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Investigating the Requirements for the ISO 19152 LADM Survey Encodings

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SUMMARY

The ISO 19152:2012 Land Administration Domain Model (LADM), focuses on standardised modelling of land information at the conceptual level, and together with LADM's three main packages, it has a dedicated sub package for Spatial and Surveying representation. The first edition of the standard provides multiple spatial representations, and a rather generic survey model based on the ISO 19156:2011 Observations and Measurement Standard (O&M).

As an ISO standard, the LADM is subject to periodic revision, and currently, its revision is ongoing and among other refinements, the enhanced support of the surveying model, both at conceptual and implementation level is expected. In this scene, in order for LADM to support a broad range in surveying and data acquisition approaches and accuracies, a refinement is ongoing considering the recent evolution of technology and the encodings used in practice.

Therefore, a refined survey model has been prepared and is included at the New Working Item Proposal for LADM Edition II – Part 2, with various data acquisition techniques, as presented in this paper. Based on it and on the experience and requirements from the industry and the standardization organisations, this paper presents the requirements that encoding formats should fulfill to support the revised surveying model.

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1. INTRODUCTION

The international survey industry introduced several encodings/ formats that have been developed to serve the modelling, storage and exchange of the cadastral survey information. Those formats present similarities and discrepancies on various characteristics, such as: the number and level of detail of the attributes that they allow to be stored, the support of topology/ geometry, the support of 3D topology/ geometry, their dependencies on specific vendors, their interoperability support, as well as their simplicity. Apart from the stand-alone encodings, there are also multiple workflows and collaborative environments that have been developed for the collaboration between different instances of the surveying process (i.e. on-site data collection/ office work/ registration) which is of vital importance for the efficient and accurate completion and exchange of surveying information.

Some of those encodings have been developed or adopted through standardisation organisations (i.e. ISO, OGC, BuildingSmart), or they are dominant cadastral information exchange formats due to their massive use and adoption by surveyors and cadastral authorities worldwide, while the developed workflows are usually proprietary and depend on the vendor that has developed the collaborative environment. Hence, a standardised encoding addressing the current needs of the surveying industry, mostly oriented on the cadastral registration, is expected to improve quality and productivity.

In this scene, in the context of the revision of the ISO 19152:2012 LADM (ISO, 2012), the need to provide further support on the documentation of the surveying information has been underlined. Specifically, the survey model of the standard is being refined considering the following aspects:

1. the evolution of technology in the surveying, AECOO and GIS industry,
2. the need to provide support to a broad range of surveying and data acquisition approaches and accuracies,
3. the needs that have been addressed through the inspection of the existing LADM country profiles and relate to the modelling of the surveying-related information,
4. the formats/encodings that are used in practice to model, store and exchange such information.

Therefore, the LADM has been revised at conceptual level, which is included in the proposal for the development of Part 2 of the LADM Edition II, while the encoding(s) that will facilitate its implementation need(s) to be investigated. The aim of this paper is to initiate such a discussion, bringing together experts from the surveying, AECOO and GIS industry, Cadastral Authorities and users/ surveyors in order to reach conclusions on:

1. whether existing encoding(s) may serve the efficient implementation of the LADM survey part at their current version;
2. whether existing encoding(s) can be revised to serve the LADM survey part or
3. new encoding(s) should be developed for this reason.

Therefore, in this paper we specify the requirements for the survey encodings that will support LADM Edition II (and will be described in Part 6) taking into account the technological trends in the field (i.e. web services, cloud storage, big data, AI, ML, etc.) are being specified.

The rest of the paper is structured as follows: Section 2 presents an overview of the related research and mainly on the standards that have been developed and used so far in order to store and exchange surveying-related information, without being limited to cadastral registrations. Moreover, in Section 3 the requirements are being described and a theory-based comparison based on a literature review and the multidisciplinary experience of the co-authors team is made and presented as a comparison matrix. Finally, the last Section is devoted to the conclusions of this work and describes the next steps at research level, but also the next actions within standardisation organisations.

