FROM DIGITAL CADASTRAL DATA TO LARGE-SCALE TOPOGRAPHIC MAPS

Ch. Brandenberger, Institute of Cartography, Federal Institute of Technology (ETHZ)
Zurich FAX ++ 41 1 633 11 53 Phone 0041 1 633 30 32

Abstract

The large-scale topographic maps in Switzerland are often out of data. But as these scales are well suited for planning, the idea is to derive these maps in future directly from actual digital cadastral data. To test the feasibility of this concept the Institute of Cartography has carried out practice-oriented research on deriving topographic maps from an existing test data-set. In this contribution we report on the workflow of such a map production process up to films ready for printing and on experiences gained along the whole project.

1. Present situation

The large-scale topographic base maps in Switzerland are in the scale-range of 1:2000 to 1:10 000. They fill the gap between the cadastral maps and the topographic map 1:25 000, the latter produced by the Federal Office of Topography. At present the large-scale topographic maps cover 97 percent of Switzerland. Their importance ist still growing especially in public work at the levels canton, region or community. But these maps are often not up-to-date and not uniform in their graphic appearance and therefore not ideally suited for planning. It was considered necessary to develop a new concept, as updates are urgent.

2. The digitization of the cadastre in Switzerland

Currently a project of numerisation of the cadastre is going on throughout the country. The cadastral data were splitted up into base data, which are compulsory for the whole territory and optional data, which are in the competence of each canton. The data are segmented in 11 different layers, like fixpoints, texts, administrative boundaries, elevation ect. This layer system is ideally suited to be handled by a CAD-system, if the data are available in numerical form. The digitization can be done manually on the basis of existing maps or by an overlay-technique on the display of the workstation, if the maps were scanned in advance or also by a totally new survey. Because a lot of cadastral data are already available in digital form, it is hoped that in future the large-scale topographic maps can be derived directly from these digital data. This way it should be possible to eliminate all existing drawbacks in the actual production of topographic maps. Such maps can then be used by a growing number of map users in a graphical manner or directly digitally in a CAD-system.

3. The test data-set and its transfer to the Intergraph-system

To test the feasibility of this idea the Institute of Cartography has carried out some research on deriving topographic maps from the existing test data-set of the community Langendorf, a village some kilometers north of the city Solothurn. The survey office of the Canton Solothurn kindly allowed us to use this test data-set. The data were originaly implemented in an Adalin-system, a system that is used in Swiss survey offices. The conversion of the original data to Intergraph compatible data was carried out for us by an external firm. The whole conversion process was divided up in two stages and executed on a very basic level. Therefore the existing area definitions and also some thematic attributes were lost. In future this should be avoided, when the official standard data exchange format will be finally established. The firm divided up the test data according the information layers into the following data-sets:

- vegetation including house numbers
- singular objects
- elevation (contour lines)
- fixpoints
- administrative boundaries (land parcels) including parcel numbers

Once again this example showed drastically, what can happen, if no data exchange standard on a high level is available. If one should be able to work efficiently, a high level data exchange is of great importance, if a topographic maps has to be produced from digital data stored in various CAD systems or if the output-system is not the same as the one used for data acquisition and editing.

4. Datapreparation and separation

In the data transfer, as mentioned earlier, five different data sets, which correspond to the five information layers were exchanged. For instance the vegetation data contain the vegetation boundaries, houses and their numbers. Without postprocessing no separation between streets, forests, sports grounds and plantations was possible. These differentiations were to establish subsequently by hand using the old topographic maps. A differentiation was required also for the buildings. As references for these separations the existing cadastral maps were used. Similar statements can be made for the four other information layers.

4.1 Close building areas

Closed areas are a prerequisit for filling in colours and/or patterns. The CAD-software Microstation from Intergraph has no tool available that closes building areas automatically. This is possible only with the GIS-software (MGE) and this in four different work steps [1]. But this process could not been used in this case, because line segments that were not connected correctly were generated by the data transfer process. All these cases had to be recognized and cleared up in advance. Fortunately the operator is supported by a semi automatic function, which allows the closure of building areas.

