Interoperability issues related to LADM profiled implementations – A first exploration

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Key words: LADM, interoperability, implementation, OCG, ISO

SUMMARY

In case of need for exchanging data or information between registries and cadasters and other organizations interoperability is an issue. This requires a common understanding expressed in semantics, vocabularies and ontologies. The Land Administration Domain Model (LADM) within the Resource Description Framework (RDF) using Web Ontology Language (OWL) provides a foundation here. As the LADM standard suggests a first step in its implementation is the development of a country profile - where national legislation and regulations are expressed.

In practice we see a profile level, semantic level, data level, format level and a communication level. Interoperability can apply within the same level and between levels. There are two mainstream international standards defining interoperability: (i) CEN/ISO 11354 (data, services, process, business) and (ii) the European Interoperability Framework (technical, semantic, organizational, legal). This paper discusses those standards in relation to a smooth implementation of a LADM local profile.

Land administration methodologies, approaches and tools develop rapidly, supported by private companies, modern technologies, and new information and communication possibilities. Further steps are needed to operationalize those methods and tools at scale (Enemark et al., 2016). Innovative thinking coupled with quickly maturing, scalable approaches is needed in many countries in order to create full coverage in land administration. (Lemmen, et al., 2019)

There is a challenge for countries on how to implement the LADM. There is a need for good practices, processes, implementation guides, and shared expertise from earlier implementations (OGC, 2019c). This paper explores interoperability issues in the context of LADM country profile implementations. This is a very first step to the development of a PhD proposal for the development, implementation and testing of use cases that prove and adjust interoperability in land administration. This ranges from the link between databases under responsibility of cadastre and land registry organizations to integrated (spatial and legal/administrative) data acquisition in the field connected to databases under cadastre and land registry. Further there is attention to output services and integration with national key data sets.

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1. INTRODUCTION

This paper develops a first outline of a PhD research proposal in the field of interoperability in land administration – a research on 'Methodology for the operationalization of LADM' that Oukes is about to start. The Open Geospatial Consortium (OGC) Land Administration Domain Working Group aims to assess existing standards and to address gaps and barriers. There is a challenge for countries on how to implement the LADM. There are many publications about implementation of the LADM. Good practices from expertise from past implementation can speed up implementation processes.

A profile level, semantic level, data level, format level and a communication level can be defined. Interoperability can apply within the same level and in between levels. A common understanding expressed in semantics, vocabularies and ontologies is key. There are two mainstream international standards for definition of interoperability: (i) CEN/ISO 11354 (data, services, process, business) and (ii) the European Interoperability Framework EIF (technical, semantic, organizational, legal). This paper discusses those standards in relation to a smooth implementation of a LADM local profile.

Chapter 2 discusses what interoperability means and provides some background of interoperability issues when creating a LADM country profiles and implementations in real cadaster and land registry environment. Chapter 3 gives an overview of the two interoperability standards of EIF and CEN/ISO 11354-1:2011. Then, based on the (preferred above EIF) ISO standard interoperability aspects of business, processes, services and data are introduced and discussed in Chapters 4 to 7. Chapter 8 discusses issues that are expected to be relevant for a PhD proposal on how to establish interoperability between LADM profiled implementations. It is expected to be very well possible to re-use implementation standards in OGC together with the development of LADM Edition II in parallel (Lemmen, et al., 2019).

2. INTEROPERABILITY

Interoperability can be contextualized in concepts as coexistence, autonomy and a federated environment, whereas integration refers more to the concepts of coordination, coherence and uniformization (Chen, Doumeingts, & Vernadat, 2008). A fully integrated system is tightly coupled, indicating that components are interdependent and cannot be separated. Interoperability means loosely coupled systems with components that are connected and can interact but still contain their own logic of operation (Chen, Doumeingts, & Vernadat, 2008). EC (2017) defines interoperability as 'the ability of organizations to interact towards mutually beneficial goals, involving the sharing of information and knowledge between these organizations, through the business processes they support, by means of the exchange of data between their ICT systems'. The CEN/ISO 11354-1:2011 (2011) defines interoperability as the 'ability of enterprises and entities within those enterprises to communicate and interact efficiently'.

As early as 1993, a number of businesses and governments had already recognized the importance of standards to ensure interoperability (Rada, 1993). Standards are the means to achieve interoperability goals. 'Standards are necessary for both integration and for interoperability' (Dogac, et al., 2008). 'Adopting standards-based integration solutions is the most promising way to reduce the long-term costs of integration and to facilitate a flexible infrastructure' (Chari & Seshadri, 2004). Based on a comparison of different definitions, Van Lier (2009) concludes that interoperability deals with the making of agreements at three levels: technical (technical exchange), semantic (content and meaning) and context (interpretation, processing, application) where today application is a service.

2.1 European Interoperability Framework (EIF)

The European Interoperability Framework is a commonly agreed approach to the delivery of European public services in an interoperable manner. It defines basic interoperability guidelines in the form of common principles, models and recommendations. (EC, 2017).

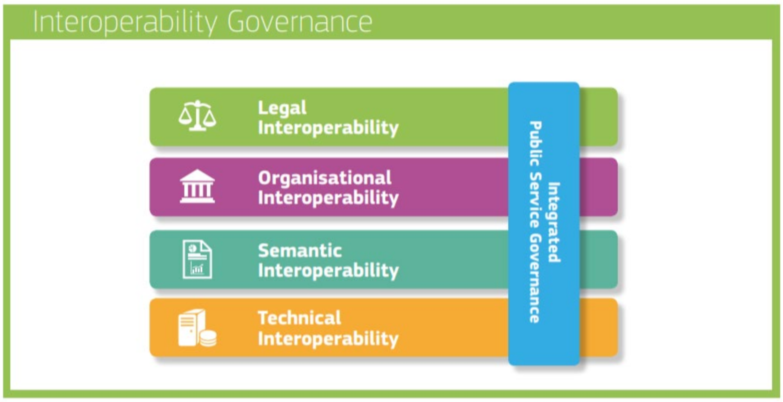

Figure 1. New European Interoperability Framework

It agrees that interoperability is more than a pure technical subject. The EIF version 1 divides interoperability into three layers (EC, 2004): (i) Technical: Interconnecting computer systems and services on a technical level (e.g. data integration, message transfer, and network), (ii) Semantic: creating a common understanding and guaranteeing processability of exchanged information in a 'meaningful manner' (e.g. data processing, data standards) and (iii) Organizational: defining of cross-organizational business goals and business process modelling (e.g. administrative issues, collaboration agreements). The second version (EC, 2010) of the EIF includes one more layer: (iv) Legal Interoperability: aligning legislation for cross border information exchange. In 2017 a third version of EIF introduced as a new Framework (figure 1) which added two layers: a cross-cutting component of the four layers (v) 'Integrated Public Service Governance': meeting end users' needs and providing public services in an integrated way - when multiple organizations are involved there is a need for coordination and governance by the authorities with a mandate for planning, implementing and operating public services, and (vi) a background layer 'Interoperability Governance': referring to decisions on interoperability frameworks, institutional arrangements, organizational structures, roles and

