The value of GI4DM for transport and water management

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ABSTRACT: The tasks and responsibilities of the ministry of Transport, Public Works and Water management in the Netherlands lie in the sectors integrated water management (water quality and water quantity), traffic and transport over waterways, rail and in the air. In the past many calamities have taken place in those sectors. Besides large(r) calamities daily traffic incident management along the main roads and waterways is a major task of the Ministry as well. On such occasions the need for (spatial) information and supporting information systems is great. That need has only grown because attention is especially drawn to a proactive/preventive phase in calamity control and incident management. In this chapter we will outline the use of geospatial information and geoservices in Disaster Management within the field of national transport and watermanagement in the Netherlands.

1 INTRODUCTION

The tasks and responsibilities of the ministry of Transport, Public Works and Water management (V&W) in the Netherlands are focussed on water management (water quality and water quantity) and traffic and transport over waterways, roads, rail and in the air. In the past several calamities have taken place in those sectors: heavy car collisions due to intense fog nearby the city of Breda (1972, 1990), pollution of Rhinewater due to fire in Sandozplant (1986), airplane crashes near Schiphol and Eindhoven (1994, 1995), derailment of chloride trains in Delfzijl and Kijfhoek (2000, 1986), river floods (1993, 1995), and recently some dike collapses due to heavy drought and rain (2003, 2004). Besides managing these large(r) calamities daily traffic incident management along the main roads and waterways is a major task of the Ministry. On all such occasions the need for (spatial) information and supporting information systems is great. That need has only grown because attention has also shifted to the proactive and preventive phase in calamity control and incident management.

The directorate-general for Public Works & Water Management (Rijkswaterstaat) as part of the Dutch ministry of V&W is since 1798 responsible for maintaining and administering the main roads and waterways in the Netherlands. These tasks include protection of the country against floods from both the rivers and the sea. V&W is an organization having 15,000 employees, an annual budget of approx. € 7 billion (US $ 9 billion), and more than 200 offices throughout the country. Accurate and up-to-date geospatial information has always been a necessity for administering the main water- and road networks of the Netherlands. As transport and water management was crucial to survive in the low-parts of the Netherlands the management of the water systems was already conducted in a sophisticated and organized way in the middle ages. There are e.g. map series of thematic maps of the water system on a scale of 1 to 19:000 (15 sheets) dated 1611. V&W thus has a longstanding tradition of mapping and geospatial data processing. Geospatial data management at V&W moves to a new stage in which the demands of today can be met. Key factors in this geospatial data management policy are centralization of geospatial data in centrally managed geodatabases, the use of open standards, the exchange of Windows-clients for small-footprint browser-based web-clients and the use of mobile technology which is seamlessly connected to the main GDI. In this chapter we will outline the Geo Data Infrastructure based on ISO/OGC web services and metadata standards and adopted application architecture and infrastructure.

The department of Geo-information and ICT of Rijkswaterstaat (RWS AGI) is responsible for providing the organization for the IT and the (geospatial) information needed for its tasks. The department of Geo-information and ICT is working with V&W to meet the challenge of reducing IT costs considerably. The strategy to meet this challenge is built on the principles of uniform working models, open standards, server-based computing and central data hosting and maintenance. In this chapter we will outline the Geo Data Infrastructure (GDI) within the ministry of Transport, Public Works and Water management in the Netherlands. Attention is given to the following subjects:

- An actual status description of Disaster management within V&W in terms of strategy, organisation, and working methods;
- Insight in the underlying renewed Geo Data Infrastructure based on ISO/OGC web services and metadata standards and adopted application architecture;
- A descriptive real-world scenario that illustrates the role and importance of geospatial information and Geo Data Infrastructures in calamities of water transport and river flood management in the Netherlands; and
- Some concluding remarks.

2 STATUS DESCRIPTION OF DM WITHIN V&W

2.1 *V&W and safety & security policy*

In the Netherlands the ministry of Transport, Public Works and Water management (V&W) has a number of tasks and responsibilities in the field of safety and security. The following domains are distinguished:

- Traffic and transportation by road, rail, water and air: examples are security at Schiphol airport, (inter-)national aviation security, social security in public transport, safety on main roads and rivers and transport of dangerous goods.
- Physical infrastructure: examples are tunnels, bridges, rail shunting emplacements and underground tubes.
- Water management: examples are protection against high water levels of rivers and sea (e.g. dikes and retention areas) (water defence), management of surface water levels in relation to fresh water intake, dumping of cooling water and/or inland shipping (water quantity) and oil and chemical spill detection and recovery (water quality)

The primary policy tasks of V&W are within these domains and the safety and security policy is an integrated part of those tasks. The ministry has formulated a generic view on safety and security which consists of the following four core elements:

- To strive for a permanent improvement of safety and security
- Within the above-mentioned domains a process of ongoing improvement has been implemented. The process is focusing on permanent reduction of (the chance of) killed and injured people and the (chance of) social disruption. It is evident that in the process of permanent improvement SMART policy objectives and milestones have to be set in order to make progress explicit.
- To weigh measures explicitly and transparently
- V&W operates in an area of constant tension in which trade-offs between economy, environment and security have to be made. Other policy aims than safety and security must explicitly be assessed, weighed and exchanged against (the chance of) mortalities and injuries and/or material damage. V&W prefers a transparent view of these assessments in order to allow for clear political choices. This is achieved by assembling parcels of measures with varying ambitions by which the positive and

negative consequences based on costs, economy, environment and security become obvious.

- To be prepared for inevitable risks
- Risks are inevitable: even though it is the aim to improve working procedures and results to the maximum and to achieve better safety situations there will always be a risk or chance of misfortune. We don't control nature and it is human nature to create risky situations. Within this context we do not always provide for sufficient financial and technical means to prevent unsafe situations. These so called 'inevitable risks' oblige V&W to take constantly into account the possibility of an accident or calamity, after which it is best to minimize the consequences of such an accident or calamity as much as possible. A useful and perhaps most important method is to practice for such events; this also allows for building and testing the quality of organizational and communicational structures and procedures.
- To obtain and maintain a safety culture within the ministry
- A necessary condition to achieve long-lasting improvement is to explicitly manage the aspect of safety and security. This can be obtained by the installation of dedicated units within the organization, by explicit reservation of funds and by agenda setting. In this way awareness is created within the organization.

