LANDSAT AND SPOT HIGH RESOLUTION SATELLITE IMAGES : A NEW COMPONENT FOR GEOGRAPHIC DATA BASES

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ABSTRACT

Satellite imagery with infra-hectometric ground resolution constitutes an apport without former example for automation in cartography. Satellites represent first of all an automatic way for data acquisition, due to their mondial extension capacity and to their repetitivity, largely improved by the possibility of oblique views (SPOT) and stereoscopy. But they bring also a very important advantage for processing and representing geographical data.

After centuries during which the draftman's hand, relayed by printing techniques, attempted to represent the real world on maps made with lines and points, satellite imagery supported by computer facilities brings suddenly a two-dimensional representation, made with surfaces and directly usable as cartographic material.

It may be of interest to think about the primary function of topographic base maps : representing all features existing on the Earth surface, and the form of it (altimetry), they constitute basically a framework through which everyone can recognize and orientate himself in his environment. From that point of view, and particularly in new countries with little planimetric density, where natural features are the majority (and how difficult to compile with conventional techniques !), satellite images after rectification and stereo-compilation for altimetric survey can play the role of a fundamental geographic background.

Together with the possibility of semi-automatic interpretation for up-dating certain topics of conventional maps and for the inventory of natural resources, the availability of new mass storage media like the digital optical disk makes it possible for satellite images to take place into geographic data bases.

INTRODUCTION

Since the advent of aerial photography and photogrammetric techniques, the image recorded remotely from the ground provides the core of identified, selected information represented on topographic maps. Common denominator of the needs of all those who use a comprehensive description of the Earth landscape, topographic maps are turning gradually, since the advent of data-processing, into geographical data bases accessible to all and in every form. Within this context, satellite images constitute the synthesis of these two evolutions : both objective recordings and digital data.

However it is only since the advent of infra-hectometric resolution satellites such as Landsat Thematic Mapper and SPOT that one can really talk of a contribution of space techniques to basic cartography. Moreover, their practical applications are still very little developed though their number and variety appear as promising, and even lead, most of time, to create utterly new products.

Among these applications, one can note that, if high resolution satellite images can be the source of numerous topographic data, they can also constitute, like aerial photographs as well, the basis of the cartographic representation itself, ultimate object of the geographical process. This possibility is better exerted as images will be more easily interpreted by users, in another word as features will be more legible, either by preponderence of natural features (of larger size, in general, than human artefacts), or by fineness of ground resolution.

Of course, along with these innovations, some problems, new themselves too, arise, about which questions have to be asked : how to choose efficiently, for instance, a minimum of conventional topographic data, required for the user's elementary reference marking, to superimpose them on an image where, by that very fact, there is no "blank" ? How to classify, in terms of specifications, the various realizable documents and their semantic contents, their accuracy and conditions of use ? In what conditions digital images come from space will then take place into geographical data ?

It is to these various points that the present communication wishes to draw attention.

A - THE IMAGE, BOTH SOURCE AND REPRESENTATION OF GEOGRAPHIC INFORMATION : VARIOUS POTENTIAL APPLICATIONS

It is undoubtedly no use reminding that image processing is one of the main forms of automatic cartography. However can be recalled the fields in which one expects to find the most important applications : revision of existing maps, carrying out of new basic tools (control networks, digital terrain models,.), production of new topographic maps and new thematic documents.

