Supporting Field to Formal Cadastre Workflows with Scalable LADM Implementation

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SUMMARY

Field to formal cadastre workflows can be successfully supported using a combination of commercial off the shelf configurable ArcGIS applications and a two staged approach to application of the Land Administration Domain Model. This paper will discuss the basics of getting started with a web-based ArcGIS system and detail the different applications within that system that have proven useful in real-world participatory fit for purpose workflows. It will be proposed that a "core" LADM be used for field data collection and a country profile be applied at a later stage, before collected property boundaries move to formal cadastre management. Finally, the "core" LADM schema will be shared, along with UML diagrams, and choices made as to what to include in this implementation will be discussed.

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1. ArcGIS AS A SCALABLE SYSTEM TO SUPPORT LAND ADMINISTRATION

ArcGIS is a multifaceted system that supports scalable implementation from collecting land tenure information in the field for the first time through managing a formal national cadastre. ArcGIS can be deployed on premises or in the cloud (Software as a Service or SaaS), or a hybrid of the two can be configured. When ArcGIS is applied to Land Administration workflows, often a hybrid approach is used, where sensitive ownership information is stored on premises behind a firewall and a selection of information such as property boundaries may be shared for public consumption or sharing with other agencies, partners or non-profit organizations using a SaaS solution. Both on premises and cloud (SaaS) implementations support common geographic information system patterns of use within land administration such as field data collection, data editing, quality control, and data sharing (Architecting the Platform). When deciding which implementation type to use to support which pattern of use, often data security and storage cost or location are the deciding factors. On premises deployments offer the peace of mind of knowing that data is securely stored on site where physical servers are located, or on the server bank of the in-country cloud service such as Amazon AWS or Microsoft Azure. The caveat being that the organization must be prepared to manage the system themselves and scale independently to fit usage. Conversely, a SaaS system is managed by the provider, and built to scale automatically to fit a user's need. The ArcGIS SaaS does include identity-based security, and data storage located within region or continent in most areas.

Data collected, edited and shared on both SaaS and on premises ArcGIS deployments can always be accessed and managed freely and completely by the owner of the data. When working with web-based geographic information systems (GIS), data is commonly put into a feature service, which can be thought of as a steel thread that can be modified and shared at several access points depending on workflow and use case. This feature service can represent one or many geometries, and one or many tables. In the case of Land Administration Domain Model "core" or FFP survey grade implementation within the ArcGIS system, geometries for Spatial Source and Spatial Unit are represented as well as related tables representing Address, RRR, and Party within one feature service. This model will be presented more fully in the following section.

Once a feature service is created, it becomes the steel thread of communication and can be accessed through several different variations of applications. To identify what applications may be applicable for a specific circumstance, it's important first to understand the workflow being applied. In the case of Fit for Purpose in Colombia, Kadaster International and Esri Colombia have coordinated with communities in formerly FARC controlled territory to train

local residents in how to collect land tenure information for the first time. Field crews plan which properties they will visit for the day and work with landowners to walk the property boundary with a high accuracy GNSS receiver to record the area. At the end of recordation, property owners share any documents proving their ownership of the land and their identification, and visually check the boundary that has been collected. Afterward, Kadaster International and Esri Colombia teams perform a preliminary check on the data to ensure when it is presented to the community at large that the property boundaries can be presented successfully to the owners for agreement. The community is brought together, they agree or disagree and resolve their disagreement on the placement of boundaries and make sure their personal information is correct, and that information is sent to the government so that deeds may be created and delivered to the landowners. Ultimately the boundaries collected will be entered into a management system at a municipal or national level. (Jones, 2020)

With workflow knowledge in hand, it is possible to create an efficient, scalable solution by identifying and aligning corresponding applications from the ArcGIS system. While not precisely the solution used in Colombia, the following could be used as a template for understanding the different components of ArcGIS that support fit for purpose workflows, and how the resulting property boundaries can be included in a formal cadastre.

1.1 Data Preparation

The first workflow is data preparation. This is where a schema or standard, such as the Land Administration Domain Model, should be first implemented. To accommodate a field collection workflow, a "core" implementation of LADM that meets the needs of an initial field data recordation is proposed. The data, once prepared, can be shared either to an on premises (ArcGIS Enterprise) or SaaS (ArcGIS Online) deployment as a feature service.

