

# Annual Report 2020

## About EuroSDR

EuroSDR - formerly known as OEEPE - is a not-for-profit organisation linking National Mapping and Cadastral Agencies with Research Institutes and Universities in Europe for the purpose of applied research in spatial data provision, management and delivery. The result is a network of delegates, effectively and practically addressing Europe's spatial data research requirements. EuroSDR also organizes, in collaboration with related organisations, international workshops and courses which address key issues in a timely and focused manner.

## Vision

EuroSDR is the recognised provider of research-based knowledge to a Europe where citizens can readily benefit from geographic information. Our mission is to develop and improve methods, systems and standards for the acquisition, processing, production, maintenance, management, visualization, and dissemination of geographic reference data in support of applications and service delivery.

## Our Member States and their Prime Delegates (2020)

<b>Austria</b>	Wolfgang Gold	Bundesamt für Eich- und Vermessungswesen
<b>Belgium</b>	Eric Bayers	Institut Géographique National Belgique
<b>Croatia</b>	Ivan Landek	Državna Geodetska Uprava
<b>Cyprus</b>	Andreas Sokratous	Tmima Ktimatologiou Kai Chorometrias
<b>Denmark</b>	Jesper Weng Haar	Styrelsen for Dataforsyning og Effektivisering
<b>Estonia</b>	Tambet Tiits	Maa-amet
<b>Finland</b>	Juha Hyyppä	Maanmittauslaitos
<b>France</b>	Bénédicte Bucher	Institut National de l'Information Géographique et Forestière
<b>Germany</b>	Paul Becker	Bundesamt für Kartographie und Geodäsie
<b>Ireland</b>	Paul Kane	Ordnance Survey Ireland
<b>Norway</b>	Jon Arne Trollvik	Statens Kartverket
<b>Poland</b>	Adam Andrzejewski	Główny Urząd Geodezji i Kartografii
<b>Slovenia</b>	Dalibor Radovan	Geodetski Inštitut Slovenije
<b>Spain</b>	Julián D. Hernández	Instituto Geográfico Nacional
<b>Sweden</b>	Tobias Lindholm	Lantmäteriet
<b>Switzerland</b>	André Streilein	Bundesamt für Landestopographie
<b>The Netherlands</b>	Jantien Stoter	Technische Universiteit Delft and Kadaster
<b>United Kingdom</b>	Sally Cooper	Ordnance Survey Great Britain

## Our Associate Members and their Representatives (2020)

<b>Esri/nFrames</b>	Nick Land & Konrad Wenzel
<b>Hexagon</b>	Simon Musäus
<b>Informatie Vlaanderen</b>	Jo Van Valckenborgh
<b>Terratec</b>	Leif Erik Blankenberg
<b>Vecxel</b>	Michael Gruber
<b>1Spatial</b>	Dan Warner

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## Message from the President

Michael Hovenbitzer



Members of the executive, fellow delegates,

The past year has presented us with the type of challenge only seen once in a generation. So allow me to preface the EuroSDR annual report for 2020 by wishing continued good health to you and your loved ones. While I am enthusiastic about the year ahead and what we can achieve together, it is important to first look back on what an unprecedented year 2020 was.

The COVID-19 pandemic has not only reshaped the way we live, for better or worse it has also drastically changed the way we work. These challenges and opportunities have put a bigger focus on digital solutions in times of crisis, whether it be the countless geospatial dashboards that were – and still are – a crucial tool in the fight against the virus, or raising public awareness of geospatial information and demonstrating the benefits it can bring.

The downside to this move online however can be most felt in our meetings and workshops, which are now entirely digital. Our two previous in person workshops were on “Crowdsourcing National Mapping” and “Spatial Data Quality”, both in early 2020. As our field is inherently digital, I think it is fair to say we were all well-prepared for these online alternatives. Yet, user and member engagement lie at the core of our activities, so there is no replacement for face-to-face discussions and exchanges. I do hope that we can get back to meeting in person again soon.

Countless projects on topics such as New Lidar technology, Point Cloud Processing, SDI's, Linked Data, Historical Imagery, Remote Sensing and Photogrammetry and GeoBIM shape the way we see things. The renewed focus on AI is more prevalent than ever, but climate concerns are still pressing topics that are not just being discussed in our field but also by the wider public. The European Commission has decided on an ambitious programme to combine these challenges in their Destination Earth initiative. Building on the newest technology and combining areas of expertise, the goal is to develop several digital twins of our planet to better inform the decisions we take – especially on a transnational or even global scale. I believe that EuroSDR could and should make an important contribution to this cause.

I would like to extend my gratitude to all members for their tireless efforts even in these circumstances. Your work lies at the heart of this organisation and shapes it to be more impactful than ever before.

This year has seen several personnel changes. It is with great pleasure that I announce and welcome our new members:

- Gottfried Mandlbürger as academic representative of Austria
- Juha Kareinen as second delegate of Finland
- Evelyn Uuemaa as academic representative of Estonia
- Simon Musäus as new representative of Hexagon

The year 2020 has also seen the retirement of some of our members. On behalf of EuroSDR I would like to express my heartfelt thanks for their commitment and contributions of each of them:

- Norbert Pfeifer as retiring representative of Austria
- Jurkka Tuokko as retiring second delegate of Finland
- Adam Andrzejewski as retiring prime delegate of Poland

- Paul Becker as retiring prime delegate of Germany
- Poul Noergaard as retiring representative of Hexagon

I am honoured to take on the role of president after the capable hands of Ireland's Paul Kane. EuroSDR has gone from strength to strength, and I am enthusiastic about working more closely with everyone.

