

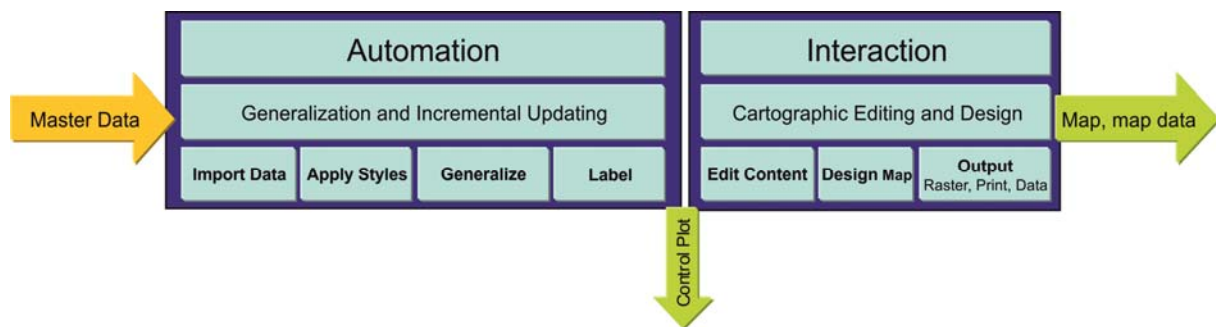
# Automatic Production and Updating of Topographic Maps - A Case Study Using the German AAA Data Model

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## 1. Motivation

In recent years there has been a lot of discussion about whether it is possible to automate the most critical, repetitive tasks in map production and updating. Some people question whether the automation of certain aspects of cartography makes sense. In times of rapid change and dwindling human and financial resources, the most important reasons for automation in map production are to ensure efficient, up-to-date and consistent production cycles without sacrificing on quality.

Automation always makes sense when it eliminates, reduces or sustainably speeds up inefficient manual work. In the case of cartography, this work is mainly repetitious production and updating tasks that are carried out with the aid of computers. The most common tasks that can be automated in cartography include applying relevant style sheets, generalization and text placement, all of which are critical for making maps readable. Automating the entire updating process, which has traditionally been extremely time-consuming, can greatly increase productivity and shorten updating cycles.



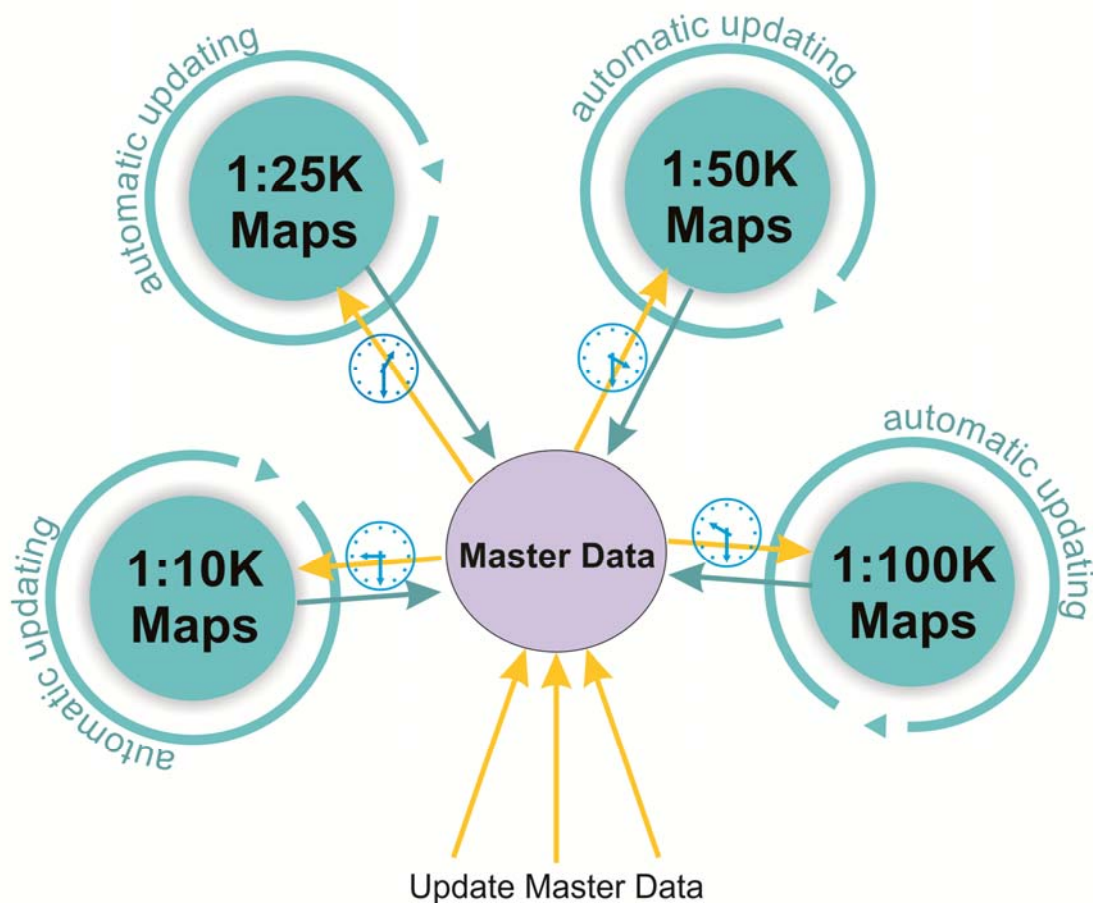
Next to text placement, generalization is the “core business” of cartography. This involves making maps readable in spite of limited space on the map. Important elements are emphasized and less important ones are eliminated. Generalization is an extremely complex process during which a multitude of contextual, geometric and topological rules need to be taken into account. For a long time, generalization was considered something that could not be automated. The challenge in automated generalization is to define contextual and geometric rules that can be read by a computer and implemented in an effective, automatic process. The operations that use these rules need to work precisely and in practically all cases take neighbouring map elements into consideration. (Käuferle et al)

