New Evidence of Land Management in the Frame of Common Agricultural Policy: needs for Standardization

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Key words: conceptual modeling, land management, Spatial Data Infrastructure, LPIS

SUMMARY

The Common Agricultural Policy (CAP) of the EU required a large amount of GI data in order to manage area-based subsidies for the European farmers. The Land Parcel Identification Systems (LPIS) are established in all MS as a state register and evidence a new kind of land management in the agricultural sector. The aim of this paper is twofold: (i) to study institutional requirements of the EU regulatory framework and (ii) to introduce the framework of conceptual modelling and methodological approaches for standardisation in this sector domain. This paper addresses the recent challenges for LPIS geographic data, such as operating within a Spatial Data Infrastructure (SDI) and its requirements for data harmonisation and interoperability. The core LPIS Conceptual Model (LCM) that represents conceptual compliance with the EU regulations is introduced. The first-cut LCM described in this paper is the initial step on the way to standardization in the IACS Spatial Data Interest Community (Devos et al, 2007). The LCM is generated by means of both (i) methodological approaches of International Standards of ISO 19100 series and the INSPIRE principles and (ii) reverse engineering of existing operational systems. The latter is based on results of a LPIS survey (Milenov and Kay, 2006) covering different national implementations.

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1. INTRODUCTION

The Common Agricultural Policy (CAP) of the EU, since its reform in 2003, aims to provide for a stable farmer's income, decoupled from production, within a framework of sustainable development of the rural areas while respecting environmental and other societal needs. In order to distribute Community aid, the MS have to establish a Paying Agency to collect, control and reimburse all farmers' applications through the Integrated Administration and Control System (IACS) with its geographical module LPIS (Land Parcel Identification System). As a result, agricultural sector has acquired a large amount of GI data, either explicitly required by EU regulations or collected for pragmatic every-day operation.

Although the regulatory requirements are unique across the sector, the particular implementations were a subject of the MS subsidiarity. Some of the MS use their cadastral system as starting point for creation of the new state registers required by the EU policy, others make use of dedicated production block system. To date, the LPIS systems greatly differ in concepts and models of representation and identification of the agricultural land use unit: the so-called "agricultural parcel". The EU regulations gave a new meaning to the notion of agricultural parcel in the traditional land management paradigm, which is strongly related to the 'use' of the land in its specific economic aspect –agricultural activity.

The EC defines clearly the legal framework of the IACS-GIS in several Council and Commission regulations. However many MS have decided to set their own legal base (compliant with the EC regulations) in order to define better the responsibilities of the governmental institutions and their interaction with the farmers. Usually the institution responsible in the MS for the LPIS is either the Paying Agency or the Ministry of Agriculture, but in some cases the technical tasks for the LPIS management and update are delegated to different body inside the government (institutes, cadastral agencies) or are outsourced to a private companies. The institutional framework, set up by the EU regulation, and enlarged at some extend by the MS regulations will be further referred in this document as "Regulations" or "regulatory framework".

The LPIS as a concept was developed already in 1992 (Council Reg. No 3508/1992), when the need of having a system for identification of the agriculture parcels to support IACS, emerged. At that time the data model was purely alphanumerical without any geospatial reference. It was in the Council Reg. 1593 from 2000, the GIS-based LPIS was promoted. 5 years have been given to the EU member states to establish LPIS in digital and georeferenced format. Thus, the first year of operational GIS-based LPIS was 2005. At present the users of the LPIS do not consider it only a supporting tool for the IACS. The LPIS is becoming in fact a Land Management Information System, integrating information from (and providing data

to) many domains. It is already evident that the LPIS could be the basic source for NSDI in the EU, if proper tools for harmonization and standardization on European level are created.

2. DEFINITIONS AND METHODOLOGY

Conceptual core models that act as a reference or standard are already developed in several application fields. In the cadastral domain, Steudler (2006) describes fifteen years experience of the Swiss cadastral core model called INTERLIS, whereas van Oosterom et al. (2006) in their paper present a core cadastral model (CCDM) suitable for cross-country use and enabling involved parties, both with in country and between different countries to communicate based on the shared ontology implied by common model. In contrary, Agriculture Data Model Project (ESRI, 2003) provided data model oriented to use at the farm level. It constitutes that farmer's spatial operations differ from those of a government agency, or the research of an agricultural scientist. Growing number of publications in modelling of land resources can be found in geological science (e.g. GSC, 2001, Lake, 2005, Babaie & Babaei, 2005). The intention of such core models is not to establish a standard to which everybody should adhere, but rather to represent common modelling components for specific domains and also permit the translation from one conceptual realm into another. In other words: all domain models can be considered as having the core model as a basis, and extending it according to their own specific requirements. National models will inevitably result in interoperable systems, which still reflect the particular demands of the different countries. Mapping will be needed between each national model and the core model in order to test conformity.

