Galileo High Accuracy Services

Support through ISO 19162 LADM Edition II

Kalogianni, Eftychia ; van Oosterom, Peter ; Schmitz, Martin; Capua, Roberto; Verbree, Edward; Dimopoulou , Efi ; Gruler, Hans-Christoph; Stubkjær, Erik; Neudiens, Ivars; Morales Guarin, Javier; LEMMEN, Christiaan

Published in:
FIG Proceedings

Publication date:
2023

Galileo High Accuracy Services support through ISO 19162 LADM Edition II

Eftychia KALOGIANNI and Peter VAN OOSTEROM, THE NETHERLANDS, Martin SCHMITZ, GERMANY, Roberto CAPUA, ITALY, Edward VERBREE, THE NETHERLANDS, Efi DIMOPOULOU, GREECE, Hans-Christoph GRULER, SWITZERLAND, Erik STUBKJÆR, DENMARK, Ivars NEUDIENS, LATVIA, Javier MORALES GUARIN and Christiaan LEMMEN, THE NETHERLANDS

Key words: Land Administration, cadastral surveying, GNSS, High Accuracy Services

SUMMARY

Land surveying is the process of determining the three-dimensional position of a fixed point on Earth relative to a certain reference frame. High accuracy positioning has been called for by the land mapping and surveying community ever since GPS's initial adoption to achieve centimeter level accuracies.

In this scene, High Accuracy Services (HAS) are considered necessary by the Land Administration sector for implementing classical institutional services such as parcel subdivision, boundary determination, new building insertion in the map, coordinate reference systems update. In this scene, Galileo (the European Union's Global Navigation Satellite System) is expected to offer a new paradigm for HAS, through the advent of satellite corrections broadcasting on the native triple frequency plan.

In this context, the H2020 GISCAD-OV project, has as main objective to design, develop and validate an innovative and cost-effective HAS for Cadastral Surveying applications, based on GPS+Galileo E6 HAS and Precise Point Positioning-Ambiguity Resolution (PPP-AR) quick convergence techniques. In this scene, a new survey model is being developed, within the context of the revision of the ISO standard 19152 Land Administration Domain Model (LADM), to enhance the surveying functionality of the standard and support HAS. To validate this proposal a series of pilots have been carried out around Europe, with the active participation of local professional surveyors.

This paper presents survey-related requirements that have been developed for LADM Edition II- Part 2; the survey model of the LADM as included in the Committee Draft (CD) of LADM Edition II Part 2 (ISO19152-2) that has been submitted to the ISOTC211 committee for review

and the main results from two of the five GISCAD-OV pilot campaigns that have been performed and their validation.

Galileo High Accuracy Services support through ISO 19162 LADM Edition II

Eftychia KALOGIANNI and Peter VAN OOSTEROM, THE NETHERLANDS, Martin SCHMITZ, GERMANY, Roberto CAPUA, ITALY, Edward VERBREE, THE NETHERLANDS, Efi DIMOPOULOU, GREECE, Hans-Christoph GRULER, SWITZERLAND, Erik STUBKJÆR, DENMARK, Ivars NEUDIENS, LATVIA, Javier MORALES GUARIN and Christiaan LEMMEN, THE NETHERLANDS

1. INTORDUCTION

Standardization has become a well-known process in the work of land administrations and land registries. In both paper-based systems and computerized systems, standards are required to identify objects, transactions, relationships between objects (e.g., parcels, generally referred to as spatial units) and persons (e.g., citizens, legally referred to as subjects and generally referred to as parties), classification of land use, land value, map representations of objects, and so on. Computerized systems require further standardization when topology and the identification of single boundaries are introduced. In existing Land Administration Systems (LASs) and land registries, standardization is generally limited to the region, or jurisdiction, where the land administration (including cadastre and/or land registry) is in operation. Open markets, globalization, and effective and efficient development and maintenance of flexible (generic) systems, require further standardization.

Land surveying is the process of determining the three-dimensional position of a fixed point on Earth relative to a certain reference frame. High accuracy positioning has been called by the land mapping and surveying community ever since GPS's initial adoption to achieve centimeter level accuracies. Techniques to fix carrier phases and subsequently, redacting the measurements error exist, but are limited to local services. Thus, service operators need to deploy and maintain dense networks of GNSS Reference Stations for providing raw measurements or error corrections to the rover receiver and allowing it to fix ambiguities and achieve the desired positioning accuracy.

HAS are needed by the Land Administration sector for implementing classical institutional services such as parcel subdivision, boundary determination, updates and new insertions in the map, coordinate reference systems update, etc. Therefore, Galileo that began the delivery of its HAS at the end of January 2023 and it is expected that Galileo HAS can lead at the end user in a completely transparent way. Specifically, these corrections will enable the computation of a high-accuracy positioning solution in real-time when processed by an appropriate algorithm in the users' receivers tracking the Galileo E6-B signal.

In this scene, the scope of this paper concerns the development of the survey model based on survey-related requirements that have been set in the context of the revision of the ISO standard 19152 LADM, in order to enhance its surveying functionality. The structure of the rest of the sections is: Section 1 gives an overview of the revision of the LADM and the new parts of the standard, while introducing the survey-related requirements that have been developed in the context of the revision. The next Section describes the conceptual model of the survey model that has been developed and submitted in Committee Draft (CD) of ISO19152-2, that meets the before-mentioned requirements, supporting different survey techniques and explicitly including new concepts, while Section 4 presents the validation of the conceptual survey model using data from the GISCAD-OV pilot campaign, through instance level diagrams. Finally, the last section is devoted to Conclusions and the future steps.

2. ISO 19152:2012 – THE LAND ADMINISTRATION MODEL AND ITS ONGOING REVISION

2.1 LADM revision

Since 2012, the LADM Edition I is extensively being used worldwide (Kalogianni et al., 2021b) and is applicable for various purposes (land-tenure, land management, valuation, marine cadastre, etc.,). However, ISO rules prescribe periodic revision within ISO/TC 211 and therefore, in May 2018 during the 46th Plenary Meeting Week of ISO/TC 211 in Copenhagen, Denmark, the ISO Stage 0 project and the development of the multipart LADM Edition II is ongoing.

Figure 1 depicts the package structure of LADM Edition II, designed in a way that meet the requirements that have been developed in the context of the LDM revision and are presented in Kara et al. (2023). As depicted, the “Party”, “Administrative” and “SpatialUnit” packages are common packages in Part 1 and Part 2. The newly added Packages in Part 3 are “Party Group” and “Source Group”, in Part 4 the “Valuation Information” Package is introduced, while in Part 5 the “Spatial Plan Information” Package. For the common packages, in Part 1 the terms defined in these packages are only introduced, while the detailed description of these packages is included in Part 2. The “Generic Conceptual Model” package, which contains the basic requirements on which each part of Edition II is based, is included in Part 1, while the “Survey and Representation” subpackage is specified in Part 2 (Kara et al., 2023).

