On the Level of Cooperation between Agricultural and Cadastral Parcel Registration

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SUMMARY

When the current situation in the rural areas of the EU is considered, it is a fact that there are two separated spatial data bases; Land Administration Systems (LASs) and Integrated Administration and Control Systems/Land Parcel Identification Systems (IACS/LPISs). They may handle different aspects of the rural land and population, but their target objects–rural land and population–are the same. This situation may be caused by varying scopes of LASs throughout the European Union (EU).

This study is aimed at analyzing a number of solutions to the problem of different, but related systems. For this purpose, the two extreme alternatives are discussed. As the first alternative a theoretical approach is introduced as an ideal system. In this case, in a LAS-land parcel, different land use types can be represented as sub-parcels. However, due to the fact that the current systems are far from this theoretical approach, a more practical approach is also introduced. In this approach, a case study (in two different case study areas) in the Netherlands is carried out with a focus on the extent to which the geometry between the two systems is shared (or at least strongly related). In addition to that, the extent to which the administrative information content of the two business processes is shared is also analyzed at an EU wide generic level.

Considering the theoretical and the practical extreme, three main alternatives are introduced. The first one is full integration. In this case (1), the two systems operate as one integrated system using different objects and different attributes. This case is theoretically applicable for the systems designed from scratch. For the legacy systems, which are already in operation, separated systems with or without information share are respectively introduced as second and third choices: (2) separate systems, but sharing their content via the Spatial Information Infrastructure (SII), and (3) separate systems, not sharing information, but having similarities in system architecture and functionality based on a (shared) Model Driven Architecture (MDA) approach (with even shared model patterns at a generic level). In all cases, the problem of how to increase the level of collaboration is discussed. The discussion on the desired level of collaboration between the two systems are also extended considering ISO's standardization initiatives in the area of Land Administration Domain Model (LADM), work on data specifications as part of INSPIRE – a standardized SDI initiative for the EU, and the usage of the MDA approach for system design.

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1. INTRODUCTION

The European Common Agricultural Policy (CAP) has changed substantially since 1992. The CAP has focused on the subsidies for the implementation of Market Policy and Rural Development Policy, and thus an integrated system has been used for the management of these policies. This integrated system is called as Integrated Administration and Control System (IACS). Countries in the EU have been using IACSs in order to administer agricultural subsidies since 1992 (Krugh, 2000; Delince, 2001; van der Molen, 2002). Over time, IACS experienced some major changes indicating the usage of concrete spatial reference systems. In this context, Land Parcel Identification Systems (LPISs) emerged in order mainly to spatially represent the activities of farmers on their lands (JRC, 2001; Kay, 2002).

During the development stages of different LPISs in different European countries, the usage of Land Administration (LA, or Cadastre) data as well as large scale topography data were on the agenda for a considerable while. Largely because different countries have different LA structures, contents and level of advancement in the usage of Information and Communication Technology (ICT) for the management of LA data, almost all countries were encouraged to use LPISs which has no direct relation with LA data although some indirect relations are possible. Some scientific publications on the relation between current LA data and LPIS/IACS data were published. They (JRC, 2001; 2002) concentrated on both current and possible future relations between the two systems.

When the current situation in the rural areas of the EU is considered, it is a fact that there are two separated spatial data bases; LASs and IACS/LPISs. They may handle different aspects of the rural land and population, but their target objects – rural land and population – are the same. The fact that establishing two datasets with a certain amount of overlap in the (geographic) content, brings with it a double effort to establish and maintain those – and thus causes extra expenses for the administration/management of rural land – has been introduced as a problem explicitly or implicitly by many scientific publications (see, JRC, 2001; 2002; Krugh, 2000; van der Molen 2002; FAO, 2006). Further, enforcing the expected consistency between two independent systems is not a trivial task.

This study is aimed at analyzing a number of solutions to this problem. For this purpose, the two extreme alternatives are discussed. As the first alternative (1) a theoretical approach is introduced as an ideal system. In this case, in a LAS-land parcel, different land use types can be represented as sub-parcels with their own refined geometry. Different implementation choices and data quality issues are considered for sub-parcels. However, due to the fact that the current systems are far from this theoretical approach (or integration), more practical approaches are also introduced considering the current legacy systems – LASs and LPISs. In these practical approaches, two case study areas in the Netherlands are studied with a focus on the extent to which the geometry between the two systems is shared (or at least strongly related). In addition to that, the extent to which the administrative information content of the two business processes is shared is also analyzed at an EU wide generic level. As a result of the analyses, two more solutions are proposed to increase the collaboration between the two systems – two independent systems (2) sharing the data content via SII, and (3) with similar pattern and system development environments.

The remainder of this paper is organized as follows. Section 2 provides the background on state of the art in LASs and LPISs in Europe. The theoretical and practical determination of the relationship between LAS and LPIS is discussed in section 3. An integrated LAS/LPIS model, the role of the SII and the use of the MDA approach are presented in section 4. Section 5 then contains an evaluation in which the INSPIRE context is assumed. Finally, the main results and conclusions can be found in section 6.

2. LAND ADMINISTRATION SYSTEMS AND RURAL LAND ADMINISTRATION IN THE EU

In 1992, the EU dramatically changed the subsidy regime of the Common Agricultural Policy (CAP) from the previous production support system to the current de-coupled Direct Payments (DP). At the very beginning, the use of LASs and large scale topographic map data to support the new subsidy regime was on the agenda. After initial applications in some European countries with a long tradition in the field of Cadastral Registration such as Germany, France, Spain, it turned out that the management of data related to agricultural subsidies was not possible in the context of available LASs. It has been alleged that there are considerable differences between the concepts of land administration and of subsidy management. Differences between farmers and land owners, differences between the legal area of the land parcel and the area used for agricultural purposes, the availability of cadastre data as well as the so-called complexity of LASs were and still are in the centre of the arguments. Differences between the LASs in the European countries were also considered as a barrier for introducing a single solution. In addition to that, difficulties in the collaboration between different organizations and time limitations were also identified as obstacles.

2.1 Different Land Administration Systems throughout the EU

The scope of Land Administration (Cadastre) Systems (LASs) differs throughout the European Union (EU) and depends on the history and the social structure of different countries. Some systems primarily aim at fiscal purposes (cadastres), and some others are firstly aimed at legal security (land registries). Satisfying those two aims is often, but not always, coordinated, but only in a few cases combined in one organization. In several countries, additional (environmental landscape or planning) aims are also served by the LAS. In some cases, the organisation includes large scale topographic mapping as a function, and in some others, it does not. There may also be some differences on the level of the technology used and of the data quality. Both the survey standards applied, as well as the approach taken during digitisation, differ and result in varied outcomes; also within one country. Even when combined in one organisation, a huge difference between the administrative "records" database and the geometric "map" database is strongly visible. Even the area of the same parcel as listed in the former differs from the result of a GIS-computation on the latter. The different setups per country are usually treasured, and seem outside of the scope of the EU's authority (article 295 of the Treaty Establishing the European Community). Initiatives as EULIS aim at one access portal, leaving the underlying systems as they are. For further understanding see e.g. Zevenbergen et al (2007). Currently, INSPIRE teem (see INSPIRE Directive, 2007) is working on the harmonization of 34 themes, including cadastral parcels (INSPIRE D2.3, 2007) between the 27 member countries of the EU.

