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Journeys of Discovery: from Paper Maps to Explorative Multimedia Cartographic Visualization

Recent Developments in Swiss Cartography

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1 Introduction

Hardly any other field in geography has changed so fundamentally in the last 10 years as cartography. Until well into the 1990s, cartographers still worked by means of scribing and fair drawing. By the 1980s, however, digital procedures and systems were already being used for the (partial) drawing up of maps. However, only in about 1995 was the time ready for a complete turnaround towards a comprehensive digital, high quality production. A good overview of the developments of the systems and applications of this time is given in the conference volume of the Cartography Congress 1996 in Interlaken (Hurni 1996). Relatively early it was asked whether the new technologies and media could maintain the quality of the maps and even improve on them, and if required, whether totally new products with broader scope could be launched. This has already been possible for a few decades thanks to professional Geographic Information Systems (GIS). However, these systems demand professional care; laypersons or non-GIS specialists find them hard to use; and they are also very expensive to acquire.

In this second digital revolution, cartography is once again manifesting certain problems in establishing itself in its new sphere of activity. Similar to GIS, development in this area was also promoted by companies and institutions with no background in the subject, for example by Traffic and Routing Information Systems. Universities must therefore play a decisive role in determining the opportunities of the new media for cartographic applications and in taking care of the expedient dissemination of the new knowledge.

The article at hand is concerned with this current exciting phase in cartography, particularly in Switzerland. The transition from conventional to digital cartography is connected to the opportunities provided by the new, interactive and explorative cartographic products.

2 Change in cartography with regard to method and content

2.1 Technological change 1980-2000

The most significant revolution for cartography in the 20th century was undoubtedly the introduction of computer-aided techniques. In 1965, the first vector systems and plotters could be used only for partial tasks. The private company Kümmerly + Frey AG pioneered work in the 1970s with a raster system, taken from textile printing techniques; however, the Swiss Federal Office of Topography also updated several map sheets in this way.

The first raster/vector based, so-called hybrid system, consisted of hardware components such as graphic workstations, digitizers, scanner/laser raster plotters and software packages such as CAD packages, raster editors and reproduction software by the U.S. company Intergraph. In Switzerland, two such production lines were in use, namely at the Institute of Cartography at ETHZ and at Orell Füssli Cartography AG Company in Zurich (Hurni 1992). Figure 1 shows part of one of the first topographical maps to have been completely drawn up by one of these systems (Hurni 1995).

The cost of obtaining and maintaining this equipment was very high and therefore out of financial reach for small cartographic companies. Furthermore, the finished map image could not be viewed on screen; the system was therefore not capable of being used in WYSIWYG («What you see is what you get») programmes. The first hybrid WYSIWYG software suitable for cartography originated from the Desktop Publishing (DTP)-World. New, entirely cartographic DTP-programs, cost between twenty to forty times more, but contain special functions. All maps today are digitally updated on such systems (Hurni & Christinat 1997).

In the process only the existing techniques have in principle been replaced; regarding contents, the products have not changed very much. In Switzerland, adaptations of the cartographic design were discussed (Spiess et al. 1998) and in various German states individual map sheets appeared with clearly increased minimal dimensions and with a more colourful appearance (Grimm 1993). Generally, of late, one can observe a certain simplification or even a «trivialisation» of conventional map products, mainly due to savings on production costs and also due to the clearly increased effort