To transform this view into more practical and concrete safety and policies the concept of 'the safety chain' is illustrated (Fig. 1). This chain is composed of five phases: pro-action, prevention, preparation, response and recovery.

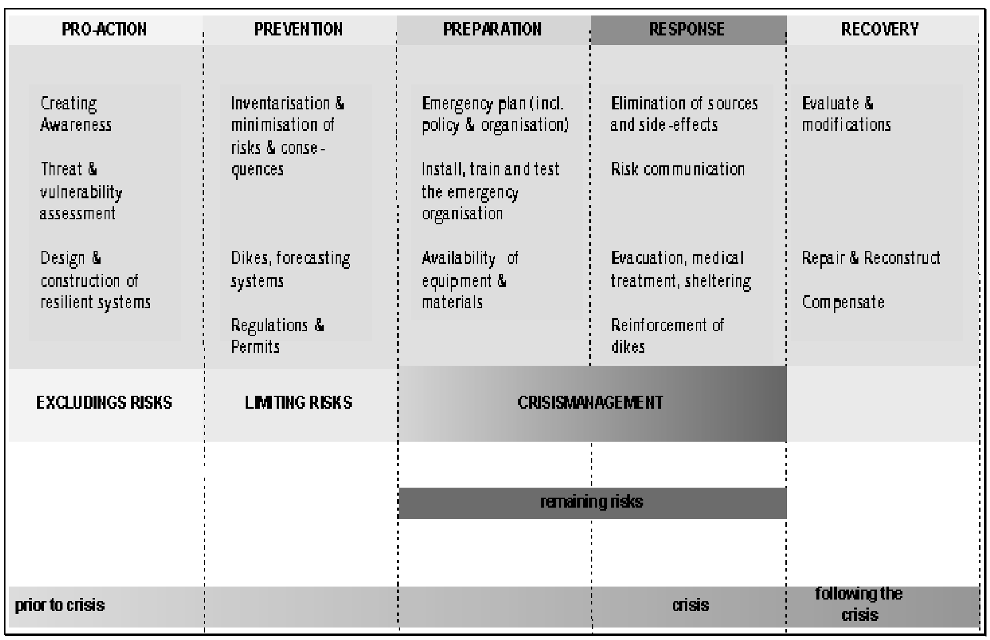

Figure 1. The safety chain

2.2 *V&W and crisis management*

Since the end of 1999 V&W has grouped its activities in the field of crisis management in the Departmental Coordination centre Crisis management (DCC). This centre builds on the strategic objective of crisis management: a decisive V&W-organisation that functions administratively, organisationally and operationally in a coherent way during incidents and calamities. From the central objective the following points have been derived:

- Development and implementation of crisis management policy: development of policy on planning, education, training and all other areas related to crisis management.
- Preparing of emergency plans in such a way that a common insight arises in the tasks and responsibilities of the organisational services concerned, insight into the dangers for

which the organisational service concerned is responsible for and the insight in relevant networks.

- Training and practising staff so that people concerned with regard to knowledge, skills and experience are well prepared for crises.
- Embedding in the organisational context. The departmental structure and working methods must be coupled to the external network. During crisis circumstances the partners in the network must be able to find each other and know they can count on each other.

2.3 *Organisation*

The generic safety and security policy of V&W is developed by the programme board safety & security; the policy for and the operational crisis management as such is the responsibility of the Departmental Coordination centre Crisis management (Fig. 2.

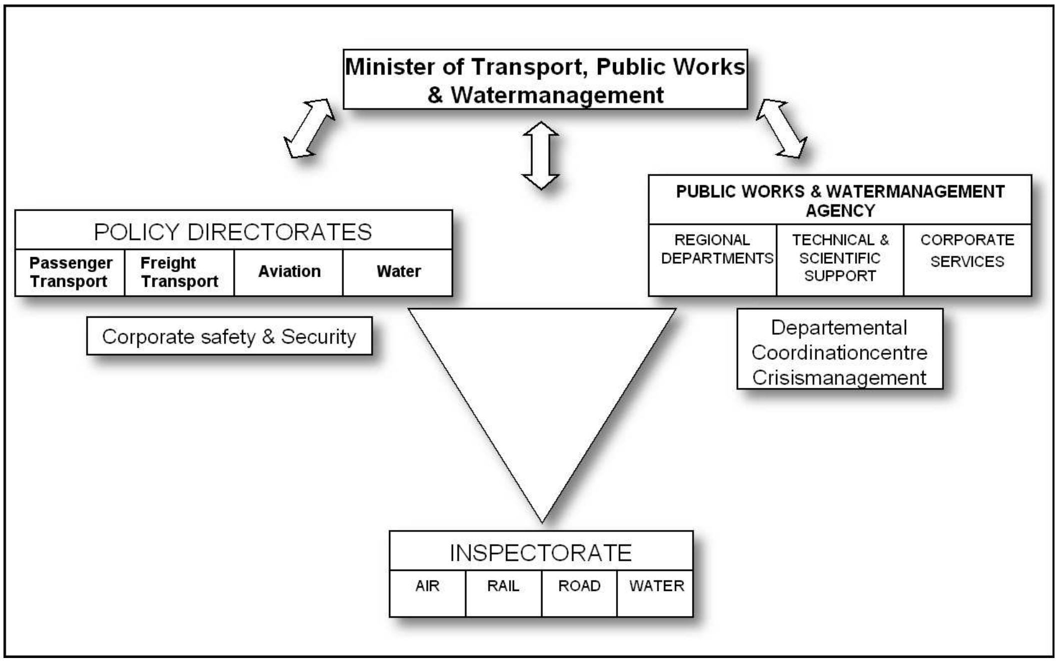

Figure 2 Organisation of crisis management within V&W

The Departmental Coordination centre Crisis management is the central office for all Directorate-Generals (DG's) and the central services within V&W. In case of a crisis a V&W alarm number is available. A protocol has been developed which describes clearly who is responsible for what and who informs who if there is a problem. This is summarised in network cards for all domains; a comprehensive overview which describes the organisational context of the organisation (Fig. 3). Onto these network cards the actors are added for each domain. These network analyses and competence diagrams together with the description of the internal organisation and checklists for decision-making form the handbook of crisis management of V&W.

