The harmonised data model for assessing Land Parcel Identification Systems compliance with requirements of direct aid and agri-environmental schemes of the CAP

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A B S T R A C T

The EU Common Agricultural Policy (CAP) subsidies to farmers are administered through dedicated information systems, a part of which is the GIS-based Land Parcel Identification System (LPIS). The requirement to map and record land eligible for payments has led to a situation where the agricultural administrations have acquired a large amount of geographic data. As the geospatial community of data producers, custodians and users has grown during the last decades, so has the need to assess the quality and consistency of the LPIS towards the EU regulations on the CAP as well as for cross compliance with environmental legislation. In view of this, a LPIS Conceptual Model (LCM) is presented in this paper in order to address harmonisation and data quality needs. The ISO 19100 series standards on geoinformatics were used for LCM development, including an UML modelling approach and the handling of the quality of geographical information. This paper describes the core elements of the LCM and their integration with data supporting management of agri-environment schemes. Later, the paper shows how the LCM is used for conformity and quality checks of the member states’ LPIS system; an Abstract Test Suite (ATS) for mapping the LCM model against existing system implementations was developed and tested in collaboration with several member states.

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1. Introduction

In the last two decades, the CAP has been reformed several times, with the aim of better targeting new challenges and controlling expenditure. The most radical change was introduced in 1992, and from then on the CAP focused on direct income support to farmers based on cultivated area instead of production, as well as on integration of environmental concerns. After the CAP reform in 2003, in order to distribute the EU subsidies, each member state established an Integrated Administration and Control System (IACS), including an identification system for agricultural parcels, known as the Land Parcel Identification System (LPIS) as the spatial component. The main functions of the LPIS are localisation, identification and quantification of agricultural land via very detailed geospatial data. In order to receive EU support farmers have to adhere to environmentally friendly land management requirements, commonly known as cross-compliance (CC) principles. Furthermore, farmers can carry out additional actions to reduce agricultural pressure on the environment or to improve the countryside biodiversity. These are known as agri-environmental measures (AEM) and incur additional monetary support. Management of information on environmentally compliant land use and agri-environmental measures is the second most important function of IACS/LPIS. As a result, nowadays there is a considerable amount of geographic data, which is used for the management of the EU agricultural policy and of the European-wide geospatial community of data providers and custodians (MARS, 2007; MARS, 2008; MARS, 2009).

Although the regulatory requirements are uniform across the sector, the particular implementations were subject to member states subsidiarity. Some of the member states used their cadastral data as the starting point for the creation of their new LPIS registers, while others made use of a dedicated production block (farmer’s block, physical block) system (Milenov and Kay, 2006; Sagris et al., 2008). Therefore, different LPIS vary over common concepts,
models of representation and spatial identification of the agricultural land use unit (Sagris et al., 2008). These days the main concern of the geospatial community and the European Commission is how well established systems are ‘fit-for-purpose’, raising questions about the conformity of the systems with the EU regulations and the quality of the datasets themselves. The spatial datasets for cross-compliance are, for the most part, collected and maintained by environmental authorities outside the LPIS in its strict sense, and therefore the different systems need to be interoperable. The majority of the spatial data in question is subject to the process of pan-European standardisation and harmonisation, triggered by the INSPIRE Directive (Directive, 2007/2/EC).

Therefore, there is a need to assess the quality and consistency of the LPIS as well as to ensure systems interoperability. The LPIS Conceptual Model (LCM) was developed in the Joint Research Centre (JRC) of the European Commission as part of the LPIS Quality Assurance framework (Devos, 2010) and is a cornerstone for these efforts. The second section of this paper describes the state-of-the-art of the database quality assessment and conformance testing issues. The third section is dedicated to the LCM, describing its development process and the most recent version. The universe of discourse or in other words the scope of the model was extended from land registration context as published in Inan et al. (2010) to include cross-compliance and AEM issues and some elements of the previous version were refined. The following chapter reviews how the LCM can be used for the conformance and quality checks by means of the developed Abstract Test Suite. In the conclusion, we discuss our experience in the model and test suite development and further possible applications of the LCM and the ATS.

