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AN OVERVIEW OF THE BRAZILIAN GEOSPATIAL COMMUNITY

Panorama da Comunidade Geoespacial Brasileira

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ABSTRACT

The development of computer processors has changed the way of working with geospatial data. The methods have evolved from mechanical to computational nearly in five decades, while the material has changed from manufacturing to electronic and digital. The computer technology paradigm has influenced the formal education and professional careers from the technical to the graduate level. Among the many different educational and professional titles related to geographic information, the cartography engineers perform the role of building geographic databases and maps and take over the process of cartographic mapping with responsibility for implementation and maintenance of the geodetic and cartographic framework. Despite the vast Brazilian territory, it is estimated that no more than 2,000 of such professionals are in the labor market, where they practice management, technical production, consulting and academic work. A sample of 212 cartography engineers confirms the profile traced previously. Moreover, a survey in two Brazilian journals of the scientific community of geodesy and cartography listed the most used keywords and linked them to research institutions. With these keywords researchers were counted in CNPq's Lattes Platform where the Brazilian scientific community tells its production through the CV Lattes. After the analysis of the professional's sample, the articles published in the two journals and the researchers extracted from the Lattes database, this article presents what is researched in the laboratories and what is done in the profession. The similarities go beyond the Brazilian geographic distribution, partly due to the development and innovation of the geospatial information technology in the research institutions and implemented by the cartographic organizations.

Keywords: Geospatial Information; Research Institution; Cartographic Engineering; Labor Market.

RESUMO

O desenvolvimento dos processadores computacionais mudou a forma de se trabalhar com os dados geoespaciais. Os métodos evoluíram de mecânicos a computacionais em cerca de cinco décadas, enquanto os materiais mudaram de manufaturados para eletrônicos e digitais. O paradigma tecnológico computacional influenciou a educação formal e as carreiras profissionais desde o nível técnico até o de pós-graduação. Entre os muitos títulos educacionais e profissionais distintos relacionados com a informação geográfica, os engenheiros cartógrafos desempenham a função de construir bancos de dados geográficos e mapas e assumem todo o processo de mapeamento cartográfico, com responsabilidade pela implantação e manutenção do arcabouço geodésico e cartográfico. Apesar do vasto território brasileiro, é provável que não haja mais de 2.000 destes profissionais no mercado de trabalho, onde praticam a gestão administrativa, a produção técnica, as consultorias e os trabalhos acadêmicos. Uma amostra de 212 engenheiros cartógrafos confirma o perfil levantado anteriormente. Por outro lado, uma pesquisa em duas revistas brasileiras da comunidade científica de geodésia e cartografia enumerou as palavras-chave mais utilizadas e relacionou-as às instituições de pesquisa. Usando as palavras, os pesquisadores foram contados na Plataforma Lattes do CNPq, onde a comunidade científica brasileira informa sua produção acadêmica através do Curriculum Vitae Lattes. Após as análises da amostra de engenheiros cartógrafos, dos artigos publicados nas duas revistas e dos pesquisadores da base Lattes, este artigo apresenta o que é pesquisado nos laboratórios e o que é feito na profissão. As coincidências vão além da distribuição regional brasileira, em parte devida ao desenvolvimento e à inovação da tecnologia da informação geoespacial investigadas nas instituições de pesquisa e implementadas nas organizações cartográficas.

Palavras-chave: Informação Geoespacial; Instituição de Pesquisa; Engenharia Cartográfica; Mercado de Trabalho.

1. INTRODUCTION

The amazing development of the computer technology opened the way for a myriad of applications in all human activities. Information and communication are two of the most benefited fields. A map or any cartographic document has the ability to communicate geographical information. Nowadays, from designers to users, the map making process have been totally based on the computer technology or even in a short chain link a digital or an electronic device is found.

The general map making process includes methods, techniques and materials pertaining to the three principal domains. The first one covers the disciplines that operate on open field such as geodesy, topography, surveying and so on. The second domain relates to the imagery disciplines, basically photogrammetry, remote sensing, computer vision, digital image processing. The last is concerned to the representation disciplines such as technical drawing, cartography, geographical information system (GIS), and cartographic or map database, to mention a few. Administration, economy, least squares adjustment, geosciences and environment are complementary but essential disciplines to make maps. Ancient disciplines were adapted to the computer age while new ones such as satellite positioning and navigation, computer vision, digital image processing, and GIS, for instance, would never be possible without the computer technology.

In the sixties, there were many scientific and engineering projects demanding computational techniques to solve their problems. Marques Filho and Vieira Neto (1999) suggest that the greatest jump in this field was done by the Jet Propulsion Laboratory, California, USA, in 1964. The authors tell that the American space program needed corrections to the Moon´s image distortions caused by the camera (lens and film) suited to the spacecraft. For the first time, the corrections were calculated by the early digital main frame computers using mathematical techniques.

The advance is due to the evolution of both software and hardware technologies. Faster and more powerful processors, in the latter domain, were possible because of the transistor miniaturization that led to the integrated circuits. Figure 1, according to the Intel technology, shows a piece of such evolution that starts in 1946 with ENIAC (Electronic Numerical Integrator Analyzer and Computer), the first electronic digital computer that weighted about 30 tons. The next year, 1947, transistors were introduced and that fact marked the expressive development of the processor technology. Thus, electronic circuits have become increasingly smaller while the number of transistors larger, binary encodings have grown at 4, 8, 16, 32 and 64 bits, until the current days that nanotechnology is employed.

While processors have been emphasized, of course other components were developed such as memory, motherboards, buses, registers, etc. Along with that, new computing paradigms, architectures and optimized algorithm implementations were added up, all to improve performance and provide robustness.

