CO-350

NEW CARTOGRAPHY OF FRANCE AT 1:100 000 SCALE: AN IGN MAPPED VECTOR DATABASE

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1. INTRODUCING 1:100 000 SCALE CARTOGRAPHY AT IGN-FRANCE

1.1. Presentation of the new TOP100

The new TOP100 is a topographic and touristic map series of French metropolitan territory in 77 sheets at 1:100 000 scale (Fig. 1 & 2). It is realised by the French Mapping Agency (Institut géographique national – IGN). It is in Lambert-93 projection, a conical, conform and secant Lambert type projection, and in RGF93 geodetic system.

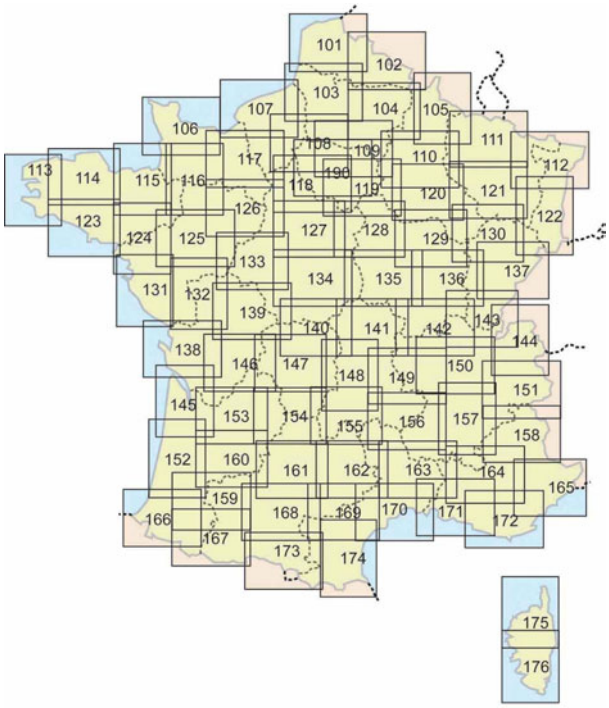

Figure 1: Index Chart of new TOP100

Figure 2:
New TOP100 cover

1.2. Historic elements

1:100 000 scaled maps have been made in the IGN since 1951. The first paper series was a military series composed of 688 sheets, completed in 1968. A first civil series had been derived during 1969. It was conceived by gathering military series sheets into a new 74 sheets series, named Série verte. It was a commercial success and the first edition was achieved in 1975. A new military series had been derived from it, starting at 1973. Touristic information has been added to the civil series to constitute the first TOP100 series at 1997. The use of IGN databases for upgrade purposes occurred at this step for the first time.

1.3. Editions and uses

In 2004 a production of a new TOP100 began; it was achieved in 2009, using 2007 data. The first edition was published partly in 2009, partly in 2010. A second edition is under development and would be delivered in 2011. TOP100 is not only a classical paper product (Fig. 3), but also a digital product. Indeed, it is used as the default background map on the IGN geo-portal at equivalent scales (http://www.geoportail.fr), and as a support map, to create a customized map for the area chosen by the user on the IGN online shop (http://loisirs.ign.fr/index.do). A military series derived from TOP100 is also realised by IGN (1st edition 2009-2011).

Figure 3: Extract from TOP100 No. 172, edition 2, *Toulon - Aix-en-Provence*

2. TECHNICAL CONTEXT FOR THE NEW TOP100

2.1. Limits of existing product and process

Considering the late 1990's context, Série verte has reached its limits. The topographic background was not up to date and did not exist as a digital layer. The upgrade of the first TOP100 was very partial despite its use of the BD CARTO® vector database. Furthermore geometries of BD CARTO® were not consistent with old 1:100 000 paper background and a double work should have been on overlapping areas; results were not consistent each with others. Upgrade was thus an unsatisfying mixed raster/vector process and

was considered too expansive. Time had come for map supersession with a new, automatic upgrade process entirely based on BD CARTO®.

2.2. BD CARTO®

BD CARTO® is an IGN database whose creation was decided during the 80's and whose resolution had been decided to be compatible with 1:100 000 scaled maps. It was achieved in the middle of the 90's. Its specifications includes the complete topographic layers needed to build a map: road, railways and water networks, land covers, main population settlements, topographic point-shaped elements (churches, castles, main water sources,…), equipment and also administrative structures, touristic information (touristic level of cities, touristic paths, main sites with touristic interest…), spots elevations... It is a 10-meter precision geographical database. It was completed with BD ALTI® database from which elevation contours could be realised.

