CONTRIBUTIONS OF REMOTE SENSING TO THE CARTOGRAPHIC DEVELOPMENT OF THE BRAZILIAN TERRITORY: AN INTRODUCTORY OVERVIEW

Maria Cecilia Bonato Brandalize & Alzir Felippe Buffara Antunes

Department of Geomatic - Federal University of Paraná
Centro Politécnico – Jardim das Américas
Curitiba, Paraná, Brasil
maria.brandalize@ufpr.br ; felipe@ufpr.br

Résumé

Le Conseil du Service Géographique (DSG), en collaboration avec l'Institut Brésilien de Géographie et de Statistique (IBGE), sont responsables de la cartographie systématique du territoire brésilien (échelle 1/1.000.000 au 1:25.000) depuis leur création, respectivement en 1890 et 1934. Compte tenu de la longue histoire dans l'établissement d'un système cartographique national, comprenant plusieurs projets de cartographie topographique au cours du siècle dernier, la plupart d'entre eux reposent sur une couverture photogrammétrique. Le territoire relevé n'a pas été mis à jour étant donné que le cartes les plus récentes datent des années 80. Le manque d'une politique de mise à jour des cartes topographiques indique la situation chaotique que les planificateurs et les gestionnaires en général connaissent actuellement au Brésil. Ainsi, bien que le territoire brésilien soit complètement couvert, depuis 1922, à l'échelle du 1 :1.000.000 (46 feuilles au total), la gamme de produits la plus courante pour cette échelle date de 1998, lorsque sa dernière mise à jour s'est appuyée sur des images de télédétection. D'autre part, des échelles plus grandes telles que 1:100.000, 1:50.000 et 1:25.000, couvrant respectivement 75%, 14% et 1% du territoire brésilien proviennent de la période entre 1908 et 1985, la plupart datant de 30 ans et sans un mise à jour périodique. Le manque de données cartographiques à des échelles aussi importantes pénalise le développement local et régional, ainsi que la planification et la surveillance de l'environnement, des plans et des actions basées sur des informations peu fiables et inexactes. Les initiatives prises par le gouvernement afin de résoudre certains problèmes de surveillance et de gestion de l'environnement, en particulier dans la région amazonienne, culminent dans des projets fondés uniquement sur les techniques de télédétection, comme les projets RADAM (Radar de l'Amazonie) et SIVAM (Système de Surveillance de l'Amazonie). D'autres initiatives sont remarquées, depuis 2006, pour la coopération entre l'IBGE et l'Alaska Satellite Facility (ASF), visant à la distribution des images de télédétection à des organismes du Gouvernement Fédéral, à des institutions de recherche et à d'autres usagers non commerciaux au Brésil. Ces images visent à accélérer le processus de cartographie du territoire et de ses mises à jour ultérieures, ce qui permet une planification plus efficace de l'action gouvernementale. Dans un pays où le développement et la diffusion des produits cartographiques sont plus avancés que le développement social et économique, de telles initiatives doivent être discutées et analysées de façon critique.

Abstract

The Geographic Service Directory (DSG), in conjunction with the Brazilian Institute of Geography and Statistics (IBGE), are responsible for the systematic mapping of the Brazilian territory (scales 1:1.000.000 to 1:25.000) since their creation, respectively, in 1890 and 1934. Considering their long trajectory in establishing the National Cartographic System, encompassing several topographic mapping projects through the last century, most of all based in photogrammetric coverages, this same territory is considered to be out of date in terms of cartographic products since the 80's decade. This out of date can be translated in numbers that can factually indicate the chaotic situation that planners and managers in general are experiencing nowadays in Brazil. In this manner, although the Brazilian territory is completely covered, since 1922, at 1:1.000.000 scale (46 charts), the most up-to-date products for this scale are from 1998, when they were updated based on remote sensing images. In the other hand, greater scales like 1:100.000, 1:50.000 and 1:25.000, which cover respectively 75%, 14% and 1% of the Brazilian territory, are from periods comprehended between 1908 and 1985, most of them with more than 30 years old and never updated. The lack of geographic information at such important scales submits regional and local development as much as environmental management and monitoring to plans and actions based on unreliable and untrue spatial information. Initiatives from the federal government in order to solve some of the environmental management and monitoring problems, especially in the Amazon Region, have culminated on projects based exclusively on remote sensing techniques, like RADAM (Radar in Amazon) and SIVAM (Amazon Vigilance System). Another initiative relies, since 2006, on the cooperation agreement between IBGE and the Alaska Satellite Facility (ASF), aiming the distribution of remote sensing images to Federal Government agencies, research institutions and other non commercial users in Brazil. These images intend to help the acceleration of the territory mapping process and its updating, allowing more efficient governmental actions planning. In a country where cartographic development is running far away behind the social and economic ones, initiatives like these must be critically analyzed and discussed. That is the topic of this article.