Finally, since 1964, satellite orbit, image processing, and geographical databases, to mention only two of so many disciplines related to the geographic information, have demonstrated

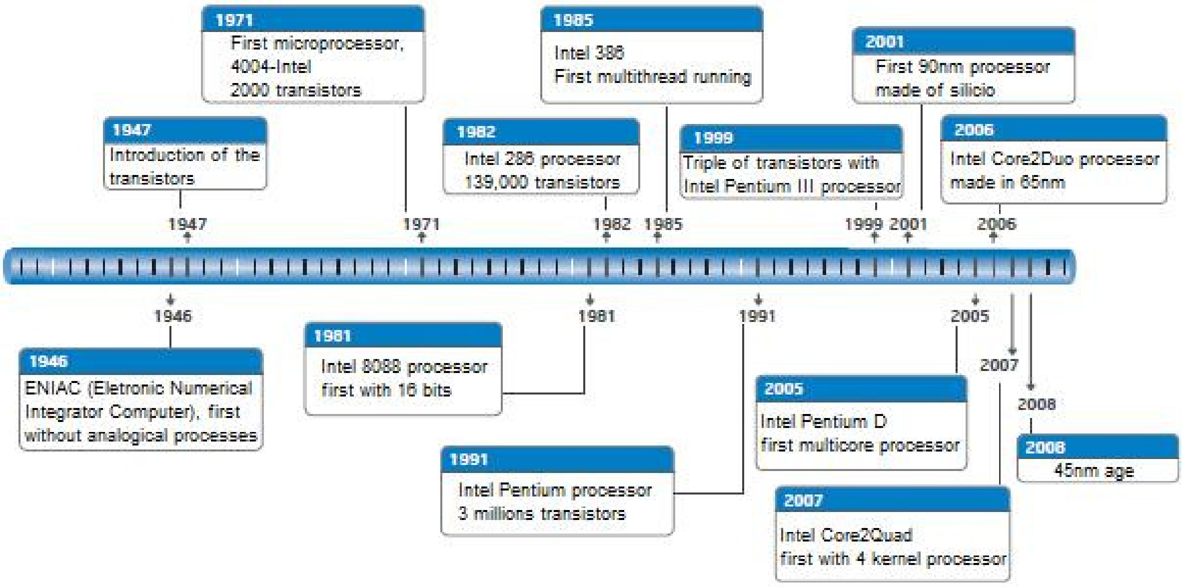

Fig. 1: Evolution of the computer processors.

significant development, driven by rapid growth of technology, extending its applications in various sectors of human activity.

Accordingly, since the late fifties and sixties, the methods have migrated from analogical to digital in the realm of the geodetic and cartographic fields, the electronic satellite receivers and orbital scanners, the analytical plotter, the electronic *correlator* and the digitizing table – to mention a few – were designed to acquire different types of electronic and digital format data. The methods used until that time could roughly be classified as manuals, graphics, and mechanical or analogical. Those decades mark the beginning of the electronic and analytic data acquisition and processing based on electronic computers. Either completely or partially the instruments started receiving the contribution of the flourishing electronic industry.

During the seventies and the eighties the international geodetic and cartographic communities contributed to build new equipments and new math models to automate the mapping process either totally or partially. The digital computers led to the digital methods in all imagery disciplines from the remote sensing (orbital, aerial, terrestrial, close range, etc.) till the cartographic phase itself (digitizing, scanner, databases, etc.). New words came to the daily oral and written communication: radar, sonar, laser, lidar, pixel, hard and software, and many others born in the electronic, digital and informational technology.

Of course the materials were changed under the influence of the new electronic then digital equipments that required other material types as the methods were reviewed, altered, renewed, and discharged to give room to new methods that demanded new materials and so on. This cycle has reached the current state of the art entirely dependent on the digital electronic technology yet pointing to the nanotechnology.

For sure such technological paradigm has influenced the formal education and the professional careers from the technician up to the graduate levels. Many branches were benefited by these advancements. The labor market strictly follows the progress so that the professionals are required to get new skills. The educational system provides formal updated knowledge through technical, undergraduate and graduate courses. Currently in Brazil, human resources for the labor market (including science and academia) are formed by several public, private, religious, and foundation educational institutions.

Among many educational titles and distinct professions related to the geographic information, the cartography engineers play the role of constructing geographic databases and maps. Although there have been professionals from all other disciplines that work on open field and with geographical information, in Brazil, the cartography engineers rely on the whole mapping and cartographic process. They are mainly in charge of the structural geodetic and cartographic framework. Despite the large Brazilian territory there may be no more than 2,000 engineers in the labor market.

Brazil´s economy has been ranked among the big ten of the world. Its efforts brought the science, technology and innovation (STI) done by Brazilian researchers to a relevant position among all the nations (ARWU, 2011). Its geopolitics demand attention to its vast territory (the 5th of the world), to the long sea and land frontiers, the natural resources, the population distribution and welfare, and also since the fifties to the science and technology made by Brazilians.

Cartography engineers and researchers aspire that their work contributes to the Brazilian nation's objectives and, by extension, committed to the qualitative improvements guided by the democratic countries. One may intend to understand the relationship between the cartography engineers and the scientific researchers considering they act in different environments such as the offices, as a reduction of the real world, and the research laboratories, respectively.

Three distinct surveys were concluded to cement this article. The first was started in 2009 as an academic task of the discipline "Scientific Labor Organization" of the Graduate Program on Cartographic Science of Unesp (*Univ Estadual Paulista*); it surveyed all articles published by *Revista Brasileira de Cartography* (RBC) and *Boletim de Ciências Geodésicas* (BCG) since 1997 (SILVA; BERVEGLIERI, 2011). As a consequence, the published keywords were entered to CNPq Lattes Platform (CLP) – CNPq stands for *Conselho Nacional de Desenvolvimento Científico e Tecnológico* – to quantify the researchers associated to each keyword. The third survey aimed at the cartography engineering labor market, in fact for the sixth time as every three years a sample has been acquired since 1996 (SILVA; SANTOS, 2007).

2. THE CARTOGRAPHY ENGINEERS IN THE LABOR MARKET

A consistent and repetitive survey process about the conditions of the cartography engineering labor market has been done for fifteen years (SILVA, 1996). The most recent survey was concluded on last March (SILVA; BERVEGLIERI, 2011). The emphasis was totally on the 212 engineers that filled the online form – a questionnaire – with questions about the gender, age, formal education, job, organization (name, city, nature, enrollment, area, and field), tasks, incomes, useful disciplines, continued education, and expectation. The Brazilian Association of Cartographic Engineers, São Paulo branch, made available its internet discussion list with more than six hundred registered professionals. The Brazilian Society of Cartography, Geodesy, Photogrammetry, and Remote Sensing also divulged the claim to fill out the online form among its affiliates.

This section presents a set of tables featuring the most recent sample profile and the related data. The complete survey results will be published soon.

A relevant question is the relative size of these samples. The total number of active professionals is really unknown. Attempts have been done by Silva; Spinelli Neto (1999) and by Mendonça; Sluter (2011). The former article is based on 131 engineers that represented around 10% of the 1341 cartographic engineers registered in the Brazilian CONFEA/CREA system; the latter informs that 988 were registered in 2008. However, it is recognized that there are many out of this system.

