Topographic Mapping at the 1:100 000 Scale in Quebec: Two Techniques; One Product

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Abstract

The topographic mapping project at the 1:100 000 scale undertaken by Quebec aims at developing a new reference database for producing consolidated information and supporting land management. The Base de données pour l'aménagement du territoire (BDAT) (land management database) completes small-scale mapping products, specifically at the 1:250 000, 1:1000 000, and 1:8 000 000 scales. With a richer planimetric and hypsometric content, the BDAT lends itself completely to regional analysis needs and topological information systems. Indeed, the BDAT is an especially valuable map reference for anyone who needs to cover large areas. It represents an excellent compromise between the quantity of map information and the volume of data to manage.

The mapping project at the 1:100 000 scales stands out for the approach used by the Ministère des Ressources naturelles (MRN) and the novelty of the production techniques. In fact, Quebec decided to generalize provincial map data at the 1:20 000 scale in which the province had invested in terms of updating and production for a many years. Production is handled internally with the help of technical resources from the industry. Private-sector firms come to acquire skills in map generalization in order to develop this market niche. On the other hand, in order to extend knowledge of the territory up to the 53rd parallel, MRN opted to use satellite photogrammetry and produce new topographic map data from SPOT panchromatic images.

Topographic mapping at the 1:100 000 scale is a major project that will lead to the production of some 260 map sheets covering an area in excess of 1 million km^2, stretching up to the 53rd parallel north.

1. Introduction

MRN initiated the project for topographic mapping at the 1:100 000 scale in April 2000. The purpose is to propose small-scale maps with planimetric and hypsometric features to support land-management activities on the regional scale.

The project makes use of two techniques: generalization of topographic data of the 1:20 000 scale south of the 51st parallel and satellite photogrammetry to produce new topographic data coverage for the area between the 51st and 53rd parallels north (see Figure 1).

The presentation describes the process selected by MRN, the production steps for both techniques, and the resultant map product.

Figure 1: *Production index for topographic data production at the 1:100 000 scale: turquoise indicates generalization; green, satellite photogrammetry; beige, mixed areas. The blue line represents the northern boundary of map coverage at the 1:20 000 scale. In all, this amounts to 260 map sheets for an area in excess of 1 million of km^2, stretching to the 53rd parallel north.*
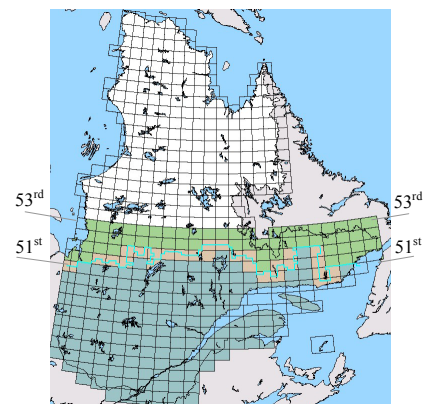
2. Two Techniques; One Product

2.1 Generalization of Existing Topographic Data at the 1:20 000 Scale

MRN opted to use map generalization for southern Quebec. The process consists in transforming geographic elements in the Base de données topographiques du Québec at the 1:20 000 scale to make them legible after scale reduction. The entire operation involves 2716 map sheets at the 1:20 000 scale and will lead to the production of 190 map sheets at the 1:100 000 scale.

2.1.1 Defining Standards

The production standards for the 1:100 000 scale were initially developed by drawing heavily on those for the 1:20 000 scale. The product contains topographic objects related to planimetry (hydrography, transportation corridors, buildings, vegetation, etc.) and hypsometry (contours and elevation points). The topographic data are structured to respond to the requirements of geographic information systems. Object geometry responds to the needs of topological systems in terms of connectivity and area closure. In addition to geometric data, the product contains complementary descriptive data (toponymy, object classes, etc.), as well as the relevant metadata.

2.1.2 Testing

A testbed then made it possible to propose a method, train staff, and set up a work flow consisting of a series of over 180 actions executed in a precise order. The testbed provided the means for determining the actions that can be automated and those that require the intervention of a technician. Since each of these operations require a number of algorithms, the testbed also made it possible to choose the best algorithms to use. (Table 1)

Table 1:

Generalization Operators	Action	Intervention	
		Automatic	Interactive
Selection	Removes less meaningful features.	X	X
Simplification (Douglas)	Simplifies the graphic representation by reducing the meanderings of a linear entity by simplifying the contours of a surface.	X	
Aggregation	Groups together a series of relatively small objects, which, after scale reduction, can no longer be individually distinguished.	X	X
Reduction	Reduces the size of features.	X	X
Typification	Reduces density and level of detail.	X	X

Note: The operators of exaggeration, classification, displacement, and smoothing, often used for map generalization, were not involved in this project. The features of the resultant map preserves all the geometric accuracy of the source data and relations.

