

# **Data model for Multipurpose Cadastre Adjustments in Colombia according to the LADM-COL profile**

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**Key words:** Application model, LADM, Model Driven Approach

## **SUMMARY**

The Multipurpose Cadaster project in Colombia has been developing for several years, in a first stage it contemplated the elaboration of technical specifications of the product, the standardization of data and to be able to develop pilots executed by private companies to generate a methodology that allows to be implemented. In the second phase of the project called the expansion phase, which defines the massive intervention of municipalities.

In this sense, before starting the expansion phase, a stage of adjustments to the technical specifications of the product is contemplated according to the lessons learned that were obtained as a result of the different pilots developed in the first phase, the LADM\_COL model being one of the standards to be implemented in this new public policy is one of the elements to be reviewed.

LADM has a model-based approach (MDA), which, among other relevant aspects, allows conceptual data models to be neutral to the technology of its implementation, which is very convenient for the field of land administration. On the other hand, when implementing LADM\_COL as a data model for the implementation of the Multipurpose Cadastre, it creates a challenge in the implementation for the institutions that are part of this project.

In the phase of adjustments to the model, the results obtained by USAID in the pilot project of mass formalization developed in the municipality of Ovejas-Sucre are analyzed mainly, among other aspects because this pilot managed to deliver the data of the massive survey in the field under the structure of LADM\_COL, but several difficulties were found to achieve this purpose, which are analyzed to make an adjustment in the model and to have the new version of LADM\_COL.

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## **1. INTRODUCTION**

A Land Administration System is a set of norms, standards, tools, processes and actors, to adopt a data model for land administration in Colombia will require institutional efforts to improve the value chain of the data managed by each entity. Additionally it should ensure the interoperability of the data with other institutions that are part of this model and consider the citizens as the end users of the information, since the vision of an efficient land administration system puts the citizen in a central role, and therefore, tries to improve the processes that impact on the citizen.

Older models of land management and land surveying are inadequate to meet the needs of a modern and sustainable society (Williamson, 2009), The paradigm of land management focuses on providing tools to decision makers with the objective of the sustainable development (Williamson, 2009), This is one of the pillars of the transformation processes and vision of territorial approach that seeks, among other objectives, the integrated rural development.

The implementation of the new public policy of multipurpose cadaster, implies major challenges for entities that are part of the management of territorial objects. Among these challenges, we can find the redefinition and adjustment of the technological components such as information systems, that enable the information management, through the adaptation it's the software components, hardware and communication networks to make them more efficient and to allow the exchange of information and the data publication based on the new strategic framework defined in the Land Administration Model.

As defined in the CONPES 3958 of 2019, the implementation of the multipurpose cadaster will be gradual and stepped in time. This requires a transition scheme that allows to work on the new approach while the entities adopt the processes and tools into their missional systems. The CONPES 3958 implements the public policy in an articulated manner and according to the three principles for the strengthening of territorial capacities, gradualism in coverage and encourage the use of cadastral information represent adjustments in various fields one and is the technology and will be the field will be developed herein, are as important as defining institutional agreements, the processes defined for land administration, etc. will not be described herein aspects.

One of the problems identified, among others, is the existence of a monopoly in the provision of cadastral activities- The national government has been developing strategies within public policy to decentralize the cadastral management at territorial level. This is done through the

1950 law of 2019, that creates the Cadastral Manager body, that offers to the municipalities the option to carry out the management of cadastral procedures. For this, prior authorization by the IGAC is needed and it can be done by the municipality itself or to delegate it to a third party, which opens a whole system of free competition in the provision of public service in the land sector.

Another problem of the current cadastral information system is the limited capacity to interoperate with other systems and to serve as a source of basic information for entities requiring cadastral information, what causes that this entities use information that is not updated and uncoupled, what is against the principle of legal independence (Stuedler, 1998)

Part of the diagnosis made in Colombia in recent years clearly demonstrates the need to create public policies focused on a territorial vision, this has been the basis for the proposed Multipurpose Cadastre. On the other hand, one of the biggest problems is the lack of integration between cadastral and registry information in the country. In the cases where the integration has been done (in pilot studies like in Bogota), the percentage of correlation has been low.