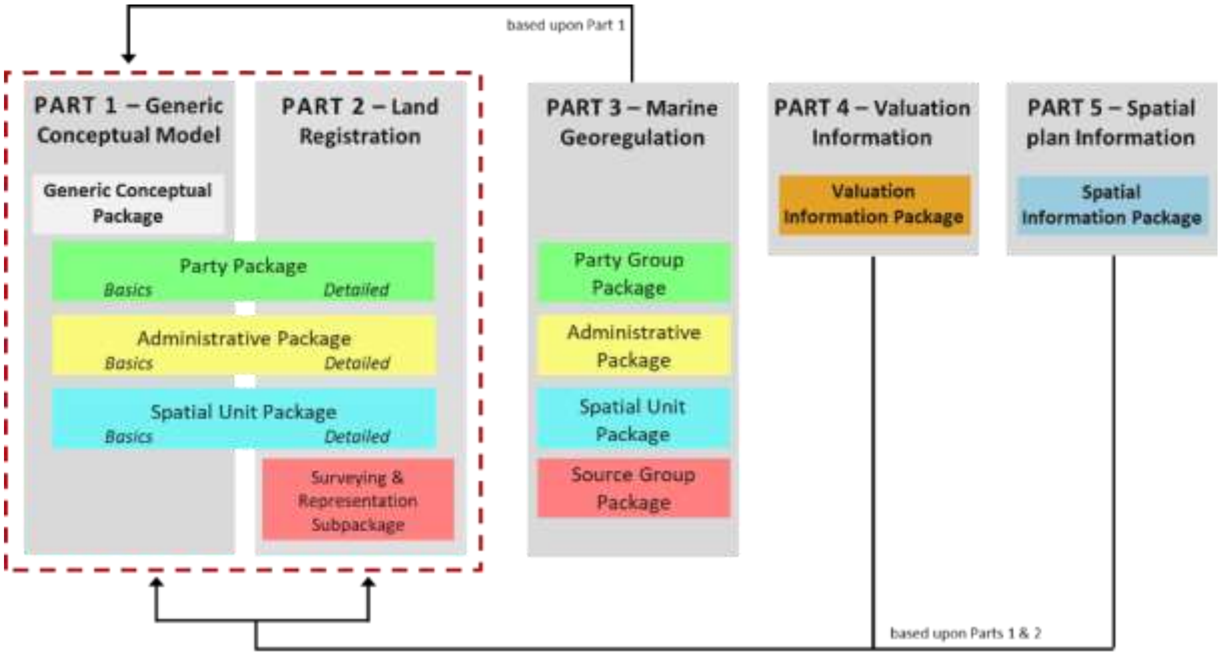

Figure 1. *Packages of LADM Edition II Parts*

2.2 Survey-related requirements for LADM Edition II- Part 2

At the structure of the second edition of LADM and the definition of the (operational) capabilities of this new edition, particular attention is given to the requirements and the design-related decisions taken in the revision process. For acceptance of the standard during all the respective stages of the ISO standardisation process, interaction is needed with its future users, inside and outside the ISO TC 211 committee. The standard should meet users' requirements, which may change over time and for this reason, new Editions of the LADM need to be developed periodically. At the ISO approach of the standards' development, standards should include a set of requirements, which form the basis for the scope/content of the standard, and which are further used to specify an abstract test suite. The packages of the Parts of the second Edition of the standard are being updated and the new ones developed, based on the respective requirements, which are presented by Kara et al., 2023.

Among others, at the requirements defined for Part 2, there are some that refer to the surveying model and are presented at the table below. It is noted that the coding and the numbering of the first four requirements, are those proposed within the ISO revision process. The last two requirements have been added as conclusions drawn from the activities performed in Task 6.1 of the H2020 GISCAD-OV project (Requirements 1-01 and 1-02).

Table 1. *The proposed survey-related requirement for LADM Edition II - Part 2*

Requirement	Description
Requirement 2-12 SurveyBasedMaps: Cadastral maps should be based on surveys	Cadastral maps shall be based on cadastral surveys including distance, level, image, angular, GNSS, total station, ground penetrated radar, multibeam echo sounding, as well as point cloud observations.
Requirement 2-13 DataAcquisitionMethods: Different data acquisition methods can be used to identify boundaries of spatial unit(s)	Various data acquisition and surveying techniques shall be supported. Cadastral boundary should be included in relation to 'Object' in the Triple (Object-Right-Subject). Surveys may concern the identification of boundaries of spatial units on a photograph, an image, or a topographic map. In all cases the representation of 'legal' reality should be distincted from the 'physical' reality. Depending on the local situation, different registrations or recordings of land rights are possible.
Requirement 2-14 CadastralReferenceSystem: Cadastral surveys should be represented in a reference system	Efficient LASs compatible with this part of LADM shall be capable of producing coordinates, forming an essential component of cadastral systems. Provisions should be made to accommodate future changes in the network that may occur as a result of technical improvements. These may affect all coordinate-based systems. Imagery can be used depending on the user requirements, cost, and timing among other factors. It should be possible to include all documentation on data collected as evidence from the field.
Requirement 2-15 DataQuality: Quality of cadastral data should be specified	The cadastral information shall be as complete as possible, reliable (which means ready when required), and rapidly accessible. Users of cadastral information need clarity, simplicity and speed in the registration process. Consistency between spatial and legal administrative data is important. Topology integrated with geometry and other attributes is relevant. The system must be ready to keep the information up to date. Data quality of spatial data may be improved in a later stage of development of a LAS, this has to be documented. For combined data products from different sources the quality descriptions and meta data related to the original data are relevant in relation to liability and information assurance.
Requirement 1-01 Model simplicity: The data model describing	The conceptual model that describes the data acquisition for cadastral surveying purposes shall be coherent, complete and simple, in order to be used.

the surveying process should be simple.	
Requirement 1-02 GNSS corrections: GNSS corrections should be supported	The various types of GNSS correction sources, that all provide information that improves GNSS performance and precision, shall be efficiently supported.

3. SPATIAL UNIT PACKAGE AND SURVEYING AND REPRESENTATION SUB-PACKAGE OF ISO19152-2

As reported also by Kalogianni et al. (2021a) the survey model of the LADM Edition I is being further refined 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. What is more, the refinement is needed as the first Edition of the LADM refers to ISO 19156:2011 Observations and Measurements, in a very generic form and therefore, a refined model for different survey techniques, which addresses survey related aspects is required. To facilitate a comprehensive spatial description of the survey components, the refined version includes an improved link to ISO 19156:2011. Specifically, the option to store the geometry of a spatial unit and not the topological relationship is addressed through the new attribute geometry GM_Object at the LA_SpatialUnit class.

In this scene, the survey model has constantly been updated in the context of the LADM revision and the H2020 GISCAD-OV project, while the various versions of the survey model has been published in proceedings of international conferences and peer-reviewed journals (Shnaidman et al., 2019; Kalogianni et al., 2021a; 2021b; 2022) in order to also consider the feedback of the experts' and the community.