responsibilities, policies, agreements and other aspects related to ensuring and monitoring interoperability at national and EU levels.
The interoperability between the levels is not clearly stated in EIF. Translation is needed from one level to the next and back. The principles and recommendations are commonly defined where member states have to translate them into a National Interoperability Framework (NIF) which can be one or more documents that define frameworks, policies, strategies, guidelines and action plans on interoperability in a Member State.

2.2 ISO

The Athena framework (Berre, et al., 2007) (figure 2) is developed within the European Union.

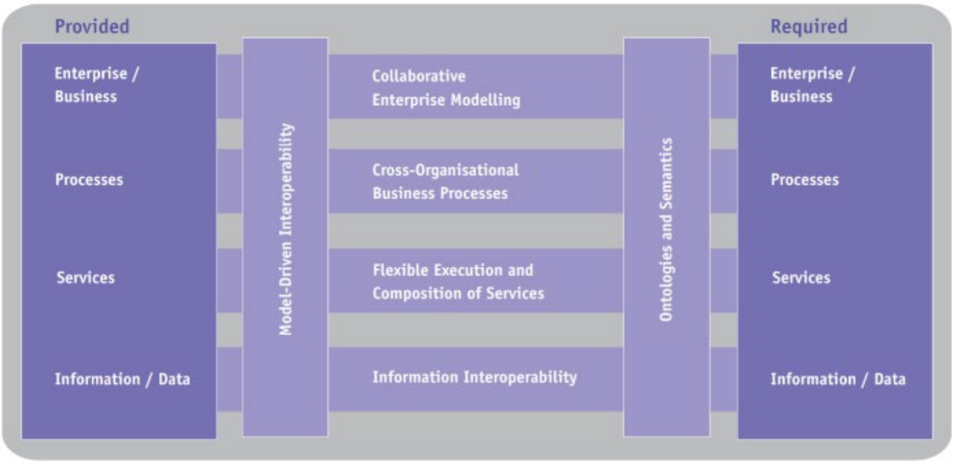

Figure 2. The Athena Interoperability Framework (Berre et al., 2007).

Berre et al. prescribe a model-driven 'Interoperability Approach' for each of the levels Business, Processes, Services, information/Data where models are used to formalize and exchange the provided and required artefacts that must be negotiated and agreed upon. Berre et al. say 'To overcome the semantic barriers which emerge from different interpretations of syntactic descriptions, precise, computer processable meaning must be associated with each concept'.

The Athena framework today is the CEN/ISO standard 11354-1:2011 (ISO, 2011) (figure 3).
As visualized in figure 3, this ISO standard added three basic dimensions:

- 'Interoperability Concerns' represent interoperability concerns between two enterprises: Data, Service, Process, Business. Data is used by services or functions. Services (functions/activities) are employed by processes in order to realize the business of the enterprise. Processes employ services/functions which in turn need data to perform activities. (ISO, 2011)
- 'Interoperability Barriers' represent incompatibilities between entities within the enterprise obstructing the exchange of information and other entities, the utilization of

services or the common understanding of exchange items: Conceptual, Technological and Organisational.

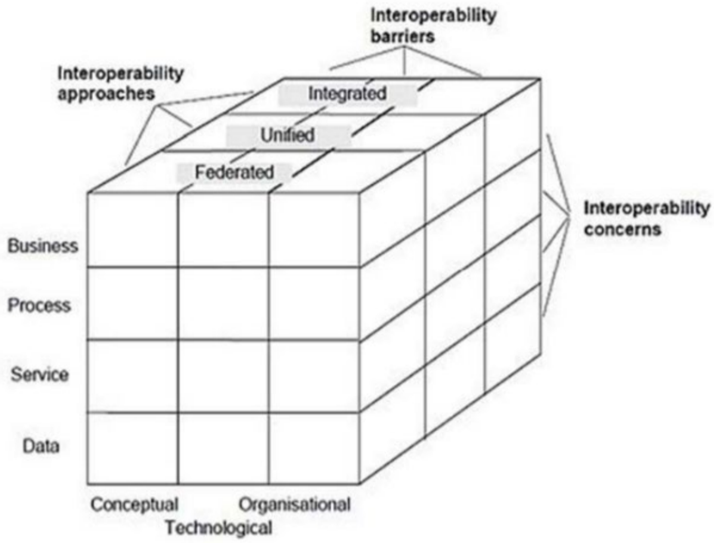

Figure 3. Framework for Enterprise Interoperability a part of CEN/ISO standard 11354-1:2011 (ISO, 2011)

Typically 'Barriers' prevent process interoperability because of different semantics and syntaxes used in different process modelling languages, incompatible process execution engines and platforms, different process organization mechanisms, configurations and managements. (Chen D. , 2009).

- 'Interoperability Approaches' represent the ways in which the barriers are removed: Integrated, Unified, Federated. 'Interoperability Approach' depends on the desired level of integration; these levels are defined in ISO 14258:1998; Industrial automation systems - Concepts and rules for enterprise models.

Interoperability of Communication is an essential condition to enable interoperability. Interoperability of Communication protocols and interfaces are part of the ISO/IEC 7498-1.

The EIF provides organizations guidance with principles and recommendations. On implementation and operationalization level there are no guidelines. The CEN/ISO 11354-1:2011 standard is a complete model which can serve as basis for the 'Interoperability Approaches', 'Concerns' and 'Barriers' of the implementation of the LADM local model. This standard includes also cross level interoperability and 'Concerns' of stakeholders at these levels where EIF looks at service to meet end users' needs. Based on the properties the CEN/ISO 11354-1:2011 standard fits best to implement and secure interoperability of LADM in a distributed environment and will describe the levels business, process, services, data in Chapters 4 to 7 in more detail.

