The Potential of a National Atlas as Integral Part of the Spatial Data Infrastructure Exemplified by the New Dutch National Atlas

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Abstract
The recent developments around national spatial data infrastructures have stimulated interest to review and renew the national atlas concept. In a recent project a feasibility study and prototype implementation of an automatic visualisation of spatial data available through the spatial data infrastructure (SDI) have been executed in a systematic and cartographically accountable way to guarantee an up-to-date national atlas. The objective was to investigate how the national atlas could be organised as an integral part of the spatial data infrastructure. The atlas would benefit from an up-to-date data flow, and the SDI would benefit from integrated visual summaries of available spatial data and geoservices in well-designed comparable maps using the narrative characteristics of the atlas. As such the national atlas provides alternative interactive and dynamic access to the SDI.

Keywords: national atlas, spatial data infrastructure (SDI), web mapping.

1. INTRODUCTION

National atlases present a synthesis of the spatial knowledge that characterises a country. They contain comprehensive combinations of spatial datasets represented by maps that each completely covers a country, with an added narrative function. All information in national atlases refers to the same area, the national territory. Generally these maps are based on datasets that are the most detailed available on the national scale. An important aspect of atlases in general, but particularly of national atlases, is that all information is rendered at the same scale and resolution by applying the same level of generalisation. As far as possible, all information in national atlases is collected for comparable reference periods. In addition, as much as feasible or relevant, similar classification methods are used. To allow for fruitful temporal comparisons, national atlases aim to use similar class boundaries and legend colours. Together, this allows for comparing maps in the national atlas and for deducing information. Today national atlases are found both as books and as digital publication on DVD or the Internet (Sieber and Huber, 2007).

Before the maps can be compared, the structure of the cartographic image of the mapped phenomenon in each individual map has to be studied. What is its extent? What is its distribution? What is its pattern? What is its spatial association? What is its spatial interaction? (Board, 1984). In an atlas environment one can elaborate on these questions and process those into atlas use scenario's (see Figure 1).

When knowledge about the overall pattern of a phenomenon (scenario 3 in Figure 1) is required, for example, the overall extent of the phenomenon can be ascertained as well as its sub-regionalisation. Highest and lowest concentrations/values of the phenomenon can be described as well as the spatial anomalies. Studying spatial areal processes (scenario 5b in Figure 1) requires definition of the initial and final extent of the phenomenon, as well as determining the changes between them and the growth patterns they result from.

Figure 1: Atlas use scenarios.

Scenario 1: What exist at a specific (point) location?
Scenario 1a: Where is a specific geographical object located?

Scenario 2: What is (the value) of the phenomenon for a specific area?
Scenario 2a: Which objects are located within a specific area?

Scenario 3: What is the overall pattern of that phenomenon?

Scenario 4: What are the relationships between these patterns? [*]
Scenario 4a: What are the temporal trends in that phenomenon?

Scenario 5a: Which linear spatial processes are taking place in that area?
Scenario 5b: What areal spatial processes are taking place in that area?

Scenario 6: What are the overall geographical characteristics of that area?

[*] Comparison of atlas maps can take different forms: there can be *temporal comparisons* when we compare the situation for a specific theme at different moments in time. Then there are *geographical comparisons*, and for this we produce maps of the same theme, with the same specifications, but for different areas. The point of such comparisons would be for instance the discovery of specific types of settlements, or distribution patterns over an area. Finally there is *topical* or *thematic comparison*, when different map themes are compared for the same area.

Based on the above scenario's the required functionality needed in the atlas can be established. Examples are the ability to put two maps alongside in order to allow for visual comparison, and a direct link between those maps to reflect action in one map immediately in the other maps such scale changes. Zoom and scroll functions are basic, but one could also consider functions like querying the database underlying the data used for the map, or the ability to query all map objects.

Why use national atlases at all when searching for spatial data? All users of geospatial information had atlases when they were first confronted with this kind of data. At school they were taught how to deal with them through the concepts that the school atlases were building on: areal and thematic subdivisions, map comparison, geo-referencing, datum's, among others. A national atlas will not only provide access to the atlas information, but also access to the underlying datasets and - when functioning as a geo-portal - also to all other related datasets made available by the national geospatial data providers. Thus, it offers these data providers also a 'presentation outlet'. The main benefits of having the national atlas as the portal towards the nation's geospatial information are: ease of use because of familiar concepts and ease of access because of the topical atlas structure.