In order to have updated cadastral information updated, and as it has been said before, it is necessary to think about the decentralized operation of cadastral processes. This operational scheme should consider well defined standards and technical specifications of the information to be produced and delivered to the cadastral authority, based on the principles of interoperability The land should be the basis of information for land administration and to fulfill the function of a multipurpose cadastre.

In this sense, the adoption of the LADM model described in the ISO 19152 standard: 2012 through the definition of the national profile (LADM-COL) and its adoption by the IGAC as cadastral authority and SNR as registration authority is a clear evidence of the institutional commitment to adopt technical standards that are internationally recognized. This allows to normalize the semantics of the cadastral model and facilitates the implementation of the decentralization model where municipalities will be the managers of cadastral information themselves.

Although these decisions show clear strategic lines in the implementation phase of the LADM model and the transformation of the conceptual model into implementation model, this generates new challenges at technical and interinstitutional level as mentioned (Jenni, 2017). The mechanisms defined in MDA may be useful for the implementation of the model in different organizational schemes according to the country At this point, it is important to describe the differences between the extended model and application models, which will be described in this paper.

## **2. MODEL DRIVEN APPROACH IN LADM**

Having a set of related models to be implemented is necessary, but variables must be abstracted according to the process in which the model is being implemented, in the case of Colombia, to standardize the delivery of information by operators from the field collection it is necessary to

generate an application model, which has been called the operating model, this model is an abstraction of the Colombian profile LADM\_COL, which makes it comply with the defined semantics, but at the same time this should not affect The process of data validation.

The operating model according to LADM\_COL, seeks to be flexible and characterize only the attributes that must be captured by operators in the field, this allows to have a model that also serves for institutions to do quality control over this, which is articulated with The principles of territorial intervention cost efficient.

## 2.1 LADM

The domain model for land administration defined in the ISO 19152: 2012 LADM is a standard that seeks to represent the relationships between local objects and people from the rights, restrictions and responsibilities that exist in the territory at the conceptual level, and the spatial representation of these territorial objects. As described by (Lemmen C., 2012) the domain model for land administration describes the general standards for information management, considering the legal information, the interested parties, and the space units- It may also contain geometric information of each unit.

It is important to consider the LADM as a metamodel that is as a conceptual model and not as a product specification data (Lemmen, Oosterom, & Bennett, 2015). UML diagrams are commonly used to describe the LADM, which allows users to view and discuss the relationship between administrative objects existing on the earth (the BAUnits) and their structural components like parts, rights, restrictions or responsibilities that a party can have on an administrative object together with the spatial representation that this object can have. Therefore, the LADM provides a standard based on the semantic structure of land administration (Lemmen, et al 2015).

LADM is structured in three main packages: parties package, administration package and space unit package. Additionally, a topography and representation sub package is described (ISO 19152: 2012). shows the relationships between the packages. One of the objectives of structuring the standard in packages is to facilitate maintenance of the different data sets by each entity responsible for managing the specific data.

As shown in the figure 1 LADM core is based on four fundamental classes. These classes are, at the same time, related to other classes that are part of the model and allow the include more attributes characterizing land administration. The main classes are:

1. LA\_Party class: This is the main class of the parties package. This class includes information that relates all those who have any interest in land administration. The LA\_Party class relates to two classes in the same package LA\_PartyMember and LA\_GroupParty. At package level, it relates to LA\_RRR class of the Administration package.

2. LA\_RRR class This is an abstract class, that includes rights, restrictions and responsibilities (RRR)(For its acronym in English) as specialized classes. The LA\_RRR class related to the class LA\_BaUnit administrative package and the class LA\_Party package concerned.

3. LA\_BaUnit Class: This class describes Basic Administrative Units, The BaUnit is the basic property unit and should be a uniform right throughout the unit. LA\_BaUnit. It relates to LA\_RRR classes of the Administrative package and LA\_SpatialUnit classes of the Space Unit package.

