

# **Preliminary Analysis of the Possibilities for the Implementation of 3D Cadastre in Brazil**

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**Key words:** Brazilian Cadastre, 3D Cadastre, Land Registration in Brazil

## **SUMMARY**

The Brazilian cadastre situation is complex. Its administrative structure is broken up into rural land records, which are a federal responsibility, and urban land records, a municipal responsibility. New laws recommend creating multipurpose cadastres, which means it is time to review the need for a 3D cadastre. This article presents the Brazilian cadastre in its present context and a proposal to define an organization responsible for managing it and standardizing its procedures. It also identifies instances of the need to include tridimensional information in the cadastre and analyses the legal and administrative aspects involved in implementing a 3D cadastre in Brazil.

# Preliminary Analysis of the Possibilities for the Implementation of 3D Cadastre in Brazil

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## 1. INTRODUCTION

The cadastre concept evolved over time, based on location since it is the result of the laws, habits and customs of a country. Nevertheless, an excellent definition of cadastre, defined by various studies and FIG - the International Federation of Surveyors - (FIG, 1995) is the following: *The cadastre is a public inventory of methodically organized data based on survey boundaries for existing parcels of a certain territory.*

The main objective of the cadastre is to obtain precise information about ownership and use of land in a certain region to facilitate public management of land planning. Equipped with reliable information, the government will be able to better plan the use of public funds, directing investment to the neediest regions and creating strategies for their social and economic development.

A well-structured cadastre has as its cornerstones the legal status (legal), physical status (geometric description and location), value (fiscal) and actual use and potential (socioeconomic) of property. Since Brazil is a democratic society in which one of the constitutional principles of economic activity is private ownership, the legal status of property is an essential element of the cadastre, but it is not necessarily the survey focus since the identification and tabulation of irregular status is extremely important for obtaining solutions.

Based on a complete cadastre with clear and updated information, the government can better define public policy and manage the use of budget funds to identify the most varied situations. Some examples of the potential of this cadastre can be stated:

- a) problems existing in a certain region: lack of basic sanitation, insufficient number of schools and healthcare facilities for the population index;
- b) industrial centers: the need for new roads and railways to link producers to ports and airports (export incentive), the need for technical courses aimed at creating skilled labor for the region;
- c) rural production: tax incentives for productive regions, technical support for farmers.

A land cadastre should not be used only for tax collection, focusing only on fiscal goals. It is an essential land management tool and serves to support other types of political-administrative management (economic, social, public safety, homeland security, infrastructure, agrarian reform, education, etc.).

The objective of this study is to demonstrate the urgent need for creating and regulating a multipurpose cadastral system that includes all urban and rural properties in the country. In addition, it seems appropriate to investigate whether it is time to take advantage of existing technology and implement a tridimensional cadastre (3D Cadastre) that could represent a wide variety of situations, as the traditional survey has proved unable to meet economic demands and security needs of the population.

For a proper understanding of the cadastral situation in Brazil, section 2 shows the reality of separate Brazilian cadastres for rural and urban land. Section 3 discusses the suitability of integrating the various cadastre systems by forming a multipurpose land cadastre able to meet land management needs. Finally, section 4 presents an analysis of situations that are not addressed in a 2D cadastre. These are becoming more common as the demand for land use increases beyond availability. Based on these examples and the 3D Cadastre models presented by Stoter (2003), it is proposed that vertical component information be introduced gradually into the cadastre.

## **2. THE REALITY OF THE BRAZILIAN CADASTRE**

The Brazilian real estate cadastre is not unified. The rural cadastre is centralized and managed by the Federal Government, while the urban cadastre is the direct responsibility of the municipalities. That is, its control is spread over 5,565 municipal administrations without any law to standardize procedures.

### **2.1 The rural cadastre**

The cadastre of rural properties throughout the country is regulated by INCRA - National Institute of Colonization and Agrarian Reform - the federal agency responsible for managing the National Rural Cadastre System (SNCR), under article 3 of Decree no. 72.106, dated 18 April 1973.

Rural property is registered by a declaration from the owner, holder of useful domain or holder in any capacity. The literal and declarative content is the biggest database problem for the SNCR, since data fed into the cadastral system is only reviewed as a formality, with no control over the accuracy of declarations.

According to paragraph I of article 2 of Decree no. 72.106/73, this rural property cadastral system is focused on the following objectives: tax collection (calculating the ITR – Rural Land Tax); agricultural policy (supplying technical assistance and credit to farmers); and agrarian reform and colonization (principal mission of the INCRA).

However, INCRA is no longer responsible for collecting the Rural Land Tax; since 1990, this has become the duty of the Federal Revenue Service, and since 1999, the Ministry of Agriculture no longer handles “tax collection” and “agricultural policy”. They are now the focus of the rural cadastre manager. Before this, the cadastre was managed and produced with almost exclusive emphasis on agrarian reform and colonization.