Considering the broader scope of the revised version of the standard and the need to support the description of a wide range of spatial unit types, the categories of the legal spaces of cadastral objects (Edition I: LA_LegalSpaceBuildingUnit and LA_LegalSpaceUtilityNetworkElement) are enriched, with two newly added subclasses at the LA_SpatialUnit, the LA_LegalSpaceCivilEngineeringElement and the LA_LegalSpaceParcel (**Figure 2**). The first class of the new ones added serves a reference to the physical (technical) description of the different types of infrastructure objects (i.e. tunnels, bridges, etc.), while the second to the parcel surface.

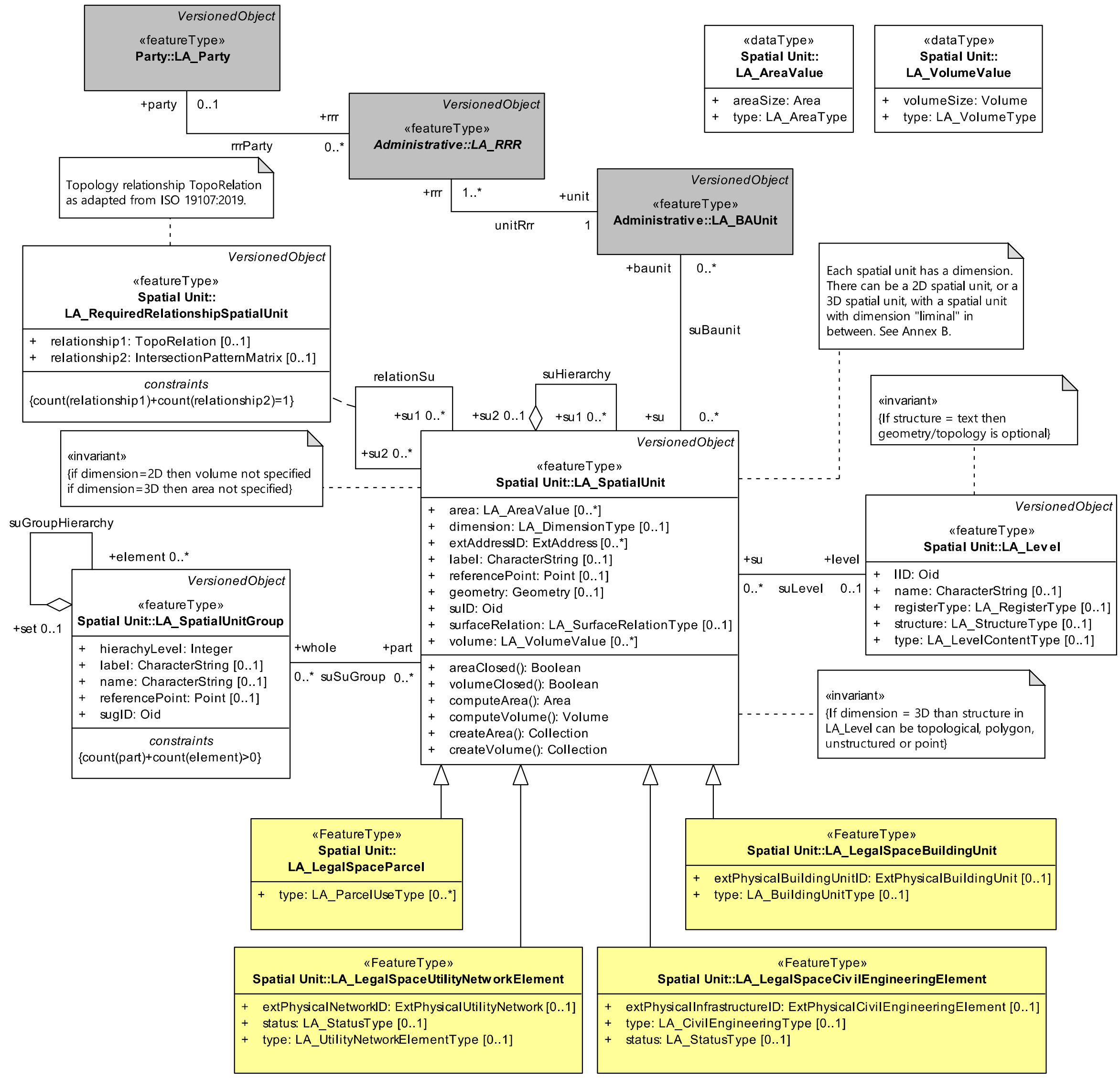

Figure 2. *Content of Spatial Unit Package with associations to other basic classes*

Regarding the refinement of the spatial source content (and therefore the class LA_SpatialSource) in order to provide explicitly more efficient support at the surveying functionality of the standard, two new subclasses are added. The LA_SpatialSource class as defined in LADM Edition I, is being updated and extended (Figure 3). Specifically, the attributes of the class are now defined as follows: *type* (defining the type of the source, that was already an existing attribute in Edition I, but the code list values are extended), *media* (portraying the source related to media type), *automationLevel* (illustrating the assorted process automation level types) and *surveyPurpose* (including all the individual survey purpose types).

