Automatic updating of Map and Map Data Products - Case Studies from the Field

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Using four examples from the field, this article shows how good automatic generalization increases efficiency in the production of maps and provides a basis for automatic, incremental updating. It discusses how automatic, incremental updating makes a significant difference in the consistency of map quality and the timeliness of maps and data. The article shows that the real value of automatic generalization lies in its use as the basis for regular, repeated automatic updating of maps and map data products over time.

Key words: topographic maps, generalization, incremental updating, automation, survey map, German base map 1:5'000

1. Automatic Generalization - A Topic for Discussion

Over the years, automatic generalization has been at the forefront of discussions about automation in cartography and map production. High-quality automatic generalization improves efficiency during the map production process by cutting down the amount of manual editing required.

To this day, generalization has remained a part of a linear production process. When base data is updated, this linear process is repeated in its entirety. This means that each time there is an update to the data, the generalization and all manual map editing starts over from the beginning. This in itself is yet another linear process - generalize, edit, produce and throw away. It is exactly this repetition of generalization and manual editing that destroys the efficiency of automated processes.

The benefits of automatic generalization are more significant and sustainable when it serves as a foundation for regular and user-defined automatic updating of map and data products. In order to guarantee that map and data products stay up-to-date, automatic updating should be carried out as soon as an area or a theme in the source data has been changed or updated. This can be done without waiting for the entire data set to be updated. Only those objects that are influenced by the most recent changes are considered in the generalization that follows and the rest are left untouched. This type of differential generalization is called 'incremental updating'. The updated objects can then undergo a quality check and only those few that require further changes need to be manually edited.

In order to meet the need for ever-increasing recurring, efficient and short updating cycles, Axes Systems' cartography system *axpand* and its automation component *axpand ng* have been integrated into several different map production process scenarios. Using case studies from the field, this article describes some of the ways that the axpand is currently being used for automation and map production. Although the examples here are configured for specific data models and architecture, in principle, the flexibility of the system allows for its use with all data models and system architectures.

The components necessary for automatic generalization and updating can be integrated into and used in existing systems landscapes. However, to make automation as useful as possible, the components should be part of a recurring set of process steps which maintain the manual changes to map data and allow for interventions at each step of the process. This is best achieved by integrating all of the steps involved in the map-making process into one system in a so-called 'circular process' that is flexible enough to allow for interventions at any point in the process chain. The automation component is an indispensible building block in this chain.

2. Derivation of Digital Topographic Maps from Base Data - Three Case Studies

The first two case studies here describe the derivation and updating of digital topographic maps data using the German ATKIS digital landscape model (DLM) according to German AAA standards. In the first example, axpand is used as the entire production system. In the second example, it serves as the automation component for an existing editing system.

2.1 - Case Study One: Complete automatic derivation and updating of a digital topographic cartography model from a base digital landscape model in one system

In this case study, the data is stored in an external primary data base as a digital landscape model and transferred in increments using a Geography Markup Language (GML) based standard data exchange format for Germany called NAS to *axpand* production system, which then generates the required digital cartographic model (DCM) out of the DLM and is subsequently used to carry out manual map finishing (Illustration 1). This process is set up for the official map scales in Germany - 1:10,000, 1:25,000, 1:50,000 and 1:100,000.