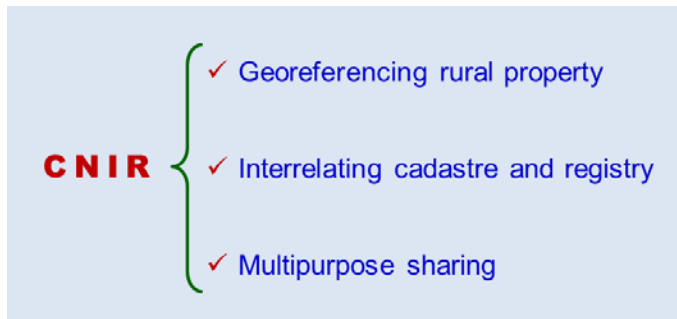
Aware of the importance of a well-structured cadastre for national development, the Federal Government enacted Law no. 10.267/2001, which created the National Rural Property Cadastre (CNIR), by changing Article 1 of Law no. 5.868/72:

*§2 – The National Rural Property Cadastre - CNIR is created, which will have a common information base, managed jointly by INCRA and the Secretary of the Federal Revenue Service, produced and shared by the various federal and state public institutions that produce and use information about Brazilian rural areas.*

As emphasized at the end of this legal provision, the CNIR database should be "produced and shared by the various federal and state public institutions that produce and use information about Brazilian rural areas". Although it excluded municipal and private institutions from

sharing, this is a huge step forward because the law insightfully characterized the CNIR as a multipurpose land registry base.

Besides defining the multipurpose nature of the rural property cadastre, Law no. 10.267/2001 created a relevant and bold restructuring of the rural property cadastral system. It created innovation with some real estate registry rules and improved the geodetic structure of the country. The new laws, created to provide support for the CNIR, summed up the obligation to georeference all rural properties and correlate information between the INCRA and the Land Registry.



**Figure 1. Characteristics of the CNIR**

The reason driving these legislative innovations was the need to end illegal occupation of public lands by creating instruments that could identify these invasions.

Mandatory georeferencing of rural property instituted a new legal framework for describing real estate in Brazil. Until then, the custom of poor description prevailed. It was merely descriptive, with no connection to the rules of Land Surveying, and this practice was accepted by jurisprudence because of benevolent laws. The current law, however, is different. The survey stresses positional accuracy which shows the true location, form and size of rural property. To perform the technical work of georeferencing rural property, the surveyor must be certified by INCRA. Presently, there are little more than 6,000 accredited professionals, the majority of these operating in the South, Southeast and Midwest, where the real estate market is much more dynamic.

After completing the georeferenced survey, the surveyor must submit technical papers and corresponding documentation to INCRA to certify that the geometric definition of the rural property limits does not overlap any other coordinates appearing on the georeferenced cadastre. He must also show that the work was performed according to Technical Norms for Georeferencing Rural Property. By 16 September 2011, INCRA had certified a total of 30,051 georeferenced rural properties across Brazil.

Only after certification, is the survey appraised by the Land Registry which is responsible for overseeing the accuracy of true right of ownership. This is because INCRA's certification of technical work does not include recognition of ownership for the geometric unit certified; nor does it imply accuracy of the limits and boundaries of that unit. And it does not exempt the owner and surveyor from responsibility for information submitted.

Georeferencing laws represent a great opportunity to provide the country with truly robust and efficient land management. However, never before has it been necessary to tackle new and complex questions with a professional approach, and getting the various institutions to integrate and cooperate involved a lot of problems. Ten years after the law was published,

many obstacles still exist and adjustments are sorely needed, but the relevance of the law and its benefits to development in the country is clear.

## **2.2 The urban cadastre**

Unlike the cadastre for rural areas which, despite having many faults, is systematically performed and centralized, the cadastre for urban areas of Brazil has no national administrative structure. To do a complete study of the urban land cadastre, information has to be surveyed directly in the local government. This makes the task extremely complicated because there are presently 5,565 cities in the country, with rather diverse socioeconomic realities and different needs and abilities to implement and develop the real estate cadastre (Brandão, Carneiro and Philips, 2010).

With rare exceptions, the cities have taken action in the cadastral area for tax purposes only, since they are responsible for imposing and collecting property tax (the IPTU), betterment contributions and some property fees. To meet this goal, this type of cadastre generally includes the following information: basic property measures (total land area measured from the “tested” and total developed area; property value (of land, additions and improvements); taxpayer information (owner, holder of domain or holder in any capacity), and municipal public services and improvements to the property (sewers, paving, street lights, and garbage collection).

When the 1988 Federal Constitution imposed the obligation on municipalities with a population over twenty thousand inhabitants to create a Master Plan, the search for a more efficient cadastral system became a necessity. The Master Plan is the basic tool of development policy and urban expansion. For it to be truly effective, it must be developed based on a complete, well-structured cadastre which can provide the information needed to show the actual current status of the city because goals will be set based on this information.

The Statute of the City (Law no. 10.257/2001) created a series of instruments aimed at planning urban development, spatial distribution of the population and economic activities developed on city land. However, the majority of these new legal instruments can only be used if the city has a Master Plan, which makes it even more essential to search for a more robust and systematic cadastre.

The urban territorial cadastre currently used in Brazilian municipalities follows a model proposed by the CIATA (Technical-Administrative Improvement Incentive Agreement for Cities). This project was introduced by the Federal Government in the 1970s. It consists of a database of maps showing graphs of the territory divided into parcels and a descriptive database with records of physical and abstract attributes of parcels identified on maps.

According to Carneiro (2003), for the majority of Brazilian cities the map database is made up of the cadastral reference map, urban equipment map and the map of city blocks. These maps are normally obtained by aerial photographic or topographic surveys. Except for some differences in terminology or implementation methods, when the reference maps are linked geographically, they correlate with the Geological Map of Brazil to the Millionth Scale. The result is isolated blocks obtained without the support of a geodetic reference network.