1.2 Field Data Collection

There are two possible field data collection applications that run on both iOS and Android that may be deployed on mobile devices for field data collection – ArcGIS Field Maps or ArcGIS Survey123. While Field Maps allows for collection to a feature service such as the "core" LADM implementation suggested, Survey123 does not. While Survey123 has been used successfully by fit for purpose field data collection purposes, we will focus on Field Maps for the purpose of this paper. Field Maps enables the data collector to modify forms to suit their needs in a web interface that can be modified to reflect language or used to rearrange existing fields that need to be collected. Offline areas may also be selected in this interface, which enable field crews to continue to visualize where they are at on an imagery basemap if connected to a GNSS receiver. High accuracy data collection is supported, and Spatial Unit or Spatial Source geometries can be configured to capture GNSS metadata as it is collected.

1.3 Community Feedback

Following field data collection, the results of property boundary collection may be displayed to the community at large in the form of an ArcGIS Dashboard by configuring a dashboard template with the LADM feature service. Here, metrics such as number of properties collected, when they were collected and how many have been titled may be shown. Additionally, when collecting community feedback, a web mapping application created using

either the ArcGIS API for JavaScript or configured using ArcGIS Web AppBuilder enables community members to visualize the location of their property, along with any identification and additional details of tenure as necessary in the form of a popup. The LADM feature service that was created in the data preparation stage and edited in the field can also be edited in this web mapping application environment to resolve boundary disputes or other misinformation on the spot.

1.4 Parcel Management

After boundaries collected using the "core" LADM implementation have been recognized by the government, the LADM feature service may be transferred to a government entity at the municipal or national level, or both, and migrated into the ArcGIS Parcel Fabric which can be accessed within the ArcGIS Pro desktop application. Once in the parcel fabric, parcel data may either be edited within a local file geodatabase or published on premises to ArcGIS Enterprise, where edits to the parcel data can be managed using service oriented versioned editing. At the time of transfer, it is proposed that a more formal LADM country profile be applied to the existing data. The parcel fabric itself can be configured to support the land administration domain model and is compliant with ISO 19152. Moving forward, parcels may be edited by versions allocated to municipalities from a national level or managed at the municipal level and shared up to a central repository.

1.5 Data Sharing

Finally, parcel data can be shared to an integrated geospatial infrastructure managed by a central governmental entity and shared via web mapping applications embedded on a web page interface through Enterprise Sites or, if shared to a SaaS model, ArcGIS Hub. Additionally, parcel data may be shared from an on premises deployment as an Open Geospatial Consortium, Inc. Web Map Service (WMS) specification.