Resumo

A Diretoria do Serviço Geográfico (DSG), em conjunto com o Instituto Brasileiro de Geografia e Estatística (IBGE), são responsáveis pelo mapeamento sistemático do território brasileiro (escala 1:1.000.000 a 1:25.000) desde sua criação,

respectivamente, em 1890 e 1934. Considerando a longa trajetória no estabelecimento de um Sistema Cartográfico Nacional, compreendendo vários projetos de mapeamento topográfico ao longo do último século, a maioria deles baseada em coberturas fotogramétricas, este mesmo território encontra-se com um alto grau de desatualização visto que as cartas mais atuais datam da década de 80. Esta desatualização, quando expressa em números, indica a situação caótica que planejadores e gestores em geral experimentam atualmente no Brasil. Desta forma, embora o território brasileiro esteja completamente coberto, desde 1922, pela escala 1:1.000.000 (num total de 46 folhas), o produto mais atual para esta escala data de 1998, quando da sua última atualização realizada com base em imagens de sensoriamento remoto. Por outro lado, escalas maiores como a 1:100.000, 1:50.000 e 1:25.000, que cobrem respectivamente 75%, 14% e 1% do território brasileiro, provêm do período compreendido entre 1908 e 1985, a maioria delas com mais de 30 anos e jamais atualizadas. A falta de dados cartográficos atualizados para escalas tão importantes como estas, submete o desenvolvimento local e regional, assim como o planejamento e o monitoramento ambiental, a planos e ações baseados em informações não confiáveis e irreais. Iniciativas do governo federal com o intuito de resolver alguns dos problemas de monitoramento e gestão ambiental, especialmente na região amazônica, culminaram com projetos baseados exclusivamente em técnicas de sensoriamento remoto, como os projetos RADAM (Radar na Amazônia) e SIVAM (Sistema de Vigilância da Amazônia). Outras iniciativas se apóiam, desde 2006, na cooperação entre o IBGE e o Alaska Satellite Facility (ASF), objetivando a distribuição de imagens de sensoriamento remoto às agências do Governo Federal, às instituições de pesquisa e a outros usuários não comerciais no Brasil. Estas imagens pretendem acelerar o processo de mapeamento do território e sua conseqüente atualização, permitindo ações governamentais de planejamento mais eficientes. Num país onde o desenvolvimento e a disponibilização de produtos cartográficos confiáveis está muito aquém do desenvolvimento social e econômico, iniciativas como esta devem ser criticamente analisadas e discutidas.

The history of cartography in Brazil is as old as the discovery of its territory in 1500, when the drawing of maps started to record only the coast, indicating the location of rivers, capes, bays, and other geographical features of importance, as the islands.

In fact, the first attempt to demarcate the boundaries of the Brazilian territory began even before its discovery, with the Treaty of Tordesillas in 1494. In 1713, the Treaty of Utrecht with France sought to define the limits of the Brazil's colonial empire. But only after 1751, with the Treaty of Madrid, the geographical boundaries began to be precisely determined, under the responsibility of the newly created Brazilian Demarcation Boundary Commissions. In cartographic terms, Brazil has begun to have full knowledge of its borders only from the second half of the nineteenth century, when new measuring methods and equipments have been embedded in field surveys.