The descriptive database for the urban cadastre is made up of data about the property and its owner or holder. According to the model adopted in practically the entire country, this information is collected through two documents: the Street Bulletin (BL) and the Real Estate

Cadastre Bulletin (BCI). Information contained in these two documents corresponds to the database that facilitates processing and introduction of taxes.

All of the public zones of the city are codified in the BL, and the existing urban services and market value per square meter of land are shown (according to the property value map, which indicates property values according to city zone).

The BCI gathers all information referring to urban property, such as physical characteristics, location and personal characteristics of the taxpayer (owner or holder).

However, although there is a certain similarity between procedures, the urban cadastre is far from being standardized, because contrary to events for rural properties, there is no law imposing objective regulations on reporting methods for this important and necessary cadastre. Another issue that makes it difficult to implement an efficient cadastre is the lack of enough cartographic databases to meet the need.

Obviously, in this context, Brazil urgently needs a technical property cadastre designed to serve as a basis for all other cadastres. One sole cadastre needs to be created that can be used to create all of the other land information systems (that can be classified as thematic cadastres). Only if it has these attributes will the cadastre actually be multipurpose.

### **3. MULTIPURPOSE TERRITORIAL CADASTRE**

According to the Dale and McLaughlin definition (1990): *a multipurpose cadastre is a system of territorial information designed to serve both public and private organizations, as well as to serve citizens*. In Brazil the multipurpose aspect has been addressed differently for urban and rural cadastres.

#### **3.1 The multipurpose rural cadastre**

The focus of the Multipurpose Territorial Cadastre survey is the parcel, which is the smallest territorial survey unit of public interest. Therefore, a parcel may represent a property registered (according to the land register), a group of registrations (rural property under the Land Act, Law no. 4,504 of 30 November 1964) or just a portion of it (legal reserve, existing within a registered property). To better understand this concept of parcel, it is necessary first to show the difference between the concept of property under Civil Law (listed on the property registry) and Agrarian Law (listed on the Incra cadastre).

The Civil Code (Law no. 10,406 of 10 January 2002) regulated real estate rights to property with traditional precision and based acquisition of these rights on the land registry. The Public Records Law (Law no. 6,015, de 31 December 1973) supplements these rules, establishing the informant system for property registration. It regulates the method and procedures for registering property rights.

*Art. 227 – All property having a title to be registered must be recorded in Book no. 2 - General Registry – to comply with the provisions of Article 176.*

*Art. 176 - Book no. 2 - General Registry – is for registration of property and registration or recording of documents listed in article 167 which are not assigned to Book no. 3.*

*§1º - Book no. 2 registration will follow these rules:*

*I – each property will have its own record, which will be opened with the first record in effect under this law;*

For registration uniformity, every property has its own record and every record refers to only one property. Therefore, when defining the right of ownership, the unit of real estate used is the property described and featured in the real estate ownership record.

For Agrarian Law, the concept of rural property is presented by the Land Act:

*Art. 4 – For the purposes of this law, the following are defined:*

*I – Rural Property, rustic property on continuous area, regardless of location, that is intended for extractive use in agriculture, ranching or agribusiness, whether through public valuation plans or private initiative.*

The agrarian law definition emphasizes the issue directly linked to its objectives, which is the rural nature of the property. On this land the encouragement, regulation and control of productivity in agriculture, ranching and agribusiness are directly reflected in the economy and development of the country.

Thus, it is common for rural property registered in INCRA to be made up of several records or transcripts (that is, several rural properties) or of non-titled areas (areas of ownership). This has never hindered the functional objectives of local authorities since, to date, information about ownership or real estate liens on property has not been important.

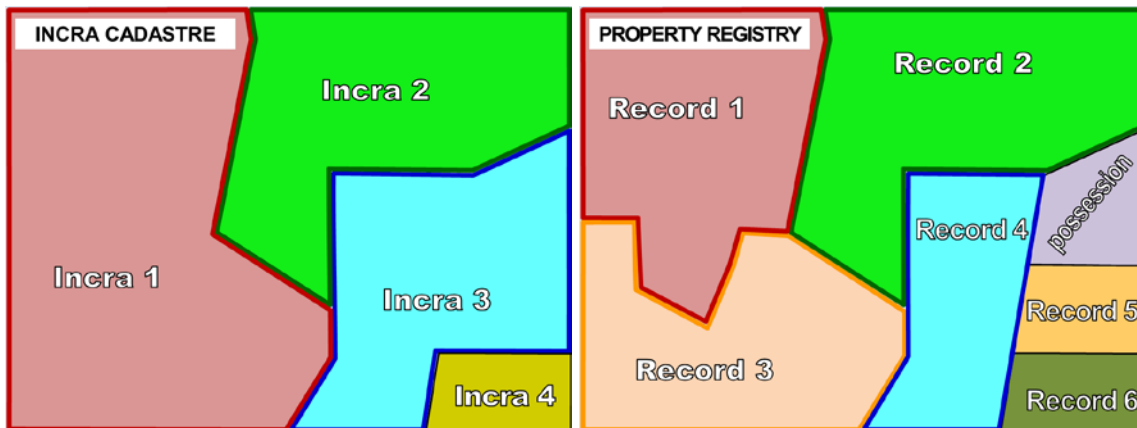
For this reason, the rural property cadastre never had to match exactly the rural property represented by the registration. Instead, the “rural property” to be included in the cadastre just had to meet the concept under agrarian law.

Because of this, the property unit has two distinct concepts:

- a) for Incra: the rural economic unit, encompassing registered areas and areas of ownership; and
- b) for the Property Registry: the registration, i.e. the legally established “real property”.