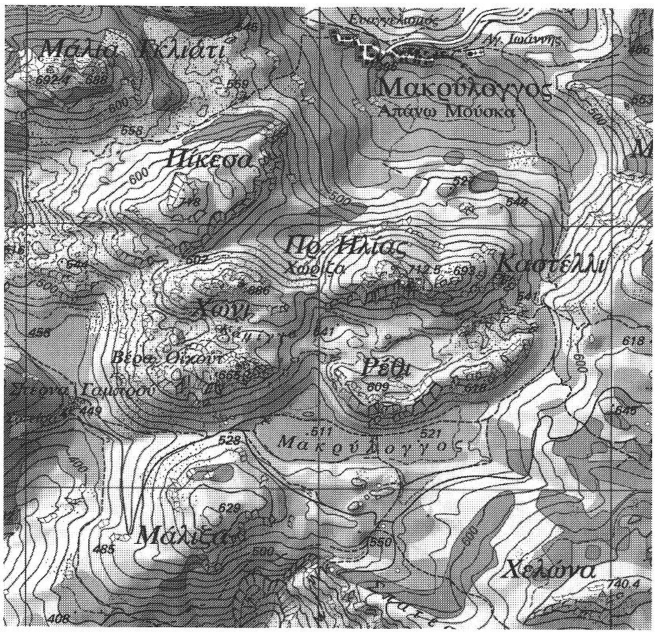

Fig. 1: Part of a completely digitally drawn up topographical map of the Methana peninsula in Greece
Ausschnitt aus einer vollständig digital erstellten topographischen Karte der Halbinsel Methana in Griechenland
Extrait de la carte topographique de la presqu'île de Methana en Grèce. Cette carte a été produite intégralement de manière digitale.
Source: HURNI 1995

required in using conventional maps. The latter is most likely the result of today's surplus of information and certain deficits in school and military education, and not due to the quality of current cartography.

«Thematic cartography» was supported in various textbooks during the 1960s and 1970s (WITT 1970; IMHOF 1972; ARNBERGER 1993). Their advocates reacted to the increased demand for modelling, analysis, and visualisation of projects, phenomena and problem areas with an increased degree of abstraction and complexity. A new research direction developed, parallel to that of quantitative geography, which exercised a decisive influence on thematic cartography (BRASSEL et al. 1998).

2.2 From the static to the explorative, multimedia map

A map printed on paper is static; it represents a predetermined temporal situation and changes can only be visualised with difficulty. Cartometry, the reading of information from the maps, is made more difficult. Furthermore, production and updating methods are relatively sluggish. It is therefore not surprising that in the last 15 years Geographic Information Systems have increasingly assumed the tasks of many thematic maps. GIS, however, aside from the comparatively high acquisition and maintenance costs, are difficult to handle and have weaknesses in the area of cartographic visualisation. In the last few years, a possible solution and a further sphere of activity for cartography has opened up due to multimedia cartography. Today's software applications also allow for a strengthened individual use of spatially relative rudimentary materials; and therefore, one can work exploratively.

«Multimedia Atlases» as some of the digital, interactive cartographic products are called, unite cartographic knowledge with GIS and multimedia elements such as image and sound. An interactive atlas with analysis functions should include a whole range of maps, images and text materials, an original concept with regard to graphic design, access and use. They should also contain a user interface, which encourages discovery, and well-developed navigation and orientation aids. They also make possible the integration of interactive comparative actions (e.g. dynamic changes in space and time) and the inclusion of three-dimensional models (SIEBER & BÄR 1996).

Cartography discovered these new types of media relatively late because in the 1990s most companies and institutions were pre-occupied with the change from conventional to digital production methods. So the first web-based map systems and mobile Location Based Systems (LBS) were developed by people who were not cartographers, resulting in particularly inadequate map graphics due to the already graphically limited display devices. Cartographers are now beginning to recognise the gap in the market and are making their knowledge and services available for the improvement of these products (REICHENBACHER et al. 2002). Therefore, at the moment, a major emphasis in cartographic research is placed on the synthesis between GIS, cartographic techniques and the new media.