2.2 Different Land Parcel Identification Systems (LPIS) for IACS

In the course of time, different member or candidate countries preferred different solutions for the establishment of their LPISs, depending on their current cadastre and land administration systems, availability of large scale topographic maps, ortho imagery/photos, etc. (JRC, 2003a; Kay and Milenov, 2007). In Article 20 of the Regulation (EC) No 1782/2003, it is stated that the identification system for agricultural parcels (LPIS) shall be established on the basis of maps or land registry documents or other cartographic references. This article legalizes the current situation of the stand alone LPIS establishment.

As a result of the above mentioned developments, countries in the EU have been using LPIS/IACSs in order to administer agricultural subsidies. In the recent years, there has also been an inclination to form the basis for rural land management information infrastructure via LPIS/IACS (Kay and Milenov, 2007). They mainly record agricultural land use information as declared by farmers rather than property rights information. So, agricultural parcels as a unit defined by one type of activity by only one farmer are regarded as the smallest unit of the system – agricultural parcel. However, considering the fact that in many cases it is not possible to keep the information of such agricultural parcels up to date, the current LPIS systems use reference parcels (Farmers Block, Physical Block) in which agricultural parcels are over-generalized. The LPISs of this kind are regarded as relatively easy to build, update and manage, and also as so-called low cost systems.

A vast variety of spatial referencing systems (LPIS parcel definitions) and demarcation methods and combinations of these have been used for LPISs in different countries throughout the EU. Basic spatial referencing systems in LPISs are called reference parcels. Reference parcels may be cadastral parcels, or any other kind of parcels the boundaries of which are robustly defined by using any kind of appropriate cartographic material such as ortho photo/image and large scale topographic maps (Kay and Milenov, 2007; Inan and Cete, 2007). In fact, the countries having a tradition and good organization of large scale mapping (1:10.000 or larger) take the advantage of deriving data from this source. Similar to this, some countries or states make use of their LAS for this purpose. Yet, all countries have been encouraged to use stand alone special reference systems taking the advantage of using ortho photo/image coverage. These proposed reference systems (see Figure 1) are described below.

– Agricultural Parcel: A continuous piece of land with a single crop cultivated by a single farmer (Figure 1).
– Farmer Blocks (ilot): Grouping together a number of neighbouring agricultural parcels cultivated by the same farmer. Inside a farmer block, there may be some different agricultural activities or products (Figure 1).
– Physical Block: Grouping together a number of neighbouring agricultural parcels cultivated by one or several farmers and delineated by the most stable boundaries (*see* Fig 1) (JRC, 2001). Some countries define agricultural parcels or farmer blocks (ilot) inside blocks to reach a certain level of administrative power over declarations.

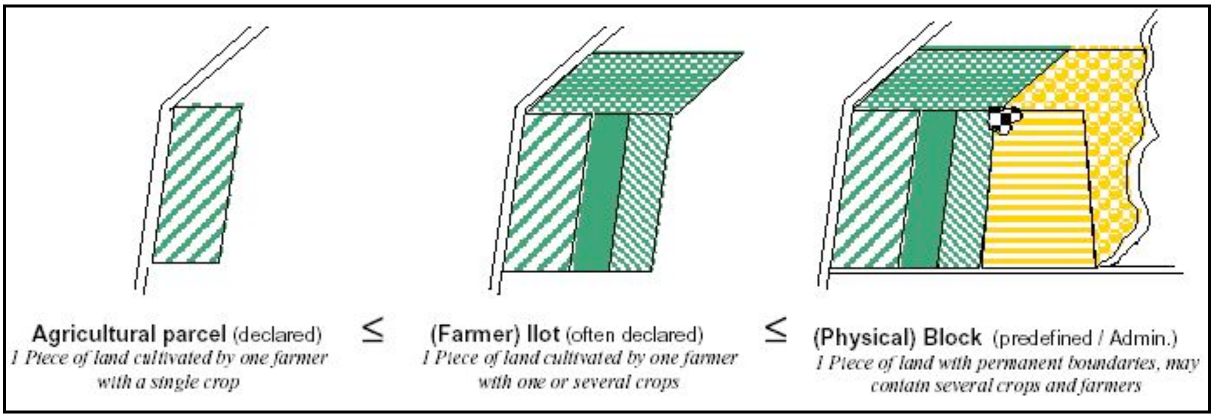

Figure 1. Methods for the identification of reference parcels (JRC, 2001).

A majority of EU countries have been using ortho photo products as the main source of information in the establishment and maintenance of their LPISs. There are few countries namely Poland, Spain, Italy and some Lander in Germany which uses LAS data for their LPIS. Interestingly, United Kingdom (UK) is the only country not using ortho products or LAS data for this purpose. In fact, in the UK, large scale topographic mapping is the only spatial data source (JRC, 2003a; Kay and Milenov, 2007; Inan and Cete, 2007). Some countries such as the Netherlands use a combination of Physical Block and Agricultural Parcel (partly based op 1:10:000 topographic data) in their LPIS to reach a certain level of data consistency and administer related subsidies more precisely. In many other systems, there is a certain level of uncertainty between the reference parcels and farmer declarations.

3. DETERMINATION OF THE RELATION BETWEEN LAS AND LPIS

In this chapter, two approaches are introduced for the determination of the relation between Land Administration Systems (LASs) and Land Parcel Identification Systems (LPISs) as the spatial component of IACSs. In the first approach, theoretical relations are defined to be used for modeling purposes, in the second one, spatial data (geometry) overlap between two legacy systems is analyzed in two case study areas in the Netherlands. In addition to that, administrative information content share is determined considering current LASs and LPISs as legacy systems.

3.1 Theoretical Approach

After the introduction of LPISs, the most important issue which has been regarded as a fundamental drawback of LASs against LPISs is that they basically deal with property rights (ownership and land tenure), not agricultural activities (Inan and Cete, 2007). At a conventional viewing angle, there have been many differences between LASs as legacy systems, and even they are not capable of representing all types of land tenure information. However, when we draw the image of a modern multi-purpose cadastral system, it turns out that LASs should facilitate the management of land tenure, land value and land use (see Enemark 2005). In addition to that, the vision of Cadastre 2014 developed by Kaufmann and Steudler (1998) should also be considered. This vision suggests the registration of all private and public rights and restrictions relating to land in the form of “land objects” under the cadastral systems. In addition, standardization efforts on the field of LAS (van Oosterom et al., 2006; Lemmen and van Oosterom 2006) are also considered as accompanying forces to this theoretical approach.