2.3. Research projects benefits

Furthermore, in 1999, research projects dealing with generalisation and automated updating came to an end. The European AGENT project (1997-2000), led by IGN, provided automatic tools in intrinsic generalisation. It had gathered five partners: COGIT laboratory of IGN, LaserScan Limited (now 1Spatial Ltd.), the Leibniz laboratory of INPG and the Geography Departments of Zurich and Edinburgh Universities. They based their works on the PhD research works of Anne Ruas [1]. Generalisation PhD work (2001) by Matthias Bader [2] from the University of Zurich brought automatic tools in contextual generalisation. Update principles were based on PhD thesis of Thierry Badard [3] achieved in the COGIT laboratory (1996-2000).

2.4. The Carto2001 project

In 1999 IGN entrusted to the Carto2001 project led by François Lecordix [4, 5, 6] with designing the process leading the realisation and maintenance of the new TOP100 series. It was also decided to renew completely the symbolisation of the map and to use the new legal projection in France Lambert-93, taking place of four former Lambert-zones projections.

The Carto2001 project took place from 1999 till 2004 and set up main axes of the processes of map supersession and upgrade. 1Spatial Ltd software Lamps2 was chosen as GIS for production. Lamps2 provides an object-oriented, topological database. Thanks to a segmented datasets system it allows several simultaneous custom works in the same dataset.

The Carto2001 project also suggested a new specification of contents and prepared its implementation in Lamps2 and STAR-APIC software Mercator for edition.

2.5. Industrialisation in the Department of Cartography

2004 shows the end of the Carto2001 project and prototyping phase. Industrialisation process was then led by the Department of Cartography of the IGN (SDC). Map supersession and first edition run in parallel. Industrialisation process achieved in 2010. It had proceeded in four main axes.

2.5.1. Finalisation of cartographic treatments.

Specifications of the new product were naturally finalised and validated quickly. Thus the symbolisation was implemented either in Lamps2, either in Mercator, Lamps2 symbolisation being as closed as possible to Mercator symbolisation.

Cartographic treatments that needed to be achieved concerned inter-thematic coherence, generalisation (networks and points), texts placements, elements of altimetry, kilometric network and other 'minor' elements. Development team of SDC took over Carto2001 project. It finalised the topologic and semantic structure of the dataset, set the parameters of the automatic processes and organised the multi-user mode. A significant number of bugs were solved or by-passed.

Above all, it created number of control tools to fix all the unsolved problems that result from the automatic processes. In a general manner, interactive steps, managed by human cartographers, were added to the automatic steps to form a global process. A large number of views were implemented to allow interactive work of operators.

To achieve generalisation, inheritance of AGENT was implemented in the structure, more particularly for point-shaped generalisation. Texts placement was partly automated thanks to an IGN developed software WinPAT. Kilometric network was recovered from another IGN series and made denser. Elements of altimetry were recovered from BD ALTI®: a selection of elevation points had to be made and contour lines had to be treated. Apart of kilometric elements, a few other objects had to be added in the TOP100 dataset: these features were either absent elements of existing BD CARTO® layers (for instance orographic spots), or elements of absent layers (such as electric poles). All these last phases had to be realised by cartographers in interactive modes using new tools to be developed.

2.5.2. Preparation of production.

Besides, hardware settlement and organisation of training sessions had to be done. Since most cartographers worked for the first time on object-oriented topologic database, in a largely automatic process, the training had to emphasize the particularities of this approach. A documentation effort has therefore been made particularly.

2.5.3. Finalisation of upgrade process.

Besides planned finalisation of automatic upgrade process, an interactive phase had to be set up. As an unforeseen, intermediate upgrade has been decided and run in 2007, an experiment in real condition could be achieved revealing errors and lacks. These had to be resolved for the next upgrade (2009-2010). Controls had to be strengthened and a comparison with BD CARTO® reference dataset was developed. In 2008 projection of BD CARTO® has moved to Lambert-93, modifying all the update IDs. A specific process had to be realised as well to propagate this evolution in the TOP100 update process.

2.5.4. Development of the process for military derived map.

This axis of work does not concern directly TOP100 as it is mainly related to another product.

3. MAP SUPERSESSION PROCESS

3.1. General presentation

Three main steps were planned by the Carto2001 project: coherence treatments, generalisation and 'cartography' at this order (Fig. 4). As a first update of data occurred in 2007 (see 3.2), an interactive update phase needed to be implemented. Next, an additional step was added for pre-edition work. If one considers a sheet of the series, map refection was then done in five steps, corresponding to five different segmented datasets branched to main TOP100 dataset.

Each step includes sequences of coherence controls, automatic processes and interactive adjustments. For instance, in generalisation step, beams contextual generalisation is constituted by prior topologic controls, automated generalisation marking up unsolved problems, post topologic controls, and interactive resolutions of mark-ups. A paper work phase for preparation or final control can be inserted if needed. Topologic controls are systematically run at the end of segmented dataset life.