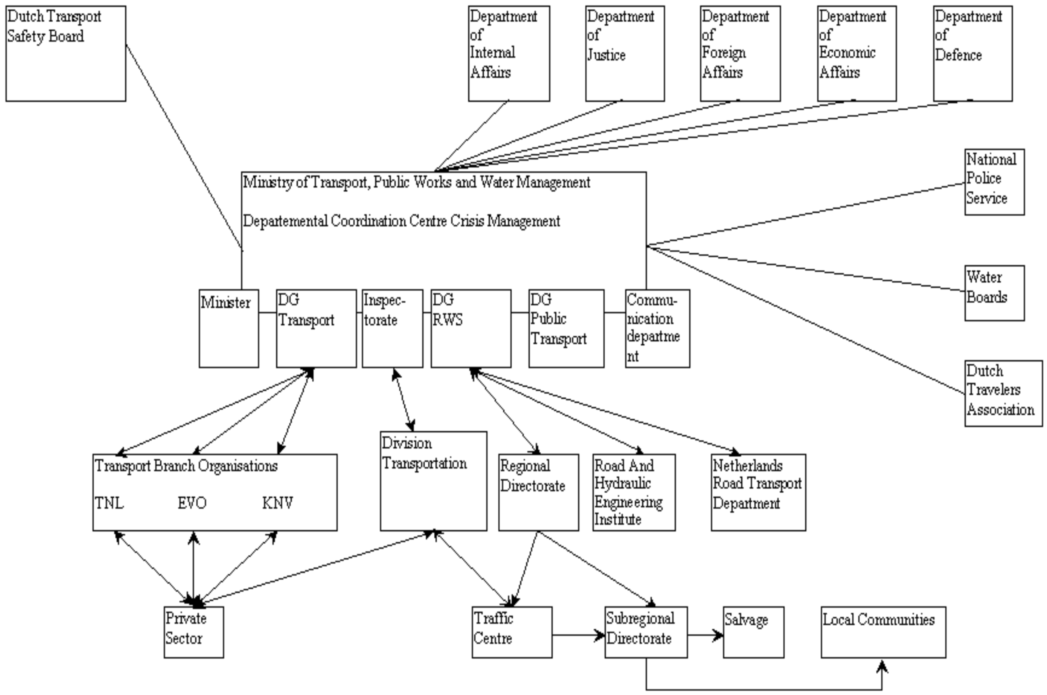

Figure 3. Operational organisation network during crisis events on main roads

2.4 *Working methods*

At a strategic level the topics of safety, security and crisis management are being developed in a number of ways. Examples are the internalisation of external costs, development of performance indicators for measuring policy effectiveness, developing future scenarios in order to review safety and security plans, developing uniform and accepted models for risk assessment and last but not least working on public confidence. Each of these themes is analysed on several aspects. The economic aspect is considering safety and security as an economic problem; a central question is for example "how much money does it cost to protect “X” capital goods or “Y” lives. The aspect of spatial planning approaches security and crisis management as spatial problem with questions such as "where can I plan houses or industrial areas and where definitely not". If security is considered as an administrative problem questions include "who has which responsibilities and mandates and are they properly addressed?". The fourth and more generic approach considers security and crisis management as a social problem and aims at developing socially acceptable security level/dangers as parameters for decision-making and aims at a more integrated approach in which the aforesaid aspects are incorporated..

3 V&W GEO DATA INFRASTRUCTURE

3.1 *Towards a V&W corporate Geo Data Infrastructure*

To ensure the adequate use of geospatial information and systems in large organisations a framework is needed. Since the beginning of the nineties within V&W this framework existed and was known as Geo-information Infrastructure (GII). The V&W GII was considered as the complete set of geospatial information, GIS and geospatial applications, standards, policy, IT infrastructure and organisation to ensure an efficient and effective use of geospatial information within the organisation. Nowadays, the term Geo Data Infrastructure (GDI) or Spatial Data Infrastructure (SDI) is internationally acknowledged (Groot and McLaughlin 2000). The main goal of a GDI is ensuring an optimal availability and usability of geospatial information and information systems through open interfaces that operate on the web services concept of publish-find-bind. V&W started in 2003 with the adoption of these new interface concepts. This has resulted in a geoservices application architecture (Fig 4.).