Once again, I wish you all well and I hope we can get back to seeing each other in person sooner rather than later.

## Message from the Vice-President

Fabio Remondino



Dear friends,

2020 was another intense and prosperous year for EuroSDR which confirmed its leaderships and presence in the geospatial sector through many scientific events, research activities and cooperation with sister organisations. The main research activities of EuroSDR in 2020 dealt with:

- technical development in geospatial data acquisition, processing, updating and visualization;
- integration of Artificial Intelligence methods in the daily processing of geodata;
- use of historical aerial images for territorial mapping and change detection;
- BIM/GIS integration;
- spatial data quality issues;
- crowdsourcing in national mapping.

Some **projects** have been finalized with a scientific report and new projects have been launched, often based on open questions at workshops or breakout sessions at the Board of Delegates meetings. This includes, for example, *“Drone-based point-cloud collection and interpretation”*, *“Benchmark for 3D meshes”*, *“Geo-processing of historical aerial images”*, etc.

In terms of **publications**, there have been some scientific and official publication of EuroSDR, namely the report on *“EuroGeographics/EuroSDR/OGC/ISO TC 211/ICA workshop on Spatial Data Quality”*, the report on the *“Survey on initiatives for providing data and tools for research and education”*, the report on *“Academia-Business survey on needs and cooperation in field of Spatial Data Infrastructures”*, the report on the *“EuroSDR workshop on Crowdsourcing in National Mapping”*.

2020 has also set for all of us new ways of working, doing research and meetings as well as communicating with people. The still ongoing pandemic situation has dramatically changed our habits but has also given us the opportunity to re-think the importance of travels, meetings and being in the office.

But despite COVID-19, 2020 was still a productive and successful year for EuroSDR with many more new research activities, events and educational courses planned for 2021, either virtual or physical!

## Interesting examples of real life practices at NMCAs based on results of existing applied research

### 1. ESTONIAN LAND BOARD IS STARTING PRODUCTION OF 3D DATA ESTONIAN LAND BOARD (HANNO KUUS)

The Land Board provides Estonian society with up-to-date and reliable spatial data. The classical cartographic products of the Land Board (e.g. Estonian Base Map and Estonian Basic Map) were supplemented by increasingly high-quality orthoimages and airborne laser scanning data in the first two decades of this century. By now the technological capabilities have been developed further in order to advance to the next stage and provide a wider assortment of three-dimensional (3D) data.

Creating 3D models of real world objects is made possible by utilizing airborne laser scanning data. Land Board is using the *RIEGL VQ-1560i* for High Point Density and Ultra-Wide Area Mapping. The system is mounted into a Cessna Grand Caravan 208B aircraft and is operated simultaneously with an aerial camera system. In use since 2017, such a setup has enabled to cover the whole country with elevation data at 2.1 p/m<sup>2</sup> in four years. In urban areas the point density is even higher— 18 p/m<sup>2</sup>.

The first 3D dataset was produced by combining laser scanning point cloud with 2D buildings data from Estonian Topographic Database (ETD). 3D representations of buildings, including roof structures (LOD 2) were created with TerraScan and later processed with tools provided by ArcGIS. Attribute data was added to 3D building models by spatial joins to building footprints (ETD) and land parcels, resulting in rich set of semantic data (address, links to different national registries, etc.), as well as appropriate metadata. A less detailed version of geometry (LOD 1) was also created. The final processing steps included creation of Scene Layer Packages and uploading data to ArcGIS Online cloud environment. ArcGIS API for Python have been used to update the 3D models according to changes in ETD and other linked registries.

The data are displayed in 3D viewing application, hosted in ArcGIS Online. The application includes Digital Terrain Model (DTM) and 3D buildings (LOD 1 and LOD 2, over 800 000 objects in both layers). The DTM used in the application has a spatial scale of 1:3 500, and it contains over 2 million tiles. The application also includes point cloud data in the biggest cities, visualized by classification codes. The Esri 3D Basemaps solution was used to generate thematic and analytic trees from the point cloud, and several examples are included in the application as well. A choice of 2D data (base maps, cadastral parcels, land use restrictions) is also provided to complement the 3D objects.

The Geo3D strategic program, initiated by the Land Board, will allow significant expansion of the portfolio of data and services offered by the Board in the coming years. The program, calling for large-scale overhaul of GIS data production and distribution systems, will offer various services using OGC and industry standards for accessing detailed 3D models of buildings and structures, as well as natural objects (e.g. trees). The data and services will be made available to the public step by step, according the advances in data production and processing. The first examples of 3D data were made public through the [3D web map application](#) in March 2021.