Considering the current drawbacks and future needs of LASs, the relation between LASs and LPISs are theoretically defined. For the representation of different agricultural activities in a land parcel, the term *sub-parcel* (see Figure 2) is introduced as a piece of land to represent certain types of land use (see Table 1 for types of land use) in a land parcel. It is closely related to the concepts of the agricultural parcels and farmer blocks (ilot). In order to represent farming rights on land parcels, the person role type *farmer* (see Figure 5 and 6) is also introduced. Being a farmer does not always mean that the person must be a farmer with all kind of activities related to land. In fact, a farmer is a person who is entitled to be a farmer as a role. The same farmer may be an owner, a conveyor, a surveyor, and may have any other non-defined roles.

In the following two sub-sections, a proposed data model for a theoretical full integration between LPIS/IACS and LAS is defined in detail.

3.1.1 Definition of the Data Model for Sub-Parcels in LAS

Sub-Parcel is defined as a basic subdivision of a land parcel in a LAS. The reason for this is the need for representing different land use types. In fact, the LPIS is an inventory similar to the cadastral records, and it is applied for the administration of agricultural aid (Perez, 2005). For the LPIS, “agricultural parcel” is a continuous piece of land with a single crop cultivated by a single farmer. For the Cadastre, “parcel” is a continuous piece of land with homogeneous rights in one ownership (see UN-ECE, 2004). Cadastral parcels are divided in “sub-parcels” according to the different types of land use in the same parcel. So, the concepts “agricultural parcel” and “cadastral sub-parcel” are physically comparable (Perez, 2003). Similar to the definition of sub-parcels by Perez (2003), three main land use types are defined – Cultivated, Planted and NonAgricultural (see Table 1 for more detailed definitions) in this study. However, the reason for this definition is a bit different. In a land parcel, there may be many kinds of agricultural land use types. Yet, representation of them is almost impossible considering the system implementation and maintenance. So, in the design of sub parcel types, special attention is given to the permanence of boundaries. In fact, rare changes in the boundaries of the three main sub-parcel types are expected. Yet, different agricultural activities inside a sub-parcel must be managed administratively just as in the case of physical blocks or farmer blocks in a LPIS.

Spatial representation of sub-parcel boundaries is defined in Figure 2. Establishment of such boundaries may be done during cadastral surveys or it may be done later in time using otho photography/imagery by competent organizations responsible for LAS or Agricultural Activities.

The sub-parcel model provides the functionality to register some important agricultural permanent crops such as olive groves, vineyards, and different kind of nuts as a different spatial feature in relation with the land parcels where they coincide. Theoretically, adjacent sub-parcels can not be the same type of sub-parcel. However, this rule may be removed for the representation of certain permanent agricultural crops which should be administered in a different manner than the regular ones. By defining this discrimination, there will not be a need for separate spatial identification systems for special crops (see JRC, 2003b). There may be different administrative systems referring to the same spatial object in a LAS including this kind of sub-parcels.

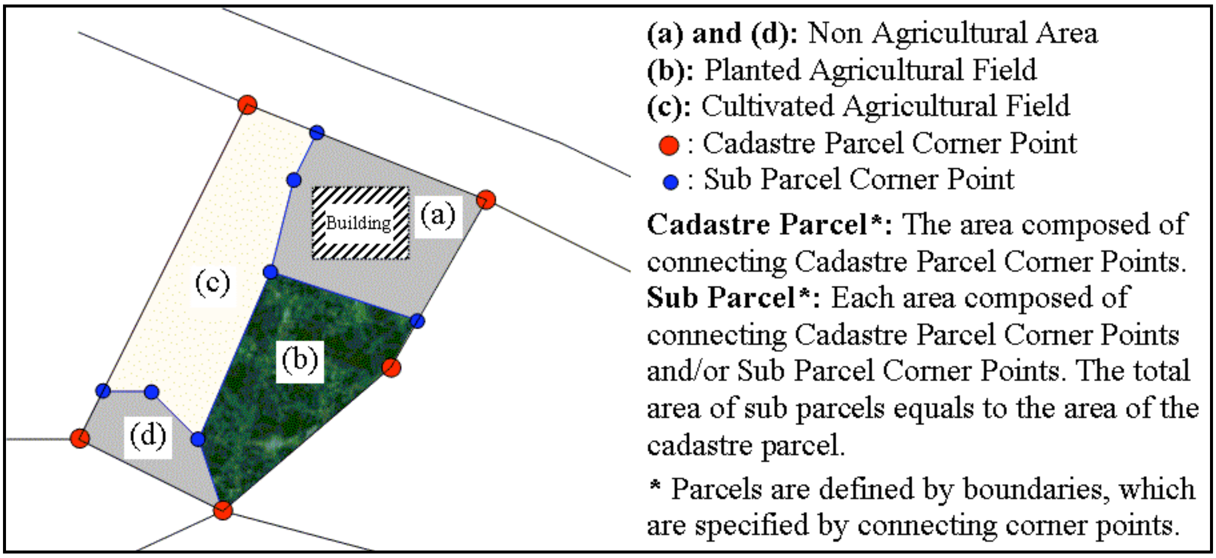

Figure 2. Cadastre Parcel and Sub-Parcel Data Model

As for the topological structure of sub-parcels, they must be inside land parcels, they can not overlap, and there must be no gaps between them. Registered buildings must be inside nonagricultural sub-parcels. Sub-parcel corner points can not cause any splits along the edges of land parcels.

Table 1. Main land use types for sub parcels

Main Types	Descriptin of the Type
Cultivated	Includes agricultural areas cultivated with yearly crops. Types of agricultural products within these areas are quite varying. Vegetable gardens and set-aside areas (fallow land) are also included in this type of agricultural land. Permanent greenhouses may be classified as a seperated main type.
Planted	Includes agricultural areas planted with some kind of agricultural threes (Permanet crops). Such areas as Vineyards, Olive Groves, Fruit Orchards and, may be Forests.
Not Agricultural	The areas not subject to any agricultural production. Urban land, rocky areas, areas with brushwood, roods are some examples.

With the sub-parcel model in this study, it is mainly aimed at supporting LASs towards a more integrated rural land administration. Therefore, sub-parcels, which also include the areas used for agricultural purposes (planted and cultivated agricultural areas) similar to agricultural parcels in LPISs, are designed inside LAS-land parcels. However, it is known that, in some cases, agricultural parcels cover more than one LAS-land parcel or they are part of multiple LAS-land parcels. In two case study areas, the existence of such cases can be seen. It is also seen that there is no agricultural parcels crossing more than one reference parcel (physical block). This is basically because reference parcels in the LPIS are base parcels that agricultural parcels are topologically dependant on. Similar to that, in the sub-parcel data model, sub-parcels are dependant on LAS-land parcels. Yet, it is technically possible to have sub-parcels being a part of multiple LAS-parcels. Please note that such kind of sub-parcels do not comply with the scope of sub-parcel definition specified in this paper. Rather, they may actually be similar to agricultural parcels in LPISs and so they should be called as cross-lots. It is a fact that the administrative control of cross-lots under LASs is not possible in the way defined in this paper for the administration of sub-parcels. In fact, inclusion of cross-lots will definitely cause some hardship for the effort to integrate both systems, or, may be, make it impossible. So, if this is strongly required for subsidy management or other agricultural policies. This must be further studied. Yet, just as a transition stage and to facilitate usage of LAS-land parcels for this purpose, cross-lots may be included neglecting complete compliance with LASs as defined in Section 4.1.1.