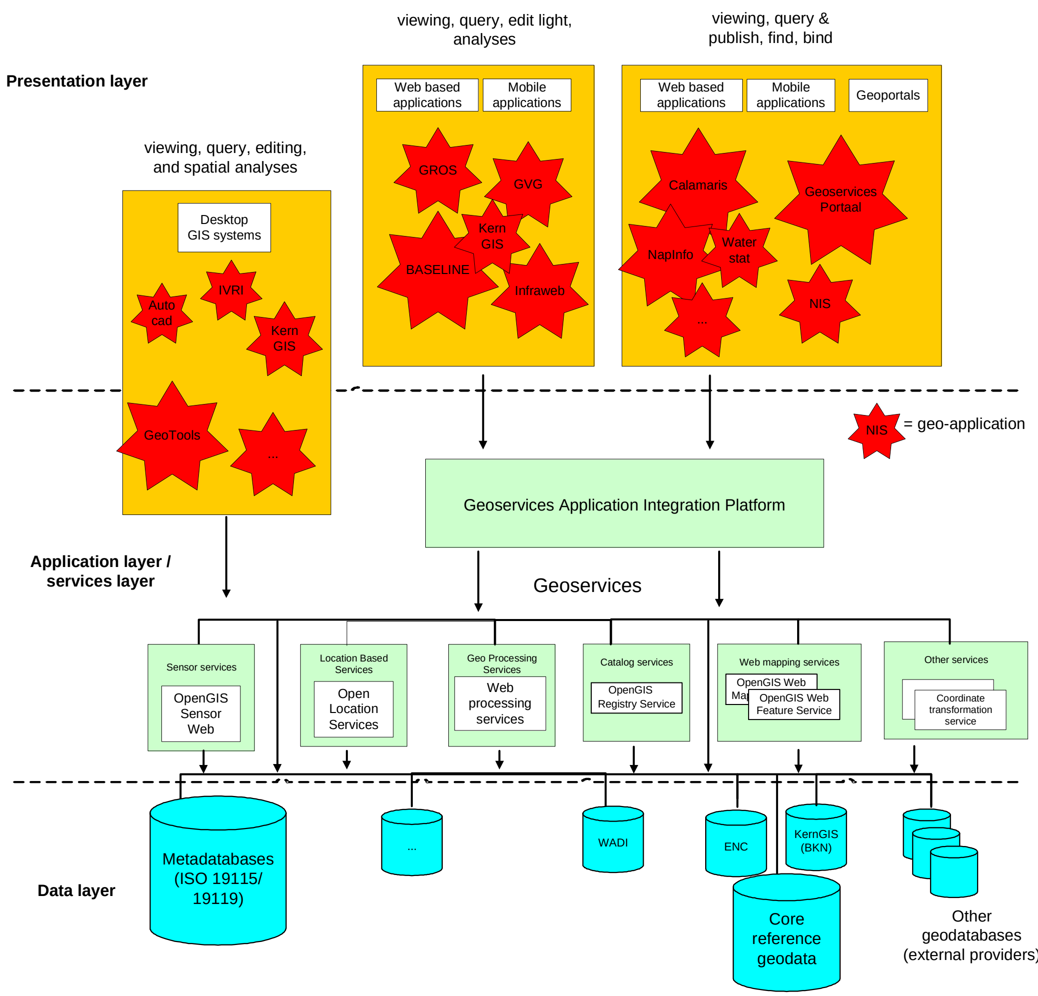

Figure 4. The V&W GDI-based application architecture

The GDI application architecture can be considered from different perspectives. Here we consider the GDI from the application perspective consisting of the presentation layer (the applications), the geoservices layer and the database layer. The presentation layer consists of different types of geospatial applications. Within V&W circa 50-60 different geospatial applications exist that are used in the different application fields of the ministry: besides disaster and emergency management there is also public works and asset management, road transport management, water quality management and policy development and evaluation in these fields. Three types of geospatial applications are distinguished; desktop GIS based applications (within V&W software mainly from ESRI and Autodesk), browser based geospatial applications and mobile geospatial applications (also browser based). The geoservices layer consists of different types of services that offer access to spatial data from different sources, perform transformations on spatial data and offer portrayal services for the different types of clients (desktop, browser apps and mobile apps). These geoservices are based on the open standards of Open GeoSpatial Consortium (OGC) and ISO. The geoservices application integration platform offers the instruments to develop applications; from RAD software, geographical user interface components and instruments for services chaining.

At the database level data access is offered to all geospatial referenced information in the organisation. Core reference geospatial information for V&W DM consists of several types of base maps, like high scale topographic maps, aerial photo's, satellite images, object information and cadastral data. The core geospatial information is centrally served through web services from different proprietary data formats to these distributed applications. Within the V&W GDI the availability of metadata on data and services is obliged. CEN- and ISO-based metadata standards are used (ISO 19115 for datasets and ISO 19119 for services). Since 1992 V&W has developed and implemented a profile for the CEN98 metadata standard for geospatial information is developed. Recently this profile is translated to the ISO 19115 metadata standard.

The GDI based approach should offer V&W an optimal access to core geospatial information and geo-referenced information needed for applications of disaster management and incident management within V&W. In the next paragraph we outline the adopted parts of the GDI software within V&W.

3.2 *The V&W catalogue and web mapping services architecture*

Since 2003 V&W is working on the implementation of a central, OGC-based services architecture infrastructure. The most powerful element of the OGC-based web services architecture is the concept of "publish-find-bind". This web services concept works as follows (Fig. 5). The data manager publishes geospatial information in the form of maps and served by an Internet map server in a registry. The registry is known as the OGC Web Catalogue Services (WCS). The user of an application has a find button, for access to the registry and to answer the questions: which map servers are available and which maps are available? After the maps are found in the catalogue database, the user can bind the maps through the web mapping user interface of the application. The OGC web services concept is based on a distributed systems concept. Data is directly accessible at the source database through an OGC-based services interface. Sharing geospatial information in an open and transparent way is what this is all about. The architecture offers users of geospatial information an easy way to access, publish, find and bind geospatial information through Internet technology.

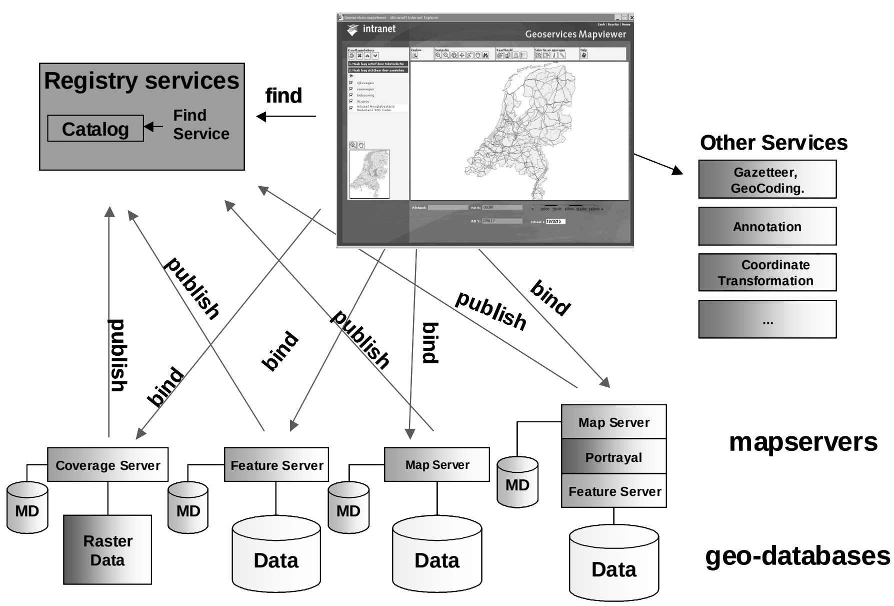

Figure 5. The web services concept of publish-find-bind of geographical data

This geospatial information infrastructure based on the OGC web services architecture has been established using both open source software products and commercial-off-the-shelf components. This infrastructure has already enabled broad geospatial information sharing throughout the organization and has proven to be cost effective. The adopted software architecture is characterised by a three layers architecture: presentation layer, services layer and data layer

(Fig. 6). The architecture is modular and scalable. The kernel of the architecture is the services layer. The modularity of the services layer is illustrated by the fact that several different software components for the Java/J2EE platform as well as the Apache/PHP platform.