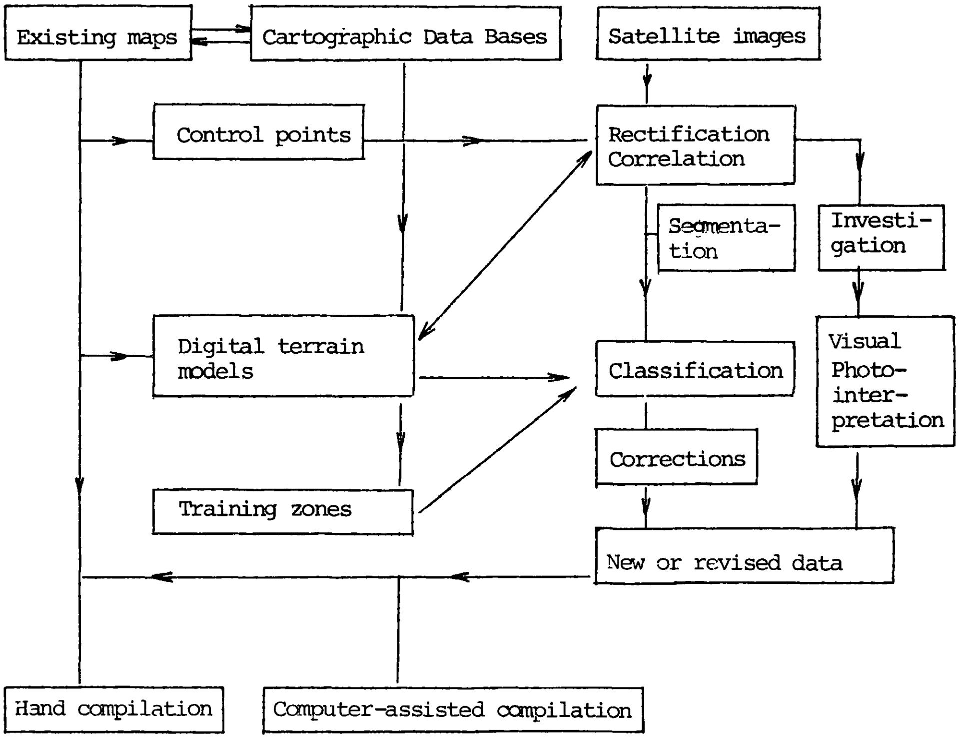
The revision of existing maps can be supported by a double step :

(i) a process of automatic read-out, based on artificial intelligence, either by radiometric classification of pixels taken individually, or segmentation of the image into strips or pattern recognition (i.e. sub-groups of pixels belonging to the same feature) followed by a classification of features obtained from their statistical "signatures" ;

(ii) a process of visual photo-identification, according to which the cartographer compares the contents of image and map, analyzes the modifications made, sets them up and ensures their map compilation.

This last method is practically the same as the one usually carried out with aerial photographs, and it allows to process all the topics which can be identified on the satellite image. On the other hand, the first process can be applied only to topics currently accessible by automatisms, i.e. for radiometric classifications, to surface topics such as forests, water, towns. For pattern recognition algorithms, application fields are still little explored, but logically, for all the fields processed by photo-identification, it should be possible, in the future, to process them by artificial intelligence, including taking into account the stereoscopic effect and the 3rd dimension.

The whole of possible processes can be schematized in the following form :



For the time being, the practical difficulties to be solved, apart from theoretical difficulties of artificial intelligence algorithms, can be of two types :

. the "semantic" contradiction which exists between the realistic terrain image, at a small scale, and the map cognitive image : the language of shapes is not the same and the very position of features read-out from satellite information is frequently incompatible even in the absence of error from the map, with that of corresponding features on the map, which have been shifted for problems of symbolization and juxtaposition, and this the more as small scale is used ;

. the complication brought sometimes by the space process within a cartographic chain already complex : actually, the satellite image does not permit, for the moment, to identify with certainty all the topographic features represented on maps ; then it must be completed by the use of aerial photographs or other sources of information. Thus while speeding up considerably one part of the operations, it does not outdate the other processes and is superadded to them.

Moreover it leads to a partial autonomy of small-scale map updating with respect to that of medium-scale base maps, which may introduce transitory difficulties in the management of cartographic programmes.

The carrying out of new basic tools, such as geodetic control networks and digital terrain models, is part of the initial phase of photogrammetric processes. The principle of these determinations lies on the geometry of models made up of images covering all in one block broad areas (34,225 sq.km with Landsat, 3,600 sq.km with SPOT), and still much more if one uses consecutive images belonging to the same orbit, and representing a same continuity of recordings, forming "strips" of images.

SPOT images modelling lies itself on the characteristics of the push-broom sensor which imposes a fixed geometry to the successive lines of images but renders these ones unfit for conventional photogrammetric plotting on analogical instruments. On the other hand, analytical plotters, computer-aided, are adapted to modelling of such images provided that ad-hoc software (case of Traster T1 from MATRA), developed by IGN-F, are transformed. This modelling lies on two types of information :

. control points on the ground, at a minimum number of 3 theoretically per scene, practically 6 (10 for one strip, which amounts to 1 or 2 points per scene) ;

. approximate satellite orbit and altitude data which are recorded on the heading blocks of image-files on magnetic tapes.