4.2 Finding road axes

Using numerical cadastral data for the production of topographic maps at a 1:10 000 scale or smaller small roads can no longer be represented in their true scale. In this case an exaggeration can help. Moreover there are roads with excavations (sand boxes, carparks etc.), details that can not been shown any more in the topographic maps. In these sections new road axes had to be determined. In the vegetation layer the right and left border lines of the road are available. The operator has two possibilities at disposal for determing these axes. He can find the axes through a manual digitization on base of the vegetation layer displayed on the workstation. This labour-intensive digitising is inaccurate and slow. An faster and easier to handle alternative shows Figure 1. In a first stage the open vector road network is manually closed. Then follows a rasterisation of the vector data into binary raster data. This road network can be filled-in subsequently by a pixel filling algorithm. The road is then represented as a broad pixelband. A vectorisation is used to convert the pixels back to vector data. The vectorised road axes are subsequently interactively edited and classified according to additional information. Editing graphically correct road-axes was very labour-intensive. A conversion of the vectorised axes to smoothed curves was intended in the beginning. But it was only in parts possible, because the data topology needed was mostly not given.

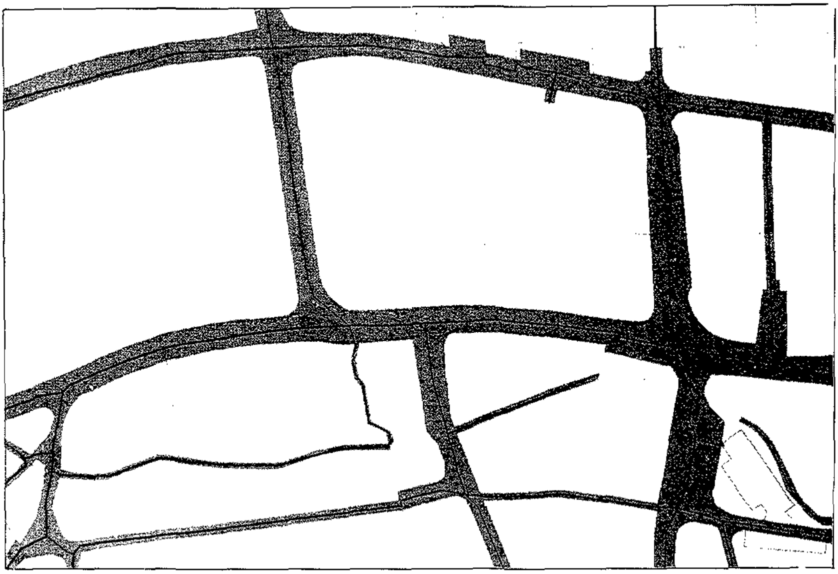

Figure 1: Finding the road axes, by means of a rasterisation of the road network succeeded by a vectorisation.

4.3 Clearing-up contour lines

The contour lines were extracted from a digital terrain model. Therefore they look partly shivering and its appearance is unnatural. Pointfiltering with a Forsen Douglas Peucker-algorithm can be performed. In order to obtain correct crossings of the contour lines over the new symbolised roads a lot of interactive and labour-intensive editing work must be done by the operator, till all lines fit correctly or at least satisfactorily the roads.

4.4 Clearing up graphical short-commings

The single lines in the layer of the land parcels are not attributed. For instance a line may be only a parcel boundary or at the same time also a county boundary? The latter had to be

Figure 3: *To the left, original outlines of the houses; to the right, manually re-digitalised outlines.*

5. Data symbolisation

The elements in the topographic maps have to be graphically differentiated. According to the fixed legend a catalog of symbols was created and stored in a cell library. These symbols could be dragged from the library and placed at the distinct positions. There are point, linear and area symbolisation. Typical representatives of point symbols are: triangulation points, altitude points, grid crosses, trees etc. All boundaries, hachures, railways and last but not least the roads belong to the category of the linear symbols. The signatures for fruit plantations, cementry etc. could be sumed up as area symbols. The placement of point symbols can be realized without any difficulties. The operator has at its disposal for placing of linear symbols various algorithms. In addition interactive editing work is necessary for producing pleasing maps. Special consideration must be given to the road junctions, where numerous arcs had to be added manually. However, the operator is supported by a function, which allows the construction of tangents to predefined arcs (Figure 4). The specification of the line thickness, part of the symbolisation, is done in the so-called pen table.

6. Data output on film by a laserrasterplotter

This work runs in three steps:

1. Rasterisation of the vector data according to the specifications fixed in the pen table. For this purpose the data must be separated in such a way, that the desired map can be produced by the lithographic process. This rasterisation process allows also the spreading of the house areas as explained earlier.

doubt the existence of well-established generalisation algorithms, which use only a few parameters which are easy to determine.