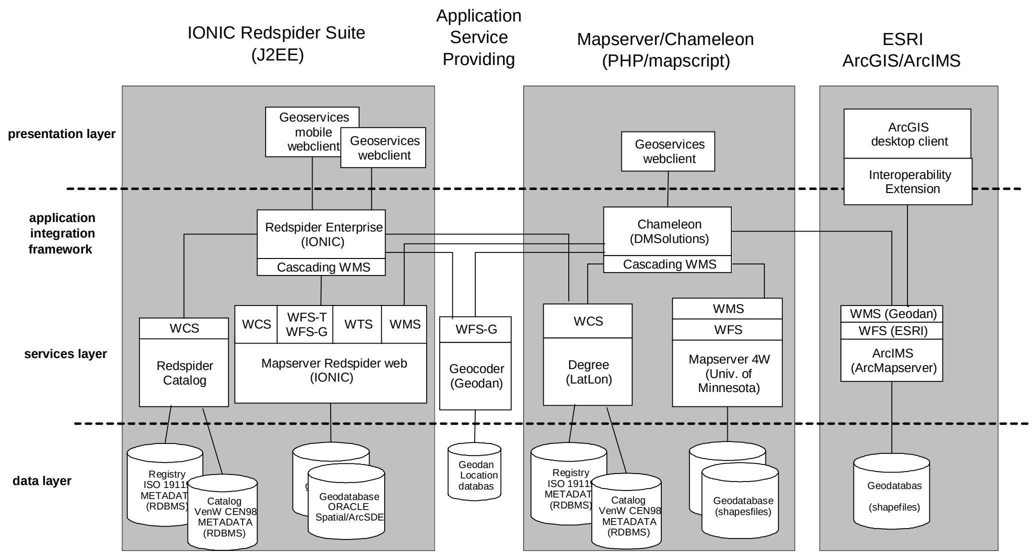

Figure 6. Adopted OGC-based software infrastructure

For basic web mapping services OGC Web Map Server, Web Feature Server and Web Coverage Server Rijkswaterstaat uses the Redspider suite of IONIC and the Minnesota MapServer (MS4W) of the University of Minnesota (Open Source Software). The Web Catalogue Service is the Open Source Software (OSS) product Degree from the German vendor LatLon. Degree is Java based. A Dutch company Geodan offers a geocoder service based on the Application Services Providing (ASP) business model, to gazetteer. An underlying location database offers access to all addresses, postcodes and municipalities in the Netherlands. The client software platform is based on IONIC's Redspider studio and the Canadian product Chameleon that is based on a PHP server-side scripting language. Furthermore ArcIMS from ESRI is also used for mapping, especially for web mapping in combination with the ESRI's ArcGIS desktop client software.

3.3 *The V&W location based services architecture*

To carry out the day-to-day activities many Rijkswaterstaat employees are out in the field-inspecting infrastructure, checking permits and regulations etc. To supply these workers with hand-held mobile computers with GPS location and a wireless connection to the office network proved to be very productive. Apart from the time saved also the quality of the decisions made increased because of the information available on the spot. In a pilot project mobile computers running a web browser were connected to several distributed databases and able to do vector editing with WFS-T in these databases all through OGC standard protocols. Expected future implementations include the implementation of a transactional web feature service for mobile clients. Location-based Services (LBS) are information services, accessible through devices such as mobile phones, PDA's, tablet and laptops. Their essence is the ability to locate a user or an object in space, and to use this to make information processes aware of the location dimension. Location-based services are indispensable in emergency services and disaster management.

3.4 *Towards a GI4DM architecture*

The above-mentioned GDI architecture is not an end in itself. It should support applications with for geospatial information processing capabilities. The illustrated GDI services are geoprocessing components for building risk management applications. However information systems that support DM should have other services available as well. The approach of Orchestra (Annoni et al 2005) is worth consideration. Orchestra puts forward an architecture that can be considered as a collection of services, tools and methodologies that so-called system users can use to develop disaster management information systems for end users. For instance the above-mentioned mapping and location-based services are providing geospatial information processing capabilities. Additional to these geoservices Orchestra outlines a services framework for risk management that can be applied for different risk and disaster situations with services for formula access, diagramming, documents access, sensor access schema mapping, ontology access and service chaining (Uslander 2005).

4 A DM SCENARIO IN TRANSPORT AND WATER MANAGEMENT

4.1 *Introduction*

Information systems for Disaster Management will benefit from the developments in open Geo Data Infrastructures in an evolutionary way. These benefits can best be shown by outlining a DM scenario. The scenario is an as realistic as possible attempt to demonstrate the usefulness of geographical web services based on the ISO/OGC web services architecture. Information management and information systems for flood defense and disaster management will benefit from these new developments in an evolutionary way. The flood defense crisis is situated near Nijmegen on the river Waal, where flooding conditions due to abundant rain and melting snow coincide with stormy conditions. Four crisis centers communicate using open geographical web services technology provided by a series of governmental organizations resulting in effective and efficient information sharing and quick response to the disaster 'nearly' developing. Here cooperation and information sharing boosts information control.

