Delivering Multi-Purpose Cadastre Based on FIG Cadastre 2014 and ArcGIS

Steve GRISÉ, USA and Jerry JOHNSON, the Netherlands

Key words: Cadastre 2014, ArcGIS, Data Model, Multi-Purpose Cadastre.

SUMMARY

Governments require the benefits from investments in cadastre systems that deliver on the broader goals of sustainable development. ESRI supports the ideas and concepts within the cadastre 2014 Commission 7 study, and has developed an initial 2014 cadastre data model. The 2014 data model is an open, customizable data model that supports the legal framework and business processes within a cadastre agency. This paper will look at the concepts and design of the new data model and highlight how it is integrated into the ESRI ArcGIS tool set for Cadastre.

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1. INTRODUCTION

ESRI systems have been used extensively for cadastre applications throughout the world for many years. With the evolution of IT systems and technology over the last 10 years, ESRI has evolved its core cadastre tools to take advantage of new standards, networking architecture and spatial databases. In addition to extending application tools, added benefits have been to provide greater integration of disciplines within a rich data-modeling environment for GIS functions and applications.

In 2001, ESRI introduced ArcGIS, and the capability of GIS technology to model complex systems. The geodatabase is an open storage structure for storing and managing GIS-related (spatial, geometry, tabular and Imagery) in a database management system (DBMS). At ArcGIS 8.3, ESRI introduced a new suite of editing tools necessary to construct and maintain user defined topological relationships with a geodatabase. In addition, tools have been developed to connect the geodatabase to the survey world, ESRI and Leica introduced unique survey data management capabilities to store and manage survey coordinates, measurements, computations and survey points.

ESRI has also been working to build a set of data model templates for use with ArcGIS. The approach is to work with various industry leaders to develop data models for transportation, utilities, land records, agriculture, topographic mapping and other disciplines. Within the Cadastre community, ESRI has formed a close relationship with leading organizations that understand cadastre data modeling, so that industry requirements are adequately reflected in its cadastre data modeling directions. The goal is not to create a new standards exercise, but to provide practical data model templates that support standards. ESRI, jointly with FIG, ITC and other parties working in the cadastre data-modeling arena, have started to define an open and generic cadastre data model.

2. CADASTRE 2014 DATA MODEL CONCEPTS

At the heart of Cadastre 2014 is a series of statements about the future of cadastral systems. We can use these statements to construct an accompanying data model. While the tendency has been towards complex analysis, it is important that we take a simple approach and understand the basic requirements from a data model perspective.

2.1 Statement 1 on Cadastre 2014 (FIG, 2000)

Statement 1 gives important guidance on the content of the data model and includes the complete spectrum of rights and interests in land. Further guidance is provided in 3.4.5.

