Cartographic Visualization Aspects of the web-based

Dutch National Risk map

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ABSTRACT:

13 May 2000: an explosion in a firework plant in Enschede (The Netherlands) kills 22 persons. As a response to this disaster, the Dutch government decides to set up a national GIS-based Risk Management System to supply professionals and civilians with recent information on risk factors and their impact. Information is supplied by interactive GIS based web maps, which also act as GUI to underlying data. High priority is given to cartographic design and user interface aspects, keeping in mind user perception, platform and web performance.

INTRODUCTION:

Saturday 13 may 2000. It is a sunny day in Enschede (The Netherlands) and people enjoy their free weekend. In Roombeek, one of the more populated districts of Enschede, a small fire near some older buildings attracts the interest of a growing public. The fire brigade arrives and starts quenching the fire. The atmosphere is relaxed, while policemen start to keep the public away from the fire. Suddenly a firework explosion bursts out of the fire creating panic in the small streets surrounding the buildings. Just a few minutes later a second, devastating explosion destroys a whole city area: 22 persons (among three fire brigade guards) are killed or missed, 950 persons are (seriously) wounded, 500 houses and 50 commercial buildings are destroyed , 1500 houses are damaged beyond repair. 60 Artists, housed in a former textile factory lose all their belongings and artwork. (Figure 1).

Figure 1: Firework explosion in the City of Enschede, The Netherlands, May 2001 (Copyright ANP)

The total financial damage is estimated to be at least Euro 500.000.000. Just a few months later, at New Years Eve 2001, 13 young people are killed and 120 seriously wounded during a fire in a bar-disco in Volendam.

The Dutch Government established an Investigation Committee that came up with a number of conclusions and recommendations. They concluded that the government had seriously failed in legal approval control, disaster management and appropriate information distribution to rescue and aid services and civilians. For instance, the Enschede fire brigade did not know that in the buildings a firework storage and factory was housed. About 100 ton explosive material was stored outside in containers on open terrain without official approval. Rescue personnel had to find their way with black-white copies of outdated commercial city-plans.

The Committee formulated a number of objectives:

Legal rules should be consistent and consistently applied.

Safety policy and regulations should be transparent.

Responsibilities should be clearly allocated to involved authorities.

To achieve these objectives in total 150 action points were defined, divided into 11 "clusters". These included the organization of governmental bodies, external security, fire security, disaster management and impeagment and financial handling and reconstruction. Within the cluster Disaster Management, a number of sub-categories were defined such as: district definition, risk analysis, risk prevention, planning, education and training, information distribution, national facilities and supervision. Within the sub-category "Risk Analysis" attention was given to legal approval registration and a national risk survey.

A web based "National Risk Map" (NRM) should be one of the information provision tools for civilians and professionals. It was decided that each of the twelve Dutch provinces would be responsible for the operation and maintenance of that part of the National Risk Map covering the involved province.

The Dutch Cadastre and the Dutch Topographic Survey, Municipalities, fire departments, police and other rescue and aid authorities should supply necessary information. The NRM user-interface and cartographic symbolization of the map should be in accordance to governmental standard-specifications as defined in the Dutch National Model Risk Map (MRM). The Department of Geoinformation of the International Institute for Geoinformation Science and Earth Observation (ITC), Enschede, the Netherlands was requested to advise on the MRM specifications.

Type and nature of the data to be shown in the National Risk Map.

The NRM shows the results of a survey of risks, potentially harmful for humans and/or the environment. These are for instance related to airports, routes for transport of dangerous goods, roads with a more than average accident risk, flooding, fires in nature areas, industrial objects etc. Additional attribute information is given of each location and object. This includes for instance: object description and name, legal approval number and date of issue, nature of stored materials (explosive, toxic, flammability), number of persons working or housed in the building etc. Next to its function as information provision tool, the NRM may also as a pre-action and prevention measurement tool. For instance, municipality bodies can apply the NRM for development planning and management purposes. All information should be given at Provincial as well as Municipality level.

The surveyed risks can be broadly distinguished into two main groups:

Risks that affect a single person (local risks) or

Risks that affect a group of persons (group risks).