3. CHALLENGES

The OGC Land Administration Domain Working Group (LandAdmin DWG) is focusing on the preparation of best practices that enable nations to address their needs in less time, cost, and effort through standards-based implementations (OGC, 2019c). The development of a land administration framework is challenging because it has to support a wide variety of regulatory and policy environments. Interoperability between underlying technologies and systems is key in providing the necessary flexibility.

The Fit-For-Purpose approach in Land Administration (FIG/World Bank, 2014; UN-Habitat/GLTN/Kadaster, 2016) has been developed in support to the challenges set by the overall Global Agenda for Sustainable Development. The Fit-For-Purpose approach argues for cost-effective, time-efficient, transparent, scalable and participatory land administration, including Participatory Surveying. Interoperability at lower levels (semantic, service, data and communication) increase the potential for reuse of existing ICT solutions, in this way reducing cost and implementation time.

The 'Interoperability Barrier' is mentioned by Jenni et al. (2017) as a disconnected mode. Not all areas / stakeholders are connected, like for example in Colombia where a large number of institutions is involved in land administration. As a consequence there is a need for legal independence (Kaufmann & Steudler, 1998) and improved data interoperability. Bringing all state/federal agencies to one single architecture/platform is in practice an almost impossible challenge and not always really a requirement. If there are shared views about processes, ontologies and semantics, about the use of products and services the interoperability can achieved at a technical level.

The delivery of online services requires shifting mindsets. Challenge is to change focus from bureaucratic procedures to citizen-centric approaches. Focus to the organization is not sufficient – it is more about the way in which the organization mediates a critical relationship between government and citizen that matters (Undheim & Blakemore, 2007).

Another challenge is in legislation, In some cases processes are paper based because of legal requirements and automated processes run parallel.

Next challenge is in siloed systems & data where each organization has its own IS. Use of standards contributes to the avoidance of inconsistencies between data maintained in different organizations, because data duplication can be avoided as much as possible. It should be noted here that implementing a standardized data model can be supportive in the detection of existing inconsistencies. (Van Oosterom & Lemmen, 2015).

A major obstacle to interoperability arises from legacy systems, technological obstacles are a challenge here. This is about incompatibility, heterogeneous environments, lack of standards, lack of documentation, etc. (Reaboi, 2015). Today there still are legacy information systems on legacy hardware like Mainframe/COBOL, data, data formats, exchange formats like SOAP / XML over HTTP, JMS / message queues and Fat files /Files over FTP and Custom binary protocols. Today protocols like REST/JSON over HTTP are more alike. (Bandara, 2015).

Historically, applications and information systems in public administrations were developed in a bottom-up fashion, trying to solve domain-specific and local problems. This resulted in fragmented ICT islands which are difficult to interoperate (EC, 2017). This brings a need for translation or new service interface. Existing and new systems has to coexist next to each other are able to exchange data.

The benefit of web-based land administration is in transparency and easy and efficient access to data, publicity can be significantly improved. Services can be organized in such way that clients do not need to go anymore several times to different offices for one single transaction on land rights. Greater transparency reduces opportunities for bribery. The cadastre and land registry offices-staff can expect a decreased workload where they can focus on the maintenance processes resulting in an up to date and verified cadastre and land registration information (Zakout, Werhmann, & Törhönen, 2006).

4. BUSINESS

As described in Chapter 3 governmental organizations use a variety of applications to serve citizens. The use of IT reduces the time to serve and increases efficiency. Yet, most of these applications operate in silos and are not connected to each other. This disconnect implies that possible interactions between them are not established. This would also lose some important insight about citizen data due to the absence of a holistic view of the citizen. (Bandara, 2015). Today citizens are interested in certain information which is partly available or distributed over more organizations while those distributed systems are not connected and are not able to deliver an integrated service. The citizen has to find his or her way for information.

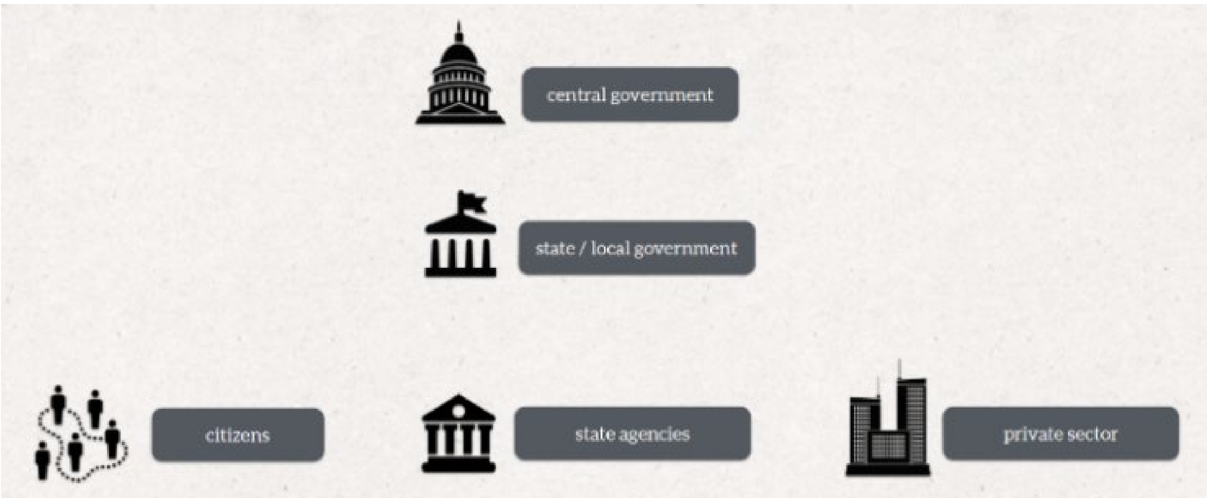

Figure 4. Stakeholders Governmental environment (Banddar, 2015)

government models (figure 4). Centrally owned and managed: Systems are centrally owned but locally governed - a nation-wide system is implemented where each local government is a tenant in the system and gets a basic to advanced level of customizability. Most policies are set at national level and pushed to local government level. The central management, provides a consistent and transparent system to local governments – in this way implementing national policies. Systems are centrally owned and funded, but locally managed. These are instances where the central government funds infrastructure for the local government. Local governments can deploy their own services on top of it.

Local governance requires enough flexibility to create and implement local policies and requires locally ownership and management. In this situation systems are deployed at within the organization of local government without any involvement of the central government. Policies are may exist at national level - but not implemented. Local governance, provides sufficient flexibility to develop and implement local policies.

In Colombia Jenni et al. (2017) developed a Process and Methodology (figure 6) for implementing the conceptual Colombian LADM Profile.