2. THE DUTCH SITUATION

Although the first actions to produce a national atlas started already in 1929, it was only after the second world war, that the first edition of the Netherlands national atlas materialised (1963-1978). This was due to the global economic crisis in the 1930s and the decision to first produce a national atlas of Indonesia To that end a Foundation for the Scientific Atlas of the Netherlands was set up in 1958, backed by the Ministry of Educa-

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tion, the Royal Netherlands Geographical Society, the Topographic Survey and universities. An Atlas Bureau was set up at the national physical planning agency, paid for by the Ministry of Education. This atlas was an inventory of all geospatial data, perhaps more targeted at the area than at its inhabitants. A most detailed soil map 1:250 000 formed its backbone, but it is difficult to perceive it as a narrative of the country, more as an incidental combination of contributions from various fields of science.

In the second edition, published 1989-1995, this was mended and this edition is clearly centred on the inhabitants of the country and only deals with aspects of the sciences (climate, geology, soil, etc) when this was deemed relevant for explaining the way Dutchmen provided for themselves. So the atlas contained no geological maps per se, but maps of economic geology or of the strata from which natural gas could be mined. The Atlas Bureau, transferred to the national mapping agency, could continue its ministry-backed work for the production of this second edition, but when it was completed the Ministry's outlook had changed, claiming that from now on such endeavours as a national atlas should be self-supporting, and resulting in the atlas bureau's closing. However, the foundation was to keep the national atlas concept alive, and to this end it was decided to make all maps from the previous two editions available on the web (through http://www.nationaleatlas.nl). With 1,5M hits since mid 2000 this website seems to answer the needs of high school students that have to do projects as well as the geospatial information needs of a larger informed audience. But, as the information contained in these scanned maps is getting out of date, new initiatives were needed.

The developments around the SDI in the Netherlands are seen as a great opportunity to revive the National Atlas. It might stimulate and improve the accessibility of the SDI by the narrative of the atlas. The atlas itself makes use of the spatial data and geo-services available through the SDI to create interactive and well designed atlas maps. The various data sets provided would be made comparable, and be visualised according to specific templates. Apart from serving as any map in a national atlas would, these maps may also function as an alternative entry to the SDI. They should be clickable and provide the underlying statistics used, but also allow to zoom in on a specific area and taxonomy level in the atlas so that all the data sources for that query combination are displayed as footprint on the atlas maps and accessed via hyperlinks. The highest levels of high school are likely to show interest in the ready-made maps, and professional users in the geoportal function.

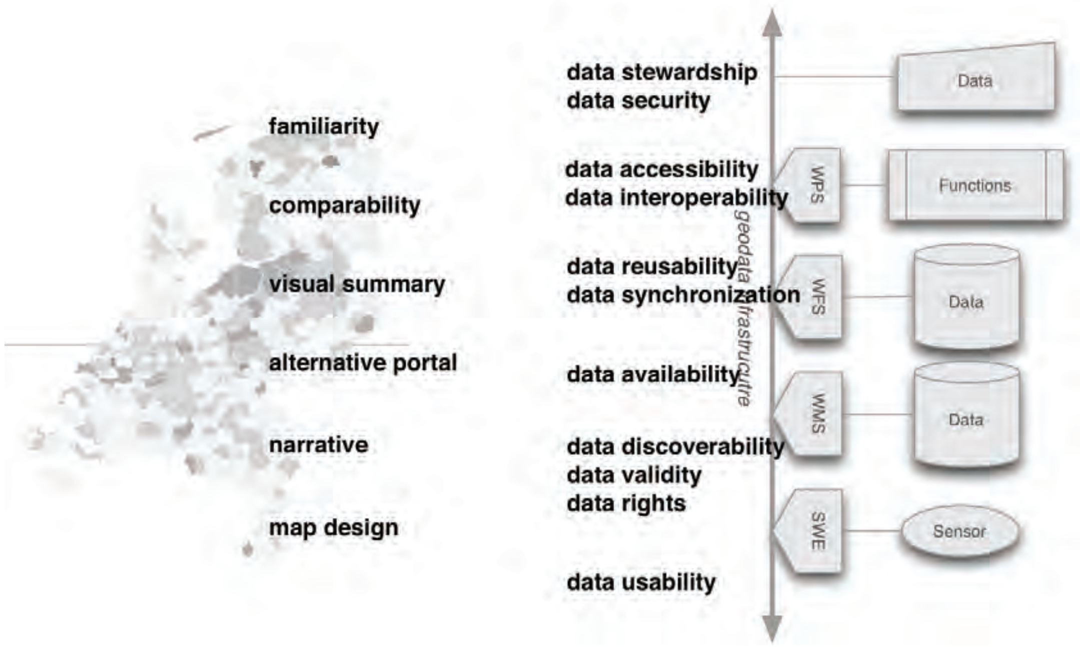
The philosophy behind the realisation of the Dutch national atlas is to enable the creation of the 3rd edition of the national atlas from datasets available from national data providers (like Central Bureau of Statistics, or Geological Survey) by using a style template that would make the resulting maps comparable. The shell in which these maps could be produced requires functionality that allows for, for example, map comparisons and data queries, based on the atlas use scenario's mentioned in the map use section. This functionality is covered in section 5 of this article, but first the atlas will be positioned in the national spatial data infrastructure.

