

Recent Improvements to the Digital Files of International Borders of France

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SUMMARY

The French National Geographic Institute (IGN) continuously improves its digital geographical reference data. The digital files of international borders of France had been provided to the European Location Frame (ELF) project which produces edge-matching tools (it aims to enable interoperability in accordance with the INSPIRE directive). A comparison of the boundary lines in the large-scale datasets of other national mapping or cadastral agencies made it possible to adopt, almost everywhere, a technical compromise line, which will be improved by the work of Joint Boundaries Commissions.

RESUMÉ

L'Institut national de l'information géographique et forestière (IGN) améliore continuellement ses données géographiques numériques de référence (RGE). Les fichiers des frontières internationales de la France ont été fournis au projet de Cadre européen de localisation (ELF) des agences nationales de cartographie ou de cadastre (NMCA). Ce projet réalise des outils d'appariement entre fichiers de données géographiques afin de faciliter l'interopérabilité demandée par la directive INSPIRE. La comparaison des lignes-frontière dans les différents jeux de données à grande échelle a permis à l'IGN d'adopter presque partout, avec l'agence cartographique du pays voisin, une ligne de compromis technique pour le projet ELF; elle sera améliorée par le travail des commissions mixtes de délimitation ou d'entretien des frontières.

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1. INTRODUCTION

We will describe how the National Institute of Geographic and Forest Information (IGN) is improving the digital files of international borders of France.

This work is carried in collaboration with neighboring countries, in the framework of EuroGeographics (the association of European national mapping and cadastral agencies) and of the joint demarcation committees (*commissions mixtes d'abornement*) when they exist.

2. SOURCE OF BOUNDARY FILES

2.1 Plotting on topographic maps

International boundaries are first-order administrative boundaries. The surveyors of the *Service géographique de l'Armée* (1887-1940) and then those of IGN (*institut géographique national*, 1940-2011; now *institut national de l'information géographique et forestière*) had surveyed administrative limits on the photogrammetric plot of the initial edition of topographic 1:20 000 maps by reference to the cadastral map, with proportional dividers.

Then, for updating the 1:25 000 topographic maps, the possible changes of municipal boundaries were plotted from the cadastral map (Bacchus, 2004).

However, the national boundary survey has a specific process: the surveyor reads the text of delimitation treaty (and demarcation records, when available), he seeks for the boundary-pillars with the assistance of local authorities and he surveys these marks, most of them being identified on the printed map.



Italie, 1825



Espagne, 1863 + 1959



Espagne, 1868

According to the text of the treaty, the boundary between the marks may be a straight line or it may follow a topographic element (path, river, divisoria); then, especially in mountain areas, the plotting on the topographic map is often more precise than the cadastral line.

2.2 Topographic data bases

The Cartographic database (BD CARTO), issued of digitizing 1:50 000 maps, has provided, in the late 1980's, an administrative limits file with a ten-meter accuracy.

Since the end of 1990's, IGN's main task is to build and maintain the large-scale reference frame (*Référentiel à grande échelle*: RGE). It is composed of four interoperable databases: orthophotography database (BD ORTHO), topography database (BDTOPO), Postal addresses database (BD ADRESSE) and Land Parcels database (BDPARCELLAIRE, made in collaboration with the Tax Department). The photogrammetric survey of the topographic layer (BDTopo) meets the one-meter accuracy for all topographic features which are not hidden by vegetation cover. The administrative boundaries layer does not yet meet everywhere this one-meter standard. Often, the large-scale administrative boundary was first derived from that of the BD CARTO (up to 30 meters); when the limit seemed to follow an object in the topographic database (way, stream), it was merged with it and in this case has the same accuracy as the object (if it is indeed the holder of the limit and that its path has not been modified).

2.3 Cadastral files

The Tax Department (*Direction générale des finances publiques*: DGFip) has digitized cadastral maps of every French municipality; it provides the PCI (*plan cadastral informatisé*) on www.cadastre.gouv.fr, either in Raster mode or in Vector mode (80 %, growing).

Adjusting and assembling these digital sheets, IGN has made a continuous Parcels database (BDPARCELLAIRE), which is part of RGE.

Sometimes, the cadastral maps of two neighboring French municipalities (communes) do not match: the limit is not the same on the different sheets. Indeed the territories of French municipalities were demarcated as the first stage of cadastral surveying, in the first half of the nineteenth century (Clergeot, 2007).

Establishing a single cadastral representation (*représentation parcellaire et cadastrale unique*: RPCU) with verified communal limits was decided in May 2014 and production by DGFip and IGN began, but it will last ten to twelve years to be completed.

