AIRBORNE LASER SCANNING IN THE BRAZILIAN MARKET

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ABSTRACT:

The use of laser, as a remote sensory instrument, has been in a developing stage for over 30 years. Starting in 1995, the commercial development of Light Detection and Ranging technology (LIDAR) grew fast and became an important technique for obtaining data of digital model of land, as well as digital model of surfaces. In Brazil, the first use of mapping with LIDAR, was performed in 2001 by an aerosurvey company, which has been using the sensor mainly to survey strips of ducts for correcting orthophotos and projects of highway engineering. In 2002, a research institute and a specialized company in cartography also acquired the sensor, which is being used in surveys and research in Brazil. This work has the objective of reporting the use of LIDAR technology in Brazil, to show its application, results and expectations obtained, as related to the development of the technology at national level. The information for the work was obtained by interviews with main Brazilian professionals who are working directly with applications of LIDAR and with those who are developing research in this area.

1. INTRODUCTION

In Brazil, there are several companies which obtain aerosurveys for the production of maps in large scale. They are located mainly in the more developed part of the country, which is, in the south and southeast. These companies are using the digital photogrammetry in the mapping process, at least for ten years. Therefore, in spite of the fact many researchers consider South America, and even Brazil, as being technologically backwards in the production of maps; this is far from the truth.

The fact is that there is a very large discrepancy in updating the systematic national mapping, which is the federal government's responsibility. Most of our cities have no mapping compatible with urban planning. This is a result of two facts: (a) lack of investment policy for federal cartography and (b) scanty resources appropriated for this purpose.

However, the development of the country brought up new needs and they are interrelated to the physical knowledge of the land, the property, and the socio-environmental topics. All this needs to be physically determined and specialized and calls for good maps. We have a country, which is a continent, to map, we have compatible technology, however, we have few economical resources, which justify the concern for cost/benefit in the investments in new technologies, as the Laser Scanner.

Mello (2002), reviewing the situation of the Brazilian market for the suborbital imaging sensors, concludes that the high cost of the new technologies are only assimilated in the market when the advantages and applications are compensatory. This is not only true in Brazil, but anywhere in the world, for any enterprise. Therefore, the recent acquisition of the Laser Scanner sensors, by three Brazilian companies, must have been a result of this knowledge.

The first sensor was acquired in the year of 2001 by an aerosurvey company. In 2002 they have acquired two more sensors, one for a specialized company in cartography and another for the technology institute for development (LACTEC), linked to UFPR (Federal University of the State of Paraná) and COPEL (Power Company of the State of Paraná).

Several researches are in the making by companies which have the sensors, as well as by researchers in Brazilian universities. It is exactly the current situation of these applications of LIDAR, in Brazil, that the following article is going to touch on.

2. DESCRIPTION OF LIDAR SYSTEMS USED IN BRAZIL

Altimetry for LASER, more commonly referred to, in the commercial sector, as LIDAR mapping (Light Detection and Ranging), is becoming a common operational tool in the fields of the remote sensing control, photogrammetry, and mapping. LIDAR technology is capable to generate fast, dense and accurate digital model of the topography and the vertical structure of a surface. For a lot of applications that need high accuracy in elevation models, LIDAR technology offers unique technical capabilities; it reduces costs of field operations, and reduces the time and effort of post-processing, when compared to the traditional surveying methods. The commercial development of LIDAR technology is growing rapidly, since 1995 (FLOOD, 2001).

Plate 1 presents the institute and the Brazilian companies which possess the LIDAR system, the model, the manufacturer of the system and year of acquisition.

Company/ institution	ESTEIO S.A.	GEOID Ltda	LACTEC
System Model ALS	ALTM 2025	ALTM 1225	ALTM 2050
Manufacturer	Optech Inc.	Optech Inc.	Optech Inc.
Maximum operational flying altitude	2000 m	1200 m	2000 m
Average laser repetition	25 kHz	25kHz	50 kHz
Year of acquisition	2001	2002	2002

Plate 1: Laser Scanner sensors used in Brazil.

3. SURVEYS MADE IN BRAZIL USING LIDAR TECHNOLOGY

The first surveys, using LIDAR technology in Brazil, were performed in strips of ducts of Petroleo Brasileiro S/A Company (PETROBRÁS) spread throughout the country. The purpose was the mapping through altimetry of this strip, with the purpose of obtaining a Digital Terrain Model (DTM) for orthophotos rectification. The survey was performed along the servitude strip. At this stage, they traveled about 3.000 lineal km with an average strip of 700m, which is equal to 2.100 sq km of data of LIDAR.
LIDAR surveys were already performed: for the area of highway engineering, surveys in strips for electric power transmission lines and strips of peroleum ducts, in urban areas, in mining areas, for areas of interest for hydraulic potential and of hydric resources, in reforestation and native forest for biomass estimates and vegetation classification.
Table 1 displays the amounts obtained by two companies, showing that 8.600 sq km were imaged in several places and for several purposes.