The most recent sample features 79.2% of men and 20.8% of women. They averaged 33.5 years of age, as it follows: less than 25 years, 10 engineers; between 25-34 years, 116; 35-44, 46; 45-54, 37; 55-64, only 3; and no one more than 64 years of age.

The current sample is the youngest ever, but 10.1 years mean sufficient experience to deliver reliable data and information.

This is an almost fifty-fifty sample, although there are reasons to believe that there are more undergrad than graduate professionals in the work market.

Table 1 – Sample sizes

95/96	98/99	01/fev	04/mai	07/ago	10/nov
152	131	109	141	223	212

Table 2 – Average age (AA), Time from the graduation (TG), AND Average age at (under) graduation (AG) in years

Surveys	AA	TG	AG
1995/96	36.1	11.9	24.2
1998/99	40.4	14.4	26.0
2001/02	36.4	12.9	23.5
2004/05	34.3	10.8	23.5
2007/08	35.2	11.1	24.1
2010/11	33.5	10.1	23.4
Average	**36.0**	**11.9**	**24.1**

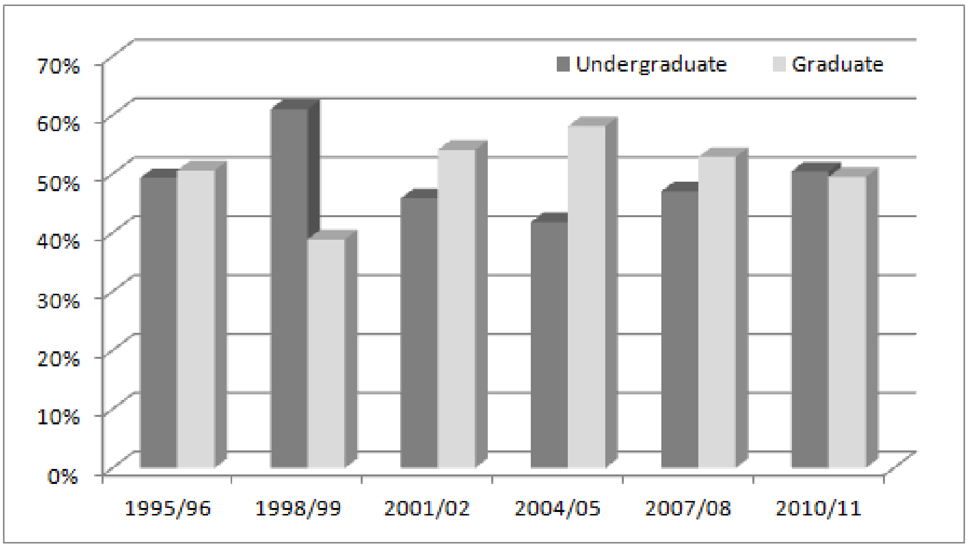

Fig. 2: Undergraduate and graduate proportions along the six surveys.

Cartography (Cart in table 3) remains the most cited in all surveys (except 98/99, when it was intentionally out of the poll). Photogrammetry (Photo in the table) does not appear in the last three surveys. The disciplines related to ground survey have been present since 2004. This may be explained by the legal regulation related to the rural property georeference law approved in 2001 (BRASIL, 2001). GIS in the table 3 confirms the constant presence of geospatial database applications in accordance with the information technology growth.

The complete list of disciplines is shown in table 4 for undergrad and graduated engineers. The numbers mean the quantity of nominations.

The geographic distribution of the professional relationships (Table 5) has expressive figures in the Southeastern and Southern regions that respond for 80% of the sample. This follows, approximately, the Brazilian regional economic and population parameters.

Two hundred and three cartography engineers work in fifty cities in Brazil (Table 6) and one in USA. The top five cities are state capitals. Recife, in the Northeastern region, is the site of one of the only six cartography engineering undergrad courses in Brazil (Table 7). Presidente Prudente, 560 km,

Table 3 – The most cited disciplines in the surveys (undergrad)

95/96	98/99	01/fev	04/mai	07/ago	10/nov
Cart	Comp	Cart	Cart	Cart	Cart
Geod	Topo	Topo	Geod	Topo	Geod
Topo	II	Comp	GPS	Geod	GPS
Photo	Photo	Photo	Topo	GPS	Topo
GIS	GPS	GPS	GIS	GIS	GIS

Table 4 – Undergrad and graduate disciplines

Discipline	Under	Discipline	Grad
Cartography	172	Geographic Information Systems	43
Geodesy	141	Digital Image Processing	37
Satellite Geodesy	137	Remote Sensing	36
Topography	134	Adjustment of Observations	31
Geographic Information Systems	114	Computing	30
Remote Sensing	101	Statistics	30
Photogrammetry	96	Satellite Geodesy	29
Computing	95	Geodesy	27
Photointerpretation	88	Photogrammetry	23
Statistics	88	Computer Graphics	22
Adjustment of Observations	88	Cartography	18
Digital Image Processing	77	Mathematics	18
Planning	71	Planning	18
Mathematics	70	Cadastre	15
Administration	64	Urban and Rural Planning	15
Cadastre	63	Environment	14
Drafting	60	Others	13
Physical Geodesy	58	Administration	12
Law	54	Topography	12
Computer Graphics	50	Physical Geodesy	11
Environment	47	Law	11
Geography	38	Photointerpretation	10
Urban and Rural Planning	37	Urban and Rural Landscape	10
Applied Law	37	Soils and Vegetation	9
Hydrography	32	Geomorphology	7
Geomorphology	28	Hydrography	7
Geology	28	Drafting	5
Soils and Vegetation	26	Ecology	5
Hydrology	26	Physics	5
Physics	26	Geology	5
Others	22	Positioning Astronomy	4
Economy	19	Climatology	4
Urban and Rural Landscape	17	Applied Law	4
Positioning Astronomy	16	Geography	4
Sanitation	13	Hydrology	4
Ecology	12	Economics	2
Meteorology	11	Sanitation	2
Climatology	10	Meteorology	1
Sociology	6	Sociology	1