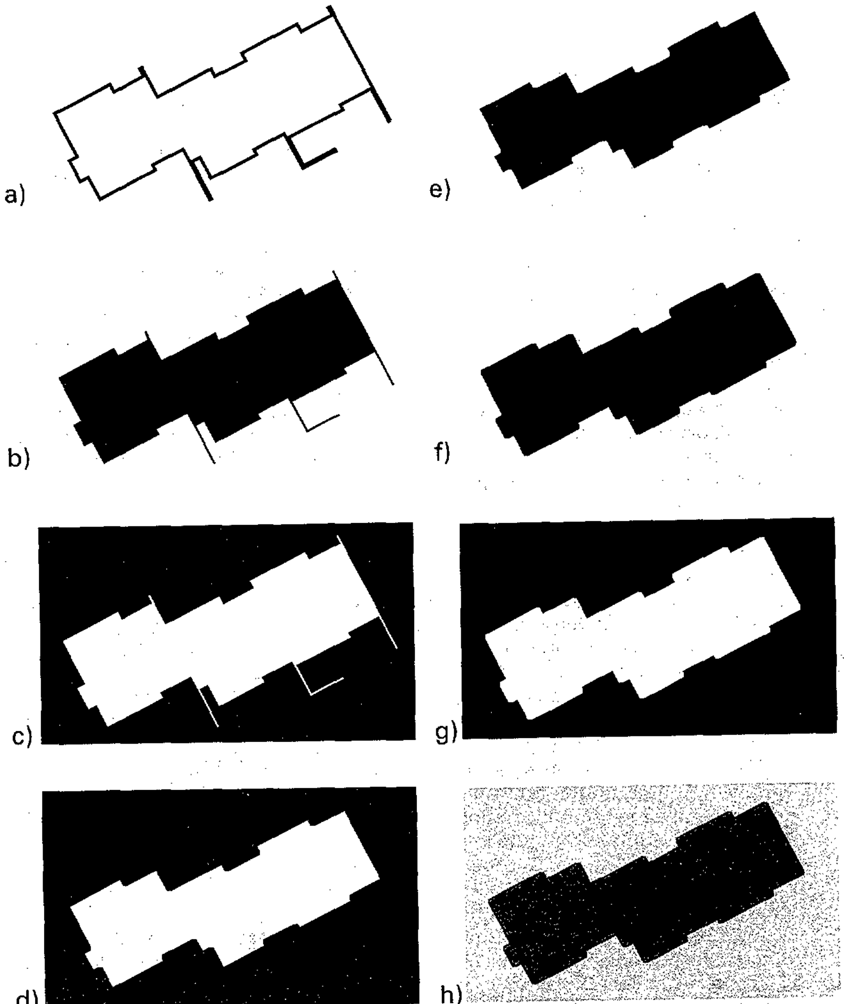

Figure 2: Generalisation of the buildings by raster spreading and masking operations

moved interactively on another data layer. Parcel lines which are identical with border lines of roads were eliminited interactively. In cadastral maps rivers are mostly separated as an own parcel. However, in topographic maps they are often represented only by a single line. In such cases a re-digitalisation of the centerline was needed.

4.5 Data additions

All lettering, with the exception of house, land parcel and contour linenumbers was not available in the original data set. An addition of these elements was necessary. The same is true for gridlines, hachures, fruit plantations and individual trees. All these elements are not surveyed and lack in the numerical cadastral data set, or may be in a form which is not appropriate for producing topographic maps.

4.6 Generalisation of the outlines of houses

Outlines of houses contained in the cadastral data could not be used without further processing for small-scale maps. Many details fall below the minimal dimensions. In order to fulfill the requirements for readable and graphically correct maps, a simplification (generalisation) of the buildings has to be to performed. The operator can make use of three different generalisation method for this purpose.

1. Using an appropriate generalisation algorithm for houses. At the moment we have no such algorithm at our disposal. From the literature two algorithms are known [2,3]. Both of them require a special data structure. To realise it subsequently means that an enormous expense of time is to be spent.