A *conceptual model* represents description of the application field or domain in formal way. Any description of reality is always an abstraction, always partial, and always just one of many possible 'views' depending on the application field (ISO 19109). The portion of the real world containing all phenomena of interest, their properties and relations constitutes the '*universe of discourse'* (UoD). *Conceptual data modelling* is a pathway from the UoD down to geographic and non-geographic data, which reflect our phenomena of interest in a computerized database. The modelling process consists of the creation of an abstract description and a set of concepts about the world of interest by means of conceptual formalism. It results in a conceptual model, which can be described verbally or be documented by means of a conceptual schema language (e.g. UML). The formal description of a conceptual model for some portion of the real world by means of conceptual modelling language constitutes a *conceptual schema***.** Conceptual schema, which provides data structure and content used for the implementation in a particular domain is called *application schema*. The ISO series 19100 of International Standards provides the methodological framework of conceptual modelling of geographic information including standard methodologies as well as IT industry standards for development tools.

When designed with Unified Markup Language (UML) the conceptual model becomes a starting point from which other implementations can be derived (forward engineering). The first step is to define the vocabulary of the domain by means of identifying basic concepts of application field. These concepts will be represented as 'classes' or 'features' in the model.

Another approach is bottom-up, it consists of analysis of the data structure, function and operation of existing implementations (reverse engineering). By means of common tools (e.g. XML Schema, GML) the conformance at least partial of the data structure implemented in the LPIS system can be ensure. The OGC standards need to be supported by both GIS software and data models if one intends to introduce Web-based services using interoperable standards of XML/GML.

The CAP Regulations define one and only one portion of the real world concerning the Direct Payments for European farmers, so the resulting UoD is common for all stakeholders. By way of examination of basic concepts laid down in the Regulations we arrived to first-cut model, which we refined through study of LPIS implementations in the MS. Generic classes of first-cut model were further enhanced with their properties: attributes, association, specific sub-types etc.. Additional classes, which concepts are not explicitly spelled out by the Regulations, but needed to fulfil the requirements, were introduced into the model at this stage.

The INSPIRE directive is a pan-European initiative for creation of European SDI and standardization of GI data for the environment. The INSPIRE methodology applies the same methodological framework proposed by international standards. Several data themes included in the INSPIRE annexes have a multi-purpose use and are widely incorporated in IACS-GIS for the LPIS creation and update and for the controls. Applying at the very beginning the same principals which are laid down by the INSPIRE directive will be of great benefit to the standardization process in LPIS domain.

3. BASIC SPATIAL AND NON-SPATIAL CONCEPTS

3.1. Institutional framework for IACS and LIPS

From the legislative body of the CAP there are two documents, which are mostly relevant to the institutional framework of IACS and LPIS: (i) the Council Regulation (EC) No 1782/2003 establishing common rules for direct support schemes under the Common Agricultural Policy and establishing certain support schemes for farmers; and the Commission Regulation (EC) No 796/2004 which is laying down detailed rules for the implementation of cross-compliance, modulation and the integrated administration and control system (IACS) provided for in of Council Regulation (EC) No 1782/2003.

The central concept connecting all stockholders in the domain is the farmer's Single Application. Farmer lodges his application for aid to Paying Agency, established or nominated by the MS administration. Among other data, farmer's application shall contain (CR (EC) No 796/2004): (a) the identity of the farmer; (b) the aid scheme(s) concerned; (c) the identification of payment entitlements; (d) particulars permitting identification of agricultural parcels in holding and their area. To handle this data the Paying Agency is in charge to run the integrated administration and control system (IACS). In order to manage data farmers' applications IACS should (CR (EC) No 1782/2003, Art 17) contain following components: (b) an identification system for agricultural parcels also known as LPIS; (c) a

system for identification of entitlements; (d) register for aid applications; (e) an integrated control system; (f) identification system for farmers. In short, it is information system containing several interrelated state registers, one of them has geographic content (LPIS) and others are alphanumerical databases. Each of these elements can be addressed as a module or package in conceptual modelling exercise

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3.2. Agricultural parcel versus Reference parcel

An **agricultural parcel (AP)** is a key concept applied in relation to area-based payments, which determines the subject of the aid application, geographic location and extent (area) of agricultural activity.
The Commission Regulation (EC) No 796/2004 Art *2* defines that:
'Agricultural parcel' shall mean a continuous area of land on which a single crop group is cultivated by a single farmer. However, where a separate declaration of the use of an area is required in the context of this Regulation that specific use shall further limit the agricultural parcel.