Understanding these differences, it is necessary to see how the concept of “parcel” can resolve this and other differences existing in the various individual cadastres that will use the multipurpose cadastral database.

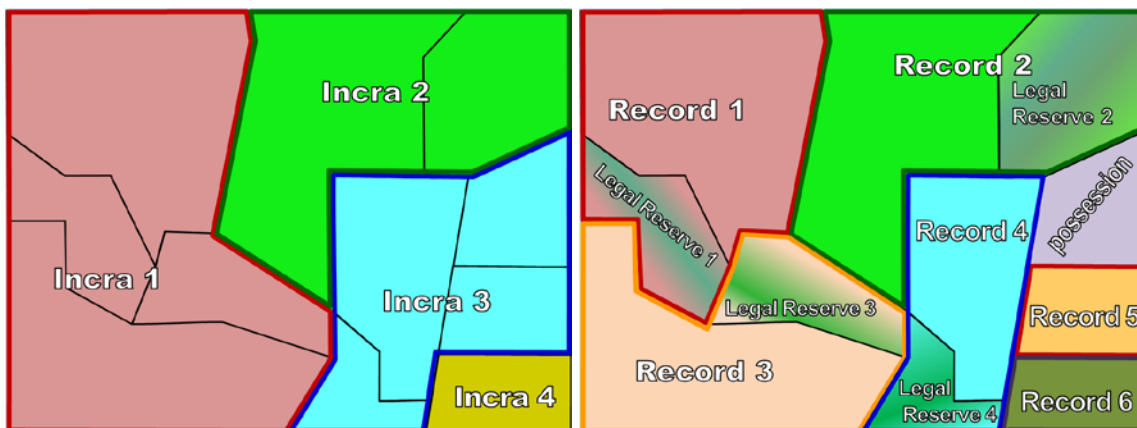
Figure 2 shows that only records 2 and 6 perfectly match the Incra rural cadastre (cadastres 2 e 4). The remaining property units are different, which would make a cadastre based only on these criteria incomplete and useless.



**Figure 2. Difference between the Incra cadastre and ownership status on the property registry**

The parcel concept is not subject to any one of these criteria, but rather to all of them together. This facilitates the “assembly of parts”, i.e. use of the cadastral database by all public and private organizations engaging in territorial management.

Other information of cadastral interest was included in figure 3: the legal reserve area that encumbers the property without changing private ownership. This new information, along with data shown in figure 2, enables to understand the extent of the “parcel” concept. This concept tries to delimit the smallest territorial unit that must be included in the cadastral survey.



**Figure 3. Definition of parcels that are adjusted perfectly in the arrangement of "rural agrarian property" and "real property"**

Thus, the parcel can, at the same time, represent both the Incra rural cadastre and ownership status in the registry (record 6 in the property registry = parcel 4 in the Incra cadastre). It may also represent a group of parcels in one or the other, or both. This is what happens with records 1 and 3, which each have 2 parcels (an open area and an area encumbered by legal reserve), while the Incra rural cadastre generated Incra no.1, formed by these 4 parcels grouped together. It is a different situation for the property recorded as Incra no. 3, which was formed by 4 parcels, 2 from record 4, one from record 5 and one ownership area, i.e. a non-titled area.



Based on this, it is possible to conclude that using the parcel as the territorial unit facilitates creation of a truly multipurpose cadastre that can be used by public and private institutions in practically all areas (social, economic, rural, domain, public safety, etc.).

Although the law has defined the CNIR as a multipurpose cadastre and is conceptually precise, ten years after its implementation it has still not taken form. Difficulties defining the management model and integration problems with INCRA internal sectors can be cited as the main causes of its failure.

Certification of georeferenced properties that should be used to fuel the CNIR did not consider the idea of the parcel. They also did not consider including the delimitation of records. This is information of major importance because it refers to the constitutional right of private ownership. For certification, Incra limited itself to creating a cadastre based on the agrarian concept of rural property. It cared only about setting up its own cadastre, which does not serve as the basis for the majority of other cadastrals in the country.

To comply with Article 176 of the Public Records Law, after Incra certification, all georeferenced work had to be taken to the property registry to correct the property description on record. All georeferenced surveys had to show true ownership status, record by record. However, Incra has not entered these parcels in the system. It has limited itself to including only the outer perimeter because, for local authorities, rural property has to be shown in terms of the Land Act.

In addition to these problems, the legal stipulation to georeference property exists only in the Public Records Law, which means that the territorial unit to be certified is the land record. Because of this, Incra's operations failed to approve all of the work done to that point. More than thirty thousand certifications of rural property delimitations are no longer included on the system.

Changing this procedure is perhaps the most urgent problem to be solved. One solution for this serious question is to remove certification of rural property and the CNIR from Incra's list of duties. This important cadastre cannot be managed by any special interest organization. It should be managed by an autonomous, impartial organization that can create a truly multipurpose cadastral database to meet all of the Nation's needs.

### **3.2 The multipurpose urban cadastre**

Until the end of the first decade of the twenty-first century, the greatest limitation to the urban cadastre was the lack of laws to standardize its implementation and uniformity across the country.