2. RELATED RESEARCH

This section presents the related research in the field and specifically the latest developments on the refined survey model of LADM Edition II (Subsection 2.1), as well as related research and standards (Subsection 2.2).

2.1 ISO 19152:2012 LADM Refined Survey Model

As indicated at the previous sections, the first Edition of the LADM included a very simple survey model based on the ISO 19156:2011 Observations and Measurement Standard (O&M). The model was abstract, as at the time of the release of the first Edition of the standard, focus was given on describing the people-to-land relationship through the detailed definition of Rights, Restrictions and Responsibilities (RRRs) associated with the spatial units. Since then, multiple LADM based country profiles have been developed and from their inspection (Kalogianni et al., 2021b) it is revealed that the survey model needs to be further detailed and enriched. What is more, as cadastral surveying forms the basis for land administration through the definition of the properties' boundaries, accurate descriptions and records (an associated RRRs with their right holders) of land/ water/ air/ underground parcels are the fundamentals to their rational use and conservation and form the core of well-established Land Administration Systems (LASs).

In this scene, the revision of the survey model of LADM has been initiated in 2019 (Shnaidman et al., 2019) proposing new attributes at the class LA_SpatialSource, several association classes and corresponding code lists. Following, Kalogianni et al. (2021a) further refine this model by identifying the concepts of data acquisition methodologies and tools that need to be included to address the current needs and align with related standards (i.e. OGC LandInfra). On top of this, in the context of the H2020 GISCAD-OV project (https://giscad-ov.eu, GISCAD-OV, 2022) feedback has been provided by experts regarding the support of GNSS surveys with satellite-based and earth/location-based corrections, including among others the Galileo High-Accuracy Services (HAS). Taking this work into account, at the New Working Item Proposal of LADM Edition II - Part 2: Land Registration, the proposed refined survey model is included and its main UML diagrams and concepts are presented below.

