A New generation TOP10vector data in the Netherlands

Nico Bakker & Bert Kolk,
Research & Development Department
Topographic Service of The Netherlands
P.O. Box 115
7800 AC Emmen
The Netherlands
Email: nbakker@tdn.nl , bkolk@tdn.nl

Introduction

At the beginning of the new century the Topografische Dienst (the Dutch National Mapping Agency) starts with a new generation of topographical vector data to fulfil new demands of the users of geo-information. In the last decade all the vector-data at the scales 1:10.000, 1:50.000, 1:250.000 and 1:500,000 were produced of the whole country and are sold to mainly governmental institutions. The vector data are also the base for the 'traditional" paper maps and nowadays we derive raster-data direct from the vector-data.
The Topografische Dienst (TDN), exists since 1815 as a part of the Dutch Ministry of Defence. It has mapped the Dutch territory starting at the scale 1:115,000, and since the midth of the 19th century it produces 1:50,000 scale maps. This map series was completed in 1864. In 1866 already a full mapping at the scale 1:25,000 had begun. This was completed at the end of the 19^{th} century and since then frequently updated with an interval of approximately 15 to 20 years. In 1952 the first maps at the scale 1:10,000 were produced. This is still the largest scale, which is produced for the whole country by the Topografische Dienst. The Dutch Cadastre and the utility companies produce a Large-scale Base Map of the Netherlands at the scale 1:1,000.

The need for a new database

The content and the database structure of the TOPvector products dates from the end of the eighties of the last century. The production environment was built with internally developt software based upon Microstation. Already in 1975 the first proof was done at the scale 1:10,000, but we realised that the hardware and software were far from useable or efficient for our goal. So we started digitising the smaller scale maps (1:250,000), because they were less complex and had less data. In the eighties the maps at the scale 1:50,000 were partly converted from analogue to digital vector-files, and in 1991 the first 1:10,000 scale maps were converted.
Now we face a new challenge. The TOPvector products (1:10,000, 1:50,000, 1:100,000 1:25,000 and 1:500,000) are fully accepted in the Dutch GIS community, but new applications and the wish to link the topographic data with thematic databases, urges us to think about a new data structure.
The Netherlands Council for Geographic Information (RAVI) has been coordinating the efforts to develop a nationwide core database at scale 1:10,000. Such a core database should serve as a reference for GIS-applications in the Netherlands. TOP10vector is chosen to be the core database. Some years ago TDN has established a TOP10vector-user-forum called OGT, in which all interested users can participate. In this forum, user-requirements can be formulated and, when accepted, implemented in TOP10vector. Important users are various ministries, provinces, municipalities, water boards and utility companies.
To understand the needed changes in database structure and production flow the current production of TOP10vector is shortly described in the next chapter.

The current TOP10vector

TDN started the production of the map series 1:10,000 in 1952. The monochrome maps form also the basis for the full colour map 1:25,000. The information collected for the map 1:10,000 is also used for the smaller scales.
In the early nineties, it was difficult to set up the specifications for a product like TOP10vector. User-requirements could not be formulated because experienced digital data-users did not exist. Therefore, three main starting points were formulated:

- TOP10vector should be kept simple in order to be useful for as many users as possible,

- TOP10vector should be compatible with as many GIS-systems as possible,
- The maps 1:10,000 and 1:25,000 should be produced directly from TOP10vector.

As a result, TOP10vector contains all map features that appear on the maps 1:10,000 and 1:25,000. To comply with the second starting point, it was decided to structure the vector data in such a way that it facilitates the use of the data in GIS. It was also decided to produce TOP10vector in a CAD-environment, in this case Microstation-software running on Intergraph-workstations, because the geometrical objects and their attributes can be produced efficiently in this environment. Although TOP10vector is produced in a CAD-environment, many attributes can be stored, mainly to describe the features in the database. TOP10vector contains coded points, lines and areas. Multiple coding is applied in order to store the necessary attributes. These attributes are stored within the applicable geometric features. The data is structured: all areas are closed and left/right information is added as attribute data.
TOP10vector is a digital topographic database in vector-format, which can be used in the scale-range 1:5,000 - 1:25,000. All the TOPvector data, which are sold for GIS-use, are also the base for the map production. By adding the text and the marginal map-information, no further manually work is needed for the representation of the coded map features in a cartographic representation (see figures 1 and 2).

