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Spatial information in European agricultural data management. Requirements and interoperability supported by a domain model

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ABSTRACT

Data compatibility and system interoperability are fundamental for crosswalks and collaboration between domains. The most frequently used references for information sharing are time and location. In order to understand the requirements, fundamental processes, and core information concepts of a domain, a comprehensive, but standardised documentation is needed. In spatial data infrastructures models presented in Unified Modelling Language (UML) are widely used to facilitate the uptake of standards and valorise best practices of various communities.

The European agricultural decision makers must deal with many components described in the Common Agricultural Policy (CAP) in order to optimize data integration and achieve transparency. Geospatial information plays a key role in the implementation of this policy, which comprises the establishment and maintenance of the Integrated Administration and Control System (IACS).

In the past the IACS of the MS has principally served a single high level business case: to run a correct administration of the CAP. However, the recent reform and the synergies with environmental and societal policies create increasing expectations for IACS, which impact upon system interoperability and data usability. These objectives can be achieved by establishing a framework that is standard based, allows flexible extensions, and that supports efficient implementation and information exchange between the stakeholders.

This paper presents the development process and describes the structure of a domain model we propose for IACS. This standard driven model was designed to translate requirements into technical elements, ensuring interoperability, and providing flexible extensions at the same time. For this purpose we set-up a formal requirement model, formalized use cases, and integrated ISO/TC 211 and INSPIRE UML based class diagrams. As such, this paper proposes a methodology to help guide how the policy can be implemented.

The importance of traceability from IACS and third party business rules to the information concepts was proven by simulation runs. The developed modelling approach yielded a reference for conformance testing, indicated critical points of potential errors, and highlighted the impact of eventual changes. Storing all concepts and implementation options of IACS in a unique framework helps to eliminate redundant efforts, provides a strong basis for developing various applications, underpins interoperability with other domains and enhances transparency of the CAP.

1. Introduction

The Common Agricultural Policy (CAP), being one of the oldest policies of the European Union, aims at maintaining a stable supply of safe and affordable food to the consumers and ensuring that EU farmers can make a reasonable living whilst preserving the rural landscape and natural environment (European Commission, 2012). The objectives, tools, and measures for the implementation of CAP are laid down in the legal acts, adopted by the European Council and the Parliament and, by delegation, by the Commission. Member States are responsible for the implementation of CAP, which comprises the establishment and running of the Integrated Administration and Control System (IACS).

The recently adopted new legal framework of CAP (European Parliament and the Council of the European Union, 2013a,b,c; European Commission, 2014a; European Commission, 2013a; European Commission, 2014b) sets up genuinely new require-

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ments promoting agricultural practices beneficial for the climate and environment. These new requirements are also referred to as the "greening" of the CAP. Greening and the introduction of the geospatial aid application for farmers set new challenges to spatial information management in the domain.

Council Regulation (EC) No 73/2009 (Council of European Union, 2009) referred to the identification system of agricultural parcels as an information system established on the basis of maps or land registry documents or other cartographic references that make use of computerised geographical information system techniques. The user community translated this formulation as "the single GIS of IACS" (European Commission DG JRC, 2015b) and introduced the term of LPIS to identify the corresponding spatial dataset. LPIS has to support two fundamental processes: the application of the farmers and the controls of authorities, by localisation and quantification of agricultural land eligible for the EU support. This approach remained in place after the 2013–2014 year CAP reform.

Relating information to location plays a fundamental role in agriculture. Beyond such classical fields as agro-statistics, crop monitoring, land registry, or the management of the CAP this method is becoming more and more pertinent (Pelorosso et al., 2009). Among the emerging fields we can mention food security (Singh et al., 2014; Candel et al., 2014), rural development(Van Berkel and Verburg, 2011; Pašakarnis et al., 2013), management of specialty agricultural crop management (Ozcelik and Nisanci, 2015), precision farming (Möckel 2015; Řezník et al., 2015), and analysis of agro-ecosystems (Wainger et al., 2010). The greening of the CAP adds a further significant area where spatial data plays a key role.

Translating greening into spatial data terms requires the extension of the LPIS by new feature types to capture objects that provide ecosystem services and, at the same time, fulfil some administrative restrictions. These objects, which include ecological focus areas (EFA), support biodiversity, contribute to climate resilience and protect soils and habitats as well as ground and surface water. The tight implementation deadline (the EFA elements had to be mapped preferably until 2015, but not later than 2018) put in perspective the keep data at the source principle (Lemmen et al., 2015), which implies importing and reusing third-party environmental datasets in LPIS, rather than collecting new data.