3. THE DUTCH SPATIAL DATA INFRASTRUCTURE

The stimulus for spatial data infrastructures originates from the motto "collect once, use many times". They have been defined by Groot and McLaughlin (2000) as "A set of institutional, technical and economical arrangements, to enhance the availability (access and use) for correct, up-to-date, fit-for-purpose and integrated geo-information, timely and at an affordable price, with the goals to support decision making processes related to countries' sustainable development". In the European Union, the INSPIRE Directive implements the SDI concept. INSPIRE emphasises several basic principles which are also applicable to the national atlas concept as presented here (see Figure 2):

1. Data stewardship and data security. Data is collected once and maintained at the level where this can be done most effectively. For the atlas it means that it does not need a database of its own.
2. Conditions of data accessibility, and data interoperability. It is possible to combine seamlessly spatial data from different sources across Europe and share it between many users and applications. For the atlas this translates to a national level where similar problems occur.
3. Data reusability and data synchronisation. It is possible for spatial data collected at one level to be shared with other levels, e.g. detailed for those performing exhaustive investigations, but more general for strategic purposes. For the national atlas this might be less relevant since data is only presented at a single national level.
4. Data availability. Spatial data is abundant and widely available under conditions that do not restrain its extensive use. The atlas concept as such follows this principle.
5. Data discoverability, data validity and data rights. It is easy to discover which spatial data is available that fits the needs for a particular use and under what conditions it is available. An atlas has several relevant facilities for data discovery, such as an index for geographical names, a topical index, and index maps. The atlas can act as an integrated visual summary of available spatial data and geoservices and as such act as alternative interactive and dynamic access to the SDI.
6. Data usability. Spatial data must become easy to understand and interpret because it can be visualised within the appropriate context and can be selected in a user-friendly way. This is the atlas' natural habitat. It has a narrative to tell the story of the atlas objective is well design maps.

Figure 2: The contributions of a national atlas embedded in the spatial data infrastructure.



In the Netherlands the INSPIRE implementation is translated into practice guided by the GIDEON report (Ministry of Housing, Spatial Planning and Environment, 2008). The

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challenge for the National Atlas Foundation is to have the new national atlas concept embedded in the national spatial data infrastructure, based on the recognition that a central place is needed where all different spatial datasets are made comparable, and that can moreover function as a most useful geoportal.

4. THE NEW NATIONAL ATLAS CONCEPT

In accordance with the scenario's and required functionality described above a prototype of the national atlas (3rd edition) was designed and implemented (see http://www.nationaleatlas.nl/) Figure 3 summarises the main components of the atlas. The sections 5 and 7 address the atlas in more detail. Displaying maps is the main objective of the atlas. If a user selects a topic, for instance the number of inhabitants per municipality (A-I), the request goes to a geo-service, which returns the necessary data that allows for the creation of an interactive map (A-II). Alternatively it is possible to search for a topic or for a geographical name (B-I). In this last case the geo-service will return all names with the text string entered and map topic on the base map (B-II).

All maps are interactive and allow for the display of the data behind the symbols. It is also possible to search the SDI for alternative datasets (C-I). Through the atlas maps, which will display the footprint of the available datasets, the metadata of those datasets can be evaluated (C-II).