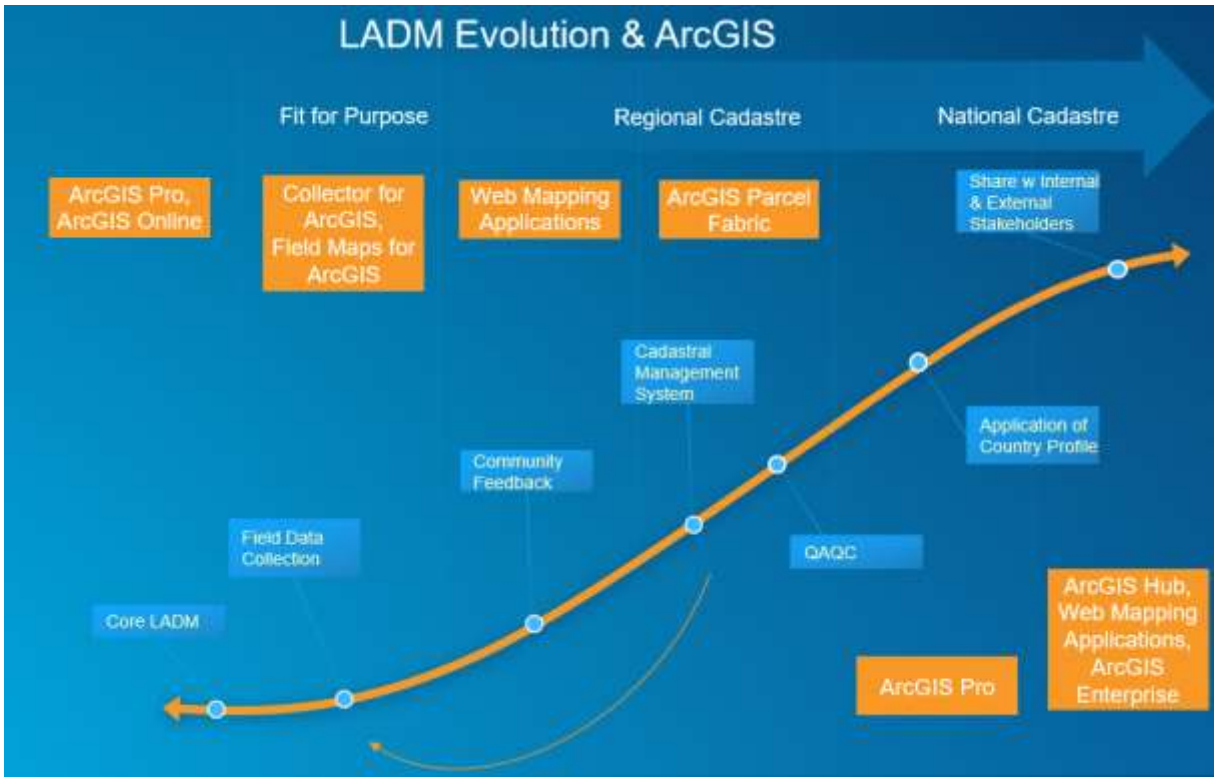

Figure 1. LADM Implementation with ArcGIS Components

2. A CORE LADM IMPLEMENTATION FOR FFP WORKFLOWS

When collecting property boundary and tenure information for the first time, it may be argued that the LADM, at its center, serves the primary purpose of providing a basis of understanding property boundaries and the RRRs of the people who own the property. When capturing tenure for the first time, and especially when training local residents in the art of data collection, simplicity is key to success. With ease of field data collection in mind, it is proposed that the "core" elements of LADM that absolutely must be collected on initial recordation are the Spatial Unit, along with related Address, RRR and Party tables and Spatial Source, along with Responsible Party tables. In this core implementation, Spatial Source can be represented spatially either by point or polygon – as often a stationary point may serve as the best ground truth of a Spatial Unit. For example, where a fence post delineates the boundary between two properties, or where a survey marker has been placed in the past. It should be noted that for both Spatial Unit and Spatial Source in this implementation, the organization managing collection should update the fields to collect and their related choices (ex. RRR, mortgage) to reflect the reality on the ground in the specific location they will be collecting data. Additionally, if a country profile has already been implemented or if a profile has been agreed upon, the tables corresponding to Spatial Unit and Spatial Source should reflect what has been agreed upon to streamline the application of the country profile later on when transitioning to a cadastre management workflow.

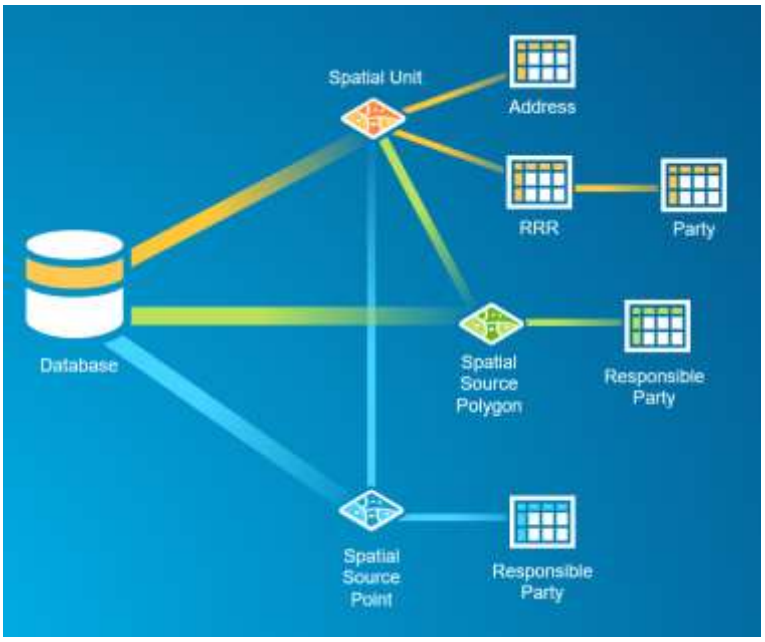

Figure 2. Conceptual Diagram of a Core LADM Implementation in ArcGIS

In this core implementation, Spatial Unit geometry is related to an Address table, which may contain basic locational information about the Spatial Unit itself. It is also related to an RRR table, with share percentage being represented in addition to description and document type. Attachments are enabled for this table for entry of photos or scans of any physical documents that support the RRR. Additionally, Party is related to RRR – so one or more parties who hold RRR may be represented. Of note in this Spatial Unit configuration is the absence of the Administrative Unit that may be applied in later stages with a formal country profile if necessary but has been removed for purposes of ease of field recordation. Please refer to the UML diagram following (Figure 3).