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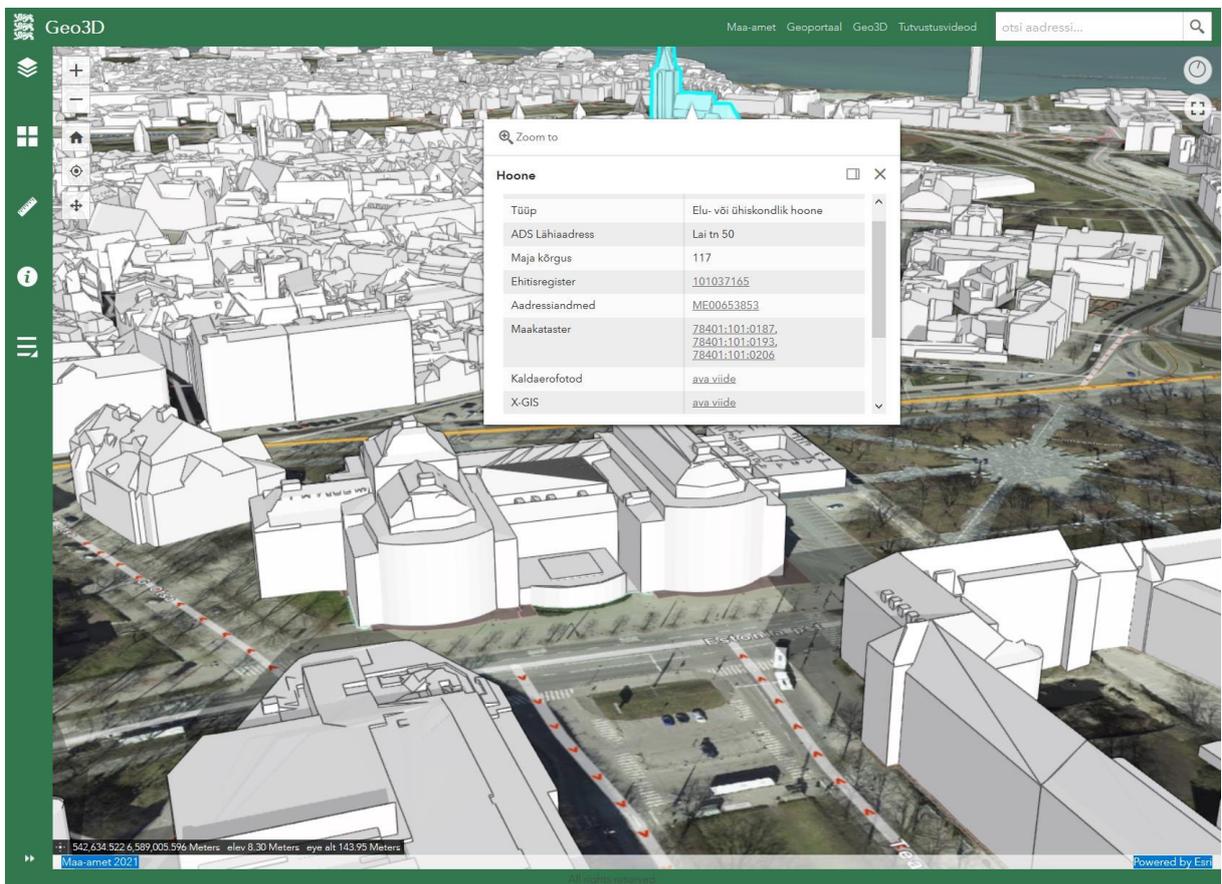
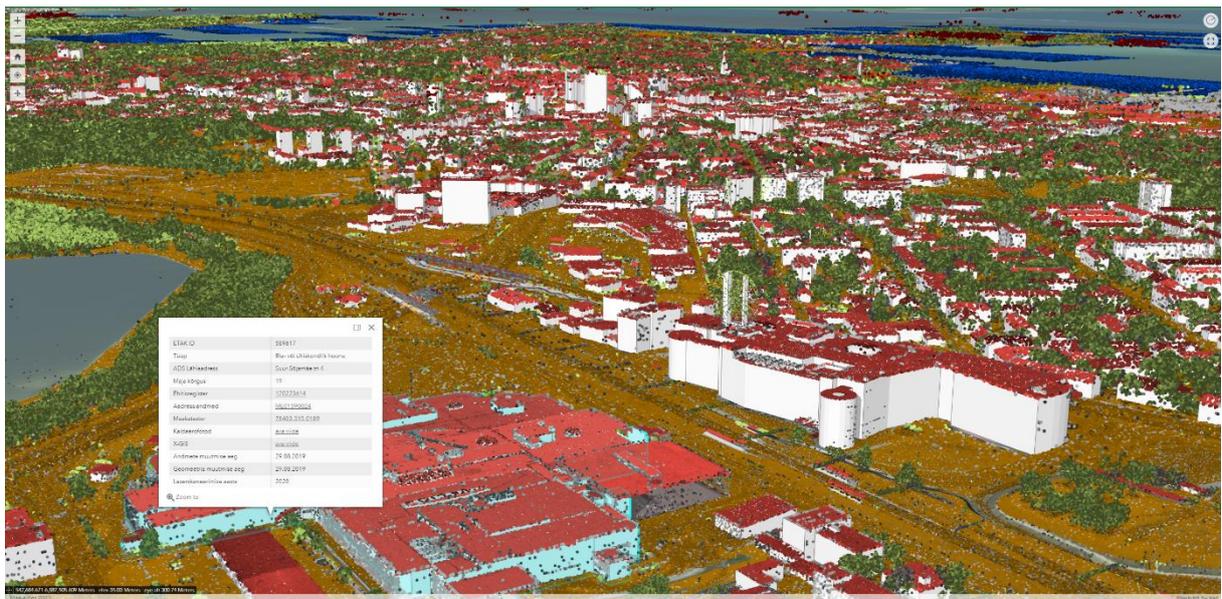
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## 2. NATIONAL FOREST DATABASE PRODUCTION WITH DEEP LEARNING AT IGN FRANCE IGN FRANCE (MATTHIEU PORTE)

The BD Forêt v2 is a reference vector database for the forest space and semi-natural environments covering metropolitan France. It describes forest and natural vegetation formations using a land cover approach giving a description of the stand's cover density, composition and dominant species.