2. Methodology for testing conformance — state of the art

Information about the quality of available geographic datasets is vital to the managing of agricultural subsidies and proper handling of the distribution of funds. Paying agencies confront situations requiring extremely accurate data in order to justify their decisions to the farmer and the auditing authority. Therefore, paying agencies need instruments to assess and demonstrate how well their datasets are aligned with the legislative requirements. The standardised description of the quality of geographic data may facilitate this need.

In order to describe and measure quality International Standards for geographic information provide the framework which consists of quality principles (ISO 19113) and concepts of conformance and testing (ISO 19105). The cornerstones of quality principles are quality elements, which describe different aspects of data quality. There are data quality overview elements (purpose, usage, lineage) and quality elements (completeness, logical consistency, positional temporal and thematic accuracy). Each quality element can be tested for conformance by means of quality procedures, quality measures and quality tests. Standards define conformance for geographic data as the fulfilment of specific requirements (ISO 19105) and conformance quality level as a threshold value or set of threshold values for data quality results used to determine how well a dataset meets the criteria set forth in its product specification or user requirements (ISO 19113). In this article, we also use ‘conformity’ as a synonym to the term ‘conformance’ used by the ISO.

Therefore, the objective for conformance testing in the agricultural domain is the testing of a candidate product or system for specific characteristics required by the CAP regulation. ISO 19105 provides two steps of conformance testing as illustrated by Fig. 3. The first step, called the Abstract Test Suite (ATS), identifies the logical consistency of dataset(s) with the requirements in order to ensure that the basic concepts of the universe of discourse are represented in an appropriate way by analysing the data specification. The second step (Executable Test Suite, ETS) examines the datasets themselves for completeness, positional, temporal and thematic accuracy against elements of the universe of discourse (e.g. correct land cover type recording, its extent and precise delineation by dataset objects) as well as against their own specifications, tested in step 1 (e.g. only attribute values allowed by specification are used). In this article, we concentrate on the ATS and testing of logical consistency quality element, which implies examination of database structure, attribute domain values, format and topological consistency. In other words, we test if the database setup is designed correctly to reflect important elements of the universe of discourse.

However, geospatial data cannot be directly tested with respect to legislative text. An additional step, a ‘translation’ of the basic concepts into a common conceptual model, is necessary. Conceptual models can be expressed in a formal modelling language such as UML. In addition, a XML/GML schema can be produced based on the model, also known as a conceptual schema or geospatial community data specification. The structure of the real geographical database can be described by application models and application schemas. In order to evaluate the conformity of the implemented database, the application schema should be mapped against a conceptual schema. In cases when different datasets of different organisations and institutions need to be integrated for any kind of visualisation and analysis, data can be transformed in the structure of the conceptual schema using ‘mapping’ parameters. Therefore, conceptual models and data specifications serve as the basis for conformance testing. These models are subject to an agreement between the geoinformation community members, i.e. data providers, custodians and users.