Table 5 – Regional distribuition

N	NE	CW	SE	S	Total
3	28	11	120	41	203
1.5%	13.8%	5.4%	59.1%	20.2%	100.0%

Table 6 – Cartography engineers in the cities

1	São Paulo	SP	40
2	Rio de Janeiro	RJ	25
3	Recife	PE	17
4	Curitiba	PR	16
5	Porto Alegre	RS	13
6	Presidente Prudente	SP	9
7	Assis	SP	8
8	Brasília	DF	8
9	São José dos Campos	SP	6
10	Campinas	SP	4
11	Aracaju	SE	3
12	Belo Horizonte	MG	3
13	Macaé	RJ	3
14	Nova Lima	MG	3
15	Salvador	BA	3
16	São José do Rio Preto	SP	3
17	Belém	PA	2
18	Capivari	SP	2
19	Florianópolis	SC	2
20	Joinville	SC	2
21	Sinop	MT	2
22	Araçatuba	SP	1
23	Atalaia	AL	1
24	Bataguassu	MS	1
25	Campo Largo	PR	1
26	Fortaleza	CE	1
27	Foz do Iguaçu	PR	1
28	Franca	SP	1
29	Goiânia	GO	1
30	Gravataí	RS	1
31	Guaíba	RS	1
32	Inconfidentes	MG	1
33	Itajaí	SC	1
34	Limeira	SP	1
35	Marília	SP	1
36	Mineiros	GO	1
37	Mogi das Cruzes	SP	1
38	Mossoró	RN	1
39	Palmas	TO	1
40	Piracicaba	SP	1
41	Rio Branco do Sul	PR	1
42	Rio do Sul	SC	1
43	Rio Negro	SC	1
44	Santos	SP	1
45	São Carlos	SP	1
46	Starkville, Mississippi	USA	1
47	Taquaritinga do Norte	PE	1
48	Três Lagoas	MS	1
49	Uberlândia	MG	1
50	Vitória	ES	1
51	Xanxerê	SC	1

Table 7 – The cartography engineers in the major cities

City	95/96	98/99	01/fev	04/mai	07/ago	10/nov
São Paulo (SP)	7.2%	13.6%	12.5%	15.9%	13.2%	19.7%
Rio de Janeiro (RJ)	32.2%	29.7%	17.3%	15.8%	18.3%	12.3%
Recife (PE)	-	-	-	-	-	8.4%
Curitiba (PR)	14.5%	2.5%	19.5%	11.1%	12.2%	7.4%
Porto Alegre (RS)	3.9%	0.0%	1.9%	4.8%	5.1%	6.4%
Pres.Prudente (SP)	14.5%	11.0%	11.5%	4.7%	5.6%	4.4%
Brasília (DF)	2.0%	3.4%	5.8%	6.3%	5.1%	3.9%

and Assis, 440 km far west from São Paulo city, start the list of hinterland cities. It is a proof of the trend verified along the last decade: there are cartography jobs in non capital cities. The availability of the information technology in a growing number of hinterland towns may be an adequate explanation.

For the first time, this sample brings Recife as one of the major cities in the Brazilian cartographic scenario.

The employer organization types are:

The public sector employs more than the private one and others (Table 8). It seems that this late survey settles the trend to 52%.

The professional areas are administration (Adm=26.0%), technical and production (Tec=36.7%); sales, consulting, publishing, and marketing (SCPM=20.9%); and academic and scientific (AaS=16.5%).

Although the figures vary among the surveys, the ocurrencies have been quite similar. This current sample shows a lesser number of engineers in administration and technical-production areas versus the increment in the areas of sales, consulting, and marketing and of academic-scientific. A reasonable explanation would be the knowledge requirements to commercialize technology and STI demand researchers.

During a decade eight branches alterned as the main organization brances (Table 9). Besides the branches listed in table 10, there are

Table 8 – Labor market in public and private sectors

Years	Public	Private	Others
1995/95	76.9%	19.6%	3.5%
1998/99	57.4%	39.0%	3.5%
2001/02	52.3%	40.4%	7.3%
2004/05	51.9%	38.8%	9.3%
2007/08	51.6%	42.2%	6.2%
2010/11	52.2%	43.3%	4.4%

organizations related to technologic research and innovation activities; they are 46 developing, 43 projecting, 20 consulting, 9 integrating, 6 investing, and 2 financing. Technologic innovation, in the realm of this article, means the organization´s or engineer´s participation as investor, financer, consultant, projector (deviser), developer or assembler in scientific and technologic content projects that involve the creation, development or even improvement of products, services, and technologic solutions.

Tables 11 and 12 show the daily tasks performed by the professionals. The former – during the last decade – presents eleven distinct activities. The latter relates the recent sample in decreasing citation order.

Table 9 – Organization Branches

2001/02	2004/05	2007/08	2010/11
Base Mapping	Thematic Mapping	Thematic Mapping	Base Mapping
Environment	Planning	Environment	Thematic Mapping
Planning	Environment	Base Mapping	Planning
Computing and Informatics	Base Mapping	Planning	Environment
Technologic Research	Boundaries	Land Management	Land Management

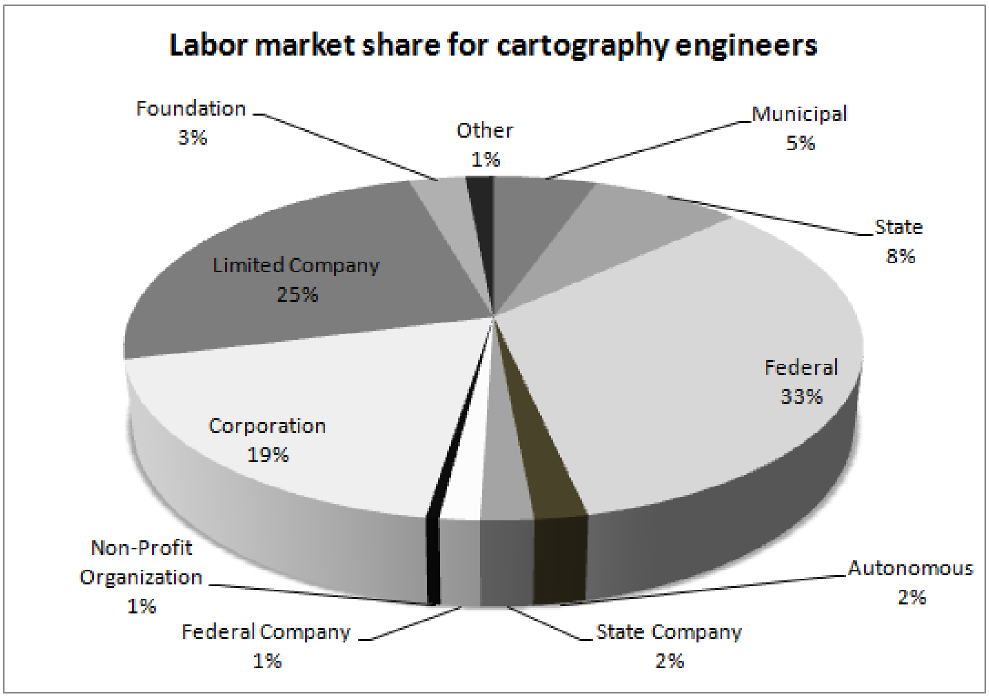

Fig. 3: Cartography engineers and their employers.