TYPE OF SURVEY	**AREA SURVEYED (SQ. Km)**	**(%)**
Strip survey (transmission lines, servitude strips of ducts)	3225	37,5
Altimetry deviation (DTM for ortho-photo rectification and to produce contour lines)	2150	25,0
Hydric Resources	1800	21,0
Highway Engineering	975	11,23
Urban and rural mapping	400	4,7
Reforestation	50	0,57
TOTAL	**8600**	**100**

Table 1: mapped area using Laser Scanner sensor in Brazil

The mapping of hydric resources looked for inventories of hydroelectric power plants and for the determination of inundation quota. In the application for reforestations and native forests, it was used to aid in the biomass estimates, as well as in the classification of the vegetation (using altitude in relation to terrestrial surface). In highway engineering, mapping was performed in preliminary studies of the final project of highways. Studies are in the process of seeking the use of the technology in the final phase of highway projects. Urban and rural maps have been generated, in some cases, utilizing only by-products of the Laser Scanner sensor, in other cases, they are the result of fusing Laser Scanner data and products of digital photographys, as the orthophotos.

4. PRODUCTS DEVELOPED BY COMPANIES USING INFORMATION DERIVING FROM THE LASER SCANNER SENSOR

a) Starting from cloud points of the Laser Scanner, countour lines are created, Hypsometrical Maps, Digital Terrain Models and Digital Surface Model, compositions of hypsometry colors and intensity image.
b) Development of applications (during the last two years) for the owners of LIDAR equipments in the country: for biomass estimates in reforestation areas; 3D mapping of transmission lines; programs, exclusively, to work with the technology, as in the case of a software to deal with information resulting from the LIDAR system seeking the automatic search of falling in bodies of water.
c) Fusion of Laser Scanner data and others: Some customers only need the altimetry of a region, for this purpose, the Laser Scanner is the final product (as the example of Mining Companies and of engineering projects). The by-products are demands or customer's needs. If the purpose is to obtain orthophotos, planialtimetry, etc., the Laser Scanner is a tool that complements the process, acting in one of the phases (DTM aquisition). There are already areas in the country, where maps were produced just by using the products of the Laser Scanner sensor, without the need of any other by-product (they used elevation contours derived from laser points and images resulting from composition of hypsometry and LIDAR intensity image).

5. RESEARCH IN TEACHING INSTITUTIONS

From the beginning of LIDAR technology in the country, several research projects are being developed by companies which have the technology as well as by researchers at universities. In this manner, the publications begin to appear in national and international levels of the results reached by these researchers.
Before the existence of LIDAR technology in the country, there were already researchers in accord with German universities, developing works involving Laser Scanner products, which brought the technique to the country. Since then, researchers have been developing projects and products, using the technology, in the country. The first researches, at university level, were accomplished taking as examples, for their area of study, urban environments of European cities. They mainly involved classification of spectral and space images of the Laser Scanner sensor, detection and identification of constructions and vegetation.
Nowadays there are several dissertations and theses in progress, in the country, having as study subject, LIDAR, its products and applications. And several already finished. Schäfer (2004), studied of application of LIDAR and orthophotos integration for use in highway enginnering projects.
One research line is related to the handling of by-products of LIDAR, as filtering, classification and creation of terrain models. Subjects as the operational safety of the Laser Scanner sensor was also a topic of study.
A doctorate thesis is in progress at the Federal university of Santa Catarina (UFSC). It involves the comparison of results obtained with the LIDAR system, as related to other types of available products, to see whether the results are compatible with the existing cartographic standards in the country.
Another line of research seeks the use of LIDAR by-products for a great variety of applications. Among the utilizations in study, we may cite highway projects (figure 1 and 2) (Schäfer, 2004), the study of relief in areas of hydroelectric plants, characterization and the monitoring of natural resources (Groszewicz, 2003), drainage problems, distribution of energy (Müller, 2002), transmission lines (Baungarten, 2003) and studies in urban areas (Calmon, 2003; Groszewicz, 2003). There are already finished researches, including master degree dissertations, in this line of study.