The technology for a comprehensive automation of the production and update of maps, which is examined in this article was developed by the Swiss company Axes Systems AG and based on their core product "axpand", a database driven cartographic GIS. Axes Systems investigated in co-operation with the geographical Institute of the University of Zurich, the feasibility of various approaches of process-controlled generalization in the scope of two KTI/CTI research projects from 2004 to 2007, (Weibel, Burghardt, Petzold, Bobzien Neun, Mathur et al). The findings of these research co-operations led a new approach of automatic generalization and incremental updating as a product "axpand ng", designed and developed by Axes Systems.

Axes Systems has most recently configured axpand for the German land survey according to their AAA model and the style sheet regulations of the German Cadastral and Surveying Authorities. Configurations are available in axpand for the automatic production and updating of topographic maps in the scales of 1:10,000, 1:25,000, 1:50,000 and 1:100,000. These scales can be configured for any data set.

## ***2. Generalizing German AAA Data***

In the case of the production of maps using the German AAA model, the data for each scale is derived and updated directly from the master data (ATKIS©-Base-DLM digital landscape model, ALKIS©-Buildings as well as Relief- and Altitude information from the 'DGM' or digital elevation model). Map objects that have been generalized and updated are included in a post-process, automated updating process and the process of manual adjustment. The method of creating relationships between source and target data allows for the derivation of various scales solely from the updated master data.



*Illustration 2: Same master data source for all scales*

### **3. Automated Generalization**

Experience shows that although a large number of well-functioning algorithms are important, more important still is the logic of the sequence of these algorithms during generalization. Good automated generalization mirrors the order of the steps that are taken by a cartographer during manual generalization. In order to design the logic of automated generalization, the following need to be considered: 1) how does a map look at a certain scale after the data has been manually generalized? 2) Which steps does a cartographer take to obtain these results? 3) In what order are these steps carried out during manual generalization? These three questions determine the order of steps in an automated generalization workflow.

Alongside the logic in a generalization workflow, i.e. the order of generalization steps, the constraints or generalization rules are critical. These rules are determined by the map scale, the map theme (also known as the context of the map) and the density of the data. The constraints mirror the knowledge of the cartographer and are translated into logical, mathematical terms that can be read by the computer system. Generalization tasks such as displacement, aggregation, selection and enhancement are driven by the constraints that are

applied to each type of generalization step. The constraints aid in identifying potential conflicts, deciding which solution is most plausible and once the generalization has been completed, carrying out quality assurance. When a conflict is detected, the system proceeds to carry out the appropriate steps. Each step is carried out in several iterations until the constraint is fully applied and conflict is solved as completely as possible. If a conflict cannot be solved without producing new conflicts or creating errors in topology, the system searches for the best possible geometric solution of the object in question. Quality assurance checks adherence to the generalization rules and ensures that no further editing is required for elements that fulfil the constraints. In cases where a conflict cannot be solved sufficiently, *axpand* provides an attribute value that aids cartographers in quickly finding those elements that need to be examined and possibly manually edited after the automated generalization is complete. Within *axpand* editor, the cartographer can immediately jump to places in the data that may need manual editing. New products in various scales can be produced by adjusting the constraints and in some cases the order of the workflow. Generalization steps are automatically carried out in *axpand* in a fraction of the time of manual generalization and produce consistent, reproducible results.