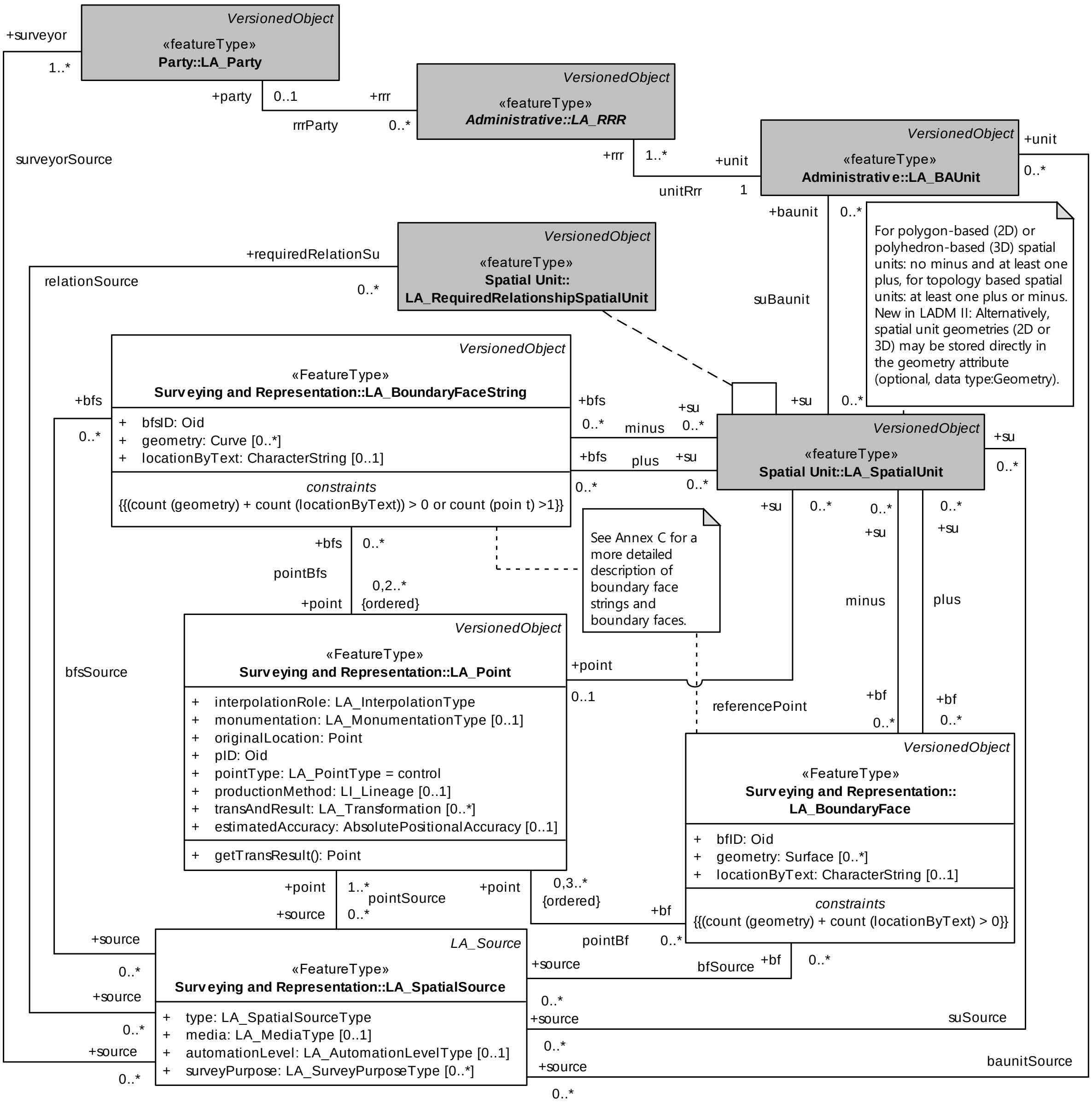

Figure 3. *Basic Classes of Surveying and Representation Sub-package as submitted in CD of ISO19152-2 (1)*

The class LA_SurveySource is one of the subclasses of class LA_SpatialSource and describes a set of measurements such as distances, bearings, GNNS observations etc., which may be obtained via various survey techniques and stored on designated media (see **Figure 4**). It is noted that the class LA_SurveySource and some of its subclasses and code list values are adapted/ inspired from OGC's LandInfra/InfraGML (OGC, 2016). The second subclass of class LA_SpatialSource is the class LA_DesignSource and refers to a source from the design phase of the lifecycle that enables information reuse (see **Figure 4**).

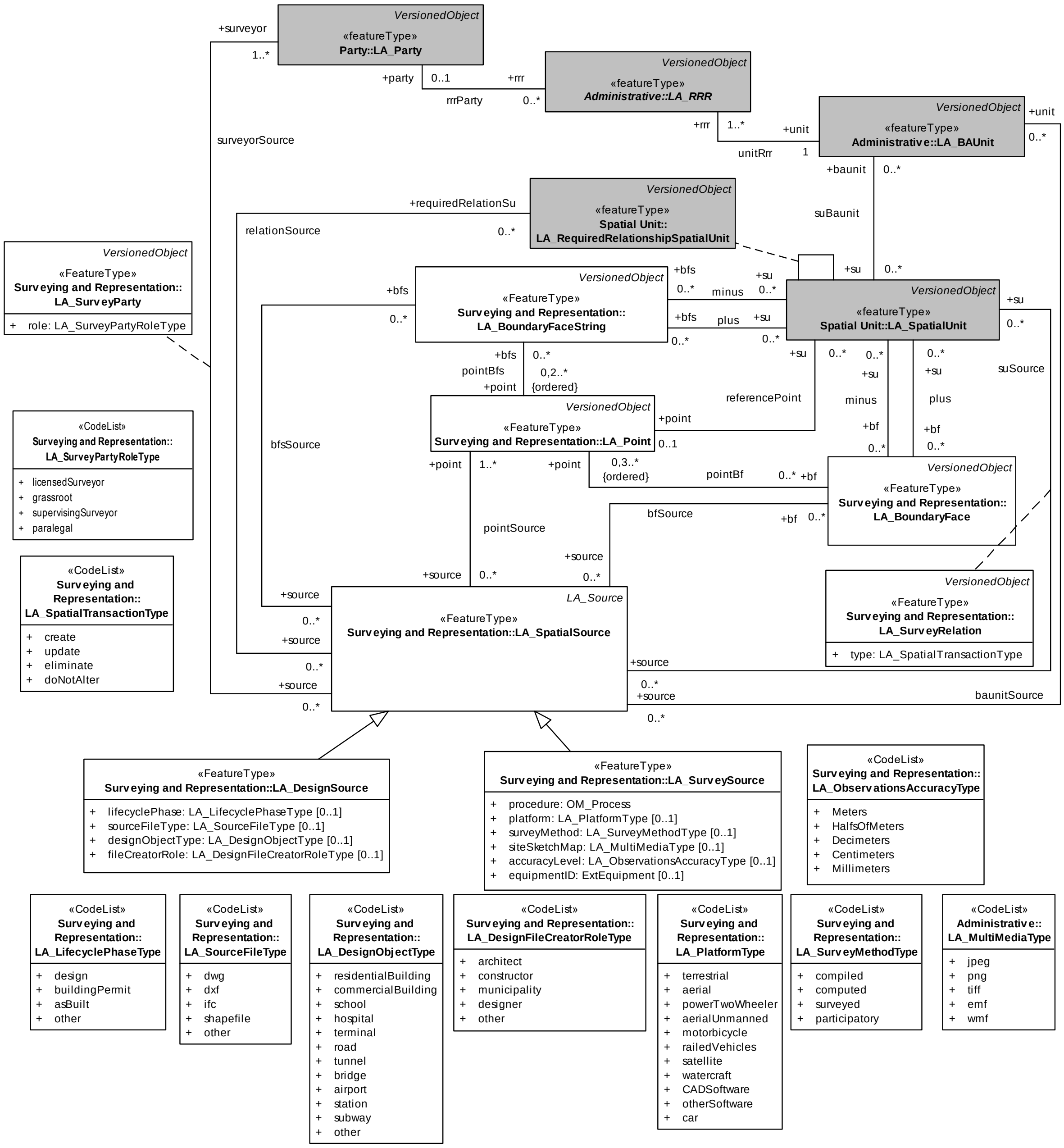

Figure 4. *Basic Classes of Surveying and Representation Sub-package as submitted in CD of ISO19152-2 (2)*

What is more the association class LA_SurveyParty is introduced, as an association class between LA_Party and LA_SpatialSource, presenting the role of the party in the spatial data update and maintenance process. In this scene, to give more insights about the type of spatial transaction, the association class LA_SurveyRelation between LA_SpatialSource and LA_SpatialUnit, is introduced.