Aware of this, the Ministry of Cities in Brazil began work to define a new strategy to reverse the situation. In 2007, a Study Group was created under the National Training Program for Cities (PNCC). It was composed of civil servants and renowned experts from various public and private institutions. Its objective was to develop a proposal to create, institute and implement a Multipurpose Territorial Cadastre (CTM). As a result of this Study Group, Administrative Directive no. 511 was published on 7 December 2009 containing guidelines for the creation, institution and implementation of the Multipurpose Territorial Cadastre in Brazilian cities. This Administrative Directive creates an important advance for the cadastre in Brazil, especially from a conceptual viewpoint:

*Art. 1º - The Multipurpose Territorial Cadastre (CTM), when adopted by Brazilian Cities, will be the official systematic territorial inventory for cities and*

*will be based on surveying the boundaries of every parcel, which will receive a definite identification number.*

*Art. 2° - The cadastral parcel is the smallest unit of the cadastre, defined as a contiguous portion of land surface with a single legal system.*

This Administrative Directive established guidelines to implement the CTM, focusing on issues related to cartography, the multipurpose aspect of the cadastre, its management and funding and property appraisal.

Administrative Directive no. 511/2009 does not describe technical procedures to be adopted for implementing the cadastre with respect to the diversity of Brazilian cities. Some cities that have the advantage of technical and economic resources have already adopted some of the principles presented; but even those without these advantages can build databases for a multipurpose cadastre using basic principles and they can plan its implementation according to their capabilities.

One of the basic technical features was establishment of a single identifier for each parcel. This allows all users to recognize the same item in their systems without error.

Another important feature is the unequivocal location of each parcel, obtained by referencing its vertices on the official geodetic system, which is the Brazilian Geodetic System.

Besides the essential technical features for the implementation of a multipurpose system, the guidelines also look at practical strategies for determining land value. This is an important attribute of a cadastre and the guidelines try to show that this value has importance beyond its tax application.

The success of a cadastral system, even a perfectly planned one, greatly depends on its management model and funding of updates. Chapter 4 of the Administrative Directive addresses this issue, indicating actions for management success, such as establishing a local technical team specialized in maintaining and continuing the cadastre. An important guideline, especially for small cities, is the possibility of establishing consortiums specifically aimed at reducing implementation costs. Guidelines also recommend that part of the revenue generated by cadastral updates be used for maintenance.

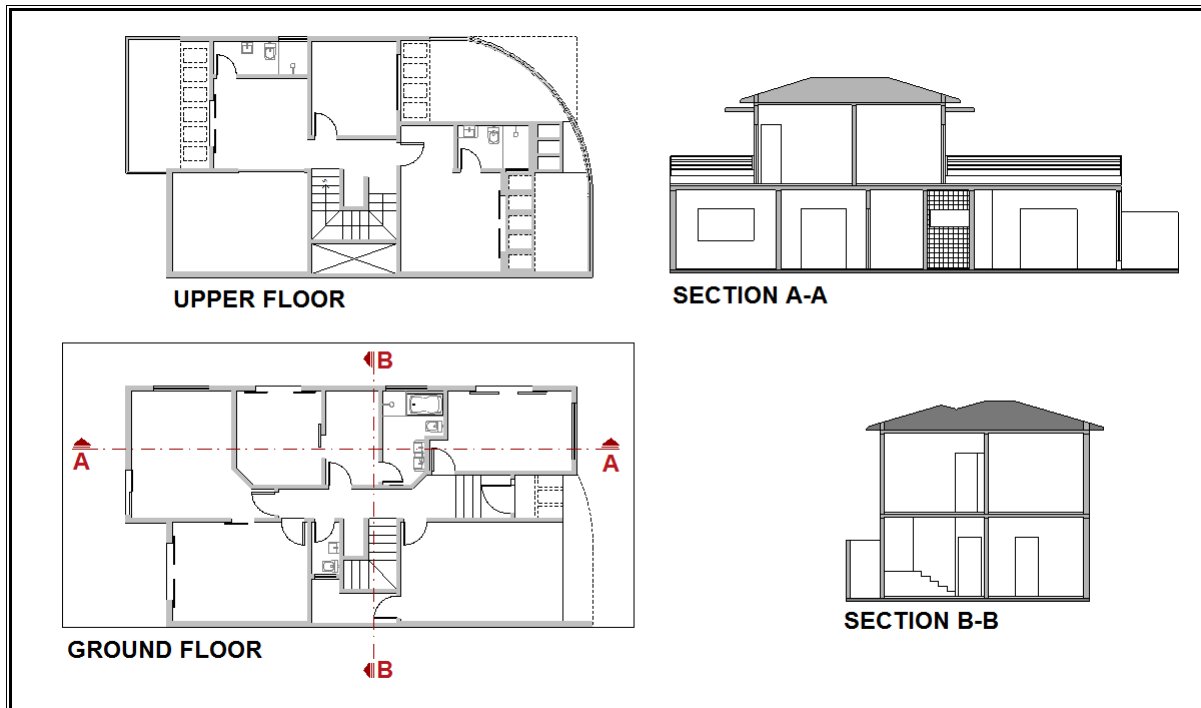
Finally, this is a very important government initiative but still insufficient, because the Administrative Directive only provides guidelines; it is not enforceable by any Brazilian municipality.

#### **4. THE MULTIPURPOSE 3D CADASTRE**

Considering the complexity of territorial occupation in the country, it is important to explore cases where recording information in a 3D environment would be possible.

Two situations can be identified in the country: overlapping titles of ownership on the same parcel, and different types of ownership across more than one parcel.

In the simplest case, rights may belong to the same owner, but information is distributed vertically for spatial representation. In these cases, the cadastres still record a single parcel; but buildings shown in orthogonal projection (planimetric survey) and longitudinal projection (cross section) which provide a true picture in three dimensions (figure 4).