3.1.2 Definition of Farmers and Farming Rights in LAS

The LPIS deals with farmers/users and the Cadastre deals with owners (Perez, 2003; JRC, 2001) (or other right holders of registered property rights), and they may not be the same person (Perez, 2003). Unlike such kind of common understanding, LASs, by definition, deal with a wide range of information related to land including ownership, land use rights, farming rights, restrictions, responsibilities etc. However, it is a fact that conventional LASs as legacy systems are not always capable of administering all kinds of land related rights. This is why LASs are generally underestimated by third parties. Therefore, registration of farmers and farming rights in a LAS has been regarded as an obstacle when compared with LPIS. In fact, a farmer is a person who does some kind of agricultural activity on some piece of land. Farmers may own some land for their activities. They may lease and/or get some kind of consent for another piece of land. Actually, in Turkey, there are three main ways of having farming right on a land parcel. One of them is ownership. It provides full right on a land parcel. Leasing is another one. The last one is deed of consent (or notary statement) from share holders or first order relatives.

Registration of all land related rights in LASs is really not an easy task. Yet, after the registration, it will serve many invaluable functionalities for a vast variety of users. In this study, registration of farmers and farming rights are investigated. Farmers' authorization information and other personal data about farming activities should be administered in a farmer's registry outside LASs because they are really outside the scope of the LAS. In Turkey, they are registered under National Registry of Farmers (NRF) system, in the EU, they are registered in LPISs. However, farming rights related to land should be registered and administered under LASs for a more integrated administration of rights related to land. In Turkey, actually, they are stored and administered under the NRF system. In the majority of the European countries, there are no such records even in LPISs. In some cases, they are recorded in LASs, but there is not a convenient communication between LASs and LPISs. On the other hand, even after the registration of all kinds of farming rights, it is not adequate to represent agricultural activities. In fact, farmers do not have to do continuous agricultural activities on the land parcels where they have farming rights. So, similar to LPISs, declarations by farmers should also be registered annually or on a time basis defined by responsible authorities. Fortunately, once you have all kinds of rights in LAS, registration of farmer declarations turns out to be a considerably easy task because it is enough to put a boolean indication on the related right that is already registered under the LAS.

3.2 Practical Approach

3.2.1 Determination of Geometry Overlap

Since the establishment of LPISs as spatial part of IACSs in Europe, it has been alleged that boundaries of land parcels in LASs do not coincide with the boundaries of agricultural parcels or farmer blocks. Yet, a thorough report as a proof of this has not been published yet. Beyond that, this determination may help define a more robust geometrical relation between land parcels in LAS and agricultural parcels in LPIS. It may also help decide on what should be done first for a more integrated solution or even investigating whether it is possible or not.

During the determination of geometry share, the history of the land registry system should be considered as an important factor. In fact, theoretically, the date at which the initial cadastre was created, as well as subsequent land management activities (e.g. land consolidation) should be regarded as crucial factors, which may affect the geometrical relations between the two systems. In addition to that, data quality and accuracy issues between the two systems should also be considered to get meaningful and reliable results.

Analysis of geometry overlap is carried out in two case study areas in the Netherlands which are selected partly considering different aspects raised above. One of them is North East Polder (NO-Polder).It is one of the areas that were reclaimed from the sea in the 20th century. After 1942, development activities started to be done there. A very symmetric parcellation pattern was designed, built on rectangular blocks of six hectares each. Enlargement of farms, new infrastructure and expansion of urban areas has deteriorated this symmetric pattern at some points, but much of it is still very visible (see Figure 3 left), and with its rectangular shapes and straight lines makes for easy parcel identification, both for land administration and for agricultural purposes. The other case study area is Twente. When compared with NO-Polder, Twente is an old region and has a completely different pattern of landscape. Land parcels and agricultural parcels are not in even shapes (see Figure 3 right).

Figure 3. Sample views from Cadastre data set of NO-Polder (left) and Twente (right).

Three data sets are used for the determination of geometry overlap in each case study area. Reference Parcel (RP) and Agricultural Parcel (AP) data sets (LPIS data set) are provided by the related government bodies of the Dutch Ministry of Agriculture, Nature and Food Quality. The RP data set is actually an extract of the related features in TOP10NL topographic data set. Besides objects related to rural landscape, it also includes many objects related to urban landscape. So, these objects are eliminated before the analysis. As for AP data set, it is formed as a result of the declarations by farmers. Agricultural parcels in this data set are defined inside reference parcels. The third data set used for the geometry overlap analysis is Cadastre data set (as a part of LAS). Due to unavailability of most up-to-date data set, a previous version of the Cadastre data set is used in the analysis.

For the analysis of geometry overlap a basic intersection method is used. Different spatial tolerances (1, 2, 3 and 5 meters) are used to have a clear idea on what is the actual geometry overlap between data sets. In the intersection overly process, only boundary features in data sets are used, which makes the analysis a robust method for determination of geometry overlap. In addition, overlapping features in resultant line data sets are eliminated. So, the results are technically effective and reliable. The analyses are carried out between Cadastre and RP data sets and also between Cadastre and AP data sets.

Agricultural Parcel data sets of NO-Polder and Twente include 9.310 and 43.457 agricultural parcels respectively. These parcels have total boundary lengths of 6.407 and 21.715 kilometers (km) in NO-Polder and Twente. As for the Physical Block data sets, there are 4.538 and 44.099 reference parcels spatially coinciding with agricultural parcels in NO-Polder and Twente. Total lengths of their boundaries are 4.423 and 22.451 km. All the descriptive information about the LPIS data set used in the analysis is presented in Table 2.

Table 2. Descriptive information of LPIS data sets used in the analyses.

	NO-Polder		**Twente**	
	Agri. Parcel	**Ref. Parcel**	**Agri. Parcel**	**Ref. Parcel**
Number of Parcels	9.310	4.538	43.457	44.099
Length of Boundaries (km)	6.407	4.423	21.715	22.451
Area of Parcels (km^2)	374,40	396,71	865,70	1044,65

The degree of boundary overlap are decided considering the length of boundary that they share with the Cadastre parcel boundaries. For a more clear understanding, shared boundary determination is divided in two categories. In one, every boundary share within the special tolerance is considered as a shared boundary. In the other, only boundaries having at least 100 meters continuous length is regarded as shared boundary. For the second one, all adjoining shared boundaries in each layer generated as a result of each intersection analysis are dissolved into one single boundary in order to make sure that there are no divided boundaries. The results of all the analyses are presented in Table 3.