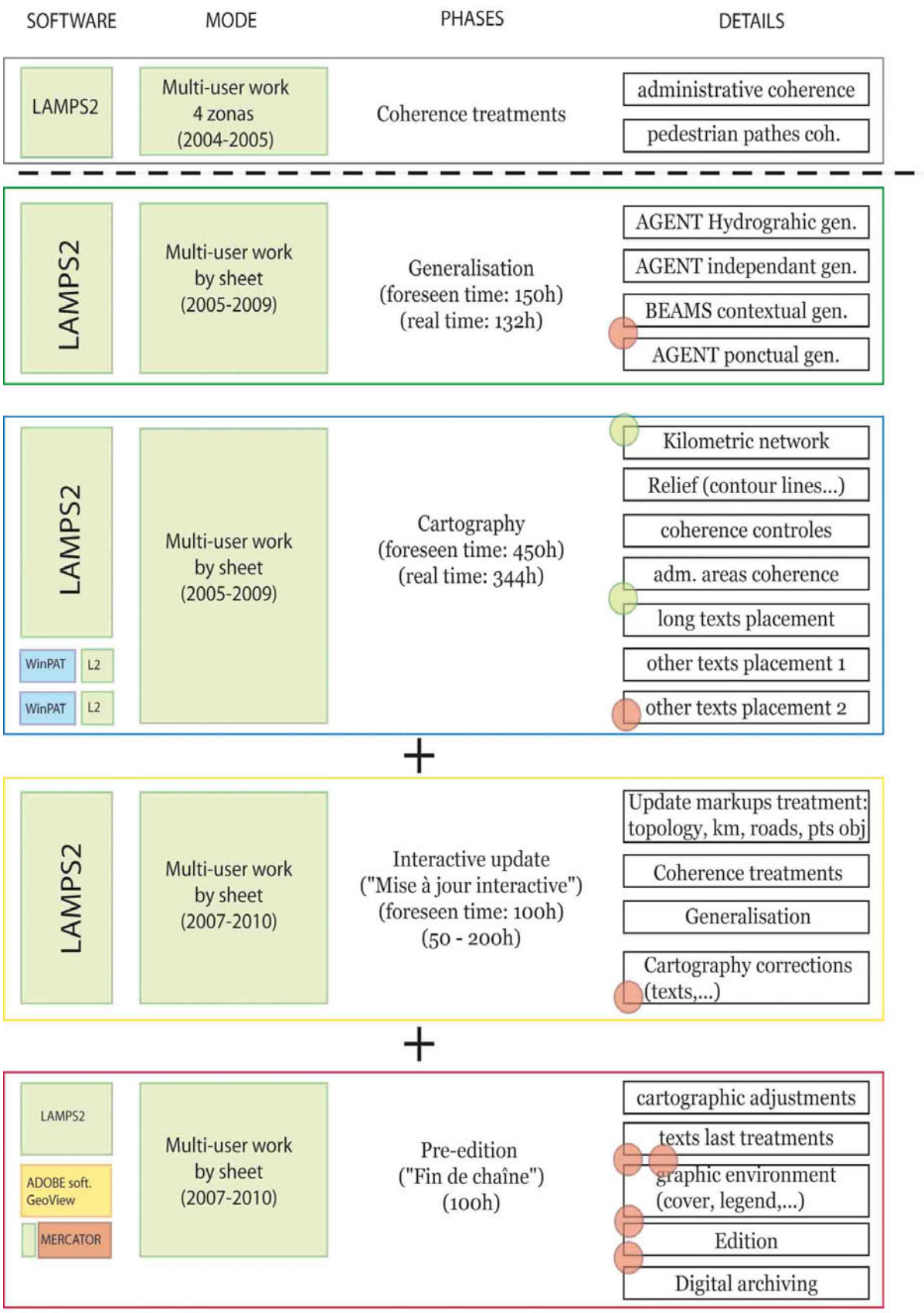

Figure 4: TOP100 Making Process
Life of a Sheet

3.2. Adaptation to production constraints

Production and developments run in parallel since 2004. Engineers carried out the support of production in the same time they provided development. Corrections could be done in a short time and steps of the process needed to be adapted as it went along. For instance coherence of regulated areas (military areas, natural parks...) with administrative lines or roads were finally realised in an interactive mode, for automatic processes created more interactive resumptions. In the same manner, the occurrences of a text placed in several sheets were increased to manage the overlapping zones and, thus, management of references between text and object wearing the text should be amended.

A hard constraint for production was the management of a unique dataset on which segmented datasets (branches) run in the same time, meaning eleven cartographers working simultaneously (Fig. 5). When work is in progress with one sheet, all overlapping sheets are locked and cannot be treated. This critical constraint was softened by grouping several sheets for certain phases, and by customising geographical extents on which branches were created.