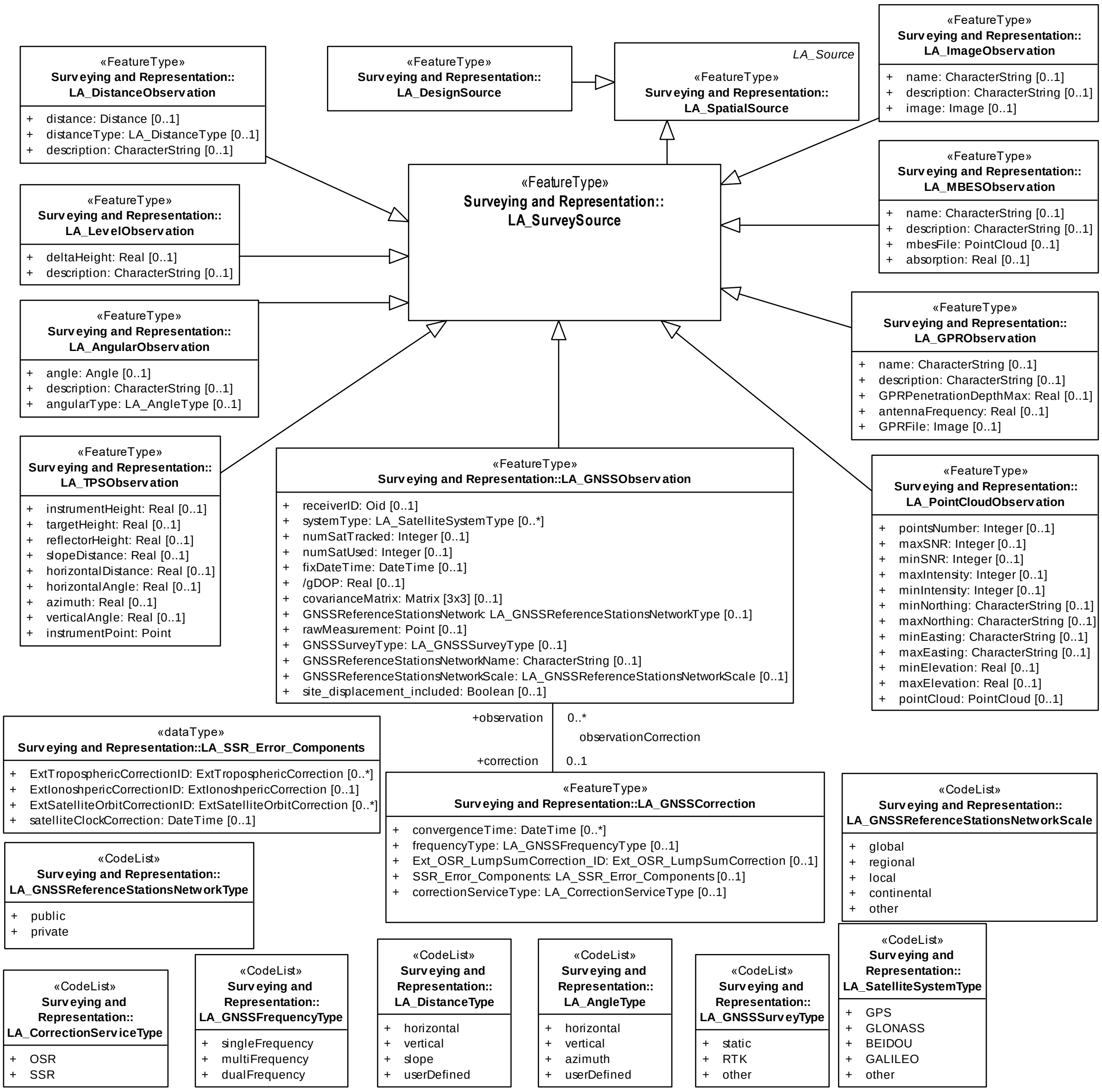

Figure 5. *Basic Classes of Surveying and Representation Sub-package as submitted in CD of ISO19152-2 (3)*

To provide additional functionality nine (9) subclasses are added at the LA_SurveySource, representing the different methods for observations' acquisition (**Figure 5**):

- LA_DistanceObservation referring to distance observations;
- LA_LevelObservation concerning level observations;
- LA_AngularObservation referring to angular measurements;
- LA_ImageObservation for image-based observations obtained by aerial images, satellite, oblique, etc.;
- LA_TPSObservation observations obtained by using total-station;

- LA_PointCloudObservation for point clouds observations obtained by Lidar and other equipment;
- LA_GNSSObservation obtained by using GNSS receivers;
- LA_GPRObservation obtained by ground penetrated radar and
- LA_MBESObservation obtained by multibeam echosounder.

To explicitly support the corrections of the GNSS measurements, a subclass of the LA_GNSSObservation, the LA_GNSSCorrection is introduced and contains all the data related to the corrections of GNSS observation. The development of the model has taken into account the requirements presented in Table 1. In order to test whether a specific application schema (i.e. a country profile) is conformant with the LADM, an abstract test suite is included in annex A – Abstract Test Suite of ISO19152-2, in conformance with ISO 19105. Testing whether a specific data set is conformant, means checking the data set content against the corresponding conformant LADM application schema (package and level). For each one of the three packages and one subpackage of the LADM a conformance test is specified and there are three conformance levels per (sub)package: level 1 (low level); level 2 (medium level) and level 3 (high level). For all the requirements presented in Table 1, a test case identifier is defined concerning the test method and purpose.

4. VALIDATION OF THE PROPOSED SURVEYING AND REPRESENTATION SUB-PACKAGE OF ISO19152-2

4.1. Two real-world cadastral survey cases

To validate the proposed developments on the Survey Package and the Surveying and Representation Sub-package, real-world data from the pilot campaigns of the H2020 GISCAD-OV project were used.

Specifically, the results from one of the pilots that took place at an urban setup in Germany from 19-22 September 2022, and the results from one site/ building surveyed in Estonia at the beginning of December 2022 are presented. For each one of those, the corresponding instance level diagrams from the conceptual model have been created and presented in Figure 6 and Figure 9 respectively.

The first instance level diagram refers to the cadastral survey that took place at an urban setup, measuring a parcel, situated outside of Olpe in North Rhine-Westphalia, in the grasslands. There are two types of measurements acquired, where:

- the points were only measured with PPP-RTK method, when the conditions were not good enough, in terms of limited satellite availability and
- the measurements were collected with both PPP-RTK and Galileo HAS. It is noted that the datasets were acquired using the GPS-Galileo multi-constellation (9 GPS and 6 Galileo satellites).

For both cases, the data collected in the field were then processed and analysed. Additionally, to the data collected from GNSS measurements, data from other sources have been collected, mainly:

- The Height model from Olpe: From the Geobasis from North Rhine- Westphalia, provided by the German governmental district of Cologne, a height model was used. The Digital Terrain Model (DTM) was used to derive the z-coordinates from the points of interest, or double check them.
- The 3D building model for Olpe: An open dataset 3D building model for Olpe in Level of Detail 2 (LoD2) was obtained from the (Geobasis NRW) in OGC CityGML format. The tileset contained the area of the urban parcel.

