CO-353

AUTOMATING THE MAP PRODUCTION AND UPDATING PROCESS - RESULTS FROM THE FIELD

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BACKGROUND AND OBJECTIVES

In the past few years the German authorities have begun the process of producing topographic maps using the AAA© data model and the NAS interface standard. They are subject to substantial time constraints for map production and updating that have created challenges when using conventional production techniques. In 2010, the first fully automated process for producing and updating maps using specifications by the German authorities, which include automated generalization, automated incremental updating and automated map labelling, was made available in *axpand*. This paper sets out to show how this automated map production process was designed and what effect it has on the efficiency of the creation and updating of topographic map products.

APPROACH AND METHODS

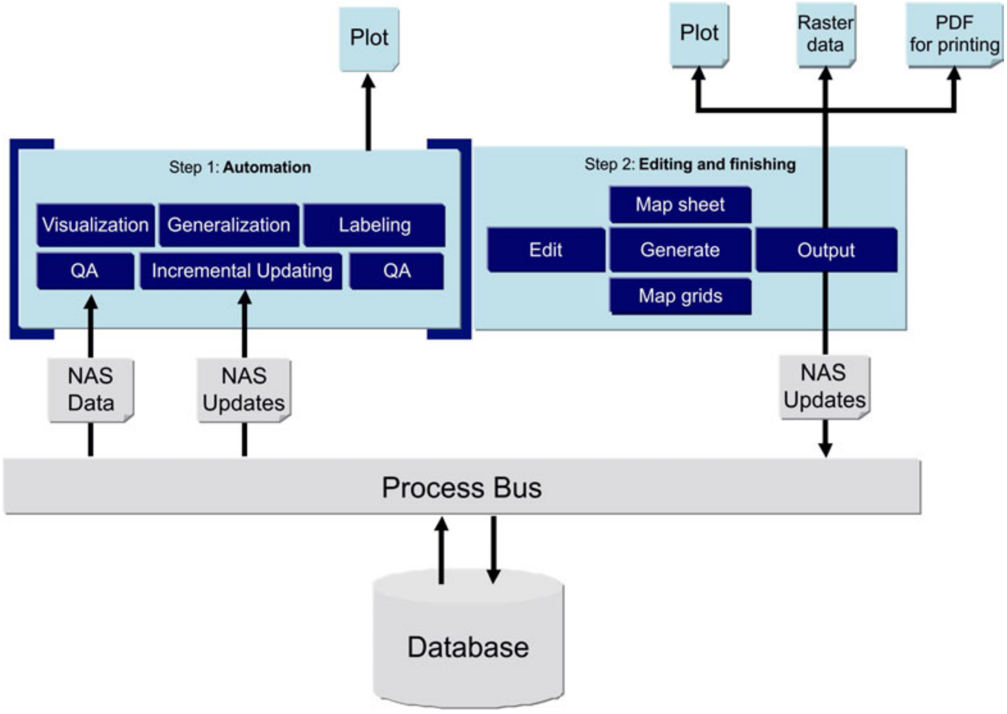
In response to a call from data users for more up-to-date data, the German AdV (Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany) has introduced new requirements for timeliness of geo-data. The previous 5-year cycle was no longer satisfactory to data users in the face of rapid changes on the earth's surface. To refine this requirement, the German authorities provided a list of objects and attributes for the DLM (digitial landscape model) that were expected to be cyclically updated according to a new set of rules. The time-frame for these updating cycles included the time between an actual change on the earth and the integration of that change into the base data as well as the topographic maps that are derived from the DLM. Contrary to the previous cyclical updating that was the complete substitution of all existing data in a data set and was undertaken over several years, the new rules included the continuous updating of specific objects and attributes. These specific objects and attributes are to be updated within very short time frames. The new requirements for updating can be referred to as 'continuous updating'. (Gericke, Katzur)

The original list of objects and attributes defined by the Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany (AdV) for continuous updating included the integration of changes in federal highways, national, state and city roads including tunnels and bridges within three months. Within six months airports and their geographic names, take off and landing areas with their names and functions, rest areas on highways with their geographic names, etc. need to be updated. A third group of objects and attributes are to be integrated every 12 months.