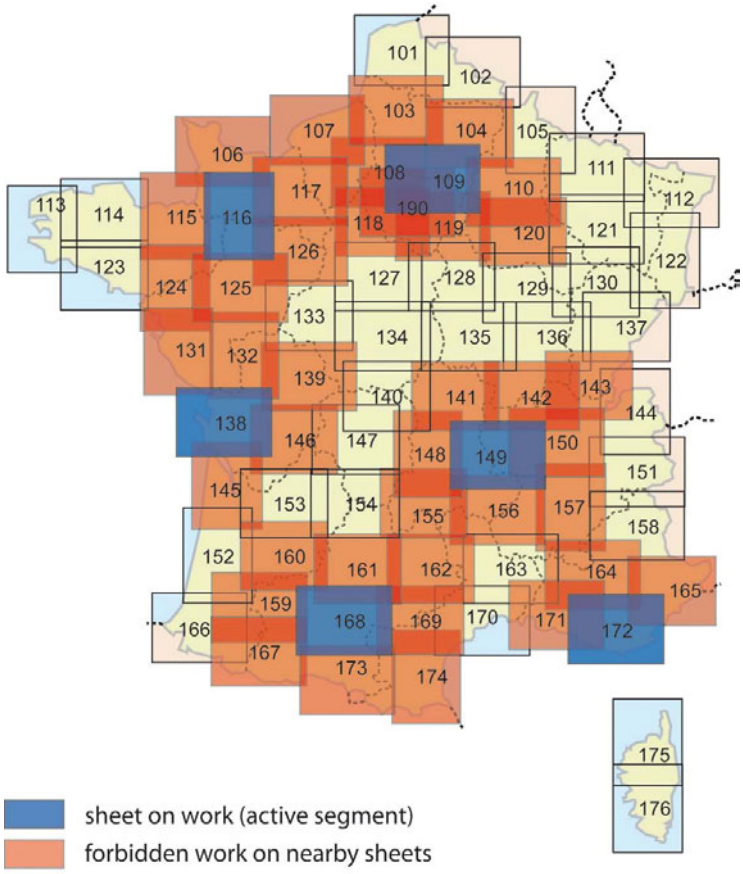

Figure 5: Constraint of Work with Segmented Datasets
Given Instance with 6 Users

In 2007 it was decided, for commercial reason, to run a first automatic update. That implied that some sheets were left at different states of supersession process. In other words, some sheets were left without being generalised or without cartography being done. Process had to be adapted to treat these different cases. Furthermore, an error in the supplied evolution dataset dragged a geometric mixture on road and railways networks points. Developments had to be found in order to bypass problems and then solve them.

3.3. Statement

Map supersession was planned for 3.5 years (2004-2008) but finally took place during 5 years (2004-2009) including unplanned update in 2007. Branches had to be stopped and / or restarted from time to time, implying work stop for agents. Despite the difficulty of production management and thanks to the motivation and efficiency of cartographers, the delay stayed reasonable. One taught lesson is that a full automatic mapmaking is currently not feasible. The quality required for this kind of map still requires interactive work by experienced cartographers.

4. UPGRADE PROCESS

4.1. Main principles

Update retrieval is run between two states of BD CARTO® corresponding to two dates: date of the beginning of the current TOP100 edition (ti) and date of the beginning of the new edition (ti+1). The retrieval attributes MD5 ID to geographic features to be updated. It creates midterm objects in charge of managing update type on objects: deletions, creations, semantic updates, geometric updates, mixed updates, scissions, fusions, aggregations, and disintegrations. These evolution-class objects refer to old or new geographic class objects, on the one hand, and class objects managing update status, on the other hand. An ESRI shape format evolution dataset (ti+1-ti) is then provided from BD CARTO® and imported to a specific Lamps2 evolution dataset. There, an automatic process is run integrating updates in the complete Lamps2 TOP100 dataset. At the issue of the automatic process an interactive process per sheet begins (Fig. 6).