Its production requires to date a large part of human photo-interpretation: the national production of the last version of the BD Forêt was spread over 11 years. In order to allow for more frequent production, the IGN has initiated an overhaul of its production method to integrate the automatic information extraction capacities made possible by advances in remote sensing, particularly by deep learning methods.

These methods, which are capable of extracting statistical regularities from unstructured, very high-dimensional data, such as aerial or satellite images, constitute the state of the art in contemporary remote sensing for land cover analysis. Research work, conducted at LaSTIG, a research lab attached to IGN, has sought to perfect these computer vision methods: in addition to the use of classic convolutional neural network architectures for image analysis, including multi-spectral images, model architectures have been proposed to exploit the Sentinel-2 time series - by exploiting the temporal structure and the low spatial resolution (Garnot et al. 2020). Methodological contributions have also been made to learn hierarchically organised classifications (Garnot et Landrieu 2020).

One of the critical steps in the application of machine learning methods in operational workflows is the formulation of the tasks given to the models. These depend on at least three factors:

- The state of the art of existing algorithm architectures mentioned hereinabove.
- The availability of suitable training data, or the ability to generate new training data. The direct use of historical databases poses significant problems of temporal registration of data, historical availability of some sensors (e.g. Sentinel-2), or over-generalisation of objects in the database for classical deep learning models - therefore the input of specific training data is usually required;
- User criteria with respect to the output, which must be dependent on the user's needs: should we, for example, favour very reliable contour information, regular meshing of the information, etc.?

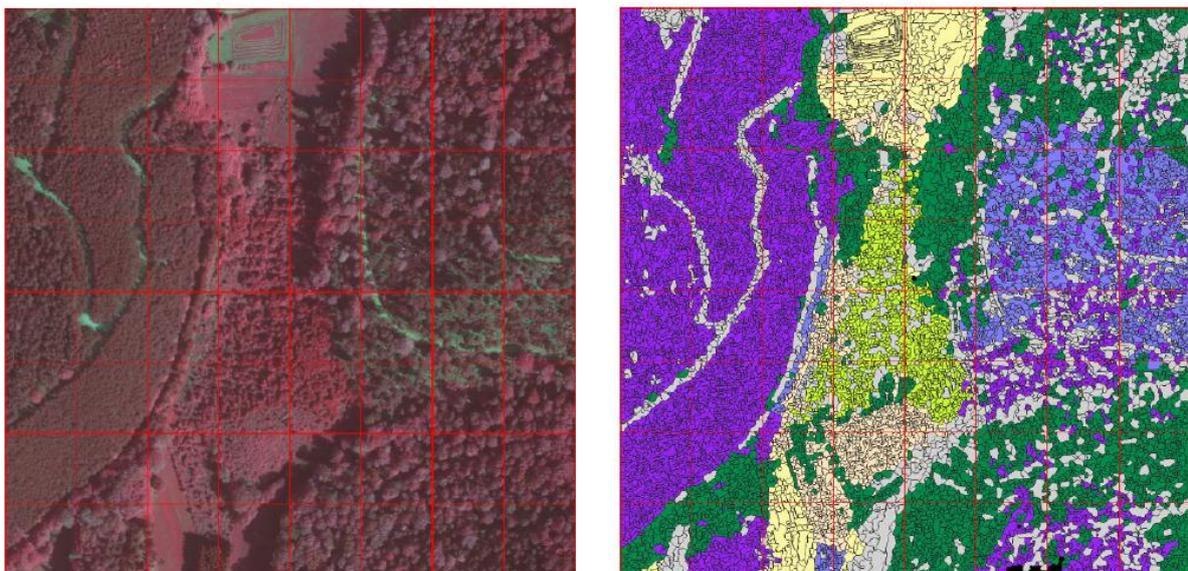


Figure 1: Large-scale ("tree-level") training data annotation

To address all these issues, our workflow automation approach is based on several principles. First, a large number of task formulations are explored and evaluated. Three semantic levels (forest/non-forest, stand composition, dominant species in closed forests) and two task formulations (classification of polygons extracted from a geometric segmentation or semantic segmentation "at the pixel") are systematically crossed. The evaluation is carried out by measuring the quantitative and qualitative performance of the model, the production costs of the training data and the costs of post-processing. Moreover, these different formulations can also correspond to different evolutions of the BD Forêt product specifications, and therefore a collaborative approach is being initiated to expose the productions of artificial intelligence methods associated with the different task formulations and to identify the forms that best meet the needs.