The first challenge for the German states was to put methods in place that would ensure the capture of this new data. The second, more complex challenge was to ensure that the changes flowed through to the appropriate topographical map products. To ensure standardization across the country, a new data model - the AAA© - was introduced and an agreement was put in place for a new data input and output interface format, namely the GML-based NAS standard. A new signature catalogue for each of the 1:10K, 1.25K, 1:50K and 1:100K scales was introduced. These signatures are recorded in the AdV's 'GeoInfoDok' which at the time of this writing is at version 6.01.

The initial step in creating an automated process to expediate updating of these map scales using the new interface, model and signature catalogue, was to fully understand the requirements of the new rules for map production and updating set out by the German authorities. Axes Systems set out to analyze and build the AAA model and the signatures that corresponded to the map scales mentioned above using the signature catalogue as it appeared in GeoInfoDok, a document officially recognized by the AdV. Once this had been completed, the next step was to build a process that included both automatic and manual steps. The process in *axpand* was to include creating a fluent interface to any external system that was holding the base data. In the case of Germany, this was the NAS standard. Once the NAS data was in the system, it was to be automatically visualized, move through automatic model and cartographic generalization and automatic text placement. The automation was configured to apply specifically to each individual map scale. The most challenging part of building the automated process was to understand how to carry out automated generalization based on data that was imported over the NAS interface and held in a AAA© model and to satisfy the requirements for generalization. Later, and most importantly for timeliness, the updating process was to be automated.

The production process in *axpand* is divided into two main steps. Step one is automatic and step two is mostly interactive. The following graphic shows how this works for the German-specific topographic maps that are produced using data from the digital landscape model or DLM.



The automated generalization process in step one in *axpand* mimics the steps that a cartographer would employ during manual model and cartographic generalization. Hence, the cartographer's input is critical at this point since the introduction of generalization rules to the system requires a 'translation' of the cartographer's manual tasks. This translation of tasks from manual to machine is managed through a set of constraints. Constraints can be understood as a set of rules that define how data is generalized and in which situations. Constraints are specific to map scales and need to be unambiguous. The constraints are defined with the view that once the constraints are met, no further manual work is required on the features that have been generalized. A sequence of generalization steps is created by using workflow logic which calls on groups of algorithms (operators) and the generalization rules or constraints for each map scale. This logic defines which generalization steps take place in which order.

Depending on the constraints, initial generalization steps, which are often referred to as model generalization, can include selection, which is a method used for semantic thinning, identification of isolated objects, simplification and scaling of lines and areas, aggregation and several different types of geometry-type change including area to line, line to point, etc.. Once these semantic changes have taken place, the system begins implementing cartographic generalization. This includes a series of actions, again based on scale-specific constraints and modelled to mimic the manual steps performed by the cartographer, which can include line and point displacement, area displacement, border adjustment, parallel adjustment of lines and placement of symbols, among others. Cartographic generalization, unlike model generalization, takes the sizes of map graphics and symbology styles into account. Topology is maintained through special detection techniques that are built into the algorithms and the workflow. Where conflicts cannot be resolved, the objects are flagged. As a final step, after the cartographic generalization and quality control of the results, text is automatically placed according to a set of rules. Since the automatic generalization in axpand shows up to 80% correct results, the interactive editing required is kept to a minimum of around 20% of the remaining objects. This is a second area where the cartographer's input remains critical.

Basically, the reason for automating any process is to aid the user of a system in reducing the volume of manual work and/or become more efficient and/or produce more products and/or increase the consistency of quality. The automated generalization process, because it produces up to 80% correct results, is obviously one area where high levels of efficiency can be obtained. The second, more important area is automatic updating. In order to enable authorities to maintain their updating cycles within tight timeframes, Axes Systems has built and tested a second critical automatic system process for updating. This includes maintaining a history of all changes over time in a multi-representation data base.

Automatic updating is a ground-breaking process that helps meet tight requirements for timeliness of data. In the German example, the updating process begins with the NAS interface. When data changes or changes have occurred on the earth's surface, they are introduced to the system using NAS. In *axpand* it is possible to use a 'relevance check' on import. This means that the system is configured to identify whether or not the changes that are being introduced to the system fulfill certain criteria and are, therefore, relevant to the product derived out of this data. The level of relevance can be configured by the user. Once an update has been identified as relevant, it then goes through a re-generalization. Because of the level of accuracy of the NAS data and the definition of updating in Germany, there was no need to include any steps in the process that would determine whether or not data that was being introduced to the system had been changed significantly enough to move through the (re)-generalization process. The assumption was that all new or changed data showed significant enough changes to merit re-generalization.