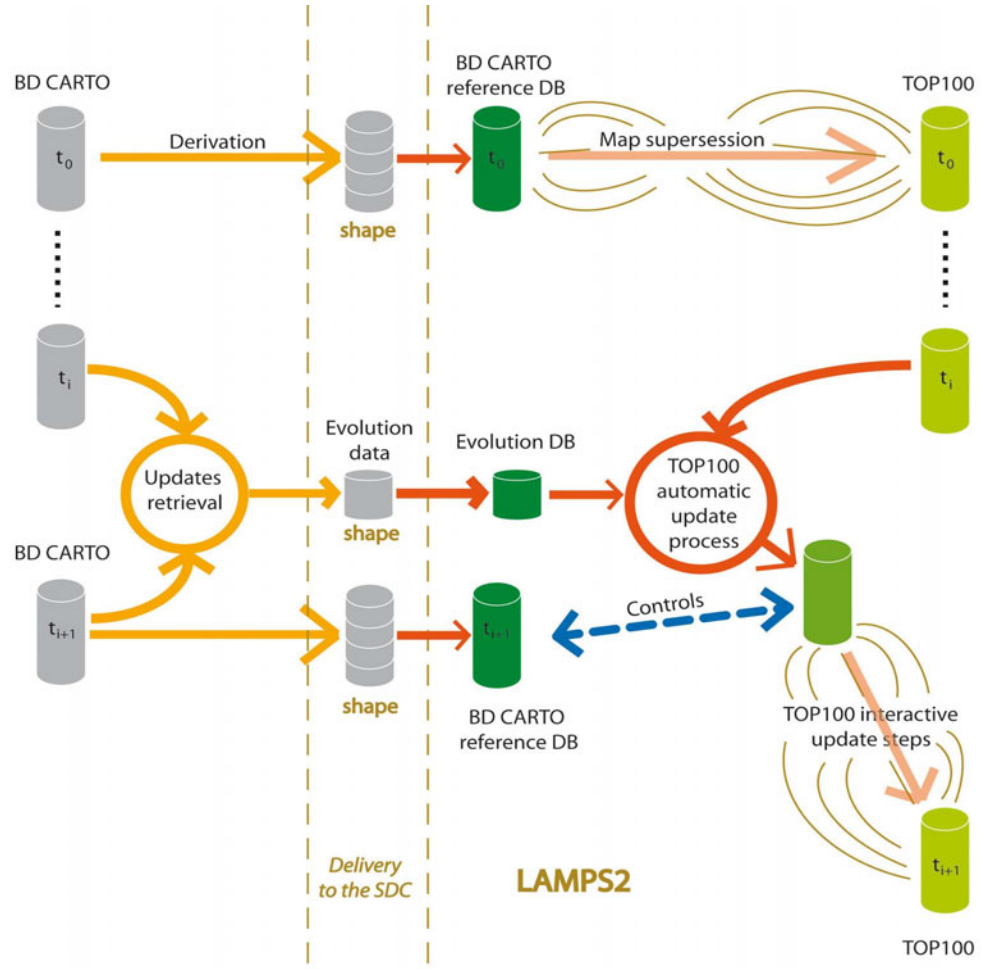

Figure 6: TOP100 Update Principles

4.2. The automatic process

The automatic process is divided into six main steps: deletion of references between objects; deletion of objects; semantic updates; creation of non topologic objects and complex objects; geometric updates and creation of network connected objects; creation of references between objects.

It is preceded by a validation phase of the TOP100 dataset (presence of IDs, of references, of initial BD CARTO® geometry, topological consistency...), by the building of Lamps2 evolution datasets, and by a geometric filtration. It is immediately followed by several controls: control of the sufficiency of the update on the evolution dataset; ID comparison between updated TOP100 dataset and a referent BD CARTO® dataset; topological consistency...). The automatic process ends with a delayed propagation allowing the creation of texts associated with linear objects (such as road numbers).

Lamps2 'object life-cycle' system is particularly used for automatic update process. A set of reflex methods instantiated to geographic class objects allow to create, modify or delete an object by checking its ability and way to be created, modified, deleted, notably in regard with dependent objects. Reflex methods

have been customised by the SDC specifically for TOP100 update process. For instance, when a road is updated, all its attributes shall be correctly populated according to the TOP100 structure and specifications of symbolisation, but also attributes of dependent road numbers.

A classical automatic update runs in around one month, for a one year update. It includes preparation and control phases. For more than 6.5 millions of TOP100 geographic objects (3/4 of whom being topologic objects), more than 200 000 objects are updated (Fig. 7 & 8).