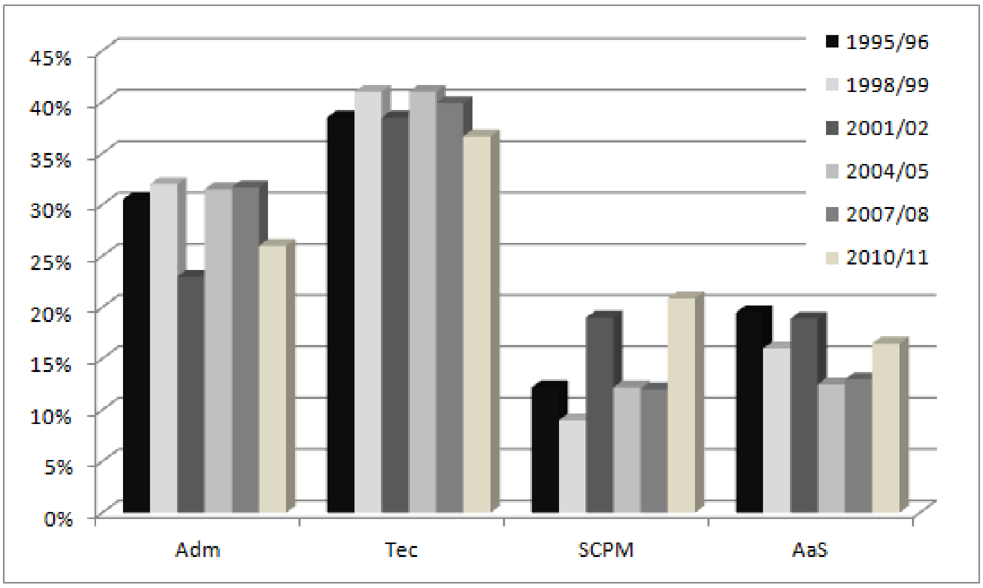

Fig. 4: Professional branches.

Table 10 – Organization branches (2010/11)

Base mapping	85
Thematic mapping	82
Planning	68
Environment	64
Land management	56
Boundaries	54
Air/Space	45
Environment analysis	43
Land issues	40
Geography	39
Oil	39
Others	38
Electric energy	37
Computing	36
Construction	34
Natural resources	34
Transportation	33
Education	32
Informatics	32
Urbanism	32
Agronomy	27
Water and sanitation	27
Reforestation	27
Agriculture	26
Gas	25
Geology	21
Mining	21
Geophysics	17
Tax	16
Public safety	15
Telecommunication	15
Architecture	13
Meteorology	8
Public health	6
Archeology	5

Table 12 – Cartography engineer´s routine tasks

Geodetic surveying	89
Topographic surveying	76
Coordination	75
Planning	75
Cartographic Production	75
Database	72
Geodetic analysis	64
Image analysis	61
Consulting	56
Map handling	56
Digital terrain model	55
Administration	50
Supervision	50
Research	47
Network adjustment	45
Training	45
Advice	43
Orthophoto	41
Services	41
Technologic inovation	37
Teaching	37
Urban and rural planning	37
Environment analysis	31
Others	30
Academic orientation	23
Geoid surveying	22
Digitizing	21
Aerial triangulation	19
Photogrammetric plotting	17
Sales	16
Homologation	13
Extension	12

Table 11 – Cartography engineer's daily activities

2001/02	2004/05	2007/08	2010/11
Coordination	Cartographic Production	Planning	Geodetic surveying
Cartographic Production	Coordination	Coordination	Topographic surveying
Planning	Planning	Cartographic Production	Coordination
Map handling	Training	Topographic surveying	Planning
Administration	Consulting	Database	Cartographic Production

Geodetic and topographic surveying reflect the legal requirement for rural properties established in 2001 (BRASIL) and also the economic growth in the last decade (BRASIL, 2007) especially on infrastructure constructions. Concerning the routine tasks related to technological research and innovation, the sample has 34 developers, 22 consultants, 20 devisers, 9 integrators, and one investor and one financer.

3. THE BRAZILIAN GEOSPATIAL RESEARCHERS

RBC and BCG are the two most important Brazilian journals of the geodetic and cartographic branch. Since 1997, they have published 53 online editions with 430 articles. The afore mentioned survey in their sites revealed interesting figures related to authors and their institutions (Figure 5).

All the 104 institutions appeared 634 times and the most frequent are some Brazilian public universities and research institutes. There also are 46 foreign institutions from 16 countries.

Quite similar to the regional geographic distribution of cities and cartography engineer jobs, the Brazilian research institutions are located mostly in the Southeast region (Table 13).

The main research institutions in Brazil are fully public either universities or research institutes as shown in table 14.

4. THE MAIN KEYWORDS AND THE RESEARCH COMMUNITY

The search into both journal´s sites returned hundreds of scattered keywords. Obviously, the analysis of such a variety would not be reasonable so the keywords were grouped into categories. Table

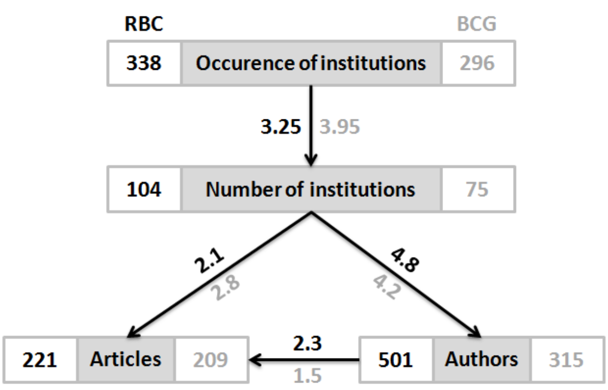

Fig. 5: Institutions, authors, and articles: numerical (statistical) synthesis.