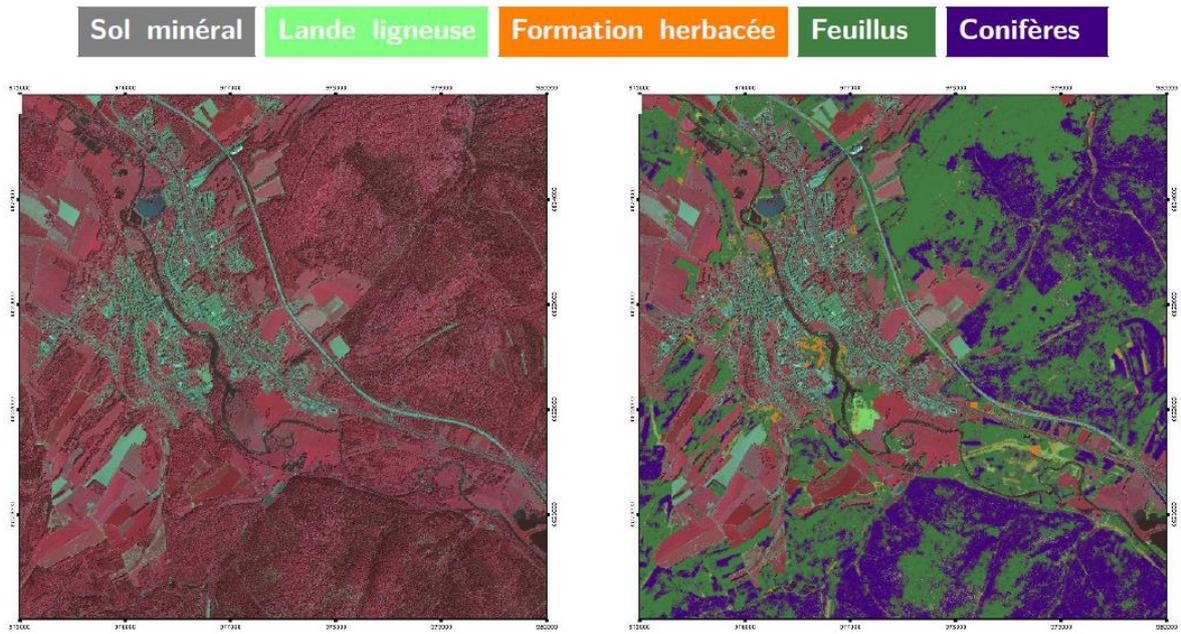


Figure 2: Inference results on the second semantic level

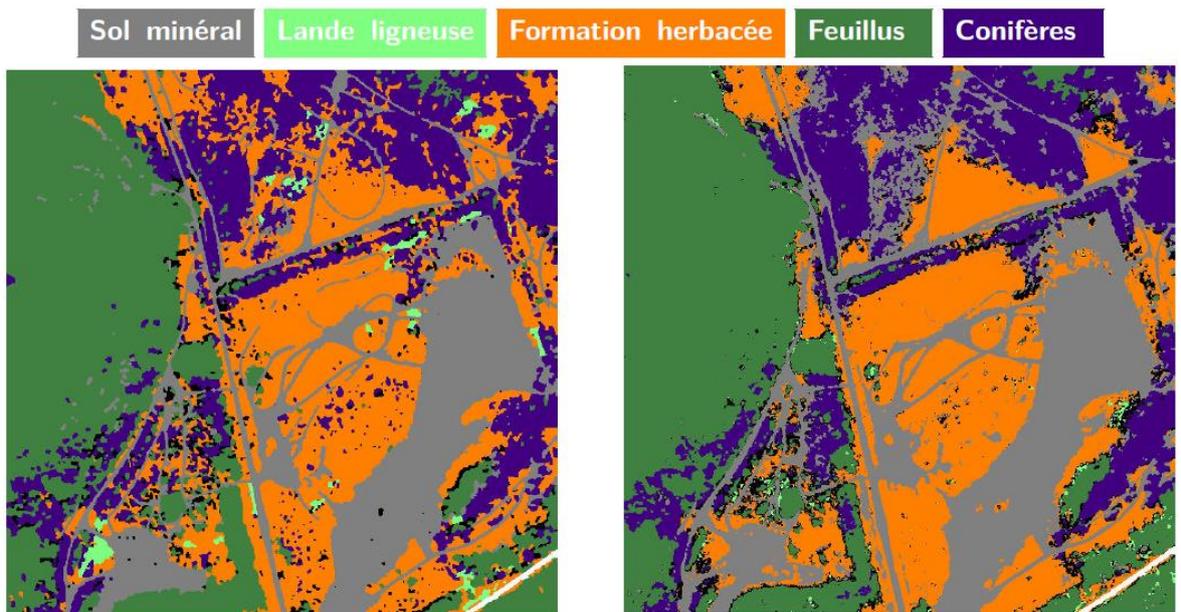


Figure 3: Inference on a sample of test set for the second semantic level. Left: annotation ; Right: Predictions.

This work, which will continue over the next few years, illustrates several success factors for research application projects at IGN, particularly in artificial intelligence:

- The direct circulation of agents between research and applications - the conduct of experiments are led by a former LaSTIG researcher who contributed to the methodological advances mentioned;
- The involvement of "multi-disciplinary" teams, through close collaboration with the product teams and joint work with a forestry expert photo-interpreter, who is the bearer of domain knowledge;
- In return, the ability to formulate new research problems arising during applied studies - in this case, for example, on the proper management of mixture classes in deep learning, on multi-task learning or on the fusion of representations learned by different deep neural networks.

Garnot, Vivien Sainte Fare, et Loic Landrieu. 2020. « Leveraging Class Hierarchies with Metric-Guided Prototype Learning ». *arXiv:2007.03047 [cs, stat]*, octobre. <http://arxiv.org/abs/2007.03047>.