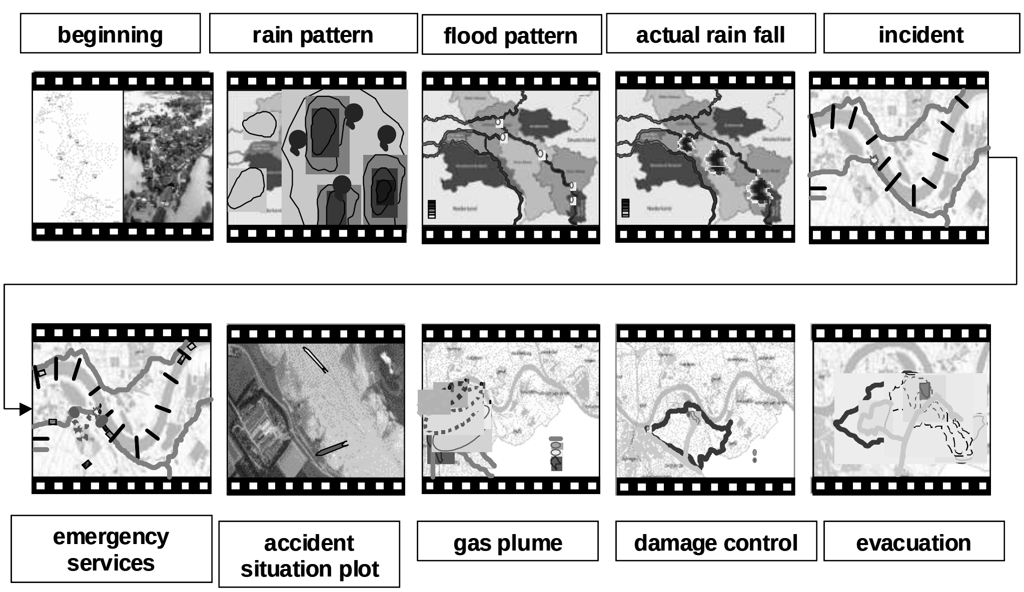

Figure 7. Geospatial information scenes of the DM flooding scenario script

This scenario consists of a number of scenes in which flood defence is simulated and disaster management in the Netherlands is illustrated (Fig. 7). It is a fictive simulation of a ship crash at the Rhine river near Nijmegen in the Netherlands during a critical high water situation. Any resemblance of the events and people in this scenario with reality are due to the merest coincidence. This scenario is a developed for a OGC web services simulation by V&W Department of Geo-Information and ICT, Twynstra en Gudde Management Consultants and the project organizations Viking, NOAH and HIS.

4.2 *DM scenario; the beginning*

It is Monday morning when Willem van der Gaag, crisis coordinator of the V&W Institute for Inland Water Management and Waste Water Treatment (RIZA), starts up his computer and inspects the water information system of the rivers Rhine and Maas. He knows, today the water level is expected to rise to alarming heights. Yesterday at the national news showed the first alarming pictures of floods from excessive rainfall in NordRhein Westfalen and the Eiffel (Germany). Combined with extreme high rise water levels of the rivers caused by melting water and rainfall in Switzerland and part of the East of France this will lead to floods in the rivers basins in the Netherlands. RIZA is responsible for the river water level monitoring and discharge (water transport per m3 per second) at Lobith and Borgharen, the locations where respectively Rhine and Maas enter the Netherlands. Besides water quantity, RIZA also monitors water quality. RIZA calculates the expected water rise and water level. As soon as the actual water transport level in combination with the expected time of transport exceeds the defined limits, RIZA will alarm the regional and local water managers. In case of an expected flood situation, the local fire fighting and police department will be informed as a precaution. Willem van de Gaag is checking the situation in Lobith using his geographical information system (GIS); the maps show the situation of the water system Rhine at the location Lobith. He also checks the Rheinatlas (http://www.iksr.org) where he explores the previously predefined flood risk areas.

4.2.1 *Scene 1; Mapping the weather forecast*

Willem is evaluating the water situation in Lobith. He predicts the expected water levels in the next 48 hours. In order to have realistic water predictions he needs information about the local weather situation in the water system of Rhine and Maas. Therefore he accesses the database of the Royal Netherlands Meteorological Institute (KNMI). While the water rise prediction system calculates the expected water levels, Willem is inspecting the weather maps of KNMI with his GIS. He displays the rain fall maps of the last three days and the rainfall predictions of the next three days. He also takes a look at the maps of the actual and expected wind directions and wind speed. These maps show an increasing rainfall in the river basin area. When he receives the prediction outcomes, he knows that Wednesday morning Lobith is expecting a high water transport level with an expected maximum peak Wednesday evening.

This information leads to the sending of a ‘flood warning message’ to the regional and local water managers and emergency services (local fire fighting and police departments). This message is an early warning that a flood crisis is to be expected. The message consists of all relevant information including the maps and is offered through geographical web services technology. Especially the map location where the Rhine meets the Waal, Netherrhine and IJssel shows an alarming flood situation. Even taking the uncertainty of the predictions into account, a two-day flood situation is expected with even a chance of extreme floods. Through email, fax, phone and geographical web services all responsible and involved parties are informed.

4.2.2 *Scene 2; High water rise*

In Arnhem the regional crisis manager Joost Hilhorst receives the incoming flood warning message and is going to measure the ‘exact’ water rise level per kilometre section. This means that for each kilometre at the waterway the expected water level and discharge is calculated. As long the calculated levels remain under the level of the dikes along the waterway, no floods will occur. However with strong winds and river surges this could lead to floods. Especially at locations with weaker dike stability this can have impacts. The dike management information system of Rijkswaterstaat will inform the regional crisis manager about the status and stability of the dikes. The weak dike spots are mapped together with the detailed, predicted water levels for each river section and located on a risk map. Joost Hilhorst puts forward the risk map during a meeting with other flood experts. They decide that it is time to express ‘Warning phase 1’. The decision is in particular based on the fact that the map shows a maximum of 0.8 meters water rise in the Waalbandijk in the Ooijpolder and 0.4 meters at the lock in this dike. Joost and his colleagues also know that during renewal of the road deck the asphalt at the dike road is removed the last week. This even makes the spot more vulnerable.

4.2.3 *Scene 3; Extreme rainfall*

Tuesday morning Joost Hilhorst is inspecting the latest weather forecasts. These show increased possibility of extreme rainfall in the Rhine water system in Gelderland and Noord Limburg. The weather radar maps show heavy rainfall patterns with strong winds near Wesel and Nijmegen. Messages of water floods in cellars of houses and tunnels in the region give a strong indication that the water level at the waterways will increasingly rise and the emergency services (especially fire fighting units) will be busy in next hours. At the same time the weather forecast shows stormy weather expected on Wednesday evening.

Because of the water level and waves due to the expected stormy weather Joost and his colleagues expect that the transport possibilities at the Waal river will be limited to zero at Wednesday afternoon. A warning to professional shipping companies is sent out; between Wednesday 1200 hours and Friday evening 1200 hours ship traffic will closed at the Waal corridor between Lobith and Weurt. The margin of the dike stem level for each dike section remains under the critical levels and therefore restricted ship traffic is still possible. The warning message to the ships is accompanied by a map with detailed restrictions.