When new data is introduced to the system it is automatically re-generalized according to the generalization constraints. In order to prevent unnecessary re-generalization of neighboring objects, re-generalization is carried out in updating 'zones'. This means that only those objects that are within certain vicinity from the new object are included in the re-generalization. If the re-generalization of the nearest objects is significant enough to require re-generalization of objects that are slightly further away, the system will include a widening circle of zones until there is no necessity for additional re-generalization.

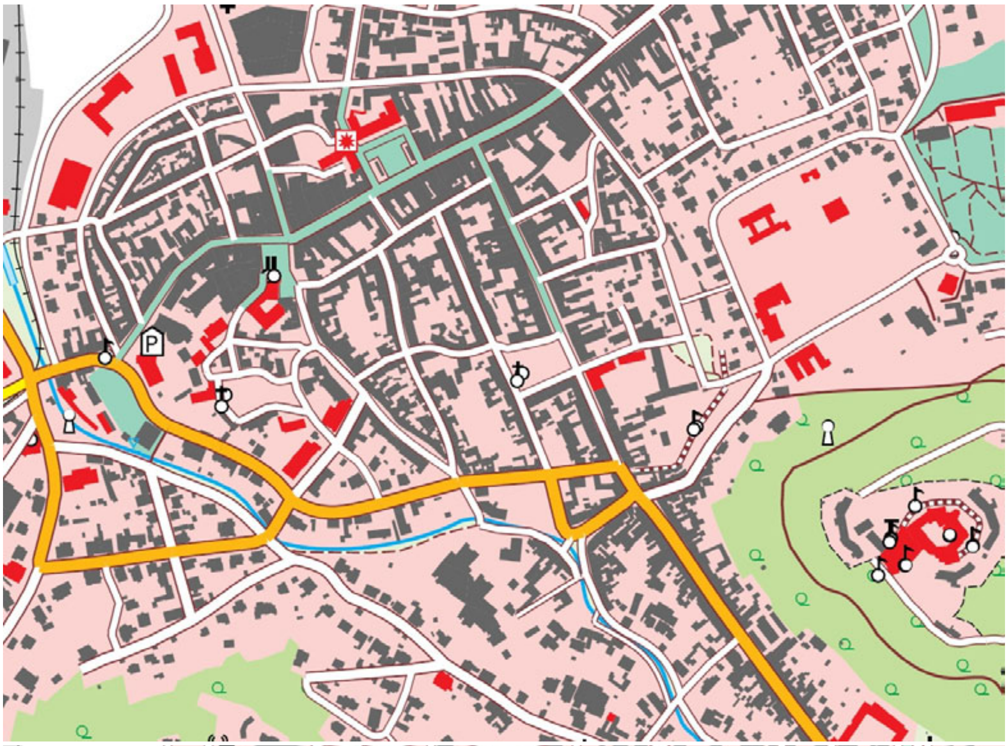
When modified objects are introduced as updates or when interactive editing has taken place, these objects are assigned a historical link to their previous states in a multi-representation data base. This makes it possible to re-trace any object at any point in time to its previous state(s). This is also true of objects that are modified during the generalization process through operations such as aggregation. IDs are maintained and/or replaced according to specifications. These modified objects undergo a relevance check for re-generalization. If the modifications are deemed relevant, then the objects will undergo re-generalization.