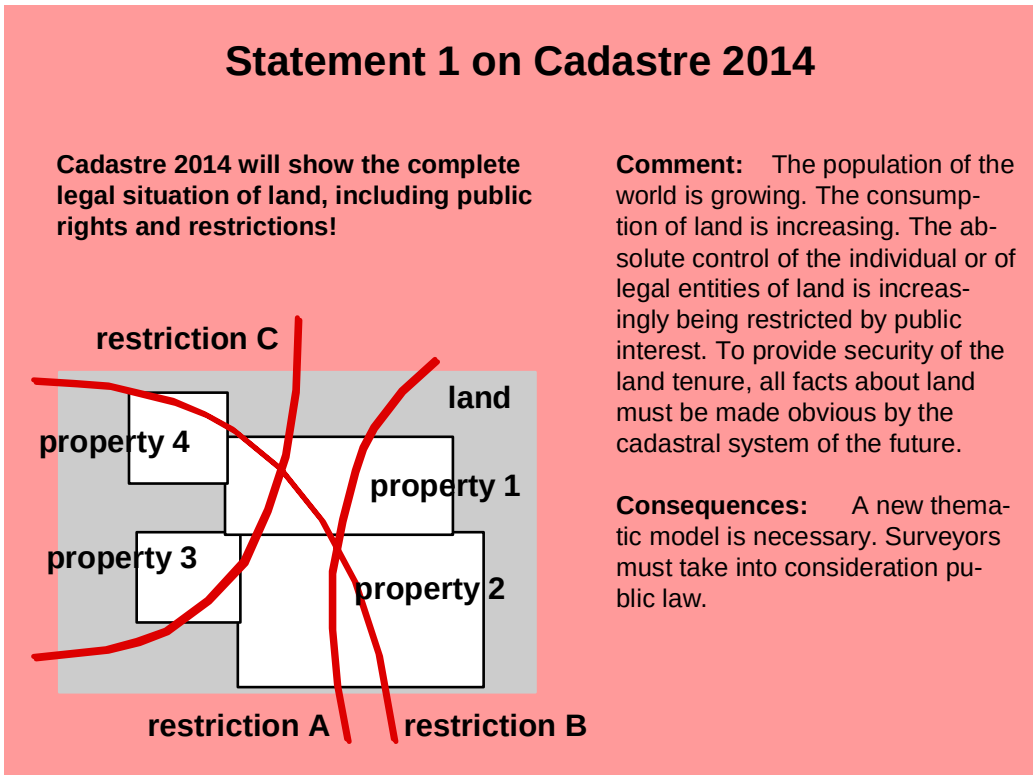
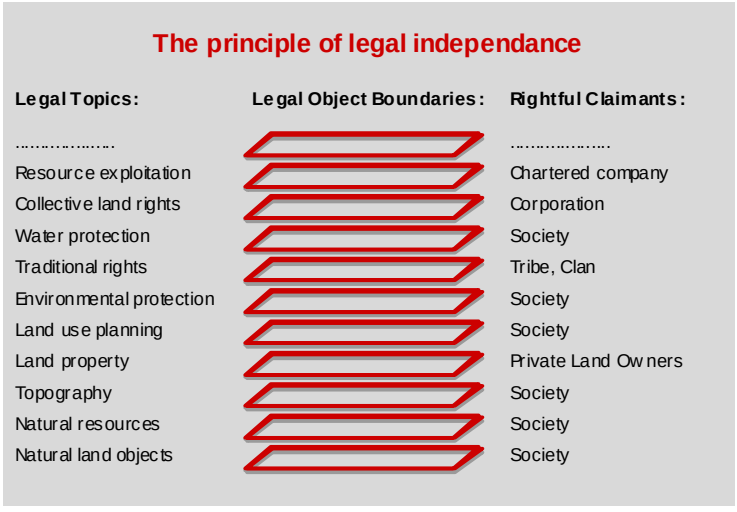


Figure 1 Statement 1 on Cadastre 2014 (FIG, 2000)

This section shows that for each legal right and interest in land we should have a "data layer". In terms of the data model this does not necessarily mean that each topic is a "class" in a UML (Unified Modeling Language) model or a "table" in our database. We can make these decisions later in our design as the specific attributes for the classes become apparent: we may discover opportunities for a simple data model.



3.4.5 Respect of the Principle of Legal Independence

The principle of legal independence is a key item in the realization of Cadastre 2014. The principle stipulates that: legal land objects, being subject to the same law and underlying a unique adjudication procedure, have to be arranged in one individual data layer; and for every adjudicative process defined by a certain law, a special data layer for the legal land objects underlying this process has to be created.

Cadastre 2014 is therefore based on a data model, organized according to the legislation for the different legal land objects in a particular country or district. The Cadastre 2014 system is documenting all of these different categories of legal land objects, adjudicated to different rightful claimants, independently but in a common reference system.

Figure 2 Section 3.4.5 from Cadastre 2014 (FIG, 2000)

2.2 Legal Topics and Rightful Claimants

Another important concept introduced in 3.4.5 is the relationship between Legal Topics and Rightful Claimants. In a general way we can represent this in UML as:

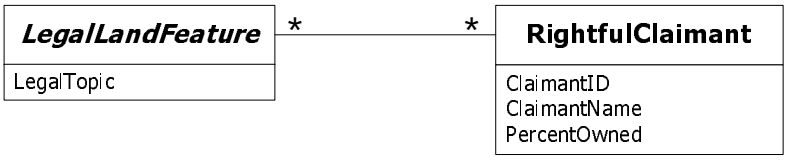


Figure 3 Relationship between Features and Owners

The italics indicate that this is an abstract class – we expect a number of additional classes will be created based on specific legal topics in a jurisdiction. Each RightfulClaimant may have multiple interests in land, each LegalLandFeature may have many owners or RightfulClaimants. This is a simple but important part of the data model for Cadastre 2014. Based on the current data model for legal rights and interests in the United States we could see the following subclasses of LegalLandFeature:

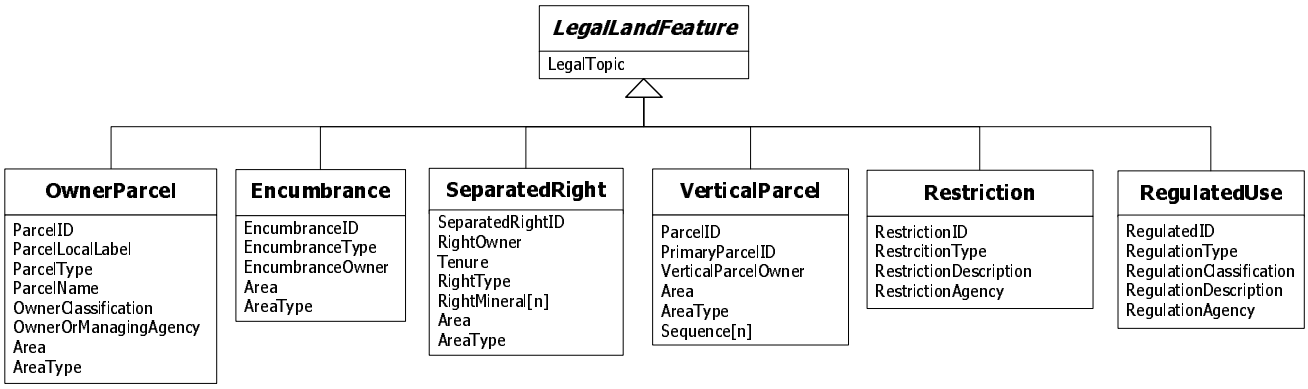


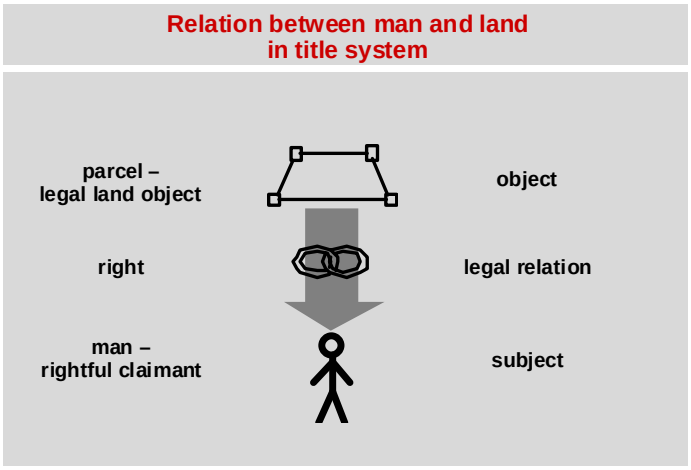
Figure 4 Types of Legal Land Features

It is expected that the list of legal topics will vary between countries; this example is provided to illustrate the concepts. In these diagrams, Legal Topic is an attribute of each legal feature, but this could also be accomplished through a relationship to handle more complex legal concepts. This should be explored in more detail in the context of real project work.

2.3 Land Title Systems

Another important aspect of the data model is the relationship to land title systems. It is likely that an organization will already have a sophisticated system for managing land titles even though they may not have a supporting system to manage the spatial data. Even if a new land titles system is developed in parallel with spatial data, in most cases we expect some level of integration between two distinct information systems. From another perspective, there are usually time lags between when a transaction is recorded in a titling system and when the spatial/map records are updated. In the coming years organizations will pursue daily or even hourly time lags between these updates, but from a systems standpoint even a difference of a

few minutes may force us to separate the data elements. The result of these combined factors leads us to a general model pattern of a “Title Reference” rather than a comprehensive title system.



Cadastre 2014, dealing with legal land objects under traditional, private, and public law knows only the title registration approach to land rights. The legal land object, with the rightful claimant and the parameters of the right referring to it, is registered.

