# Implementation of Automatic Generalisation in the Production Process of the 1:50.000 Map Series

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## 1. Introduction

At IGN Belgium we are conducting in-house tests to see if existing software, possibly complemented with proper code, can be useful in the automation of the generalisation process. The reference scale is 1:10 000 and the scale of the generalised dataset is 1:50 000. For the third edition of this generalised data, the update process has been limited to the roads and the buildings.

As far as the roads are concerned, we have opted for incremental updates. For the buildings, however, we found it more efficient to generate the whole building class again, instead of trying to update what had changed only.

In accordance with our technical and selection criteria, the generalisation process distinguishes between the specified buildings on the one hand, such as town halls or police stations, and non-specified buildings on the other hand, for instance private houses or small commercial buildings.

At this moment, the specified buildings are still generalised manually, but this will change in the next few months. The treatment of the non-specified buildings depends on the area they are situated in. In dense areas, such as village and town centres, built-up areas are generated automatically by means of a script in ArcGIS. They simplify the map image, making it easier to read. Specified buildings remain independent units within these built-up areas. This paper focuses only on the developments that were conducted on non-specified buildings in sparsely built areas.

We chose Radius Clarity, developed by the company 1Spatial, as the generalisation platform we would work with.

In the meantime, the results of the tests have been integrated in the production line.

## 2. Reason

The aim of these developments was to automate the repetitive and labour-intensive tasks which generalisation brings along. The main advantages for the NGI are a gain of time and a higher quality of our product.

The gain of time is by far the most important advantage. It results from the higher speed of the automatic generalisation process, compared to the manual process. Moreover, the time the cartographer spent on generalisation tasks can now be allotted to other tasks. An additional advantage is that the automatic processes can be started up after the traditional working hours.

Besides, the quality of the dataset is enhanced as it has a higher consistency. In fact, during the generalisation process, the cartographer has to make certain decisions in situations, which could be rather exceptional. These decisions depend mainly on the cartographer's insight and experience and the results will differ from one cartographer to another.

## 3. Technology used

On the basis of our own experiences and those of other NMA's, the members of the MAGNET consortium (Regnauld et al 2007), we have opted for the software package Radius Clarity, developed by the company 1Spatial. The description by Regnauld et al. (2012) summarizes the possibilities of this platform: "Radius Clarity is a stand-alone application that uses 'Agent' technology to make map objects 'self and context aware'. This allows objects to 'co-operate' to achieve acceptable automatic cartographic (product) generalised results by trying a number of strategies to achieve local feature goals and selecting the set of results that provide the 'happiest' result across the entire dataset." This package can be complemented with proper code, for instance with our own constraints or algorithms. Our code in this platform is exclusively written in Java.

The starting point was the idea that the result after the automatic generalisation process would coincide as much as possible with the result after an interactive generalisation. However, when we notice that certain operations are too difficult or impossible to achieve, it is possible to adapt our technical criteria.

Interactive generalisation processes such as the quality control, and corrections where needed, of the automatic generalisation results, are executed in the ArcGIS editing platform.

## 4. Achievements

Since the testing activities have been started, quite some time and money have been invested in learning how to use this generalisation platform. We can definitely talk about an exponential learning curve and corresponding results. The incomplete and outdated manuals and guides delivered with the release of Clarity certainly played a role in the rather slow start of learning how to work with this software.

### 4.1 Data model

First of all, we fitted the application data model, the model which describes our own data, into the Radius Clarity data model (1Spatial 2012). However, as we became more familiar with the software, we have adapted this application data model a few more times. For example, we split up our linear object classes into subclasses, according to the width of the symbol which represents the object. This finer subdivision was necessary because the provided displacement algorithm takes only one parameter per class into account, being "width of line including casing", when moving buildings which overlap with roads. To use this constraint, this value needs to be filled in, in the map specification and can't be read from an attribute value. In order to make these adaptations smoother and to work in more structured way, we dropped the idea of managing this model by means of the provided GUI schema definition and we defined the data model completely with Java code.

