

Map revision supported by digital vector/raster techniques
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Abstract

The Federal Office of Topography is responsible for the geodetic and cartographic bases of Switzerland. The official map scales are 1:25'000, 1:50'000, 1:100'000, 1:200'000 and 1:500'000. The maps at all of these scales were completed in 1979. Currently the main task of the Office is the revision of these maps.

Recently the Office acquired an analytical plotter and a raster based cartographic system with a digital scanner. The main task for this system is the establishment of a digital terrain model and a topographic data set.

Parallel to this task we made an experiment in map revision to test the application possibilities of the new technology. The map changes were restituted on the analytical plotter and registered in digital form with the appropriate labels and structure. The data was transformed on a general purpose system, introduced into the raster system and transformed with the corresponding signature tables into raster form. The data was then merged with the original data, scanned from the available color overlays.

The results of this test are presented in detail and the advantages and disadvantages of this new procedure are discussed.

1. Introduction

The Federal Office of Topography is responsible for the geodetic control and the cartographic bases of our country. It is an independent division of the Department of Defence and employs 150 surveying and mapping specialists. The three main branches are: geodesy, topography and reproduction. In 1935, the Swiss government decided to establish a new map series called the National Map series. These maps were completed in 1979. They include 249 sheets at the scale 1:25'000, 78 sheets at 1:50'000, 23 sheets 1:100'000, 4 sheets 1:200'000 and one sheet 1:500'000.

All of these typically topographic maps have a very high accuracy standard and a high information content.

Since 1968, the maps are being systematically revised using aerial photography and stereo-compilation to collect the new information. After the National Map series had been completed, revision became the main task of our Office. In 1982 we started a project in the area of digital cartography. The main goal was to establish a digital height model (DHM) of Switzerland using the map information, contours and spot heights as primary input. The necessary equipment was acquired with respect to future applications in digital mapping and map revision. The described work is the first result of our application tests.

2. The map revision procedure

In 1968, after a few revision tests, the Office decided to start a regular revision program for all maps in a 6-year cycle (Figure 1). This program runs very successfully. Currently we are in the middle of the fourth revision cycle. The steps of the revision are the following:

Every year we acquire aerial photographs of one sixth of our country at an approximate image scale of 1:25'000. In a first step, the photographs and the 6-year-old maps are compared in the office using stereo-interpretation and any differences are registered on a sketch-map. In the second step, this sketch-map is completed with a field check, a task which we consider to be very important. In the third step, all new elements indicated in the sketch-map are compiled with photogrammetric instruments. The plotting base consists of a coated glass plate containing a copy of the old map. For the smaller scales (1:50'000 and smaller) we reduce this information and select the scale-relevant features.

Because of meteorological and administrative reasons, signalisation of control points in our country would be too expensive and time-consuming. Therefore, we use exclusively map elements (crossroads, houses, spot heights, etc.) for ground control. These map elements are digitized and used in a computer program to calculate the relative and absolute orientation parameters using the bundle approach. Experience has shown that we can maintain our accuracy standards of ± 0.1 to 0.3 millimeters in planimetry and ± 1 to 2 meters in height.

Last year we changed our procedure slightly. Instead of comparing the images with the old maps using a mirror-stereoscope, the comparison, together with the compilation, is made directly on the photogrammetric instrument. This allows us to work with the original high-resolution film instead of the prints, and with the incorporated zoom optics on the plotting instruments, we have much better viewing conditions. The result of this first step is a compilation showing the new items of the map sheet. Parallel to the compilation, the photogrammetrist makes note of all interpretation problems in a special list. This list is used afterwards in the field check, the different locations are visited and the interpretation is completed.

In most cases, the result of the field work leads to only a correction of the compilation. Since the photogrammetrist is instructed to compile as much as he can see, we very rarely have to recompile a model at the stereoplotter.

The advantage of this change is a save in time since the interpretation part falls together with the photogrammetric restitution.