As it is seen in Table 2, over fifty thousand agricultural parcels are used in the geometry overlap analysis. When different data sets having different accuracies are considered, determining the exact spatial tolerance which should be used is a bit troublesome. Although all data sets are digital, conventional scales (1:1000 for cadastre data, 1:5000 or 1:10.000 for TOP10NL cartographic data) and data acquisition methods (agricultural parcels are digitized on ortho images) give an idea on the spatial tolerance which should be used. Yet, determining an exact one is almost impossible. So, for each analysis, four different tolerances are used and their results are compared. As a result, it is agreed that spatial tolerance should be between 2 and 3 meters. For the interpretation of overall results, 3m spatial tolerance and its results are focused.

For NO-Polder region, 38% of agricultural parcel boundaries overlaps with cadastre parcel boundaries. This overlap is the least among others. Yet, evenly designed rural landscapes are responsible for this result. In fact, reference parcels are very similar to cadastral parcels in this region. But, reference parcels are not similar to agricultural parcels. Rather, reference parcels includes many agricultural parcels. In fact, total lengths of their boundaries are considerably different and they have only 51% of boundaries in common. This causes many agricultural parcel boundaries crossing cadastre parcels, which causes less shared boundaries between cadastre and agricultural parcels. In the same region, however, 58% of reference parcel boundaries overlaps with cadastre parcel boundaries. In Twente region, percentages of overlapping boundaries are almost 60%. They are very close to each other (59 and 57%). This figure indicates both that there are a considerable overlap between cadastre parcels and LPIS data (agricultural and reference parcels), and that reference parcels and agricultural parcels are quite similar. This similarity is also proved by two other facts. One is that total lengths of their boundaries are very close to each other (see Table 2). The other is that they have 71% of boundaries in common.

Table 3. Length and percentage of overlapping boundaries between cadastre parcels and agricultural parcels / reference parcels

		Intersection		**with Agricultural Parcels**				**with Reference Parcels**			
		Tolerance		**1m**	**2m**	**3m**	**5m**	**1m**	**2m**	**3m**	**5m**
Boundary Overlap	**NO-Polder**	any	km	1479	2140	2449	2715	1530	2259	2556	2792
			%	23	33	**38**	42	35	51	**58**	63
		> 100m	km	1408	2092	2412	2678	1425	2166	2471	2693
			%	22	33	**38**	42	32	49	**56**	61
	Twente	any	km	7146	11407	12908	13408	5800	10803	12721	12815
			%	33	53	**59**	62	25	48	**57**	57
		> 100m	km	5479	9723	11228	11271	4212	8956	10825	10295
			%	25	45	**52**	52	19	40	**48**	46

Before the analyses, it is expected to reach better results in the NO-Polder region. After the analyses, it turned out that there is not much difference between them. The only difference between two regions is the overlap ratio with agricultural parcels. The reason for that is clarified in the text above. This suggests that there is a close relationship between cadastre parcels and reference parcels in their shapes and boundaries that they share. Agricultural parcels have similar relation with cadastre parcels. However, they tend to be more detailed.

Beyond the analysis of boundaries in common, length of common boundaries is also taken into consideration. Common boundaries which have a length of at least one hundred meters are also evaluated (see Table 3). Results of this evaluation suggest that there is a strong and continuous relation between cadastre boundaries and reference parcels or agricultural parcels.

3.2.2 Determination of Administrative Information Content Share

In the determination of the administrative information content share, the meaning of person (natural as well as non-natural) and the land use types registered under the two systems are considered, because these two concepts have different meanings in the context of each system.

In LASs, person indicates the person who legally holds some property right over a real property. Person in an LPIS/IACS, on the other hand, means a farmer who performs some agricultural activities on a real property or on a piece of land (agricultural parcel, farmer block/ilot). In fact, persons in a LAS may own, lease or have some other rights/restrictions on land parcels as legal real properties. However, persons in LPISs may use a land parcel or a piece of land without referring to the legal right holder (owner). That is to say informal rights are established on land. Conflicts are resolved among farmers or by relevant authorities informally. Legal documents may be used only if the conflicts can not be resolved using alternative informal ways legalized under the regulations EC no 1782/2003 and EC no 796/2004.

As for the land use concept, it means a general classification of land use types in LASs, whereas it indicates a detailed description of different agricultural activities in LPIS/IACSs. In fact, land use classifications of LASs in different countries may differ. Classification systems in LASs are basically defined for the identification of main types of land use (see UsageType class in Figure 6). On the other hand, land use classification in LPISs focuses on the classification of some certain agricultural land use types. Depending on the importance of the agricultural activities (see AgriActivityType class in Figure 4), they may be represented as a land use class. In this style of classification, the economic value of the agricultural product may affect the classification system. Some special permanent agricultural crops, for example, are classified as different classes. Olive groves, vineyards, fruit orchards, different nuts are some of these special crops. Many yearly agricultural crops on the other hand are classified together and only their amounts are administered separately.

4. A MORE INTEGRATED SOLUTION

In this section, the Spatial Information Infrastructure (SII) required for the integration of LASs and LPIS or for a more integrated solution through information share and the usage of Model Driven Architecture (MDA) approach in the design of SII are discussed.

4.1 **Required SII**

Both for a full integration of LASs and LPISs and for some kind of collaboration or information share between the two systems, SIIs play a crucial role. In fact, SIIs provide the harmonization for any integration, communication or information share without causing inconsistencies or redundancies in data sets. So, the need for such kind of SIIs is discussed in this section.

4.1.1 SII Design for the Theoretical Approach

Integration of LASs and LPISs is theoretically possible as introduced in section 3.1. In a LAS, representation of farmers and farming rights are possible. To be able to grasp the philosophy of this theory more explicitly and to draw an image of required SII, it is applied on a generic LAS model – Land Administration Domain Model (LADM). LADM was initially developed as Core Cadastral Domain Model (CCDM). It was discussed in a number of scientific meetings. Two main versions of CCDM are published by van Oosterom et al. (2006); Lemmen and van Oosterom (2006). The third one (the LADM version) has been recently submitted to ISO TC/211 as a new work item proposal for an international standard. Therefore, the LADM generic model is used in this study in order to represent the probable full integration between LASs and LPISs. In the UML class diagrams, current LADM classes are modified or new classes are added for this purpose (Figures 3, 4 and 5). In the following paragraphs, the proposed model for full integration is clarified by referring to existing, modified LADM classes or the newly added ones. All class names are written with no spaces (e.g., SubParcel) and all attributes of classes are written in *italics* (e.g. *agriActivity*) for reader's comfort.

For the representation of different types of land use in a land parcel (see section 3.1.1), the class SubParcel is designed as a subdivision of the class RegisterParcel. That is SubParcel class aggregates from RegisterParcel class (Figure 4). Zero or more SubParcels may be related with each RegisterParcel. All SubParcels related to one RegisterParcel should be topologically structured without overlaps and gaps (gaps may be possible in case gaps stand only for nonagricultural areas).