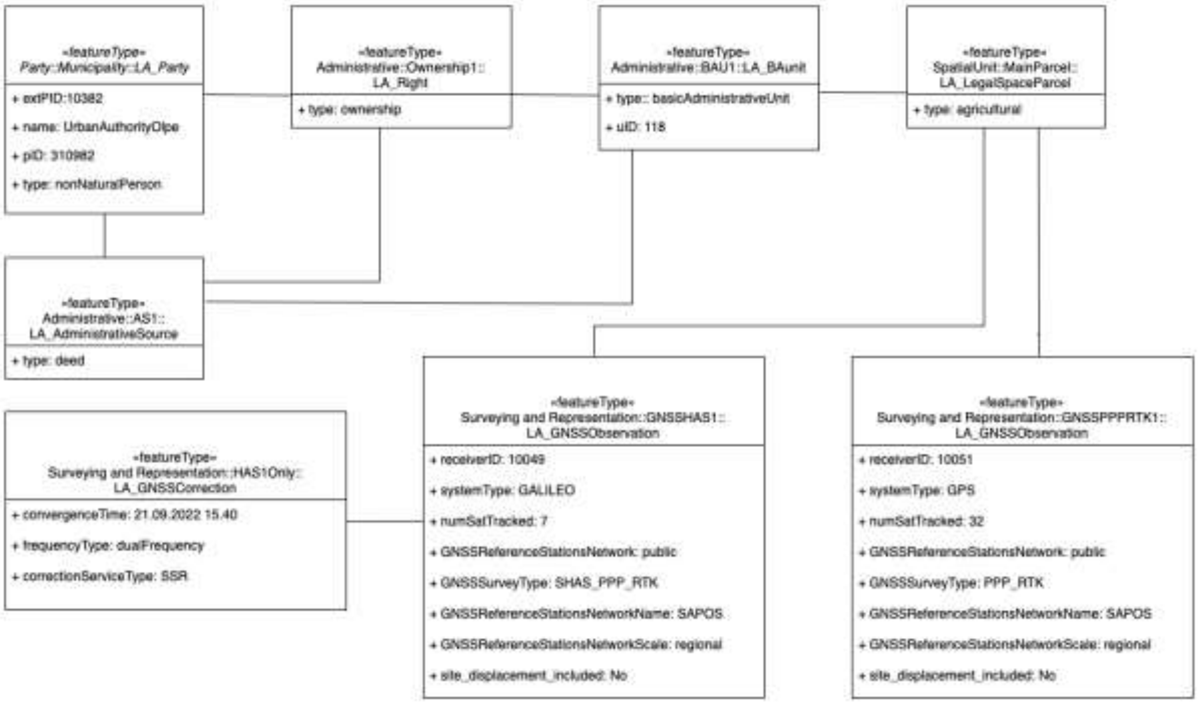

Figure 6. *Instance level diagram for one pilot parcel in Olpe, Germany where datasets acquired using Galileo HAS.*

The next and last pilot of the H2020 GISCAD-OV project took place in the city of Tallinn, Estonia, where the same procedure for the GNSS measurements and Galileo HAS measurement was followed as at the pilot in Germany. In this case, the plot where the building of the Cultural Center is located was measured.

Additionally, to the data surveyed in the field, the as-built model has been provided by the Municipality of Tallinn, in IFC format (BIM) and was used in combination with the observation collected form the Galileo only measurements. The purpose of the survey was to reconstruct a boundary and for that reason, Galileo only measurements and Galileo HAS corrections are used. The following instance level diagram validates the proposed survey model, while it also validates the concept of integrated source (both administrative and spatial sources), and the reuse of information from design sources, and specifically reusing the ‘asBuilt’ file.

Figure 7. Pilot execution at the plot where the Kaja cultural centre of Tallinn, Estonia is located