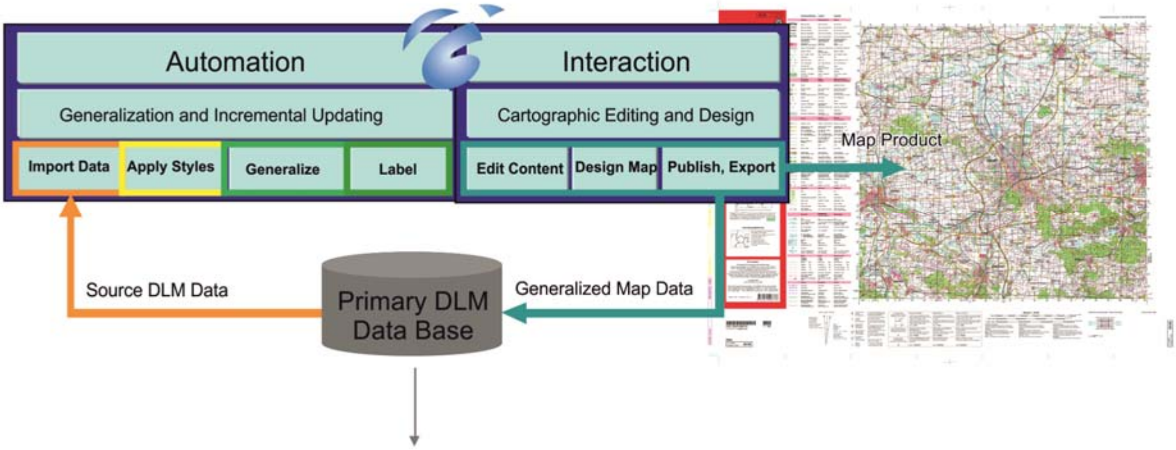


Illustration 1 - Complete automatic derivation and updating of a digital topographic cartography model from a base digital landscape model in one system

The following is an example of how an initial generalization takes place. A DLM road object is delivered from the primary data base to the automation component. This same source DLM street object is used to generate DCM street objects in four scales 1:10,000, 1:25,000, 1:50,000, 1:100,000. Illustration number 2a describes the situation after a first import from the primary data base and the introduction of buildings from a cadastre data base. These source objects maintain their original geometries and IDs and the street object is generalized. It may undergo smoothing and/or displacement. The result is the creation of a cartographic object (DCM) that represents the source DLM object in the map scale being generated. As a result of the generalization, this object now has its own geometry and ID and is available to the cartographer for visualization and/or subsequent editing/map finishing (see illustration 2b).

Illustration 2a

Illustration 2b

The DCM object maintains a relationship to the original source data object, which remains unchanged. The relationship between a source object and a map object can be 1:1, n:1 or n:m. Where necessary, source objects and objects that have been derived through generalization can be manually edited using axpand editing tools. Objects that are manually edited are automatically stored as map geometry (DCM) objects and maintain a relationship to the source object. The system maintains a history of all of the changes to an object over time so that objects that have been manually edited are also considered during recurring automatic updating. Illustration 2c shows a situation after the import of a new increment which includes changes to the data. The system identifies and marks the areas that are influenced by the update increment and generalizes only the areas that are affected (see illustration 2d)

Illustration 2c

Illustration 2d

The maintenance of 1:1, 1:n or n:m relationships allows for easy handling of map geometry objects which are derived from one or more source objects through generalization operations such as aggregation and typification. This includes, for example, new building block objects that are created by the aggregation of several source building objects, landcover areas that have been aggregated or single objects that result from thinning of source objects which were lying too close together. This type of generalization is essential for the derivation of mid- to small scale maps, eg. 1:50.000, 1:100,000 or smaller. At present, some of the GIS-based editors being used for map production may face difficulty dealing with map geometry objects. This is especially true for objects with 1:n relationships to source objects.

2.2 - Case Study Two: Using an automation component as an enhancement to an existing editor

In this case study, the automation component works as an enhancement to existing editing software (illustration 3). The DLM data in standard GML-based “NAS” data exchange format is sent by the editing system to expand automation component for generalization. After the automated generalization, the generalized DCM data is sent back as an increment to the editing system for manual finishing. Alternatively, the data exchange can take place directly between the primary DLM data base and the automation component as shown in the illustration 4.