Next, we examined the data topology. "By default there is only one manifold, but it is possible to have any number of different manifolds which separate out the topological relationships between the different real world classes. For example topographic landcover polygon data could make use of one manifold and a road network could use another. Each class can have a set of relationships between other classes, expressed in terms of a snapping tolerance and a topology rule." (Revell 2008:4) Since both reference data, being the buildings which have to be generalised and the linear objects which will constitute the basis for the partitioning, and already generalised data were imported, we work with two manifolds: one for the reference data and one for the already generalised data. Figure 1 is an example of reference and generalised data with their topological structuring. The red lines represent the topological links of the reference data and the black lines these of the already generalised data.

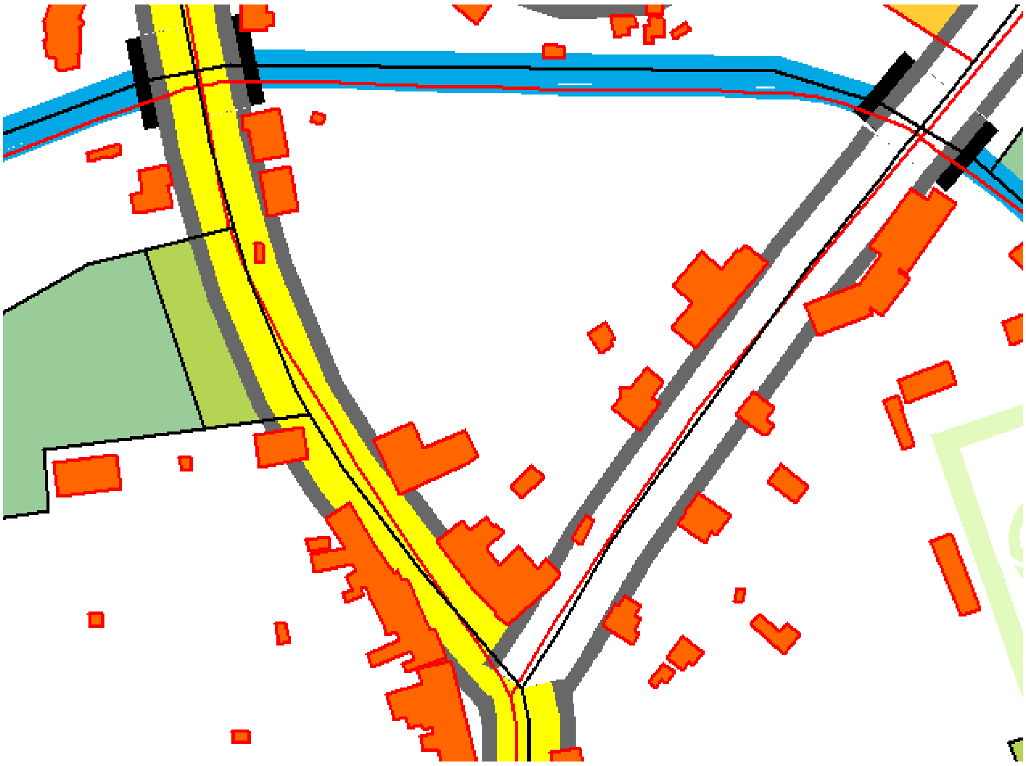

Figure 1. The topological links of the two manifolds.

Afterwards, a basic dataset was created in which our data model had been integrated. As a result, we only have to make a copy of the dataset for each map sheet – the update at the NGI is executed per map sheet – and to load the data into it.

## 4.2 Representation

As soon as this phase was over, we started making a Portrayal file. This is an xml file containing the description of the data symbology. This allows us to represent the data in Radius Clarity in a way which is similar to what we are used to in ArcGIS, which of course makes it easier to handle.