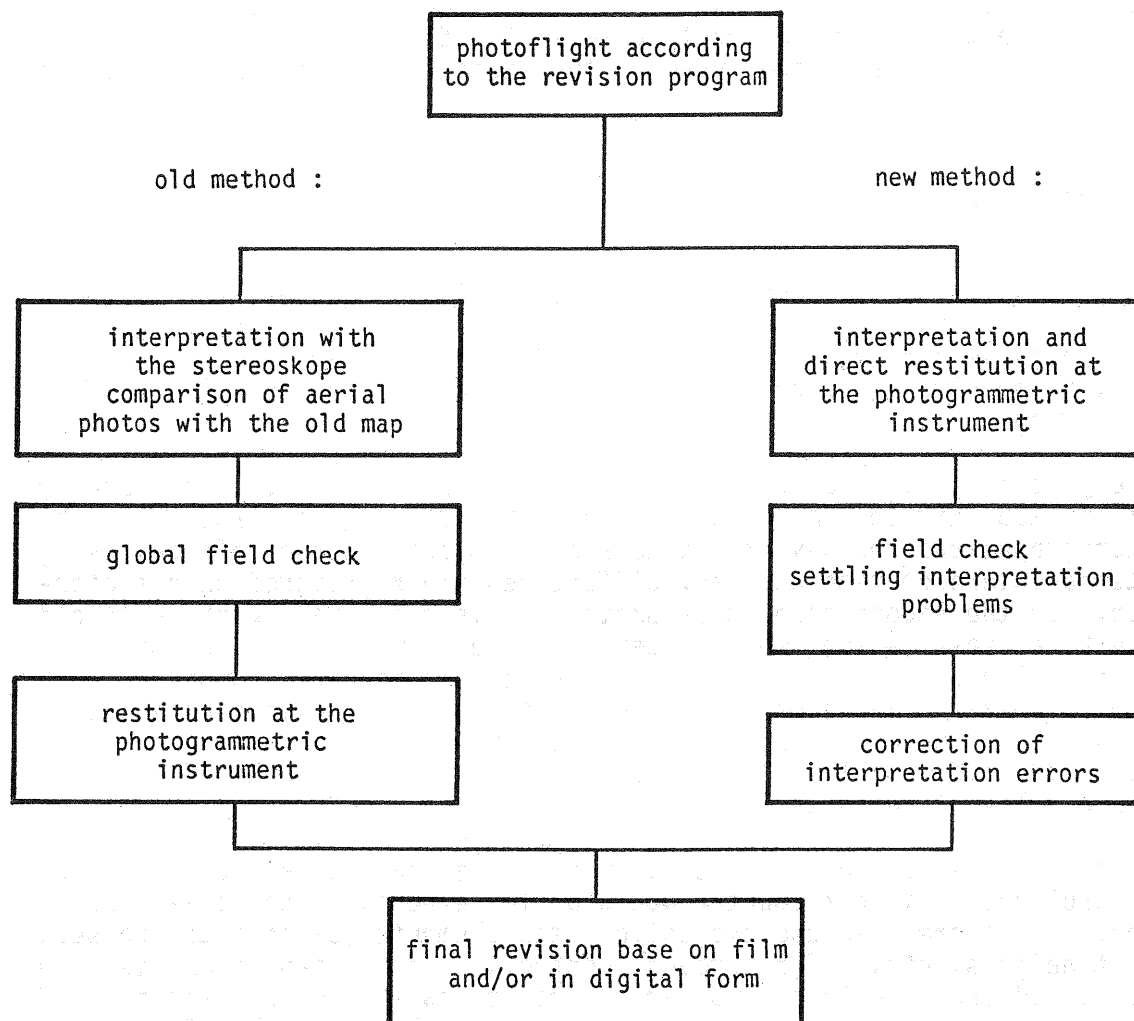


Figure 1 : Map revision process

3. The project DIKART

At our Office, the activities in digital mapping started with the growing interest of the military in digital height information. This led to our project DIKART (German : Digitale KARTE) which was started in 1982.

The principal goal of DIKART is to establish a uniform digital height model of Switzerland based on a dense grid. After having evaluated different technical solutions, we decided to derive the model from the digitized height information (contours, spot heights) of our 1:25'000 maps. In the mountainous parts however, the contours do not give enough information on the ridge lines. These ridge lines are neces-

sary to model the terrain with sufficient accuracy in these areas. Therefore, we decided to complement the height information of the maps with photogrammetric measurements of the ridge lines using the existing aerial photography of the revision work.