4. LA\_SpatialUnit Class: This class is responsible for the spatial description of the spatial object. In this case, the relationship between the Administrative unit and the topography and representation sub package allows the geometric and geographical characterization of the element that is being administered.

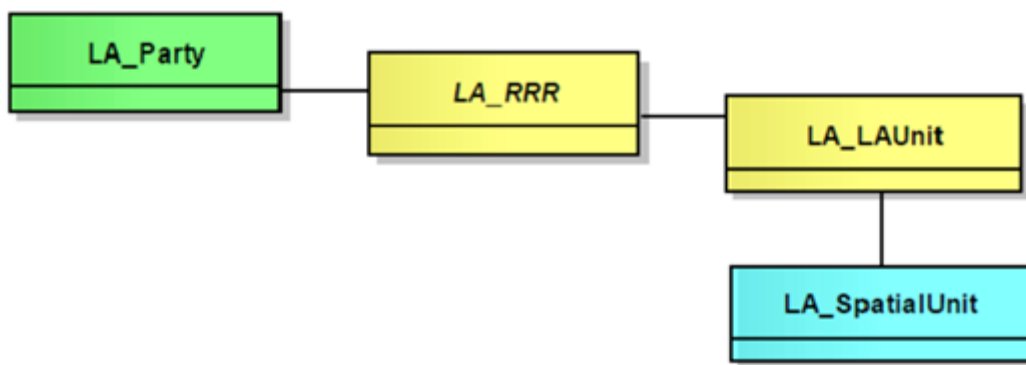


Figure 1. Basic classes of LADM. Source: ISO 19152: 2012

## 2.2 Defining a model – based approach

The new paradigm in the land information management focuses on providing tools to decision makers with the purpose of sustainable development (Williamson, 2009). The characterization of objects at the territory level, generates new challenges in the information management process for entities related to land administration, from conceptualization of the information until data maintenance.

To achieve an efficient land administration, it is necessary to consider several factors involved in an integral way. The first one relates to the alignment of the institutional organization with the public policies of territorial management. The institutions need to consider the as defined by (Kaufmann & Steudler, 1998), which includes the principle of legal independence. This principle should be the strategy line for the institutions, and will ensure data quality and data management by the entities, and facilitate the articulation of this data with the data generated and managed by other entities , adding value within the institutional processes This means to stop thinking about business processes to meet the needs of the organization to start thinking

about management processes based on the territory, designed according to the needs of the parties.

Another important factor to be considered is the technology. An efficient land administration boosts information exchange based on the data interoperability. At architecture level, there are several solution schemes at general level for implementing a land administration model. All of them should seek to optimize data management by the entities with the vision to respect the legal independence of the institutions

Modularity in land administration is essential to have proper information management and to respect the principle legal independence of the institutions. As part of the conceptual model of the ISO 19152: 2012, some examples of how the core is the orchestrator of information between different subjects are shown. In the development of the national profile of the standard in Colombia, (LADM-COL), the national entities have generated a version of the core that adapts to the needing of the country, according to the model-based approach figure 2 shows the concept of extended models in the implementation of the standard in Colombia.