Figure 5 Title Systems Conceptual Relationships (FIG, 2000)

The result is another many-to-many relationship. We should further constrain the relationship to indicate that a TitleReference must always refer to at least one Feature, and that a Feature must always have a TitleReference.

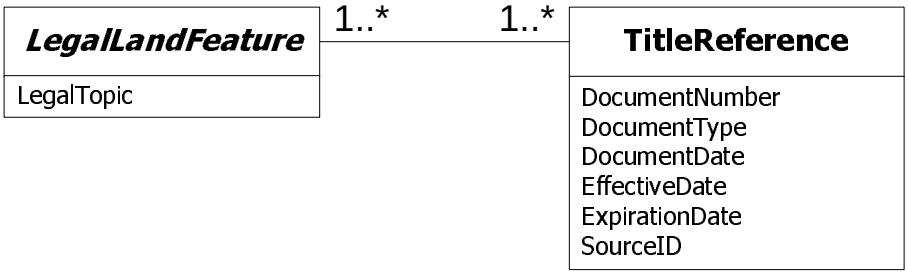


Figure 6 Relationship between Features and Land Titles

It is possible that one feature will have many title references over time, and that a single title reference may apply to multiple features. A more complete analysis of this relationship should be explored in the context of several real projects to determine if a universal pattern can be established. One thing is more certain: that a common, comprehensive data model for a title system may be difficult to achieve. Again, this is an important aspect of the data model that should be explored in the context of real projects.

2.4 Relationship To Field Survey

The general principle of Cadastre 2014 is that legal objects will be located through field survey.

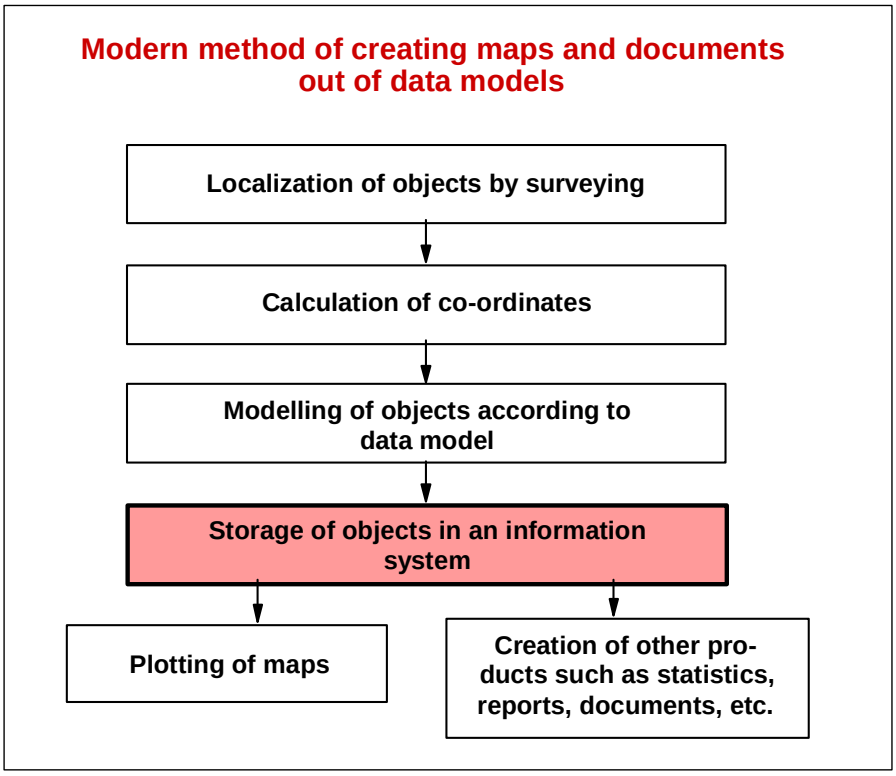


Figure 7 Modern Cadastral Workflow (FIG, 2000)

In ArcGIS we accomplish this by making features "Survey Aware". A complete discussion of the technical approach is beyond the scope of this paper, but this is an important implicit linkage in the data model and workflow for Cadastre 2014. Specifically, we link GIS features to survey points and boundaries. The following diagram provides an introduction to the general approach to field survey and workflow.