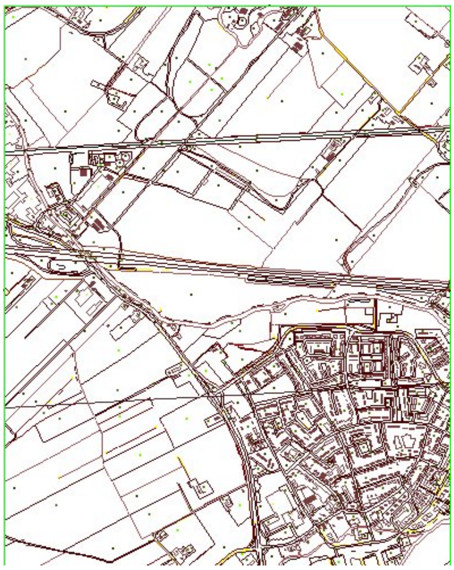

Figure 1 TOP10vector

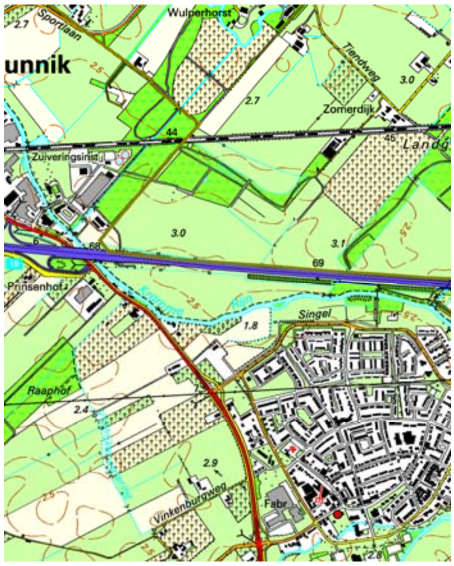

Figure 2 Map 1:25,000

Data capture for TOP10vector

TOP10vector is based on an intensive reconnaissance survey, using monochrome aerial photographs at scale 1:18,000. These aerial photographs are enlarged to scale 1:10,000. The process starts with a comparison between the existing map and the aerial photograph. New topography is annotated on the photographs with the help of a stereoscope. Not all changed topography can be interpreted. Also additional information, like land cover classification and geographic names, has to be collected. Therefore, topographers carry out a reconnaissance survey after the preparation in the office. In the field, the same procedure is followed: disappeared map features are marked on the film; new topography is annotated on the photograph. While the topographers are collecting field changes, photogrammetry is carried out to provide orthophoto’s for the digitising process.
When the topographers return from fieldwork, the enlarged aerial photographs are scanned with 1-meter resolution.
Heads-up digitising is applied to add the new topography to the vector-file. The digital orthophoto serves as a background image. The operator digitises the annotations from the orthophoto. The operator does not need to interpret the orthophoto itself, because all features are annotated. These symbols represent the codes that must be attached to the points, lines and areas (see fig. 3). When digitising is finished, software is applied to check the data-structure and to build the areas as closed polygons. A check-plot is made, which is

compared with the markings on the film and the annotations on the photograph in order to check whether all features are correctly digitised. When the corrections are completed, TOP10vector-production is finished. The TOP10vector-dataset is used for map production at scales 1:10,000 and 1:25,000, and for the production of TOP50vector. TOP50vector is the digital topographic database at scale 1:50,000 and is produced through the interactive generalization of TOP10vector.