Garnot, Vivien Sainte Fare, Loic Landrieu, Sebastien Giordano, et Nesrine Chehata. 2020. « Satellite Image Time Series Classification With Pixel-Set Encoders and Temporal Self-Attention ». In , 12325-34. [https://openaccess.thecvf.com/content\\_CVPR\\_2020/html/Garnot\\_Satellite\\_Image\\_Time\\_Series\\_Classification\\_With\\_Pixel-Set\\_Encoders\\_and\\_Temporal\\_CVPR\\_2020\\_paper.html](https://openaccess.thecvf.com/content_CVPR_2020/html/Garnot_Satellite_Image_Time_Series_Classification_With_Pixel-Set_Encoders_and_Temporal_CVPR_2020_paper.html).

**Matthieu Porte, coordinator of AI activities, IGN (matthieu.porte@ign.fr)<sup>1</sup>**

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<sup>1</sup> The author warmly thanks all members of the BDForêt team for their contribution and reviewing of this article.

### 3. POLAND NMCA'S ACTIVITIES HEAD OFFICE OF GEODESY AND CARTOGRAPHY (GUGIK)

The most important news from 2020 is the amendment of the Polish Geodetic and Cartographic Law, which introduced significant and expected changes. The following **data of the Central Geodetic and Cartographic Resource is now freely available** (without any restrictions) for download via [www.mapy.geoportal.gov.pl](http://www.mapy.geoportal.gov.pl):

- topographic database (BDOT10k),
- orthoimagery,
- laser scanning data (LIDAR),
- digital elevation model (DEM),
- digital surface model (DSM),
- geodetic control networks data,
- basic data on parcels and buildings.

Over 320 TB data have been downloaded since the spatial data was released. Instructions for downloading data can be found on the [Head Office Geodesy and Cartography YouTube channel](#). The opening of spatial data improves data availability for citizens and boosts the development of businesses operating in the spatial domain. The amendment eliminated bureaucracy in geodetic works and accelerated the investment process by shortening the time needed for data update in the land and buildings registers.

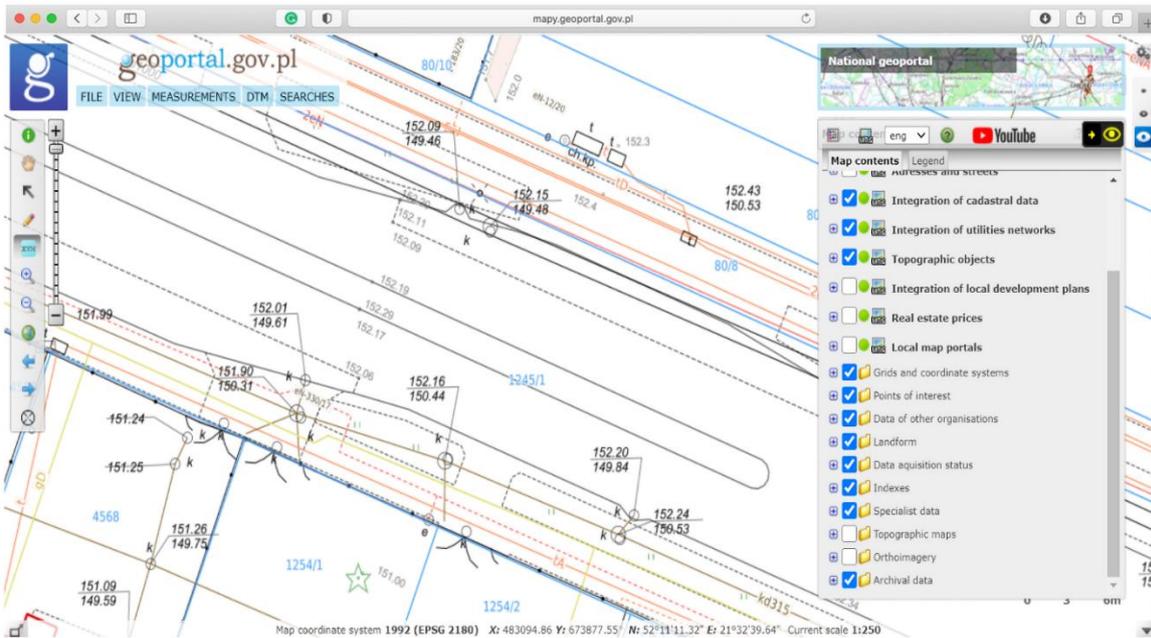
Besides, during 2020 Head Office of Geodesy and Cartography (GUGiK) conducted a number of activities aimed at building reference databases for the entire country. In the previous year, the Central Geodetic and Cartographic Resource was enriched with new or updated spatial data for the area of over 70% of the country:

- 225 291 photogrammetric aerial imagery,
- 224 790 km<sup>2</sup> of orthoimagery (with GSD 0.10 m or better for cities, 0.25 m for other areas),
- 2 920 km<sup>2</sup> of laser scanning data for cities (12points/m<sup>2</sup>),
- 236 158 km<sup>2</sup> of digital elevation model (1m/5m),
- 2 777 km<sup>2</sup> of digital surface model (DSM),
- topographic data (BDOT10k) for 61 counties,
- 2205 km<sup>2</sup> of intensity images.