In addition to being the subject of the payment calculation, AP is also a subject of administrative cross-checks and control procedures established in IACS. It is also worth mentioning that, due to the dynamic nature of agricultural activities, AP can be unstable over time and space (crop rotation, out of use, aggregation or subdivision of fields, different extent of use, conditions for eligibility for payments etc.). Therefore, the Regulations set up that for purpose of identification of the APs the reference parcel (RP) as basic unit of LPIS. The Regulations specifies that reference parcel can be either cadastral parcel or production block. RP may contain one or many AP parcels declared for aid by farmer(s) and shall have a unique identifier at national (in some countries regional) level. No aid can be claimed outside Reference parcels of the LPIS.

In practice, some of the MS decided not to use the idea of RP and record their geographic data for each Agricultural parcel. Advantage of this approach is that each declared by farmer field can be easily measured and identified in GIS and therefore can be directly addressed by queries of other registers. On the other hand, it means annual and costly revision of whole database. Countries which opted for block system made use of two approaches: adjacent APs create (i) a *Farmer's block/ilot* (FB) based on production pattern or (ii) a *Physical block* (PB) according to physical (topographic) boundaries of agricultural land. Block-based system are much more stable over the time, but involve more sophisticated procedures for control of farmers' applications. And finally, some of the MS made their choice for conventional *Cadastral parcel*. Cadastre-based systems have specific problems due to the different philosophy of the cadastral parcel (based on ownership) comparing to the other LPIS Reference parcels (based on land use) (Milenov and Kay, 2006). Difficulties related to identification of AP become more pronounced when system created for purpose of fiscal legal register no longer matches the agricultural pattern. Table 1 presents different types of Reference parcel and their main properties.

Table 1. Different types of Reference parcel and their main properties.

	= Agricultural parcel	< Farmer block/ilot	< Physical block	Cadastral parcel
land use for aid scheme	one single crop group	one or several crop groups	one or several crop groups	do not match agricultural pattern
applicants	single farmer	single farmer	one or several farmers	one or several farmers
temporal aspect	annual	multi-annual	semi-permanent	land tenure cycle
main data source	farmer's application	farmer's survey	administration survey	land register/cadastre

The overview (Milenov and Kay, 2006) of approaches adopted by the EU MS based on survey form 2006 – covering 23 Member States and 2 CC – noted that the most commonly used reference parcel is 'physical block' (10 countries), followed by 'agricultural parcels' and 'farmer blocks' in equal proportion (5 & 5), and finally cadastral parcels (4 countries). Federal States of Germany vary greatly in approach from CP to PB/FB/AP. The choice of the reference parcel is an example of subsidiarity in the adoption of the EU Regulations in order to find the most appropriate solutions for the agricultural pattern of each country/

3.3. Land use/ land cover

The definition of Agricultural parcel above includes the notions "area of land cultivated" and "agricultural use of an area" which fully comply with what is known as **land use.** Even more, specific use shall further 'limit' the extend of agricultural parcel, due to the fact that different payment schema correspond to different use. On the other hand, farmer's entitlement for Community aid (eligible hectare) can be allocated over "area of the holding taken up by arable land and permanent pasture except areas under permanent crops, forests or used for non agricultural activities" which matches the definition of the **land cover**.

Since there are no specific regulatory requirements to provide geographic data for specific land use/land cover the MS came up with diverse solutions. For AP based systems it is possible to define one land use/land cover inside of parcel polygon, and it is often recorded as parcel attribute. For block-based system and especially for cadastre-based separate layers are seemed to be most appropriate solution. Encoding of the land use/cover is also much varied depending of the particular situation in the MS, examples of which can be seen in table 2.

Table 2. Examples of different land use/land cover classes stored in LPIS data sets.