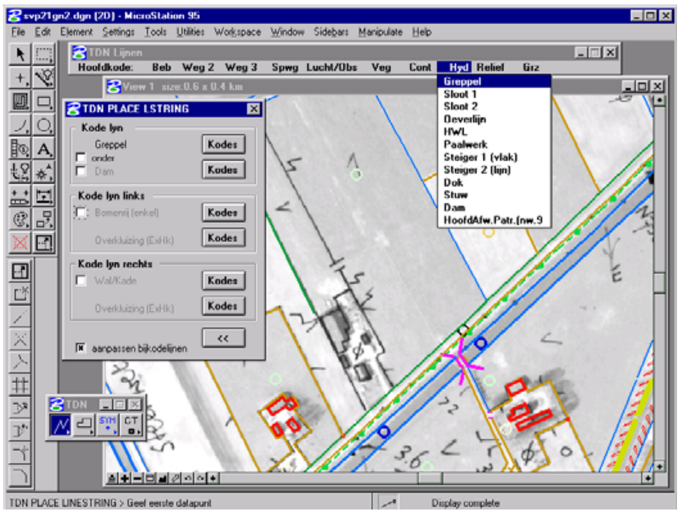

Figure 3 Digitising interface

Codes versus objects

In the present data structure the data in TOP10vector is stored as lines, points and areas. This data model is primarily based on the legend of the paper maps, and counts about 175 codes. With this coding system the elements can be selected by code, a map sheet or another area selection (fig. 4).
The user organization OGT in the Netherlands have asked the TDN to re-engineer their topographic data into a object-oriented data model.

#1000	building, house
#1010	built-up area
#1020	large building, complex of buildings
#1030	high-rise building
#1040	wall
#1050	barn
#1060	greenhouse
#1090	tank
#1100	police-station
#1110	post-office
#1120	municipal hall
#2000	motorway
#2020	motorway under construction
#2030	motorway, planned
#2040	motorway without median

Figure 4 Data model TOP10vector (fragment)

	Object	Road
	Identifying characteristic	
	Attribute	**Domain**
	Road_ID	
	Descriptic characteristic	
	Attribute	**Domain**
1	**Type**	through route
		junction
		area
	Attribuut	**Domain**
2	**Fysical outlook**	at fixed part of bridge
		at movable part of bridge
		on dike
		lowered
		overbuilt
		in tunnel
		other

Figure 5 New data model (fragment)

In the new object-oriented data model the objects will receive an unique Identification (ID) and the objects will be classified in features and attributes. These attributes have a value or a property. The features and attributes will be described in the TDN data model (fig. 5). This data model is based on the current content of TOP10vector and the smaller scale databases. The data model will comply with the existing standard in the Netherlands, called NEN 3610. For international exchange we also want to be compatible with (original military standard, but also for civil purposes used) DIGEST/FACC standard. Figure 6 gives an example of objects with attributes created from the existing database TOP10vector.