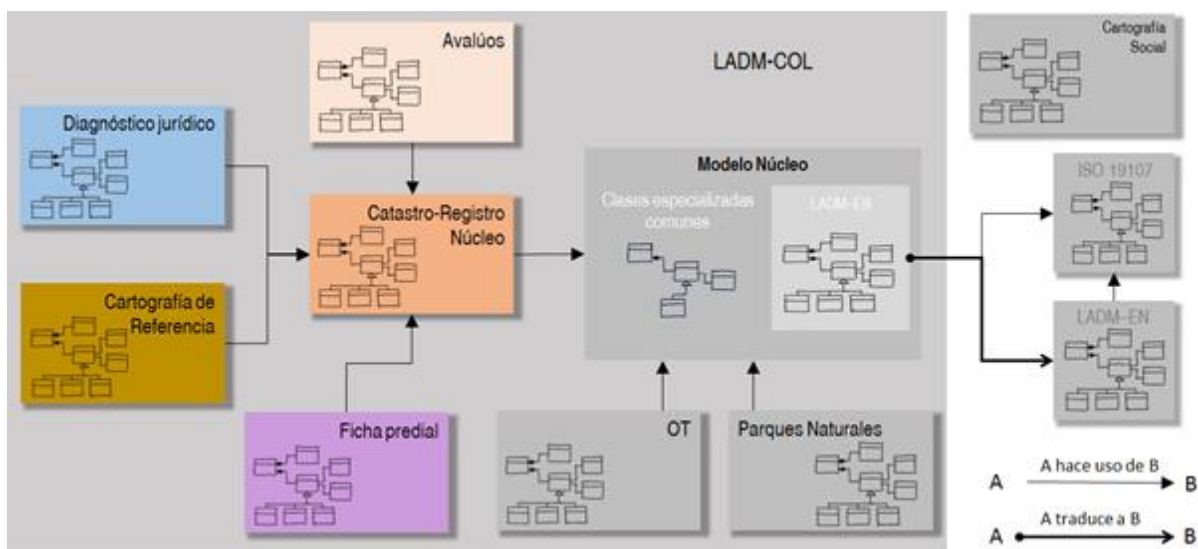


Figure 2. Model articulation in accordance with LADM\_COL

In a more national-oriented approach and the operation of the multipurpose cadastre public policy that is being developed in the country, it is necessary to go down from a conceptual level to application models and under this concept models have been developed that do not necessarily they are extended, if not that they are abstractions of different models that represent the variables that are necessary to define a certain context, but that are semantic level conforming to what is defined in the conceptual model.

Based on the model approach which is defined as "an approach that enables developers to build models of a project without the knowledge of other application models, to combine them later

to create applications" (Rosa et al, 2013) and taking into account the approach-that considers the oriented model architecture which is defined as "an architecture for models and a series of guides to structure specifications expressed as models" This approach is open, with an orientation of technological neutrality for interoperability systems, depending on standards such as unified modeling language (UML), Meta Object Facility (MOF) and XML metadata exchange (XMI) "(Karakostas & Zorgos, 2008) Finally, understanding what is defined in (Mejia et al, 2017) that states "the use of INTERLIS and the tools developed to manage it, allows the implementation of an infrastructure according to the MDA approach, which facilitates the implementation of the LADM country profile described with that language"

From the above perspective, the Colombian profile of the ISO 19152:2012standard: started as the metamodel and it was conceived with the purpose of the interrelationship cadastre-register and which is the core of land administration in Colombia. This is the initial phase to subsequently create new models in different domains at this point, the model-based approach have a particular significance. Although in the case of land administration idea is unified, there are different moments in which the information is built. Therefore, conceptualization of a unique metamodel profile of the standard is not sufficient for the needs of the activities carried out by the different actors in the administration. The application models start from a core metamodel with the fundamental conceptualization of the theme to be described, to later specialize in a specific application moment, thus allowing to adapt and interoperate between models according to the different situations at different moments

### **2.3 Multipurpose Cadaster pilots lessons learned**

In the process of building the Colombian profile of ISO 19152:2012standard a series of pilot projects were developed, to test the technical product specifications by capturing information from different municipalities. This municipalities presented different states of outdated cadastral information and high levels of informality in land tenure. As a result of these pilots, it has been possible to identify lessons learned which provided valuable information on how to improve LADM-COL model and possible methodologies of implementation.

The first phase of pilots were developed over 11 municipalities, which aspects were found as an institutional divergence, including technical aspects of specifications developed by the cadastral and registration subsequently authority pilot held in the municipality of Sheep, Department Sucre, which was developed by USAID (United States Agency for International Development), and where results were obtained much more tangible as expressed in article press office of the presidency of Colombia, "ceremony was held 1058 titles, of which 763 correspond to the allocation of vacant land to a natural person and 295, to formalize private land "(President, 2019).