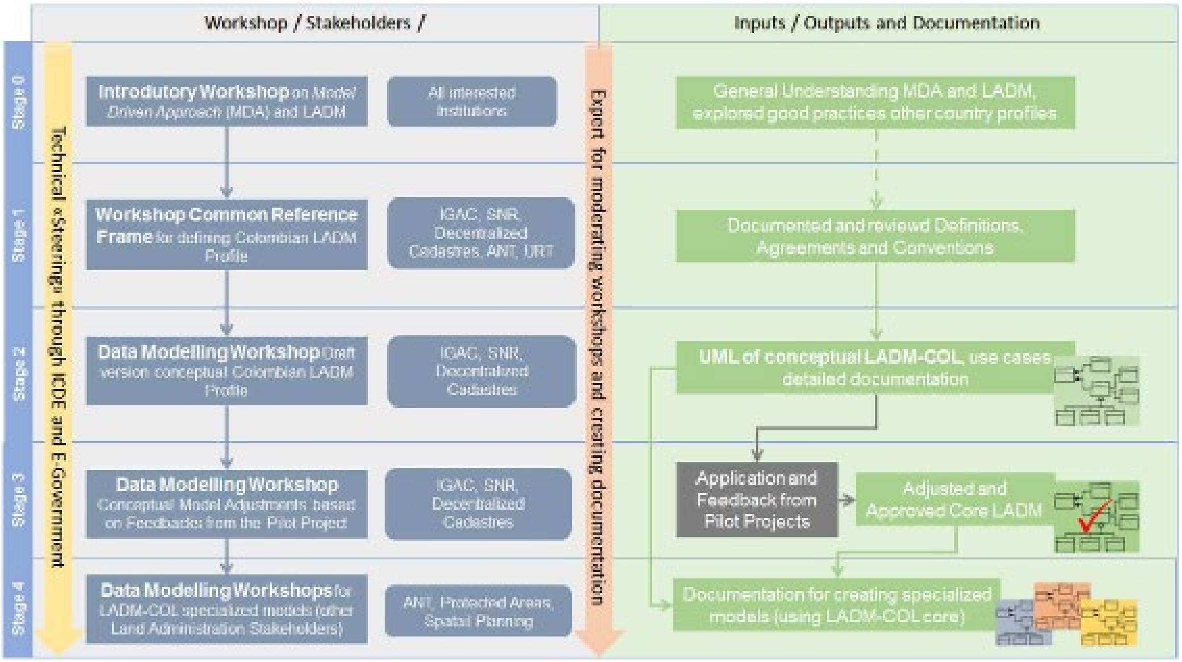

Figure 5. Process and Methodology for defining the conceptual Colombian LADM Profile (Jenni et al.2017

All involved institutions are independent and have their own legal foundation and regulations and mandates related to specific tasks and missional processes. This environment requires a careful structuring of the implementation of the LADM. In this setting, the LADM-profile model is modularized, defined and structured around a core (or minimum) model (figure 7).

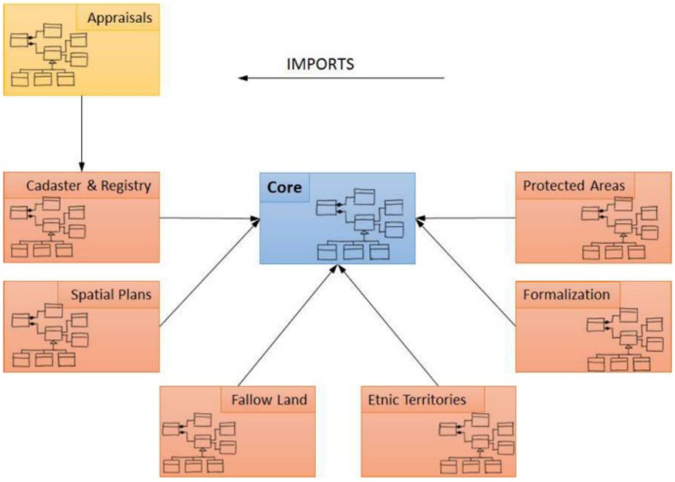

Figure 6. Example Modularization of the LADM-profile of Colombia (Jenni et al., 2017)

4.1 Model driven Architecture

LADM is a MDA and applicable to a local profile conceptual model which can be transformed to a system design Platform Independent Model (PIM) and even to a Platform Specific Model (PSM). The MDA development live cycle is initiated by describing the user requirements (mostly in text). Then, based on user requirements, the artifacts are created. The artifacts are formal models that can be understood by both humans and computers. First a PIM with a high level of abstraction and independent of any implantation technology is designed. When the PIM is available, it can be transformed into one or more PSMs. A PSM is tailored to specify a system in terms of the implementation constructs that are available in one specific implementation technology i.e. PostgreSQL or Oracle, ESRI. Tools are supporting MDA implementations for several years. The best known are also two well-known: INTERLIS (INTERLIS, 2019) and Enterprise Architect (EA) (Sparx, 2019). Note: INTERLIS is not a standard. Both have their pros and cons to provide a basis for the creation and implementation of the database. The major advantage of MDA tools is that the transformation from PIM to PSM is automated. But still expert knowledge is needed to use and apply these tools today. An example figure 8 shows a workflow with INTERLIS (Kalogianni,et al., 2017). However, as

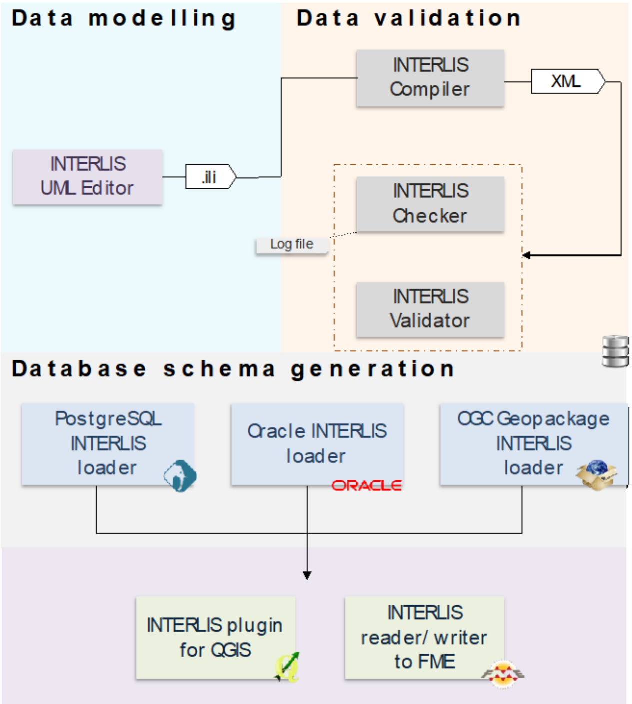

Figure 7. INTERLIS tools workflow (Kalogianni, et al., 2017)