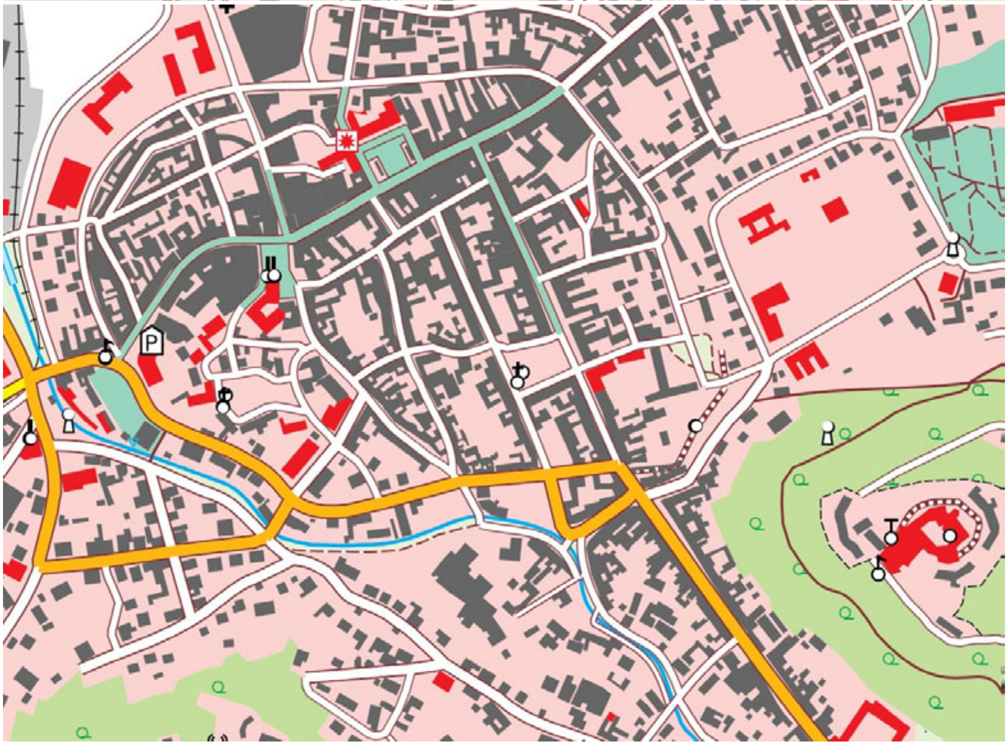
Step two in the production process includes creation of map sheets, automatically generating and labelling grids and configuring output formats. It also includes interactive editing to resolve the 20% remaining conflicts in the map objects. It is of particular importance that all modifications, including those that occur during manual editing, are maintained and given a history in the database. This eliminates the necessity of repeating actions and/or re-doing interactive editing on new updates.

