Neue Landeskarte der Schweiz

Erfahrungen bei der Realisierung eines GIS-basierten Kartografischen Produktionssystems bei der swisstopo

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ABSTRACT

A new cartographic production system is being developed at the Federal Office of Topography in Switzerland (swisstopo). This new system consists of a cartographic database and interactive editing system (called Genius-DB) and a generalization system (called SysDab, built by a non-ESRI third party). Genius-DB is being built by ESRI Switzerland based on ESRI ArcGIS 9.2/9.3, a commercial off the shelf GIS software platform. Genius-DB is one of the first applications to make use of the cartographic representations technology that is new since ArcGIS 9.2. This paper is based on Eicher et al., 2007 and presents some background on this project, explains the driving forces behind upgrading the current system, and describes some selected theory important to the overall architecture of the system [1]. The bulk of the paper explores some major technical themes in the project: the development of GIS data and representation models, designing overall workflows and data flows, and the optimization of the cartographic editing user experience.

1 INTRODUCTION

Advances in the cartographic capabilities of commercial GIS packages are ushering in an exciting period of change for all types of mapping agencies (e.g. national civilian or military). GIS has been traditionally strong for capturing, maintaining, analyzing, and supporting the display of vector geographic data. Currently, further improvements are being seen in GIS software that allow for high quality representation of vector data. Such symbolization facilities enable even mapping agencies with challenging symbolization specifications to realize the production of map products and digital data within a single system based on a commercial GIS software platform. Additionally, GIS software now includes capabilities to model cartographic information together with vector geographic data in commercial relational database management systems. These new technologies are making it easier to build complete GIS-based cartographic production systems based on a landscape data model-cartographic data model approach. swisstopo, together with ESRI Switzerland, are developing such a cartographic data and map production system based on ESRI ArcGIS 9.2/9.3. This paper describes some of the technical challenges, and their solutions, encountered in this work.

2 GENIUS-DB PROJECT OVERVIEW AND STATUS

2.1 swisstopo

The Federal Office of Topography (swisstopo) is the Swiss Confederation's national agency responsible for geographic reference data and maps. swisstopo creates and maintains geodetic, topographic and geological data for the whole of Switzerland, publishes the national (civilian and military) map series at a variety of scales, and keeps these data and maps up to date. swisstopo's national map carries with it a rich history of measurement and cartography and enjoys highest international recognition [7].

2.2 ESRI

Environmental Systems Research Institute Inc. (ESRI) is the world's leading GIS software and services company, employing over four thousand employees and serving over one million customers worldwide.

ESRI Geoinformatik AG (Switzerland), a wholly owned entity of ESRI Geoinformatik GmbH (Germany), is the official distributor for ESRI software and provides consulting, training, support and development services to ESRI customers.

2.3 Project context

Broad change is being carried out within swisstopo as they wholly update their internal processes for producing topographic data as well as maps. As part of this, they are transitioning away from a sheet-based map production system where maps are produced first, and then data is derived from the maps (Fig. 1).

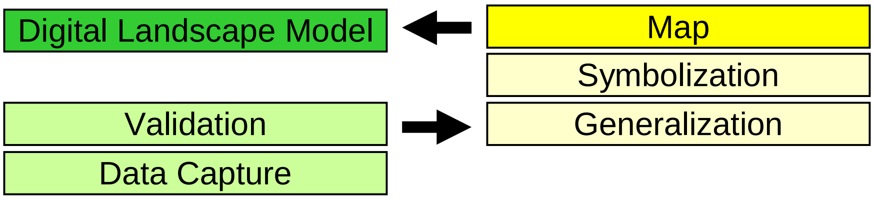

Figure 1 – Traditional map production workflow at swisstopo

In the new production workflow (Fig. 2) digital landscape data is seamless across Switzerland (and necessary portions of neighboring countries). Advantages of the new workflow include: better positional accuracy of this data, a faster update process, and a more versatile and flexible data model.

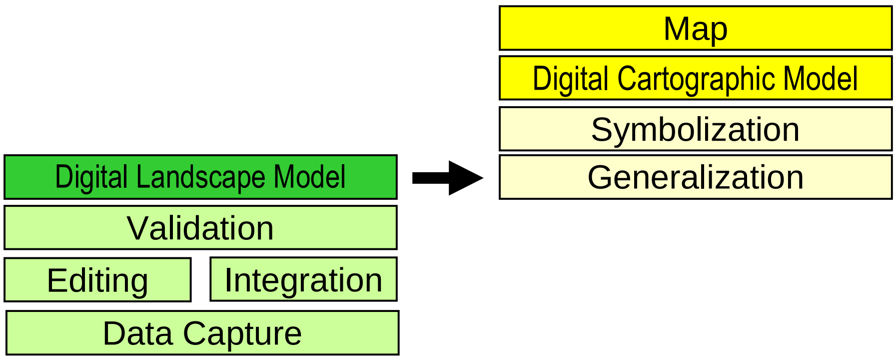

Figure 2 – New map production workflow at swisstopo

While detailed aspects of the new workflow are described in [6], a key concept explored in this paper is the separation of landscape data from cartographic data. The basic idea is that data are captured from the landscape at a very high resolution and stored in a topographic landscape model (TLM). Then, through generalization, a digital cartographic model (DCM) is derived from the TLM. Section 4 of this paper covers this in greater detail.