Tabela 13 – Regional geographic distribuition of cartography engineers and research institutions

Regions	Total per region and %					
	Cities		Engineers		Institutions	
North	2	4.1%	3	1.5%	4	3.1%
Northeastern	7	14.3%	27	13.4%	16	12.2%
Central-West	6	12.2%	14	6.9%	17	13.0%
Southeastern	21	42.8	116	57.4%	64	48.9%
South	13	26.5%	42	20,8%	30	22.9%
Total	49		202		131	

Table 14 – The most frequent geodetic and cartographic research institutions

Institution	RBC	BCG	Total	Region	Type
UNESP	48	66	114	SE	SP
UFPR	21	89	110	S	FP
INPE	39	11	50	SE	FP
UFPE	10	9	19	NE	FP
USP	12	7	19	SE	SP
UFRGS	6	10	16	S	FP
UNICAMP	14	1	15	SE	SP
UFRJ	12	2	14	SE	FP
EMBRAPA	10	1	11	SE+NE	FP
OTHERS (142)	158	100	258	All	All
Total of institutions: 151	**330**	**296**	**626**	-	-

FP: Federal and public. SP: State and public.

15 summarizes the 33 resulting categories ordered by the total. Still not low, this number may suggest a generic approach to the geodetic and cartographic research subjects but it respects the keyword original meanings.

The Table 16 was built from the Table 14 by relating the main keyword categories. Most of the institutions have their scientific production in more than one field which is shown by distinct categories.

4.1 The Population of Brazilian Researchers

The academic production of the whole Brazilian scientific community can be surveyed and even researched in the so called CNPq Lattes Platform (CLP). It is the database fed by the registered researchers themselves and was created by CNPq. It really represents the Brazilian population of scientific researchers. CLP is an always open system so the researcher inserts his/her scientific production anytime. The data used in this article were collected on 16/11/2010. The search into CLP

Table 15 – Keyword groups (categories) from rbc and bcg sites

Category	Quantity RBC	Quantity BCG	Total
Methods and models	67	101	168
Geodesy and topography	41	96	137
Remote sensing	96	37	133
GNSS	26	77	103
Cartography	65	34	99
Photogrammetry	28	64	92
Statistics and MMQ	28	34	62
Detection and extraction	30	30	60
Images	29	25	54
Digital image processing	24	23	47
Ecology and environment	40	6	46
Geographic information systems	36	7	43
Administration	30	10	40
Maps and mapping	25	14	39
Soils and vegetation	36	3	39
Water	33	5	38
Analysis	25	11	36
Technology	15	13	28
Atmosphere, climatology and meteorology	11	15	26
Classification and patter recognition	16	10	26
DEM, DSM and DTM	16	8	24
Place names	20	2	22
Other systems	12	8	20
Data and database	16	3	19
Laser and other instruments	-	17	17
Altimetry	11	5	16
Agronomy and land use	15	-	15
Disciplines	12	3	15
Geoprocessing	14	-	14
Visualization	11	3	14
Cadastre	12	-	12
Amazonia	9	-	9
Education	6	-	6
Total	**855**	**664**	**1519**

Table 16 – Major institutions and the main keyword categories

	Category						
Institution	**MM**	**GT**	**RS**	**GNSS**	**Photo**	**Carto**	**Total**
UNESP	20	0	0	12	15	2	**49**
INPE	4	0	36	2	0	0	**42**
UFPR	7	9	0	11	8	3	**38**
USP	0	3	0	2	1	3	**9**
UFPE	0	0	0	0	0	3	**3**
Total	**31**	**12**	**36**	**27**	**24**	**11**	**141**

MM: Methods and Models; GT: Geodesy and Topography; GNSS: *Global Navigation Satellite Systems*; Photo: Photogrammetry; Carto: Cartography; RS: Remote Sensing.

Table 17 – The number of researchers related to the main keywords of all categories in CNPq

Category (group of keywords)/Most cited keywords in the category	Ph. D.		non Ph.D.		Total (all)	
	Area	Subarea	Area	Subarea	Area	Subarea
	Geosciences	Geodesy	Geosciences	Geodesy	Geosciences	Geodesy
Águas (Water)/ Bacia (basin)	3579	127	3606	291	7185	418
Ecologia e ambiente (Ecology and environment)/ Ambiental (Environmental)	2393	150	4678	491	7071	641
Dados e banco de dados (Data and database)/ Dados (Data)	2354	219	2560	416	4914	635
Mapas e mapeamento (Maps and mapping)/ Mapeamento (Mapping)	1736	171	2452	375	4188	546
Solos e vegetação (Soils and vegetation)/ Solo (Soil)	1755	117	2270	256	4025	373
Imagens (Images)/ Imagem/Imagens (Image/Images)	1718	259	2114	541	3832	800
Mapas e mapeamento (Maps and mapping)/ Mapa/mapas (Map/Maps)	1666	220	1959	387	3625	607
Outros systems (Other systems)/ Sistemas (Systems)	1750	186	1596	273	3346	459
Métodos e modelos (Methods and models)/ Modelo (Model)	1797	177	1523	249	3320	426
Educação (Education)/ Ensino (Teaching)	1303	123	1970	174	3273	297
Administração (Administration)/ Planejamento (Planning)	1283	120	1700	240	2983	360
Administração (Administration)/ Monitoramento (Monitoring)	1343	122	1447	204	2790	326
Sensoriamento remoto (Remote sensing)/ Sensoriamento remoto (Remote Sensing)	1170	144	1589	331	2759	475
Análise (Analysis)/ Análise Espacial (Spatial analysis)	1167	127	1132	167	2299	294
Cartography (Cartography)/Cartography (Cartography)	930	180	1212	314	2142	494
Sistemas de informações geográficas (Geographic information systems)/SIG (GIS)	824	142	1221	316	2045	458
Disciplines (Disciplines)/ Geomorfologia (Geomorphology)	806	34	1015	73	1821	107
Agronomia e uso da terra (Agronomy and land use)/ Uso da terra (Land Use)	954	78	862	113	1816	191
Classificação e padrões (Classification and patterns)/ Classificação (Classification)	1029	111	783	149	1812	260
Amazonia (Amazonia)/ Amazonia (Amazonia)	938	37	872	79	1810	116
Métodos e modelos (Methods and models)/ Rede (Network)	843	138	869	168	1712	306
Solos e vegetação (Soils and vegetation)/ Vegetação (Vegetation)	769	49	751	95	1520	144
Sistemas de informações geográficas/ Sistema de informações geográficas	561	118	613	164	1174	282
MDE. MDS e MDT (DEM, DSM and DTM)/ Modelo digital (Digital model)	645	135	471	147	1116	282
GNSS/GPS	425	169	639	295	1064	464
Detecção e extração (Detection and extraction)/ Extração	525	43	417	65	942	108
Detecção e extração (Detection and extraction)/ Extração	525	43	417	65	942	108
Detecção e extração/Detecção	497	73	338	63	835	136
Análise (Analysis)/ Análise estatistica (Statistic Analysis)	520	51	271	32	791	83
Cadastre (Cadaster)/Cadastre	294	121	367	159	661	280
GNSS/Posicionamento (Positioning)	313	112	271	132	584	244
Tecnologia (Technology)/Internet	232	49	239	46	471	95
Estatistica e MMQ (Statistics and LSM)/ Precisão (Precision)	264	104	196	93	460	197
Processamento digital de imagens (Digital image processing)/ Processamento digital de imagem	229	67	132	50	361	117
Visualização (Visualization)/Visual	193	28	164	29	357	57
Geodesia e topografia (Geodesy and topography)/ Geodesy	163	119	132	108	295	227