Our interest in digital cartography had a strong influence on the evaluation of the hardware and software. With the new system, we wanted to be able to experiment in the field of digital thematic and topographic cartography. After a careful evaluation, we decided to acquire a SCITEX Response 280 system together with a WILD BC 1 analytical plotter. The actual configuration is shown in Figure 2. The system consists of three connected but independent computer units running in single user mode. Two of them are used to drive the two interactive graphic workstations, the third is used either to drive the scanner or to do batch processing with the data. The system is essentially a raster system with a few vector capabilities. It was developed in the graphic arts/reproduction area and is very well-suited for fine graphic work.

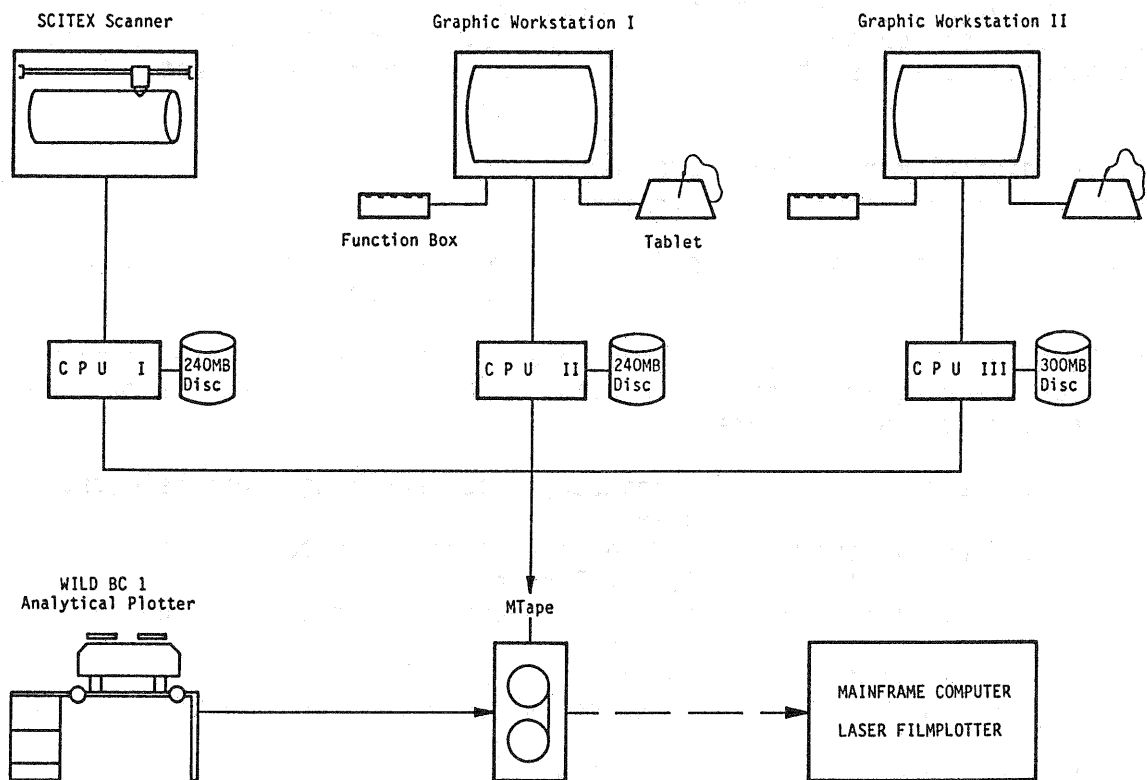


Figure 2 : Hardware configuration

With the scanner we can collect and separate up to 12 colors at resolutions from 4 to 48 lines per millimeter. Basically we scan the films of the color separations of the map. To build the digital height model, we proceed in the following way:

- Scanning of the brown plate (contours), the blue plate (glacier contours), the black plate (rock contours) and the forest tint (to improve the identification on the monitor)
- Correcting the contours in raster mode in order to get uninterrupted lines
- Extracting the contours, raster to vector conversion
- Tagging the contours with the appropriate height information
- Merging the contours with the ridge lines and the spot heights
- Interpolating the final DHM25 in a 25-meter grid

The work with the scanning and processing of topographic maps for the extraction of contour lines gave us some experience and ideas and encouraged us to use the configuration for a map revision test.