Despite these positive results, technical challenges arised, this because the operator who performed activities farm scanning mass not initially used the LADM-COL model version 2.2.1 but through applications and developments themselves up all the information requested on the deliverables of multipurpose cadastre, this created difficulties when migrating data to the

Colombian profile, because not all information stored by the operator, fell within this model, and the same. Thus, there are variables that were not worked by the operator due to different aspects of one of the most important is the institutional competition.

This led to the lesson that for future activities predial sweeps massive existed a model of application-oriented property taxes sweeps massive, adjusted to the needs of these activities, taking as a moment in which the information is collected, pre-processing they will have to give institutions to officially be in the metamodel of the Colombian profile standard ISO 19152: 2012.

## 2.4 Profile national LADM-COL Tweaked

Given the lessons learned from the pilots developed multipurpose cadastre was necessary to make a series of adjustments to the same (see Figure 3), which take into account the specific requirements of the moments in which data is managed, it is key know this, because if one metamodel extended models, data was assumed in many cases would not be complete, or some would not be in the database not be present in the model. That is why the idea manage application models, which retain the essence of the metamodel through its core and adapt to every moment in which information is managed is conceived.

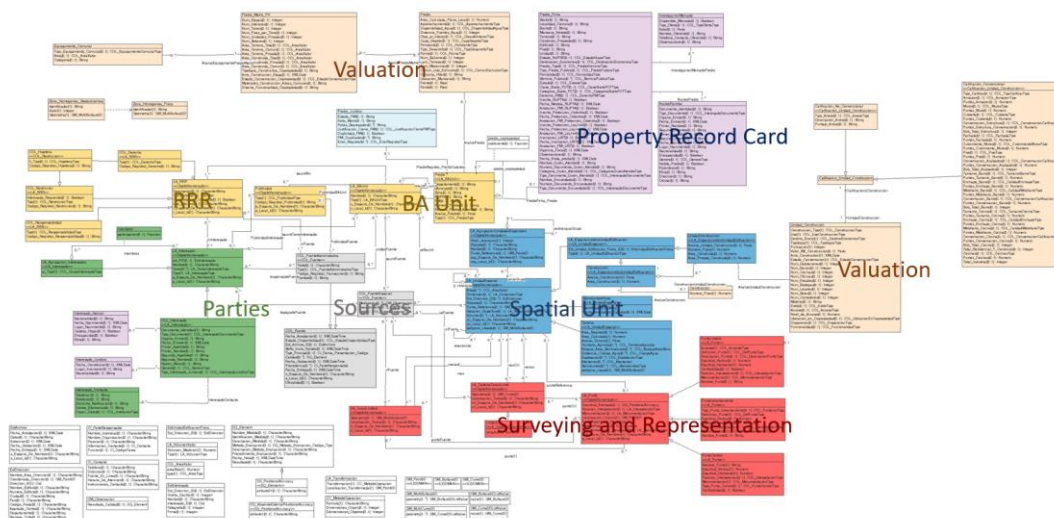


Figure 3. LADM-COL model used in version 2.2.1 drivers multipurpose cadastre

An adjustment was made to the metamodel Cadastral-Registry (see Figure 4), because the previous version was an adjustment of the Colombian reality to the ISO 19152 standard: 2012 and did not find that it recognize all aspects of reality of the country, which tried to take into account in this case was to estimate the attributes that were not taken into account in the model, they added all those that are in the systems both cadastral and registration, and likewise,



eliminated all variables that suggested the norm (not required for a specific level of compliance) and that were not used at any given time by the institutions responsible for this subject.