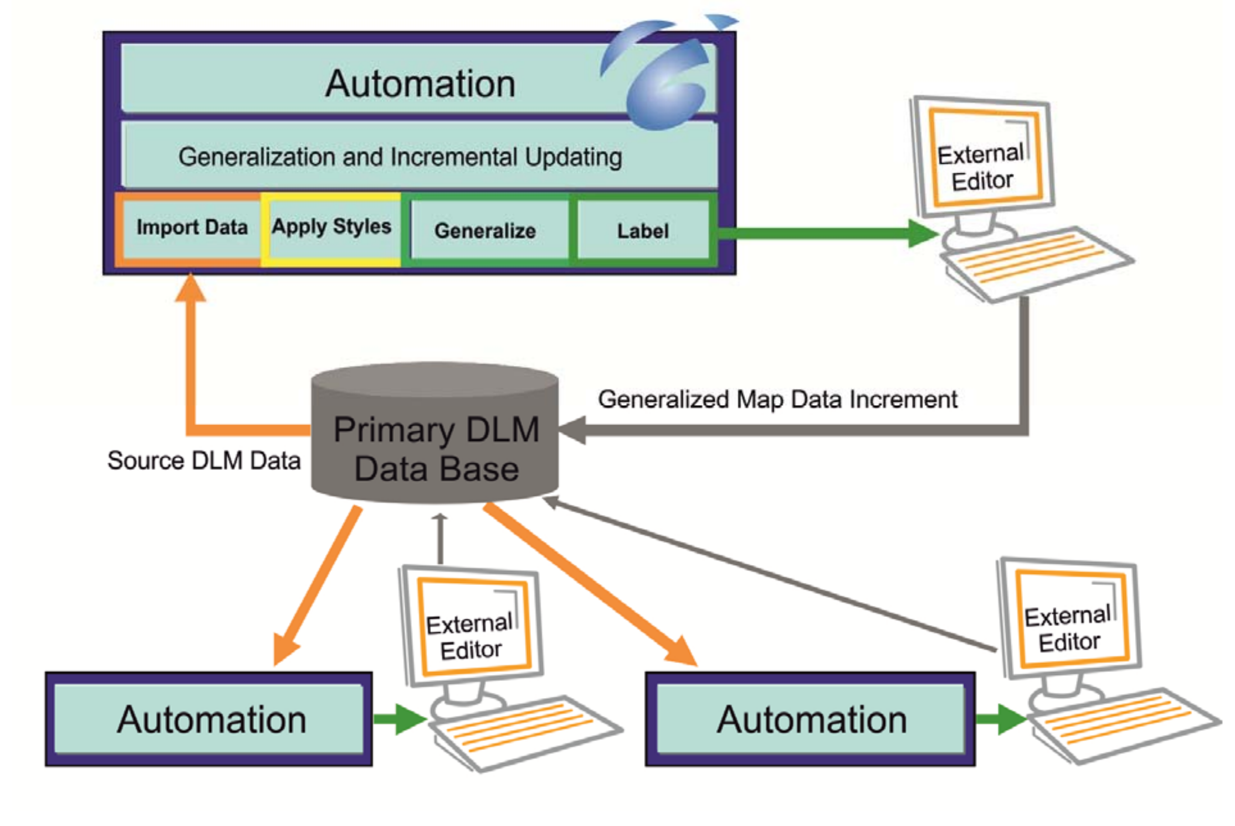


Illustration 3

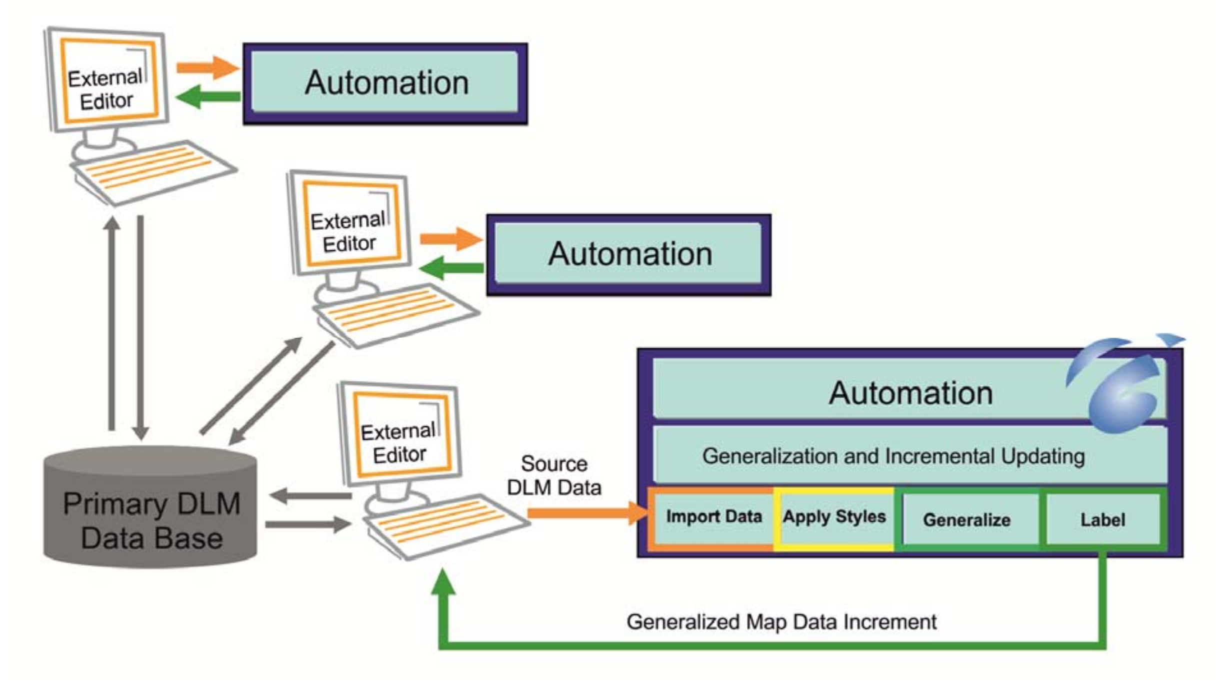


Illustration 4

Once the data is generalized and the increment is processed, the data is deleted from the automation component. Each data set, which is normally the size of a map sheet, undergoes the same process. This process allows for axpand automation component to be used as an enhancement and an accelerator to existing editing software to reduce manual exiting to a minimum.

2.3 - Case Study 3: Preparing base DLM data for generalization

Due to the traditional methods and the scale used for data capture, the base DLM data can be very complex and detailed. This includes not only a high density of coordinates, but also a large numbers of area objects with the same attributes. The complexity of the source data is a disadvantage when it comes to manual work of creating aesthetic, readable maps. The amount of work required to "clean" the DLM data, makes manual editing a time and resource intensive and expensive.

The automatic generalization process includes simplification as well as aggregation of such data in order to have a clean data for cartographic generalization. This can create a large number of DCM objects with 1:n relationships to the DLM source objects, especially due to aggregation steps. This is not a problem in case study one above, where axpand is used for the entire production process (see 2.1 above), including manual editing. Some GIS-based editors might face difficulty dealing with DCM map objects derived this way, especially when they show 1:n relationships with the DLM source data. In situations such as that in case study 2.2 above, a data preparation step is built into the production process.