#### ***4. Building a Generalization workflow***

Generalization workflows in *axpand* consist of ‘tasks’. Each task contains generalization operators or sub-workflows. Operators in *axpand* are logical combinations of algorithms - eg. algorithms for selection, analysis, geometry change, evaluation, etc - that carry out specific generalization steps according to the constraints for the appropriate scale. Both implicit and explicit topology is maintained within the operators. The generalization workflow can be set up so that generalization steps can be embedded, can follow in succession or be carried out in parallel where necessary. The results of each step in the generalization workflow is written into a so-called ‘generalization resolution’ from which they can be repeated and/or used by other parts of the workflow.

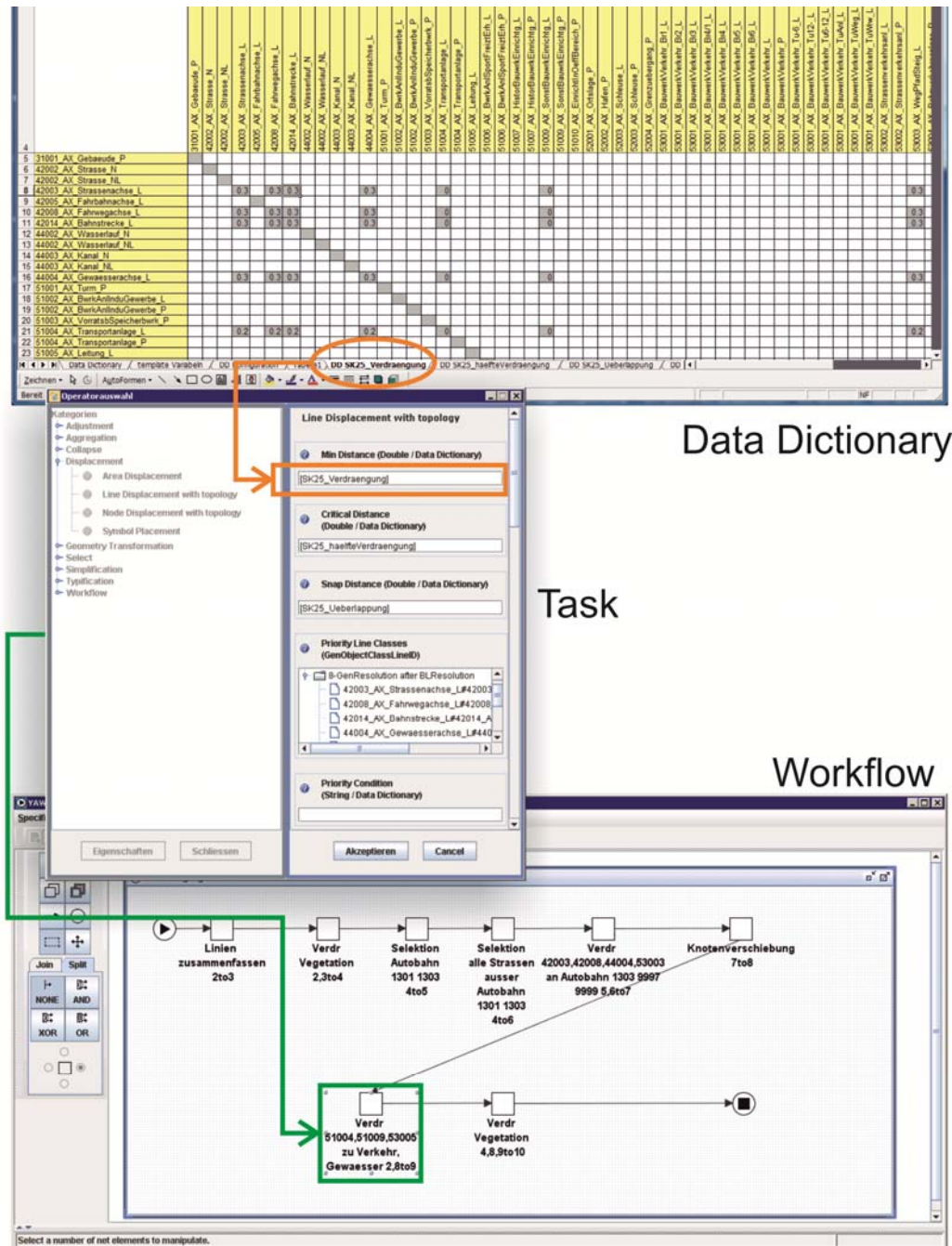


Illustration 3: Configuration Components