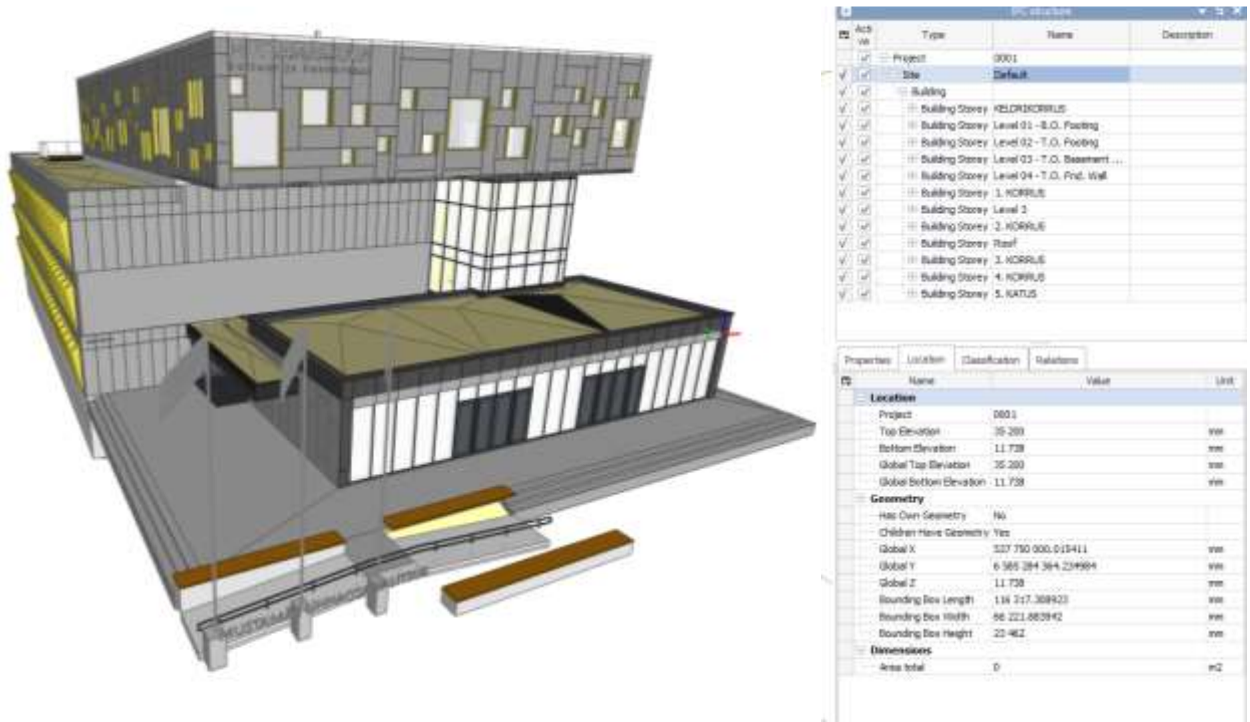

Figure 8. The BIM file for the Kaja cultural centre of Tallinn, Estonia

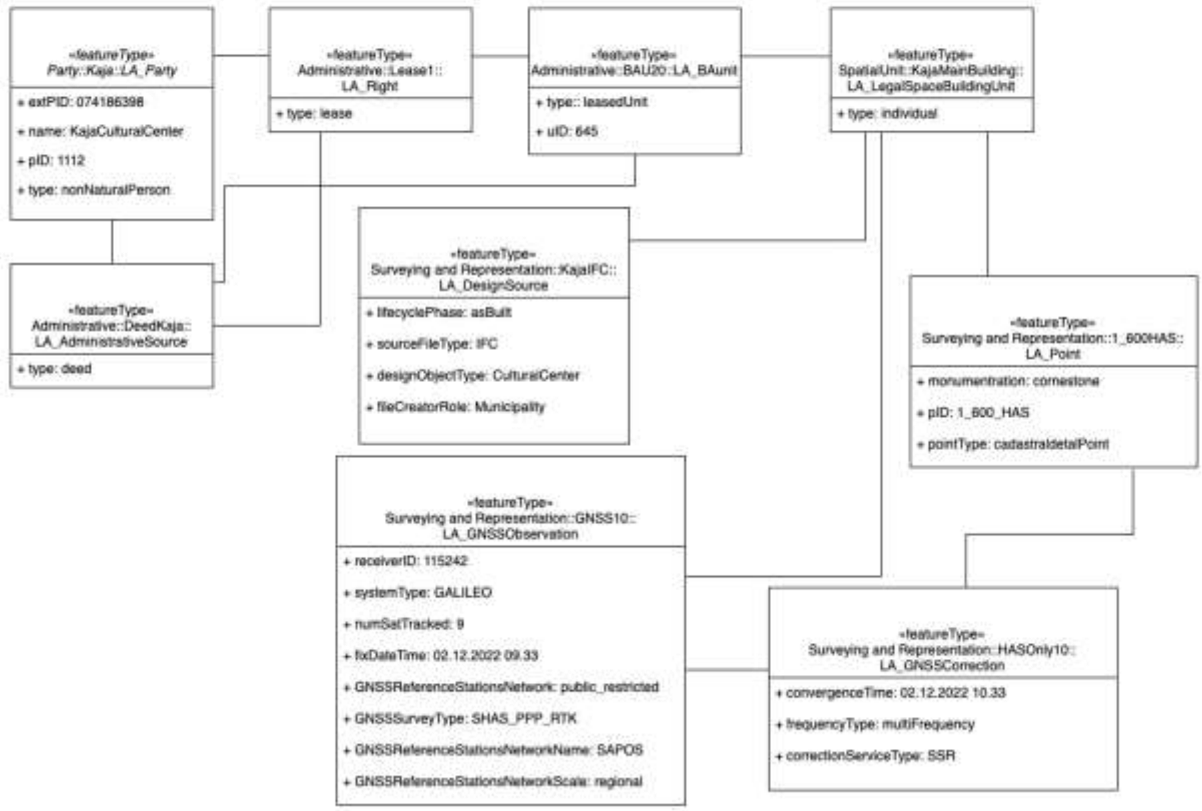

Figure 9. Instance level diagram for the plot of the Kaja cultural centre of Tallinn, Estonia

4.2. Evaluation of real-world cadastral survey cases' validation

From the creation of the instance level diagrams it occurs that the proposed model meets the needs of cadastral surveying, also supporting GNSS corrections. Data from two countries, with different legislative framework and Land Administration System, acquired for various cadastral purposes validate the conceptual model. From the implementation of those use cases, the evaluation of the proposed refined survey model is explicit meaning that there are no attributes missing, all data that has been obtained or calculated and need to be modelled have been modelled, while the relationships fitted the real survey.

It has been noticed that for the case that not all attributes related to the correction/quality of GNNS corrections could be directly obtained from the results of the survey, but need to be recalculated in the back-end and perform analysis, this does not affect the model, as the Galileo HAS have very recently been operated, it is expected that it is a matter of time that the software and equipment providers will improve and develop the relevant products that will allow the explicit derivation of such attributes.

5. CONCLUSIONS AND FUTURE WORK

The paper presents the latest advances related to a more detailed survey model with support to Galileo HAS, in the context of LADM revision and specifically ISO19152-2 (Land Registration). Starting with the definition of survey-related requirements that shall be taken into account during the modelling procedure of the surveying part, which are generic that can apply to international context and at the same time are fundamental for the development of a detailed and comprehensive survey model. Those requirements are a demand for acceptance of the ISO standard during all the respective stages of the standardisation process within ISOTC 211.

Therefore, the latest version of the Survey Package and the Surveying and Representation Sub-package, as submitted at the CD of ISO19152-2, are presented into detail. Specific attention is given at the new class proposed to explicitly document the various GNSS corrections (LA_GNSSCorrections), which also includes the support to the newly operating Galileo HAS. The model is validated through the data of two pilots that took place in Germany and Estonia in the context of H2020 GISCAD-OV, proving that the classes and the attributes that have been modelled are being used when executing cadastral surveying measurements using Galileo HAS.

As the presented developments have been submitted to the ISOTC211 committee working on the ISO19152-2 and the discussions with the community is an ongoing and dynamic process, the next steps include the revision of the model according to the comments received by the country members that participate in the process. What is more, the data from the rest of the five (5) pilots that took place in various European countries will be used to further test the model, also validating that it can be used in different countries based on various legislative frameworks and land administration systems and for a number of cadastral surveying purposes.

ACKNOWLEDGEMENTS

This publication is part of the project GISCAD-OV that has received funding from the European GNSS Agency under the European Union’s Horizon 2020 research and innovation programme under grant agreement No. 870231.
The authors would like to thank the Municipality of Tallinn for providing the as-built file of the Kaja Cultural Center in Tallinn in IFC format.

REFERENCES

ISO. ISO 19152:2012. (2012). Geographic Information–Land Administration Domain Model (LADM); International Organisation for Standardisation: Geneva, Switzerland, 2012.

Kalogianni, E.; Dimopoulou, E.; Gruler, H.C.; Stubkjaer, E.; Lemmen, C.H.J. and van Oosterom, P.J.M. (2021a) Developing the refined survey model for the LADM revision supporting interoperability with LandInfra. In: Proceedings of the FIG e-Working Week 2021: Challenges in a new reality.

Kalogianni, E., Janecka, K., Kalantari, M., Dimopoulou, E., Bydłosz, J., Radulovic, A., Vucic, N., Sladic, D., Govedarica, M., Lemmen, C.H.J., van Oosterom, P.J.M. (2021b). Methodology for the development of LADM country profiles. Land Use Policy 105.

Kalogianni, E., Gruler, H.C., Bar Maor, A., Harold, B., Lemmon, T., Lemmen C.H.J., van Oosterom, P.J.M. (2022). Investigating the Requirements for the ISO 19152 LADM Survey Encodings. 10th International FIG workshop on the Land Administration Domain Model, 31 March - 2 April 2022, Dubrovnik, Croatia.

Kara, A., Lemmen, C.H.J., van Oosterom, P.JM., Kalogianni, E., Abdullah, A., Indrajit, A. (2023). Functionality of the Edition II of the Land Administration Domain Model. LUP (during review process).