2.1.3   Initiating Production

MRN opted for DYNAGEN software by Intergraph Corporation; the development of certain of the software's functionalities were speeded up to meet the demand. While MRN decided to carry out the project with internal resources, private-sector firms were invited to take part and also acquire skills in this precursor field. As a result, since November 2001, professionals and technical people have joined the MRN team to form the overall implementation team. It takes 4 to 5 days of work to prepare input 16 files and apply generalization operators for a map sheet at the 1:100 000 scale.

Figure 2:
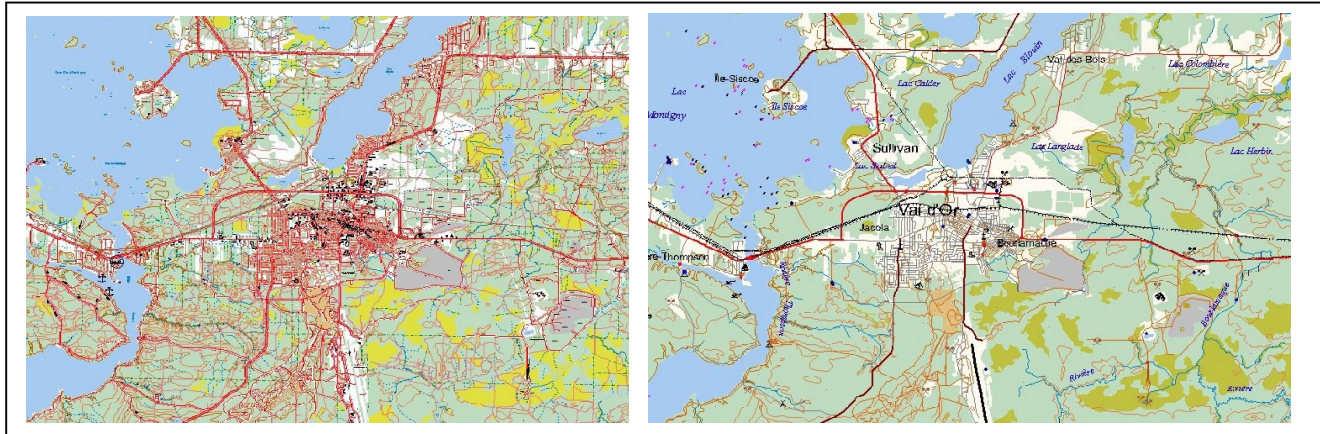
Initial map at the 1:20 000 scale	Same map after generalization at the 1:100 000 scale

2.2 Satellite Photogrammetry

SPOT images processed using satellite photogrammetry will make it possible to produce 70 topographic map sheets at the 1:100 000. The project will provide the opportunity to map the territory lying between the 51st and 53rd parallels north. The challenge facing the production team consists in using SPOT panchromatic images for topographic mapping over such a vast territory.

Satellite photogrammetry, which uses images from earth observation satellites, makes it possible to determine the shape, dimensions, and positions of observed phenomena in a given reference system. It applies the same rigor as digital photogrammetry based on aerial photography with accuracy that depends on data resolution. It should be clear that satellite images with a pixel resolution of 10 m, such as a SPOT panchromatic image, do not meet the production standards for large-scale maps. It is, however, quite suitable for producing small- to medium-scale maps, such as at the 1:100 000 scale.

2.2.1   Capturing Images

The SPOT earth observation satellite provides the oblique view that is essential to reconstituting the relief with satellite photogrammetry. Indeed, the angle of satellite sensors can be programmed to change. The programming instructions orient the sensors along two opposing angles at two different times. The two images recorded will form the stereopair of the target area. The angles for the images should ideally fall between ± 18 and ± 30 degrees.

2.2.2   Modeling Images

In the first stage of production, the image pairs are modeled using spatial triangulation to rectify and orient them in order to reproduce the earth's surface as faithfully as possible. Ground control points must be found in order to model the images accurately. Such points can come from a variety of sources such as aerial photographs and their aerotriangulation points from existing mapping work. When these data were not available, two field surveys were carried out to acquire the control points necessary in the area to be mapped. This required using a helicopter-borne GPS receptor to capture control points providing geometric (X and Y positions) and altimetric (Z positions) information. Small lakes, spits of land, and islands

visible on satellite imagery represent good choices for control points. Seven control points per 300-km strip are required, which is about one band of 5 consecutive images on one orbit.