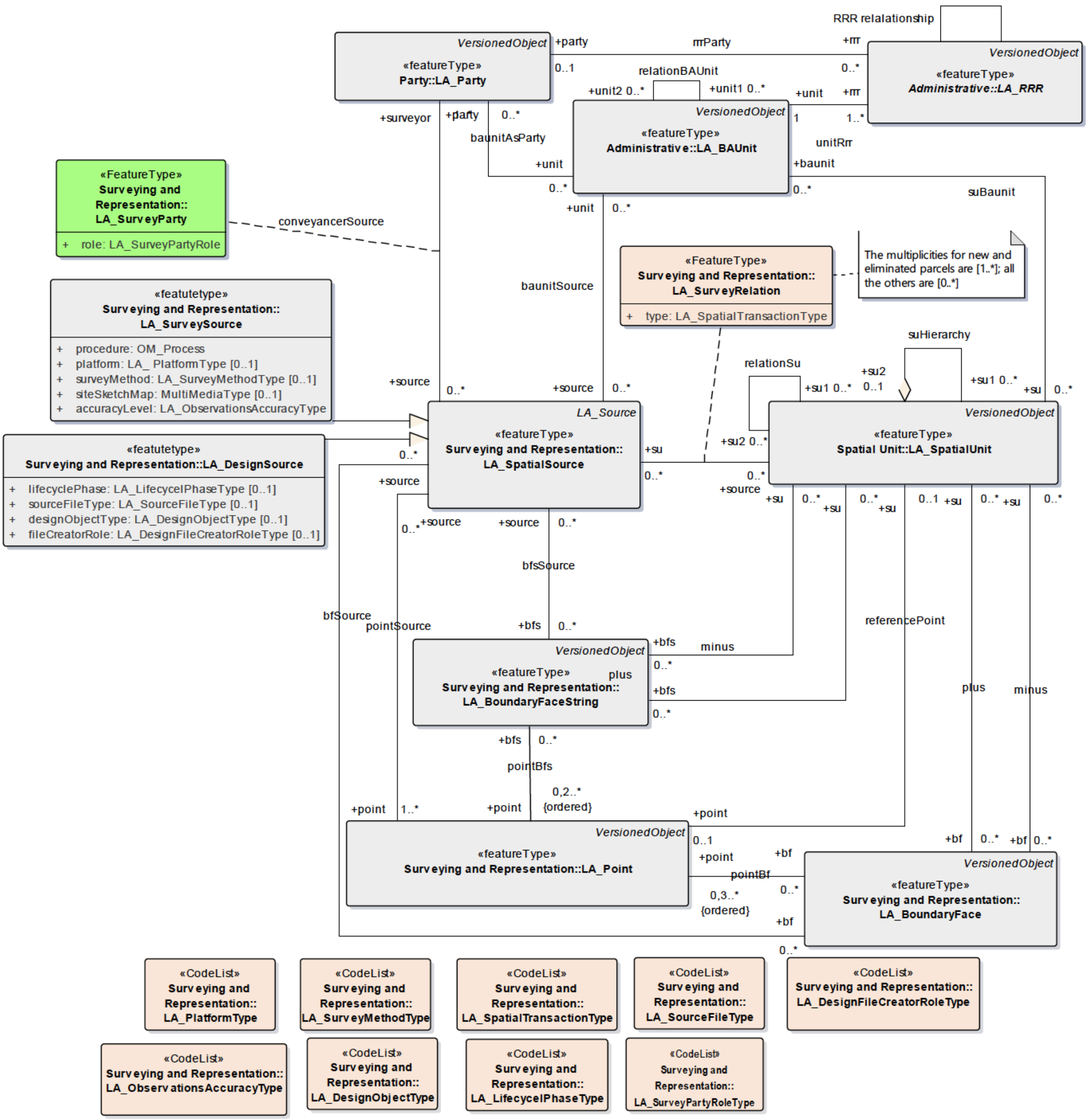

Figure 1. Proposed basic classes of the Surveying Representation sub-package of the Part 2 of LADM Edition II [1]

To start with, Figures 1 and 2 present an overview of the basic classes of the Surveying Representation sub-package. The main refinement refers to the LA_SpatialSource, which includes new attributes compared to LADM Edition I and has two subclasses; the LA_SurveySource and the LA_DesignSource, supporting the modelling of information arising various data acquisition techniques (from single distance measurements to point-cloud and GNSS measurements) through the inclusion of new classes, attributes, code list values and associations.

Therefore, the conceptual model of the refined survey model has been developed and it is based on the surveying encodings that will facilitate its implementation.