The data are also available via WMS /WMTS and also published in the national broker [geoportal.gov.pl](http://geoportal.gov.pl).

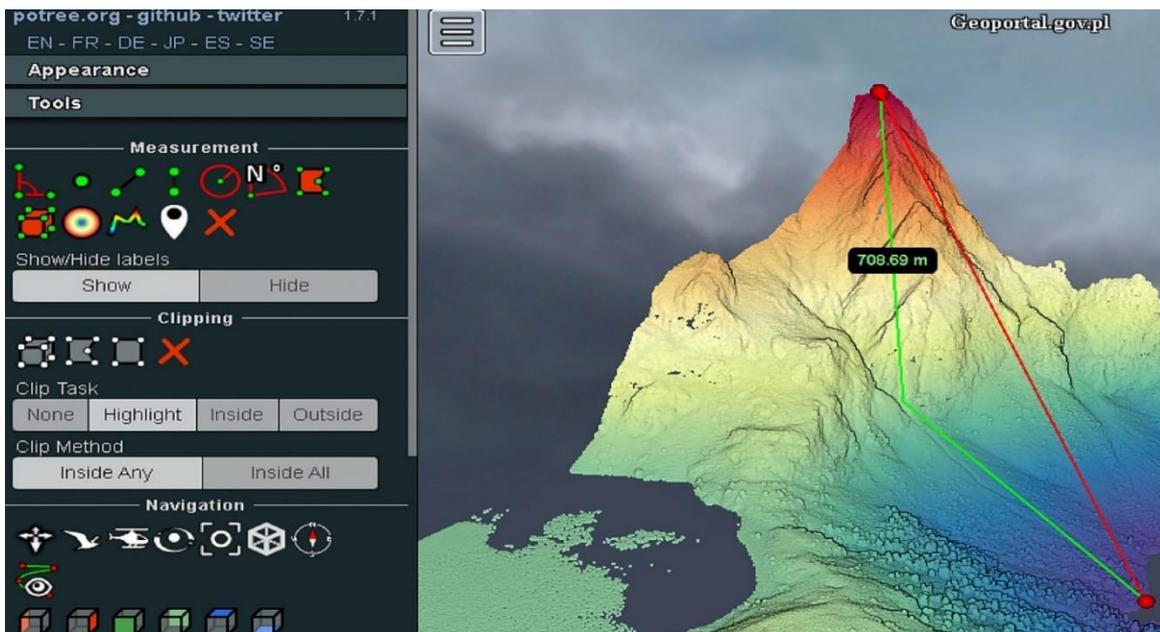
Additionally, in 2020, GUGiK noticed record statistics:

- Over 5,46 million users visited the [geoportal.gov.pl](http://geoportal.gov.pl) website in 2020. This is 38% more compared to 2019. Service [geoportal.gov.pl](http://geoportal.gov.pl) is ranked 3rd among government portals.
- 12% increase of the number of active users of the ASG-EUPOS system (Real-time services based on DGNS- *Differential GNSS* or RTK – *Real-Time Kinematics*)
- Record use of integrated service: KIEG-providing cadastral data (cadastral parcels and buildings) - in 2020 were 2 140 000 000 calls, an increase of over 40% compared of 2019.