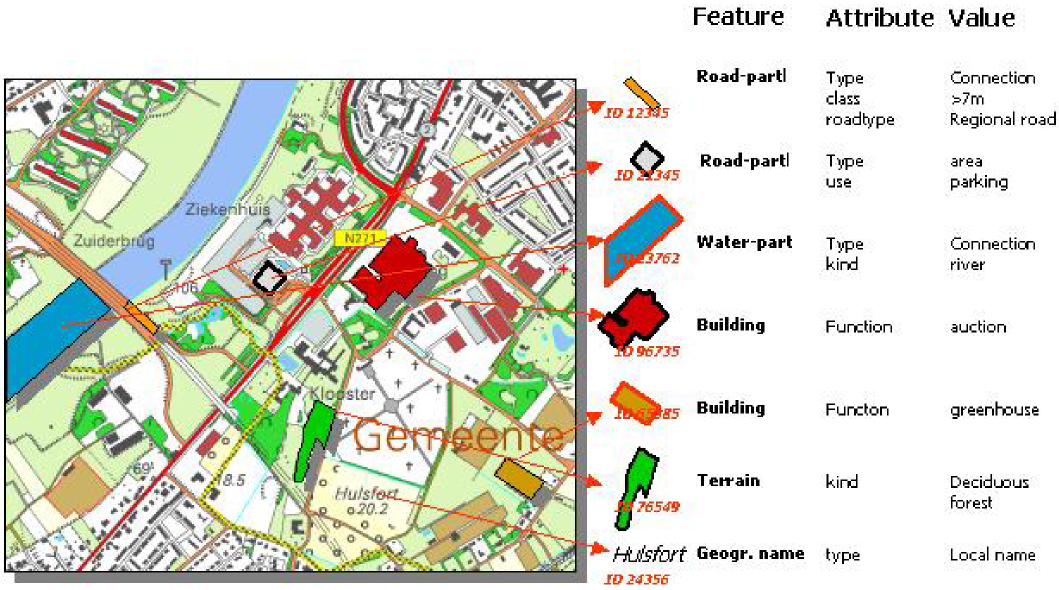

Figure 6 Object creation

Re-engineering the vector-databases

For the development of the object-oriented database the TDN has started a project called 'Object-oriented TOP10vector'. The project will last several years. The prior conditions are:

- Advanced structure of the database
- Use of modern information and communication technology
- Unique identifiers for the objects
- Based on the international Geo standards (ISO and OpenGIS)
- Innovated production methods for data capture, monitoring and supply of Geographical data

For reasons of handling the whole re-engineering, the project has been divided in some smaller projects. The first project comprehends the design of the database structure for TOP10vector and TOP10road-centerlines. A prototype will be built and presented to the user community for feedback. This project is explained in more detail in the next chapter.

In the second project the smaller scales will be examined. One of the goals of the object-oriented structure is to facilitate automated generalisation as far as possible. It should be possible to attribute different geometries to an object. In our production-flow we have to deal with the scale-range from 1:10,000 to 1:500,000. In the next project phase the migration of the production-flows and the used hardware and software will be investigated. Nowadays we produce the data in a CAD-environment with Microstation. Do we need other software and hardware? Do we need to change our data-capture process? Benchmarks of different production platforms will be carried out.

Further the new production-environment has to be built. The right definition of the objects and the way the database is built and can be used, needs detailed description in production-specifications and product-specifications. Also the differences between the existing database and the new object-oriented database needs to be described in detail for the users. Topographers and cartographers need additional education in the renewed production-environment and changed database-content.

Finally the existing database has to be converted to the object-database. A lot of extra attributing of objects will be needed.

Object-oriented TOP10vector

The first project started in 2000 and will be finished by the end of 2001

The following phases are distinguished:

a. Inventory of user requirements
b. Development of a data model
c. Building a prototype based on OpenGIS specifications
d. Evaluation of the prototype by the users
e. Final datamodel.

The project is carried out in co-operation with the Centre for Geo Information of Wageningen University (CGI), the International Institute for Aerospace Survey and Earth Sciences Enschede (ITC) and the Section GIS Technology of the faculty Geodesy of Delft University of Technology (TU Delft).

User-requirements

The first phase of the project was to establish the user-requirements for the re-engineering of the database. The next requirements and wishes were formulated

Forward and backward compatibility	*Needed*
Open Standards	*Needed*
Meta-data	*Needed*
Real world objects	*Needed*
Coverage of the country without gaps	*Needed*
Monitoring objects in time	*Needed*
Multi-level representation	*Wished*
Linking pin to other databases	*Wished*
Usability	*Wished*
Network communication	*Nice to have*

Forward and backward compatibility

Existing TOP10vector versions and the new object oriented data should be exchangeable. Investments of users must not be thrown away. For a longer time the old versions must be maintained.

Open Standards

For the new database open standards have to be used. At present the TDN delivers vector-data in 5 different exchange formats (DGN, dxf, Arc/Info, NEN1878 and SUF2). Looking at the developments in the OpenGIS Consortium and ISO TC 211 we expect that these problems will become history and one format will support the data exchange

Since there is a growing demand to distribute the data in an open transfer format, the data model will be implemented using Geography Markup Language (GML) The first proofs of the prototypes using GML 2.0 standards, have been completed in May 2001.

