0	1	0	0	0	0
Geluidswal	2	0	0	1	1	0	0	0	0	2	0	0	2	0	0	0	0	0
Portaal	0	0	0	0	0	0	0	0	0	5	0	0	1	1	1	1	1	0
Duikers	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0
Riolering	1	0	0	0	0	0	1	0	0	5	0	2	2	1	0	0	0	0
Buizen	0	0	0	0	0	0	0	0	0	3	0	0	0	0	3	0	0	0
Faunavoorziening	0	0	0	0	0	0	0	0	0	3	0	2	1	0	0	0	0	0
Objecten van derden	0	0	0	0	0	0	0	0	0	7	0	0	0	3	1	1	1	0
Omgeving	2	0	1	0	1	0	0	0	0	11	1	3	5	1	0	1	0	0
Locatie	9	4	2	0	3	0	0	0	0	8	0	3	0	3	0	0	0	1
Beheergebied	29	0	24	3	0	2	0	0	0	60	0	0	0	0	60	0	0	0

Supplement 20: BPS example



Addresses

Author

Name: Marcel de Rink
Email: m_a_derink@hotmail.com
Tel. nr: 06-46250453

Supervisors

Name: A.M. den Boer
Email: A.M.dBoer@agi.rws.minvenw.nl
Tel. nr: 015-2757575

Name: Dr. ir. M.J.P.M. Lemmens
Email: M.J.P.M.Lemmens@otb.tudelft.nl
Tel. nr: 015-2781042