returns all the curricula vitae (CV) related to an entered keyword.

For the "methods and models" category the keyword entered was "model" and it returned 1,797 CVs stored as Philosophy Doctors (Ph. D.) in Geosciences area, and 177 in Geodesy subarea; 1,523 CVs and 249 CVs of all researchers (all but Ph. D.) stored in the Geosciences and Geodesy, area and subarea, respectively. Every line of the Table 17 presents the category (column 1) and the keyword entered to search CLP (column2). The columns 3 and 4 shows the Ph. D. quantity of the returned CV for the search in the Geosciences area and in the Geodesy subarea, then the same area and subarea for non Ph. D. (columns 5 and 6) and it finishes with the totals (columns 7 and 8). The categories and the original keywords are written in Portuguese otherwise the returned numbers would be different. The corresponding English expression or word is in the parenthesis.

The geosciences area means the entire number of researchers that has scientific interest on matters related to a certain keyword and it contains the specialized community of geodetic and cartographic researchers represented by the subarea Geodesy. In CLP the subarea Geodesy also includes Photogrammetry, Base Cartography, Geomatics, and all disciplines or terms related to the cartographic mapping.

4.2 The branches of the organizations in the market and the issues of interest to research institutions

Both organization branches and research keyword categories are more general definitions of the scientific and technologic knowledge applications. Table 8 informs that public sector still is dominant in the cartography engineer´s labor market while table 14 confirms that the science, technology and innovation in geodesy and cartography in Brazil is totally dependent on the public research institutions.

Cartography engineers work for public and private organizations whose main interests are the application branches (table 18, column 1) of what the researchers say, according to the articles published by RBC and BCG, that their interests (same table, column 3) may be represented by knowledge disciplines (see table 4), which are mainly studied, researched, and taught in public universities.

4.3 The routine tasks and the main research keywords

In table 12, cartography engineers say that their main habitual tasks (reproduced in table 19, column 1) include technical, administration, and consulting activities, very well consistent to figure 4. Seven keyword expressions are coincident for the geosciences area and the geodetic subarea (Table 19, columns 3 and 5), recovered from CLP (Table 17). In a broad sense, they denote interest on methods, techniques, and material to work with environmental data. Concerning to the more general area, namely geosciences, the remaining four words point to social (planning and teaching) and to geographical (basin and soil) issues. In the more specific subarea – geodesy – the words clearly define four fundamental disciplines (Cartography, GIS, GPS, and Remote Sensing). There should be noted, again, that in CLP geodesy includes all the mentioned disciplines.

5. ENGINEERING, SCIENCE, AND BUSINESS IN THE KNOWLEDGE ROUND TABLE

Besides the scientific and technical knowledge, engineers must learn about the relevant innovation so they keep themselves able to apply and analyze the knowledge to the world and people needs. From this reality new questions may arise and more necessities can be attended so the engineers can help to formulate or reformulate other scientific problems. Scientists must overcome the novel challenges so their research work may provide more advances to the knowledge. The solutions of the new or reformulated scientific problems are

Table 18: Organization branches and the research keyword categories

Organization Branches		Keyword Category	
Base mapping	85	Methods and models	168
Thematic mapping	82	Geodesy and Topography	137
Planning	68	Remote Sensing	133
Environment	64	GNSS	103
Land management	56	Cartography	99
Land limits	54	Photogrammetry	92
Aerial/Space	45	Statistics and LSE	62
Environment analysis	43	Detection and Extraction	60
Land issues	40	Images	54
Geography	39	Digital Image Processing	47
Oil	39	Ecology and Environment	46

Table 19 – Cartography engineer's routine tasks and the research keywords

Routine Tasks		Keywords for Geosciences Area		Keywords for Geodetic Subarea	
Geodetic surveying	89	Basin	7185	Image/images	800
Topographic surveying	76	Environment	7071	Environment	641
Coordination	75	Data	4914	Data	635
Planning	75	Mapping	4188	Map/maps	607
Cartographic production	75	Soil	4025	Mapping	546
Database	72	Image/images	3832	Cartography	494
Geodetic analysis	64	Map/maps	3625	Remote sensing	475
Image analysis	61	Systems	3346	GPS	464
Consulting	56	Model	3320	Systems	459
Map use	56	Teaching	3273	GIS	458
Digital terrain model	55	Planning	2983	Model	426

applied again by business and engineering companies to the world reality.

The survey informs that the cartography engineers are looking for studying opportunities and continuing to improve their educational level and technical skills such as online and e-learning education (100/212 = 47%), conferences and university extension courses (42% each), lato sensu specialization courses (41%), part time master degree (37%), refresher courses (36%), and integral master degree (23/212 = 11%). The questionnaire allowed more than one option. It is interesting that such a sample already is half balanced between under graduate and post graduate engineers and it additionally shows that there are motivation to continue the studies to improve knowledge and skills. The 212 cartography engineers filled the forms out with themes and topics they want to proceed studying (Table 20).

GIS, Geodesy, Cartography, Administration and Photogrammetry, in citation decreasing order, represent the whole mapping process. Geodesy on open field, Photogrammetry on images, Cartography for visualization, and GIS and Administration for planning illustrate a very clear scenario for the next future: although advanced knowledge will bring new technology, the map production mainstream is firmly defined so it settles the cartography engineer professional identification.