3 The development of cartographic education in Switzerland

Professional cartography can be studied in a four-year course, at the moment available only at the Swiss Federal Office of Topography. Theoretical instruction is taught at the School of Design in Berne. As of January 1, 2000 the education regulations were revised in cooperation with three private cartography firms (HURNI & FELDMANN 2001). A polytechnic education does not exist in Switzerland. However, most universities in Switzerland offer lectures on the essentials of cartography as part of a geography degree. Regrettably, there are hardly any specific courses for those interested in pursuing specialised topics. A comprehensive unified course in cartography can only be covered within the 5-year geomatics

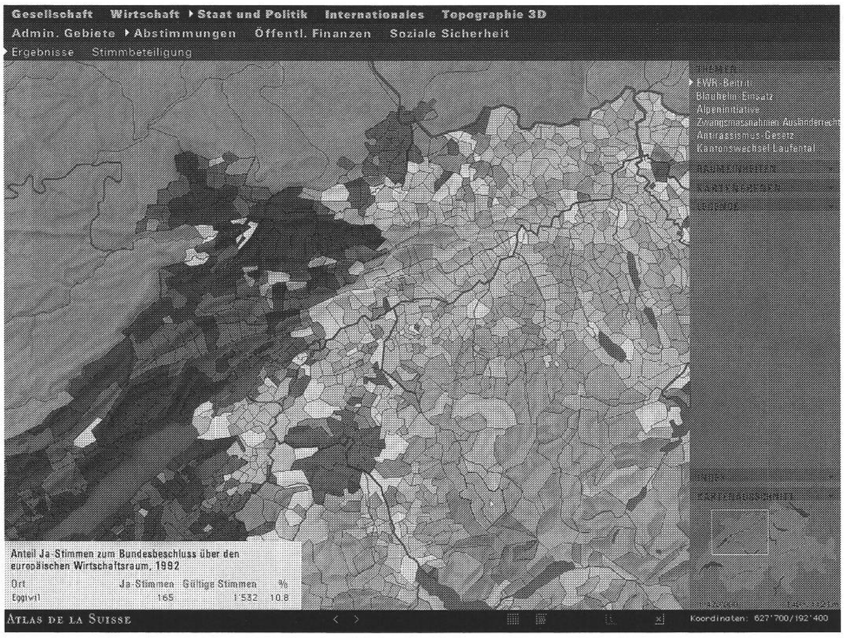

Fig. 2: Thematic, interactive multimedia cartography in the «Atlas of Switzerland – Interactive»: visualisation of results according to municipalities of the 1992 referendum on the accession of Switzerland to the EEA. Dark shades: approval; light shades: rejection.
Thematische, interaktive Multimedia-Kartographie im «Atlas der Schweiz – interaktiv»: Gemeindeweise Visualisierung von Resultaten zur Abstimmung von 1992 über den Beitritt der Schweiz zum EWR. Dunkle Töne: Zustimmung; helle Töne: Ablehnung.
Cartographie thématique multimédia interactive dans l'«Atlas de la Suisse – interactif»: Visualisation par commune du résultat du vote concernant l'arrêté fédéral sur l'Espace économique européen en 1992. Teintes sombres: consentement; teintes claires: refus.

degree, offered at the ETH Zurich. The subject can also be taken by students of other universities as a minor subject (Hurni et al 2001). For geomatics engineers and geographers, jobs are available mostly in GIS-areas with the authorities, private engineering companies or research institutions.

4 Research: current projects at the ETH and the University of Zurich

4.1 The Institute of Cartography of the ETH Zurich (IKA-ETHZ)

The Institute of Cartography (IKA) at the ETH Zurich was founded by Professor Imhof in 1925 (Hurni et al. 2000a). The diverse activities of the institute reflect the changing history of cartography in the last century. In two atlas projects, «Atlas of Switzerland» and «Swiss World Atlas», Professors Imhof and Spiess significantly contributed towards a comprehensive cartographic system of theories and to high standards of Swiss cartography. The following two examples will highlight the emphasis of current research at the institute.