Whilst on one hand the INSPIRE Directive (European Parliament and the Council of the European Union, 2007) and national spatial data infrastructures (SDI) may provide valuable input for the CAP, new data explicitly collected for populating EFA can be shared within the SDI. This may amplify the impact of freshly collected data fostering agro-environmental research and management, or contribute to the maintenance of the digital topographic databases. Needless to say that data sharing makes savings of public resources.

Undoubtedly the conditions for data discovery and assessing their fitness for purpose have substantially improved with the implementation of INSPIRE. Geoportals established at European, national, and regional levels make both metadata and spatial data services accessible (Kliment et al., 2013) in the domain of the spatial data themes listed in the annexes of the directive (European Commission and European Environmental Agency, 2014). INSPIRE also foresees a gradual data harmonisation. However, for the data themes relevant for greening the interoperability problems may persist until 2020, as the majority of environmental thematic datasets such as soils, natural risk zones, bio-geographic regions, habitats and biotopes and species distribution are included in Annex III of the Directive and so are not immediately addressed.

The experience of INSPIRE and the national SDIs show that the easiest way towards knowledge integration and interoperability leads through a framework that presents the shared "language" between communities (Lasschuyt and Hekken van, 2001). This framework, which includes harmonised semantics, data structures, and spatial representation, relies on standards and other well-established practices of user communities. INSPIRE successfully used conceptual models for documenting standard-driven interoperability specifications for a large number of spatial data themes using the common principles of the Generic Conceptual Model.

The new requirements of CAP, the on-going domain related standardisation of geographic information in ISO/TC 211 and OGC and the success of the INSPIRE data specification process in 34 data themes (European Commission DG JRC, 2014; Geospatial World Forum, 2015) urged us to outline a generic domain model for IACS that targets a dual objective: to express the requirements of the CAP in technical terms, and to serve interoperability.

1.1. Background

Standardisation of geographic information in the agricultural domain is on the agenda in a number of organizations. The most relevant initiatives are the on-going work of the Agriculture Domain Working Group of the Open Geospatial Consortium (OGC, 2015), the development of agroXML (Association for Technologies and Structures in Agriculture, 2012), the accepted Land Administration Domain Model (LADM) standard (ISO/TC211, 2012b), the INSPIRE data specification on Agricultural and Aquaculture Facilities (INSPIRE Thematic Working Group Agricultural and Aquaculture Facilities, 2013) and the LPIS Core Model (LCM) (Sagris and Devos, 2010). The ultimate goal of these initiatives is to facilitate a platform independent exchange of geographic data using shared semantics and the Geography Markup Language (GML).

With the exception of agroXML, which focuses at the development of an appropriate XML extension, the above mentioned initiatives widely use the Unified Modelling Language (UML) to document the information concepts and in some cases (INSPIRE) the main use cases. The formalism of a conceptual schema language is necessary to turn such models into machine readable conceptual schemas (ISO/TC211, 2005a).

The LCM was developed to support the LPIS implementation of the Member States (MS), especially to provide an input for model conformance testing (Sagris and Devos, 2010). This conceptual model detailed the properties of reference parcels together with their relationships with other component of IACS, in particular, with Declarations and payments, Farmer register, and Cross compliance (Inan et al., 2010). Consequently the LCM presented a simplified collaboration diagram between selected classes of IACS.

Although IACS/LPIS implementations are subject to MS subsidiarity (Inan et al., 2010), the early LCM was successful in presenting uniform requirements across the sector. The content, structure, and the properties of the model were described by (Inan et al., 2010; Sagris et al., 2013). A detailed technical specification of LCM (LCM v 1.2) was given by (Sagris and Devos, 2010). The main feature types introduced by this model were the reference parcel, land cover type, farming limitation, farmer, aid application, agricultural parcel, farmer sketch and crop code.

The development of LCM was tightly linked with the LPIS quality assurance process (LPIS QA). In addition to conformance testing it served as a documentation basis of the so called eligibility profile, which accommodated specific implementation conditions in terms of land cover (Milenov and Devos, 2012). However the model did not address some other important usability aspects like validity of data or their state in the updating cycle.

It is important to note that LCM v1.2 used some standards. The attributes were specified as types of ISO 19103 Geographic Information – Conceptual Schema Language standard (ISO/TC211, 2005b). As the developments of LCM and the LADM were running in parallel, the LPIS community actively contributed to this latter. Annex H of LADM (ISO/TC211, 2012b) presents LCM as a conforming profile.