MDA is not yet mature, limitations were discovered by Psomadaki et al. (2016): inheritance from the core LADM in the MDA as a UML model was implemented with Enterprise Architect and could be handled in a two table implementations (Parent – Child) where the child element was provided with a foreign key to the parent element. In practice this implementation created difficulties in applying queries to the database where violation of the integrity constraints might take place. There is no normative way to translate CodeLists into SQL expressions. CodeLists are characterized by their extensibility, in comparison to the Enumerated Types of PostgreSQL, which are static. What we would rather like to have is CodeLists automatically created as a SQL table with the values present in the UML diagram to be imported into its records (Psomadaki, Dimopoulou, & Van Oosterom, 2016).

An example of using EA is done by ITC to model the LADM Local model of Colombia by Jenni et al. (2017) in a smaller model in support to data collection in the field. This model is implemented in a PSM PostgreSQL GeoDatabase which is connected to ArcGIS Online. The field application Collector App from Esri is configured directly by a Service in ArcGis Online. Maps and existing data can be retrieved by the Surveyors from this service in ArcGIS Online and can be send back after adding data in the field. This demonstrates the advantage of tools to support the implementation of LADM local profile by INTERLIS and also EA.

4.2 Unified Modeling Language (UML)

The Object Management Group (OMG) has defined a number of modelling languages that are suitable to develop either PIM or PSM. Well-known is the Unified Modeling Language (UML), that is used to specify, visualize, construct and document the artifacts of a software system (Rumbaugh et al., 2004). However Arlow et al (1999) found it difficult for non-technical end users, managers, and business experts to understand UML syntax. The Literate Modeling approach may help these stakeholders to understand UML semantics. Literate Models are UML diagrams that are embedded in texts explaining the model (Arlow, Emmerich, & Quinn, 1999). It is quite common that after a few months the analyst who designed the model is unable to explain the requirements behind the model. The Literate Model is a good choice for the land administration domain modelling to express knowledge gaps between stakeholders and designers.

4.3 Model Driven Interoperability

The Model Driven Interoperability (MDI) methodology was elaborated in the framework of the Task Group 2 (TG2) of INTEROP-NoE (Bourey et al. 2007) which proposed an approach, inspired from OMG MDA (see above). The goal is to tackle the interoperability problem at each abstraction level defined in MDA and to use model transformation techniques to link vertically the different levels of abstraction, or horizontally to ensure interoperability of models at each level (Vallespir & Ducq, 2018).

5. PROCESSES

Land administration is described as the process of determining, recording and disseminating information about the relationship between people and land (ISO, 2012). Interoperability of processes aims to make various processes work together. A process defines in which order services (functions) are provided according to the requirements of a organization. Generally in a organization, processes run in interaction (in series or parallel). In the case of the networked enterprise, it is necessary to study how to connect internal processes of organizations to create a single and common process. Developing process interoperability means to find solutions to allow mapping, connecting, merging, translations of heterogeneous process models and applications. Lemmen et al. (2019) describes the main goals of processes modeling as: 'Establishing a comprehensive inventory of all land administration related processes, both fundamental and accessory processes and proposing a standardized representation methodology thereof'. In the development of the LADM Edition II processes are proposed to be included. Processes are organized per package and cover both data input and output. (Lemmen, et al., 2019) The core processes of LADM refer to the data acquisition, storage, representation, quality control, query and distribution.

The construction of external databases with party data, address data, taxation data, land use data, land cover data, valuation data, physical utility network data, and archive data, is outside the scope of the LADM. However, the LADM provides stereotype classes for these data sets (if available). The general methodology for process modelling is of a hierarchical nature. Each process encompasses principle components and forms the legal or spatial correlation between them.

The proposed LADM Edition II (ISO TC 211/SC, 2019) provides an approach for modelling land administration processes (Lemmen, et al., 2019) by a framework consisting of 4 steps. Step 1: Identification of all the actors/elements involved in a process according to the specified elements - where the actors and/or the elements might differ from country to country subject to laws and procedures. Step 2: Identification of process phases, in other words groups or subprocesses relating to a certain topic and provision of generic description. Step 3: Identification of basic activities. And the final step 4: Building of a model. The first two steps may be depicted by use case diagrams in UML, whereas step three and four can be presented by activity and/or sequence diagrams.

In addition to the data modelling aspect of the dynamic processes, the proposed LADM Edition II provides support for investigating how functions and processes are related to each other. The UML class diagrams should therefore be further extended for example with state diagrams. Activity diagrams show how processes are related to the information (data), and how it 'flows' from one into the other. In all other types of UML diagrams, actors or organizations play an important role, and this can be dependent on (national) arrangements.

6. SERVICES

Services are needed for demands such as easy accessible web portals to view parcel and ownership information, easy to use applications for office staff, and even the Chief Executive Officers, Chief information Officers, Chief Financial officers (in short CxO's) like Dashboards for CxOs (the elected members) in which they see in (near) real time the status of the cadaster and or land registration. Services delivered by portals are automated tasks, providing access to document repositories and reports. With availability of Application Programable Interfaces (API) it is more easy to exchange information electronically to other organizations like notary, banks, surveyors, building construction authorities etc. Quality of service in terms of Accessibility, Security, Scalability, Privacy, Reliability have to be incorporated in the design of the services. When a register or administration is paper based, the above needs are unfeasible (Bandara, 2015). With well designed services data can easily be made available. Exchange of data (social, spatial, images, pictures, documents, etc.) is available in upload, download, coverage, etc. services. Service can be found in a so-called Services catalogue.

The Model Driven Service Engineering Architecture (MDSEA) (figure 8) is inspired from MDA. This methodology was developed in the frame of the FP7- 12 MSEE project (Manufacturing SErvice Ecosystem) (MSEE, 2012). One objective of MSEE was to facilitate the transition to a challenged business of Product and Service manufacturing. MDSEA provides an integrated methodology dealing with modelling languages at various abstraction levels to support Service Models and Service System design and implementation. (Vallespir & Ducq, 2018).