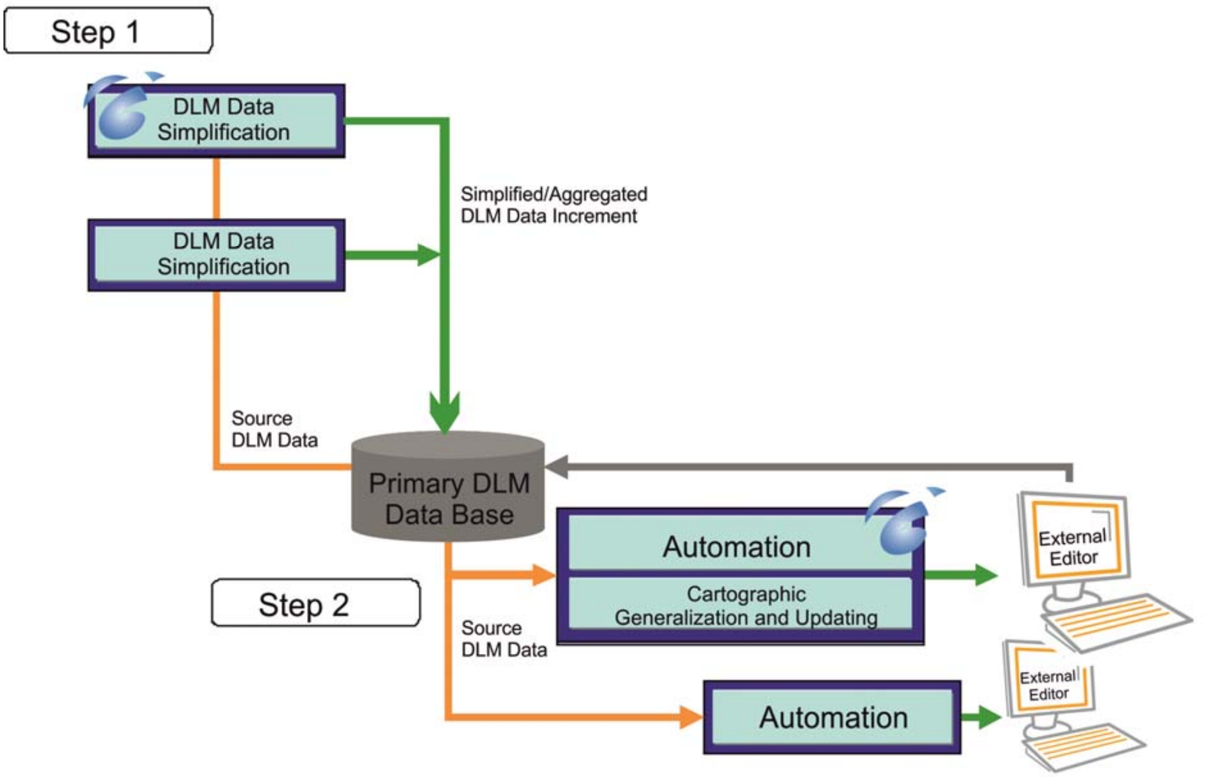


Illustration 5

This step ensures that point reduction (illustration 5a-5d) and area aggregation (illustration 6a-6b) happens directly in the base DLM data. This cleans up the DLM and eliminates the necessity to build these steps into the cartographic generalization thus reducing the number of DCM objects. In this case, the automation component carries out these changes in the source DLM data up to the edge of specified map sheets. This ensures that point reduction and aggregation of the DLM data is carried out per map sheet and it is not necessary to block large sections of the DLM data base while this data preparation step is in process (illustration 5e).

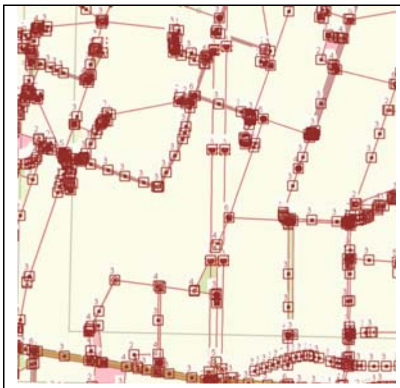
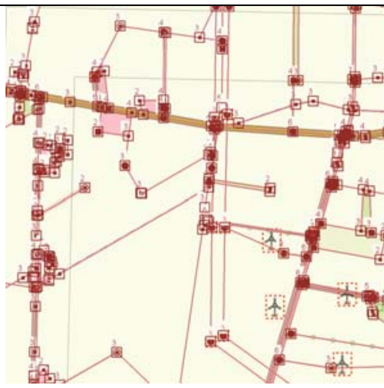