Conceptual models, sometimes referred to as core models, are widely used in different application fields. In the cadastral domain, Steudler (2006) describes fifteen years experience of the Swiss cadastral core model called INTERLIS. In their paper van Oosterom et al. (2006) present a Core Cadastral Data Model (CCDM) which is suitable for cross-country use and which enables involved parties to communicate information on land property. The FutureFarm initiative (Sørensen et al., 2010) proposes a conceptual model for a farm management information system (FMIS) that is designed to be used at farm level, enabling communication of different applications and devices. The development and implementation of models such as the FutureFarm or LandIT projects (Iftikhar and Pedersen, 2011) are largely based on such initiatives as AgroXML and AgriXchange which are dedicated to standards for data exchange in the farmer’s business chain and especially used to exchange data with third party systems such as contractors, suppliers, consultants, etc. (Iftikhar and Pedersen, 2011). The recent adoption of the ISO 19152 Land Administration Domain Model (LADM), which is built upon the CCDM and to which the LCM acted as input to modelling efforts concerning land administration in agriculture, led to comparative analysis of cadastral systems in Pouliot et al. (in press) and implementation of the cadastral system extension in Stoter et al. (in press). A growing number of publications on modelling of land resources can be found in geological science (Sen and Duffy, 2005; Lake, 2005; Babaie and Babaei, 2005; Simons et al., 2006). In the environmental domain, the INSPIRE data specifications (INSPIRE, 2007) are examples of common conceptual models for different data themes agreed by stakeholders. The INSPIRE Directive makes provision for 34 common data specifications covering reference (or general geographic) and thematic environmental data. Several INSPIRE data specifications are relevant to cross-compliance issues in the CAP, e.g. land cover, land use, cadastral parcel and protected sites.
As the means for conformance testing, ISO 19105 proposes a framework of the ATS, which was initially developed for testing geoinformation products and systems against the requirements of the ISO/TC 211 family of international standards on geomatics. Its development was based on common testing practices in software engineering and graphics and image processing (ISO 19105). Assuming that common data specifications and models can be seen as standards for geospatial community, we can extend the ATS framework to our use case. The methodology of the ATS foreshadows the manual comparison of application specifications towards the specification of the standard by using basic and capability tests.

The testing and schema mapping issues are currently in the focus of geospatial research mainly due to the testing of the INSPIRE Annex II and III Data Specification (INSPIRE, 2008; Lutz, 2009). The INSPIRE methodology includes two methods: (1) manual comparison via templates and/or (2) the so-called transformation method. Transformation testing can be applied offline or online through web services. The goal of the testing exercise (Lutz, 2009), as seen by INSPIRE thematic working groups, is to test and tune the Implementation Rules, data specifications and guidance documents. On the other hand, spatial data communities and data custodians have the possibility to assess how well their datasets are aligned with the INSPIRE data specifications requirements. The recent INSPIRE guideline documents (INSPIRE, 2010a,b) contain an analysis of the state-of-the-art on schema mapping and transformation issues. According to this analysis, one of the challenges is the lack of a standard metamodel for model mappings. The XSLT – Extensible Stylesheet Language Transformation – can be used to transform XML encoded datasets, but is reported to have weak performance when it comes to processing large GML files. There are several commercial and research transformation tools available, e.g. Feature Manipulation Engine (FME) (Safe Software), GoPublisher (Snowflake Software) and Radius Studio (1Spatial). Mapping rules expressed in one software environment cannot be easily used in or imported into another.

3. LPIS Conceptual Model (LCM)

3.1. Background

The LCM has been developed by the Monitoring of Agriculture Resources (MARS) unit of the EC-JRC. The first version was available for discussion among the LPIS geoinformatics community from January 2008 and published later that same year (Sagris and Devis, 2008a,b). It has been under discussion among the geospatial community and has been modified several times before the latest version of the LCM became available at the end of 2009 (Sagris and Devis, 2009). The development of the LCM was greatly influenced by the results of the Abstract Test Suite trial in which five member states participated. The collaboration model between the LCM and land administration (cadastral) domain was proposed by Inan et al. (2010). Since that publication, core classes of the model were refined and the scope of the model was extended towards environmental issues in LPIS.

First, basic concepts from the EU legislation were extracted and documented. They became the basic, spatial and non-spatial, classes of the first-cut UML model. By further analysing of existing LPIS implementations, the basic classes were refined with specialisations, attributes, and code lists for the attributes. Environmental issues concepts that were already modelled in the INSPIRE domain and became a part of the INSPIRE reference model were re-used in the LCM as external classes. Finally, the UML model was converted into a GML application schema. The modelling work was done using Enterprise Architect (by Sparx Systems) software, whereas ShapeChange software (by interactive instruments GmbH) was used for the UML-GML conversion.