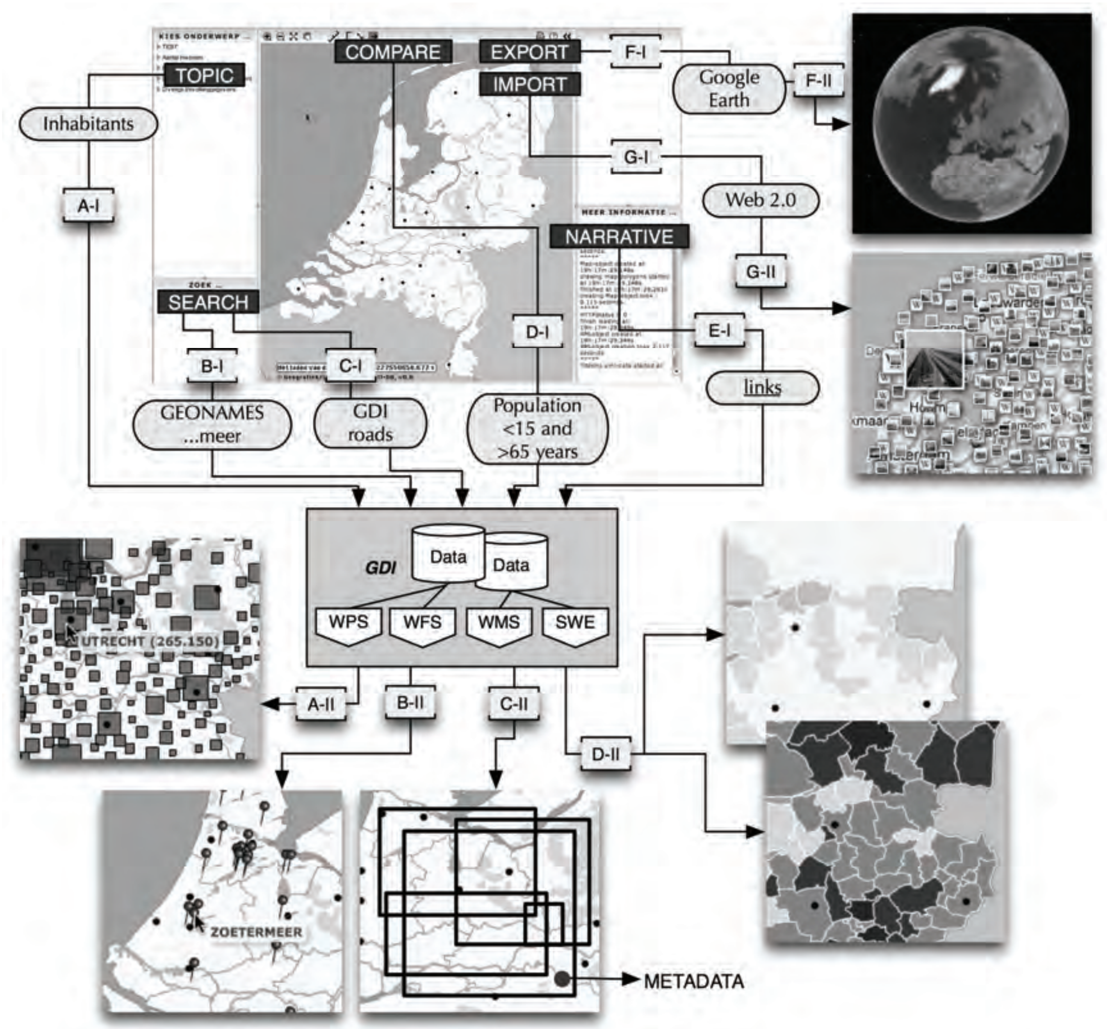
One of the characteristics of an atlas is that one can compare different themes, for instance the distribution of the young or of the elderly (D-I). Such request results in two maps that allow for the comparison of spatial patterns. For each topic the atlas provides a narrative, the story behind the map in a wider context (E-I). This will also result in access through web-links to other related information accessible via the SDI (E-I). Finally, it is possible to export (F-I) atlas maps to a Google Earth environment where users might combine the particular maps with their own data (F-II). However, it will also be possible to import (G-I) user data to be combine with the atlas maps (G-II).

The necessary technology to make this concept work has been elaborated by a PhD study (Aditya, 2007). For the realisation of the organisational framework it is necessary to convince the national spatial data providers to make their data accessible and comparable through this newly developed GUI (Geographical User Interface), and make them realise that the atlas would provide for added value apart from providing an extra presentation outlet.