2.2.3   *Extracting Information*

Once geometric modeling has been completed, the process for extracting the topographic information from the SPOT images begins. This information can be planimetric (hydrography, vegetation, landforms, infrastructure, etc.) or hypsometric (contours). Planimetric elements are entered using a digital photogrammetric station with a stereoscopic viewing system. The digital elevation model is semiautomated, combining automatic image correlation and manual editing. The contours are then automatically produced using the digital elevation model. Lastly, all topographic information extracted from SPOT images is structured for coherence. The mapping accuracy obtained is about 6 to 7 m along the X- and Y-axes, and 10 m along the Z-axis .

Figure 3:
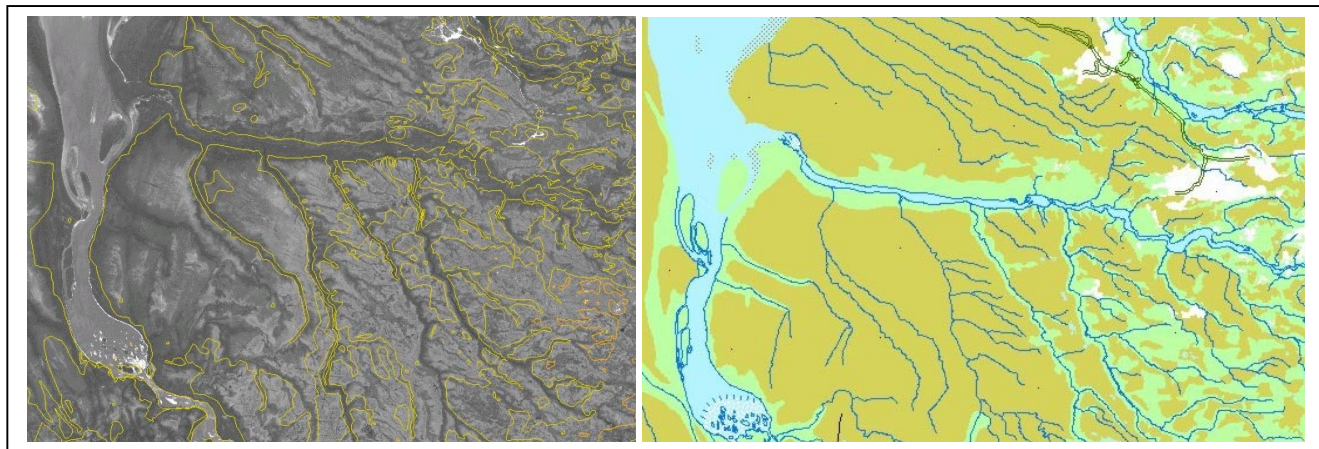
One of the SPOT images used to produce the DEM   *Plot of the topographic map generated*
needed to automatically
produce the contours (in yellow)

The new topographic data at the 1:100 000 derived from SPOT image are being produced in cooperation with firms working in the field of geomatics. In this first year, the firms are putting their expertise to work in producing 40 of the 70 map sheets for the area lying between the 51st and the 53rd parallels north.

2.3 Product Characteristics

Whether derived from generalization of data at the 1:20 000 or derived from satellite photogrammetry, the product will have the same characteristics. To begin with, it will only be available in digital format (ArcInfo coverage). Adjusted administrative boundaries will be integrated into the product.

The product contains topographic objects related to planimetry (hydrography, transportation corridors, buildings, vegetation, etc.) and hypsometry (contours and elevation points). Contours will be represented every 20 m.

File volume after generalization is 80% smaller (about 50 MB) and comparable to the results produced by satellite photogrammetry.

3. Conclusion

The topographic mapping project at the 1:100 000 scale is underway. About 80 map sheets are already available.

3.1 Automatic Generalization

The experience of the generalization team, comprising professional and technical people from MRN and industry, has proven very interesting. A new work dynamic has been implemented, giving a real boost to the implementation team.

Nevertheless, map generalization is not a simple process and it requires many adjustments on the part of the implementation team. Many changes were made in the work flow in order to preserve the greatest number of automatic actions in the generalization process.

3.2 Satellite Photogrammetry

The portion of the operation in involving satellite photogrammetry enabled the firms working in this area to fine-tune production procedures using remote-sensing imagery. The work was especially demanding in managing images that did not have the optimal acquisition characteristics for automatic correlation.   The new map data generated by SPOT has been enriched with derived products. Indeed, the digital elevation models and orthoimages used in producing maps can also be applied very effectively to geographic information systems.

The new database at the 1:100 000 scale for land-use planning provides regional development players with information perfectly suited to their needs for having an overview of the territory. These structured data can be easily integrated into geographic information systems. Moreover, the 1:100 000 scale is a good compromise between the amount of information and the size of the digital file.