The first control net results checked on a test-area specially equipped for SPOT in-orbit checkout in France (south-east) show a standard error of about half a pixel in planimetry and altimetry, i.e. 5 m in panchromatic mode, in the most favourable cases (B/H of about 1).

As for the acquisition of digital terrain models, it can be approached by two channels : stereo-plotting on TRASTER (contour lines), automatic correlation by searching along almost-epipolar lines. It is still too soon to announce results on real images (and not on simulated ones),except a test of altimetric plotting of a fairly hilly 25 x 30 km sample : at the scale of 1:50 000, plotting contour lines with 40 m interval (with interpolated contours at 20 m and 10 m) required some fifteen hours.

The production of new small-scale maps in regions which have none or the existing maps of which are considered as out-of-date, represents of course the major objective of photogrammetry applied to satellite images. As a rule this application requires stereoscopic images in order to be able to restore the 3rd dimension, as well as instruments adapted to the non-conventional geometry of these images (see above). Two main families of cartographic products can be distinguished :

(i) line maps, obtained by photogrammetric plotting, including both planimetry and altimetry, and similar to conventional maps in their presentation, but much cheaper ;

(ii) "space-maps" or maps on satellite image base, similar to conventional photomaps (but generally coloured), and including a mosaic of rectified images, used as planimetric base on which is superimposed a group of topographic data (among which altimetry) facilitating or completing the reader's information.

One shall note that this second family of products is mainly applicable in low planimetric density regions, and where natural features form the essential part of the landscape - this is the case particularly of desert regions - : the cartographic expression brought by the image happens to be actually both the most expressive and objective, while the quickest and cheapest, never known within a cartographer's memory. However is set the problem of topographic information combination, in particular contour lines, and their global legibility on the image background. In the last part we shall see the various categories of documents that can be distinguished from this point of view.

The various possible contributions of satellite imagery to basic cartographic equipment make it a perfect tool for digital data bases the contents of which must be adapted, as an assumption, to any potential application. The study of image storage and handling conditions in data bases, such as they are carried out at the Institut Géographique National - France, is summed up hereunder.

B - SATELLITE IMAGES AND DATA BASES

We have just seen that satellite information could be used in two forms :

- raw or improved images (used as cartographic backgrounds or photo-interpretation sources) ;
- interpreted cartographic data (revision, control networks, line maps).

This second form of data is made up of conventional features (points, lines, areas) the management and storage of which in data bases are similar to those practised for data from other origins and do not set any original problem.

On the other hand storage and management of image-files within a geographic data base require special arrangements in terms of contents, sheet-line system, storage medium and management system.

It has been proposed to the IGN-F to experiment the production of a rectified image data base which would cover the territory systematically and be available to both inside and outside users. Such a base would be characterized as follows :

(i) contents : the various available imageries would be filed : in priority Landsat MSS and SPOT, with for each of them :

- raw, date or season-homogeneous images,
- images rectified and resampled in the single rectangular Lambert II extended system (national grid), either in "level 2" (for Landsat) with polynomial deformation on control points, or in "level 3" (for SPOT) with correction of parallaxes due to relief, using digital terrain models read-out from the national altimetric data base.
- corresponding mosaics, carried out in order to prevent users from having to worry about the sheet-line system based on scenes, variable from one satellite to another,
- supplementary data : dates, various describers, if need be distortion grids adapted to other projections.

(ii) sheet-line system : the original and rectified scenes would be preserved in their present state, i.e. at the number of :

. 50 for Landsat) covering the French territory
.170 for SPOT)

i.e. a total volume amounting to 2.6 G-bytes , for Landsat MSS, to 17 G-bytes for panchromatic SPOT.

Mosaics would be divided into 100 x 150 km rectangular blocks, this size corresponding to the maximum quantity of information that can be stored on a big-size magnetic tape (2,400 feet ; 1,600 bpi).