5. THE ATLAS FUNCTIONALITY

As indicated in section 1 (see Figure 1), a number of scenarios has been developed based on the functionality needed (Simon van Leeuwen, 1996) to enable those specific types of map use. Elementary atlas functions include the ability to put maps next to each other to allow comparison. Database functions allow for querying the database 'behind the map' such as the statistical dataset the map is based on, but also the topographical elements regarding their object type, name, class or category they belong to or exact value for the phenomenon in question. Basic cartographic functions are the ability to zoom or scroll. In some cases, for larger countries than the Netherlands, this should also include the ability to change the projection of the map. Educational functions are those that monitor achievements of the students. Navigation functions refer to the possibility to follow specific pre-set paths through the atlas, in order to present the various maps in a specific self-explaining sequence that makes sense (the narrative). Generic functions such as import, export or print the data or the resulting maps are included. Map functions refer to pop-up legends, the highlighting of specific legend classes, or the use of hotspots, but also offer the possibility to annotate maps, measure distances or surface areas, or use buffers and overlays.

Figure 3: The national atlas concept. The specific atlas functions have been integrated with geo-web services available via the spatial data infrastructure.



These functionalities provide for a first level of map use, to be extended to include the possibility to describe and summarise spatial data, to generalise concerning (related) complex spatial patterns, to use samples of spatial data to infer characteristics for a larger set of spatial data (population), to determine if the magnitude or frequency of some phenomenon differs from one location to another, or to learn whether an actual spatial pattern matches some expected pattern or the pattern of another phenomenon (correlation coefficients). Not all of these can be realised in a national atlas, so some form of prioritising has to be applied.

The development of the national atlas interface focuses on three principles. First the Atlas will provide for a uniform interface to the Dutch SDI where specific attention is paid to well-designed maps. Providing an overview is more important than in-depth analysis, which limits the scale of the maps. Secondly, the Atlas will have a modular design and therefore be able to serve different groups of users. Finally, the user should

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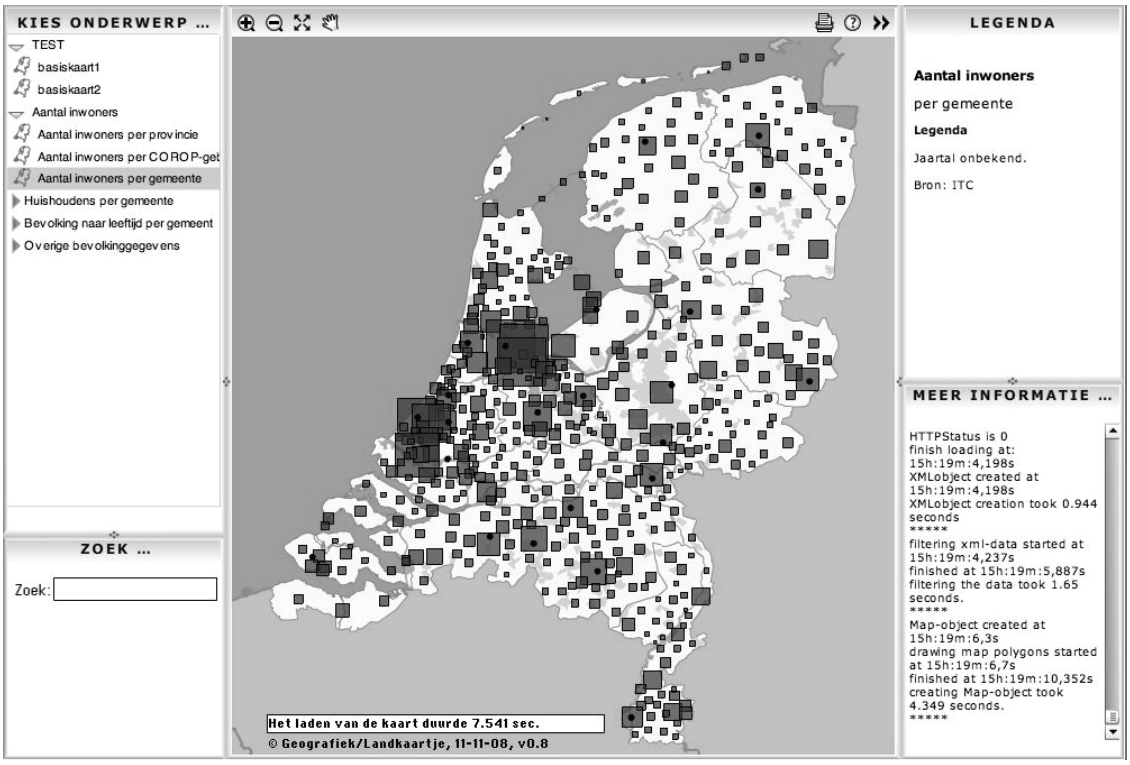
experience 'instant satisfaction' using the Atlas. Speed while loading and manipulating the maps and a clear and easy to use interface are essential to achieve this goal. The interface of the national atlas will eventually include two components, an editor's interface and a user interface. The editor's interface, a tool to manipulate maps and data, will be developed later on.