4.2 Multimedia Cartography, using the example of «Atlas of Switzerland – Interactive»

After the Second World War, thematic cartography experienced an upturn. In 1941, Imhof suggested the creation of a Swiss National Atlas as a thematic counterpart to national maps, which at that time was certainly a welcome means of strengthening identity (Imhof 1941). However, the «Atlas of Switzerland» project could only be started in 1961. It leaned upon a HumboldTian regional studies approach propagated by Salicev and Lehmann (Salicev 1960). Owing to the rise of new topics, data, media and opportunities for description and also to the changed demands of (visual) habits and needs of the targeted audience, a new dual concept was formulated for the «Atlas of Switzerland» in 1995 (Sieber & Bär 1996). A modular structure, arranged according to main and sub-topics, allows for constant vertical extension; and it makes possible the thematic-horizontal, and absorption of topical contents (Figures 2 and 3). The multimedia edition of the «Atlas of Switzerland» appeals to both personal and public scientific interests, and through its multilingualism the potential user circles are not lim-

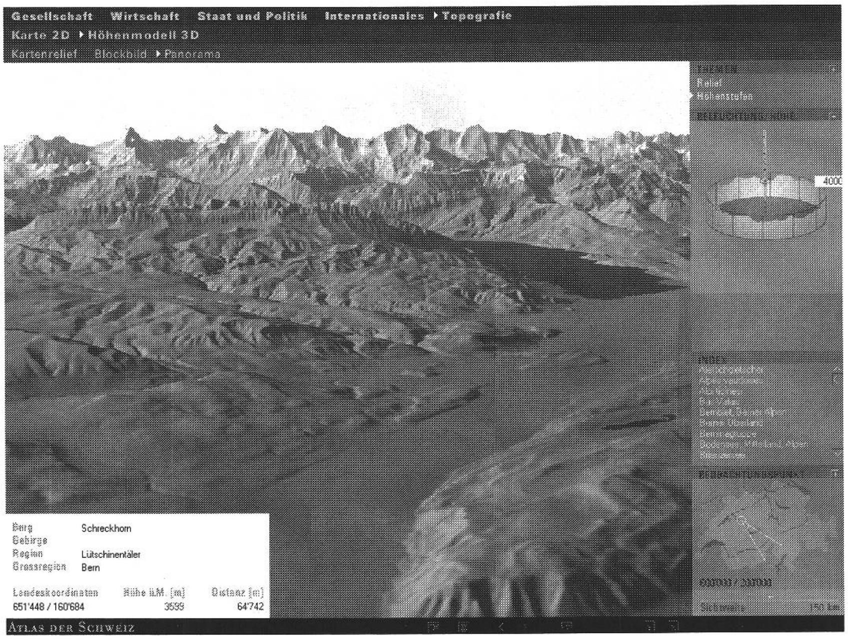

Fig. 3: Depiction of a panorama of the Bernese Alps in the «Atlas of Switzerland – Interactive».
Panoramadarstellung der Berner Alpen im «Atlas der Schweiz – interaktiv».
Présentation d'un panorama des Alpes Bernoises dans l'«Atlas de la Suisse – interactif».
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ited to Switzerland alone (www.atlasofswitzerland.ch). The publication of the first multimedia version of the «Atlas of Switzerland – Interactive» occurred in early 2000 (HURNI et al. 2000b). An extended version, emphasising «Nature and Environment», has been planned for the first half of 2004.