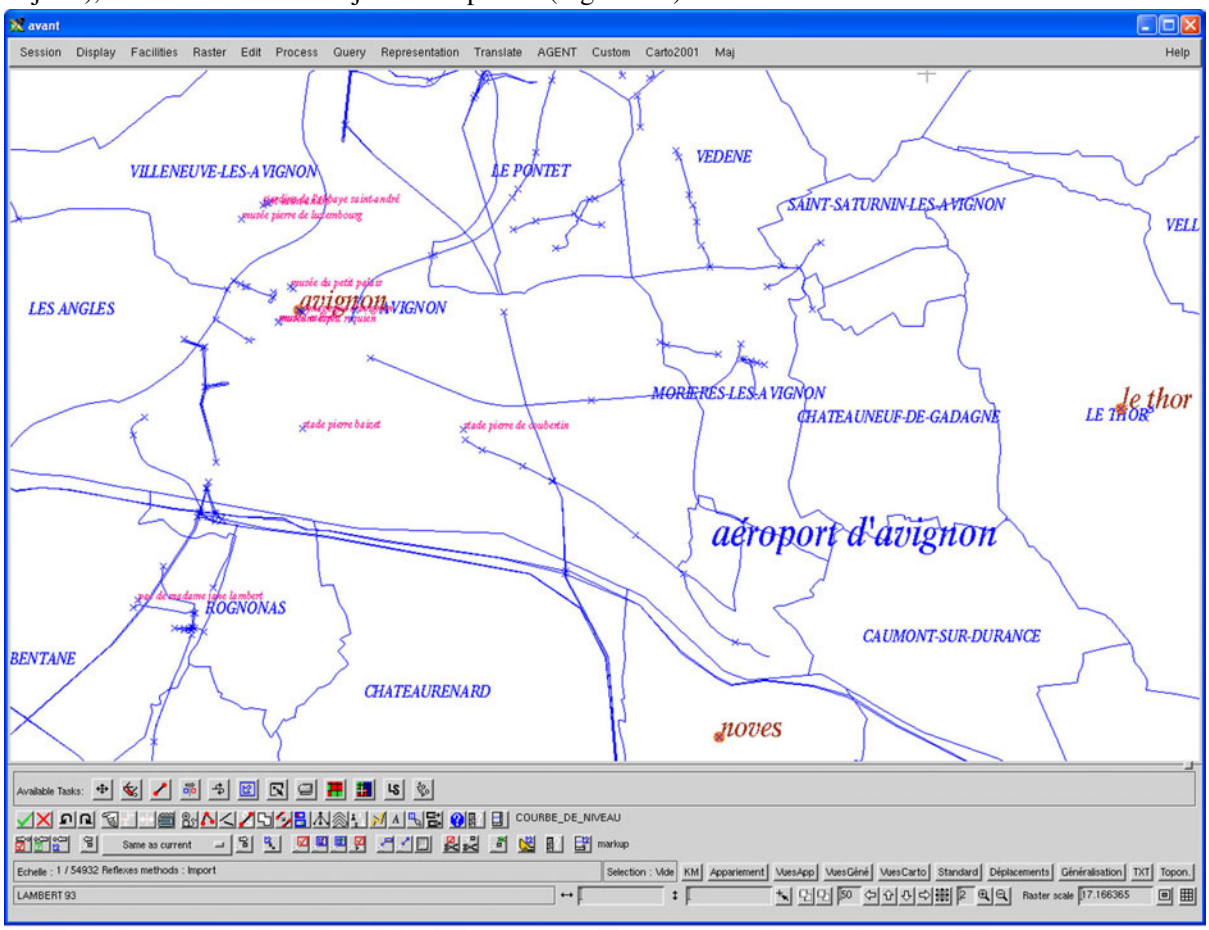

Figure 7: View of TOP100 Evolution Dataset (to compare with figure 8)