Local risk is defined as: the yearly estimated probability rate for a person to get killed by an accident caused by location or object. Group risk is defined as the probability rate that a group of min. 10 persons is killed by an accident related to a location or object. For instance, there is 1: 700 years' probability that an accident near an airport results in the loss of more then 10 lives. The probability that the explosion of a LPG filling station kills more then 100 persons is estimated at once per 5000 years. The Dutch government has decided that no persons may live near locations or objects where the probability rate is >

1: 10^{-6}.

Based upon this estimated rate, objects and locations are surveyed, classified and described in an index list (National Risk Register: RRGS). This list describes all registered objects and installations where activities are executed related to storage, handling and utilization of dangerous materials. In total 18 different types of such objects and installations can be distinguished.Also included in the list is a specific category, the "BRZO" (Govt. Decree on Hazards of Major Accidents) installations

These are legal registered objects / installations with are considered to have higher risk factor because of specific circumstances. For all objects so-called "effect distances" are calculated which are also included in the list. These "effect-distances" indicate the zone in which humans may either be killed (lethal) or seriously wounded in case of a casualty. Also "Risk-contours" are included in the RRGS. These are based upon the interpolated probability rate numbers.

Cartographic concept:

A number of provinces have already produced a prototype Risk Map and some of them are already accessible trough the Internet. Most of the provinces started designing the proto-types without the availability of the MRM standards. Therefore it is not surprising that each of them gives a different impression. Some of them are certainly not bad from a cartographic point of view; however, one quickly gets the impression that the cartographic design is mainly based upon the RRGS division and attribute data structure (supply-driven) and not upon user requirements (user-driven). Therefore the maps are more of use to professionals as to the general public who are interested in the answer to the question whether the location where they are living, working or relaxing is "save or not"! The accompanying map legends are not very clear either; they are mainly expressing the applied symbols in the official juridical terminology as applied in the RRGS list. The provinces are also left autonomous in the choice of the software. The majority of the prototype Risk Maps is based upon the swg Flash vector format. The prototype version of the Province of Utrecht is ArcIMS based. This has led to a different `feel and look" of the prototype maps. (Figure 2)

Some of the prototype maps are impressive from a creative point of view and show a rather dynamic character. For instance, clicking on a factory symbol, may result in an animated, "exploding" symbol. Some of the swg based maps lack a dynamic database link, so updating these maps will be a cumbersome and expensive job! Moreover, one would need rather specialized staff to execute this.

As a first step in the definition of the MRM, two expected main user groups are defined: Civilian users and Professional users

Civilian user is every inhabitant of the Netherlands, professional users are constitutional users and authorities engaged in spatial, regional, environmental and legal license planning and management Also operational units such as fire brigades, police and medical aid services have been regarded as professional users. Despite these two user groups with their own specific user requirements, one standard cartographic interface is proposed, as the location of risk-objects and vulnerable objects is identical for both groups. However, it can be assumed that the professional user is more interested in the underlying information as available in the data set. Such information can be consulted and displayed at a deeper level then the first entrance level, or can be made available to authorized users only. One aspect that should be mentioned is the fact that a map such as this one is not only a source of spatially related information. There is also the psychological perception of the map that has been taken into account. It should be avoided that civilians get the impression that they are living in a dangerous, hazardous country surrounded with risks endangering their living circumstances and environment. A balance is found in-between avoiding this perception and supplying correct risk information to the civilian.

Map scale:

Although in principle web-maps are scale-less a number of reference default scales have been defined based upon a user and map use analysis. The definition of these default scales is necessary as they define the content, design and display of especially the topographic base map information. At local and municipality level it was decided to apply scale 1: 25,000; this scale enables the exact location of buildings, installations and other objects while many Dutch municipalities can (at this scale) be completely displayed at a 17-inch, 1024 x 768 pixels sized monitor. At regional level it is proposed to apply scale 1: 100, 000; at provincial level (which is also the NRM entrance level) the scale 1: 250, 000 is proposed.