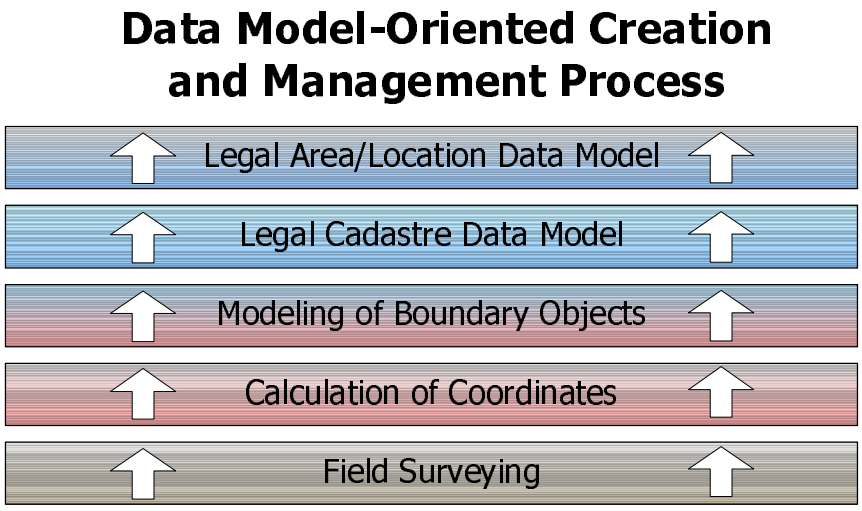


Figure 8 Workflow for managing GIS data linked to Field Survey

Some possible examples of boundary and survey point feature classes are included here. These are meant to illustrate concepts and need further investigation for use outside of North America.

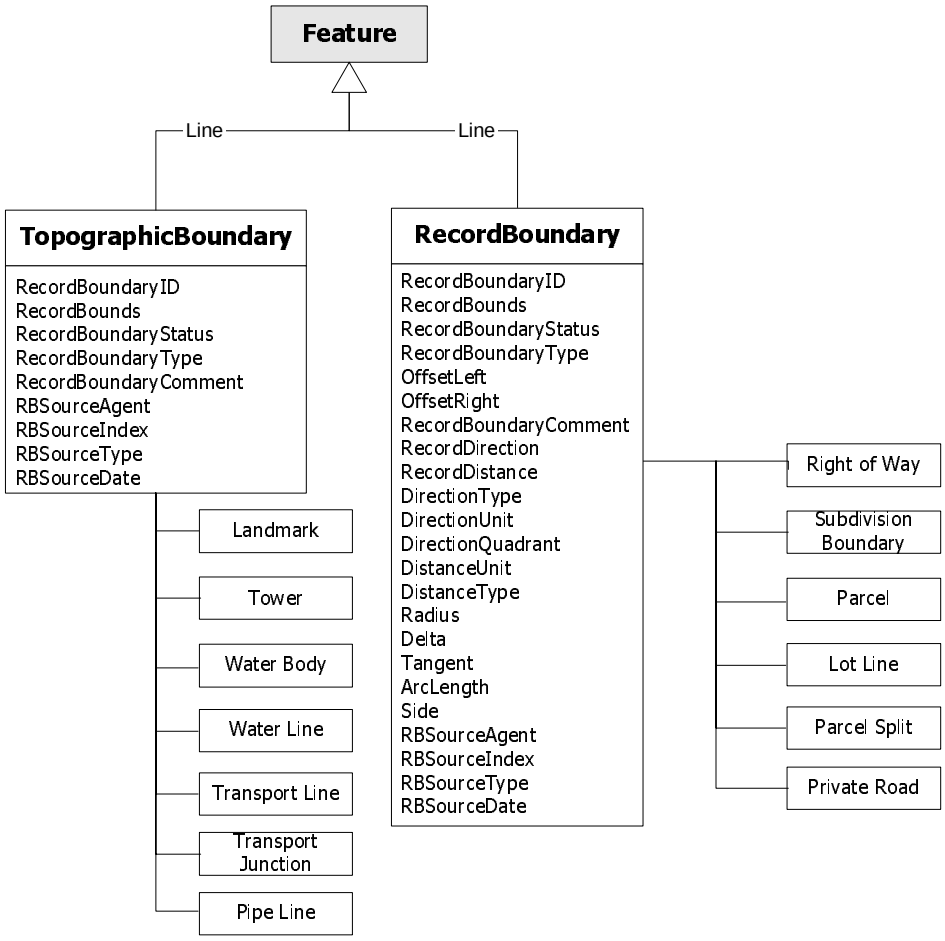


Figure 9 Example Boundary Feature Classes

Two main types of Boundary are described here. The first is a "Topographic" boundary – something derived from the natural landscape. This might be a high water line on a lake or other identifiable geographic boundary. The other type of boundary relates to survey measurements. This might be a simple distance and bearing measure or a more complex construction.