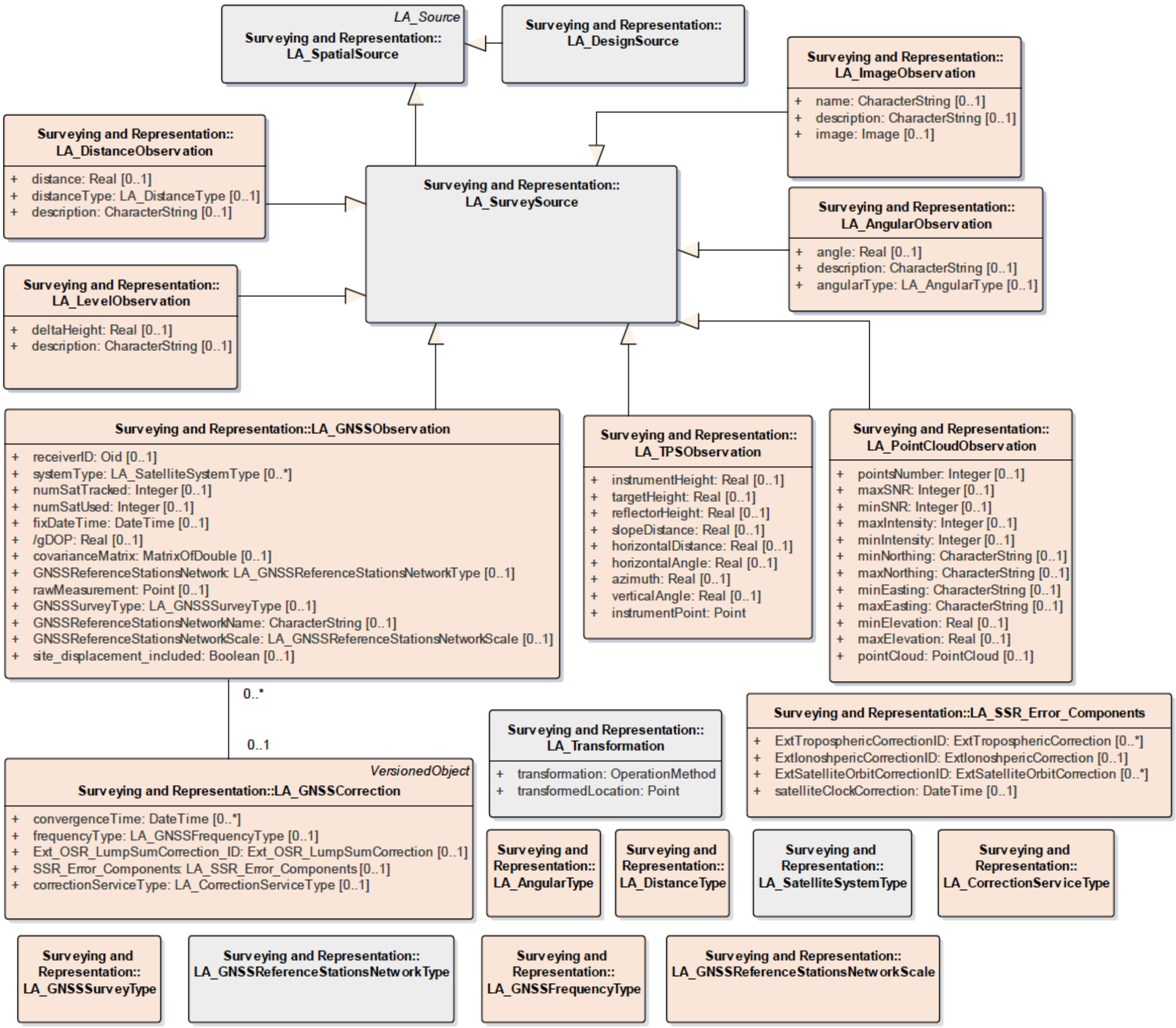

Figure 2. Proposed basic classes of the Surveying Representation sub-package of the Part 2 of LADM Edition II [2]

2.2 Related Standards and Developments at the Surveying Encodings Field

In order to define the surveying encodings (for data storage and exchange) that will be included in the LADM Edition II - Part 6: Implementations, the related developments, similar ongoing projects as well as standards that allow the storage and exchange of surveying-related information are examined.

2.2.1 LandXML, OGC Landinfra/ InfraGML

Starting with LandXML, an XML- based, open data model for representing civil engineering and survey measurement data (LandXML, 2016). LandXML is not recognised as an official standard by any standards organization, however, it has been widely used by the surveying community in several countries. It supports the registration of both 2D and 3D (Thompson et al., 2017).

LandXML has been proven difficult to implement (reported that it was poorly adopted by Surveyors in NSW Australia; only 5% of submitted plans (Grosvenor, 2019)) there were significant variations between jurisdictions that undermined support from survey software suppliers, while there is no capability for 3D digital exchange (Haanen, 2021).

OGC Land and Infrastructure Conceptual Model (LandInfra, OGC, 2016) was proposed as the successor to LandXML, based on a subset of its functionality, but implemented with GML (as InfraGML) and supported by a UML conceptual model. LandInfra has a devoted module to model surveying-related information (LandInfra Survey) needed to locate infrastructure facilities on the terrain in compliance with interests in land (OGC, 2016).