The mapping of the territory as a whole, however, emerged as a need to accelerate the development of the country still in the nineteenth century. In this context the first initiative was taken by the Geographical and Geological Commission of the Province of São Paulo which, based on surveys carried out in 1905, has had much of the province's territory mapped at scale 1:100,000.

In 1920, the arrival of the Austrian Military Cartographic Mission to the Brazilian Army has marked the official beginning of the use of Photogrammetry as a mapping technology although studies have revealed that the science has been applied in academic works prior to that date. Other applications in this field include the geological mapping of the territory initiated in the 60's with the use of panchromatic airphotos which are nowadays available for most of the country at scale 1:60,000.

Concerning the systematic topographic mapping of the Brazilian territory this has began in 1922 with the publication of the first map at scale 1:1,000,000. The Geographic Service Directory (DSG), in conjunction with the Brazilian Institute of Geography and Statistics (IBGE), are responsible for the systematic mapping (scales 1:1,000,000 to 1:25,000) since their creation, respectively in 1890 and 1934. Considering the long trajectory of these public institutions in the establishment of the National Cartographic System, encompassing several topographic mapping projects developed through the last century and being most of them based in photogrammetric coverages, it was expected that the cartographic products derived from such projects were up to date and ready to supply users' needs in general. The out of date of the Brazilian cartographic products can be translated in numbers that can indicate the problematic situation that planners and managers are experiencing nowadays. In this manner, although the Brazilian territory is completely covered since 1922 at scale 1:1,000,000 (a total of 46 charts), the most up-to-date products for this scale are from 1998, when techniques based on remote sensing images were first employed to update the charts. On the other hand, mapping scales at 1:100,000, 1:50,000 and 1:25,000, which cover respectively 75%, 14% and 1% of the Brazilian territory, are from periods comprehended between 1908 and 1985, with at least 30 years of outdating.

The lack of geographic information at such important scales submits the regional and local development as much as the environmental management and monitoring to plans and actions relying on misleading spatial information. Initiatives from the federal government in order to solve some of the environmental management and monitoring problems, especially in the Amazon Region, have culminated with projects based exclusively on remote sensing techniques, like RADAM (Radar in Amazon) and SIVAM (Amazon Vigilance System). Another initiative relies, since 2006, on the cooperation agreement between IBGE and the Alaska Satellite Facility (ASF), aiming the distribution of remote sensing images to the Federal Government agencies, research institutions and other non commercial users in the country. These images intend to help the acceleration of the territory's mapping process and its updating which intends to allow efficiently governmental actions planning.

The SIVAM project as it is known nowadays has as benefit the effective support to cartographic activities which encompasses a series of applications ranging from agricultural production mapping, land use

mapping, indigenous lands mapping, and the monitoring and mapping of forest fires and deforestation.

Nevertheless the milestone in the history of Remote Sensing as the driver of cartography in Brazil occurred in 1965 with the RADAMBRASIL Project.
As a result of a close association between NASA (EUA) and the National Commission on Space Activities (NCEA), a program was initiated to implement scientific researches in the remote sensing field of knowledge. The project was initially designed to perform the integrated survey of the natural resources in an area of 1,500,000 square kilometers located in the region of influence of the Transamazonic Road. The sensor used was a side looking radar known as SLAR (Side Looking Airborne Radar) which was chosen to map an area with high incidence of clouds and intermittent rainfall in the Amazon Region.