2.4 Projects TOPGIS, OPTINA-LK and Genius-DB

Figure 3 shows how the above mentioned changes are divided into two major projects at swisstopo: TOPGIS and OPTINA-LK. The Genius-DB system forms the majority of the new cartographic production environment being part of OPTINA-LK, and it is the focus of this paper.

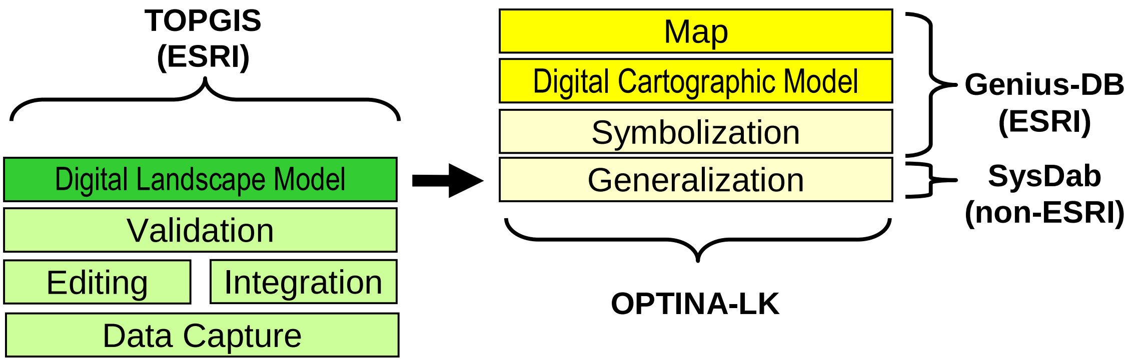

Figure 3 – Projects at swisstopo

TOPGIS creates a high performance infrastructure for capturing and managing topographic landscape model (TLM) data. TOPGIS is built by ESRI Switzerland and partners, and it is based on ESRI ArcGIS 9.2.

OPTINA-LK is the project for realizing the new cartographic data production and is executed in parallel with TOPGIS. This project has several subprojects and includes the Genius-DB system, which is the ArcGIS-based data storage and map production system, and a cartographic generalization system (SysDab, being developed from a third party). The TOPGIS TLM is the input data for cartographic production in the cartographic production environment.

2.5 Genius-DB project motivations and schedule

One important motivation for the new cartographic production environment is to shorten the time frame between data collection and finished map product (reduced from up to two years to as few as six months). An additional motivation for Genius-DB is to leverage the strength of GIS for creating, editing, and managing data. In particular, a production system based on vector GIS data and relational database technology creates a much more efficient process for handling future changes (previous systems relied more on raster data editing). So-called incremental updates, triggered by real change on the landscape, are better handled in such systems.

In Genius-DB, one concern for swisstopo is to avoid any slippage in quality in the appearance of their printed maps and digital map products. The cartographic representations functionality in ArcGIS is the key to maintaining this high quality standard [2, 5].

For the Genius-DB project, ESRI Switzerland is the main contractor to swisstopo, partnering with Swiss companies GEOCOM and INSER. The project was on tender in August 2005. Work began at ESRI in June 2006. System specification is complete. The project is currently in the acceptance phase of the already developed prototype based on ArcGIS 9.2. The next step is a pilot phase, after which the system, then based on ArcGIS 9.3 enters full-scale production in 2009.

3 PROJECT THEME I: DATA MODELLING

3.1 Data and representation models

Digital cartographic models (DCMs) are central components to the Genius-DB system. These models describe how swisstopo's geographic data (core GIS data) and cartographic data (map signatures and cartographic attributes) are managed in the system. For Genius-DB, a DCM is divided into a data model and a representation model to store these two sets of information. Multiple data and representation models are defined and built, and these models are later manifested as physical geodatabase schemas which store data in the working system.

A DCM data model defines the core geodatabase schema for vector geographic information for a given map scale. Specific swisstopo examples are seen in Figure 4 where DCM25 corresponds to map scale 1:25,000, DCM50 to map scale 1:50,000, and so forth.

A representation model defines the schema necessary to store signature information for a particular map product. A representation model is attached to a DCM data model. As an example, for the DCM25 data model, two representation models could be defined: one for the Swiss national (topographic) map product, and another for a hiking map.