Metadata

Metadata are very important for the direct use of the data and the exchange of data. Metadata should include the source, the accuracy and actuality of the objects (see figure 7).

Figure 7 Metadata

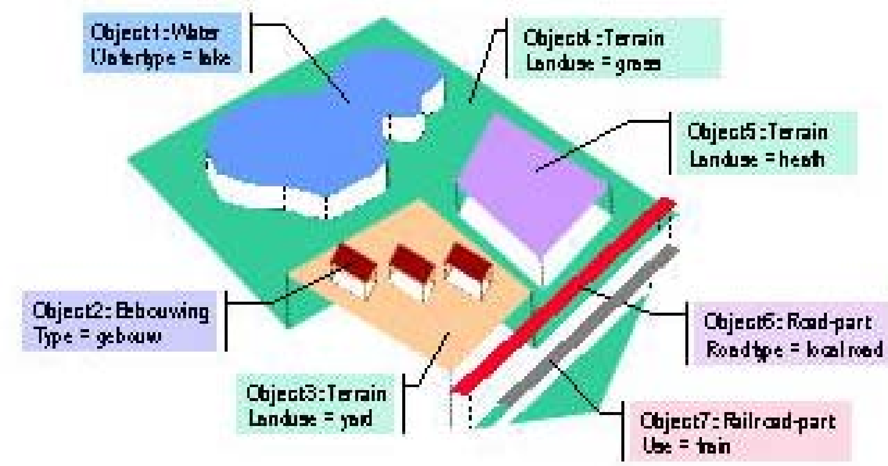

Figure 8 Partition of the world

Real world objects
The objects in the database are recognizable in the field and will be appropriate for the applications.

Coverage of the country
In the existing database the data is stored per the map sheet. In the future we need a seamless database. Also the whole area is covered by objects, there are no gaps in the terrain (fig.8).

Monitoring objects in time
The history of the objects will be stored. When the geometry or one of the attributes changes the object gets a new object-ID and the old object will be kept in the database. For any moment in the history the situation can be restored.

Multi-level representation
A long existing wish of the users is a scale-less database. Until now it seemd impossible to realize automated generalization in topographical databases. Recent research shows that a necessary condition for scale-less databases is the availability of objects. The designed data model should support these generalization actions. Also is foreseen that an object can have more geometric representations at the same scale (f.i. area and line)

Linking pin to other databases
An important starting-point is the link-function of the new database. The topographic objects need to be linked to other topographic and thematic data by the users. Different datasets have to be combined with the TOP10 data as a base. This means that the defined objects need a common definition. The semantic content of different datasets needs to be compared. Further, it must be possible that the users can add own attributes to the objects, while the link properties will remain. In the Netherlands the following databases will be taken into consideration: Large-scale database of the Netherlands (1:1,000), Digital Elevation model of the Netherlands, National Road database, Land use database, ZIP code database, Building registration and others.

Usability
Usability means, among others, that we need a clear classification of objects with good definitions in user-friendly manuals. They are illustrated with terrain situations. All kinds of SQL inquiries can be asked to the database. There are not limitations in selections of objects, regions or cross-sections in time.

Network communication
According to the technological developments there is no longer a need for users to store their own copy of the data. It is possible to fill a central database where the users can log-in via internet, intranet or extranet and execute their applications, also combining the data with other data on the same or different servers and only download the results of their query or analyses.

The above mentioned user-requirements have been formulated in the first phase of the project. After realising the data model and building the prototype with real topographic objects, the result will be evaluated by the users. Based on this evaluation the definite database structure will be realised.