2. Elimination of small offsets along the outline of a house and minor walls through a process of raster spreading and masking. Figure 2 shows the necessary work steps for this process.
   a) Rasterisation of the original house contours with twice the desired line thickness.
   b) Filling the original house areas with pixels.
   c) Generating a negative of the original areas by a pixel flip process.
   d) Small walls are eliminated after the following spread process.
   e) Positive of the spreaded house areas after another pixel flip operation.
   f) Situation after a second spreading process.
   g) Creating a negative of figure f).
   h) Result after a combination of steps a), f) and g).
   This method gives a better result in comparison to an output of the unchanged original houses. Some drawbacks like rounded house corners must been taken into account. However, some offsets along houses, which are less than the minimal dimension, still remain. Therefore a generalisation that takes account of the minimal dimensions is necessary.

3. Re-digitalisation of the buildings on the display. The operator can thereby eliminate all too small buildings and house offsets (Figure 3). But he risks to loose due to different enlargements on the display all relation to dimension. He can only get an impression over the current display enlargement through repeating distance measuring. If hundres of houses must be handled, this method is quite cumbersome. A prerequisit for an efficient production of topographic maps on the basis of cadastral data is without any

2. The photolab process
   The traditional assembling of all originals and masks to colour separation films is performed by an electronic rasterisation. The former proof copy is replaced by a WYSIWYG-possibility on the display of the workstation. Detected mistakes on the display can be corrected at the appropriate stage in the map production process. Plotfiles are the result of the photolab process.

3. Laserraster plotting
   In this process only the black separated print ready film is produced from the plotfiles with the laserrasterplotter Optronics 5040. This film is of best graphic quality and can be used directly for producing the printing plate.

The Institute of Cartography is in a very comfortable situation as it has a highend CAD-system for data preparation and editing as well as to a precise data-output possibility at its disposal. However, not all map producers have such a system at their disposal. Often a possibility exists in generating POSTSCRIPT-datafiles, which can be easily transfered to the RIP of laserrasterplotter.

Figure 4: To the left, situation after a new symbolisation of the vectorised road network; to the right, situation after an editing of the road junctions.

7. Discussion of the results

In the following some of the executed examples are shortly described and its benefits and drawbacks discussed. In Figure 5 the original cadastral data set graphically differentiaed in 3 line-thicknesses is shown. It is a graphically weak map. In Figure 6 we have also the original data, but now supplemented with text, gridlines and a symbolisation for the various borders. Still a lot of to small buildings, which are below the minimal dimension of 0.4x0.4 mm can be detected. On the whole this is not yet a satisfactory result! Also it contains too small walls and house offsets. Therefore the house contours seems to be shivering and are partly not clear. In this scale the left and right border line of the road fall together on small roads and create an ugly thick black line. The same problem do we have with the rivers. The contour lines are not in the usual form of a topographic map. For a satisfying result an interactive editing phase is necessary. If the land parcels are an element of the map additional graphical disadvantages appear, because many parcel boundaries are quasi identical with outlines of the vegetation layer. In Figure 6 all houses are treated with the spread algorithm explained above. Walls that were too small could be eliminated that way. A prerequisit of this procedure is, that appropriate program moduls are at disposal.

Figure 5: *A section of the original cadastral data set without any interactive manipulations*

In all the discussed variants the outlines of the houses are still insufficient. Also the roadnet is not conform to the usual standard. Therefore a manual and very time- and labour-intensive editing phase is necessary. It consists in a new symbolisation of the road network and a manual re-digitalisation on the display. At the same time a generalisation of all buildings is performed. In addition all houses that are too small must be eliminated. Figure 7 shows a section of a map, which corresponds to the usual standards of such topographic maps. A comparison with the first test (Figure 5) demonstrates that by interactive editing the clarity and readability of the map is improved and the result is of better quality. No doubt a large amount of work is required to produce such graphically correct topographic map.