2.2.2 Building Information Modeling/ ISO 16739-1 Industry Foundation Classes (IFC)

From the rapid increase in the use of BIM models it is expected that in the future not all survey plans may originate from surveys, but quite a number of them might result from design and mainly from BIM/IFC models. Limited research has been carried out regarding the modeling of the survey observations in BIM, however BIM is very rich in information and should be examined whether it can be used also as a survey encoding. Till today, several issues with the georeference of the BIM models have arisen, although a number of georeference options have been developed. What is more, with the Scan-to-BIM method, the process of creating the BIM model of a building or an existing space, starting from the data acquired from the survey carried out with advanced technologies, such as 3D laser scanning, is gaining ground and provides very detailed information about the object being surveyed.

2.2.3 3D Cadastral Survey Data Model and Exchange (3D CSDM) project

Currently, there is an ongoing Australian-New Zealand project on building the Intergovernmental Committee on Surveying and Mapping (ICSM) Conceptual Model for 3D Cadastral Survey Dataset Submissions in a standard way of transferring cadastral survey datasets in all nine Australian states and territories and New Zealand. This solution is supported by the survey software suppliers operating in the Australian and New Zealand market, involving actively the surveying community to comment and provide feedback at the standard in order the surveyors to progressively transition from lodging paper or PDF files to fully digital data. The harmonised data model will cover all cadastral survey data components required by the responsible cadastral agencies, including both 2D and 3D elements (Haanen, 2021).

3. REQUIREMENTS TO ASSESS THE EXISTING SURVEY ENCODINGS

At this section, the requirements that survey encodings that can be used for LADM survey model implementation shall meet are being investigated and presented. Therefore, it is considered that the standardised encodings should:

1. have industry support for both the survey and GIS vendors/ software providers through the whole lifecycle of the encoding (i.e. support from the various systems at the different versions of the encoding that are being used);
2. user experience and familiarity with the encoding;
3. possible requirements/ mandates from regulations that apply to various jurisdictions and specifically from the Cadastral Authorities that usually collect and store them;
4. being supported by various ETL tools or other systems that facilitate the interoperability with other encodings;
5. be an open and scalable format;
6. allow for automatic and effective translation from the conceptual model to it;
7. support both topology and geometry in 2D and 3D;
8. be human readable (preferable ASCII formats) and not binary;
9. be vendor neutral;
10. support georeference and storage of coordinate reference systems;
11. automatic conversion from the conceptual survey model (therefore to be rich in semantics and provide sufficient support of thematic attributes);
12. be the foundation for collaboration between different instances (field/ office/ registration) as collaboration of vital importance and a standardised encoding can improve quality and productivity;
13. “web friendly” - ability to transport efficiently using web services, efficient parsing.

Within the structure of the following matrix, the most dominant and well-known existing survey encodings can be assessed against those requirements. The selection of those encodings has been made through literature review research, on the results of questionnaires regarding the use of surveying encoding in some countries that have been carried out by the Council of European Geodetic Surveyors (CLGE) (GISCAD-OV, 2021), as well as the expertise of the co-authors team.

Table 1. Comparison Matrix

Requirements/ Encodings	AutoCAD dxf	Autodesk dwg	ESRI shp[1]	LandXML	OGC InfraGML[2]	ISO IFC	OGC Geo Package	JSON	GeoJSON
Survey Industry support									
GIS Industry support									
Experience/ Familiarity of the users (those that submit & authorities that receive them)									
Imposed by regulations (Cadastral Authority) **jurisdiction dependent*									
Interoperability with web services/ other formats									
Be an open format									
Be scalable									
Automatic conversion from the conceptual survey model									
Be "web friendly"									
Support both topology and geometry									

[1] Esri Feature Services and Esri mobile Geodatabase will be examined
[2] other GML-based formats will be examined

Support both 2D & 3D geometry									
Support rasters									
Be human readable									
Be simple and compact									
Vendor neutral/ platform independent									
Support of coordinate reference system/ Georeference & Units of measurements									

It is noted that this is ongoing research. The assessment itself is under development and the results will be presented during the 10th LADM Workshop in Dubrovnik, Croatia in March/April 2022. This version of the paper will be published at the related website[3].