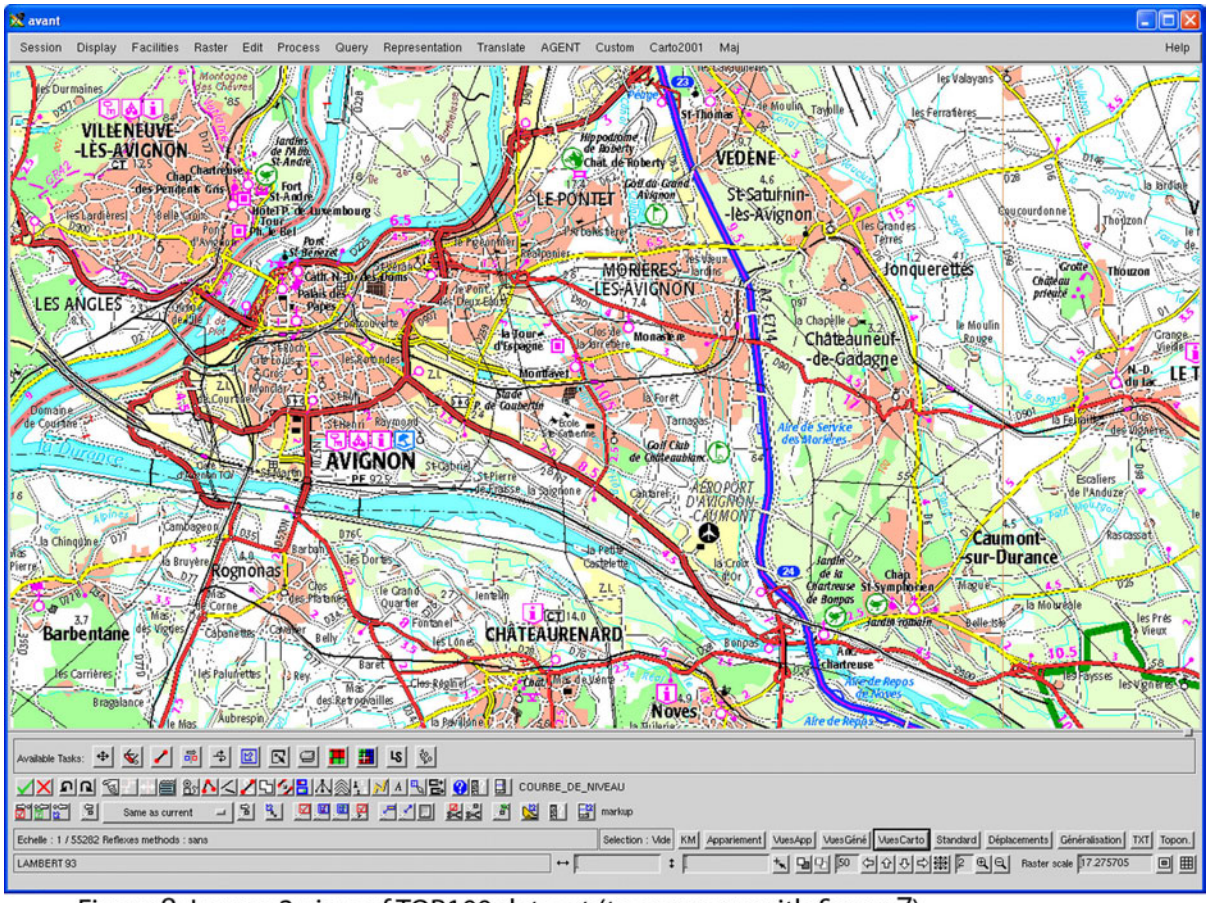

Figure 8: Lamps 2 view of TOP100 dataset (to compare with figure 7)

4.3. The interactive process

The interactive process runs in multi-user mode in TOP100. It takes up two of the supersession steps: interactive update and pre-edition. The interactive update repeats the same principles as supersession for updated objects: resumption of kilometric treatments, coherence treatments, generalisation, and texts treatment.

Six to seven people worked for the 2nd edition (2010-2011). Next update will happen in mid 2011. Then four cartographers are foreseen to work for the 3rd edition, slowing down the rhythm of upgrade to every 2 years.

4.4. Statement

The 2009-2010 update process was very particular since it took place in four steps. The 1st step consisted in fixing the geometric problem appeared during the 2007 update. The 3rd consisted in applying the projection change of BD CARTO®. The 2nd and 4th steps were classical processes (2007-2008 and 2008-2009 respectively). The update process was carefully followed and validated by comparison with BD CARTO®. It involved minor default easily fixed, and interactive update and pre-edition processes have run since without any significant problems.

Nevertheless the upgrade process remains a delicate phase for TOP100 dataset life. Updates retrieval delivering the evolution files is solely dedicated to TOP100. No change in the BD CARTO® structure has been planned and then is possible in the current process.

5. GLOBAL STATEMENT AND PROSPECT

5.1. Global statement

5.1.1. Database problems

BD CARTO® themes are not complete in the same ways. Some themes, such as hamlets, are very frequent implying impossibility of an optimal text placement; others, such as elevation spots or footpaths appear in a rather partial manner in the database. In addition, from a semantic point of view, other themes are difficult to complete; for instance sand zones that are not separated into wet or dry zones and cycle paths that are mentioned only when they are independent from classical roads. Furthermore, since contour lines are created from an extra database, inconsistencies appeared with water surfaces.

Solutions have been partially settled: elevation spots have been digitised from former TOP100 or wet sands have been digitised thanks to the tide line. A choice had to be made by the cartographers for names of hamlets. Yet in regard to former TOP100, vineyards and orchards cannot be distinguished, cliffs and embankments have disappeared and above all, isolated buildings do not exist anymore.

Moreover the high number of objects in database (19.5 millions of objects in 415 classes, among whom 96 classes for 6.7 millions of geographic objects) engendered a significant number of errors or particular cases to be treated interactively.

5.1.2. Software problems and solutions

Besides obvious advantages, Lamps2 GIS suffers from problems which can hardly be surmounted despite an active support by 1Spatial Limited.

Hill shading cannot be included in Lamps2 environment since transparency is not possible. Area patterns could not have been settled. There is therefore no complete WYSIWYG work with Lamps2. Cartographic tools are not complete, especially for text management. Apart of memory overruns, a few structural instabilities might occur. Topologic and geometric management thanks to specific primitives are complex and create problems with segments for multi-user mode or emergence of 'orphaned' topologic primitives – meaning primitives without any geographic associated object. For this last problem 1Spatial provides a transfer of all the data from the production dataset to a new empty one before and after every automatic upgrade phase.