3.2. Universe of discourse and core classes

Farming and management of the agricultural land constitute the universe of discourse for the LCM. The universe of discourse is further constrained by the EU legislation defining types of activity and environmental standards, which make farmer’s activity eligible for Community support. Fig. 1 represents main concepts of the IACS/LPIS system modelled as core classes (see also Sagris, 2010, and Inan et al., 2010). The key concept of direct aid in the CAP is a farmer’s single application, which is represented in the model as the AyApplication class. A farmer, either a person or an association of farmers, is represented by the Farmer class and is registered in IACS via the farmers’ register. Farmer combines all claims for aid from the different support schemes such as area based, crop payments, livestock payment, rural development, etc. in one single application form. A farmer can submit 0 or 1 application each year. In order to do this, the farmer should have payment entitlements which constitute the financial envelope for his aid application – class Entitlement in the model. These payment entitlements exist only in member states that apply the Single Payment Scheme; namely all ‘old’ member states of the EU-15, as well as Malta and Slovenia. Therefore, Fig. 1 presents the most general case. Among other information, the single farmer’s application contains records on agricultural parcels, which the farmer cultivates and has on his holding as well as the farmer’s sketch, where he indicates the location of parcels – classes AgriculturalParcel and FarmerSketch respectively.

Each agricultural parcel declared by the farmer in his application has to refer, via an identifier, to one of the reference parcels (ReferenceParcel class) of the LPIS. The AgriculturalParcel has to be located inside one of the ReferenceParcels of the LPIS, but on the other hand, each ReferenceParcel can contain none, one or several declared agricultural parcels. Each reference parcel can have none, one or several farming limitations from cross-compliance requirements and standards. They are handled through the class FarmingLimitation.

The AgriculturalParcel is a production unit for which subsidy is claimed. It is part of the alphanumerical database of the application register and does not have a spatial dimension. The ReferenceParcel class is a spatial container for agricultural parcel(s) and core dataset maintained by LPIS systems. Therefore, the AgriculturalParcel and the ReferenceParcel have different sets of attributes (Fig. 1). The attributes of the agricultural parcel reflect the payment administration process as the first main function of the IACS/LPIS. The essence of the process is correct identification of the agricultural land area to be paid. The attribute declaredArea stores the parcel area as estimated by the farmer at the time of application, while digitisedArea of ReferenceParcel class correspond to the geometry of a spatial object as it is digitised in the LPIS database. However, the precision for reference parcel digitisation is set to 0.1 ha (all non-eligible features bigger than this threshold should be excluded out of the otherwise ‘pure’ eligible land) by the legislation, while precision of the determination of the area for payment is set to 0.01 ha. It means that some very small non-eligible objects can still remain inside the polygon of the reference parcel and the LPIS custodian in charge needs to evaluate the parcel and establish the referenceArea, in other words, the maximum eligible area that can be claimed by the farmer(s) inside the parcel in question. This value should be communicated to the farmer(s) before the application campaign in spring. The attribute farmedArea is a sum of areas declared by the farmer(s) inside a reference parcel. It cannot exceed the referenceArea, and if it does, we have a case of over-declaration either by mistake or by fraud. The farmer’s applications connected to this reference parcel should be checked and the inconsistency should be resolved. Finally, determinedArea of
AgriculturalParcel class corresponds to the result of a crosscheck process undertaken by the administration, which establishes the area to be paid, applying a particular paymentType.

The spatial relation between AgriculturalParcel and ReferenceParcel and representation of land cover/land use in the IACS/LPIS databases are important characteristics of different agricultural systems across Europe. There is a great variety of types of reference parcels in the EU member states. The earlier LCM versions propose four (Sagris and Devos, 2009), and the current version reference parcels in the EU member states. The earlier LCM versions centered on subsidies administration and land registration issues and the latter as cropCode of the AgriculturalParcel class. In the context of the LCM, we speak about land cover only as the physical and biological cover of the earth’s surface, which can be unambiguously mapped from orthophoto imagery or field survey. Therefore, arable land will be classified as arable land independently of any particular arable crop — wheat, rye, oats, etc. The use of area in terms of the type of crop or ground cover or the absence of a crop (Comm Reg (EC) No. 1122/2009 Art. 2) constitutes the agricultural use of land, and the term land use would be more appropriate (Fig. 1).