Lemmen, C.H.J., Abdullah, A., Indrajit, A., Kalogianni, E., Kara, A., van Oosterom, P.J.M., Oukes, P. (2021). The Foundation of Edition II of the Land Administration Domain Model. In: Proceedings of the FIG Working Week 2021, Online, pp. 17.

OGC (2016). OGC®Land and Infrastructure conceptual model standard. Document No. 15-111r1; 2016.

Shnaidman, A.; van Oosterom, P.J.M. and, Lemmen C.H.J. (2019) LADM Refined Survey Model. In: Proceedings of the 8th International FIG workshop on the Land Administration Domain Model.

BIOGRAPHICAL NOTES

Eftychia Kalogianni is a PhD candidate in the 'GIS Technology' Chair, Digital Technologies Section, Faculty of Architecture and the Built Environment, Delft University of Technology, the Netherlands. Her PhD research topic is about adopting a holistic approach to treat 3D Land Administration Systems within the spatial development chain, in the context of LADM ISO 19152 revision. She holds MSc in Geoinformatics from NTUA and MSc in Geomatics from TUDelft.

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 database. Since 2000, he is Professor at Delft University of Technology, and head of the 'GIS Technology' Chair, Digital Technologies Section, Faculty of Architecture and the Built Environment, Delft University of Technology, the Netherlands. He is the current chair of the FIG Working Group on '3D Cadastres' and co-editor of the International Standard for Land Administration Domain, ISO 19152.

Dr.-Ing. Martin Schmitz received his PhD in geodesy from the University of Hannover, Germany. He has been working in the field of GNSS since 1991 and is involved in research and development of precise GNSS positioning with a focus on RTK networks and SSR technology, antenna and station calibration. He is a member of working groups of the IGS and RTCM.

Dr Roberto CAPUA is Senior Manager at Sogei' Digital Laboratory and Research and is currently the Chairman of the RTCM SC-134 Committee.
Edward VERBREE received the M.Sc. degree in geodesy from the Delft University of Technology, in 1992. Since 1997, he has been working as an Assistant Professor with the GIS Technology Department, Delft University of Technology. His research interests include tetrahedralizations, tessellations, surface reconstruction, explorative point clouds, location awareness, and indoor positioning.

Prof. Dr.-Ing. Efi Dimopoulou is Full Professor at the School of Rural, Surveying and Geoinforematics Engineering, N.T.U.A., in the fields of Land Administration (LA), Spatial Information Management (SIM), 3D Cadastres and 3D Modelling. President of the Hellenic Society for Geographical Information Systems (HellasGIs, 2014 - 2016). Programme Director of the N.T.U.A. Inter-Departmental Postgraduate Course «Environment and Development». She has participated in 27 funded Research Projects, in Scientific Committees and FIG Commisisons on "3D Land Administration and Standardisation". She has published 3 books; she authored or co-authored more than 120 papers in scientific journals and reviewed conference proceedings and editorials. She chaired International Conferences and Workshops and she is PC-member and chairman session in many international congresses and scientific events.

Hans-Christoph Gruler is the representative of Leica Geosystems, part of Hexagon 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.

Erik Stubkjær is emeritus professor, having served as professor of Cadastre and Land Law at Department of Development and Planning, Aalborg University 1977 - 2008. He has published more than 120 papers, including 'Doctoral research on cadastral development' with Prof. Dr. Volkan Çağdaş, Yildiz Technical University, Turkey. He is engaged in standardization activities, contributing to the OGC standards LandInfra and InfraGML and is co-author of the Cadastre and Land Administration Thesaurus (CaLAThe), issued 2011 and now referenced by 'The Basic Register of Thesauri, Ontologies & Classifications (BARTOC)', 'The OGC Definitions Server', and 'The Linked Land Governance Thesaurus (LandVoc)'.

Ivars Nudiens obtained an MSc in Geodesy and Cartography in 2008 from Riga Technical University, Latvia. Almost 20 years he works in field of geodesy and land surveying in company Ģeodēzists, recently as Technical director. He becomes certified geodesist in 2011. Since 2020 Ivars Nudiens involved in GISCA-OV project as Chief Technical Officer from CLGE to coordinate and conduct pilot project surveys and data collection in the European partner countries, validate results, contribute to standardization and regulation.

Dr Javier Morales Guarin is Assistant Professor in GeoWeb Architectures at the at the Faculty of GeoInformation Science and Earth Observation of the University of Twente in the Netherlands. His expertise is in systems and software engineering, spatial databases & Web development. He has extensive experience in executing land administration projects.

Prof. Dr.-Ing. 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. He is co-editor of the International Standard for the Land Administration Domain, ISO 19152. He is co-chair of the Land Administration Domain Working Group of the Open Geo Spatial Consortium.

CONTACTS

Ing. Eftychia Kalogianni
PhD Candidate, Delft University of Technology
Faculty of Architecture and the Built Environment
Julianalaan 134, 2628 BL, Delft, THE NETHERLANDS
E-mail: E.Kalogianni@tudelft.nl
Website: http://www.gdmc.nl

Prof. Dr. Peter van Oosterom
Professor, Delft University of Technology
Faculty of Architecture and the Built Environment
Julianalaan 134, 2628 BL, Delft, THE NETHERLANDS
E-mail: P.J.M.vanOosterom@tudelft.nl
Website: http://www.gdmc.nl

Dr.-Ing. Martin Schmitz
Geo++ GmbH
30827 Garbsen, Germany
E-mail: martin.schmitz@geopp.de
Website: www.geopp.de

Dr. Roberto CAPUA
Sogei, Digital Research Lab Senior Manager
via Mario Carucci 99, 00143, Rome, ITALY
Email: rcapua@sogei.it
Website: www.sogei.it

Edward Verbree
Delft University of Technology
Faculty of Architecture and the Built Environment
P.O. Box 5030, 2600 GA Delft, THE NETHERLANDS
E-mail: E.Verbree@tudelft.nl
Website: http://www.gdmc.nl

Prof. Dr.-Ing. Efi Dimopoulou
Prof. National Technical University of Athens
School of Rural, Surveying and Geoinformatics Engineering

9, Iroon Polytechneiou, 15780, Zografos, GREECE
Email: efi@survey.ntua.gr

Hans-Christoph Gruler
Leica Geosystems AG,
9435 Heerbrugg, SWITZERLAND
Email: hans-christoph.gruler@leica-geosystems.com
Website: http://www.leica-geosystems.com

Prof Dr. Erik Stubkjær
Professor Emeritus, Department of Planning, Aalborg University
Rendsburggade 14, DK-9000 Aalborg, DENMARK
E-mail: est@plan.aau.dk
Website: https://vbn.aau.dk/en/persons/erik-stubkjaer

Prof. Dr.-Ing. Christiaan Lemmen
Faculty of Geo-Information Science and Earth Observation/ITC
P.O. Box 217, 7500 AE Enschede, THE NETHERLANDS
E-mail: C.H.J.Lemmen@utwente.nl
Website: https://www.itc.nl