For the critical situation at the Waalbandijk in the Ooijpolder it is decided to raise the dike stem level with an extra layer of sandbags. Wednesday morning a contractor of Rijkswaterstaat will place a double row of sandbags (40 cm) at a length of 30 meters next to the lock at the Waalbandijk.

4.2.4 *Scene4; Incident; shipping accident*

The same Wednesday morning 10.00 hours a ship incident message arrives at the emergency room of the regional Fire Fighting Unit. At the location of river section or ‘kilometerraaij’ 854 two ships have crashed. The captain of one of the ships, loaded with coal, indicates that he manoeuvred his ship into a dike in order to try to avoid the crash. According to the incident protocol Henk Groen at the emergency room collects the necessary information from the captain and tries to figure out if any human victims are involved, whether there is fire or a leak with chemicals or gasoline. The captain of the Rhine vessel loaded with coal is confused and with the second ship there is no contact. Henk Groen decides to contact the river information services system in order to obtain information about the actual traffic at the incident location. At the same time he warns emergency services including a diving team. Boat units of Rijkswaterstaat and police are ordered to the incident spot as well. Henk can track and trace the mobile units on the computer.

The incident spot is marked in the system and because of the expected impact the crisis situation is scaled upwards. First, there is a possibility of a breach in the dike at the spot of the large coal vessel during a flood. Second, it is expected that this ship restricts the water transport with a strong chance of water damming. Henk Groen views the municipality map and informs the crisis coordinator of the municipality. At the same time an inter local warning is dispatched to the surrounding municipalities in case the incident accumulates.

4.2.5 *Scene 5; Crisis coordination*

After a couple of minutes the first police surveillance unit is near the incident spot. Through their C2000 communication system the unit informs the emergency room about the local situation. However, the police surveillance is confronted with the roadblock of sand and other maintenance materials for the renewal of the asphalt layer. The unit is 300 meters away from the incident spot and continues on foot. At first visual inspection they do not observe fire or any other alarming activity. The emergency room decides to order the contractor to clear the road. Also the voluntary fire-fighting unit of the municipality of Ubbergen arrives at the roadblock and cannot access the incident spot. The police unit on foot discovers a small sandy track in the direction of the stranded coal vessel. This small track is not on the map of the emergency room and Henk Groen asks for a more detailed roadmap from the local road network manager. It seems that there is a small track that gives access 300 meters downstream the incident location. The emergency room informs and guides the diving team from Nijmegen to this spot.

4.2.6 *Scene 6; The ammoniac tanker and it's gas plume*

Then by phone the emergency room Gelderland-Zuid in Nijmegen receives the information about the second ship from the River Information Centre from Rotterdam. There is a strong indication that the second ship might be the ammoniac tanker Diana from Düsseldorf. Up till now it was not possible to reach the ship by phone. According the GPS-based River Information System the last location of the ship is 100 meters downstream of the stranded coal vessel. This indicates that the tanker is damaged. Henk Groen immediately informs the mobile rescue units via C2000 to perform observations at the Waalbandijk of a possible gas leak from the ammoniac tanker. This warning is also communicated with the regional crisis centre of the security region of Gelderland Zuid, which became operational during the last couple of hours. The potential of a gas plume calamity makes this incident an intermunicipal incident being a treat for a large group of the population.

4.2.7 *Scene 7; Gas plume evacuation scenario's*

Martin Slootsdijk, being responsible information manager at the regional crisis centre Gelderland-Zuid, immediately investigates the wind maps, the actual ship movements at the Waal. Next he calculates a plume using an integrated plume model of TNO-FEL in case of a gas explosion at the ammoniac tanker. The resulting gas plume maps are overlayed with the maps of housing and inhabitants, economic activities, cattle and the road network in order to get an indication of numbers of persons and cattle for evacuation. Because of the fact that the tanker still moves downstream he also copies the plumes to downstream locations and recalculates the number of evacuees. It is obvious that the tanker should be stopped in order to avoid plumes at the larger dense populated city of Nijmegen. He alarms the water police and Rijkswaterstaat to stop the tanker from proceeding downstream.

4.2.8 *Scene 8; Prevention*

In the mean time at the crisis centre of Rijkswaterstaat East in Arnhem the crisis team is working on a strategy to avoid further damage at the dike by the Rhine vessel. Repairing the damage is one activity of the strategy, the other is trying to avoid further damage because of the fact that the ship's position is on top of the water direction. This might cause in combination with the heavy rainfall and strong winds an additional water rise of 0.15 m as is calculated by one of the information systems. The safety margin becomes very narrow. At the same time there a possibility that the coal ship is floating away, causing more damage at the dike.

In order to the prevent damage the most recent information about industrial activities (dangerous goods that might have environmental impact) and heritage sites (especially monuments) in the area that are threatened by possible floods are collected. At the Risk Map of the Netherlands it is shown that one industrial site is located in the area; it is a stone/concrete factory. Through the permit database it is shown that that the factory has permits for storage of oil spill depot. The crisis centre orders these goods to be removed. The monuments database (or KICH-portal) shows that several monuments are located in the area. However, it is decided that no further actions are necessary to prevent damage of goods in these monuments (all private properties).

4.2.9 *Scene 9; High water evacuation*

In the mean time at the regional crisis centre of Gelderland-Zuid the crisis team is gathering the necessary information to see whether evacuation of people and cattle will become inevitable considering the potential gas plume and possibility of floods. At that moment a message from the water police arrives at the centre. There has been communication with the ammoniac tanker. The captain of the tanker has confirmed that his gas tank pressure level is OK and he and his crew did not observe any visual damage to the gas tanks. It is decided that the ammoniac tanker will be sent for further visual inspection to the coal harbour of Weurt.

In the mean time several calculations are performed in order to determine the size of an possible evacuation of people, cattle and goods. Through model based calculation with the HIS system (www.hisinfo.nl) it is shown large parts of the Ooijpolder will be flooded. In a period of one hour after a major dike collapse the water will reach the village of Ooij. However the inhabitants will need 3 hours to leave through the southern and eastern route. Ooij has 4 elderly homes with 25 inhabitants, and three public archives of the Municipality of Ubbergen that need special attention.