(iii) storage and management : in addition to magnetic tapes the project provides for using a digital optical disk and a data base management system (DBMS) which remains to be determined. Functions to be carried out in the future would be :

- storage
- retrieval according to various criteria : place, date...
- image display
- index display
- read-out
- image and supplementary data management.

For this purpose, the computer configuration shall include a specialized image-processor permitting to reduce the load of the host-computer, and manage several on-line optical disks ("juke-box").

C - AN EXAMPLE OF APPLICATION : MAPS ON IMAGE BACKGROUNDS

From data bases of this type, the production of "space-maps", using both images as they are and overprinted topographic elements, is theoretically adapted to an almost complete automation, or at least to a full digital process. However two channels are to be considered :

- a channel using both raster mode (for image plotting) and vector mode (for topography plotting), with a combination of the two plottings through photo-mechanical processes ;

- a channel using raster mode only, combining image-data and topographic data and carrying out the final editing in computer-aided design, then in direct output on film in four-colour printing.

In order to test these two channels a pilot-operation has been carried out jointly by the Institut National de Cartographie - Algeria and the IGN-France, over the region of Ghardaïa (Algeria), using a Landsat MSS image and topographic data acquired by conventional photogrammetry. These tests have been printed in the form of two main documents, very different from each other in terms of presentation and cost, along with comparing documents (conventional map, variant). In a way these documents present some "symmetrical" features :

- the integral digital "raster" mode is quicker and cheaper to exploit, but the representation results schematized by the discretization into pixels ;

- the conventional editing (hand one or in vector mode) is much longer and heavier in cost, but offers a more careful representation, similar to that of a traditional base map, and much richer than this one (thanks to satellite imagery contribution).

In both cases, the use of aerial photogrammetry leads to cumulate the process costs (image processing and photogrammetry), while SPOT stereoscopic images will allow to break free from aerial photographs, at least for altimetry, and then reduce costs considerably.

This example has also shown that it was essential to define precisely the various documents that could be produced by using the new satellite data now available. Without such a definition, comparisons would be groundless, bearing on documents apparently similar but with very different internal characteristics, and being likely hence to deceive "decision-makers" who have to choose between these various documents.

So a study has been carried out by the IGN-F, which consists in identifying first the classification <u>criteria</u> : 5 of them have been determined with, for each of them, 3 value levels :

1. Metric value of the image used as a background (rectification quality).
2. Contents of the topographic information added to the image (richness and reliability).
3. Accuracy of the added topographic information (origin and process).
4. Type of cartographic system used (projection, sheetline system, legend, format...).
5. Quality of the cartographic expression (images matching, mapsmatching, ...).

From these criteria and values linked to them, a provisional classification has permitted to identify some ten separate <u>products</u>, the hereunder list of which is but indicatory(but allows to catch the complexity of the problem) :

Images	1. Isolated space image, rectified on control points.
	2. Uninformed space image mosaic, with more or less visible matching.
	3. Informed space image mosaic (topographic information added).
	4. Informed poster or placard, without visible matching.
Back-grounds	5. Planimetric background on space image, with regular sheet-line system and more or less visible matching.
	6. Topographic background on space image, idem 5. + altimetry.
	7. Thematic background on space image, idem 5. + particular topics.
Maps	8. Planimetric map on space image : regular map in the meaning of the 5 selected criteria.
	9. Topographic map on space image : idem 8. + altimetry.
	10. Thematic map on space image : idem 8. + particular topics.

Beyond this list, we find indeed again the conventional line maps (topographic and thematic ones) where all the information is interpreted and symbolized and where the image is no more visible : the satellite information is totally integrated into cartography.