4. The digital map revision procedure

The digital map revision procedure that we used in this first test (Figure 3) is actually very simple and straightforward:

a) First we scan the different map layers with an appropriate resolution, keeping the resulting digital 'map image' in raster form. We use the following layers :

- | | |
|------------------|---|
| . black | planimetry, rock scribing, spot heights, names |
| . blue linework | hydrography, glacier contours, names |
| . blue tint | lake color mask |
| . green linework | forest boundaries, single trees, bushes, orchards |
| . green tint | forest color mask |
| . brown | contours, slope hatchures, skilifts |

The two screened plates with the hill shading are not used in the digital process. However, we do produce a road mask with the system in order to mask the hill shading before printing.

- b) In the second step we create working sets by overlaying the scanned 'map images' on top of each other. The layer we want to treat in the working set is always on top of the set (Figure 4a).
- c) Corresponding to the described procedure, the map revision information is compiled on the analytical plotter in digital form using an appropriate system of feature codes to represent the map legend. The result is a coded vector file in the national coordinate system containing the complete revision information.

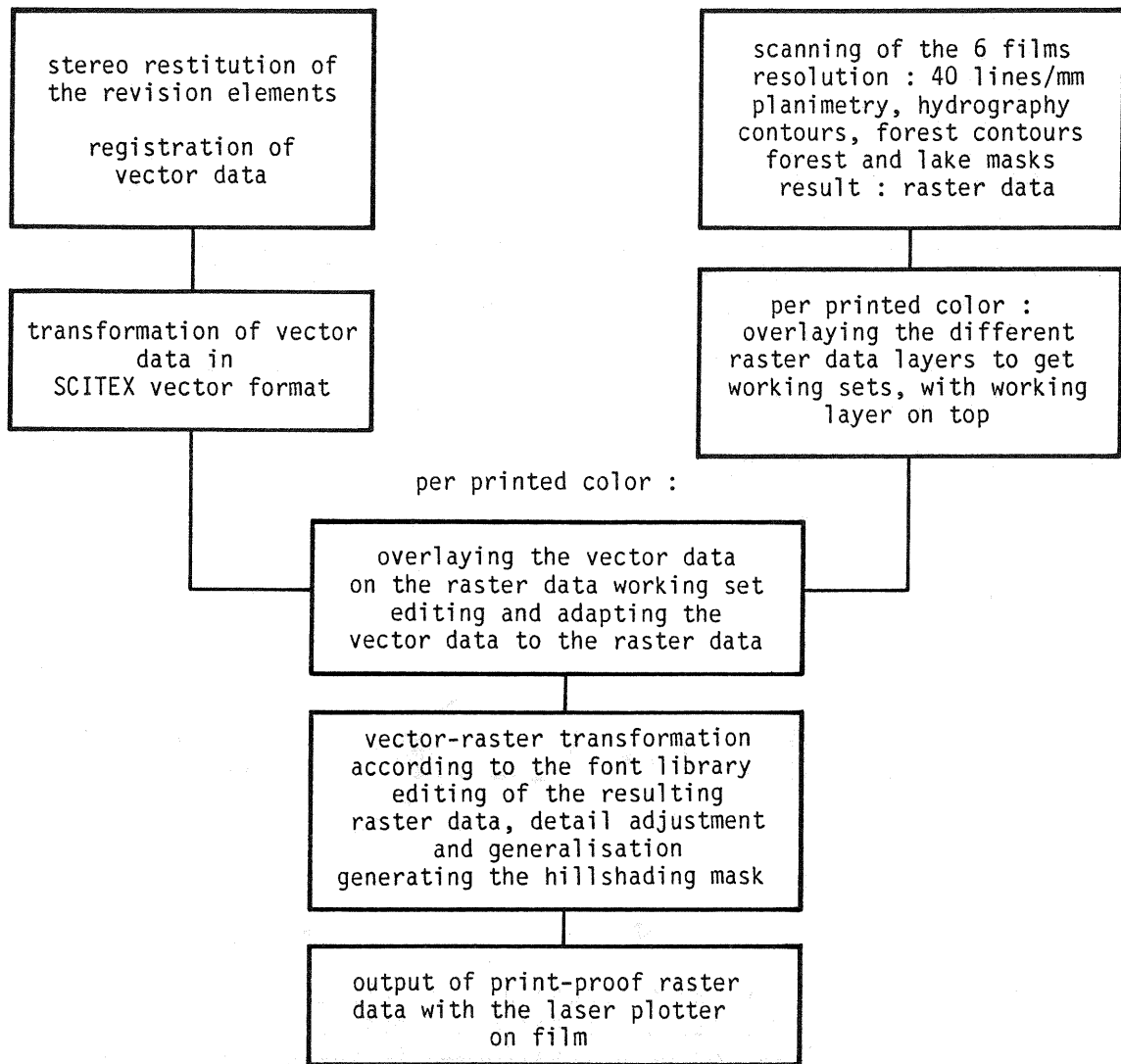


Figure 3 : Testing procedure for digital map revision

- d) In the next step, the revision information is transformed into the raster coordinate system and structured according to the feature code. The feature code itself is transformed via lookup table into the SCITEX font code according to a specially established font library. The information is still in vector form (Figure 4b).