3.3. Environmental issues in the LCM

Current version of the LCM now includes datasets dealing with environmental aspects, whereas previous versions were concentrated on subsidies administration and land registration issues (Sagris et al., 2008; Inan et al., 2010). Therefore, we can state that the version presented in this paper has eventually extended the scope of the model towards the whole universe of discourse of the
The integration of environmental concerns into the EU agricultural policy is currently based on its two-pillar structure. The first pillar (so-called Direct aid) assures that farming is performed in a sustainable way: in order to get full CAP support farmers are asked to respect common rules and standards for preserving the environment and the landscape as well as public, animal and plant health and animal welfare standards (so-called cross-compliance principle, CC); these farming practices are considered as ‘policy baseline’ and therefore receive no specific financial support. Environmental standards include among others special land management in the protected areas, control on the nutrient influx, measures against erosion and preservation of landscape elements such as hedges and river buffer stripes. The second pillar (Rural Development) encourages farmers to produce environmentally beneficial public goods and services that go beyond what farmers are expected to deliver by respecting the compulsory legislation: in this regard, farmers have to voluntarily engage in environmental activities supported by agri-environmental schemes and they receive financial support respective of the measures implemented. Examples of AEM are afforestation of former arable land and support to less favoured agricultural areas. In the current debate for reforming the CAP post-2013 the above structure seems to be confirmed, with environmental integration to be reinforced.

All those practices involve some limitations to the farming activity, but only farming limitations that have a spatial distribution and can be presented by spatial data layers are included in the LCM. The source datasets for farming limitations can be external data (e.g. extNatura2000 class) or data especially created for the management of the CAP requirements (e.g. LFA — less favoured areas for agriculture). A reference parcel may be situated entirely inside or overlay with areas of farming limitation. Therefore, we designed the FarmingLimitation class with the Intersect class, which has three attributes — resultArea, resultBoolean, and resultPercentage — to handle all possible options (Fig. 2).

In practice, in LPIS systems there are two approaches of how cross-compliance data can be integrated with reference parcel data. The first approach is to calculate or re-calculate all data at the time of the reference parcel creation or update. Results are stored in a reference parcel layer via attributes or in special ‘consolidated’ tables. The second approach implies that values are produced ‘on-the-fly’ when they are needed for the administrative checks via dedicated database operations. The choice of approach depends on

![Fig. 2. Modelling of farming limitations versus ReferenceParcel.](image-url)
several considerations such as the need for speeding up the administrative checks or facilitating the work of operators and controllers. However, the existence of separate geographic layers, corresponding to data relevant to cross-compliances and holders for intersection results, is necessary for both approaches. Fig. 2 presents only one of the possible modelling solutions. In the testing procedure described in the next chapter, the authority, claiming conformance with the LCM, needs to demonstrate the availability of data sources for cross-compliance checks in their systems.

4. The Abstract Test Suite
4.1. Methodology and structure

In order to design a comprehensive test suite that enables conformity testing of the various LPIS systems, we have applied the methodology of the ISO 19105 ‘Conformance and Testing’. The ATS deals with the logical consistency and conceptual completeness of the database structure, and checks whether the database design is ‘fit-for-purpose’. The actual testing of data quality for positional, temporal and thematic accuracy is specified by the ISO 19105 as an Executable Test Suite (ETS). Conformity of the data model is a prerequisite for meaningful ETS-results (Fig. 3).