Within Spatial Source, an optional Spatial Source point has been added. This use may be applied to collection of spatially significant landmarks on the ground during the survey process. Both polygon and point have a related table containing information about the Responsible Party and attachments and are joined to the Spatial Unit in a many to many relationship. Please refer to the UML diagram following (Figure 4).

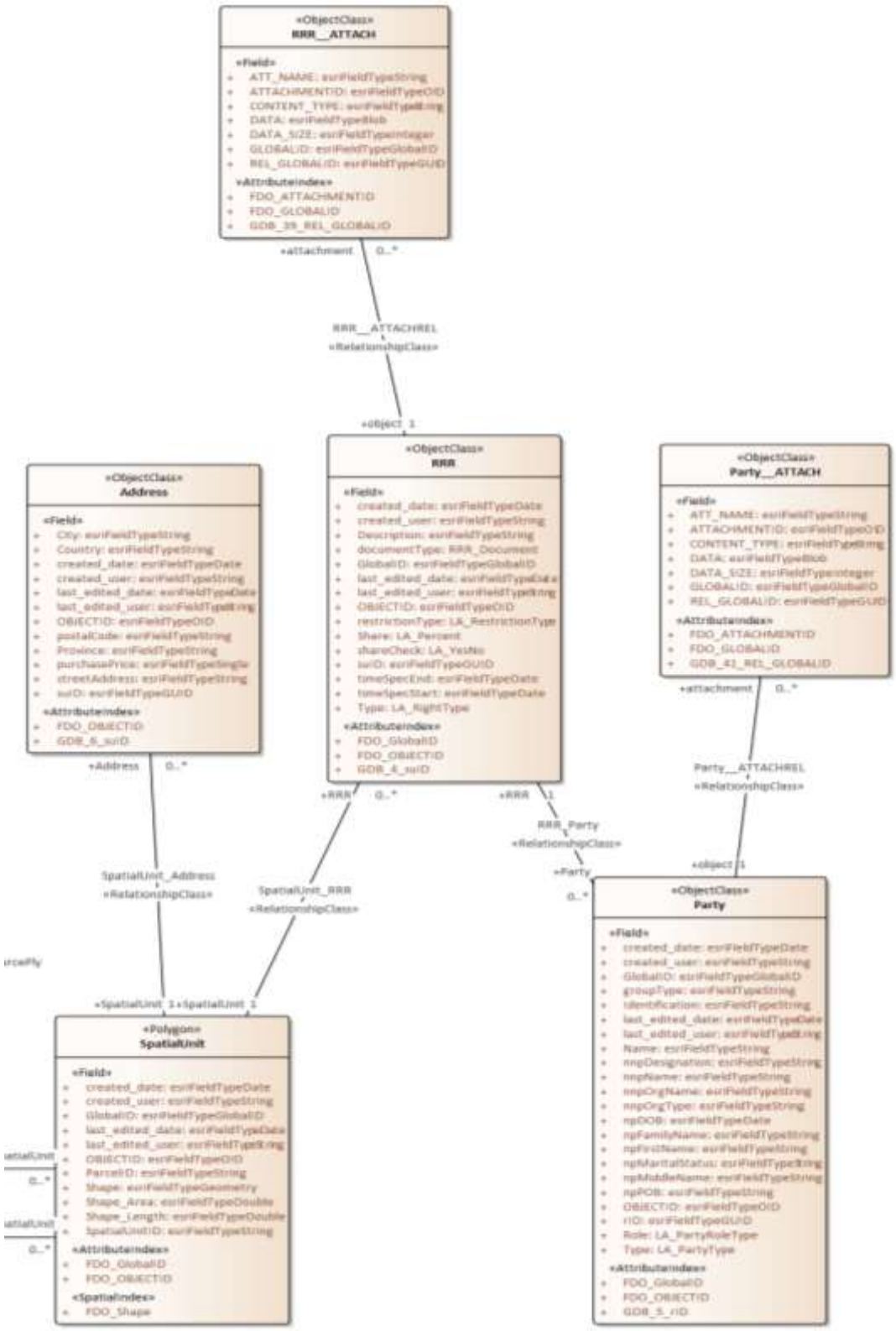

Figure 3. Spatial Unit within the proposed "core" LADM implementation.