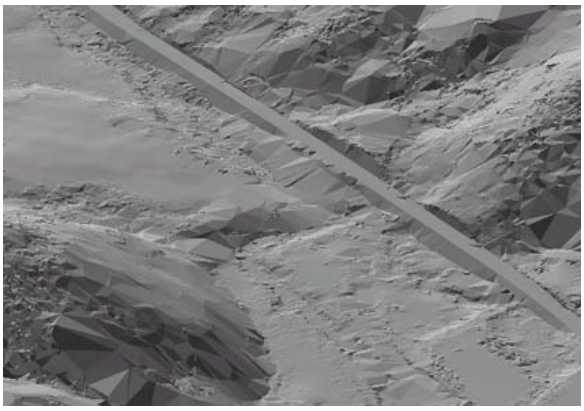

Figure 1. application of LIDAR derived products in highway projects (DTM with simulation of projected highway).

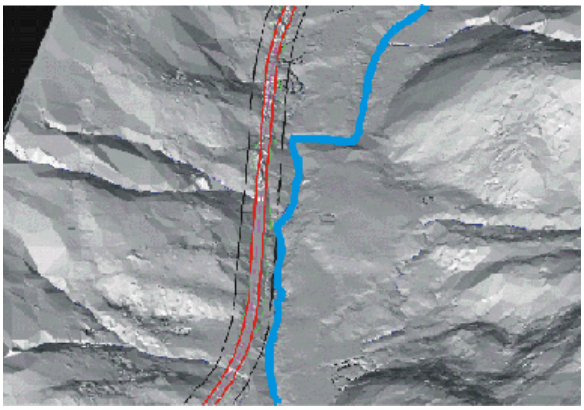

Figure 2. application of LIDAR derived products in highway projects (detection of possible environmental problems right-of-way).

6. PROBLEMS FACED BY THE OWNERS OF LIDAR SYSTEM

The largest problem mentioned by the system owners is the high cost of maintenance of the equipment, considering that it is a high technology of the latest generation. Another problem is the understanding of the uses and limitations of the technology, on the part of the customers, who are influenced by concepts given out by people who have no knowledge of Laser Scanner equipment and its limitations and potentialities.

Another difficulty is the need of a highly specialized and trained team of people to work in the acquisition of the LIDAR data (planning and carrying out the flights, data processing), treatment (filtering, classification), making products (DTM/DSM, hypsometric maps, etc), as well as the application of these products for a great variety of uses.

It should be pointed out that it is a work for specialized engineers; otherwise, there is the risk of producing data which may be incoherent with reality. Besides, in order to obtain better results, there is a need for correct interpretation of the objectives of the project to be executed, in the phase of acquisition of data as well as in the processing phase.

7. DIFFICULTIES TERMS OF MARKET

The owners of LIDAR technology in the country agree that the cartography market in the country is already difficult by itself. The LIDAR technology is still an innovation for many contracting parties of mapping in Brazil. In the cartographic community Laser Scanner can be considered a new technology experienced in tests and approved for the maps production .

Besides, this market is polluted for conservative ideas that tend to refute new technologies without at least to try knows them. It is difficult for a customer (usually a state organization) to understand the by-product of the Laser Scanner survey. The subject of altimetric quality is an example of that; many don't get to dissociate of contour line obtained by photogrammetry, whose quality on it influences of operator subjectivity and of mapping scale. The explanation of that new product becomes a task as arduous as the surveying itself. Another important fact is the question of cost of a Laser Scanner survey. It is still too high for a restricted market with a Brazilian.

8. EXPECTATIONS ABOUT OF LIDAR TECHNOLOGY FUTURE IN BRAZIL

The surveing and researches already accomplished and in development are enlarging the possibilities of LIDAR technology application at the country. The approval of the law 10.257 (city statute) in 2001, it turned obrigatory the master plan implantation for the Brazilian cities with more than 20.000 inhabitants, doing still more urgent the need of mapping realization of those cities. Although mapping demand is elevated, the financial resources to accomplish them are limited. The Laser Scanner sensor can be an alternative to map the cities with goal of master plan execution.

The GIS application for urban planning, environmental and forest purpose, electric power sections, etc. it is constituted in vast field for application of LIDAR technology in Brazil. Still more being taken into account that the data are usable in digital ambient, a new form of using space data and remote sensor products.

It is waited that next years new surveing and researches bring benefits for the following areas:

1. environment: antropic actions monitoring, creation of digital digital models and of elevation, erosion monitoramento, mapeamento of basins hidrográficas, control of floods;
2. forest section: height of the vegetation, virtual removal of the vegetation, biomass estimate;
3. urban planning: urban drainage, telecommunications, digital models of elevation urban;
4. electric section: project and monitoramento of transmission lines, mapeamento of basins hidrográficas, modelling of reservoirs;
5. other: cut-and-fill volumes, highway engineering projects and rail, petroleum and gas.

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