ISO 19105 standard specifies the structure of each particular test and the hierarchical organisation of the test suite (Fig. 4), where tests can be logically combined together into modules and sub-modules. According to the ISO standard, the ATS consists of basic and capability tests. A basic test is an initial test intended to identify clear cases of non-conformance, e.g. to establish conformance of basic concepts in order to evaluate applicability of all subsequent test procedures. Whereas a capability test is a test designed to determine whether an implementation under test is consistent with a particular requirement as described in the test purpose and to investigate causes for failure. Each test can be evaluated as ‘Conforming’, ‘non-Conforming’ or ‘nonEvaluated’. The ISO standard also suggests several methods for the aggregation of results at the test suite level, from particular tests and modules through to what is considered a desirable answer, or if an implementation is conformant to requirements, to what a degree of conformance it is. The input to the ATS is a database model specification of the implementation under test, which can be accompanied by a descriptive explanation when necessary. As a verification method, the standard foresees manual comparison of the two specifications and the method can be characterised as template based mapping.

Based on the above-mentioned methodology, we have designed the ATS for testing conformance with the LCM. The testing purpose is ‘to verify the conformance of the LPIS implementation under test towards the concepts and business rules laid down in the CAP regulation for direct aids’. The ATS consists of three modules (Fig. 4), and each of them may contain further sub-modules or tests. Altogether, there are 30 basic and capability tests in the current version of the suite.

Module A_11 consists of basic tests, which examine the concept of the reference parcel in use. The purpose of the test is to describe the semantic of the ReferenceParcel class in order to ensure that the rest of the test suite is applied correctly. Information on the database (where geometry of reference parcels is stored in the LPIS database are the result of test A_111: it is necessary to indicate ALL datasets/layers/tables with original names which are in use in the tested database (e.g. layer of ‘active’ claimed parcel for area based support scheme, layer of inactive parcels, layer of parcel for agri-environmental schemes etc.). The capability tests of module A_12 verified how, and more importantly, where in the database the area of eligible land is recorded. Test A_121 specifies which attribute(s) deals with LandCoverType information, for which land cover types codes are stored. Tests A_122 – A_124 deal with additional aspects of eligibility such as historical eligibility layer or layer of exclusions. The tests of this module help to establish a connection between the database and the so-called ‘eligibility profile’, which is necessary for testing data thematic quality. The country or regional eligibility profile deals with correspondence between the types of land cover mapped in LPIS on one hand and eligibility of these types to be part of payment schemes on the other hand: the combinations can be member state and region specific and depend on specific legislation and business rules. Land cover type eligibility is relevant for the calculation of the ‘maximum eligible area’ and for counting the presence of ineligible features in the ETS.

Module A_13 consists of three sub-modules. Sub-module A_131 establishes a connection between the attributes/operations of a particular LPIS and the referenceArea, digitisedArea and farmedArea of the LCM. Sub-module A_133 deals with the specific attributes of reference parcel sub-types. In sub-module A_132, the representation of information relevant to the cross-compliance with environmental issues is tested. As described in the previous chapter, there are two approaches of how cross-compliance relevant data can be integrated in the system: (1) assigned to reference parcel via attributes or (2) handled via on-the-fly operations. Sub-module tests the source dataset and if applicable, the table or layer holding intersection results should be stated.

The documentation of the ATS includes the model specification of the implementation under test and records of findings for all tests stored in the ATS-log report, so both input and output of the test can be verified. The conclusion of the tests suite is an aggregated result of all tests documented in the log. For the aggregation of the results on the test suite level, we have put forward a 100% conformance. It means that all test results for the mandatory elements should be conforming. Our argument in support of this
statement is the fact that we check the logical consistency of the LPIS implementation with the regulations.

4.2. The trial and full-scale implementation of the ATS

After the release of the LCM version 1.0, the trial for ATS with five member states was carried out in cooperation with member state Paying Agencies during 2008/2009. Participant member states had different types of the reference parcel so we had the opportunity to test all of them. The results from the ATS trial showed that its execution by an IT system administrator is feasible within the estimated 2–3 week timeframe, using the existing resources available in the member state administration. Depending on the LPIS workflow complexity, external key experts were consulted at different stages.