Country	Type of land use recorded	Type of RP
DK, UK-NI	None	PB
HU	eligible/ non-eligible	PB
SE	Agricultural land only	PB
LT	- Agricultural blocks; - Build-up blocks - Miscellaneous blocks - Grassland blocks - Orchard blocks - Non-subsidized area blocks are abandoned and treated as ineligible area	PB
PL	1-forest; 2-tree or bushes; 3-water; 4-roads; 5-industrial area; 6-habitats; 7-other; 8-permanent grasslands; 9-orchards; 10-arable land; 11- gardens	Cad. Parcel
DE-Bavaria	farmland, permanent grassland, permanent orchard, vineyard	FB
FI	Field, forest (forestation and environmental schema) and pasture.	FB
IE	Forage; Arable; Set-aside; Forestry; Other plus 250 crop types...	AP

3.4. Farming limitations

Cross-compliance is a concept for ensuring that agricultural activity of farmers is undertaken with respect to rural sustainability, environmental and sanitary requirements. According to Art. 2(31) of the Commission Regulation (EC) No 796/2004 ‘areas of cross-compliance’ mean the “policies” established by European Environment Directives and Directives on public and animal health. The MS should also ensure that all agricultural land is maintained in good agricultural and environmental condition (GAECs) and should established national or regional measures. One should notice that, the term “area” here has a different meaning than the strictly ‘spatial’ and does not define a spatial concept in se.. However, a considerable part of cross-compliance requirements involve geospatial components (e.g. location inside of protected zone or topographic elements such slopes prone to erosion). These requirements call for the special practices on the land (often called as ‘farming limitations’ or ‘farming restrictions’) and many MS include spatial layers in the LPIS to define their geographic extent. The spatial concepts defining geographic extend of cross-compliance elements will hereby be referred as ‘**areas of farming limitations’** (to avoid confusion with “areas of cross-compliance”).

In view of the aforementioned definitions, we can conclude that two of five main spatial concepts are internal to IACS: (1) Agricultural parcel which is a part of aid application, (2) Reference parcel which is the spatial object in LPIS and corresponds to its core data layer especially maintained for purpose of aid application administration. Concepts of (3) land cover and (4) land use need to be elaborated further in the SDIC community in order to arrive at common pragmatic and meaningful content. It worth to mentioned that land cover and land use already in the sphere of interest of INSPIRE and are Directive’s annex themes, but there

is no specification yet proposed for agriculture land. The areas of farming limitations (5) are usually external geographic data incorporated into LPIS, originating from different sources and is often produced by other relevant administrative bodies according to their specific requirements. Further on in this paper we concentrate on modelling and standardization of the LIPS core concepts, rather than on standardization and harmonization of data representing areas of farming limitations and land use. The latter is a task which is related to intentions and thematic scope of the INSPIRE Directive and should be undertaken in cooperation with the INSPIRE community.

4. THE CORE LPIS CONCEPTUAL MODEL

The first-cut core LPIS Conceptual Model (LCM) is documented by means of UML diagrams, basic elements, notations and key glossary of which can be find in number of public sources (e.g. for brief overview http://en.wikipedia.org/wiki/Unified_Modeling_Language#Diagrams; for more comprehensive cover consult http://www.omg.org/gettingstarted/what_is_uml.htm). In addition to the spatial concepts described in chap. 3, the model contains spatial and non-spatial features which purpose is to achieve appropriate level of functionality, accuracy and database management. The LCM conforms to the ISO 19101 Reference Model and be based on the Rules for Application schema defined in ISO 19109. For developing of these diagrams, free evaluation version of Enterprise Architect software by Sparx Systems was used.

4.1. Model packages and boundaries

The model is organized into several interrelated packages, which allow handling the model in smaller, more comprehensive parts. Another advantage of packages is that the process of development can be split into more or less independent parts. This paper covers the schema for the core dataset of the LPIS– layer (the Reference Parcel) and leaves cross-compliance and control aspects for the feature untouched. It does however create the opening for discussion on update package. As LPIS is so closely interrelated with other registers of IACS, the boundaries of the model should also include the relations towards relevant classes of other IACS modules. The colour code of the packages (figure 1) corresponds to the colours of feature type classes in the LCM: yellow for the Aid Application register, pink for the Farmers' register, green for the geospatial objects of ISO 19100, beige for the LPIS as described in this paper. White packages are LPIS packages, which are not covered.