## 4.3 Partitions

As we have mentioned, all themes of the generalised dataset are loaded. From the reference dataset the polygonal buildings, the roads, dirt roads and paths and the waterways are loaded. These linear objects from the reference dataset are loaded because partitions are created on the basis of these objects. Later on, they will be used in the process as meso-agents (AGENT 2000), inside which the buildings are displaced. In order to have partitions on the map edges too, a border is used (Revell 2008).

## 4.4 Process methods

The first element of the generalisation process which is executed automatically at this moment is the elimination of buildings whose surface is less than 50m². In fact, these are hardly visible at the 1:50 000 scale and do not meet the selection criteria. On the other hand, buildings whose surface lies between 50m² and 400m² are replaced automatically by a square building of 400m². These buildings are also automatically aligned with nearby linear objects such as roads and rivers.

As some of them are enlarged, there might be overlaps between them. They are therefore submitted to a typification operation. Typification reduces the number of buildings while preserving their distribution pattern (Regnauld and McMaster 2007). In order to do so, a class of point objects is created whose coordinates coincide with the centre of the polygonal buildings. This is necessary because the typification process provided by 1Spatial only works with point objects. Next, these points are gathered in clusters in which the typification is executed. This is based on the “symbol reduction factor” parameter for which a maximum overlap percentage has to be given. The resultant set of objects has the same centre of gravity and is contained in the same convex hull as the source set of objects. The results of this operation, however, do not meet the expectations yet, but as the operation improves the results, it remains a part of the production process.

All of the abovementioned processes are process methods, which imply that no Agent technology is used.

## 4.5 Agent technology

We use Agent technology for the automatic simplification of buildings which are larger than 400m² and for the automatic displacement of buildings.

Buildings which are larger than 400m² are submitted to three constraints: a squareness constraint, a granularity constraint and an enlarge rectangle constraint as seen in Figure 2.

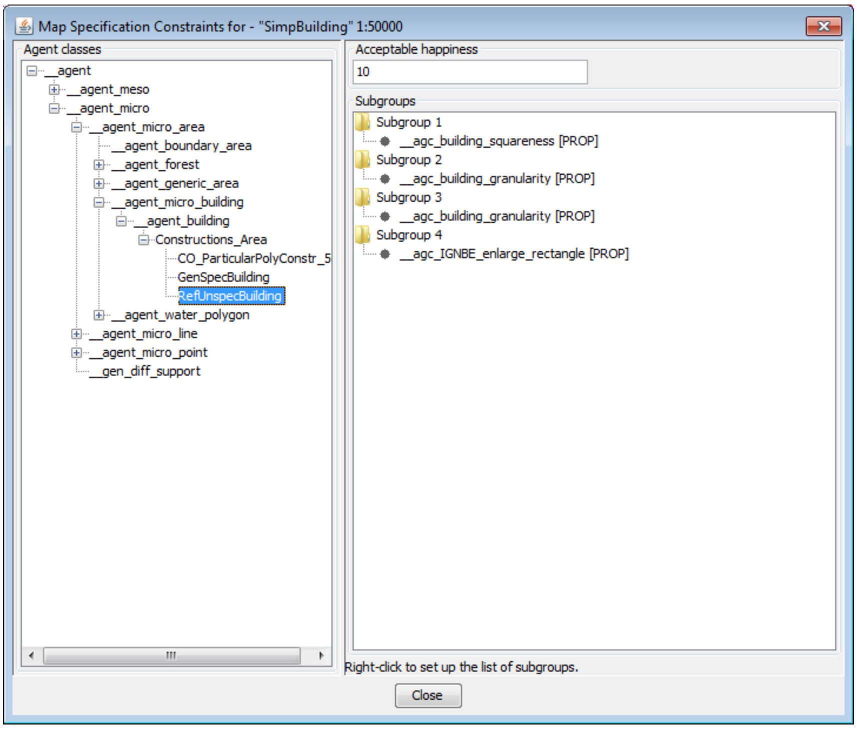

Figure 2. The constraints used to simplify buildings.