The constraints or generalization rules are entered as parameters for the operators. In the case of line displacement, for example, these parameters include minimum distance between specific object pairs. The parameters are defined according to which tasks the operator needs to carry out. These values can be entered directly into the operator or in some cases into a 'data dictionary'. When using a 'data dictionary' the constraints are managed in a commercially available Excel file and converted to a data dictionary that can be used in expand.

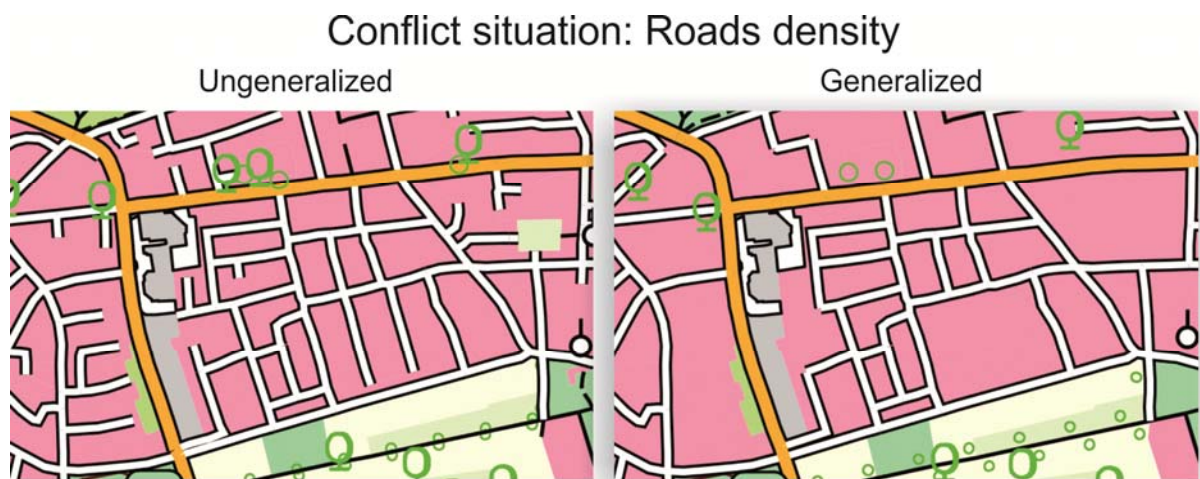


## 5. Generalization of the German DTK Data

For the generalization of the German DTK Data in the scales of 1:10,000, 1:25,000, 1:50,000 and 1:100,000 the corresponding workflows are divided into two main groups of tasks. In the first group, object classes are generalized against themselves. These are the so-called ‘preparation steps’ and include, in part, aggregation (especially for land cover), thinning of streets and small buildings, typification of point objects, geometry-type changes (including L->P, F->L, L->F), removing pseudo-nodes, simplifying area and line objects and creation of right angles.