When displayed at the monitor, users can zoom in and out. The l: 25,000 map will cover a range from scale 1: 10000 - 1: 75,000; the scale 1: 100,000 will cover the range 1: 75, 000 – 1: 250,000 while the 1: 250,000 scale will cover a range form 1: 250,000 -1: 750,000.

Based upon the definition of the default scales, the Dutch Top Ten vector map, and the Top25 raster map and Top250 raster map can be used as suitable base maps. A major advantage of the use of the raster map-versions is that provinces and municipalities are not responsible themselves for the update and the cartographic visualization of the maps and thus manpower investment and costs can be reduced. From a user point-of-view, the use of standard rasterbased topographic maps has the advantage that many map

users are already familiar with the map semantics as they are frequently used for tourist purposes.

A disadvantage of the application of the object-oriented Top10 vector database of the Dutch Topographic Survey is that provinces and municipalities must execute the visualization themselves (based upon the object attribute data). Despite this disadvantage most provinces will base their MRM upon the TopTen vector data. An additional symbol specification fore this purpose will be defined.

Geographic interface:

The user will get entrance to the NRM at provincial level. The user can opt for global or detailed information. If detailed information is preferred, a click able overview map of all municipalities will be displayed. By selecting a municipality in the map (or alternatively, by typing in the name in a query window), the appropriate 1: 25,000 scale level map will be displayed (centered at the city center area) with a standard NRM legend. The user has a number of options available to `survey" the area such as panning, (seamless) zooming between the 1: 75,000 and 1: 10,000 scale) or zooming out back to the regional level.

All risk objects displayed in the map have an inter-active function and specific events may be triggered by mouse-actions such as press or release. Such event can be the opening of a dynamically linked information panel on type of object, installation or legal issues, storage capacity, owner etc, or the display of risk effect distances. Also the legend is dynamic and enables the user to opt for a limited or extended legend version.

Risks types, risk locations and risk sources:

The National Risk Register (RRGS) describes in total 18 different types of installations and /or objects that potentially form a source of risk. These are also the objects that should be visualized in the map in combination with their effect distances and risk contours. Effect distances are important as these define the areas where specific urgent measures must be taken such as immediate evacuation etc. Effect distances and risk contours are to be displayed independent of each other. Next to Risk causing objects, there are also vulnerable objects. In total the RRGS describes 19 of such objects, ranging from schools, hospitals up to prisons and office buildings.

Cartographic design:

All proposed symbols had to be platform and software independent. This is one of the reasons that animation and the use of transparency (despite its advantages for the display of area related risks) have not been applied. All symbol specifications also cope with typical webmap design and web-technology related constraints such as download speed, display readability etc. At the same time, it is taken into account that inkjet and even offset-printing quality of the web maps should be possible. All point, line and area symbols related to the risks are designed to create a high "figure-ground" effect. Next to their visualization function, many of the symbols also have a user-interface function; at specific events such as mouse over or mouse click, tags or pop-up windows panels provide the user with attribute information, dynamically retrieved from a database. All existing prototype Risk Maps are based upon this RRGS listing. The large amount of objects, each having its own, specific character and appearance and the simultaneous inclusion

of Effect and Risk zones leads to maps that are difficult to read and understand by the average public. The simultaneous display of all risk factors is overwhelming for the average user. To assist the user in the selection of object display, most of the maps are equipped with an inter-active legend, enabling the user to switch or off the visibility of specific information. The explaining legend text is conforming the official terminology as applied in the RRGS, which is not always understandable for the average public.

Cartographic symbols for the Model Risk Map:

Due to the varying scale ranges of the MRM, several sets of map symbols are proposed. The 1:25000 - 10000 scale range has been applied to set up a basic standard set of map symbols. All map symbols, applied in the other scale ranges are derived from this standard set. All specified symbols can be applied at any scale without change of the specifications. Therefore only selection of the Risk objects to be shown according to their attributes is necessary if applied in another scale. All symbol specifications are expressed in R,G,B values and their web-safe equivalents while point, line and area size is expressed in pixel size.