4.3 GEOWARN Project

How can one assess whether a dormant volcano can awaken and become a danger to its surroundings? In each case any public warning must be well thought through and must include far-reaching measures. The three-year EU project GEOWARN (www.geowarn.org), initiated in 1999, deals with these questions in which the dormant, yet geodynamically active Nisyros Volcano, south of the island of Kos in the Aegean, is observed with the most modern surveillance methods. Between 1996 and 1998, many small earthquakes occurred, which lead to the conclusion that magma was rising up from the depths inside. The Nisyros Volcano is surveyed with a complete set of measuring devices, such as GPS-supported measurements of movements on the ground, radar interferometry (ERS satellites), high resolution satellite images (IKONOS), thermal sensors (LANDSAT, ground supported measurements), seismic, gravimetric and magnetic measurements, geochemical analyses and measurements of the temperature of fumarole gases and thermal springs, and also heat flow and CO_2 measurements. These singular parameters will be combined in a general statement. Currently, the plan is to bring the different data together in a conventional geographic information system. In this way, it will be possible to recognise correlations between surface movements and an increased transfer of heat. In a second phase, carefully chosen and partially pre-interpreted data will be transferred to a multimedia information system. By means of a user-friendly questioning and presentation technology, the data will be made available via Internet at all times (Figure 4). By means of the data sets, hazard maps can be drawn up, which will serve as the foundation for basic risk analysis.

4.4 The Department of Geography at the University of Zurich (GIUZ)

The GIUZ – as do many other geography departments – considers a basic education in cartography obligatory. Favoured by its close proximity to the IKA-ETHZ and its well-developed programmes, geography students frequently choose cartography as a minor subject. The editing and production of cartographic products, however, are not emphasised at the GIUZ, yet cartographic products for research purposes have been and still are developed «in house». Some examples are the «Structural Atlas of Switzerland» (SCHULER et al. 1985), which was completely developed by automation at an early date; the «Satellite Map of Switzerland», which can be obtained at the Federal Office

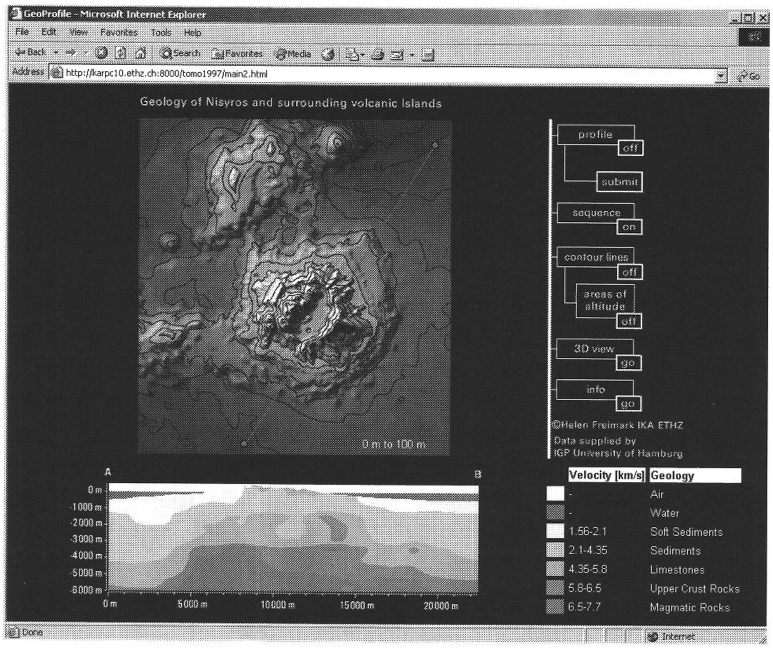

Fig. 4: Web visualisation of seismic tomographic data in the GEOWARN project: along the individually specified route, velocity profiles of underground material are drawn up and visualised from a three-dimensional data set.
Web-Visualisierung von seismischen Tomographiedaten im Projekt GEOWARN: Entlang der individuell wählbaren Strecke werden aus einem dreidimensionalen Datensatz Geschwindigkeitsprofile des Untergrundmaterials erstellt und visualisiert.
Visualisation sur le web de données de tomographie sismique dans le cadre du projet GEOWARN: le long d'un segment déterminé par l'utilisateur, sont établis et visualisés des profils de vitesse du matériel souterrain, à partir d'un ensemble de données tridimensionnelles.
Source: Freimark 2002; Tomographic Data: University of Hamburg

of National Topography (Bigler et al. 1997); and the «Atlas of Political Landscapes in Switzerland» to appear in autumn of 2003 (for its basic methodical principles, see Hermann & Leuthold 2001, 2002). Aside from the methods of interactive, photo-realistic landscape visualisation (Hirtz et al. 1999; Hoffmann et al. 2001), new visualisation forms are being researched, which present world philosophies through a combination of multivariate statistics and methods of thematic cartography in an unusual but comprehensible way both for experts and lay persons (see Figure 5). Two current projects will be described in closer detail.