It should be underlined that it was not the intention of the authors to propose an exhaustive model that covers every aspect of the system. Domain experts via further analysis and development could extend the boundaries of the first-cut model. So, candidate packages that are related to, but currently outside of the core LPIS model can include:

- spatial (coordinate) reference system;
- digital orthophotos,
- satellite imagery,
- DEM
- topographical features

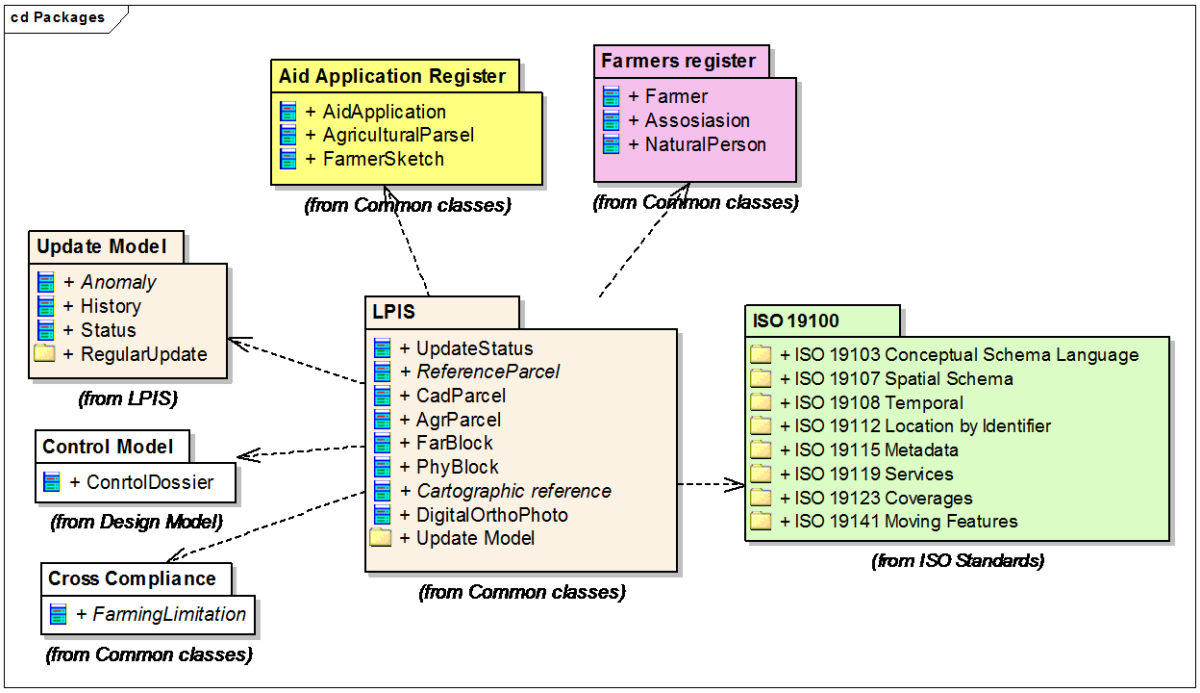

Figure 1. Packages diagram

Figure 2 represents the logical data model of the main concepts, described chap. 3. All basic concepts are represented as classes. The key concept 'Single Application' is related to a farmer and an agricultural parcel he cultivates. Each Agricultural parcel shall be located inside of one of Reference parcel of the LPIS (1:1), but on the other hand each RP can contain none, one or several active declared AP. Furthermore, each RP can have none, one or several farming limitations from cross-compliance measures. Two classes in the diagram below - *ReferenceParcel* and *FarmingLimitation* - are abstract classes; there are no object instances of those classes. They have instead a number of specialisations or subtypes that hold the actual features. In UML notation, abstract classes are indicated in *italic script*. The specialisations for class *ReferenceParcel* accommodate for the type of Reference parcel in use. For the *FarmingLimitation* class there should have two additional abstract specialisations: one for European Environment Directives and Directives on public and animal health and another for GAEC measures of MS. Both these specialisations are further differentiated by type of Directive or by GAEC measure imposing particular farming restrictions. The *ReferenceParcel* class is refined in figure 3.

