AN OPERATIONAL ERS APPLICATION : THE MAPPING OF FRENCH GUYANA USING SPACE TRIANGULATIONOF ERS IMAGES

Tonon Michaël — IGN-Espace, parc technologique du canal, 24 rue Hermès, 31527 Ramonville Saint Agne, FRANCE
Tel : (33) 05 62 19 18 18 Fax : (33) 05 61 75 03 17
E-mail : ignespace@sicoval.fr

Sylvander Sylvia — IGN-Espace, parc technologique du canal, 24 rue Hermès, 31527 Ramonville Saint Agne, FRANCE
Tel : (33) 05 62 19 18 18 Fax : (33) 05 61 75 03 17
E-mail : ignespace@sicoval.fr

Rudant Jean-Paul — Université Pierre & Marie Curie, 4 Place Jussieu, 75252 Paris, FRANCE
Tel : (33) 01 44 27 38 70 Fax : (33) 01 44 27 50 85

Cantou Jean-Philippe — IGN-Espace, parc technologique du canal, 24 rue Hermès, 31527 Ramonville Saint Agne, FRANCE
Tel : (33) 05 62 19 18 18 Fax : (33) 05 61 75 03 17
E-mail : ignespace@sicoval.fr

Abstract

IGN-Espace, the IGN branch for space mapping, has been appointed by the «Cellule díEtudes en Géographie Numérique» of the French Ministry of Defence to map the 100 000 km2 French Guyana territory. This mapping is performed with 10 radar space maps at a scale of 1:200000 using a double descending mode acquisition of 40 ERS images.
In spite of the lack of maps over the Central and Southern part of this permanently cloudy area covered with dense forest, an accurate geometric model by block triangulation has been achieved over the whole set of images with a RMS planimetric accuracy of 15 m, checked by a differential GPS field campaign led by a French military survey team. The orthorectified spacemaps were processed using a DTM derived from a selection of best available altimetric data.
A specific multidate merging software helped to improve the readability of the radar images, in order to facilitate the drawing of the main cartographic features. Thematic specialists drew up a land cover legend showing interpreted image samples.

1 - CONTEXT

French Guyana is a french department in South America, localized between latitudes 2° and 6° north. The territory is mainly covered with a tropical rain forest. The coastal plain is the most inhabited region : the rest, very underpopulated, counts few indian villages and gold washer camps. Rivers constitute the only communication links to penetrate the inland. In the central and southern parts of Guyana, the existing cartography is unprecise, old and uncomplete because of the continuous cloudy sky and the dense rain forest. The existing 1:200000 map series was done in 1956, using an uncomplete coverage of aerial photographs. The result is some planimetric sketches, with an unprecise geometry (estimated at 300 m RMS) and with completely blank (unmapped) areas where there was a lack of photographs. The sketches have no elevation data except very few spot heights.

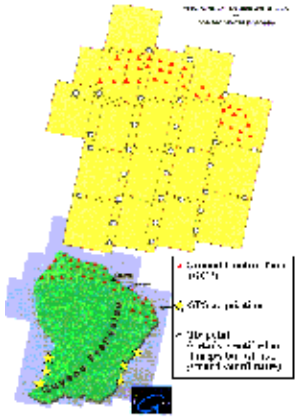

Fig. 1 Spatiotriangulation.

2 - PRODUCTION LINE

2 - 1 SPACE TRIANGULATION

Space triangulation is a block adjustment technique which allows to improve the absolute and/or relative locations of several images grouped together, using a physical description of acquisition parameters, ground control points and tie points (details identified on at least two images but not on terrain). Inside a block, radar images acquired along the same step share the same global model. In order to ensure a more comprehensive adjustment, blocks may gather several adjoining image strips. The main advantages of the space triangulation technique against single scene modelization are:

ñ the number of ground control points is reduced ;

ñ a good homogeneity of the precision is obtained on the whole block, which is very important for mosaicking purposes.

In this project, all radar scenes have been physically modelized through space triangulation technique. The ground control has been performed only on the best maps, the1:50000 map series, which covers the northern part of the territory (see fig. n°1). The

quality of the northern 1:50000 has allowed to come up with a good modelization on all the coverage due to the good endogenous ERS orbit stability (cf. [1], [2], [3]).

First, some GCPs have been picked up both on the 1:50000 maps and the image. Theoretically, our space triangulation software only needs a single GCP to register an ERS data strip. Because of, on one hand, the difficulty to identify details in the radar imagery (with speckle and rain forest), and on the other hand the doubtful maps geometrical accuracy, it was decided to take about ten points for each data strip. These GCPs were picked up near the coast, where the cartography is the best. Inside a data strip, we took two tie points per couple of adjoining scenes. Between two data strips, we took 5-6 tie points (see fig. n°1).

All tie and ground control points chosen for the first coverage were used jointly for the second one. Then, all images were rectified using a DTM. This DTM is derived from a selection of best available altimetric data, at the 1:200000 scale and from altimetric points calculated by space triangulation, using a few pairs of ascending/descending ERS scenes available in the North.