Performing the ATS involved three phases: preparation, testing and reporting. At the preparation phase, the trial revealed the absence of relevant documentation at hand for some implementations. Indeed, LPIS database specifications were created on the basis of different principles, in different formats, and were sometimes out-of-date. Another difficulty that should be hereby mentioned was the fact that the definition of the actual scope of the ATS (spatial features, layers and attributes to be included) is far from trivial when a particular LPIS database accounts for hundreds of datasets and layers. National LPIS models are more complex than the LCM—-they use aggregated identifiers, filters, etc. Finally, limited support for the application schema and GML was also an issue as data custodians preferred to operate with old-fashioned data specifications in text format.

After the trial year, some lessons have been learned and the ATS has undergone improvements (Sagris, 2010). First, an exhaustive description and instructions were published at the WikiCAP support pages to enhance the understanding of the geomatic technical language and lift that obstacle identified during the trial. Second, the ATS was better structured and reporting has been standardised. The preparation phase explicitly required an application schema or a feature catalogue as the official and technical documentation (according to ISO 19101). Moreover, a formal document Implementation Conformance Statement was introduced to describe implementation options of the LPIS implementation under test. The testing phase called for the use of an ATS-log to report all the test findings, with one record per test plus the eligibility profile. The last, reporting phase involved the transfer of the ATS results into a standardised form, according to the established XML Schemas.

Subsequently, the first full-scale ATS was conducted and reported by most EU member states in 2010 and the results were presented at the Amsterdam workshop (Wojda et al., 2011). From the 43 LPIS systems under test, 40 had completed the ATS-log (two countries from trial did not repeat) and 42 completed the eligibility profile; the main observations are summarised hereafter.

- 35 out of the 40 reported results yielded a formal “conforming” final conclusion. However, in the end, all systems felt confident they would be able to perform the subsequent data inspection of the ETS.
- Some of non-conforming LPIS implementations experienced difficulties with identifying the correct reference parcel type according to the given definition. On the other hand, in some cases the ETS revealed, that mapping units are not always delineated, as they should be according to the definition.
- Three non-conforming reports identified a design issue, related to a failure or lack of a mandatory attribute of the reference parcel, in particular farmedArea, referenceArea and LandCoverType attributes; one non-conforming report identified the lack of the historical eligibility layer (additional feature for counties applying single area payment schema). Non conformity findings were taken on board and addressed in the formal remedial action plan.
- Non-mandatory tests of the attributes of the reference parcel were considered as non-conforming by some inspections, but as not applicable or remain not evaluated by others. Methodological clarification regarding the assessment of such optional attributes will be needed for a more uniform reporting in future.

The ATS seems to have been preformed with due attention as 30 reports questioned either the applicability or the relevance of at least one test with respect to their particular system. Only 10 ATS-logs reported a mere “conforming” outcome for each individual
test. Nevertheless, all responders confirmed that the ATS-log required in the testing phase had contributed to a better understanding of their LPIS implementation.

However, the most important conclusion is that a correct ATS implementation and its satisfactory results are essential for a correct data inspection during the ETS (Wojda et al., 2011). Performing the initial ATS was a prerequisite for the LPIS custodians if they were to correctly understand the subsequent ETS test and to map their native database structure correctly into the ETS measurement terminology. For instance, the reference parcel type, identified and declared in Module A_11 has a direct impact on the ETS inspection procedure. It also affects the GML files containing the geometry of the inspected features and the conformity decisions through waivers. Similarly, the storage of digitised, reference and declared areas, identified in Module A_131 is of a key importance for the subsequent calculation of eligible land area. Finally, the reference parcel creation and update data, identified in Module A_131, will influence the analysis regarding the causes leading to non-conforming LPIS reference parcels.

The module A_12 “eligibility and land cover type” allowed for the clarifying of national eligibility profile as a set of appropriate mapping rules, which are essential for the correct implementation of the subsequent ETS inspection. Wide range of European agricultural landscapes was accommodated in the land cover code lists of their eligible profiles. Bilateral discussion with two-thirds of inspection teams enabled the individual eligibility profiles to be modified so that each team could perform its data inspection with a customised legend that was both unambiguous and comprehensive.