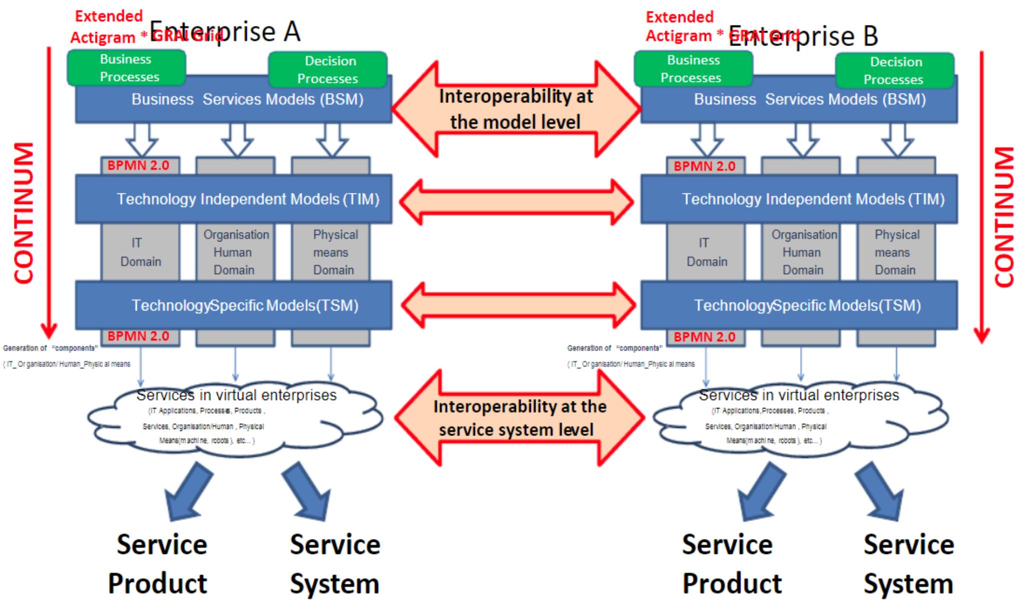

Figure 8. MDSEA: Architecture for interoperability and alignment of service system

Today there are standards (within ISO and OGC) available and also solutions in open and closed source software in support to creation of suitable services. For webservices the standards are like Application Programable Interfaces (APIs) a set of subroutine definitions, communication protocols and tools for building software, Web Feature Service (WFS) allow requests for geographical features across the web using platform-independent calls, Web mapping service (WMS) are available for serving georeferenced map images over the Internet. XML-based services with data formats GML and GeoJSON are obvious and widely used. Am advantage of GeoJSON is that it can also contain images. It is also more 'light weight' in communication than GML. For the transport of data is obvious today to use the standard internet protocols and transport channels. It is important that the privacy and integrity of the data is guaranteed and that thos issues continue to be monitored. This makes securing data stored and during transport important. Standards like ISO, NIST, etc. are available in security and data protection. In practice, OGC (2019) states 'Information Assurance (IA) Controls for OGC Web Services (OWS) have been implemented for years. The OWS Common Security Standard OGC (2019b) is to allow the implementation of IA controls and to advertise their existence in an interoperable way with minimal impact to existing implementations using a backwards-compatible approach'.

7. DATA

Folmer & Verhoosel (2010) say Inter-organizational interoperability refers to the term Inter-Organizational (Information) System (IOS), see for example (Lu, Huang, & Heng, 2006), (Rukanova, Wigand, & Tan, 2009) IOS is defined as an automated information system shared by two or more companies (Cash Jr & Konsynski, 1985). Folmer & Verhoosel refer also to Johnston & Vitale (1988) and added: 'to facilitate the creation, storage, transformation and transmission of information'. Zhu, et al. (2006) also use IOS, and make a distinction with Electronic Data Interchange (EDI), which is the concept of businesses electronically communicating information that was traditionally communicated on paper, such as purchase orders and invoices (Wikipedia, 2019a) through the use of the term Internet-based IOS: Internet-based IOS is characterized as being, on the 'content side': based on open XML based standards, low complexity and not that partner-specific; while on the 'delivery side': based on open internet communication protocols, highly interoperable and low communication costs. It also has a broad trading partner scope. Based on these characteristics, this can also be called an open standards IOS.

On the technical interoperability level, the internet has changed a lot. Technical interoperability has become more or less a choice of options and is not seen as a major issue anymore. The focus has changed to a higher level: syntactical and semantics. Syntactically we identify three phases: EDI, XML and lately Linked Data. Due to the rise of Linked Data, we also expect that more Internet-technology will be used within the standards; Standards such as RDF, SKOS, will be more extensively used within domain standards. However this will be a slow process, as we have seen earlier with the transformation from EDI to XML standards.

Even nowadays EDI implementations still exist, Today EDI is still the only option accepted by large retailers and hubs. Since January 2017 in the Netherlands it is obliged to send an e-invoice via a secure connection in the EDI format of the government and comply to the European directive (EU, 2014). LADM can be integrated with other geo-information standards - e.g., to link legal spaces to their physical 'counterpart' represented in Building

Information Modeling (BIM)/IFC, GML, CityGML, LandXML, LandInfra, IndoorGML, RDF/linked data, and GeoJSON. BIM is very important in order to establish a link between construction works and land administration in relation to spatial planning and lifecycles of buildings. LADM code lists could provide the basis for establishing a complete catalogue of global land-people relationships. Registries would be needed for managing the content of code list values and their definitions. On the technical interoperability level, the Internet has changed a lot, by which technical interoperability has become more or less a choice of options and is not seen as a major issue anymore. Currently most standards on semantics are based on XML technology, and several of them are already shifting to more developer and internet friendly formats such as JavaScript Object Notation (JSON). Common exchange formats which suits the exchange of LADM are in common API and exchange format fit for use with any administration – already under development by Esri (Esri, 2019)

More than 15 years were needed for the development of Linked Data (LD) and the Semantic Web (SW) technology to evolve from a mere envision presented in Berners-Lee et al. (2001) to a mature technology residing in the plateau of production of the Gartner diagram (Ronzhin et al., 2018). In Osterwalder's terms (Osterwalder & Pigneur, 2010), the main value propositions of implementing Linked Data (adopted from (Archer et al., 2013)) are decreased costs and increased flexibility of data integration and management. This leads to improved data quality and gives rise to new services.