3. EUROPEAN CONTEXT

3.1 INSPIRE directive

The European directive 2007/2/CE, establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), aims to ensure interoperability between databases and to

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facilitate the distribution, availability, utilization and reutilization of geographic information in Europe.

The Ministry of Ecology and Sustainable Development led the transposition of the directive into French law in 2010. Within this ministry, the Department of Research and Innovation (DRI) is INSPIRE's national contact point, responsible for relations with the European Commission. The National Council for Geographic Information (CNIG) is responsible for the national coordination structure. The IGN backs the CNIG for the implementation of the INSPIRE directive in France, and more generally, for the implementation of the national policy of geographic information.

To ensure cross-border interoperability between databases, INSPIRE directive says (art. 10.2) “*In order to ensure that spatial data relating to a geographical feature, the location of which spans the frontier between two or more Member States, are coherent, Member States shall, where appropriate, decide by mutual consent on the depiction and position of such common features*”.

The National Mapping and Cadastral Agencies (NMCAs) of Europe are specially concerned by this article 10.2. They were yet involved in edge-matching topics since a long time, for instance in the production of pan-European databases by their association EuroGeographics.

3.2 EuroGeographics products

Three EuroGeographics databases provide international boundaries as a part of their administrative layer.

EuroGlobalMap is a 1:1 million scale cartographic dataset covering 45 countries and territories in the European region. The administrative boundaries theme holds information on the administrative entities down to NUTS3 level and their administrative hierarchy. It is now available as open data.

EuroBoundaryMap (EBM, formerly SABE) is a Seamless geo-database of Administrative Boundaries of Europe at the scale 1:100 000 covering 41 countries. It contains geometry, names and codes of administrative and statistical units continuously updated by NMCAs of Europe. It links to the updated statistical LAU- and NUTS-codes for all local administrative units of the 28 member states of the European Union.

EuroRegionalMap (ERM) is a pan-European dataset containing topo-geographic information at the scale 1:250 000 (v6.0 is covering 33 European states). It is a seamless and harmonized data and is produced in cooperation by the NMCAs, using official national databases. ERM contains seven themes; the administrative boundaries theme holds information on the administrative entities up to the lowest level and their administrative hierarchy. A unified coding system for all the administrative levels is included.

For each of these databases, a coordinating NMCA had edge-matched national files. Since 2013, the common EBM/ERM set shows two different lines when official data of neighbouring countries disagree on state boundary.

3.3 Bilateral agreements between NMCA's

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French cartographic agency had bilateral agreements, for exchanging maps and geodetic data or for managing cartographic representation of foreign territory on topographic maps, with Belgian and Spanish IGN, Luxembourg ACT, three German Landesvermessungsamts, Swiss Federal Office of Topography (Swisstopo) or British, Italian and Spanish Military Geographic services. From the 1980', IGN prints on its topo maps a *facsimile* of the foreign map – and sometimes there were gaps between images of the two countries on French map –.

This topic has been revolutionized by the evolution to digital (Lecordix 2013): some of these agreements have been updated, others are now obsolete.

3.4 EuroGeographics projects - SBE

The *State Boundaries of Europe* (SBE) exchange network of EuroGeographics [formerly EuroBoundaries Project] was created to compile a multipurpose dataset, meant to be the “definitive” description of the national boundaries of European countries vision and long term goal. The SBE project aims at providing and maintaining:

- the administrative and legal definition of State boundaries, based on boundary Treaties,
- their precise geometric description expressed in ETRS89 coordinates of boundary points, marks and lines,
- as an intermediate solution, if data related to Treaties is not available, the most accurate boundary representation based on large-scale national dataset (topographic or cadastral).