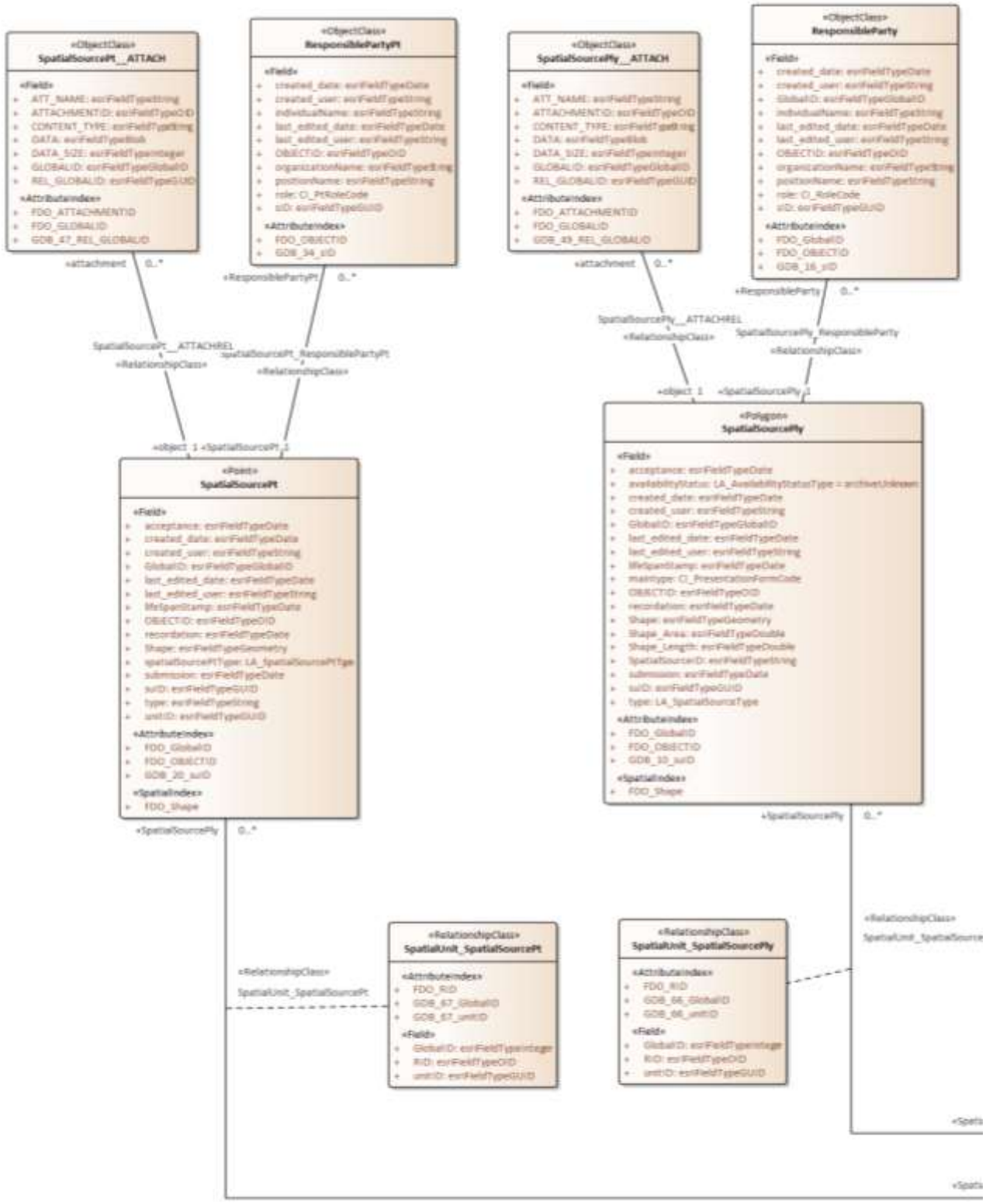

Figure 4. Spatial Source within the proposed "core" LADM implementation.

3. CONCLUSION

ArcGIS and the Land Administration Domain Model support scalable collection and maintenance of land information. ArcGIS provides several applications that may be configured to support collection of property boundaries, maintenance of parcels and can be integrated with other systems. LADM is also scalable. A proposed core implementation facilitates the use of LADM in ArcGIS for field data collection purposes. Later in the management process, a country profile may be applied to collected data to reflect regional land information.

REFERENCES

Jones, Brent. Colombia: How Mapping Land Rights Advances Peace, 21 January 2020: https://www.esri.com/about/newsroom/blog/colombia-remaps-land-for-peace/

Lemmen, Christiaan. A Domain Model for Land Administration (2012). Delft, The Netherlands. TU Delft.

BIOGRAPHICAL NOTES

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