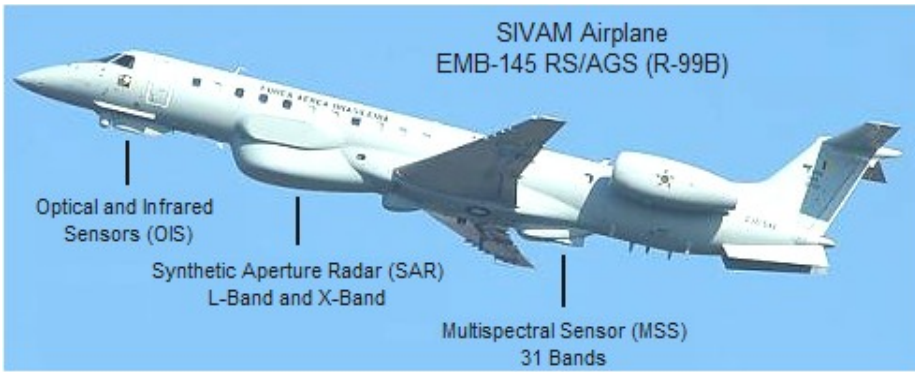

Figure 1: SIVAM Project: Airplane and Airborne Sensors. Source: adapted from (Lourenção, 2003) and (Almeida, 2008).

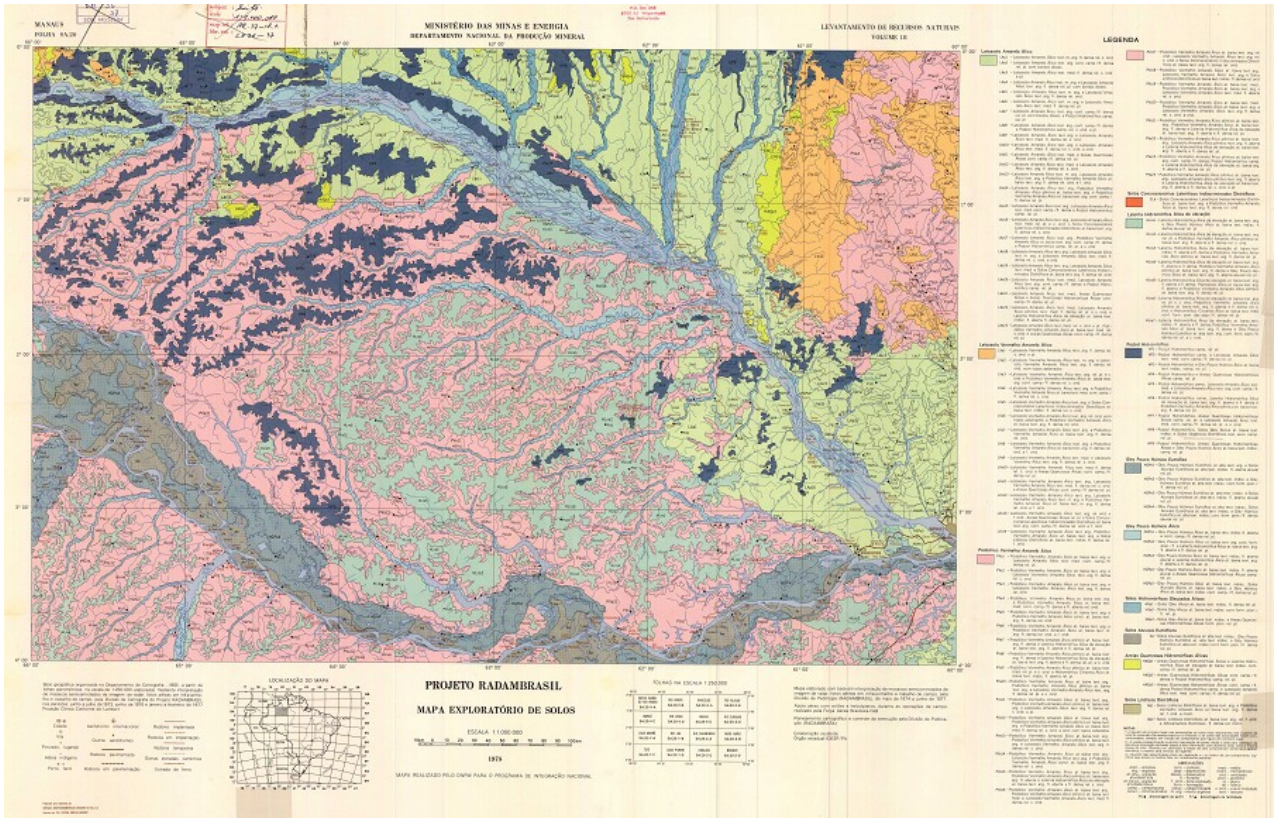

Figure 2: RADAMBRASIL Project: Exploratory Soil Map (Source: ISRIC 1978).