Table 1. Supported formats collecting Apps (by first author april 2019) *via web interface **via additional tools ***ARCGis Pro scripts ** use weblinks in Json file**

	Shape file	KML	GeoJson	WFS	CSV	MapInfo	DxF	FGDB	ARCgis Json	GML	Image
ODK	-	+	+	-	+	-	-				+****
KoBo	-	+	-	-	+	-	-				+
GeoODK	+**	+	-	-	+	-	-				
MDC for GISCloud	+*	+*	-	-	+*	+*	+*				
NextGIS Mobile	-	-	+	+	+	-	-				
MapIt GIS	-	+	+	-	+	-	+		+		
AmigoCloud	+	+	+	-	+	+	+	+			
SMART	-	+	-	-	+	-	-				
Survey123 (ARCgis Online)	+	-	+	-	+	-	-	+	-	-	+***
Collector (ARCgis Online)	+	-	+	-	+	-	-	+	-	-	+***
Mappt	+	+	+	-	+	-	-	-	-	-	+

Today it is important that field data collecting applications in support to land administration are able to upload collected alphanumeric data as well as spatial data with international open data standards for communication (transport of data) and file formats and the structures introduced by the international committees like the ISO, RFC, W3C and OGC. Examples are Hypertext Transport Protocol (http) with encryption, Exchange Markup Language (XML) and Spatial standards like Geospatial Markup Language (GML). Characteristics are: standard data exchange, International standard, supports spatial and non-spatial properties and objects, good realization of complex models, good quality control over the data exchange. The first author did a small research which formats are supported by the Field data collecting applications. As an alternative for GML to other collecting apps there is support from Comma Separated Values (CSV) files and simple file transfer for Files, like images. Experience by the first author learns that it is complicated to keep CSV file and separate image files together during the process. The reason is there is no link in CSV to the image file name.

GeoJSON is an good alternative for the near future. In a small research on collecting apps today (table 1) we see that the support of GML and WFS is limited. Support for CSV and Keyhole Markup Language (KML) is more common and also GeoJSON. Characteristics of KML: lightweight protocol, support less features as GML, support other files like images
is commonly used for spatial visualization, foremost a 3D portrayal transport, not a data exchange transport. Over 90% of GML's structures (such as, to name a few, metadata, coordinate reference systems, horizontal and vertical datums, geometric integrity of circles, ellipses, arcs, etc.) cannot be transformed to KML without loss or non-standard encoding (Wikipedia, 2019b).

GeoJSON is an open standard format designed for representation of simple geographical features, along with their non-spatial attributes. It is based on JSON, the JavaScript Object Notation. is supported by numerous mapping and GIS software packages, like ArcGIS, OpenLayers, Leaflet, MapServer, Geoforge software, GeoServer, GeoDjango, GDAL, Safe Software FME (Feature Manipulation Engine), and CartoDB. (Wikipedia, 2019c).

OGC and buildingSMART International develop InfraGML, a new standard for land and infrastructure information (OGC, 2014). This reverse engineering of LandXML fresh and developing a new candidate standard – the OGC InfraGML Encoding Standard – that provides a use case driven subset of LandXML functionality, but that is implemented with the OGC Geography Markup Language (GML) and supported by a UML (Unified Modeling Language) conceptual model. Is InfraGML positioned as the linking pin between Geo and BIM.

For exchange of data the development goes fast today, not long ago, EDI and messaging were still common, today secure web services, based on OGC Secure Services (OGC, 2019) are. Exchange between stakeholders the use of internet protocols (TCP / IP, http (s), etc) is the norm to apply. Interoperability of Communication is an essential condition to enable interoperability. Interoperability of Communication protocols and interfaces are part of the ISO/IEC 7498-1.

8. DISCUSSION: RELEVANT ISSUES FOR A PROPOSAL FOR FURTHER RESEARCH

Based on the study of interoperability studies in this paper the authors believe that the approach as in CEN/ISO 11354 – that is business, process, services, data as followed in this paper – is a good approach to organize a PhD research on LADM interoperability issues in the context of LADM country profile implementations.

The next steps are to look at use cases to approve the methodology and standards will fit to a smooth implementation of a land profile in real life systems and collecting apps. Such cases may appear from real LADM country implementations.

An 'Interoperability Barrier' viewpoint has been identified to capture the incompatibilities and mismatches that obstruct the sharing and exchanging of information and other entities. Three categories of barriers are defined: conceptual, technological and organizational. 'Interoperability Concerns' define the content of interoperation that may take place at various levels of the enterprise (data, service, process, business) (Ullberg, Chen, & Johnson, 2009).

Land administration is described as the process of determining, recording and disseminating information about the relationship between people and land. The suggested framework by LADM standard of 4 steps (ISO TC 211/SC, 2019) and experiences of Jenni et al. (2017)and other implementations can have an excellent contribution to better implementation approach. All challenges and experiences what will work and not can be combined to improve tools and to apply the best standards that fit to interoperability. This could be made available as Open Source in the interest of Land, People and the rights and relationship between them. Research on resent and past projects, initiatives and experience could be bundled as a workplan as a basic operationalization approach to create a local profile and implement into a real IS in a easy way.
UML instance level diagrams are very useful in communicating the rich functionality of LADM. In addition user-friendly documentation for non-technical people should be available for later use.

MDA and MDI tools are very rich today. From model to model like PIM to PSM are doable but translations to database or webservice and code is a challenge especially when it comes to ready-to use vendor applications. Input and further research in and from practical examples must make clear which tools are usable and where improvement is still needed.
In practice, we see the need to import existing data (paper, scan, image, digital) to the new LADM local profile registration database in the new LAS or cadaster. Also conversion from social tenure to legal tenure may require support. For both conversions it is easy to make this process complex and complex to make it easy – it may require professional support. ETL tooling is suitable for this. Research and pooling of experience in practice would make available as open source or freeware tools or as modules in existing software like Safe Software FME. This make it easy to convert existing data to LADM local profile model and import into a new LADM-based LAS.

The LADM processes are organized per package and cover both data input and output. The processes related to the core LADM packages are: Party, Administrative and Spatial Unit. The core processes or LADM refer to the data acquisition, storage, representation, quality control, query and distribution (ISO TC 211/SC, 2019). Which core/primary input and services should be implemented for exchanging data and making data available to citizens and stakeholders. Looking around us there are many solutions for land registrations, cadaster and collecting data in the field. In practice it also appears that these solutions are not ultimate and a heterogeneous landscape of solutions is created. To make exchange possible and easy, those solutions for exchanging information / data speak the same language/data format and protocol as intended on semantics in the local profile. Vendors are implementing some standard, but in practice they are the limited usable, which has to improve.