CONCLUSION

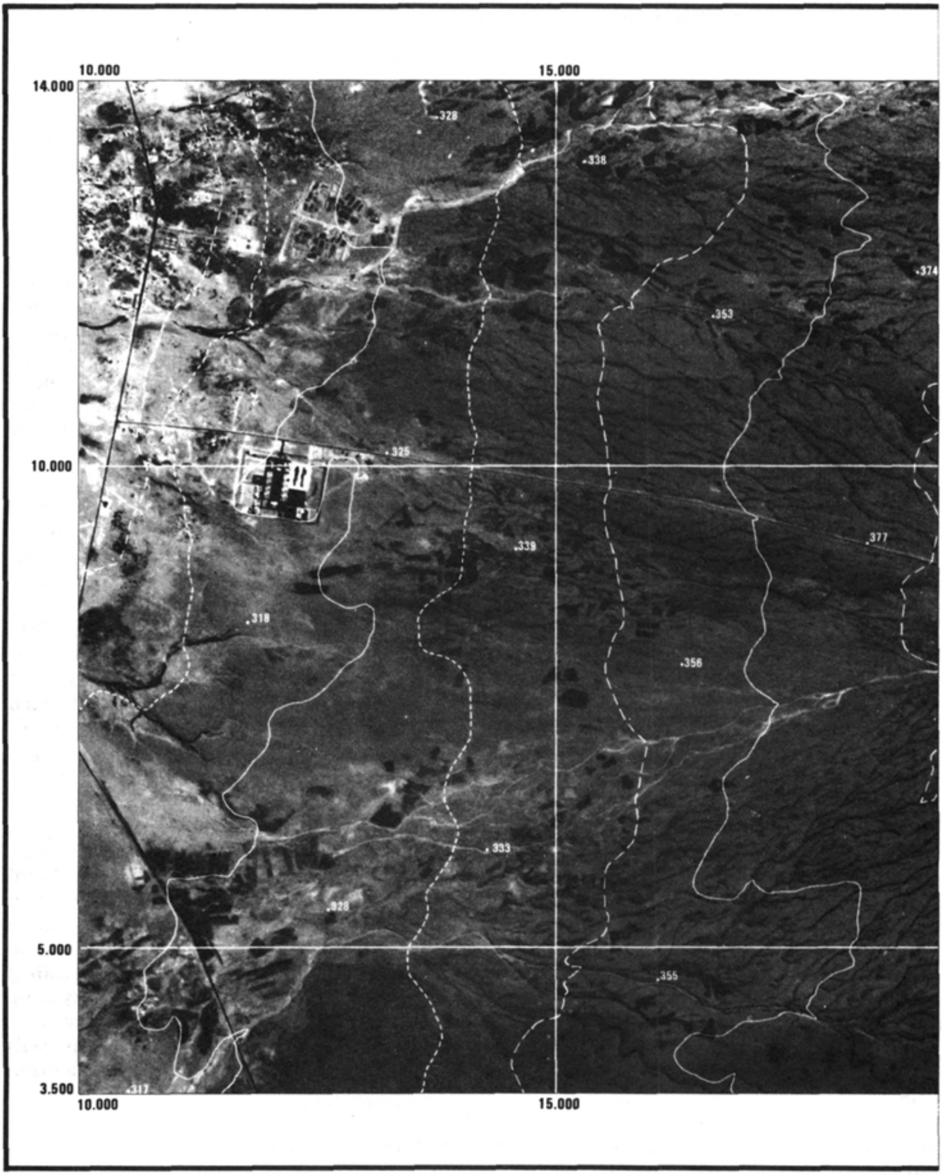
While acknowledging the revolutionary contribution of satellite images, in terms of accessibility, covered areas, repetitiveness and adaptation to data-processing, one must also study thoroughly their part and place in the geographic information systems :

. acquisition of small-scale regular cartographic data, in conditions better and better adapted to world needs ;

. utilization of images as they are, both as aid to cartographic representation and source of multiple information for all potential users.

It would be surely anticipated to assert that all the applications of such a powerful tool as satellite imagery can be dealt with. However it would not be too early to develop studies undertaken in all the fields of the cartographic chain.

SPÉCIMEN



Spatiocarte réalisée à l'I.G.N. en 1986.
Altimétrie issue d'une restitution photogrammétrique d'un couple stéréoscopique à 1 : 400 000 du satellite SPOT
Fond orthophotographique issu d'une rectification géométrique numérique de la même scène
Données SPOT (C) C.N.E.S. 1986
Dénomination I.G.N. (C) I.G.N. 1986.

0 1 2 3 4 5 Km

Ellipsoïde de Hayford
Projection Mercator Transverse (U.T.M.)
Coordonnées fictives

Équidistance des courbes : 40 m
Intercalaires : 20 m
Sous-intercalaires : 10 m