Illustration 5a	Illustration 5b
	
Illustration 5c	Illustration 5d

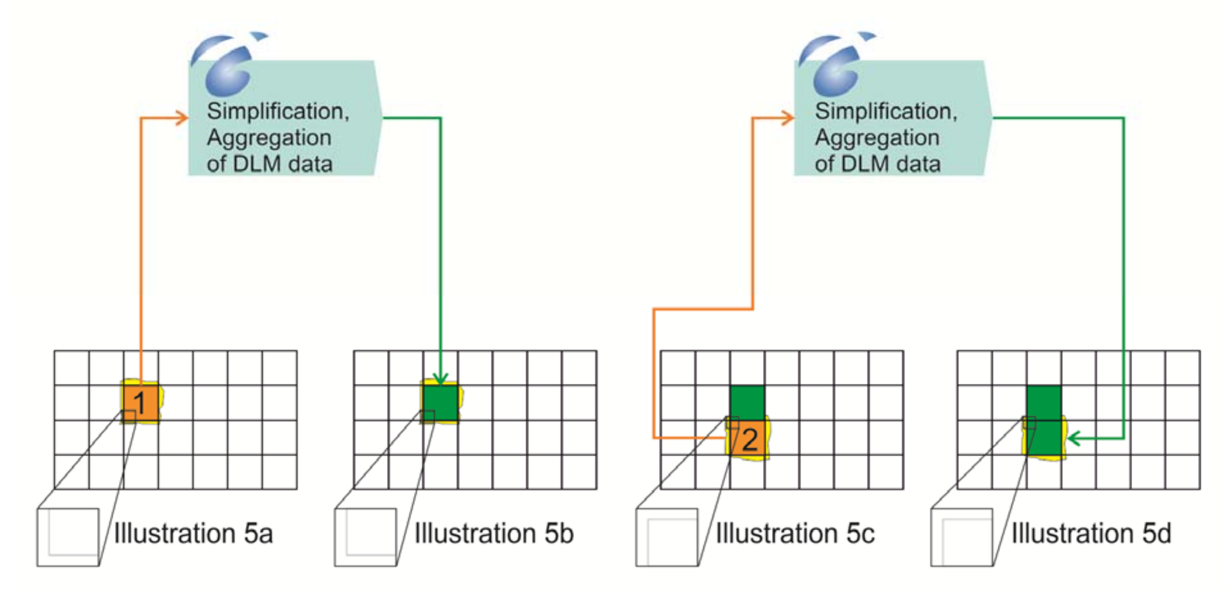


Illustration 5e

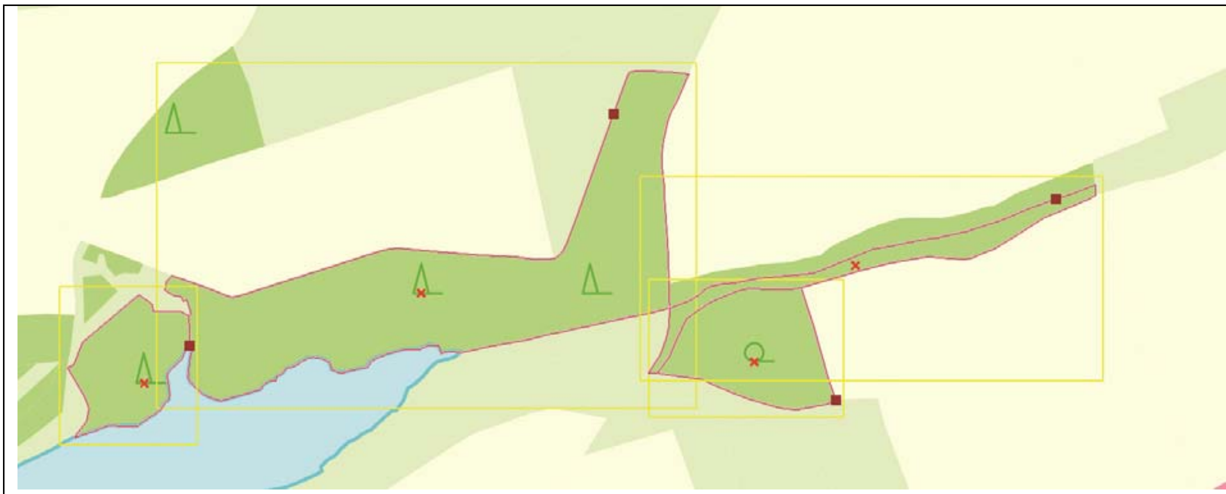


Illustration 6a

Illustration 6a

3. Case Study Four - Using Cadastre Data to Create a Cartographic Model for the Production of Survey and Planning Maps in Switzerland