The user interface basically has three windows, each divided in two panes. The window on the left side contains a list of topics and a search module. The window in the middle contains a toolbar and map area, and the window on the right side contains the key and the storyteller, where the user will find additional information to the map. The panes of the interface (except the toolbar) can be resized by dragging bars (see Figure 4).

On entering the Atlas, a default map is automatically shown. The topic of this map may pay attention to current events and should change regularly. To browse through the Atlas one can either search by keyword or location, or click one of the predefined topics from a list. For advanced search operations the search pane has a link to an advanced search pane. Here one can create queries using a combination of keywords and location, exclude certain keywords or locations plus specify a timeframe for the topic one is interested in. In the pane below the search pane, a taxonomic list is also giving entrance to the Atlas. For selecting more than one topic at the time, one can link to an expert pane where this is possible. The visualisation of multiple subjects chosen from the list of topics has three options, considering the nature of the chosen topics. The topics can be displayed on top of each other in one map, displayed in two maps next to each other, or after each other as an animation or slideshow. On selecting a topic, a link to the producer of the data underlying the specific topic is shown in the storyteller.

Figure 4: The user interface of the national atlas (http://www.nationaleatlas.nl/).



The toolbar at the top of the map area contains several easy recognisable pictograms giving access to zooming, panning and printing operations. Here one can also click a help-button for more information on how to use the atlas, while an additional button offers access to more tools like measuring and exporting the map or underlying data in a desired format. A tool-tip explains the functionality of a buttons when the cursor moves over. Clicking the 'more tools' button not only gives access to more tools, but also affects the way in which the user can manipulate the map and thus entering an 'expert mode'. In a movable pane one can, for instance, turn layers off and on or enter thresholds. The map area can contain raster or vector images, or a combination of both. The maps in vector-format will offer interactivity like clicking on an area shows additional information of that area in the tool-tip or in the storyteller pane. However, the design of the map cannot be manipulated. The visualisation of the maps will be predefined in style-sheets to maintain consistency in design throughout the Atlas. For overlaying two topics, however, the alpha of the upper layer and the saturation of the underlying layer can be manipulated.

The key to the map will explain its content, the internal identification and show elements of external identification such as the title of the map, the scale, source and copyright. Depending on the type of map the key will be more or less complicated. The storyteller is a window where all kind of additional information can be found. Here the modular design of the Atlas becomes very apparent and functional. In the standard modus one can take an atlas tour, which will guide the user through the Atlas in a sequence comparable to a paper atlas. By selecting topics from the list one can move from one topic to another whereby the accompanying storyteller will have a link for reading further on the matter, and thus entering the expert modus of the atlas. The atlas maps are designed according to cartographic guidelines found in text books and common practice.

6. NATIONAL ATLAS AND SDI

For a new Dutch National Atlas to be part of the national spatial data infrastructure, it should fit into the framework of interoperable geo-web services that make up such a SDI. There are many geo-web services available (e.g., Google Maps, Yahoo Maps, MSN Virtual Earth or MultiMap) that can be used by anybody, as their interfaces are publicly available. However, they are still proprietary since they are defined, developed and owned by commercial companies.
There is also a set of well-defined open standards for geo-web services: the Open Web Services (OWS) of the Open GeoSpatial Consortium (http://www.opengeospatial.org/standards/). There are OWS specifications for most parts of the spatial data storage, analysis and delivery process: for describing and finding spatial data there is a set of metadata specifications in the Catalog Service Web (CSW); for geographic vector data encoding there is the Geographic Markup Language (GML); for spatial data delivery the Web Coverage Service (WCS) and Web Feature Service (WFS), for querying and retrieving raster and vector data respectively; for processing of spatial data there is the Web Processing Service (WPS). And for data visualisation in the form of maps we have the Web Map Service (WMS), by far the most mature and widest adopted OWS specification. There are numerous open source as well as commercial solutions offering WMS functionality. Related to WMS are the Styled Layer Descriptor (SLD) specification, for map styling, and the Web Map Context Documents (WMCD) specification, for map setup and layout.