4.5 AGENT: Multi-agent systems and cartographic generalisations

The automation of cartographic generalisation is a problem that has been intensively researched for many years. In the context of digital cartographic systems, GIS and digital spatial databases, it is imperative to have functionality at one's disposal in this area in order to flexibly generate an adequate cartographic output. In the EU project AGENT (http://agent.ign.fr), the development of a prototype for the automated generalisation of topographic maps was pursued, using innovative computer methods (Lamy et al. 1999; Barrault et al. 2001). The main goals of the project, completed at the end of 2000 were: the development of new generalisation algorithms, adapted for the specific demands of topographic maps; and the co-ordinated use of these processes in a multi-agent system (MAS). The map elements (buildings, street sections) were modelled as agents, which on the one hand pursue individual goals (e.g. preservation of minimum size, avoiding the fine line creases), but on the other hand also attempt to reach collective goals (e.g. avoiding the overlapping of map objects by means of displacement, preservation of object density across the map). The group in the GIS division at the GIUZ, within the project as a whole, concentrated mainly on the generalisation of street networks and problems of the displacement of street networks. For the displacement of cartographic objects, very good results were obtained by making use of energy minimisation in the same way it is used *inter alia* in the engineering sciences. Here, street sections or connections between buildings are modelled as so-called elastic beams, which are displaced by the displacement energy in such a way as to retain the