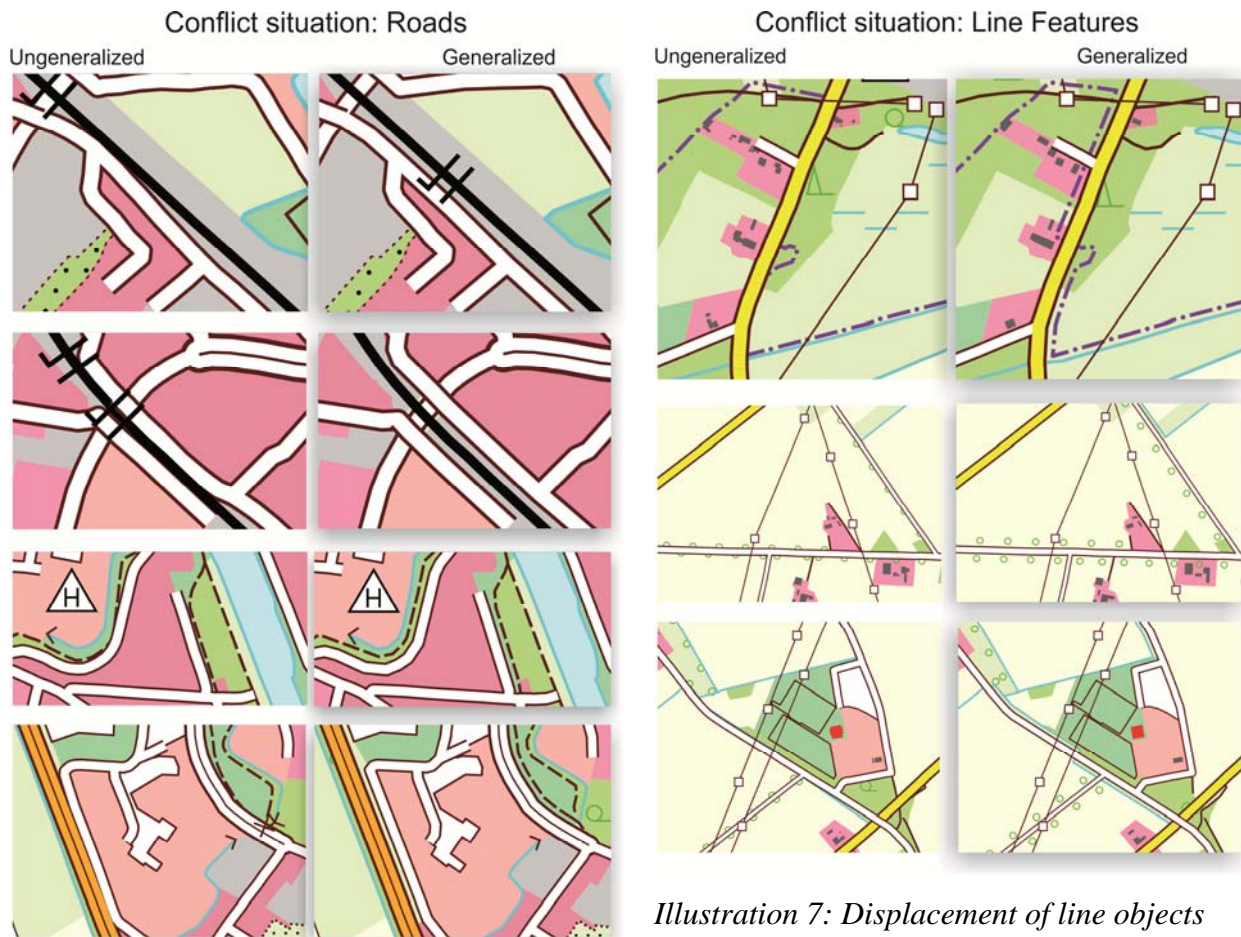


*Illustration 4: Building generalization*



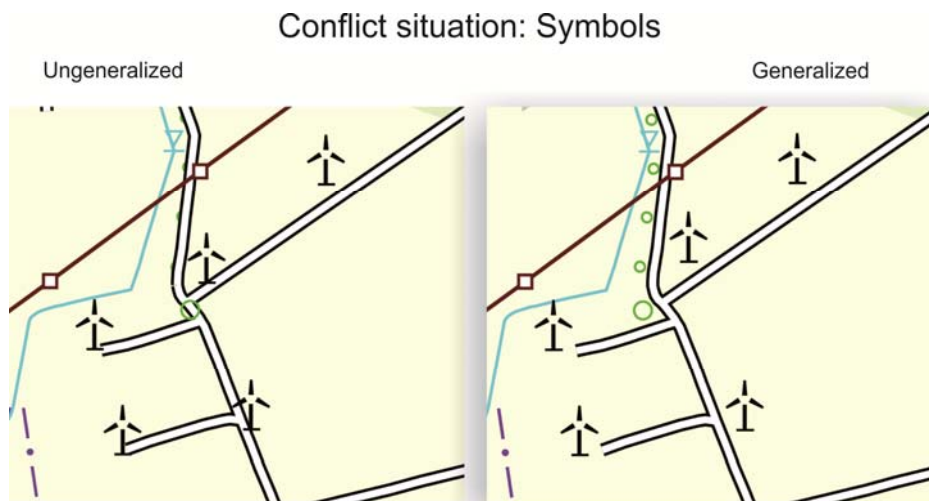
*Illustration 5: Thinning streets*

Once the ‘preparation steps’ have been successfully carried out they are followed by so-called ‘movement steps’. These are steps where objects move in relationship to other objects. This includes, among others, the displacement of lines, extension and reduction of lines to areas, displacement of buildings and displacement of point objects.