Moreover, ground surveys achieved specially by french troops in August 95 provided some GPS observations both in the frontcoast and along the east and west boarders (Oyapock and Maroni rivers, see figure n°1). The planimetric accuracy obtained in the far South, checked with the GPS measures, is 15 m RMS. **This result confirms that the endogenous ERS orbit stability enables to «transport» the ground control performed on the North down to the far South with a good accuracy**. Thus, the global geometry of the final radar mosaïc is much better than the geometry of the old 1:200000 map series, except in some specific montaineous areas where the DTM used for geocoding is too loose.

2 - 2 DIGITAL IMAGE PROCESSING AND ASSEMBLING

Each scene has been recalibrated to correct the East-to-West fading effect, in order to prevent from radiometric discrepancy between two next scenes.

The two ERS coverages have been merged using a specific multidate radar software developed in order to reduce speckle effects. This software is based on an algorithm provided by the CEGN. It consists in analysing the similarity between at least two input multitemporal scenes and in computing an adaptative merging in order to improve the readability of one of the input images called reference image, by reducing the speckle effects. This software has been developed in view to cartographic output and has been integrated into the operational mosaicking workshop.

The merging of the two ERS coverages has enabled to improve the readabality. However the merging of three or more multitemporal input images would have reduced speckle effects more efficiently.

Finally, the ten spacemap sheets have been trimmed inside the Guyana global mosaïc, according the map sheet index of the1:200000 map series.

2 - 3 LAYOUT AND OVERLAY

Each mosaic is framed with cartographic coordinates around the image in order to become a real cartographic document.

The radar space map sheet is overlayed with some vector data acquired from best available maps (1:50000 map series and 1:500000 map). The selected cartographic features overlayed are the main rivers, waterfalls, urban settlements, administrative boarders. A selection of spot heights from the best available maps (1:50000 maps when existing) shows the main relevant elevations of the territory. Moreover, the natural relief shading of the image underlay induced by the homogenous forest cover gives users an impression of French Guyanaís general topography.

2 - 4 ADDITION OF MARGINAL INFORMATION

The «Université Pierre et Marie Curie» (UPMC, Paris) has coordinated a team of scientists in achievement of a land cover legend on interpreted image samples. Six image samples are shown in margin relative to geology and forestry. Moreover, UPMC achieved a notice, which gives information about the interpretation of radar imagery in a tropical context so as to help the user to understand the radar imagery.

As a double SAR-ERS1 imagery radar cover is available (1992-93), we have chosen to use images acquired in the wet season as a reference, in order to better represent the swampy areas and savanas of the coastal plain. We also wanted to work on radar images which had been acquired at a low tide in order to better study the sand deposits and the muddy areas which limits the marine navigation close to the shoreline. Luckily (taken into account the poor operationality of the Cuiaba reception station), both (acquisition at low tide and in rainy season) helped a lot to achieve a coherent radar cover of the whole area taking into consideration the major temporal source of radiometric variations.

Concerning in a more general way information contained in the SAR-ERS1, our studies of the French Guyana evidenced the major role of pluri-thematic approaches in various domains more especially dealing with the topography, geomorphology, geology, forestry, the shoreline dynamic and hydrology.

Although the radar images lead to the senior photo-interpret an easy description of the different morphologies and landscapes, the radar images are not so easy to analyse and interpret to the juniors. As a first key to analyse, the images analysis is rather intuitive, as for instance the understanding of the interaction phenomenon of the centimetric wavelength against the topographic surface. Effectively the radar imagery gives an original and new information on the relief, the rugosity, the humidity, the presence of free water, the vegetation cover and anthropic structures which need a minimum of experiments to be revealed.

Therefore, in order to guide the user who wish to extract full information from these radar images, numerous analysed and interpreted quadrangles have been given and described on the same sheet in margin of the space maps. These interpretations were established by remote sensing experts familiar with both the radar images and such tropically areas (see reference map). They deal with various thematic domains (described above) and the test zones are widely distributed on the whole country so that the shoreline as well as the inland are taken into careful consideration.

To the north, the Kaw, Kourou and Sinnamary quadrangle interpretations deal with savannah areas, landscape and shorelines submitted to erosional or sedimentological processes. The rugosity variations and the hydrologic state, the vegetal cover allow to strongly differentiate formation by reading radar imageries. The forest cover interpretation in the inland is nearly complete and if you extract the drainage network, the radiometric signature corresponds to the different reliefs and erosional facies highlighted by the low incidence of the SAR-ERS1 (Cacao, Maripassoula and Camopi quadrangle). Then the interpretations lead mainly to the differenciations between bedrocks, possible despite the forest cover, and the presence of structural alignments and bedding.

3 - CONCLUSION

The mapping of French Guyana using ERS images shall be complete on May 97. It is the largest ERS mapping project (40 images) processed by IGN-Espace. This project has enabled IGN-Espace to validate and enrich its ERS spacemap production line. The result will be a global, homogenous, complete and geometrically-precise cartography of French Guyana. The internal geometrical quality of ERS radar imagery, processed by space triangulation, show promising prospects in space cartography of tropical and equatorial zones where the map coverage is generally uncomplete, even at medium scale.

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