Today the trend is everything as a service. The services should be available as APIs and Web services for data, map and images, etc. To find these services a service register has to be in place where to find the APIs and services and how they can be used. Input and further research in and from practical examples must make clear what is usable and where improvement is still needed.

Data exchange in terms of exchange formats seems to go strongly towards the use of XML-based standards: BIM / IFC, GML, CityGML, LandInfra, InfraGML, IndoorGML, RDF / linked data, GeoJSON, etc. Which exchange standards in data format best fit and how should these standards applied.

Exchange between stakeholders in technical way, the trend is to use web services. Also the use of internet protocols (TCP / IP, http(s), etc.) is the norm to apply on OGC secure Services (OGC, 2019) are.

Suppliers would say that it meets standards, only when it comes to exchanging in practice it does not always work and customization is required. Improvement is needed that integration, security and interoperability are by design, so that it works with a few mouse clicks.
How can suppliers (private, homebrew, government) bundle their knowledge to improve, coordinate and implement these exchange standard(s)?

9. CONCLUSION

This paper discusses standards in relation to a smooth implementation of a LADM local profile and interoperability between implementation when organizations and/or IS exchange information/data. The 'Interoperability Barrier' is mentioned by Jenni et al. (2017) as a disconnected mode. Not all areas / stakeholders are connected. The delivery of online services requires shifting mindsets. Challenge is to change focus from bureaucratic procedures to citizen-centric approaches.

siloed systems & data where each organization has its own IS will exchange information/data a challenge. Use of standards contributes to the avoidance of inconsistencies between data maintained in different organizations, because data duplication can be avoided as much as possible. The CEN/ISO 11354-1:2011 (2011) defines interoperability as the ‘ability of enterprises and entities within those enterprises to communicate and interact efficiently’. Historically, applications and information systems in public administrations were developed in a bottom-up fashion, trying to solve domain-specific and local problems. This resulted in fragmented ICT islands which are difficult to interoperate (EC, 2017). The benefit of web-based land administration is in transparency and easy and efficient access to data, publicity can be significantly improved. Land administration is described as the process of determining, recording and disseminating information about the relationship between people and land. (ISO TC 211/SC, 2019). Process and Methodology for implementing a conceptual LADM Profile is to involve all institutions with their own legal foundation and regulations and mandates related to specific tasks and missional processes to land administration and cadasters. This requires a careful structuring of the implementation of the LADM. In this setting, the LADM-profile model is modularized, defined and structured around a core or minimum model. In the scope of LADM Edition II provides an approach to modelling land administration processes (Lemmen, et al., 2019) by a framework consists of 4 steps. Step 1: Identification of all the actors/elements involved Step 2: Identification of process phases, in other words groups or subprocesses relating to a certain topic and provision of generic description. Step 3: Identification of basic activities. And the final step 4: Building of a model. The Model Driven Architecture (MDA) approach is usable from LADM to build a local profile conceptual model and translate to a system design Platform independent model (PIM) and even to a Platform Specific Model (PSM). With Services, data can easily be made available. Exchange of data (social, spatial, images, pictures, documents, etc.) are available in upload, download, coverage, etc. services. Service can be found in the so-called Services catalog. Today are sufficient standards within ISO and OGC available and also solutions in open and closed source software for creating suitable services available too. For exchange of data the development goes fast today, not long ago, EDI and messaging were still common, today secure web services, based on OGC secure Services (OGC, 2019) are. Exchange between stakeholders the use of internet protocols (TCP / IP, http (s), etc.) is the norm to apply. Interoperability of Communication is an essential condition to enable interoperability. Interoperability of Communication protocols and interfaces are part of the ISO/IEC 7498-1. The next steps are to look at use cases to approve witch the methodology and standards will fit to a smooth implementation of a land profile in real life systems and collecting apps. An ‘Interoperability Barrier’ viewpoint has been identified to capture the incompatibilities and mismatches that obstruct the sharing and exchanging of information and other entities. The Open Geospatial Consortium (OGC) Land Administration Domain Working Group on Land Administration aims to assess existing standards and to address gaps and barriers. There is a challenge for countries on how to implement the LADM. There are many publications about implementation of the LADM. Based on above standards on interoperability, good practices from expertise from past implementation can speed up implementation processes could be bundled as a workplan as a basic operationalization approach to create a local profile and implement into a real IS in a easy way.

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BIOGRAPHICAL NOTES

Peter Oukes received his MSc in Information & Management at the University of Amsterdam in 2017 on a master thesis (Dutch) 'Agile in your organization: 100 meters of Monty Python' is about Why do scrum teams and the process organization experience obstacles in their cooperation and how is the influence of the Organization culture. Peter is active in IT since 1988 in jobs as service engineer, Network specialist, IT Consultant, program leader, and since 2009 IT Architect Kadaster in the Netherlands. His contribution is to elaboration of a NSDI platform PDOK, support to standard opensource software development platform PLP for Kadaster, lead architect outsourcing Datacenter service, Contribute to Digital strategy Kadaster and leader of the theme Cloud and Introduces Cloud policy for Kadaster. Since 2017 Peter is involved in projects of Kadaster International in countries of Mozambique, Benin, Colombia, and Saint Lucia as IT consultant.

Christiaan Lemmen is full Professor Land Information Modeling at the Faculty of GeoInformation Science and Earth Observation of the University of Twente in the Netherlands. His other main job is as Senior Geodetic Advisor at Kadaster International, the international branch of the Netherlands Cadastre, Land Registry and Mapping Agency. He is director of the OICRF, the International Office of Cadastre and Land Records, one of the permanent institutions of the International Federation of Surveyors (FIG).

Erwin Folmer received his MSc in Technical Business Administration (Industrial Engineering) in 1999 at the University of Twente, based on a master thesis assignment on requirements engineering at Baan Development. From 1999 until 2001 Erwin was innovator at KPN Research involved in amongst other the order entry and billing systems of ADSL services. In 2001 Erwin joined TNO, and became senior scientist on the topic of interoperability and standards. From 2009 he part-time joined the University of Twente to start a PhD research on the standardization topic, while continuing his work for TNO. In 2012 received his PhD based on the 'Quality of Semantic Standards' thesis. In 2013-2014 Erwin was visiting researcher at ERCIS/University of Munster. From 2015 onwards Erwin joined Kadaster. At Kadaster he is leading the developments of the Linked Data platform for open geographical data. Currently this is the largest deployment of Linked Data in the Netherlands, and among the largest in the world

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