In 1975 the project was expanded to all regions of the Brazilian territory, becoming the world's largest project of radargrammetry coverage performed with airborne radar. This expansion resulted in the interpretation of more then five hundred semi-controlled radar mosaics at scale 1:250,000. These mosaics were mostly used to explore land forms and texture patterns for geological mapping (several regional scales). It is interesting to mention that the efforts made towards the full use of the information from these radar images have resulted in the formulation of a proprietary systematic methodology that in many aspects comprehended innovations of universal application.

Already in the 1980s much of the production of thematic cartography in large and medium scale in Brazil was due to the action of the National Institute for Space Research (INPE) which was originated from committees and work groups created in the 1960s. Currently, INPE is an agency that operates autonomously under the

Ministry of Science and Technology, created in 1985. INPE started in the remote sensing area in Brazil testing methods for updating systematic mapping with satellite images of medium resolution and also testing its limitations with regard to the geometry of the image. INPE helped to disseminate LANDSAT images in Brazil and several scientists have tried to maximize the possibilities of using medium resolution satellite images for updating topographic maps. In the same decade the creation of the SGI Free Software (later called SPRING) allowed the integration of remote sensing and geographic information systems.

Currently two major programs of INPE, the CBERS Program (China-Brazil Earth Resources Satellite) and PRODES Program (Monitoring of the Brazilian Amazonian Forest by Satellite), both started in the late 1980s, are considered the most important ones in the dissemination respectively of remote sensing data in Brazil and of knowledge about the deforestation of the Amazon region.

Figure 3: Launch of CBERS-2 in October of 2003 (Source: CBERS/INPE 2003).

INPE is not limited only to the dissemination of geospatial data. It is also responsible for developing public domain software to process these data, both available for free. This has proved to be a fact of fundamental importance for the development of remote sensing in Brazil and for the resurgence of Cartography. This has helped to overcome decades of stagnation caused by lack of public resources in the production of base maps, considered essential to support projects of social-economic development and of environmental monitoring and management.
The PRODES Program however has presented some difficulties related to the gathering of immediate results that could provide support to the punishment of illegal deforestation. Because of this, another important program was established, the DETER Program (Near Real Time Deforestation Detection). Through this program, information on deforestation, which with PRODES were published annually, are nowadays published monthly, contributing to environmental agencies from all levels of government (municipal, state and federal) to increase their efficiency in combating illegal deforestation and enforcement of environmental law.

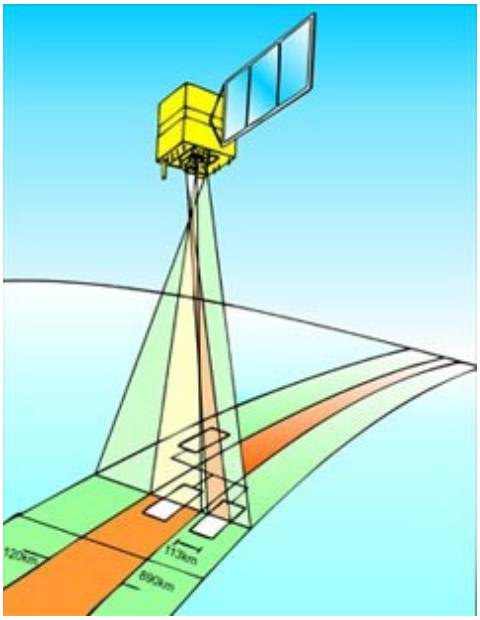

Figure 4: Different Fields of View of CBERS-1, 2 and 2B Sensors: CCD Camera, WFI and IRMSS (Source: CBERS/INPE 2007).