3.2 Modeling in Genius-DB

3.2.1 Modeling goals

Some specific goals for Genius-DB to be achieved through well modeled geographic data and representations are: High quality signatures via automated cartography with cartographic representations, best handling of incremental updates and productive manual editing.

3.2.2 Data models

Work began with the design of core data models for 1:25,000 and 1:300,000 map products Guidelines recommended by ESRI for cartographic geodatabase data modeling were followed [3]. Genius-DB data models were developed using ESRI UML CASE tools in Visio. These tools allow design (and redesign) of ESRI geodatabase schema using UML which can then be automatically converted to a real geodatabase schema. These tools were well suited to the iterative process of co-designing the data model between consultant and customer.

3.2.3 Representation models

Next, representation models for Swiss national map scales 1:25,000 and 1:300,000 were built. Main inputs were the data models mentioned above and swisstopo's symbol specifications.

Representation models were developed using a half-manual, half-automated process. To design each representation model, ESRI consultants manually built an initial representation schema by defining swisstopo's symbols as ArcGIS representation rules. This work was performed using test data to validate the result. An initial design included a representation rule for each unique symbol. Later designs took advantage of the override concept to reduce the number of representation rules managed in the system.

After initial creation of the representation model, swisstopo cartographers made manual refinements. These were passed back to ESRI where custom "harvesting" tools extracted and saved the updated representation schema to be re-applied to a different geodatabase.

3.3 Insight

3.3.1 Specificity of representation model to map product

At swisstopo a representation model is specific to a particular map product; however data models can be defined for a particular map scale which can support multiple products. Thus multiple map products can be supported at swisstopo from a single set of DCM data models. This is the case because the additional swisstopo thematic products are quite similar to the national map product (most layers are shared, and most of the signatures are similar).

3.3.2 Iterative design process for data and representation models

The best process for designing data and representation models at swisstopo was iterative. This was especially true for Genius-DB representation models. It is also important for the process to balance flexibility (e.g. allowing swisstopo cartographers to manually work on a template geodatabase to change the models) with the ability to automate (e.g. use of UML and custom harvesting tools).

4 PROJECT THEME II: DATA FLOWS AND WORKFLOWS

4.1 Data flows

4.1.1 Topographic Landscape Model (TLM)

As introduced previously, input data for Genius-DB are stored in a very accurate and 3D topographic landscape model (TLM). From the TLM several digital cartographic models are derived. Many federal offices will reference their thematic data to the features managed and updated in the TLM.

4.1.2 Digital Cartographic Model (DCM)

Cartographic data, specific to a particular map scale range are next derived from the TLM and stored in multiple digital cartographic models (DCMs). The process to produce DCMs from a TLM involves both model and cartographic generalization. Relationship links are maintained between DCM and TLM features.

4.1.3 From capture to print

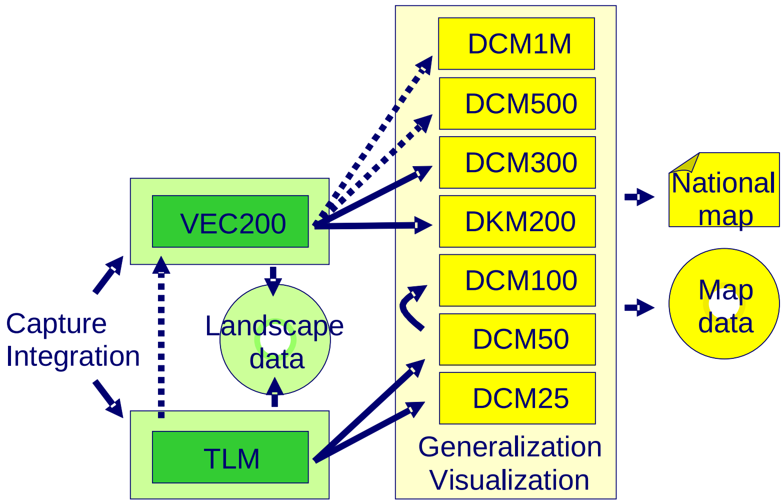

Figure 4 – System data flow from capture to print

Figure 4 shows the data flow from capture to print[1].

[1] Currently at swisstopo, a separate 1:200,000 landscape model is maintained for small scale maps. However future plans are to derive the 1:200,000 landscape model from the base TLM.

ESRI ArcGIS technology is the platform for both the TOPGIS TLM data capture and storage system, and the Genius-DB database and interactive editing system. Model generalization is handled by the ArcGIS Data Interoperability extension, and cartographic generalization is handled by SysDab, a separate software system built by a third party.

4.2 Workflow

4.2.1 Simplified steps

As part of the Genius-DB system specification project phase, a detailed set of software use cases were developed and organized into flow diagrams. Table 1 lists a simplified set of work steps in the system. Incremental update is handled with a slightly different process.