Moreover Lamps2 version now runs in an obsolescent application development environment GOTHIC4, which was upgraded by 1Spatial Ltd. before 2004 to GOTHIC5. The IGN is now the sole user of GOTHIC4 Lamps2. The IGN is currently leading a study to test an upgrade of the TOP100 from GOTHIC4 to GOTHIC5. This upgrade should solve some problems of consistency; give more efficient tools to solve the other ones; and allow the IGN to run on its own the transfer to delete the 'orphaned' primitives. Furthermore, 1Spatial support could be then more assumed.

Despite the fact that Lamps2 is the main software in the TOP100 process, interfacing makes it delicate. Lamps2 needs a UNIX-Windows emulator to run. There is no support for the emulator, which is not optimised for French language. Interfacing between Lamps2 and Mercator had to be developed and is now fixed and secure. Direct printing from Lamps2 is also delicate. Finally the path for update retrieval from BD CARTO® to Lamps2 is complex and very specific. This point is also currently under study.

5.1.3. Designing problems

In addition to the above mentioned problems (coherence, generalisation), one can regret that some parameters should have been more accurately defined for generalisation. Intrinsic linear generalisation is often considered as too smooth. A difference between mountain and plain networks should have been settled. In a general aspect, the process is highly complex and very specific.

5.1.4. Production management

As complex process, it needs much specialised cartographers and engineers. The engineer support is very important, particularly during the upgrade automatic phase. As previously said, the multi-user mode is very restrictive in term of organisation of production. Moreover, during automatic upgrade phase most of the TOP100 cartographers are in technical stop.

5.1.5. Positive balance

The Carto2001 project planned map supersession in less than 800 hours per sheet. Indeed the map supersession occurred in approximately 605 hours per sheet. 300 hours per sheet were needed in 2003 to upgrade essentially roads network. 100 hours were planned for the new TOP100. Reality gives less than 120 hours to upgrade all the themes except land cover and water network. Even if the objective cannot be reached because an entire automatic process is impossible at this quality level, the time-saving is also obvious in regard to the former process.

New TOP100 was a commercial success in its paper format. The modernisation has been well received by the public at large. TOP100 product is a modern, harmonious product. TOP100 process provides now a 1:100 000 scaled, mapped database, which is currently used for other products (military maps, hiking maps in Alps...).

5.2. Current studies

TOP100 process shall evolve. As already mentioned The IGN is studying the ability to be upgraded in GOTHIC5. It is needed to test how to manage with AGENT tools, for GOTHIC5 benefits from last stable version of AGENT environment, whereas AGENT libraries are more ancient in GOTHIC4. As most of the mapping process in the IGN run in Geoconcept SIG, another idea is to migrate the Lamps2 dataset to a Geoconcept dataset. The SDC has already and successfully tried out the migration for the military map.

The export is done from Lamps2 format towards ESRI shape format, which is then imported in Geoconcept. The main flaw of the method lies in text export. Text cannot be exported towards shape format. They lose their references with the original geographic objects and more over, curved texts are exported letter by letter. A midterm could consist to apply a process similar with Carte de Base type 2010 process.

In a long term prospect, acquisition of isolated buildings is planned. In a very long term, water networks shall be updated as well.

5.3. TOP100 in a wider context

5.3.1. TOP100 experience for Carte de Base type 2010

The IGN 1:25 000 scaled map will enter in a new complete supersession in 2011. The Nouvelle carte de base project has worked since 2004 at this important point. A complete mapped vector database dedicated to the new 1:25 000 scaled product called Carte de Base type 2010 is going to be produced during 10 years. Type 2010 will be derived from BD TOPO® database, as BD CARTO® part of IGN BD UNI® product, yet at a greater scale. The Nouvelle carte de base project has benefited from new TOP100 project and industrialisation. In particular, a single dataset in multi-user mode has been abandoned. GOTHIC platform is now used only for generalisation, whereas beams tools have been increased, and mapmaking is made on Geoconcept GIS. The acceptance of the product by the SDC before industrialisation is stricter than for TOP100, due to experience.

5.3.2. New department for developments

In term of organisation, the IGN set up in 2010 a new department in charge with developments which will be the interface between research projects and production departments. A map making pole takes place in this department as a successor of previous Carto2001 project and Nouvelle carte de base project.

5.3.3. Towards FRANCE100

One of the main projects of the department of developments is to build a pyramid of mapped, vector databases at different scales used in the IGN. Mapped, vector databases at scale of 1:1 000 000 and 1:250 000 already existed. Since 2009 a 1:100 000 scaled, mapped database exists as well. In ten years such a database will exist for the scale of 1:25 000. All these databases will provide different layers (FRANCE25, FRANCE100...) of the future pyramid. Thus life of TOP100 dataset will continue in a larger environment.

6. REFERENCES

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