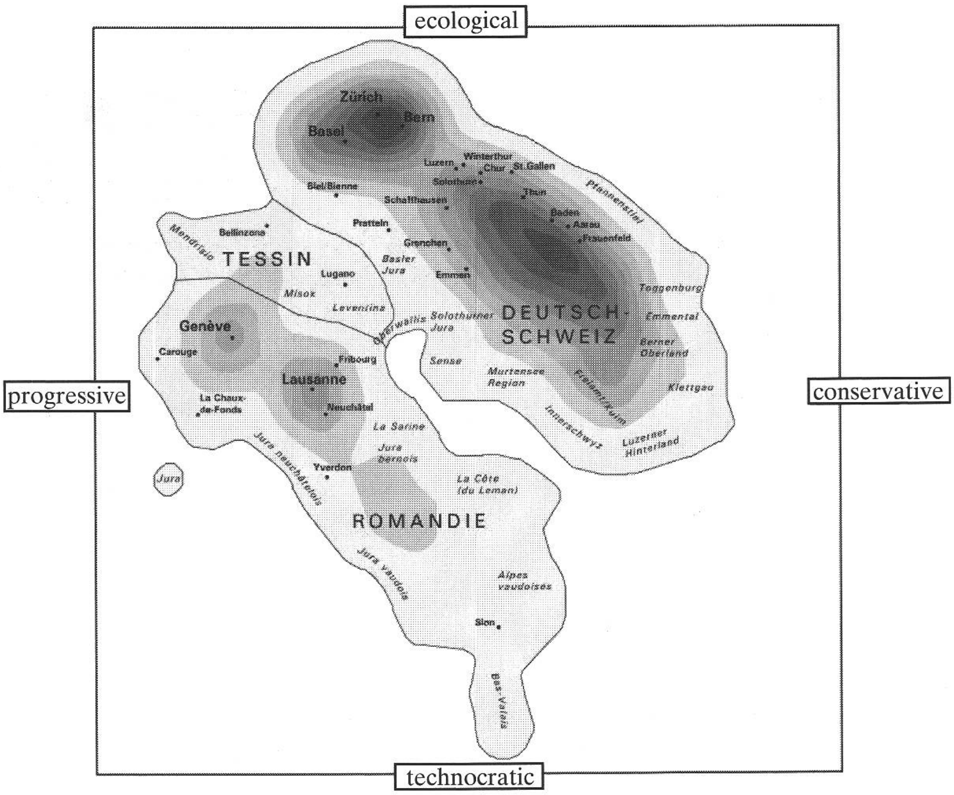

Fig. 5: Map of the political landscape of Switzerland (excerpt) shows the differences in political mentality between the three large language regions, through an explorative multivariate analysis of the Federal referenda between the years 1981 and 2001.
Die Karte der politischen Landschaft der Schweiz (Ausschnitt) zeigt die politischen Mentalitätsunterschiede zwischen den drei grossen Sprachregionen durch eine explorative multivariate Auswertung von eidgenössischen Volksabstimmungen der Jahre 1981-2001.
La cartographie du paysage politique suisse (extrait) montre les différences de mentalité politique entre les grandes régions linguistiques suisses. Catte carte a été créée en utilisant une analyse, à variables multiples, des votations populaires confédérales de 1981 à 2001.
Source: HERMANN & LEUTHOLD (2003)

shape of the object and resolving on the whole the displacement (BADER 2001). The prototype system developed on the basis of LAMPS2 was integrated into commercial software by the Laser-Scan Company following the end of the project and is already being put to productive use by various surveying administration authorities (*inter alia* France, Denmark, Belgium and Germany). Figure 6 shows an example of production at IGN.

4.6 Web Park: location based services for national parks

In the EU project, WebPark (http://www.webpark services.info), the construction of a platform for imparting location-based services (LBS) in resorts and nature conservation areas has been pursued since the end of 2001. The Swiss National Park and the GIS department of the GIUZ are the Swiss representatives in this project. The term LBS denotes location-based, personalised services, which are tailored to the individual needs of tourists and park visitors. As a result, the user receives direct access with his/her mobile device to the information in various databases and on the Internet, whereby the data are filtered and prepared according to time relevance, personal user profiles and current location. As the chosen information has spatial relevance in most cases, the information is presented on maps, and further explanations make use of text, images, sound and video. The group at the GIUZ has been entrusted with the development of the cartographic display functions, whereby the generalisation functions are given considerable significance due to the limited dissolution and size of the displays of the mobile devices. A concept worked on in an earlier project serves as the foundation of the current project and it combines databases with several scales with real time generalisation procedures (CECCONI et al. 2002). In the summer of 2002, a «rapid prototype» test system

Fig. 6: An example of the generalisation of line elements in BDCarto® of the IGN France from its production system based on AGENT technology. The scale for all diagrams is 1:100 000.
Explanation: a) The excerpt from BDCarto® (originally at the scale of 1:50 000) with line widths for 1:100 000 shows various problems of legibility, which must be solved by generalisation. b) Result after automatic generalisation of the roads (without other object classes) using AGENT, and the entirely automatic object displacement between roads, and between roads and railways respectively, using the elastic beam method.
Ein Beispiel der Generalisierung von Linienelementen der BDCarto® des IGN France aus deren Produktionssystem auf AGENT-Basis. Der Massstab für alle Abbildungen ist 1:100 000.
Un exemple de la généralisation des éléments linéaires de la BDCarto® de l'IGN France dans le système de production basé sur la technologie AGENT. L'échelle, pour l'ensemble des figures, est de 1:100 000.