**Figure 4. Tridimensional view shown by orthogonal and longitudinal projections**

The case of two multi-use condominiums in which each apartment has a different owner is more complex than the case shown in figure 4. Ownership changes on each floor (figure 5). The vertical units are autonomous parcels and each enjoys a portion of land and common area. In these cases the cartographic view is similar to the one shown in figure 4. However, cartographic links to alphanumeric databases show different owners.

The parcels are still identified in both the cadastre and property registry by unit number based on an orthogonal projection by floor. There is no tridimensional graphic information. The first digit of the ID number usually indicates the floor and gives some idea of height; however, the map does not offer a chart showing precise volume.

Besides apartment buildings, other cases of surface, subsoil and air space occupation must be addressed by the cadastre and registry. Given that, under the Civil Code, ownership covers spatially designated subsoil and air space. The owner cannot object to activities performed by a third party at a height or depth without justification for preventing such use. However, ownership of the soil does not include deposits, mines and other mineral resources, hydraulic energy potential, archaeological monuments and other property covered by special laws. These come under Federal jurisdiction and their use depends upon concessions.

In this case, cadastral information in three dimensions would be important because it would show differences in ownership and use between surface and subsoil, since ownership of mineral resources is different from ownership of land (figure 6). The current 2D cadastre has not correlated spatial information well; therefore, it cannot prevent conflicts or define responsibilities accurately.