Symbolization at reference scale 1: 25,000 -10,000 (Concept):

As mentioned before, the RRGS list is a comprehensive one and symbolizing each individual risk does certainly not foster easy identification of risks by the user. Therefore, a reclassification of risk objects as described in the RRGS has been applied. This reclassification is based upon a simple two-fold division. Objects / installations and /or zones are potentially:

1. Causing risks or

2. Vulnerable to risks.

1. Objects / installations causing specific risks are sub-divided into:

    1.1 Objects / installations causing risks.

    1.2 Other risks for humans and the environment.

1.1 The RRGS Objects / installations causing risks can be sub-divided into 9 main classes:

    1.1.1   BRZO*

    1.1.2   LPG

1.1.3   Propane

1.1.4   Nuclear

1.1.5   Army

1.1.6   Firework

1.1.7   Registered (AMVB**)

1.1.8   Non-registered (non-AMVB)

1.1.9   Storage shelters

*   *BRZO=Besluit Risico Zware Ongevallen = (Govt.) Decree on Hazards of Major Accidents*

**   *AMVB= Registered by administrative order*

The Effect Distances connected to the mentioned objects / installations expresses the zone that is affected in case of a casualty. This distance is not per definition regular. Effect distances are classified into three nominal classes: Fire, Explosion or Toxic.

1.2 The other RRGS risks for humans and the environment are subdivided into:

1.2.1   Transport routes for dangerous goods:

Highways and provincial main roads

Waterways

Railways

1.2.2   Airports:

Civil airports

Military airport

1.2.3   Water related risks:

Sea harbors

Inland harbors

Water sport area

1.2.4   Land related risks:

Highways

Main provincial roads

Tunnels

1.2.5   Earth quakes:

Earth quake sensitive areas Class 1 to 6

Fault

Caverns

1.2.4   Public disturbances:

Riots (local)

Riots (Along routes)

Panic situation (Local)

Panic situation (Along routes)

1.2.5   Floods:

Areas vulnerable to floods

Flood scenarios

1.2.7   Nature Reserves vulnerable to fire

Risk contours are shown along routes for dangerous transports and around airports.

Measure zones (which include measures to be taken on for instance evacuation, jodiumprofilaxis and sheltering) are basically applied for object / installation with a toxic risks or nuclear risk.

2) Objects/installations vulnerable to risk are divided into 7 main classes:

2.1   School

2.2   Lodging, nursery, prison

2.3   Hotel / pension

    < 25 floors

    > 25 floors

2.4   Hospital/clinic

2.5   Large public building

    < 25 floors

    > 25 floors

2.6   Large office/commercial building

    < 25 floors

    > 25 floors

2.7   Other buildings

< 25 floors

> 25 floors

Symbolization at the entrance scale 250,0000 - 750,000 (Concept):

At the smaller entrance scales, selection of objects is necessary is to avoid that symbols clutter together and thus become un-readable. Only two types of objects / installations are shown:

    1.1 Registered by administrative order (AMVB)

    1.2 Not registered (non-AMVB)

The cartographic symbolization is identical to the local, municipality scale to avoid symbol miss-interpretation by the user. For both type of objects / installations measure zones are shown; effect distances and risk contours are not shown. Another obvious difference with the local scale is the complete ommitment of the vulnerable objects.

Cartographic symbolization: selection and application of visual graphic variables for the scale range

1: 10, 000 - 75, 0000

The objective of the cartographic design of the MRM aims at the spontaneous impression the user should perceive at the moment the map is displayed: colour is related to risk. To achieve this objective all other map objects are shown in a neutral gray, although it is tempting from an aesthetic point and conventional map-reading point-of-view of view to apply colour to larger topographic base map objects such as open water (for instance light blue) or forest (for instance light green).

The nominal division between risk causing objects and risk vulnerable objects is visualized by difference in colour resulting in a strong associative and selective perception characteristic. Risk causing objects / installations are indicated in red (risk) and vulnerable objects in green (safe). The nominal division between the Effect distance types is also expressed by colour: Orange (explosion), blue-violet (toxic) and red (fire). In specific cases, yellow will be applied in conjunction with nuclear objects. The selected colors correspond with colors as also being used by other disciplines to express these risks. Measure zones are only indicated by their boundaries while the same applies to the risk contours.