- e) After transformation, the vector information of the revision is overlaid on the corresponding 'working set' and adapted to the raster data. In this phase we adapt and shift linear features such as road and river axes, buildings, etc.
- f) The corrected and adapted vectors are then transformed into raster form. The result of this conversion depends on how good the font library is composed. At this stage, road axes are converted according to the map legend into single, double and tripple lines, etc.

- g) In the next step, the new raster image of the original map, together with the revision information, can be corrected in detail. The operator is even able to correct and adapt the new information pixel by pixel. Instead of working with a scribing tool, he works with the cursor on the screen. Generalization of new items and adaption to existing generalized structures are easy to accomplish. The operator can even test different graphical solutions of critical representations of details very easily. For every layer he corrects, the full information of all other layers is available in the background of the screen (Figure 4c).
- h) In the last step, the different updated layers listed under a) are separated and plotted on film with the appropriate resolution. These films are then used directly to produce the printing plates for the offset printing press.

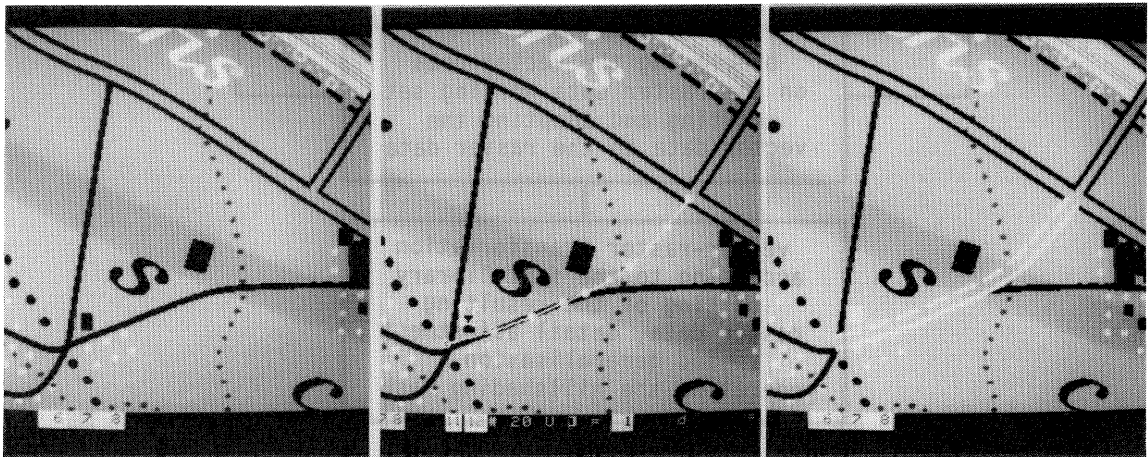


Figure 4 : a) Overlay of scanned films (left)
 b) Overlay of vector data (middle)
 c) Vector data transformed in raster form (right)

5. Experiences with the first sheet

To test the described procedure we chose the map sheet 1168 Langnau. This is a relatively simple sheet of a hilly landscape with several valleys, a few villages and extended forest areas. The amount of revision changes lies within the average.