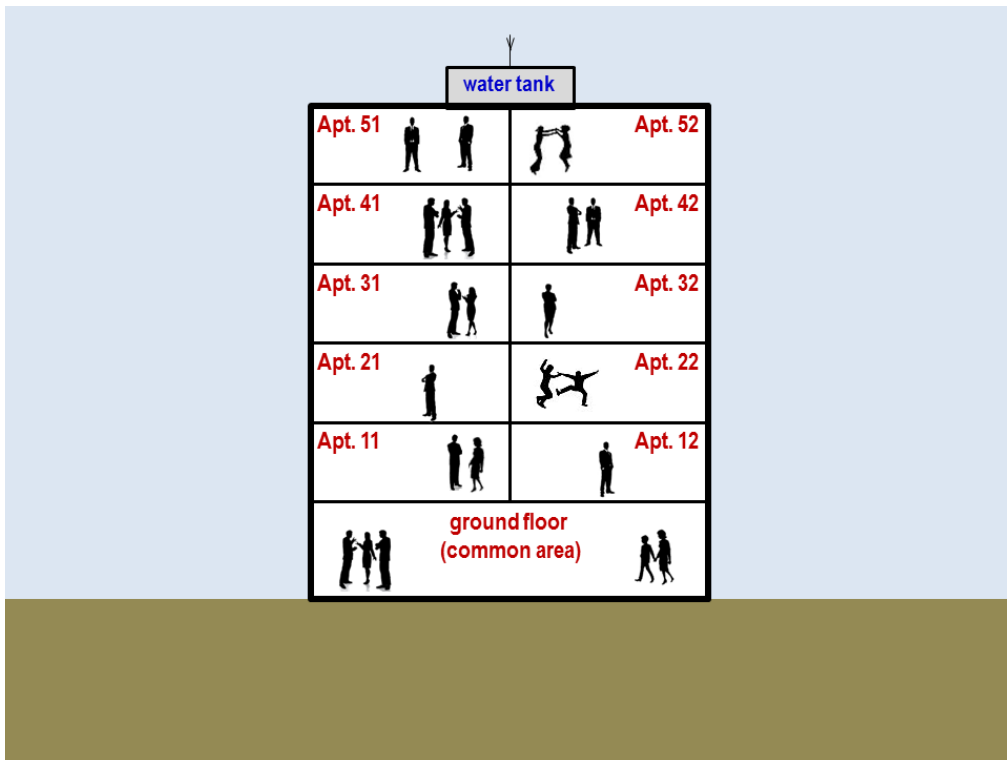


Figure 5. Overlay of parcels in a multi-use condominium

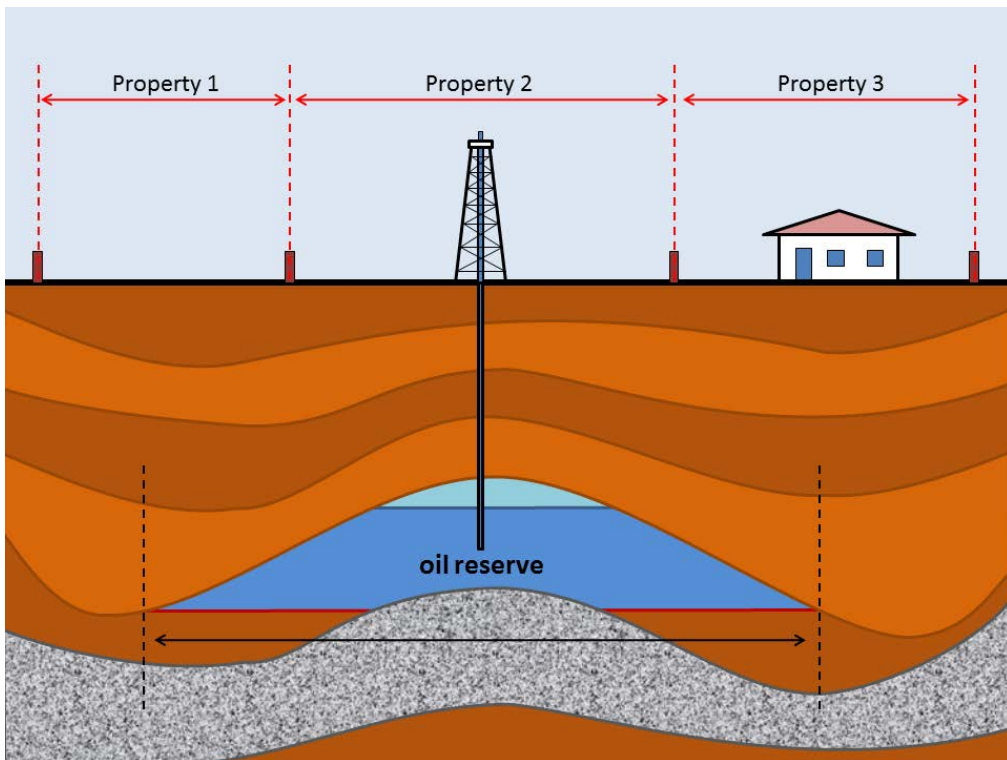


Figure 6. Demarcation of parcels on the soil surface and demarcation of concession area for extracting oil from a larger portion of the subsoil.

Another case in which the 3D Cadastre could play an important role is the control of subsoil occupation by infrastructure networks. The large cities in the country, such as São Paulo and Rio de Janeiro, have faced serious problems from accidents caused by failure to control the use of urban subsoil and air space. Cadastres and laws designed specifically for this type of occupation would surely be a great advance in the areas of engineering and geology. They could rely on subsidies encouraging regulated use and occupation of soil, subsoil and air space. In general, the growing demand for urban underground work is hampered by the lack of an updated cadastre for all existing facilities. In urban centers, as figure 7 shows, there are several overlaps both below the surface (water, sewer and gas pipes; electric, phone and cable TV network cables; rain water reservoirs; tunnels) and in the air space (power and phone grids, viaducts, overpasses), making it difficult to plan and focus a cadastral survey on all these cases.

The situation is really complicated and calls for attention, especially because spatial data for the land exists; however, there is still no institutional coordination for adopting unified reference systems and exchanging information.

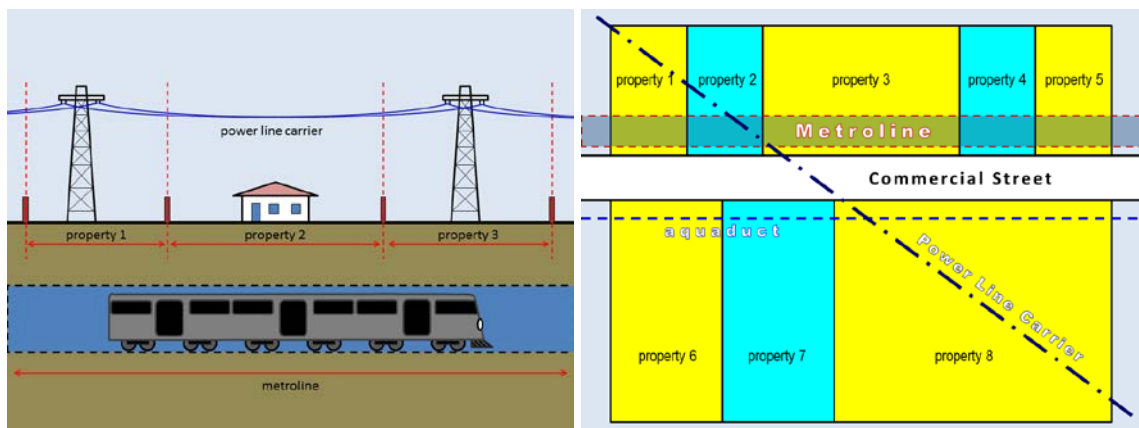


Figure 7. Integration of spatial data from different 2D sources

#### 4.1 Perspectives for implementing the 3D Cadastre in Brazil

The current cadastre situation in Brazil, depicted in items 2 and 3, shows that many challenges must still be overcome before the territorial information system in Brazil can be considered efficient. It is still based on 2D information scattered across different institutions using different reference systems.

Despite the difficulties mentioned above, the country is starting to see opportunities to reverse the situation. Decree no. 6,666/2008 instituted a National Spatial Data Infrastructure – INDE. Although it provides the approximation of an institution and data standardization, it did not include the cadastres as members. This is being bypassed by joint work between the Ministry of Cities, Incra and the Cartography Commission (CONCAR) at the Brazilian Institute of Geography and Statistics.

The first studies conducted in Brazil on the 3D Cadastre address technical issues involved in implementation (Souza, 2011; Holzschuh et. al., 2009; Souza, 2009). In this article, legal and administrative issues are discussed based on models proposed by Stoter (2004):

- a) **A 2D Cadastre with tags:** is the simplest model, suitable for immediate application in Brazil, especially because it does not require significant changes in the administrative and legal structure;

- b) **A hybrid approach:** (Stoter 2004) presents two forms, a 3D registry of rights and a 3D registry of physical objects. At first glance, this second option would be best suited to Brazil, since it highlights cadastre information above and below the land surface among the most urgent needs; and
- c) **A full 3D cadastre:** as stated in item 3, the Brazilian cadastre is now undergoing significant legal and administrative reforms. More changes are still needed for the 2D multipurpose cadastre to function adequately. The full 3D cadastre model can be considered the ideal. However, it is not feasible for Brazil because it requires a consolidated cadastre culture and would involve significant changes in the legal framework that is still being consolidated in Brazil.