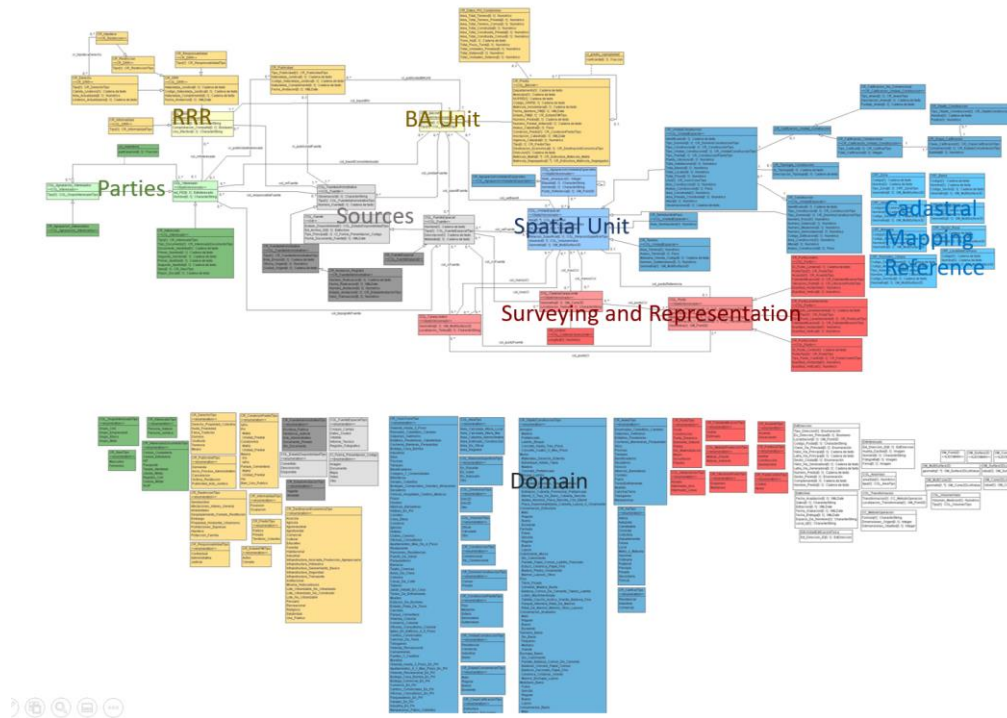


Figure 4. COL LADM-adjusted model

Already talking about application models is entered to talk about initially is where information is captured by operators through Sweeps Land Parcel Masivos (see Figure 5) in this model application, several models are managed, it is part of the core of the ISO 19152: 2012, subsequently it manages what is considered the model application operation, which will contain the variables that must fill each operator, and this model extended models of sheet Catastro Multipurpose connect, Avalúos Cartography cadastral Reference, National Land Agency, and a model that had not been taken into account, a model of inputs, which are provided by the land administrators and notary and prior registration at the start of the predial sweeps mass.