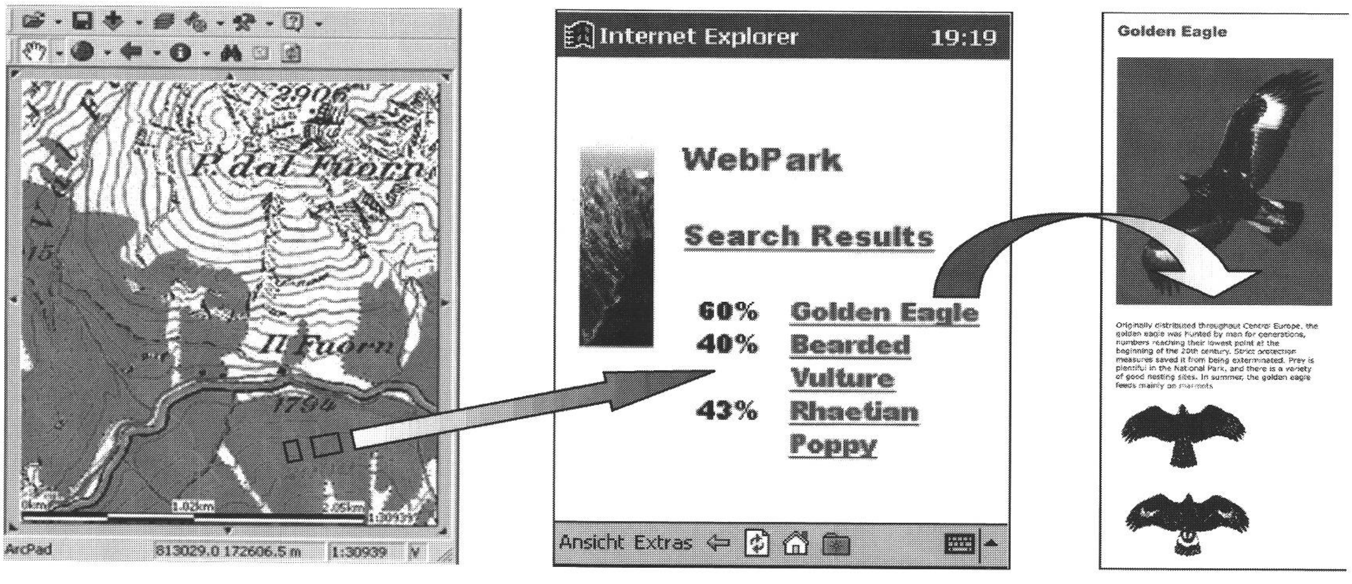

Fig. 7: Use of ArcPad-Software, produced by the ESRI Company, for a rapid prototype for the illustration of LBS during a user questionnaire in the Swiss National Park in the summer of 2002 (for details see Burghardt et al. 2003).
Nutzung der ArcPad-Software der Firma ESRI für einen Rapid Prototype zur Veranschaulichung von LBS während einer Anwenderbefragung im Schweizer Nationalpark im Sommer 2002. (Details siehe Burghardt *et al. 2003).*
Utilisation du logiciel ArcPad de la société ESRI dans le cadre d'un «Rapid Protoype», en vue d'illustrer le concept LBS durant une enquête d'utilisateurs dans le Parc National Suisse pendant l'été 2002. (Détails: voir Burghardt *et al. 2003).*

based on an existing commercial product, was implemented in order to receive early feedback from users and to illustrate its planned functionality (Figure 7).

5 Conclusion

Cartography, and especially cartography in Switzerland, has experienced in the last few years the most far-reaching changes in its history, with regard to content, technology and economics. Conventional production techniques have been superseded by completely digital work-flows. Besides static paper maps, a wide palette of interactive offline- and online-applications exist today, providing users with greater analytical and structural freedom. The task of those who produce maps has been expanded so that, aside from the wide-ranging contents, the visualisation rules and the possible analysis results have to be editorially anticipated and worked through. Most importantly, nonsensical queries should be prevented and the adherence to cartographic rules should be guaranteed (SCHNEIDER 2002). More than ever, however, in this exciting phase, groundwork in cartographic research is required. The symbiosis between research and practice continues to remain a guarantee for successful cartographic products, and especially for the high standard of cartography in Switzerland.

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