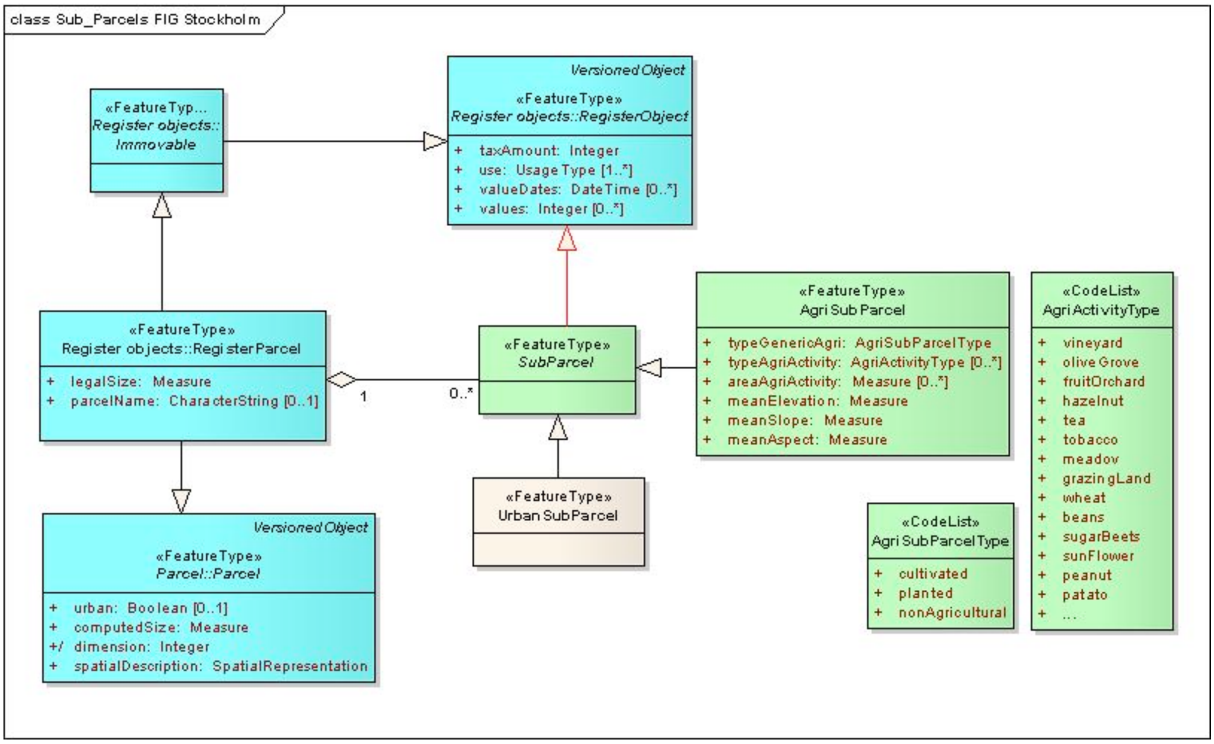

Figure 4. Sub-Parcel theory in relation with LADM classes (RegisterObject, Parcel, Immovable, RegisterParcel)

The class SubParcel does not inherit from Parcel class because there is a partition rule (no gaps and overlaps) among the instances of Parcel class. When system design of current LASs considered, SubParcel class can not inherit from the class RegisterObject because instances of it are not objects (piece of land for agriculture) subject to registration in current LASs. This is why the inheritance arrow between SubParcel and RegisterObject is drawn in red (Figure 4). However, in some LASs of specific countries, similar objects (a road inside a parcel) are registered as lots (see UN-ECE, 2004). This provides an indication that, in the future, registration of sub parcels as RegisterObjets in LASs may be possible. With this possibility, the precise representation of agricultural activities of farmers in LASs will be possible.

One instance of RegisterParcel may only be related with one kind of SubParcel (AgriSubParcel or UrbanSubParcel). Considering the overall philosophy of LADM, UrbanSubParcel is designed for urban areas and is outside of the scope of this study.

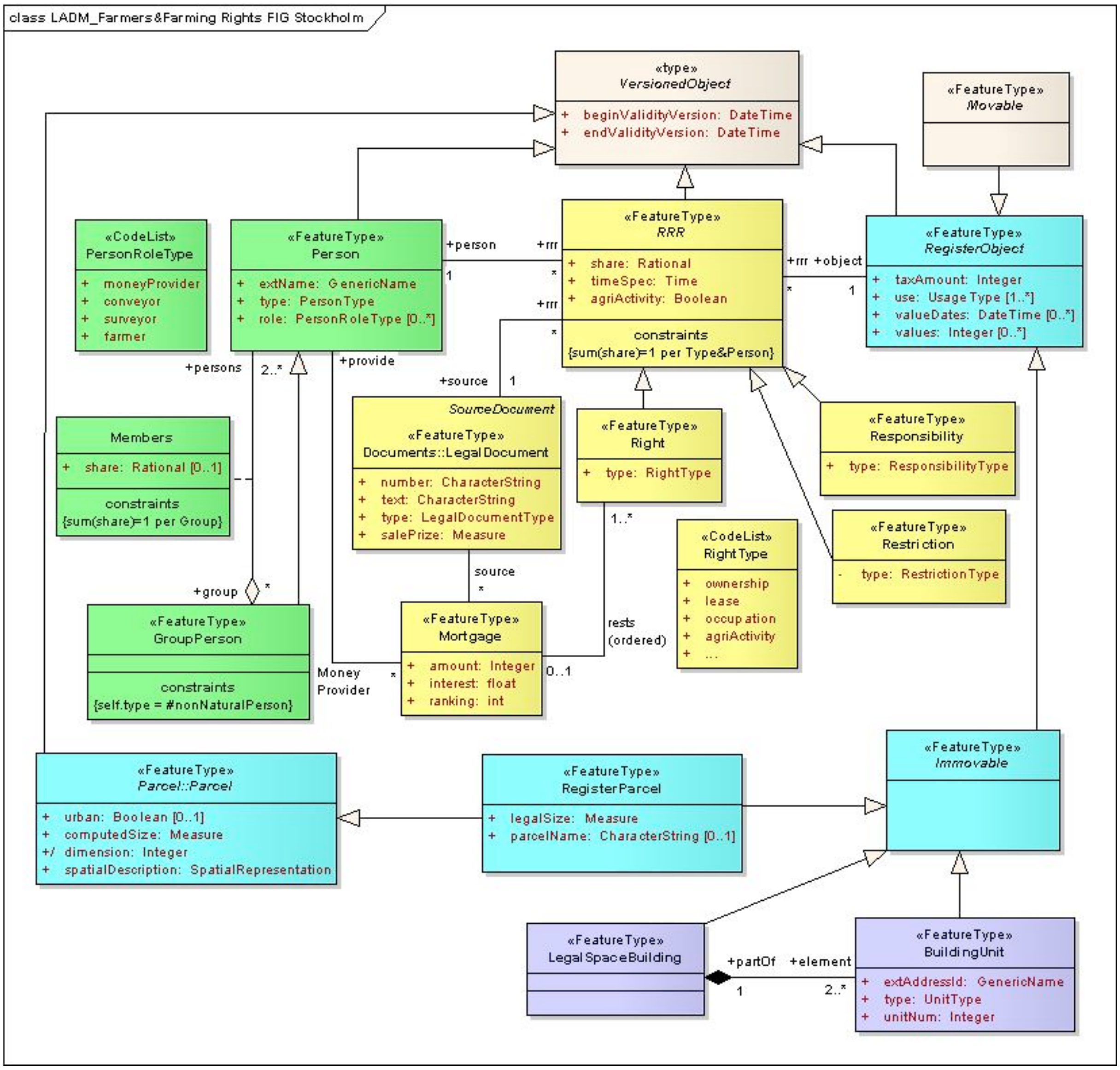

Figure 5. LADM general design and some modifications for the representation of farmers and farming rights.