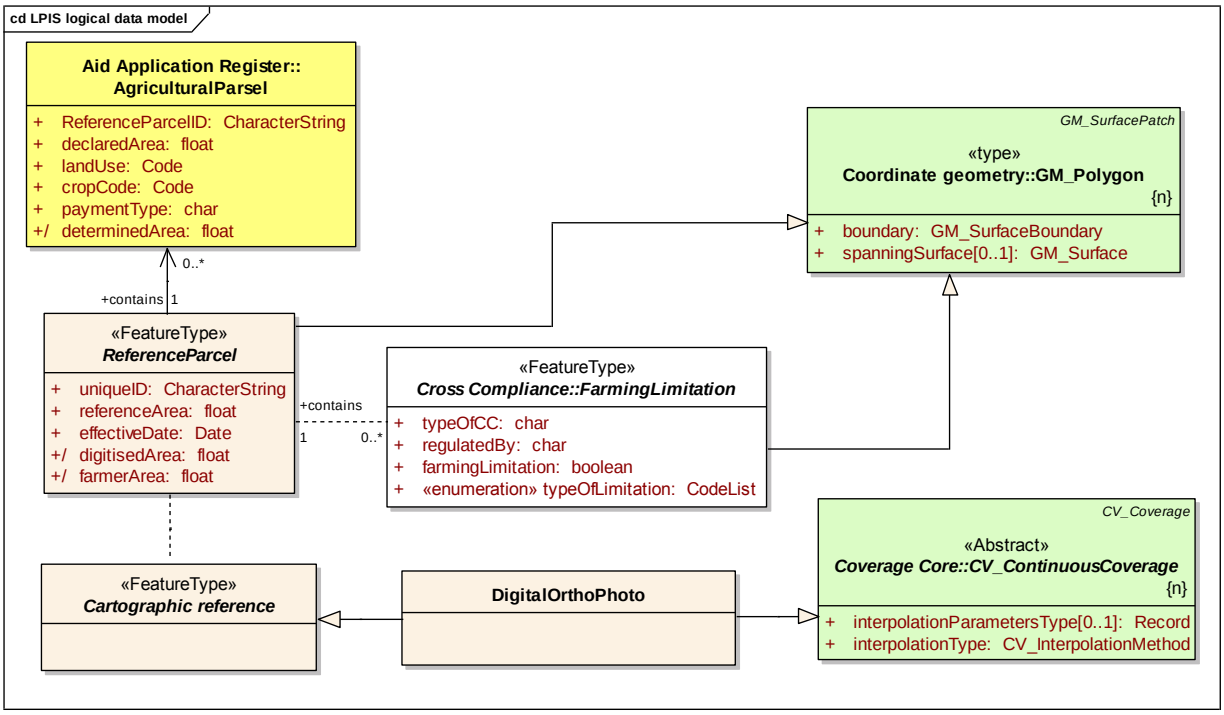

Figure 2. Logical data model

Classes *ReferenceParcel* and *FarmingLimitation* have dependency relation between each other: every Reference parcel can have none, one or several types of areas farming limitations, and farming limitations can be entirely located or overlapped with the RP in question. Both classes are spatial features and therefore specialisations (sub-types) of coordinate geometry type POLYGON as defined in ISO 19107 standard '*Spatial Schema'*. The feature class *CartographicReference* does not correspond to any of the concepts originating from the EU Regulations, but it is explicitly required by the Art. 20(1) of the Council Reg (EC) No 1782/2003. It can be represented by digital orthophoto imagery or cartographic map product at scale 1:10000 or more detailed. Since a majority of the MS have opted for orthophoto imagery, class DigitalOrthoPhoto is included as sub-type of *CartographicReference* class and it is an implementation of the ISO standard 19123 *Coverages*. In the case of a topographic map, the original application schema of that cartographic product should be aggregated with the LPIS schema.

4.2. Reference parcel in LCM

As was mentioned before, in our that *ReferenceParcel* is an abstract class which has four specialisation classes (figure 3) corresponding to different types of RP in use: CadParcel, AgrParcel, FarBlock and PhyBlock. Names of the features are conventional names currently in use, there is no semantic associations between two types of 'parcel' and 'block' from the model point of view They inherit all the properties (attributes and operations) from parent object *ReferenceParcel*. Constrain {xor} indicates that only one type of Reference parcel shall be used in LPIS implementation.

Attributes assigned to the generic class *Reference parcel* represent mandatory or core attributes serving purpose of identification and area determination and required by the Regulations. Moreover each sub-type of RP can have its specific additional attributes helping localisation, retrieval of information needed for administrative check and for cross-compliance as well as attributes for management of the spatial object in the database. Hereby we describe in more details only core attributes and some of additional attribute groups.