Following the analysis and bilateral consultations, some of the paying agencies started to consider radical changes in their LPIS systems, such as a change of the reference parcel type. The formal links between ATS and ETS inspection were tightened by binding connections in the appropriate LPIS QA Documentation (2011). To enhance the communication and reporting on the LPIS QA ATS and ETS, a Web-portal has been operating since March 2010. In the context of the Web-portal automation, first studies on the use of ATS results as preliminary mapping towards the LCM for schema transformation and spatial data exchange by means of Web services have been successfully carried out (Wiemann et al., 2012).

5. Discussion and conclusions

The goal of the described work was twofold: (1) to formalise legislative requirements in the conceptual model and (2) to provide a comprehensive test suite that enables conformity testing of the various LPIS systems. While working on the LCM and the test suite, we were also looking for a possibility to make the whole process of quality checking more automated, enabling quality monitoring of LPIS databases to be more simple, transparent and reliable.

The results of work, in order to achieve these goals can be summarised as follows:

- the LCM, in general, provides a 'correct translation' from a legal text into the language of geoinformatics;
- the LCM structure can accommodate the data layers for environmental compliance;
- the ATS trial proved its practicality and helped to fine-tune both the model and the test suite;
- the methodology allows for the repetition of the testing after major upgrade or redesign in order to prove an improvement in logical consistency.

The LCM represents the case where a common conceptual model is used for assessing the uniform quality of the LPIS across the EU member states. This is new, as we have not yet found an equivalent example of usage of conceptual models in academic literature. Even in the INSPIRE process one can only find reports concerning the testing phase of conformance assessment between conceptual models and real databases with a goal of finding gaps and of demonstrating possibilities of new technologies. The methodological challenge of this paper is to combine different pieces of contemporary GI research, which have been developed recently but at a different pace and in different ‘depth’. Furthermore, the International Standards, GIS and IS technology, principles of geoinformation interoperability are all under continuous development as they are directly influenced by the information technology advances and in particular, more powerful network services, based on open source and proprietary solutions, allowing data transformation and processing to become more accessible. This paper identifies model mapping and quality testing as a prerequisite for successful transformation services and charts requirements for future development, looking into possibilities to embed quality principles in the process.

In the future development transformation services combined together with OGC web services can facilitate data quality audit and monitoring in a more efficient way. LPIS application schemas from different member states can be mapped and data portrayed and visualised in a similar way together with relevant ancillary spatial data from different, mainly environmental, domains. Furthermore, the selected subsets of reference parcel dataset can be transformed for quality checks, but there remain several bottlenecks in technology and in the semantic issues. Because of the above considerations — lack of standards for schema mapping encoding and strong dependence on the software in use — the preparation phase for the schema mapping should be well documented in order to make schema mapping repeatable in different software environments. This task can be done through the ATS. Once the schema mapping is established and the reference parcel data is published via web services, this setup can serve for several quality checks, repeated on a periodic basis. The interoperability in this case will result in making data available between custodians and the auditing authority. The auditing authority can access data of different or even all member states in a similar way. However, the business rules of such an approach still need to be agreed on by all stakeholders. How schema mapping and transformation services technology can be used for quality assurance in the LPIS domain is part of a current research and is not in the scope of this paper.

One can foresee several new applications and practical outcomes for the LCM, not discussed in this paper. One of them would be the evaluation of the environmental policy integration into the CAP, which would be a future challenge of the recent proposal for the CAP after 2013, such as ‘greening’ of direct payments, the sustainable management of natural resources and climate actions. At present, reference parcel and cross-compliance layers in IACS/LPIS are used predominantly for administration of subsidies, but there is also great potential for policy impact assessment. The efficiency of agri-environmental schemes and cross-compliance measures can be assessed through harmonised LPIS data with more detail than can currently be done by environmental researchers via different generalised and aggregated datasets. Clear and evident connections can be established through IACS’ alphanumeric registers between agricultural land use and CAP support schemes representing instruments of ‘greening’ CAP on one hand and their effects in changing or preserving target types of land cover and landscape elements on the other hand.
References

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