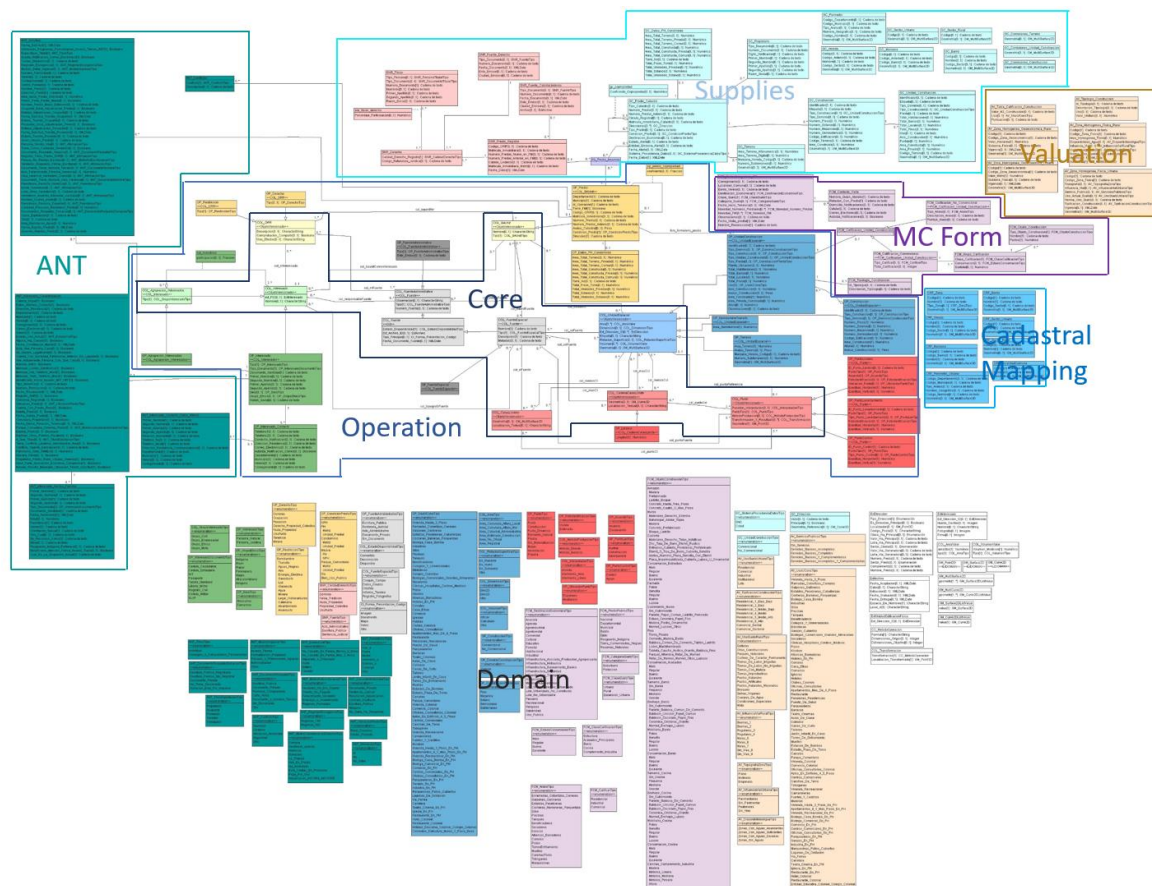


Figure 5. Application model for massive sweeps property taxes

Currently working in another application model for the exchange of information between land administrators and the superintendence of notary and registration, this will allow a relationship between the two institutions previously not had, this model will build upon the information metamodel Cadastre - Registration and other variables requiring institutions to manage them.

### 3. CONCLUSIONS

As mentioned above, moving from a conceptual model application models which respond to the needs of the business model, presents a challenge to which MDA has mechanisms to move from the abstract model to a physical model, that's where INTERLIS has one of its greatest potential. Here are some of the most important conclusions:

- Implementing a model of land administration by formulating conceptual models requires transformation mechanisms application models that allow the use according to the semantics defined in the framework

- In Colombia the creation of a national profile of the ISO 19152 standard: 2012 as a core model for the formulation of a framework for land administration requires the development and adoption of extended thematic models that will be the semantic basis with which articulate layers of information in a spatial data infrastructure correct
- Generation application models must comply with the semantic level conceptual model but not necessarily must be a generalization of the classes defined in this, so you can have classes and own relationships

## REFERENCES

Departamento Nacional de Planeación. (2019). *Estrategia de implementación del Catastro Multipropósito (CONPES 3958)*. Bogotá, Colombia: DNP.

IGAC, SNR. (2016). *Conceptualización y especificaciones para la operación del Catastro Multipropósito*. Bogotá, Colombia.

ISO/TC 211 Geographic information. (2012). *Land Administration Domain Model (LADM). ISO/CD 19152*. Lysaker, Noruega: International Organization for Standardization.

Jenni, L. (2017). *LADM Implementation in Colombia – Process, Methodology and Tools developed and applied*.

Kaufmann, J., & Steudler, D. (1998). *Cadastral 2014 - A vision for a future cadastral system*. International Federation of Surveyors FIG, Commission 7.

Lemmen, C. (2012). *A Domain Model for Land Administration*. Delft: Nederlandse Commissie voor Geodesie Netherlands Geodetic Commission 78 .

Lemmen, C., Oosterom, P., & Bennett, R. (2015). The Land Administration Domain Model. *Land Use Policy* , 49, 535–545.

Williamson, I., Enemark, S., Wallace, J., & Rajabifard, A. (2009). *Land Administration and Sustainable Development*. ESRI Press Academic.

## BIOGRAPHICAL NOTES

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through the use of INTERLIS, also in the development of the plugin Assistant LADM-COL for QGIS, among others.

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