4. DISCUSSION AND CONCLUSIONS

This paper aims to initiate the discussion on the specification of the requirements for the survey encodings that will support LADM Edition II and will be described in Part 6 of the standards taking into account the technological trends in the field. Therefore, some of the well-known and widely used encodings/ formats are listed, together with a set of requirements that will facilitate the efficient implementation of the LADM Survey Model.

In this scene, the future steps include the reflection on the LADM Survey Model based on the initial requirements specification, as well as the completion of the comparison matrix presented in Table 1. This paper is part of an ongoing research and discussion among industry suppliers (both surveying and GIS), experts and users (surveyors, etc.), hence in this paper the initial results are reported. As the implementation part of the LADM Edition II will be led by OGC in collaboration with ISO, an OGC meeting to discuss the cadastral survey standards will be held and the discussion will be initiated from this paper (will be a Join Session DWG LA and DWG

[3] https://wiki.tudelft.nl/bin/view/Research/ISO19152/LADM2022Workshop

LandInfra). The results of this session will be reported and presented in the LADM Workshop 2022.

The next step of this research is to conclude the top three encodings from the assessment that will be carried out and based on it, test them using 2D survey examples. The testing will be executed based on the updated version of the LADM conceptual survey model and provide the necessary validation loops to it. Overall, the results of this paper are expected to provide useful conclusions on how to efficiently proceed with the LADM Edition II (conceptual model in normative annex Part 2, as well as technical encodings in Part 6).

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BIOGRAPHICAL NOTES

Eftychia Kalogianni is a PhD candidate in GIS Technology Chair, Faculty of Architecture and the Built Environment at the Delft University of Technology, the Netherlands. Her PhD research topic is about adopting a holistic approach to treat 3D Cadastres within the spatial development chain, in the context of the LADM ISO 19152 revision. She holds MSc in Geoinformatics from NTUA and MSc in Geomatics from TUDelft. She is an active member of FIG Young Surveyors Network.

Hans-Christoph Gruler is the representative of Leica Geosystems in the Open Geospatial Consortium and Building Smart International. Within OGC he is the chair of the Land and Infrastructure Standard Working Group, inside bSI member of the Product Room Steering Committee. He is also part of the Integrated Digital Built Environment (IDBE) joint working group from both standard organizations that has the objective of achieving better interoperability between the geospatial and built environment domains through coordination of development of the standards. He holds a Master of Science degree in Geodesy and Geoinformatics from the University of Stuttgart.

Amir Bar-Maor graduated with a degree in geodesy from the Technion – Israel Institute of technology in 1999 and a master degree in geodesy in 2002. After working for several years designing and implementing GIS technology, he joined esri in 2008 – initially as a project manager and consultant for cadastral projects and later as a product engineer in software development. Amir is a licensed cadastral surveyor and a licensed real estate appraiser.

Bruce Harold is Product Manager at Esri Inc on the Open Platform team. He manages the ArcGIS Data Interoperability extension, built on FME technology, that delivers format translation and no-code integration capabilities into ArcGIS Pro and ArcGIS Enterprise and within the ArcGIS geoprocessing environment.

Tim Lemmon is a Marketing Director at Trimble Inc, driving Geospatial software solutions that transform the way geospatial professionals capture and digitize the physical world. Tim has over 20 years experience within the geospatial industry living in New Zealand, the United States and Australia. He holds a Bachelor and Master of Applied Science in Surveying from RMIT University and an MBA from Melbourne Business School.

Christiaan Lemmen is full Professor Land Information Modelling 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 FIG.

Peter van Oosterom obtained an MSc in Technical Computer Science in 1985 from Delft University of Technology, the Netherlands. In 1990 he received a PhD from Leiden University. From 1985 until 1995 he worked at the TNO-FEL laboratory in The Hague. From 1995 until 2000 he was senior information manager at the Dutch Cadastre, where he was involved in the renewal of the Cadastral (Geographic) database. Since 2000, he is professor at the Delft University of Technology, Faculty of Architecture and the Built Environment, Chair GIS Technology, the Netherlands. He is the current chair of the FIG Working Group on '3D Cadastres'. He is co-editor of the International Standard for the Land Administration Domain, ISO 19152.

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