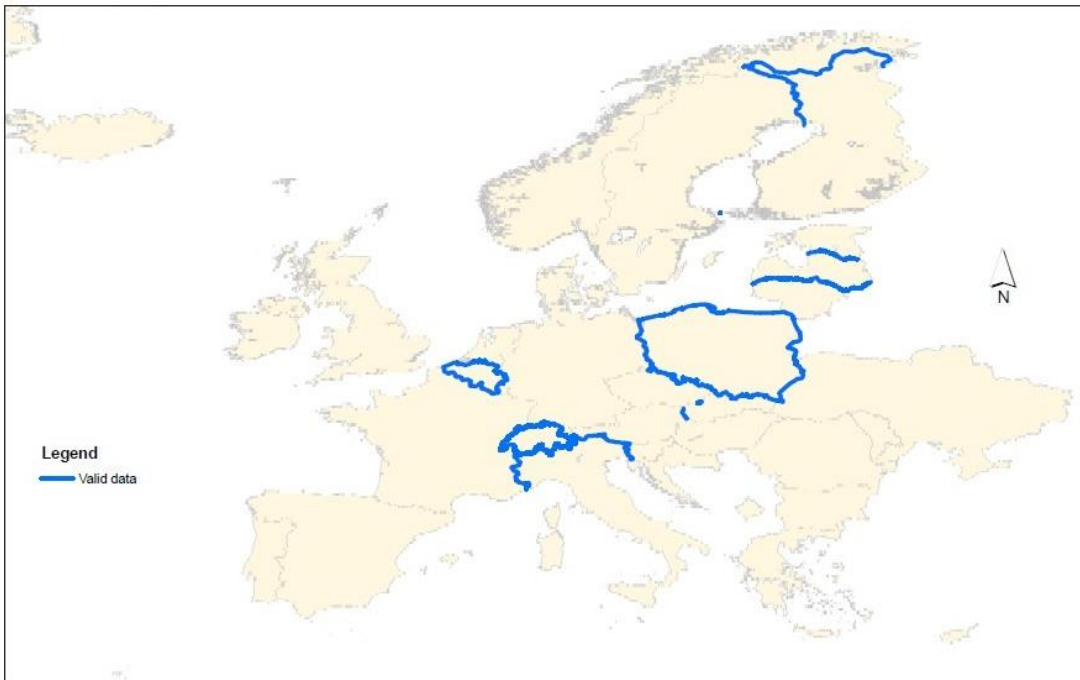
State Boundaries of Europe (SBE) will be realised for different levels of detail:

Level of detail	Scale	Type of data	Realisation
Treaty level	cadastre scale	high precision coordinates of boundary points and lines	long-term
Master data level	1:10' to 1:50'	large scale boundary lines from national basic cadastral or topographic database	mid-term → E.L.F. project
Regional level	1:100' to 1:250'	agreed state boundaries for use at medium scale → common boundaries EBM/ERM	first version available (2013)
Global level	1:500' to 1:2 M	generalised version → EGM	(end 2013)

SBE Data is archived by the Swiss NMCA, Swisstopo.

“State Boundaries of Europe” project progress on 13th October 2014.

Scale: 1:25'000'000



First meeting of SBE as a new KEN (Knowledge Exchange Network) was held in Vienna on 16-17 October 2014, attended by 26 representatives of 15 members (22 physically and 4 by webinar). Priority was given for providing data for E.L.F.

3.4 EuroGeographics projects - ELF

The goal of ELF Project (<http://www.elfproject.eu>) was to deliver the *European Location Framework* (ELF) required to provide up-to-date, authoritative, interoperable, reference geo-information for use by the European public and private sectors. Preparing the implementation of the INSPIRE Directive, the Project has produced tools for cross-border edge-matching of Reference Information from European NMCAs; it needs an International Boundary layer (IB) shared between the neighboring countries (managed by German BKG).

French IGN had yet provided to SBE Project a BDTopo dataset (Master Level SBE), late 2013; then it provided this dataset to the ELF project as IB layer.

The IGN's objective was to have metric-precision lines on all French borders, provisionally agreed with neighboring countries, before the end of 2016. The European line has been chosen (Vergez, 2016) according to the following criteria:

- a temporary consensus and only technical validation
- in cases of more than 10 m discrepancy, an intermediate line is adopted
- if irreconcilable case, 2 lines are proposed.

The progress of this work can be followed on <http://cnig.gouv.fr/APIGeoportail/PageAPI.php>.

4 JOINT DEMARCATION COMMITTEES

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4.1 Maintenance Commissions

International agreements organize the maintenance of border pillars and French border line with three countries: Switzerland (1965), Spain (1973) and Italy (1983). Three joint *Commissions mixtes d'abornement* (CMA) are planning the field work of “*délégués à l'abornement*” (in charge of pillars maintenance), the publication of official documentation and all other issues (Devemy, 2016).

In mountain areas (Alps and Pyrenees) where the cadastral map is of uneven quality, IGN has made, in 2006-2007 and 2014, a photogrammetric plotting of the topographic features (ridge lines, roads and rivers) on which relies the boundary line.