5 SCENARIO SYNTHESIS

Besides the end of the fictional scenario, because that is a matter of an exercise in collecting and handling information and decision making, this scenario implies that the traditional instruments such as phone and email for handling crisis situations will also change through the use of GDI web services. By plotting information on the map and offering online access to distributed geographic databases, these information services increase speed of handling during crisis situations. Especially, information management can benefit from OGC-compliant web services oriented architectures in crisis situations that have the following characteristics,:

- When different organisations with different responsibilities are involved;
- When organisations are located at different locations; and
- When organisations use different distributed information systems.
- In table 2 a quick scan of this disaster management scenario in the Netherlands shows the different geodatasets and information systems used and organisations involved. As shown several different types of geodatasets are generated and processed by different information systems owned by different organisations at numerous distributed locations. These are characteristics of situations where a GDI approach offers advantages.

Table 1: Overview of diversity of geospatial information and information systems and involvement of organisations within DM flood scenario in the Netherlands

Scenes	**Geo datasets**	**Systems**	**Organisations involved**
The beginning	• water system • water levels • flood risk areas	• FEWS • Rheinatlas	• Info centre RWS RIZA
Scene 1	• water system • expected water levels • rain fall last 3 days • rain fall prediction • actual wind direction and speed • predicted wind direction and speed • flood warning / high water message	• FEWS • Infocenter.nl • C2000	• Info centre RWS RIZA (KNMI, DWD, ECMWF) • Regional and local water managers • Emergency services
Scene 2 High water rise	• detailed expected water levels per km • detailed expected water discharge per km • Dike protection maps • Weak spots (dike repair)	• Dike Info system • HIS	• RWS ON • Regional and local water managers
Scene 3 Extreme rainfall	• rain fall last 3 days • rain fall prediction • actual wind direction and speed • predicted wind direction and speed • Water transport restrictions • Extra sand layer on dike spot	• IVS'90 / RIS • infocenter.nl	• RWS ON • Info centre RIZA • Contractor
Scene 4 Shipping incident	• Information on incident • Ship information • Municipalities map	• GMS • IVS'90 / RIS • Sherpa (tracking emergency units) • GIS	• Emergency room Gelderland-Zuid • Emergency services and units • RWS ON

		• C2000 • Infraweb	• Municipality
Scene 5 Crisis co-ordination	• Detailed roadmap • Incident spot	• C2000 • Navigation systems emergency units	• Emergency room Gelderland-Zuid • Emergency services and units
Scene 6 The ammoniac tanker and it's gas plume	• Ship information	• IVS'90 / RIS • C2000	• Emergency room Gelderland-Zuid • Rotterdam Water Traffic Centre • Emergency services and units • Regional crisis centre
Scene 7 Gas plume evacuation scenarios	• Wind maps • Actual ship movements • Integrated plume model • Housing • Infrastructure • Economic activities • Cattle • High risk objects • Road network	• IVS'90 / RIS • FEWS • GASMAL • HIS • National cattle database • Regional Risk atlas	• Rotterdam Water Traffic Centre • Emergency services and units Regional crisis centre
Scene 8 Prevention	• Dike damage prevention • Industrial activities • Permits industrial activities • Heritage sites	• Risk map Netherlands • KICH-portal	• Regional crisis centre Gelderland-Zuid • RWS
Scene 9 High water evacuation	• Wind maps • Actual ship movements • Integrated plume model • Housing • Infrastructure • Economic activities • Cattle • High risk objects Road network	• IVS'90 • RIS • Weather database • GASMAL • HIS • National cattle database • Regional Risk atlas • C2000	

Within V&W the High Water Information System (HIS) is more or less crucial for DM flooding scenarios. HIS has three objectives:

- Perform impact analysis of water dikes during the preparation phase of a high water situation;
- Support communication during a high water situation;
- Perform monitoring of dikes during a high water situation through relevant information.

HIS has a geographical database, different processing modules and geographical interface. HIS is a stand alone information system with specific communication interfaces to other information systems. The distribution of geospatial information is based on data duplication, especially concerning geographic core data (topographic maps, aerial photos, etc). HIS has it's own geodatabase which is regularly updated with new updates of core geodatasets through physical media. It is expected that geographical data exchange in the near future will be based on direct and online access at the core database of the supplier or a broker. Online access will be based on open interface standards of ISO/OGC. The HIS organisation has already in close cooperation with other water partners in the Netherlands and Germany (NOAH and VIKING) initiated the development of an integrated FLood Information and Warning System (FLIWAS) for the large rivers in the Netherlands FLIWAS will have their geospatial information organised and served according to GDI principles. This is part of the newly built Geo data Infrastructure of V&W.

6 FINAL REMARKS

A strategy of uniform working models, open standards, web based computing and central data hosting and maintenance is adopted in geospatial information management of V&W. This is shown to be feasible and has many advantages. This renewed GDI is based on the use of international open standards. These ISO/OGC standards, like WMS, WFS and WCS, are matured so these enable the construction of an enterprise-wide Geo Data Infrastructure. Advantages for the organization are robust spatial data management, the widespread availability of spatial data and low threshold for data sharing. This makes the concept of GDI especially suitable for application in disaster management.

Setting up successful Geo Data Infrastructure for Disaster Management is one of the greatest challenges faced by the geospatial information and disaster management community. This requires considerable effort and commitment by the various users and providers of information as well as clarity on the rights and obligations of all the parties involved. To provide a reliable information infrastructure, the availability of different building blocks is crucial. To adopt successful Geo Data Infrastructures, the availability of geospatial information and geoservices technology and (wireless) communication infrastructure is crucial. There are risks in Geo Data Infrastructure services architectures using for DM as well. One of the main risks is the reliability and availability of the internet and mobile communication infrastructures. The communication network infrastructure is an essential component of such services oriented architectures with online data access at the point of supply. The alarm organizations in the Netherlands (police, fire fighting and ambulances) use their own specific communication network (C2000), but other government organizations that have a role in DM are depending on public or private network communication infrastructures. At the same time the (core data) supplier has the responsibility of offering online data services 7 days a week and 24 hours a day. This means that clear service level agreements are necessary.

The value of geo information for disaster management within V&W is evident: hind and forecasting, scenario-analysis and not least operational management in case of events are well proven applications. For the near future the focus will be on trend analysis, development and implementation of new location based services, training, simulation and quality management of information and services.

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