The envisaged architecture of the national atlas in the national spatial data infrastructure will be employing the OWS specifications in a multi-tier setup. At the server side

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data are found offered by the data providers as well as the atlas itself. The data layer contains internal data that supports the atlas visualisations, for instance base map files, descriptive text, images and charts. The external data is not stored at the atlas server but retrieved from data providers. This can also be non-spatial data services, for instance statistical data. Metadata summaries describe all these datasets.

In many existing SDIs the maps are delivered to the end-user from WMSs. Mapping clients can combine the output of several such services in a compound map. However, this is not a desirable solution, as the portrayals of these layers are not matched to each other and to the larger overall atlas goals described earlier. Therefore the national atlas should primarily use data services instead of portrayal services: It will consume data from WFS sources, and combine and portray that data in a cartographically sound client-side application. This application is supported by the data integration and mapping components on the atlas server. The former is important in the harmonisation of data for our specific visualisation purposes. As an example, it is not uncommon for various data sources for socio-economic mapping to employ different spatial datasets of the same mapping units (e.g. municipalities), with different accuracies, and generalisation levels, for example. The data integration component will always use the one best suited for the scale and map types used in the atlas, and for other data providers only extract the attribute data and re-map these onto the preferred spatial data. The mapping component is used to determine which cartography (map type, classification) is suitable for specific data layers and their combinations, and which design templates are required to achieve this.

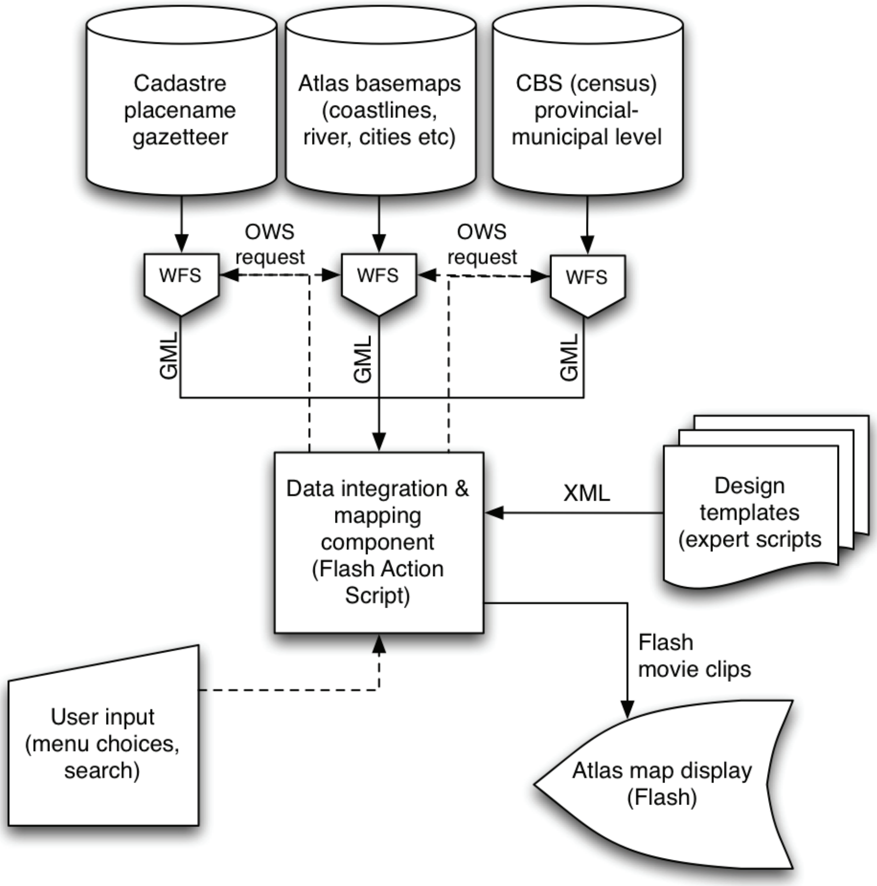
Once the mapping output and required template are defined the data is displayed on the client side. To achieve high quality and interactive visualisations, a powerful vector graphics technology should be used, such as Scalable Vector Graphics or Flash. Alternative mapping platforms such as Google Earth will also be supported, and the mapping component will also provide output formats suited for that, such as a combination of KML (now also an OGC standard) and Google Earth Network Links.