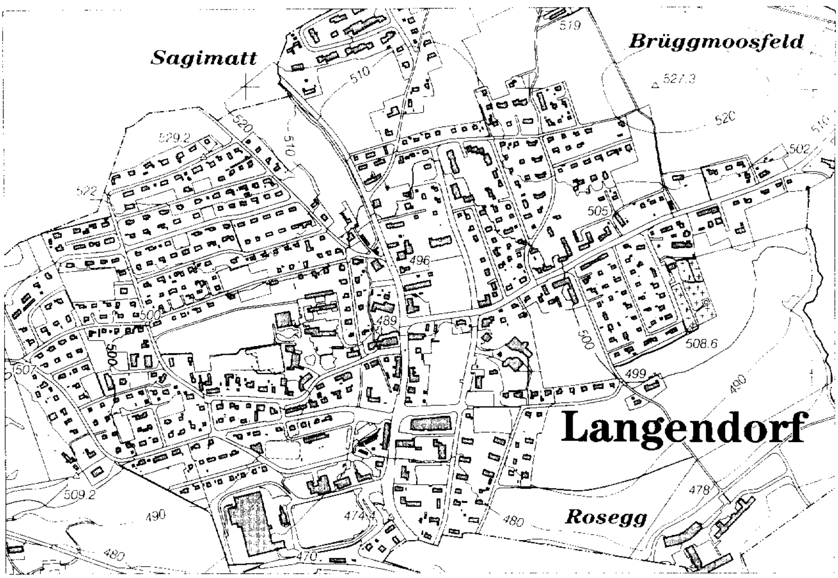

Figure 6: The original data set with a symbolisation of the different border lines. Some buildings are still too small, some roads too narrow.

8. Conclusions

In conclusion to the realized tests we found:

- A derivation of maps from digital cadastral data is possible, but additional labour-intensive interactive working steps are necessary.
- The existing Swiss cadastral data set is not well suited in every respect for a direct digital production of topographic maps.
- Some elements of the topographic maps are not contained in the cadastral data set, as e. g. hachures.
- Other elements are not ideally placed in context to the elements they belong to, as e. g. texts etc.
- Especially in producing such a map for the first time, the amount of interactive operations needed are enormous.
- Up to now efficent and universally usable generalisation algorithms do not exist. They are essential for producing well designed topographic maps.
- Updating the digital topographic map at a later stage can be done in a shorter time.
- However, digital map data allow for a straightforward production of special maps, which can be user-defined.

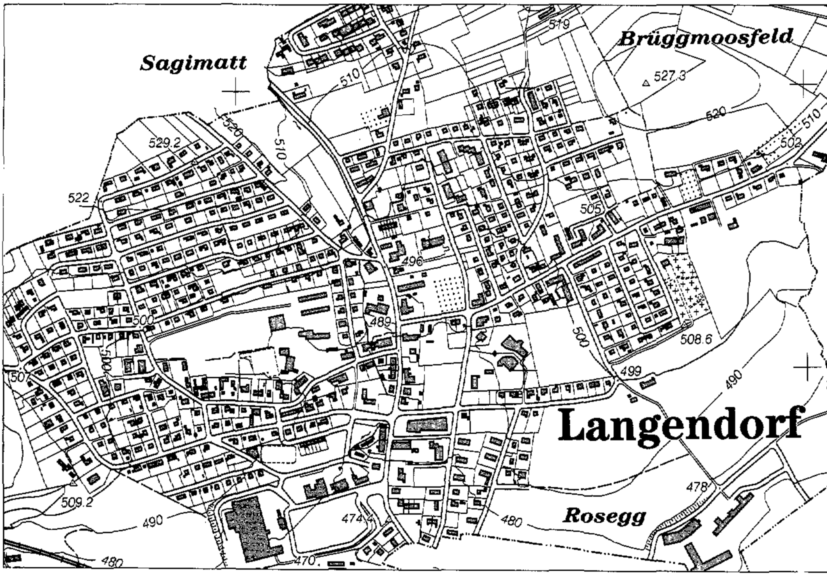

Figure 7: A section of the final map after several interactive editing steps. This result is up traditional standards for this type of topographic map.

9. References

[1] Brandenberger Ch.,1993. Von der Datenübernahme aus einem GIS bis zu druckfertigen Kartenoriginalen. Vermessung, Photogrammetrie, Kulturtechnik, Volume 1/93.

[2] Staufenbiel W.,1973. Zur Automation der Generalisierung topographischer Karten mit besonderer Berücksichtigung grossmassstäbiger Gebäudedarstellung. Reihe Wissenschaftliche Arbeiten der Lehrstühle für Geodäsie, Photogrammetrie und Kartographie an der technischen Universität Hannover, Volume 51/1973.

[3] Meyer U.,1989. Generalisierung der Siedlungsdarstellung in digitalen Situationsmodellen. Reihe Wissenschaftliche Arbeiten der Lehrstühle für Geodäsie, Photogrammetrie und Kartographie an der technischen Universität Hannover, Volume 159/1989.