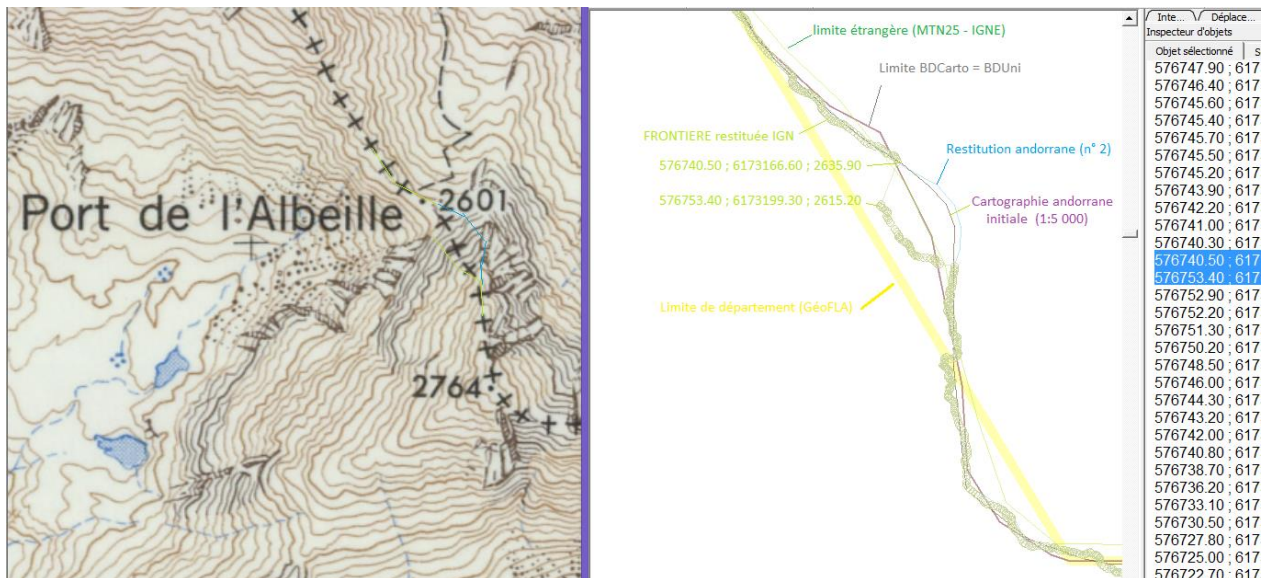
The French IGN and the Italian Military Geographical Institute (IGM) completed (from 1989 to 2008) the geodetic measurement of the coordinates of the seven hundred boundary markers (started in 1947-48, 1962-63 and 1975). IGN and IGM compared their photogrammetric lines, in the office and in the field from 2010 to 2016 (with Helicopter in higher mountains), achieving agreement for all segments between markers (except for Mont-Blanc area).

The GPS survey of the Franco-Spanish border marks began in 2011, with Spanish IGN and Army geographical centre. Most parts where border line does not follow a crest (dividing line) have been completed and the line is very accurate where it is straight line between the marks. Lesser priority was given to higher marks, of costly access. Temporary digital Franco-Spanish border, issued from comparison of photogrammetric plotting, will be improved with the progression of measurement of markers.

The comparison of the French and Swiss lines will lead to the adoption of the Swiss line, based on numerous points whose coordinates are known; it is generally in good agreement with the French cadastral plan.

4.2 Demarcation Commissions

A boundary delimitation commission with Andorra (2001-2011) has agreed on a Treaty, which was signed 2012-03-06 (effective date 2015-09-01). Photogrammetric plots will be used in 2017 by the demarcation commission for digitally define the boundary line along the Pyrenées ridge, along the Ariège River and between some points defined in the Agreement.



The Brazilian-French Joint Commission for the Demarcation of Border convened ten conferences from 1955 to 2011. The boundary of French Guiana follows the Oyapok River (whose thalweg was mapped in 1956) and a watershed surveyed in 1955-56. This dividing line is marked with seven pillars set in 1961 and 1962, whose astronomical coordinates were measured in 1954-1955 and formalized by an agreement signed in 1980 and published in 1982 (the pillar of triple point with Suriname was set in 1937). The photogrammetric control of official 1:50 000 boundary maps is based on these astronomical coordinates.

GPS coordinates were measured jointly in 1991 for only two pillars (and three additional terminals) and unofficially in 2015 for the others. Recent French 1:50 000 map, based on SPOT imagery, has aligned the boundary line on the watershed of SRTM altimetry and the main course of Oyapok.

4. CONCLUSION

The creation of a digital line of the national frontier, shared with the frontier countries, will facilitate the connection between the geographical objects of countries, for example the natural areas to be protected. Its use by applications on smartphones will also make less useful the materialization of the boundary by pillars but these will remain heritage objects, witnesses of the history.

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BIOGRAPHICAL NOTES

Mr Michel Bacchus, Geographic Engineer (IGN, 1973-2014) was involved in topographic maps updating, then in managing IGN map-library and photo-library; he was a member of French delegation in joint boundary commissions from 1988 to 2014.

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