The production of a cartographic model in scales 1:5,000, 1:10,000 and smaller using cadastre data from Swiss survey data has its own challenges. However, the potential uses of these models for the production of survey maps, thematic and leisure maps as well as data products are significant (illustration 7).

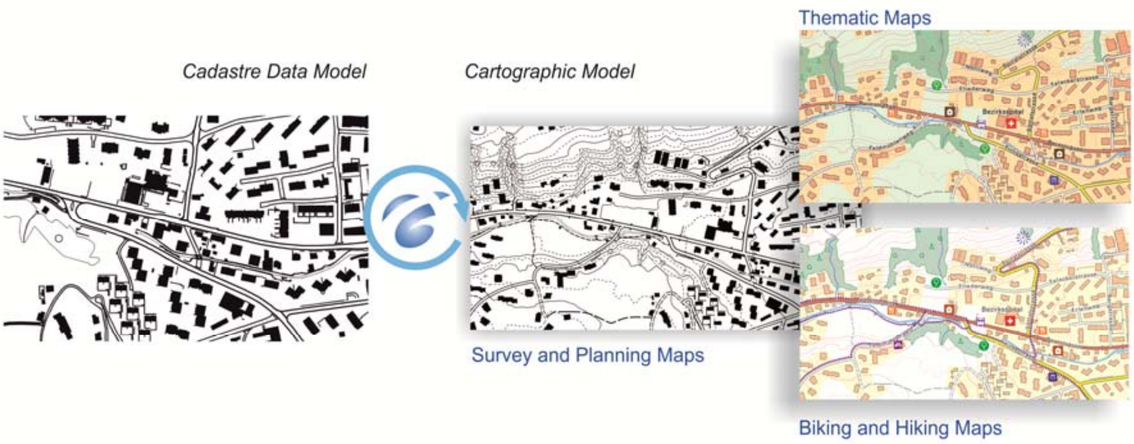


Illustration 7

Cadastre data is very dense, detailed and is generally captured at scales 1:1,000, 1:500 or larger. The standard format for Swiss cadastre data exchange is Interlis©, an xml-like exchange format. In general it's not possible to deliver updates as data increments out of the source cadastre systems, only complete data at any particular point in time. The objects rarely have a unique or stabile ID.

It can be especially challenging to produce data that requires large jumps in scale compared to the source data. This could require the creation of new data types which can only be done by changing object geometries - normally areas to lines - or through aggregation and/or typification. A new and distinct classification of source object for cartographic presentation is also necessary.

In some cases there is vector data available in the form of vector geometries or graphic files from existing plans. It is beneficial to use these whenever possible. The entire process for conversion of survey data to a cartographic model needs is ideally automatic and incremental for each update of the base survey data.

The following examples were mandated by RAWI, the survey body of canton Luzern in Switzerland, who is the owner of the survey source data, and was carried out by Axes Systems using axpand. Illustration 7a shows the data after import of survey data using the Swiss-specific interface format Interlis©. The data, which is predominantly seamless area objects, are not uniquely classified for display on a survey plan map (illustration 7b). Since the streets in the old survey plan map had been classified for graphic presentation, these were used as a template for classifying the cadastre street areas before they were converted to lines (illustration 7c). Other object classes from the old survey plan map - contour lines, embankments, etc - were used as well. After classification, the data was generalized according to a set of criteria specific to the creation of a survey plan map (illustration 7d). During the process the generalized data was assigned unique and stable IDs.