Due to the popularity of geo-technology throughout the country and the gradual development of the data sharing concept, Brazil is certainly at an appropriate point for reflecting and defining strategies to construct a 3D Cadastre. The law would assign responsibility for implementing tridimensional graphical information to the companies responsible for installing, operating and maintaining urban facilities. This would facilitate performance in their specialty areas and the necessary state control. Most importantly, it would provide greater security to the population living in this complex web of networks, pathways and other devices typical of the modern world.

## 5. CONCLUSIONS

The implementation of a 2D Multipurpose Cadastre covering all urban and rural property would vastly improve conditions for Brazil to reach greater economic and social development. In fact, laws in effect are headed in this direction. The 3D Cadastre in Brazil depends on the success of the multipurpose cadastre model and consolidation of the INDE, since this is the organization responsible for coordinating territorial data from multiple sources and institutions and setting the standards for exchanging that data.

The ability of the cities to manage local data would not be infringed upon by INDE's leading role since the cadastral database would be completely managed locally and cities would continue to be free to use it within the parameters of their constitutionally guaranteed autonomy.

In summary, with all of the technology and legislation available, it should be possible to study implementation of a 3D Cadastre that could address situations not handled by the traditional two dimensional survey. Perhaps this innovation is especially timely now that the real estate cadastral base is being restructured in Brazil.

For this proposal of a multipurpose technical cadastre to be successful, we must make our leaders aware that of the necessity of an independent and impartial organization to manage it. Much has been lost due to the lack of precise information about land in Brazil, and this has hampered the much desired national development.

## REFERENCES

- Augusto, Eduardo A.A. (2009). Property registration: essential to the democratic state of law. Masters Dissertation, Autonomous Law College (Fadisp). Sao Paulo: Fadisp.
- Brandão, A.C., Carneiro, A.F.T., Philips, J. (2010). Current Issues, Challenges and Perspectives of the Cadastre in Brazil. In: Cadastre, Training, Research and Business – Selected Papers from the First International Congress on the Unified, Multipurpose Cadastre. University of Jaen: Publication Office, pp. 471-480.
- Carneiro, A.F.T. (2003). Real Estate Cadastre and Property Registry - Law 10,267/2001, Decree 4,449/2002 and Normative Acts of the INCRA. Porto Alegre: Sergio Fabris. ISBN 8575252194.
- Dale, P.F., Mc Laughlin, J.D. (1990). Land Information Management - An Introduction with Special Reference to Cadastral Problems in Third World Countries. Oxford University Press, New York.
- Erba, Diego, (2008). A. The territorial cadastre in Latin American countries. Cambridge, MA, USA, 2008. ISBN 978-85-906701-3-1, 415 p.  
Available at:  
[http://www.lincolninst.edu/pubs/1373\\_El-catastro-territorial-en-los-pa%C3%ADses-latinoamericanos](http://www.lincolninst.edu/pubs/1373_El-catastro-territorial-en-los-pa%C3%ADses-latinoamericanos).
- Erba, Diego A. (2007). Multipurpose Cadastre Applied to the Definition of Urban Land Policy. Cambridge, MA, USA, 2007. ISBN 85-906701-0-4, 455 p.  
Available at: [http://www.lincolninst.edu/pubs/1306\\_Catastro-multifinalitario-aplicado-a-la-definici%C3%B3n-de-pol%C3%ADticas-de-suelo-Urbano](http://www.lincolninst.edu/pubs/1306_Catastro-multifinalitario-aplicado-a-la-definici%C3%B3n-de-pol%C3%ADticas-de-suelo-Urbano)
- FIG (1995). The FIG Statement on the Cadastre, FIG Publication No. 11, 0-644-4533-1.
- Holzschuh, M.L., Amorim, A., Souza, G.H.B. de (2009). Spatial Data Base and the 3D Cadastre: Case Study Using the POSTGRESQL Database and POSTGIS Spatial Extension to Represent Spatial Parcels. In: IV Brazilian Geodetic Sciences Conference, 2009, Curitiba. IV Brazilian Geodetic Sciences Conference. Curitiba: UFPR.
- Loch, C., Erba, Diego A. (2007). The technical multipurpose urban and rural cadastre. May 2007. ISBN 85-906701-2-0, 142 p.  
Available at:  
[http://www.lincolninst.edu/pubs/1243\\_Cadastre-t%C3%A9cnico-ultifinalit%C3%A1rio-urbano-e-rural](http://www.lincolninst.edu/pubs/1243_Cadastre-t%C3%A9cnico-ultifinalit%C3%A1rio-urbano-e-rural)
- Souza, G.H.B. de, Amorim, A., Holzschuh, M.L. (2009). Terrestrial Laser Scanner for the 3D Cadastre: Feasibility for Acquisition, Modeling and Representation. In: IV Brazilian Geodetic Sciences Conference, 2009, Curitiba. VI Brazilian Geodetic Sciences Conference. Curitiba: UFPR.
- Souza, G.H.B. de (2011). 3D Cadastral Systems: feasibility of the Brazilian cadastral system. Sao Paulo State University, Thesis.
- Stoter, J.E. (2004). 3D Cadastre. Delft : Netherlands Geodetic Commission (NCG), Publications on Geodesy , New Series, PhD thesis Delft University of Technology, 327 p.

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