Whereas it was considered essential that the base map should also be visible underneath the effect distance symbols, the application of transparency would be obvious. However, as all symbolization should be

software-independent, symbols based upon lines at varying distance and thick nesses were designed, resulting in an impression of transparency.

All vulnerable objects are indicted in green, form being the only variable to distinguish their nominal character. Buildings with more then 25 floors are visualized by giving a 3-d impression to the symbols by the application of a shadow casting on the right-down sides of the symbols.

As mentioned before: all attribute data, linked to the objects can be retrieved by the user and are displayed by either tags or by dynamically linked pop-up panels.

All objects have a minimum size of 13 x 13 pixels. Some symbols are slightly enlarged to obtain a visual equal-sized perception. Line work is displayed at varying sizes (depending upon their attribute which must be visualized or by their base-map contrast ratio).

All text (Arial) is given a minimum size of 10 (pica) points. Curved text is given an extra character spacing of 120%. The majority of symbols are given an anti-alias factor of 2.

After the selection of the visual graphic variables several symbol series were proposed to the MRK-committee. Also users were able to give their comments on the symbols. (Figure 3)
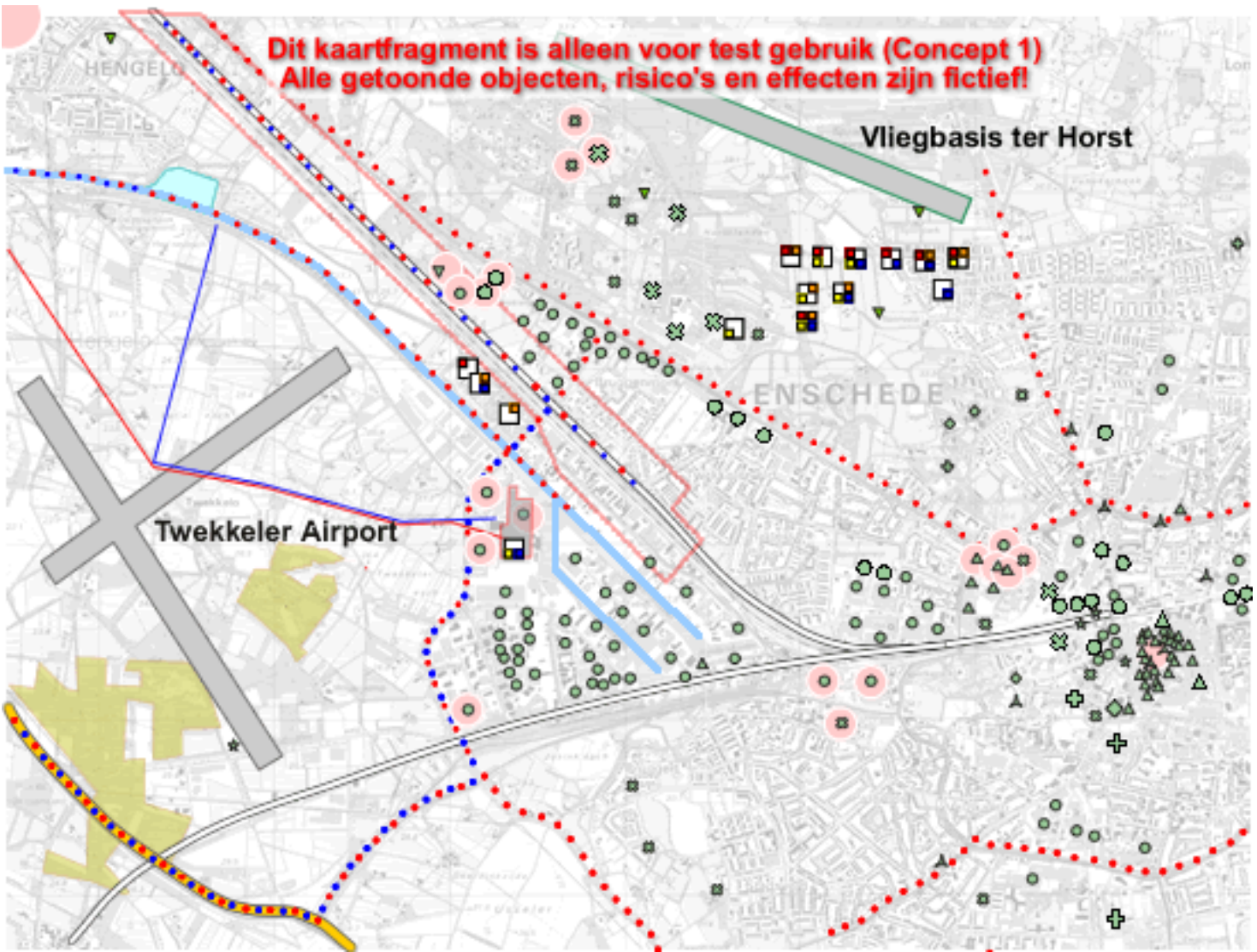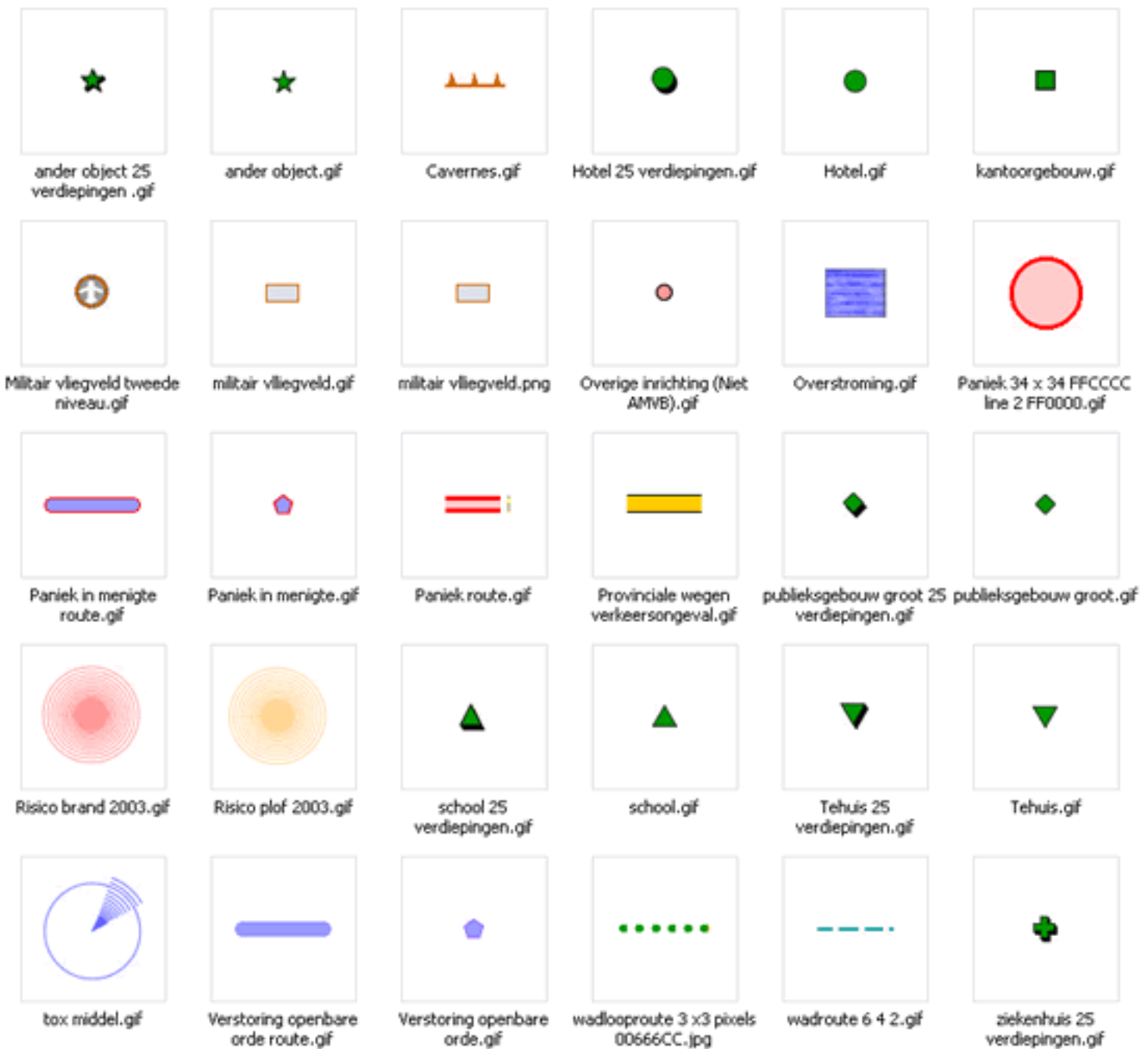
Figure 3: Application of rejected symbols