New production methods
To support the new database structure and the added attributes of the objects the data capture process and production methods have to be adapted also. On the other hand the users wish a shorter revision cycle.
In the past the revision cycle of the topographic maps at the scale 1:10,000 and 1:50,000 was 10 years. The last 20 years this moved to a cycle of 5-7-9 years and later to 4-6-8 years. Starting in 1997 the whole country is updated every 4 years. Next year we will move to 2 year for a selection of the data-set (roads and built-up areas).
To realise this with the same capacity for data capture, new techniques are examined to speed up and improve the production.

1. The field reconnaissance is traditionally carried out with aerial photographs and annotated by topographers who pass through the terrain by bicycle. The interpreted photographs are scanned and digitized later on. Experiments are performed to work with pen-computers in the field, where the latest aerial photographs are combined with the latest version of TOP10vector. The changes can be processed directly during the reconnaissance (see figures 9 and 10).

Figure 9 Topographer at work

Figure 10 Topographer with pencomputer

2. High resolution satellite images are examined for their usefulness in stead of aerial photographs. Until now the results are poor, because the resolution is not enough for the detailed information which is needed. Only as signal function for areas were changes have taken place the imagery can be used.
3. A more promising technique is the digital photography with automated orthophoto production and automatic classification of land use and objects.
4. The Large-scale Map of the Netherlands 1:1,000 (GBKN). For the main features the GBKN has a faster update then TOP10vector. Some of the objects, especially buildings, can be used in our TOP10vector database. This data is not complete for the country, but more and more data becomes available.
5. Until now the central data capture, based aerial photographs and own terrain reconnaissance was more efficient than collecting data from the local governments, like municipalities and water boards. With the growing GIS-knowledge and the declining number of municipalities, caused by the

regrouping of the municipalities, it becomes more and more obvious that a part of the data-collection can be done directly by the local suppliers.

In all these areas research is done to support a faster and more efficient production.
For faster interpretation and a better quality of the captured data we will introduce digital stereo devices. This should also reduce the time spent in the field.

Conclusion

In the Netherlands the 21st century starts with an considerable change in production and delivery of topographic databases. The re-engineering of the database and the upgrading of the production processes effects the whole organization. The new products have also consequences for the users of the data. The data will be better structured and suitable for GIS-applications. The possibility to link different existing datasets and exchange data between many organizations offers a more efficient and effective use of the geographical data in our country.

References

- *Asperen, P.C.M van, 1996, Digital updates at the Dutch Topographic Service ISPRS Conference Proceedings Commission IV, Working Group 3*
- *Asperen Paul van,* Projectplan "Onderzoek objectgerichtheid TOPproducten", versie 2.0, Topografische Dienst, 2000
- *Heres L., den Hartog-Sprockel J., Plomp P*., Basisbestand Netwerken, NWB-wegen, -vaarwegen en –spoorwegen, versie 9, 2000
- Informatiemodel Ruimtelijke Ordening (IMRO), Digitale uitwisseling in de Ruimtelijke Ordening, Ravi uitgave, augustus 2000
- *Knippers, Richard and Kraak, Menno-Jan, 2001, Objectgerichte beschrijving TOP10vector,Concept ontwerp gegevensmodel, versie 1.0. ITC, Enschede*
- *Kolk, E., 1995,* On the road with TOP10vector - a nationwide medium scale geographic database, NGT Geodesia, nr. 1, pp. 13-19 (in Dutch)
- *Michael Zeiler*, Modeling our World, the ESRI Guide to Geodatabase Design, ESRI Press, 1999
- *Molenaar, M.,* An Introduction to the Theory of Spatial Object Modelling for GIS, Taylor & Francis, 1998
- Overview specification -DNF detailed topographic data held by the user-, v1.0.c, Ordnance Survey februari 2001
- Terreinmodel Vastgoed, NEN 3610, Nederlands Normalisatie-instituut, 1995.
- *Zeeuw C.J de., Bulens J.D., Bregt A.K., Knapen R., Lentjes P.J., vand der Schans R.* , Gebruikersspecificaties TOP10-21ste eeuw, Centrum voor Geo-Informatie (CGI), Alterra, 2000