As mentioned earlier, the community of remote sensing in Brazil has a unique challenge, to meet the demands of the generation of geospatial information required for the sustainable economic development of the country. The integration of remote sensing and geographic information systems is still an issue that deserves attention. The integration of data for environmental monitoring, urban planning, land reform, among other applications, is still very shy independently of all the investments and projects being developed in this area. Paradoxically, existing technologies for extracting information from images of orbital sensors are underutilized in Brazil. The lack of human resources and of a policy of data distribution promotes a timid participation of the remote sensing science in the cartographic production. Attempts have been made by INPE, Ministry of Cities and other state government agencies in order to provide images and free software to educate the users with the ability to properly use the images and apply them for different purposes.

Moreover, the relation between map production and remote sensing has become more obvious when the Brazilian Institute of Geography and Statistics (IBGE) started to update the International Map of the World (1:1,000,000 scales) through the use of ALOS and CBERS images. IBGE is now developing integrated projects with different partners and intends to use different image resolutions to update base mapping and to cover the deficit of cartographic and thematic mapping of the Brazilian Territory.

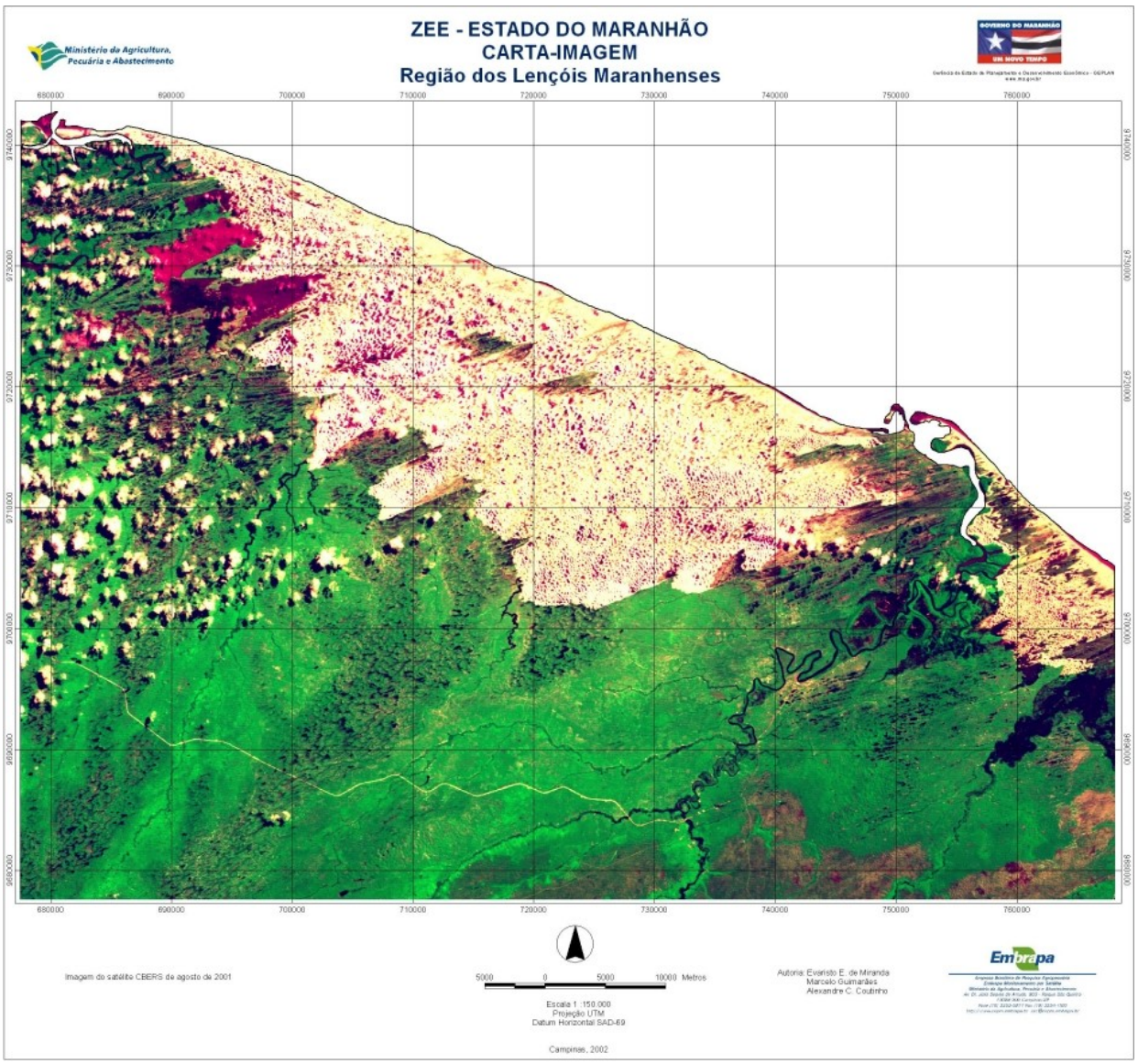

Figure 5: Ecological and Economic Zoning of Maranhão: image Map from CBERS (Source: EMBRAPA 2002).

With regard to the private mapping sector it is focused on collecting data by photogrammetric techniques with increasing investments on new technologies such as LIDAR and digital aerial cameras which are largely employed in Brazil. The mapping market although very narrow and disputed moves according to the demands of some public bodies such as city halls of major cities and companies (water, energy, telecommunications, oil and mineral exploration) that prefer well-established technologies when the subject is the production of maps. On the other hand the private market of remote sensing for cartographic production is insipient once there is a lack of knowledge about the technologies of extracting features for mapping purposes and remains the difficulty to obtain high-resolution images once these are still considered to be too expensive by the users. There is therefore a tendency of Brazilian users to merge technologies available and where possible to do it based on orbital and non-orbital data made available for free.