Considering the table 21, the public universities are related to the columns 1 till 5 (teaching: 1 and 2; researching: 3 till 5) and also to 8 (continued education). The research institutions are related to the columns 2 till 5. The cartography engineers are referred to the columns 6 (less), 7 (more) and 8. The employer organizations are related to the column 6 (more) and 7 (less). Undergrad disciplines, routine tasks and continued education have much in common. Columns 2 and 3 are very well correlated (graduation and publication).

Table 20 – Themes and topics for continued education

Matter	Number of citations
Geographical Information Systems	44
Geodesy	38
Cartography	33
Administration	20
Photogrammetry	18
Cadastre	16
Remote Sensing	14
Database	13
Geoprocessing	13
Planning and Project	10
Least Square Adjustment	9
Quality Control	8
Surveying	8
Environment	6
Topography	6
Computing	5
Law	5
GNSS	5
Georeferencing	4
Laser and radar	4
Digital Image Processing	3
Digital Terrain Model	3
Oil	3
Miscellanea	19
Total	315

6. CONCLUSION

Three distinct surveys were concluded to cement this article. They inform about the cartography engineer in the work market and the academic and scientific production of Brazilian researchers. The tasks and interests of the engineers and researchers as professionals and the private and public employer organizations and the research institutions data were analyzed.

Although the surveyed data concerned to cartography engineers has been gathered in samples, the researcher´s data is quite all the population. Both studies confirm the same geographic distribution in Brazil according to the economy and population map.

Table 21 summarizes the main disciplines, methods, techniques, and applications that may help one visualizes the scientific knowledge cycle pertaining to the geodetic and cartographic fields. All entities and actors give pieces of contribution, namely the universities, the research institutes, the government organizations, the business companies, the students, the engineers, and the researchers. The relationship among them can be seen in the tables and illustrations. It is quite reasonable to claim for a well articulated system with research themes, academic disciplines, public and private organizations performing in several branches, and engineer´s routine tasks that adjust themselves to the nation´s needs as well as to the Brazilian society.

Technologic innovation has an important share in the cartography engineering labor market so it deserves special attention in order to create and increase work opportunities to young and senior scientists. A strategic policy should encourage the engagement of scientists into industry.

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REFERENCES

ACADEMIC RANK OF WORLD UNIVERSITIES. **Rankings**. Shangai, 2011. Disponível em: <www.arwu.org.>; acesso em 01.maio.2011.

BRASIL. IBGE. **IBGE divulga nova série do sistema de contas nacionais (21.março.2007)**. Disponível em: www.ibge.gov.br/home/presidencia/noticias; acesso em 05.maio.2011.

BRASIL. **Lei 10267**, de 28 de agosto de 2001. Dispõe sobre a obrigatoriedade do georreferenciamento de imóveis rurais. Disponível

Table 21 – Main disciplines, research keywords, organization and routine tasks obtained by the three surveys

Undergrad disciplines	Graduation Disciplines	Keywords (published articles)	CLP Keywords Geosciences Area
-1	-2	-3	-4
Cartography	GIS	Methods and Models	Water Basin
Geodesy	Digital Image Processing	Geodesy and Topography	Environmental
Satellite Geodesy	Remote Sensing	Remote Sensing	Data
Topography	LS Adjustment	GNSS	Mapping
GIS	Computing	Cartography	Soil

CLP Keywords Geodetic Subarea	Organization Branches	Routine Tasks	Continued Education
-5	-6	-7	-8
Image	Fundamental Mapping	Geodetic Surveying	Geographic Information System
Environmental	Thematic Mapping	Topographic Surveying	Geodesy
Data	Planning	Coordination	Cartography
Map/Maps	Environment	Planning	Administration
Mapping	Land Administration	Cartographic Production	Photogrammetry

em <http://www.leidireto.com.br/lei-10267.html>; acesso em 23.junho.2011.

CONSELHO NACIONAL DE DESENVOLVIMENTO CIENTÍFICO E TECNOLÓGICO (CNPq). **Plataforma Lattes**. Brasília, 2011. Disponível em: <www.cnpq.br>; acesso em: 16.novembro.2010.

MARQUES FILHO, O; VIEIRA NETO, H. **Processamento Digital de Imagens**. Rio de Janeiro: Brasport, 1999, 307 p.

MENDONÇA, A.L.A.; SLUTER, C.R. Análise da relação entre ensino e pesquisa em ciências geodésicas e a cobertura do mapeamento sistemático no Brasil. **Revista Brasileira de Cartografia**, v. 63, p. 1-10. 2011.

SILVA, J. F. C. Caracterização do mercado de trabalho do engenheiro cartógrafo. **Revista Brasileira de Cartografia**, v. 47, p. 62-76, 1996.

SILVA, J. F. C.; BERVEGLIERI, A. Principais instituições que geram artigos na RBC e no BCG. **Revista Brasileira de Cartografia**. v. 63, n. 2, p. 1-10. 2011.

SILVA, J. F. C.; SANTOS, I. R. O. O panorama da profissão: quinto levantamento do programa de acompanhamento do mercado de trabalho do engenheiro cartógrafo. CONGRESSO BRASILEIRO DE CARTOGRAFIA, 23., 2007. Rio de Janeiro: Soc. Bras. Carto., Geod., Fotogram. e Senso. Remoto. **Anais**... 7p.

SILVA, J. F. C.; SPINELLI NETO, A. *Situação do engenheiro cartógrafo no mercado de trabalho*. Rio de Janeiro: Soc. Bras. Carto., Geod., Fotogram. e Senso. Remoto. **Revista Brasileira de Cartografia**, v.52, p.76-87, 2000.

SOCIEDADE BRASILEIRA DE CARTOGRAFIA, GEODÉSIA, FOTOGRAMETRIA E SENSORIAMENTO REMOTO. **Revista Brasileira de Cartografia**. Rio de Janeiro, 2010. Disponível em: <www.rbc.ufrj.br>; acesso em 30.junho.2010.

UNIVERSIDADE FEDERAL DO PARANÁ. CURSO DE PÓS-GRADUAÇÃO EM CIÊNCIAS GEODÉSICAS. **Boletim de Ciências Geodésicas**. Curitiba, 2010. Disponível em: <http://ojs.c3sl.ufpr.br/ojs2/index.php/bcg/index>; acesso em 30.junho.2010.