1. Create local geodatabase (schema only)	5. Integrate data into seamless geodatabase
2. Load generalized data for work unit (usually equivalent to a map sheet)	6. Edit features near map sheet edge (e.g. connect overlapping features)
3. Perform editing in local geodatabase	7. Run final quality checks
4. Run initial data quality checks	8. Publish new seamless dataset/ map sheet

Table 1 – System work steps

4.2.2 User roles and job tracking

Work is divided amongst several user types, for example production planning is performed by a “planner” user role and data editing by the “cartographer” user. Roles are defined and configured in the Genius-DB system data dictionary, and job tracking is handled through a combination of custom application logic and standard ESRI software. In particular, custom Genius-DB functions allow the operator to navigate through work steps (e.g. create new work unit, open/close work unit), and these functions integrate with standard functionality provided by the Job Tracking for ArcGIS (JTX) extension. User roles are also integrated between Genius-DB and JTX.

4.3 Insight

The definition of use cases during the system specification project phase was a powerful way to synthesize more detailed user requirements. These use cases later served as input to the detailed software design and system testing. Connecting use cases together in flow diagrams helped both customer and consultant validate the system architecture and workflow.

5 PROJECT THEME III: EDITING PRODUCTIVITY

5.1 Improved editing

An important goal for Genius-DB is to improve cartographers' manual editing efficiency. A large portion of map finishing tasks are automated using standard geodatabase and desktop ArcGIS functionality as well as custom developed tools and functions. Examples include geoprocessing tools to automatically calculate line-end symbology for cul-de-sac features, and the Maplex for ArcGIS extension to automate text placement. Still, given the high density of data, and the high cartographic standard for the Swiss national map, a large amount of the vector data will be "touched" by swisstopo cartographers. Building tools to make this work most efficiently is one of the primary goals of the project.

5.2 Editing environment and tools for cartographers

The ESRI ArcMap data editing environment is an excellent platform for vector data editing. ArcGIS adds to the set of existing vector editing tools by introducing a new set of cartographic editing tools specifically designed to update cartographic representations. These tools are designed with cartographic editing tasks in mind. For example, one can "move parallel" portions of an existing line segment (a common manual generalization task). Another advantage of using ESRI ArcMap as the data editing platform for Genius-DB is that the Genius-DB application developers can access ArcGIS functionality via ArcObjects. This allows developers to integrate the custom tools and framework of Genius-DB with ArcMap's standard editing tools and framework.

5.3 Insight

5.3.1 The cartographer's eye and hand

During the system specification project phase much was learned about what swisstopo cartographers desired for editing functionality.

On screen "feedback" is very important for swisstopo's cartographers while editing. Feedback here means the visual indication given which (hopefully!) clarifies the operation being performed. When performing a cartographic edit, feedback is usually some kind of graphic indicating the past, present, or future data situation. For example, while moving a marker symbol that represents a geologic measurement point, feedback may show the old location and the current location (which becomes the new location when the "move" operation is complete).

Even though map production at swisstopo has been performed in a digital system for quite some time, it is clear that cartographers still need to be able to use their eye and hand to do their work. By having edit feedback that is accurate (e.g. line feedback that shows the symbolized line width), but not too confusing (e.g. cluttering the display with too much information), swisstopo has a system that can best leverage capabilities of their expert cartographers. Such feedback might be WYSIWYG (what you see is what you get), or it could exaggerate or emphasize information pertinent to the particular user task. In particular, one might see data errors highlighted, or to see the extent of inks in the eventual print output.

5.3.2 Data modeling for efficient editing

The structure of data in the system, both core data and database-stored representation information, greatly influences the productivity of editors. Since the system is being designed mainly to support efficient and accurate editing of vector data and symbology, it makes sense that the models properly support this. As a result, the project made a big investment to collect detailed editing requirements directly from swisstopo cartographers. The support for feature-specific editing overrides in ArcGIS allowed Genius-DB data and representation models to be fine tuned to the cartographers' needs [4].

6 CONCLUSIONS

An examination of some of the project processes for the swisstopo and ESRI Switzerland Genius-DB project offers useful insight on the design of a modern, sophisticated map production system based on commercial GIS software. By looking at how data and representation models are designed for the system, one sees a real world example of cartographic modeling theory put into action. Further, by looking at data and workflows in such a system, one gains a better understanding of the possibilities for data organization and system architecture, as well as the role of different users in a map production system. Finally, the importance of end user productivity is highlighted by the need for swisstopo's cartographers to manifest their wishes on screen (and eventually on to the paper map), making use of their training and natural talent, and augmented by well-designed cartographic data editing tools. Together, all components join to create a cutting-edge system that supports swisstopo's desire to remain at the highest position in the world of geographic data and map production.

7 REFERENCES

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