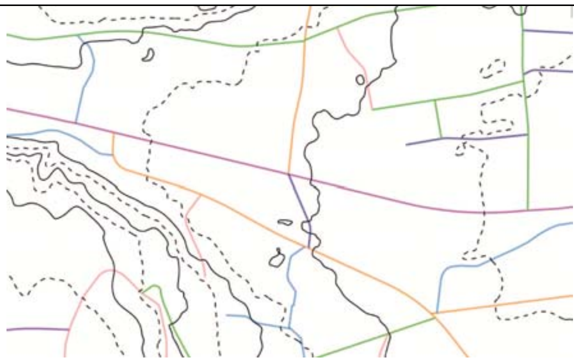
	
Illustration 7a	Illustration 7b

Illustration 7c

Illustration 7d

3.1 Building increments for updating

In this example, cadastre source data from two different points in time were used to create update increments in axpand. These were 1) the existing geometries from the survey plan map that were imported initially into axpand and a newer data set in Interlis format from the same region. The new data set was imported into the automation component using an FME plug in. An 'increment builder' axpand module was used to automatically create increments from objects that had changed over time. Illustration 7e shows increments created from data at two different points in time. The empty green areas are where objects have been deleted. A check for the relevance of the changes to the data is especially useful in this case. A relevance check using a conservative value of 0.3mm ensured that the increment contained only one-thirds the number of changed objects in comparison with an increment created without a relevance check which contained every changed object, regardless of the relevance of the change to the resulting scale. Illustration 7f shows the preparation for an incremental update of the survey plan map through re-generalization of the areas of the increment that have a relevant influence on the data. At this point in time, the streets are available in the automation system as both lines (out of the first generalization) and streets as areas from the increment.

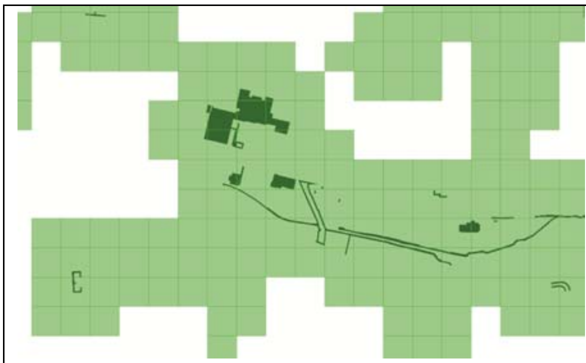


Illustration 7e

Illustration 7f

Some of the most important steps in this type of generalization are geometry type changes and building of line topology (street areas need to be converted to street lines and these lines need to be topologically connected to each other in order to build a complete network of streets), the thinning of lines (such as walls, dead-ends and small mesh areas), as well as building generalization. The buildings are generalized using selection, aggregation, alignment and displacement. After successful automatic updating using methods of generalization is complete (illustration 7g) the data is ready for label placement and manual finishing.

Illustration 7g

4. Automatic Updating - Making a Difference

The uniqueness of all of the case studies described here lies in automatic updating. This is the only process which ensures that data and maps made from source data, which is created using automatic generalization, is kept up to date. Updated source data can be introduced to the system at any time to automatically update derived map products.
Only the objects that lie within the areas of influence of the updated source data are processed during updating. Data that has been manually edited is also included in the update process. This process is incremental and therefore non-destructive. The incremental process of automatic updating ensures that product quality remains consistent over multiple updating cycles.

Although this case study focuses on survey data from a Swiss canton, this process can be used for any set of cadastre data in any model or scale.

5. Conclusion

Well-functioning automatic generalization allows for significant time-savings during the initial creation of high quality maps and data products. However, the real value of automatic generalization lies in its use as a method for incremental and cyclical updating of cartographic data and map products.

The key to maintaining the quality of updated maps and map products lies in the ability of a system to recognize which source data has undergone significant changes and needs to be reflected in products created from that data. Manual edits which are not part of update increments need to be maintained so they don't need to be repeated and the size of increments is best kept to an optimal minimum. The maintenance of information about and history of objects is also important for automatic updating. The case studies here show four real examples of how axpand solves the challenges of automatic creation and updating of data and map products.

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