Mandatory attributes are:

- Unique identifier
- Reference area
- Effective date of the parcel
- Geometry

Unique identifier (uniqueID) is a mandatory attribute of the RP, aimed at unambiguous geographical identification of agricultural parcels for aid application. The RP parcel identifier should be unique under the national system and it is a key attribute for connection with other IACS and MS national registers. The structure of the unique identifier and principles for it generation are very different among the MS. In some MS a sequential number approach is in use (e.g. Slovenia), whilst others make use of coordinates of a RP central point expressed in the national Coordinate Reference System. There are also some MS with approaches to integrate codes from administrative units, blocks or grids into the identifier (e.g. the Czech Republic, Sweden, Bulgaria). Some of approaches support spatial object 'history', referring on the ID of the previous object version in the database e.g. in case where an RP was divided into two new objects.

The aim of the attribute **reference area** (referenceArea) is a calculation of the aid amount. This attribute also referred in the Regulations as 'maximum eligible area' and caps the area of all APs that can be claimed for the RP concerned. It acts as the benchmark to test the sum of all claimed areas of the RP in execution of crosscheck in IACS databases. . The attribute has official status (compare to legal area in cadaster system) and is calculated once, at the time when current version of the RP is approved. It can be equal or differ from the GIS calculated area of a topographic polygon of the RP also called *digitised area*. The latter one could conceivably be also the vector measure in loco by GPS or other survey technique, and can be optionally stored as attribute. Another type of area, which is conventionally stored, but not explicitly required is a *farmer's area* -area claimed by all farmers inside a given reference parcel; may have geometry (map) and attribute information and depending on annual declarations of the farmers