The squareness constraint (1Spatial 2012) measures the rectangularity of the present building and will propose a plan, depending on the present happiness, to make the building more rectangular, taking into account a certain tolerance. The squaring is aligned in accordance with the longest side of the building. This constraint is provided in Radius Clarity, so it is not based on proper code.

The granularity constraint (1Spatial 2012) measures a polygon's granularity and tries to limit it. This is also a constraint which is provided in Clarity. This constraint can trigger two actions: one which replaces the geometry of the building by a rectangle, while maintaining the surface area and the orientation of the original polygon. The second action simplifies the shape of the building by trying to eliminate "step" and "hat" features from the geometry, while maintaining the global shape of the building. Since we prefer the result of the second action, where more detail is kept, we added this constraint twice to be able to prioritize this last action. To do so we put a restriction that blocks performing the first action on the first of the two constraints. The second time with no restriction on any action so if the result after the second action isn't satisfying, the polygon can be replaced by a rectangular shaped polygon.

The last constraint is an own written constraint which only applies to rectangular buildings. As we have mentioned, the sides of a building must have a length of at least 20m in the generalised dataset. When the two opposite sides of a rectangular building are shorter than this threshold value, an action is proposed which stretches these sides up to this threshold value. 1Spatial delivers a constraint called "local width constraint" (1Spatial 2012) which should be able to do the same, based on its specification. These states: "This constraint measures a building's "local width", defined as the shortest distance across the outline of a building, and attempts to increase it to meet the goal value." But tests with this constraint resulted in unwanted results. As 1Spatial's constraint, according to its specifications, should work on more than only rectangular polygons, we are of course interested in how they will solve the reported bugs.

At the end, we try to limit the overlap between buildings or between buildings and roads to a minimum by means of a displacement operation, using a displacement constraint which is available in Clarity (1Spatial 2012). This operation takes into account the different symbol widths for the different classes. As we have mentioned in the data model paragraph, this has also to be taken into account in the drawing up of the application data model.

## 5. Results

Since a few months, the first results of these developments are being integrated in the production process. The results of the automatic generalisation are exported from the gothic database. Afterwards, they are checked visually in ArcGIS and modified where necessary. In spite of this visual control, the gain of time is considerable. These automatic operations take about three hours for one map sheet. An example of the data the way they are loaded into Clarity and the final result after automatic generalisation is given in Figure 3a and 3b.

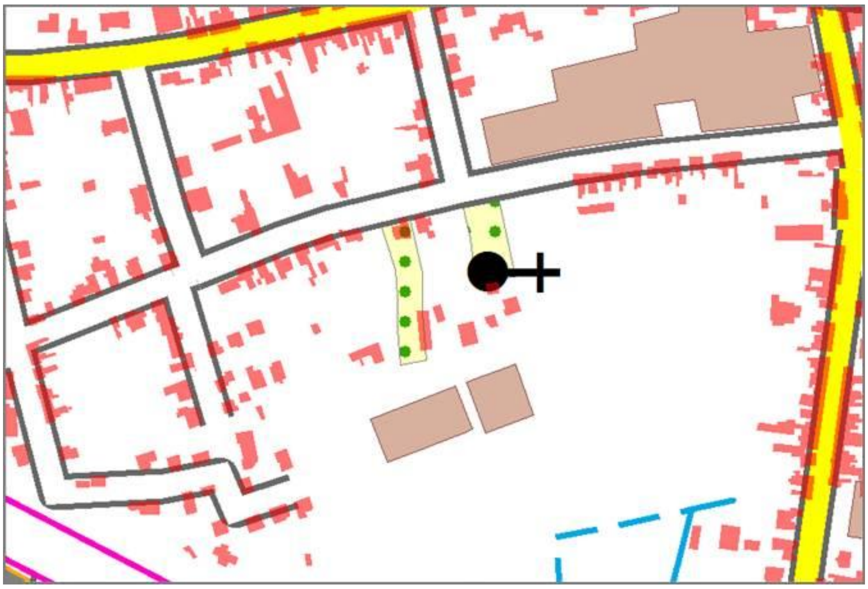
Figure 3a. Reference buildings with the already generalised roads.