The attribute *typeGenericAgri* in the AgriSubParcel class is designed for the representation of three main agricultural sub parcel types (cultivated, planted, nonagricultural) introduced previously in section 3.1.1. Instances of AgriSubParcel in an instance of RegisterParcel may be the same type (AgriSubParcelType). This is specifically proposed for the same type (cultivated, planted, nonagricultural) of AgriSubParcel which are not topologically adjacent, and also for AgriSubParcelType of *planted* due to their special value and importance (see section 3.2.2). In fact, they may be linked with other databases (olive groves, vineyards, fruit orchards, nuts etc.).

In the AgriSubParcel class, the attribute *typeAgriActivity* is designed for the representation of each type of agricultural activity just as stored under LPISs. Inside instances of SubParcel, there may be no agricultural activity (in case sub parcel is nonagricultural) or there may be more than one type of agricultural activity (typeAgriActivity). So, they should be managed as attribute data. This is advisable for the efficiency of the implementation and maintenance of seasonally or yearly changes. In fact, in many LPISs, similar approach has been used for the management of different agricultural activities.

In order to represent farmers in the LADM, in the Person class, the list of allowed values for attribute *role* is extended by adding *farmer* (Figure 5 and 6) as a PersonRoleType. In fact, farmer is not a person theoretically. It is a role that a person may be involved in just as previously designed person roles in the LADM (Figure 6). If a person has a role as a farmer, this doesn't mean that the related person may not have another role or has to have farmer role for every other possible relations with RegisterObject in a LAS. This flexibility is provided by the LADM design.

Because of complex right types (see the class Right and the code list for the attribute *right* in Figure 5) in conventional LASs, representing farming rights explicitly is a bit complex. Ownership and lease are the main right types in many LASs, and occupation is also possible for some others. In all three cases, there is a certain level of ambiguity. Ownership means full right. Owners may use their land for agricultural activities or for any other. They may lease it to other persons. The leasers may use the land they leased for agricultural activities or they may not. The same problem applies for other complex right types. Unlike complex ones, special right types which are established just for agricultural activities are easy to interpret and represent. The code list (RightType) designed for attribute *type* in class Right is extended with *agriActivity* (Figure 5 or 6) right type just to represent pure agricultural activity rights. In this stage, the code list for right types includes both complex and simple types. That is to say, farming rights can not be defined explicitly only via right types.

Simple right types only for agricultural activities may be obtained in different ways. Yet, having a special contract with shareholders or first order relatives is the common one in Turkey. As legal documents, these kinds of contracts are categorized as deed of consent and notary statement (*agriDeedOfConsent*, *agriNotaryStatement*). They are included in the code list previously designed in the LADM for attribute *type* (LegalDocumentType) in class LegalDocument. There may be special leases for agricultural usage rights, *agriLease* is also added in the code list for this purpose (Figure 6).

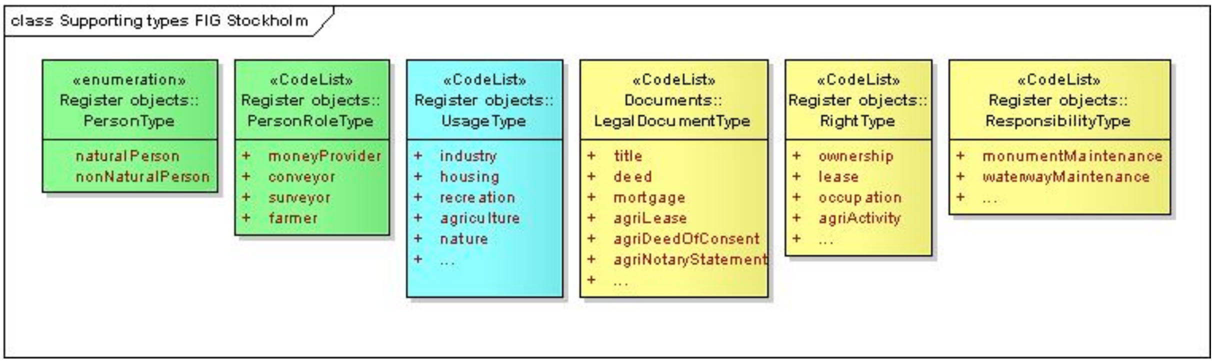

Figure 6. Basic supporting types of LADM with some extensions for the representation of farmers and farming rights.

Because right types are not adequate to represent farming rights in a LAS, the boolean indication *agriActivity* is designed as an attribute of the class RRR. By using such a boolean indication, agricultural activities of farmers can be attached to instances of RegisterObject in a LAS with the help of declarations by farmers just in the case of LPISs. This boolean indication may also be used for the identification of restrictions and responsibilities imposed by agricultural policies.

For a SII designed for full integration or LASs and LPISs, the above mentioned LADM extension will be valuable.

4.1.2 SII Collaboration for Legacy Systems (LPIS and Cadastre)

For the majority of both LASs and LPISs which are currently in operation throughout Europe, implementation of such a full integration defined and modeled on top of LADM in this paper is very hard to implement and even impossible for many cases. In fact, current LASs and LPISs were designed considering different spatial themes or phenomena. Legal boundaries stored, maintained and administered in LASs on the one hand, and land use boundaries in LPISs on the other. As it is clarified in this paper, these two themes are highly related. Yet, in most current systems, this fact is neglected. Actually, the section 3.1 in this paper is allocated for the determination of the generic relation both in terms of spatial and administrative information between two systems. Another point is that there are many differences even among the same theme (LASs or LPISs) throughout Europe. This is actually why we called them legacy systems. However, some kind of consensus should be reached among LASs and LPISs before trying to find out logical relations between two themes or legacy systems. After this kind of consensus, sharing data between the two different systems may be possible.

Data share between two independent systems requires some similarities. If some objects are required for both independent systems, they may share data (remote references to each others data, without physical copies) without causing redundancy in data production, storage and maintenance. In this case, SIIs should be designed in a way which enables the definition of the contents of SIIs, the roles and responsibilities of involved parties and the procedures to be followed for the required data share between two systems. This kind of SII designs may enable some kind of data share between LASs and LPISs. For such kind of data share, one system should rely on the other one which are responsible for the provision of specified data for other users.