The technical implementation of the current prototype can be seen in Figure 5. Being a prototype, it does not implement all of the elements mentioned above. This is partly because the Dutch National SDI does not yet include the data services needed. We therefore host some of these, such as the WFSs for socio-economic mapping (from the provincial to the municipal level), internally on the atlas server itself. This also applies to the place name gazetteer that powers the location search. However, the actual data from the original data providers are used. As soon as these data providers implement their data services, only a simple URL change in the OWS requests is required. Furthermore, at present only the Flash version of the mapping client is implemented, since it is based on existing efforts. Open standards, such as SVG, instead of the proprietary Flash technology would in the longer term be desirable. The technical implementation of the Google Earth component has been tested (see Graham, 2008; and the test site at http://geoserver.itc.nl/natatlas/GE/), but has not been integrated in the prototype yet.

7. UPDATES, EXTENSIONS AND FUTURE

The integration in the spatial data infrastructure should guarantee that the most recent data available can be used in the atlas. If for instance the Census Bureau releases new annual population statistics through the geo-services that are already in use by the national atlas, an automatic update would theoretically be possible. However, since the atlas works with its ‘own’ basic administrative boundary data it might happen that administrative boundaries have changed and the atlas boundary set have not. Also the

Figure 5: Technical implementation of the national atlas prototype in the national SDI.



statistics themselves may require a different classification due to strong increase or decrease resulting in new class boundaries. This may result in a changing legend and possibly a changing map design. Therefore the national atlas cannot do without an atlas bureau with staff. They are responsible for the quality of the atlas. This atlas bureau, apart from editing maps and regularly extending the number of ready-made maps available through the site, should keep tabs on both the new spatial information made available by national data providers as well as considering the changing needs and interests of users such as the general public, schools and professionals.

The national atlas users are also familiar with other mapping tools such as Google Earth and Google Maps. The atlas has an export function to Google Earth where users can combine the atlas data with their own data. It will be a challenge to see how the cartographic design (the 'atlas template') fits and functions within a Google environment, which still mainly consists of satellite and aerial imagery. Atlas data availability through Google might also attract more visitors to the national atlas and the SDI.

The trend of users combining Google Earth spatial data with data collected by themselves is a recent development also know as neo-geography (Turner, 2006) or Volunteered Geographic Information (Goodchild, 2007). Users could combine their data with the atlas maps as well if the atlas would have an import function. However, form the perspective of some topics it is an interesting question if it would be possible to use these communities to update/extend the map content. Not all content benefits from this approach. Topics not directly observed or measured (like geology) or those which are already very well measured (like weather) would not qualify. However, topics like the

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spread of flora and fauna, especially in the light of changing climate, could benefit. It raises all kinds of questions. How to evaluate the observations of these communities? In the traditional national atlas map workflow the scientist would provide the data, the narrative and draft maps, and one might expect a certain quality. If one intends to include Web 2.0 communities it is likely the workflow has to be changed, but how? A national atlas bureau would not be able to check all observations, irrespective from which community these would come. Goodchild talks of citizen scientist when these informal communities have their own serious protocols, such as for instance bird watchers. Their approach is probably self-cleaning enough, but how to deal with the input from others? Similar questions are relevant for the formal SDI world.

For professionals and students working with spatial data the ease of accessing and combining spatial datasets through the national atlas interface can be harvested in geo-collaboration. Here multiple users at different locations can address and amend the same image on line in planning sessions or emergency situations, deciding interactively with the shared cartographic image as medium, on the course to follow. Way beyond its static and almost per definition outdated information provision image, the national atlas that is incorporated in the spatial data infrastructure is getting a new lease of life, with many opportunities to play a useful role in middle of the dynamic world of geoinformation where everyone is a cartographer.

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