The community of remote sensing installed at the Universities of Brazil and other institutes, as INPE, IBAMA, EMBRAPA, and INCRA, is conducting many researches to meet the growing demand for geospatial data in the country that reached, in 2010, an economic growth of 7.5%. Currently in Brazil several universities have master and doctorate programs in this field of knowledge which are sponsored by several Brazilian agencies, like CAPES and CNPq. Education is then seen as a cornerstone for the specific training of human resources in this field of knowledge. International partnerships have contributed to dominate the remote sense science techniques and applications which are being gradually recognized by society as important tools for decision making. The advance and the challenge of science are, at the same time, being allied with the planet's sustainable development and the welfare of society.

More than ever information plays a vital role in development planning in continental size country. Especially important for Brazilian planning is the natural resources and urban development. When remote sensing images can generate information about geography, social and economics conditions, creative problem solving can lead to decision making with a lasting, positive impact to people’s lives. In this context

the special issue of *Revue Française de Photogrammétrie et de Télédétection* dedicated to the state of art of Remote Sensing in Brazil is an unique opportunity to gather the scientific community and presents its advances. In order to provide the Brazilian demands on geo-spatial data many articles focus on new technologies for data acquisition and processing as well as applied remote sensing for land management. Finally, the great deal of themes presented in this special edition ensures the engagement of Brazilian scientific community to the new challenges of modern society concerning environmental issues.

Figure 6: CCD/CBERS-2 image of the City of Manaus (Source: CBERS/INPE 2004).

References

Almeida, F.C., 2008 Simulação de Resposta de Estruturas Simplificadas de Vegetação ao Radar de Abertura Sintética Interferométrico. Dissertação de Mestrado. Curso de Pós-Graduação em Sensoriamento Remoto. INPE: São José dos Campos, Brasil. Accessed 16 January 2012. http://urlib.net/rep/sid.inpe.br/mtc-m18@80/2008/09.02.19.53

Cintra, J. P. et alli., 2002 O Início da Cartografia Sistemática no Brasil. In: A MIRA XI(107), pp. 23-28.