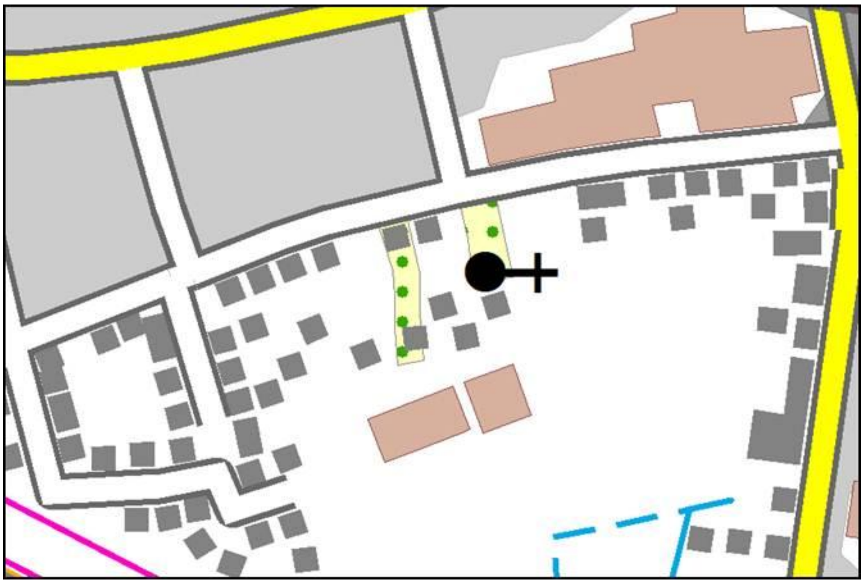
Figure 3b. The result after the automatic generalisation processes.

We have experienced a few shortcomings, which had also been pointed out to us by other MAGNET members, when we executed the displacement operation by means of the provided displacement constraint. Buildings which are contiguous before this operation is executed, no longer do so in the generalised dataset after the operation. At this moment the algorithm which is used does not take into account this existing topological relation. At road junctions we also notice that the algorithm which is used not always succeeds in avoiding overlap between buildings and the surrounding roads.

We also made a bug report about the impossibility to give the different building classes, in our case the specified and non-specified buildings, a different maximum displacement distance. This would be useful for us since the specified buildings are still generalised interactively. As the cartographer already displaced some of these buildings, we don't want the automatic process to displace these as much as the other buildings.

The most interactive adaptations, however, are still necessary because the typification algorithm is not entirely tailored to our expectations yet. It still leaves too many buildings in the dataset, as can be seen in Figure 3b. As the used value for the symbol reduction factor parameter was chosen by trial and error, changing it would do more harm than good. It should also be tested if launching a second typification operation after the building displacement operation optimizes the result.

As far as the simplification of buildings larger than 400m² is concerned, we are globally satisfied. Nevertheless, if we take into account our technical specifications, they will be rather too much simplified than too less.

## 6. Conclusion and future work

We are quite happy with the results of our tests. We definitely managed to gain quite some time by automatizing some processes. Solutions by 1Spatial for the mentioned shortcomings and bugs could of course only enlarge our satisfaction.

Future work will mainly concern the optimization of the present operations. In the short term, this means the optimization of the typification process and also the execution of automatic generalisation on the specified buildings.

In the medium term, we will focus on the automatic generalisation of the other themes, as next year will see the start of the production of the 4$^{th}$ edition of the 50.000 map series, an edition in which all themes will be updated but whose data model is still being discussed. In this area, we still have a lot of work on hand.

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