*Illustration 7: Displacement of line objects*

*Illustration 6: Displacement of transportation elements*



*Illustration 8: Symbol placement*

As a last step in generalization, the map is automatically labelled. In the case of the German DTK maps, this is done according to the specifications in 'GeoInfoDok', which defines the standards for German maps. Aggregating the areas and lines reduces the number of text objects and makes text placement easier. The automation of text placement plays a crucial



role in the reduction of the manual editing that is still necessary after automatic generalization.



*Illustration 9: Text placement*

(Source: LVerGeo Sachsen-Anhalt, Base data from: NAS-Data according to GeoInfoDok-Verison 6.0.1, © GeoBasis-DE / LVerGeo LSA, 2011, <http://www.lvermgeo.sachsen-anhalt.de/de/main.htm> (German))

Information about the relationship between source and target objects is maintained during generalization and written to the data base. This takes place in the form of a status and relationship chain in a multi-representation data base (MRDB) in axpand. This information shows the history of an object over several updating cycles and is used for the automatic, incremental updating of map data. Information about every change that an object undergoes in either the source or the target is available to the user.

## **6. Generalization Zones**

As an important enhancement to the generalization workflow, axpand supports the definition of so-called generalization 'zones'. This makes it possible to generalize different areas of a map - for example, city centres, rural areas, mountainous areas or areas with a large density of water cover - using zone specific generalization constraints. These zones are generalized using different rules during the same generalization process. The generalization zones can be defined in different ways: by manually digitizing zone areas, from geometries from existing object classes such as from "settlement area" classes, as well as automatically based on the density of buildings in a certain area. The zones act like "Filters" during the entire process of generalization. An object or object pairs are generalized based on the rules of the generalization zone in which they are located. The data is not partitioned, but generalized in a flowing process, transitioning from zone type to zone type. In this way, problems of data partitioning in the border areas are avoided. The entire generalization process is carried out using iterations (loops) for different types of generalization zones.



## 7. Automated incremental updating

There is no difference between a first generalization and a continual and incremental process of updating within axpand. The State of the objects is decisive for the updating. At first supply of the data in axpand, all objects processed are considered as "new" objects. The subsequent supply of the data may include new, changed or deleted objects. The generalization takes place only in the areas where source data has been changed, deleted or added. This data can be fed into axpand for any region, at any time and is controlled by the standard NAS/NBA interface. In cases where source data has changed, it is possible to make a determination of whether the change is relevant enough to import and if it is necessary to re-process the data. Changes to the data are re-generalized in order to automatically update the derived target model. Rules for determining the relevance of changes can be configured and maintained for each map scale. At each instance of generalization, surrounding objects of the target model are also included and processed with the modified source object thereby maintaining the consistency of the map. The relationship between the target object(s) and source object(s), or predecessor(s) is always maintained in a relationship link (MRDB). A generalized object can be manually reverted to its source state before the generalization or to its prior state at any time in axpand editor. In the case of the German AAA model, the introduction of source data for automatic incremental updating into axpand is carried out using an NAS/NBA interface. There are several other interfaces available.