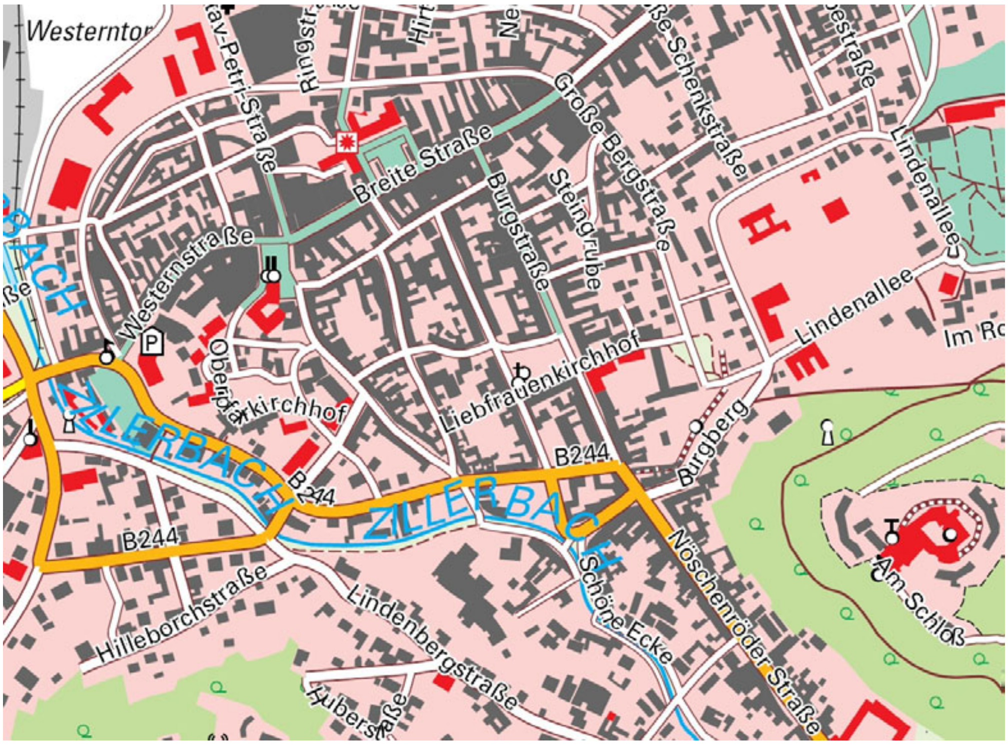
RESULTS

Once the AAA© model was built in *axpand*, the signatures for 1:10K, 1:25K and 1:50K implemented and an automatic generalization and updating process put in place for each scale, several tests were carried out. Initial tests produced results of slightly over 50% correct results after automation. After the appropriate adjustments were made to the generalization constraints and some operators were adjusted, additional tests produced up to 80% correct automation results according to the specifications of the constraints. Recurring tests showed that the generalization results were reproducible and remained consistant over time. Since the process is flexible and not 'hardwired' tests showed that it can be used with all models, scales and data sets.

The following graphics show an example of an ungeneralized 1:10K map, the same data generalized and then after automatic text placement. There was no interactive editing performed.







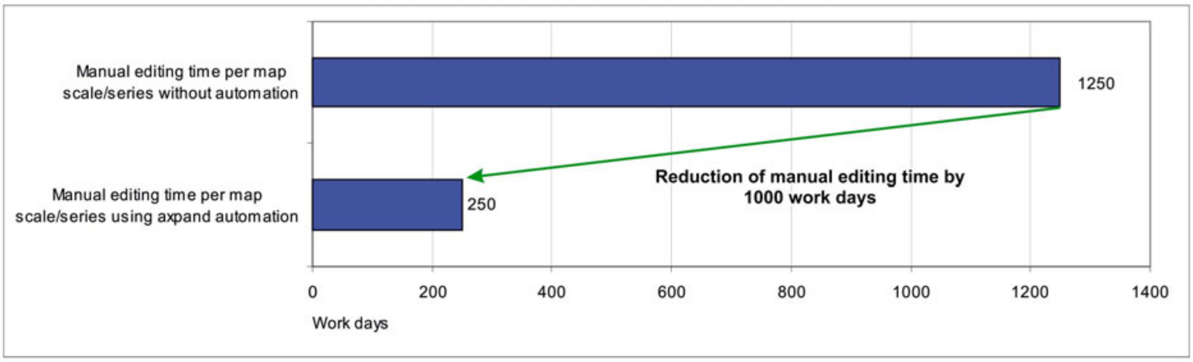
This level of automation correspondingly cut down the time necessary for manual tasks including cartographic editing and text placement. Using this method, the required updating cycles for German topographic maps can be easily met regardless of limited resources.

The following graphics show the difference in the amount of time required for manual editing for one map series without and with automation.

DTK Map Scale	**1:25'000**
Number of maps produced in this scale/series	200
Average number of objects on one map	30000
Percentage of objects that need to be edited/generalized by a user	20%
Average manual editing/generalization time per object in minutes	0.5

Manual editing time per map without automation	50	hours	6.25	days
Manual editing time per map scale/series without automation	10'000	hours	1'250	days

Percentage of objects that require manual editing after *expand* automation	**20%**



CONCLUSION AND FUTURE PLANS

In upcoming years, EU countries will be required to implement the INSPIRE requirements and to deliver geo-data in specific formats within defined time schedules. This will demand a level of process automation that will necessarily eliminate some of the production steps that are currently being managed manually. It will also require a timeliness that can only be achieved through the rigorous implementation of map and data production processes which integrate extraordinarily high levels of automation including automated model and cartographic generalization as well as automatic text placement. The standardization of data structures allows for a comprehensive re-design of the map production process and enables a new generation of automation, especially in the area of generalization.

REFERENCES

Die Realisierung der Spitzenaktualität durch den Topographischen Informationsdienst [The Implementation of Updating Cycles by the Topographic Information Service], Vermessung Brandenburg [State Survey Brandenburg], Gericke and Katzur, 2004.

LVermGeo Saxony-Anhalt, base data: NAS-Data according to ‚GeoInfoDok'-Version 6.0

Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland (AdV) [Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany (AdV)], ATKIS-Signaturenkatalog für die Digitale Topographische Karten [ATKIS Signature Catalog for Digital Topographic Maps]: http://www.adv-online.de/