If SIIs of this kind are designed without any collaboration with other systems, such kind of data share may not be possible. Such systems designed for the management of LASs or LPISs will definitely have some similarities in their patters, objects, system design and development environment. Yet, they can not share each others data. They have to be standalone. They may only visualize each other's spatial data on top of their one. Even this type of data share is not currently possible between LASs and LPISs as the current legacy systems.

4.2 Usage of MDA Approach for Better Design and Implementation

The LADM (van Oosterom et al., 2006) aims to support "an extensible basis for efficient and effective cadastral system development based on a model driven architecture (MDA)" and to "enable involved parties, both within one country and between different countries, to communicate based on the shared ontology implied by the model". The enablers in such architecture are models which are developed in itself in a standardized approach: the Unified Modeling Language (UML class diagrams as also shown in section 4.1). The UML class diagrams as a result of a modeling exercise can be used for software generation via generic ICT tools that support this conversion process from model to implementation.

In the early days of databases the support of spatial data was limited (only standard data types, operations, index structures, etc. were available). Something similar can be observed now in relation to Model Driven Architectures: the supporting tools are available, but the support in generating software with spatial functionality is not yet optimal. After significant research and development activities, nowadays most databases offer spatial functionality and a similar maturing is envisaged for the MDA tools. Therefore, current research efforts aim at a higher degree of automation or at least computer support regarding the generation of spatial database schemas from the original specification of a UML Model. Other MDA results should include: generation of XML/GML compliant schemas for data exchange and the generation of parts of the user interface (including standard map interaction and tabular form and record interfaces with basic query, analysis and update possibilities).

The LADM provides a first, generic view of the main objects and their association into dedicated packages, which should be considered on the design (or reform/renovation) of a LA system. At this level, the LADM corresponds to a Platform Independent Model (PIM) according to MDA terminology, once it conveys the basic ontology of the domain irrespective of any considerations regarding implementation, like computer data representations and platforms, specific database schemas and other implementation details. LADM specializations for a specific country or application focus (e.g. UN-Habitat or agricultural parcels) can then be developed. These specialized models, e.g. model presented in section 4.1.1, are still considered as to be PIMs.

Current research efforts at Delft University of Technology aim to evaluate and further develop tools supporting the transformation from the PIM to the Platform Specific Model (PSM) in the context of the MDA approach (Hespana et al., 2008). Special attention is paid to the specific support required by spatial information and the correct handling of constraints specified in the Object Constraint Language (OCL as semantic refinement of the UML class diagram and also applied in several situations in the LADM, e.g. the total share of all ownerships right related to one register object must be one). Initial focus is on the support of the generation of database schemas: a set SQL/Data Definition Language (DDL) commands, but also generation of exchange file formats (XML/GML schema and data) and realizations of user interfaces based on the model is within the scope of the research programme. The initial experiments are done with UML model created within Enterprise Architect (EA) software, which is being used in INSPIRE and ISO initiatives.

The preliminary conclusions of the EA-based investigations are that the transformation definitions and the EA software development kit facilitate a fully automatic conversion of object oriented models (UML class diagrams) to a relational (spatial) database model (e.g. for Oracle Spatial and PostgreSQL/PostGIS), for the MDA transformation rules that have been investigated (with regard to classes, attributes, data types and relationships). However, the fine-tuning of these transformations in the commercially available tool EA requires a lot of (programming) input. No MDA tools can be found that are fully capable of generating platform specific code for OCL constraints (e.g. for Oracle or PostgreSQL/PostGIS database). Further research is needed here.

Even in case an LPIS would share no information with the LAS in a country, the development of the LPIS system could benefit from the MDA approach in general, but specifically also from the LADM as certain model patterns can be shared and do not have to be redesigned. Examples are the basic structure of persons, land and their relationships (modelled via rights, etc.), the basic temporal and spatial structure (including topology-based structure of parcels and their boundaries, etc.). The fact that both systems would share the same model roots will make it easier for third parties to use the systems and understand the information.

5. EVALUATION OF A POSSIBLE COLLABORATION IN VIEW OF INSPIRE, LADM AND MDA

The general situation on spatial information in Europe is of fragmentation of datasets and sources, gaps in availability, lack of harmonisation between datasets at different geographical scales and duplication of information collection. (URL-1, 2008). Infrastructure for Spatial Information in the European Community (INSPIRE Directive, 2007) has long been on the agenda as a remedy for such problems. The initiative intends to trigger the creation of a European spatial information infrastructure that delivers to the users integrated spatial information services. There have also been initiatives for including core cadastral parcel information as the main spatial component of LADM within the INSPIRE generic model. Beyond that, as a result of standardization initiatives in the field of LASs, LADM has just been submitted to ISO TC211 as an international standard proposal by FIG. There are also some initiatives by JRC to meet basic qualities of INSPIRE also by LPIS data sets.

For both INSPIRE and FIG LADM generic model design, data specifications and generation of application schemas have been considered as main important issues. In this process cycle, Model Driven Architecture (MDA) plays a central role by providing the outlines of domain specific modelling, tools for Platform Independent Modelling (PIM) and translation tools for Platform Specific Models (PSM).

For all of the three main proposals introduced in this paper, the usage of MDA approach is highly esteemed. In fact, for the full integration proposal, LADM is used as a standardized LAS model in order to enable the usage of MDA in the process. For the other two alternatives, standardization both in the field of LAS and LPIS/IACS all over the EU is the prerequisite for a possible integration. This also implies the usage of MDA for the development of LASs and LPISs at least having a generic model in common (from which systems then deliver data). In fact, there have been some initiatives by JRC for a common conceptual core model of LPISs all over the EU (Sagris et al., 2007). In this case, future integration or collaboration will be possible taking the advantage of a generic model defined by using MDA approach.

6. CONCLUSIONS

In the rural areas of the EU, two different spatial information systems have been used since the major CAP reform experienced in 1992. Differences in LASs in different countries and different LPIS designs in different countries or even in the same country in different Lander are the main reasons behind the lack of collaboration between systems. It is proven in this paper that LASs and LPISs deal with different aspects of rural land (different themes), yet it is also clear that they have a considerable amount of spatial and administrative data content in common and closely related. When the current state of two systems is considered, collaboration of the two systems will not be an easy task. However, it is essential that the two systems be integrated or at least collaborate in order to eliminate current data redundancy, to reach a certain level of data integrity towards integrated rural land administration, and also reduce the long term costs for future interoperable information services through SIIs.

For full integration or a good level of cooperation of the two systems, it is clear that there is need for a new conceptual design. LADM extension should be regarded as an example of this kind of design. Yet, the implementation of such a design will not be easy because there are legacy systems currently in operation. Therefore, it is proposed that two systems – LASs and LPISs should be structured in a way to reach a European level of core model for each one. After that step, a core model for data share, integrity or collaboration between to systems will be applicable. In fact, there are already some initiatives for such kind of structuring. LADM is proposed as an international standard by FIG on the one hand, and there are proposals by JRC for a core conceptual model for LPIS on the other. Yet, there has not been any real initiative for a core model to integrate two systems or define collaboration rules between them. These aspects should also be considered well in advance for possible future collaboration.

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