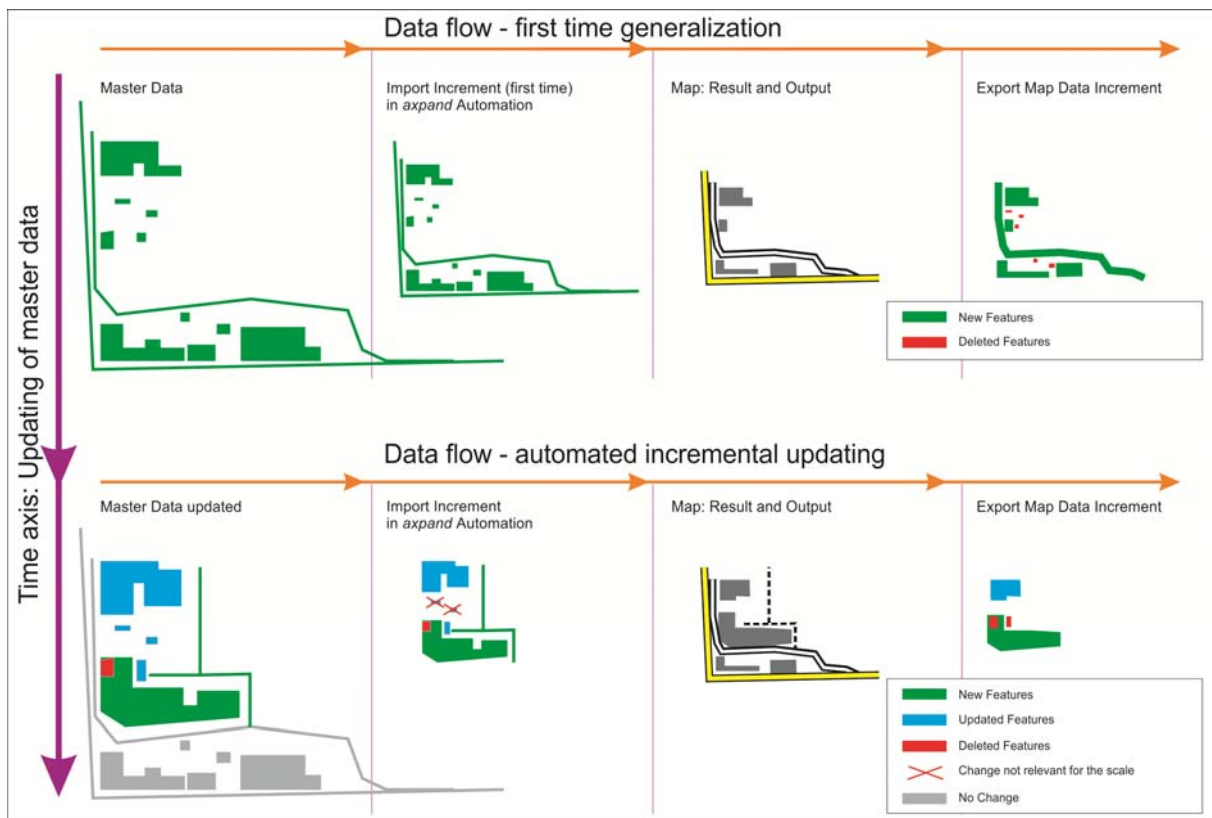


Illustration 10: Data flow- updating

axpand generates and maintains stable object identifiers (UUIDs) for the derived data during the entire generalization process and across updating cycles. Information about the relationship between source features and their derivations are created and saved in axpand so that changes can be tracked over time and used for updating. As soon as the target model has been updated through re-generalization, the data can be visualized and where necessary, manually edited. The results can be output in the form of ready-for-print PDFs of the map sheets and raster data according to the technical rules of the German governing body. Data can be sent out of the system as increments to an external data base.

## **8. Automatic Generalization Results**

The tests using the German AAA-DLM data for the generalization of 1:10,000, 1:25,000 and 1:50,000 maps showed that an average of 80% of all conflict situations were correctly generalized and did not require subsequent manual editing. In order to achieve this, a significant number of well-functioning generalization operators are used including excellent building generalization and displacement during which complex forms are simplified and correctly adjusted in relationship to each other. These excellent results are also attributed to the use of tried and true constraints for each scale. The use of the axpand editor and additional tools in the axpand system for the creation of map sheets and plots, allows for the seamless completion of map series well under the normal timeframe. Maintaining tight production schedules, accuracy and high quality maps requires a minimum of manual effort and is therefore faster than ever (Lenz et al).

## **9. Summary**

Automated processes allow for a significant reduction in the time it takes to produce and update maps. Using axpand automation to process German AAA data includes the visualization of geo-data in compliance with style sheet rules, automated generalization, automatic text placement according to style sheet rules and the repeated task of automated updating. All map scales are produced using the same source data. The automation process is driven by the use of constraints and the results are consistent and within an 80% level of correctness. This high quality reduces the time cartographers need for editing remaining conflicts by up to 20%. Calculations from the field show that axpand has a positive and impressive influence on time and cost savings.