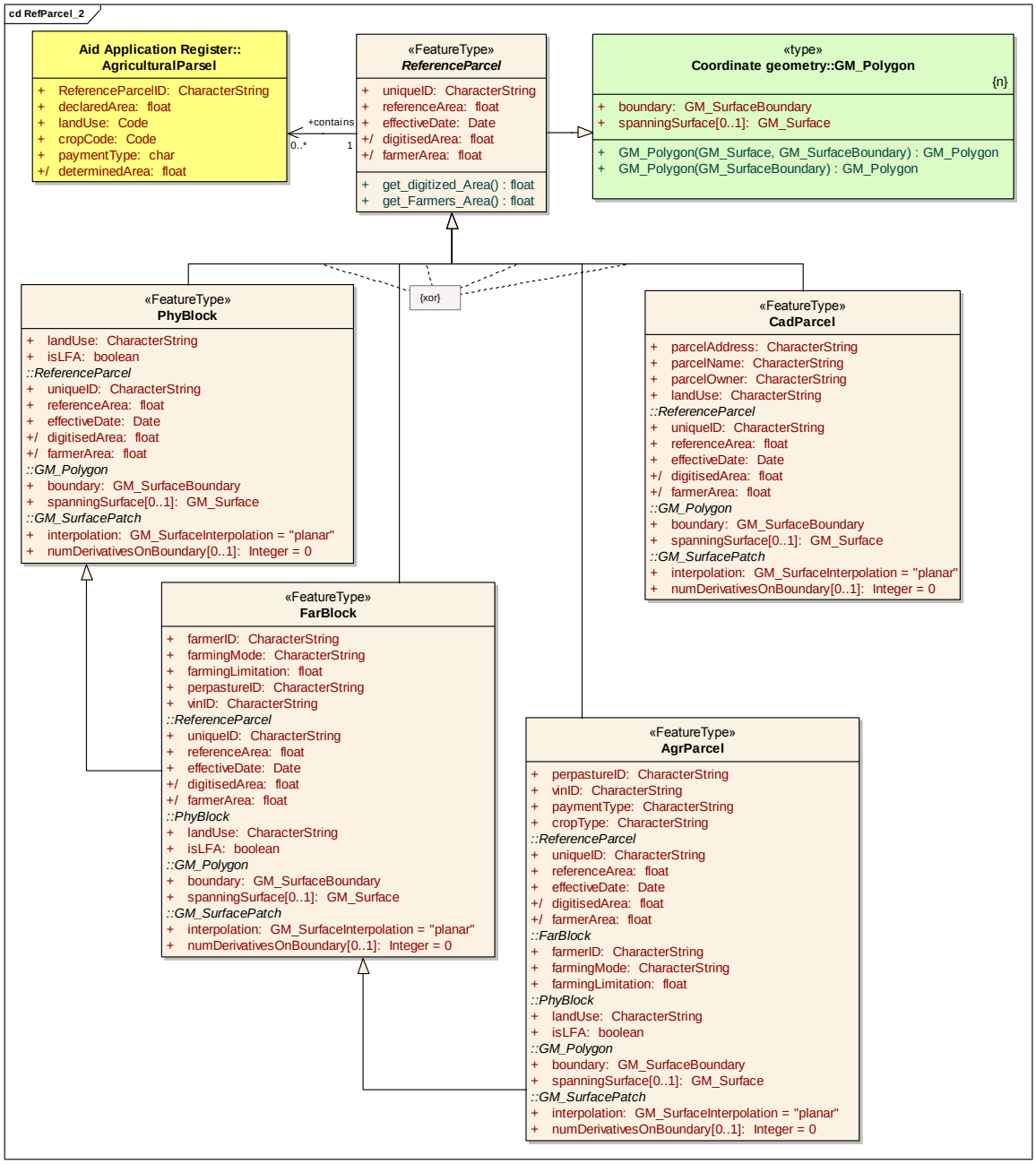

Figure 3. Specialisations of class *Reference parcel*

The **effective date** (effectiveDate) of the reference parcel is crucial for all bodies working with LPIS register. On the effective date new version and new attribute values of the RP come in to force with respect to third parties (e.g. Paying Agency) and registers. Possible dates are (i) those of the proposal for RP modification made by farmer, LPIS operator or inspector; or (ii) those specified within the time period when it is certain that a change will occur in the future (e.g. changes in use rights, lease contract, activating/transferring of entitlement). This attribute is also connected to a group of attributes concerning the RP history and database administration/management.

One can question the fact that **geometry** is among the mandatory attributes of the *ReferenceParcel* class. Geometry of the parcel consists of polygon boundaries and surface. In the cadastral system the boundaries have clearly identified legal status, their principal points are fixed on the ground. Both survey point of the cadastral parcel and its boundary can be modelled as separate concepts to distinguished classes, which form together class 'topological polygon' (van Oosterom et al., 2006). In the LPIS in general parcel boundaries can be derived from topographical linear elements, homogeneity of land cover pattern, change land use practices as well as form cadastral boundaries. Each boundary type is well elaborated in other domains of geographic information, but their conceptual roles in the LPIS are not extensively documented. However, some parts of the parcel perimeter may not correspond to terrain phenomena, so virtual boundaries could be considered to enable closure of that perimeter.

The additional (non-mandatory) attributes for different types of Reference parcels as they revealed through LPIS survey are shown in the figure 3.

5. CONCLUSIONS

The core LPIS Conceptual Model (LCM) is a domain specific semantic model, which is intended to serve at least three main purposes:

- Standardisation and data harmonisation in the domain of the area-based Direct Payments of the Common Agricultural Policy - The modelling process should not add or remove any features from a well-designed operational LPIS. The model will however provide for a formal and uniform reading of that system.

- The link to INSPIRE process; - The INSPIRE applies the same methodologyl proposed by international standards. Extending the methodologies imposed by the INSPIRE directive on themes are already widely incorporated in operational will be of great benefit to the standardization process

- Create an opening for an extended farm data exchange. –Farmer's benefit is in exchanging information at the farm level; where data exchange between various machinery, environment sensors, on traceability in food chain and business processes software becomes ever more important.

The analysis of basic spatial concepts of the UoD of the CAP has shown that two of five main spatial concepts are internal to IACS: the Agricultural parcel which is a part of aid application and the Reference parcel which is the spatial object in LPIS and corresponds to its core data layer specifically operated for the purpose of the aid application administration. Other concepts (land cover, land use and farming limitations) have rather broad multifunctional nature. The ontology of these concepts should be further detailed and adopted to the specific needs of the domain. This task can be only possible in the frame of cooperation of all stakeholder of the IACS Spatial Data Interest Community and roughly follows the INSPIRE development process.

As proposed in this paper, the first-cut LCM has illustrated that conceptual modelling is a comprehensive and flexible tool, suitable for embracing a wide range of concepts, their specialisations and interrelations. The LCM realization in the modular structure of UML packages supports a step-wise development on further extensions, in pace with the needs of particular implementation.

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