Figure 4 A selection of accepted symbols

Arguments to reject some of the proposed symbols varied between technical objections related as (web) technology constraints, platform and software to be applied, psychological perception and arguments which could simply be translated into the expression "I do not like that symbol"! The (in the view of ITC most suitable) design, giving an impression of a "Piet Mondriaan" painting (Famous Dutch painter), was rejected because of its "un-orthodox" appearance. The square formed symbol is divided into 4 inter-active parts. All risk factors have a fixed location within the square. (Figure 5). By this approach more then one risk factor related to an installation can be visualized. The accepteded symbols, which have a more conventional appearance, are based upon the visualization of the main risk, other risks are shown in text form in the pop-up information panel.
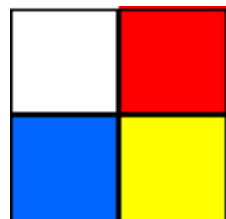
Figure 5: Rejected (inter-active) symbol indicating an installation with fire, toxic and nuclear risk.

Design of the Graphic User Interface:

The design of a map-symbol set for web maps cannot be separated from the graphic userinterface design. For the MRM the application of an inter-active legend was advised. This legend does not only explain the meaning of the (geometric) map symbols.
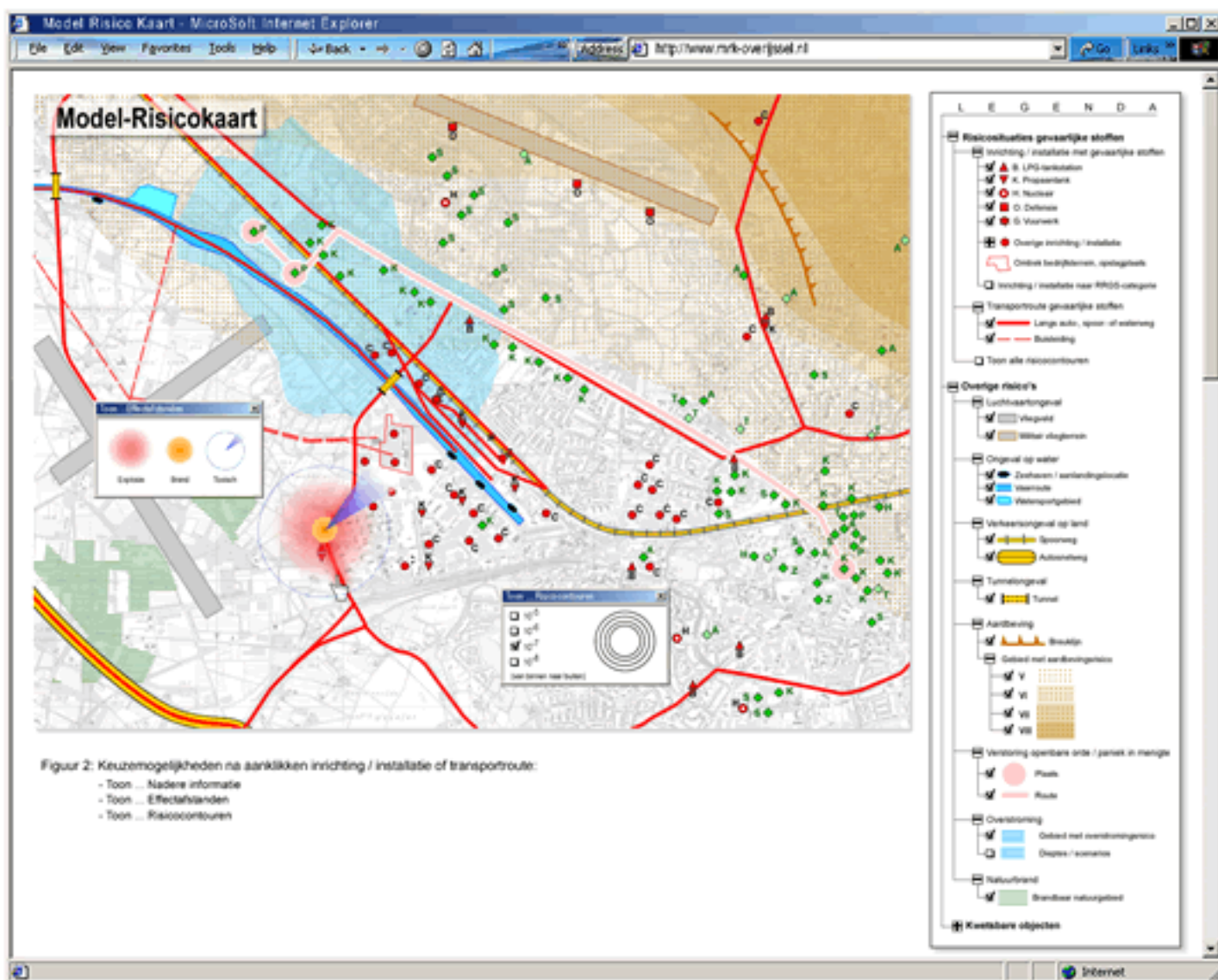