Embrapa Monitoramento por Satélites, 2002. Zoneamento Ecológico Econômico do Estado do Maranhão. Carta Imagem. Região dos Lençóis Maranhenses. Escala 1:150.000, Projeção UTM, Datum SAD-69, Imagem CBERS de Agosto de 2001, Campinas. Accessed 5 December 2011. http://www.zee.ma.gov.br/

Engel, J.M., 2011. As Comissões Brasileiras Demarcadoras de Limites: Breve Notícia Histórica. Accessed 9 September 2011. www.info.lncc.br/cbdls.html

INPE - Instituto Nacional de Pesquisas Espaciais, 2012a. Galeria de Fotos. Lançamento CBERS-2 em 21 de Outubro de 2003. Accessed 18 January 2012. http://www.cbers.inpe.br/

INPE - Instituto Nacional de Pesquisas Espaciais, 2012b. Galeria de Imagens. Seleção Capitais Brasileiras. Manaus - AM. Sensor CCD/CBERS-2, Órbita/Ponto 173_103, Composição R3G4B2, 17/08/2004. Accessed 16 January 2012. http://www.cbers.inpe.br/

INPE - Instituto Nacional de Pesquisas Espaciais, 2012c. Sobre o Satélite. Câmeras Imageadoras. CBERS-1, 2 e 2B. Diferentes Campos de Visada do CBERS-1 e 2. Apresentação CBERS, 2007. Accessed 18 January 2012. http://www.cbers.inpe.br/

ISRIC - World Soil Information Database, 2011. Manaus: Mapa Exploratório de Solos. Folha SA-20. Volume 18. Mapa Realizado pelo DNPM para o Programma de Integração Nacional. Rio de Janeiro, Brasil, 1:1.000.000, 1978. SN 21352. Library holding BR 12009.1. Accessed 5 December 2011. http://library.wur.nl/isric/

Lourenção, H.J., 2003. A Defesa Nacional e a Amazônia: O Sistema de Vigilância da Amazônia (SIVAM). Dissertação de Mestrado. UNICAMP: Campinas, Brasil. Accessed 16 January 2012. http://www.defesa.gov.br/projetosweb/livrobranco/arquivos/espaco_pesquisador/Humberto-Jose-Lourencao.pdf

Mesquita Jr., H.N. et. alli., 2008 Amazon Deforestation Monitoring System with ALOS SAR Complementary Data. International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences XXXVII (Part B8), 1067-1070.

Meneses, P.R., Liu, C.C., Paradella, W.R., 1979. A utilização de Imagens de Radar no mapeamento de áreas Pré-cambrianas Complexas: uma proposição metodológica. In: Proc. of the Second Symposium of Regional Geology, Rio Claro, SBG, Brasil, pp. 181-193.

Projeto Radam Brasil, 2011. Organizador José Henrique Vilas Boas. Accessed 10 September 2011. http://www.projeto.radam.nom.br/apresentacao.html

Silva, D.A., Vasquez, G.A., 1994. O Projeto SERE. Origem do Sensoriamento Remoto no Brasil. INPE, São José dos Campos, Brasil, 17.

Silva, E.A. de et alli., 2001. 80 Anos da Missão Cartográfica Austríaca no Exército Brasileiro. In : A MIRA XI(106), pp. 22-24.

Valeriano, D.M., 2009. Satellite Monitoring of the Brazilian Amazon. In: Capacity Development on Forest monitoring Workshop, São José dos Campos, Brasil.

Institutions and Programs of Interest

IBGE - Instituto Brasileiro de Geografia e Estatística
http://www.ibge.com.br/home/

INPE - Instituto Nacional de Pesquisas Espaciais
www.inpe.br

Post-Graduate Program on Cartographic Engineering
IME - Instituto Militar de Engenharia
www.ime.eb.br

Post-Graduate Program on Cartographic Sciences
UNESP - Universidade Estadual Paulista
http://www.fct.unesp.br

Post-Graduate Program on Geodetic Sciences
UFPR - Universidade Federal do Paraná
www.cienciasgeodesicas.ufpr.br

Post-Graduate Program on Geodetic Sciences and Geoinformation Technologies
UFPE - Universidade Federal de Pernambuco
http://www.ufpe.br/cgtg/