During the preparation we first made different scanning tests to determine the optimal resolution. The results of our scanner at 40 lines/mm showed a difference in linewidth for lines parallel to the drum (thinner) and lines perpendicular to the drum (thicker). For the map grid with a linewidth of 0.09 mm we found a difference of about 2 pixels. Since our scanner works with a normal light source (SCITEX super color scanner) we explained this phenomenon with a light dispersion or a parallax effect in the reflexion of the light beam on the scanned surface.

We made new tests with an available SCITEX laser scanner and found that this problem was solved with the laser beam.

For the resolution test, we used a film with very fine rock scribing and scanned it with resolutions of 40, 60 and 80 lines/mm. Immediately afterwards we plotted the resulting data set again with the same

resolutions using the SCITEX laser raster plotter. The three samples, together with the original film, were then printed on the offset printing press.

With a magnifying glass, one can see that the pixel structure on the films is slightly visible with resolution 40 and 60 along smooth lines and letter fonts. With resolution 80 the pixel structure is no longer visible. In the printed sample, even with resolution 40, the pixel structure disappears completely.

For our test, we decided to work with resolution 40 essentially because of the limited address space of the 16 bit computer used in the SCITEX system. This limitation allows us to scan a full map sheet with a maximum resolution of only 46 lines/mm. In the future, we plan to work with a resolution of 50 lines/mm because in creating the font library, we can adapt our map legend more precisely with steps of 0.020 mm than with steps of 0.025 mm.

The scanning of the described map layers was done without any problems on the SCITEX ELP laser scanner. The films were fixed by hand without using the punch register system.

In photogrammetry, we had to compile 16 stereomodels and proceed as usual, model by model. On the WILD BC 1 instrument, the digital registration was done parallel to the graphic output we normally produce. Instead of scribing on glass plates, we use film on the BC 1. Apart from the restitution, the most important task was preparing the feature code table on the BC 1. This table has to reflect the map legend in detail and should be composed very carefully. It is a task that has to be done only once per map type.

We soon found out that it was impossible to work with the full map sheet on the SCITEX workstation. The data volume is too large to get an acceptable system response in the interactive work. We therefore cut the raster data sets into overlapping patches according to the photogrammetric model and worked model-wise in these patches.

Except for a few minor problems always encountered in tests like this, the work proceeded extremely well and without any difficulties. This is certainly due to the fact that we had an operator experienced in photogrammetry and cartography and capable of working on the BC 1 and the SCITEX system as well.

6. Conclusions

At the time this was written, the last model was still in preparation on the SCITEX workstation. Therefore we cannot include the final result - a printed sample of the map sheet - in this paper. Nevertheless, we can state that the test shows very positive results.

We are aware that this test by no means provided us with the final solution. There are still many remaining questions and problems to solve. To mention some of them :

- The hardware and software of the SCITEX workstation are rather old and therefore restricted in capacity and performance. The workstation is also expensive compared to the more modern ones which we would like for our production.

- The way the vector data are treated on the SCITEX system may be acceptable in the beginning, but in the future, the vector data of the complete map information should be organized in a Geographical Information System GIS.
- Existing GIS have no raster capabilities in terms of reproduction. We are looking for a system capable of treating data in both raster and vector form.

The fundamental problem lies in the very limited market for cartographical systems. Therefore, we have to accept solutions developed for related disciplines like CAD/CAM or graphic arts and adapt them to our needs.

We have chosen a very simple approach in order to come to some results and experiences quickly. In a first step we only wanted to test the feasibility of the method, neglecting the economical side.

The great advantage of the method lies in the flexibility of working with digital 'map images'. The classical excuse of the cartographer in revision: 'It takes too much time to correct', is no longer valid. In comparison with scribing, digital processing is certainly more efficient. How much more can only be said after ten or more sheets. The fact that we work parallel on all layers and the accuracy of their fit, will also improve the map as a whole.

The great economical advantage will certainly appear in the reproduction section since many copying and masking processes can be avoided with a digital system.

The next steps in our work will be the following :

- Plotting the color layers and the road mask with the laser raster plotter on film
- Proof-reading with a Cromalin copy
- Printing the final map in 8 colors including the hill shading.

We would be happy to provide a copy of the final map free of charge to anyone interested in this test.

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