Figure 6: MRM with inter-active "collapsible" legend and pop-up information panels.

By selecting legend items, the user can switch on or off specific information and therefore create a map on the monitor that fulfills the user-requirements. For the NRM, the amount of information to be shown on the map is so comprehensive that showing all information simultaneously would result in a completely cluttered and un-readable map. The result of this process is an inter-active collapsible legend (Figure 6). All "professional" terminology is "translated" into more "public" terms to make understanding of the map by a wide public possible.

CONCLUSION

Effective management of risks and measures to be taken in case of casualties is only possible if all involved parties are supplied with proper and up-to-date information. Maps form an essential tool to communicate geo-spatial related information. Internet plays a major role in modern communication between the government, authorities and the public. Web maps are nowadays common on the web, but must be designed in relation to the defined user group(s) keeping in mind their requirements and accuracy expectations. Web map designers may also be confronted with conception constraints related to the subject of the theme to be visualized such as legal issues. Also web-technology related constraints play a major role during the design process. Aesthetic appealing maps foster the communication of the map content, as users feel attracted to study the displayed maps more careful. Aesthetic quality also creates the impression of a high-quality product whereupon the user can rely. The specifications of the Dutch Model Risk Map standard symbol set show how despite these constraints, the resulting map product may still fulfill user-requirements.

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http: //Www.slagenvoorveiligheid.nl/default. asp

2003, Elzakker, Drs. C. van; Advies Cartografisch Ontwerp Model-Risicokaart, ITC, Enschede, the Netherlands

Dutch Prototype Risk maps on the Internet:

Province of Overijssel: http://risicokaarten.prvoverijssel.nl/gevaarlijke_stoffen/gevaarstof_lpg/ buitenframegevaarstof_lpg_klkrt_vak_D3.htm

Province of Noord-Holand: http://risicokaart.noord-holland nl/

Province of Utrecht: http://www provincie-utrecht.nl/

Province of Groningen: http://www provinciegroningen.nl/risicokaart/

Province of Limburg: http://www.limburg.nl/nl/html/algemeen/Actueel/risicokaart/risicokaart.asp

Province of Friesland: http://www fryslan.nl/risicokaart2/risicokaart/risicokaart.htm

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