## Sources:

Käuferle et al. (2010): Käuferle, Dominik:

*Geomatik Schweiz* 5/2010, S.197. „Automatisierte Landeskartenherstellung in der Schweiz“ (Automated Map Production in Switzerland)

*Kartographische Nachrichten* 5/2010, S.274. „Automatisierte Landeskartenherstellung“ (Automated Map Production)

*VDV Vermessung und Geoinformation Magazin* 5/2010, S.342. „Automatisierte Landeskartenherstellung in der Schweiz“ (Automated Map Production in Switzerland)

Lenz et al. (2011) Lenz, Peter:

*Kartographische Nachrichten* 4/2011 (September 2011, INTERGEO issue) „Zur Fertigstellung der zivil-militärischen Topographischen Karte 1:100 000 in Thüringen“ (Completion of Civil-Military Topographic Maps 1:100,000)

*VDVmagazin* X/09 „Die Entstehung der neuen zivil-militärischen Landkarte im Maßstab 1 : 100.000 in Thüringen“ (The Creation of the New Civil-Military Maps at 1:100,000 scale in Thuringia)

Axes Systems Website: [www.axes-systems.com](http://www.axes-systems.com)

Weibel, Burghardt, Petzold, Bobzien, Neun, Mathur et al

Bobzien, M; Burghardt, D; Petzold, I; Neun, M; Weibel, R (2008). Multi-representation databases with explicitly modeled horizontal, vertical, and update relations. *Cartography and Geographic Information Science*, 35(1):3-16.

Matthias Bobzien, Ingo Petzold, Dirk Burghardt (ICC 2007) Automated Derivation of a 1:300 000 topographic map from Swiss DLM VECTOR 200.

[http://www.geo.uzh.ch/~burg/literatur/bobzien\\_2007\\_icc\\_drive.pdf](http://www.geo.uzh.ch/~burg/literatur/bobzien_2007_icc_drive.pdf)

M. Bobzien, D. Burghardt, I. Petzold, M. Neun, and R. Weibel: Multi-Representation Databases with Explicitly Modelled Intra-Resolution, Inter-Resolution and Update Relations. *AutoCarto 2006*, Vancouver (WA), USA, 2006

I. Petzold, D. Burghardt, and M. Bobzien: Workflow Management and Generalisation Services. *Workshop of the ICA Commission on Map Generalisation and Multiple Representation*. Portland, USA, June 25th 2006

Bobzien, M., Burghardt, D. & Petzold, I. (2005): Automatische Ableitung digitaler Vektormodelle - Projekt DRIVE. In: *Mitteilungen des Bundesamtes für Kartographie und Geodäsie: Arbeitsgruppe Automation in der Kartographie, Tagung 2004*, 34, 9-20.

Burghardt, D., Bobzien, M., Petzold, I. & Weibel, R. (2005): Cartographic generalisation of large scale maps with expand. In: *Proceedings of International Symposium on Generalization of Information*, Berlin, Germany

Bobzien, M., Burghardt, D. & Petzold, I. (2005): Re-Generalisation and Construction — Two Alternative Approaches to Automated Incremental Updating in MRDB. In: *Proceedings of 22nd International Cartographic Conference*, La Coruña, Spain, CD-ROM,

Burghardt, D. & Mathur, A. (2004): Derivation of Digital Vector Models – Project DRIVE. In: *Proceedings 7th ICA Workshop on Generalisation and Multiple Representation*, Leicester, UK, CD-ROM

Mathur, A. & Burghardt, D. (2004): Systemintegrierte Erstellung und Ausgabe von digitalen Karten aus Landschaftsmodellen - Das Projekt DRIVE. In: *Kartographische Schriften Band 9*, Kirschbaum Verlag Bonn, pp. 167-170

Burghardt, D. & Mathur, A. (2000): Machbarkeitsstudie zum AdV-Forschungs- und Entwicklungsvorhaben „ATKIS: Modell- und kartographische Generalisierung“. *Maptech AG im Auftrag der Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland (AdV)*

*KTI/CTI Projekt: Web based generalisation services for online maps (SerAx) <http://www.research-projects.uzh.ch/p8045.htm>*

*KTI/CTI Projekt: Derivation of topographic maps from digital landscape models  
(DRIVE – Derivation of vector models) <http://www.research-projects.uzh.ch/p4391.htm>*

*Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland (AdV), ATKIS-Signaturenkatalog für die Digitale Topographische Karten: <http://www.adv-online.de/>*

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