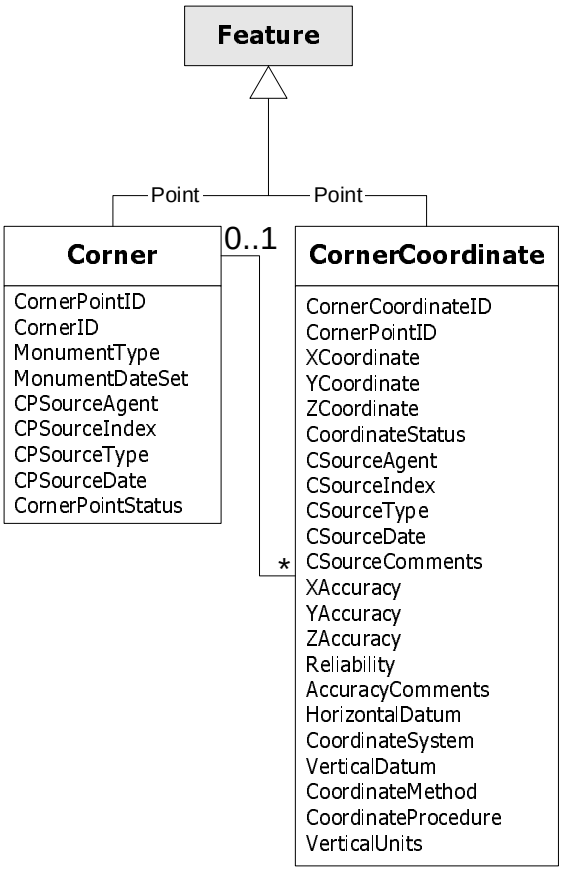


Figure 10 Example Survey Point Feature Classes

Each time we locate a Corner in a survey, we will register a slightly different coordinate. By making Corner features Survey Aware we may not need Corner Coordinates, but for data exchange and for cataloguing historical coordinate data we have included the CornerCoordinate feature class. More detailed descriptions of the attribute names can be found at: http://www.fairview-industries.com/ansi.html

2.5 Data Model Summary

The intent in this paper is to explore some of the central Cadastre 2014 data model topics and construct a basic data model that can be extended for specific projects. The broader suggestion is that through collaboration on projects we can build a practical data model template that can help organizations to achieve the goals of Cadastre 2014. This will not require extensive committee discussions and international standards. Rather, we should focus on best practices and over time decide how to evolve the experience into ISO standards.

This discussion is actively being explored through collaboration between FIG, ITC, ESRI and other participants. Further information on ESRI's activities can be found at http://support.esri.com/datamodels.

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BIOGRAPHICAL NOTES

Steve Grisé leads a series of data model projects at ESRI. Current activities include collaboration with industry leaders in over 20 industries and scientific disciplines. The results of the process are freely shared on the Internet for project teams to use a starting point for GIS data model design.

Jerry Johnson is the National Mapping Agency Development Manager, for ESRI Europe. He works with ESRI partners throughout Europe in project and business development in cadastre and other GIS sectors.

CONTACTS

Mr. Steve Grisé
Environmental Systems Research Institute (ESRI)
380 New York St
Redlands, CA
USA
92373
Tel. + 909 793 2853
Fax + 909 793 5953
Email: sgrise@esri.com
Web site: http://support.esri.com/datamodels

Mr. Jerry Johnson
Environmental Systems Research Institute (ESRI)
Groothandelsgebouw
Stationsplein 45 Postbus 29099
3001 GB Rotterdam
THE NETHERLANDS
Tel. + 31 10 2177788
Fax + 31 10 2177789
Email: jjohnson@esri.nl
Web site: http://www.esri.com