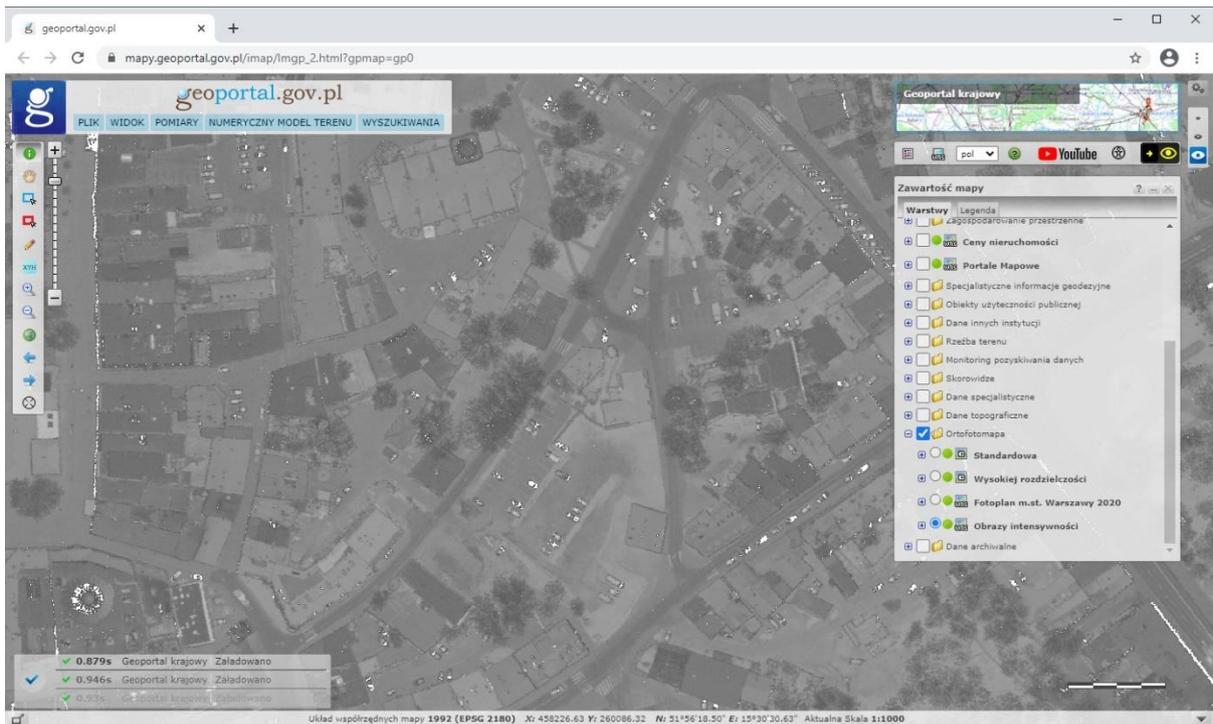


Besides, in previous year, GUGIK has launched new services, via [www.geoportal.gov.pl](http://www.geoportal.gov.pl):

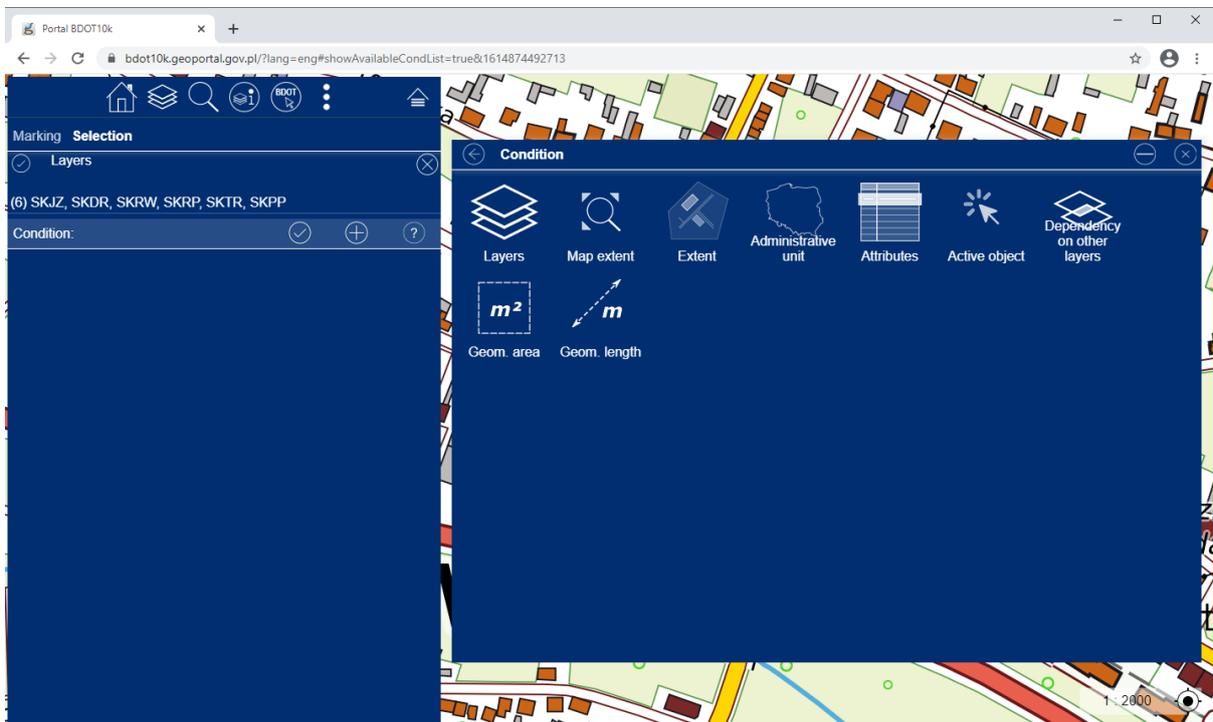
- LIDAR point cloud viewer for simple analysis and measurement:



- "Intensity Images" - data obtained with the use of Light Detection and Ranging (LIDAR) technology. The intensity images are freely available for download or via WMS service (<https://mapy.geoportal.gov.pl/wss/service/PZGIK/OI/WMS/ObrazyIntensywnosci>)



- BDOT10k service: <https://bdot10k.geoportal.gov.pl> - It enables visualization and simple analysis of topographic data from all over Poland. Users can perform simple statistical analysis, such as searching for the number of objects, e.g. schools, buildings, in a selected area.



#### 4. WEB PLATFORM FOR MONITORING AND GEOVISUALIZATION OF TERRITORIAL ATTRACTIVENESS OF THE DANUBE REGION GEODETIK INSTITUTE OF SLOVENIA

**Programme:** Interreg Danube Transnational Programme

**Project:** Attractive Danube - Improving Capacities for Enhancing Territorial Attractiveness of the Danube Region

**Home page:** <http://www.interreg-danube.eu/approved-projects/attractive-danube>

**Keywords:** geovisualization, territorial monitoring systems, territorial attractiveness, platform, Attractive Danube, Danube Region

A transnational monitoring and geovisualization system, namely Common Territorial Attractiveness Monitoring Platform (CO-TAMP) and eleven National Territorial Attractiveness Monitoring Platforms (TAMP) using attractiveness indicators, have been developed as a part of collaboration of 19 partners in the Danube Transnational Programme project Attractive Danube, which aimed to provide support to the territorial attractiveness policy priorities identification, decision-making and implementation throughout the Danube region (Figure 1).

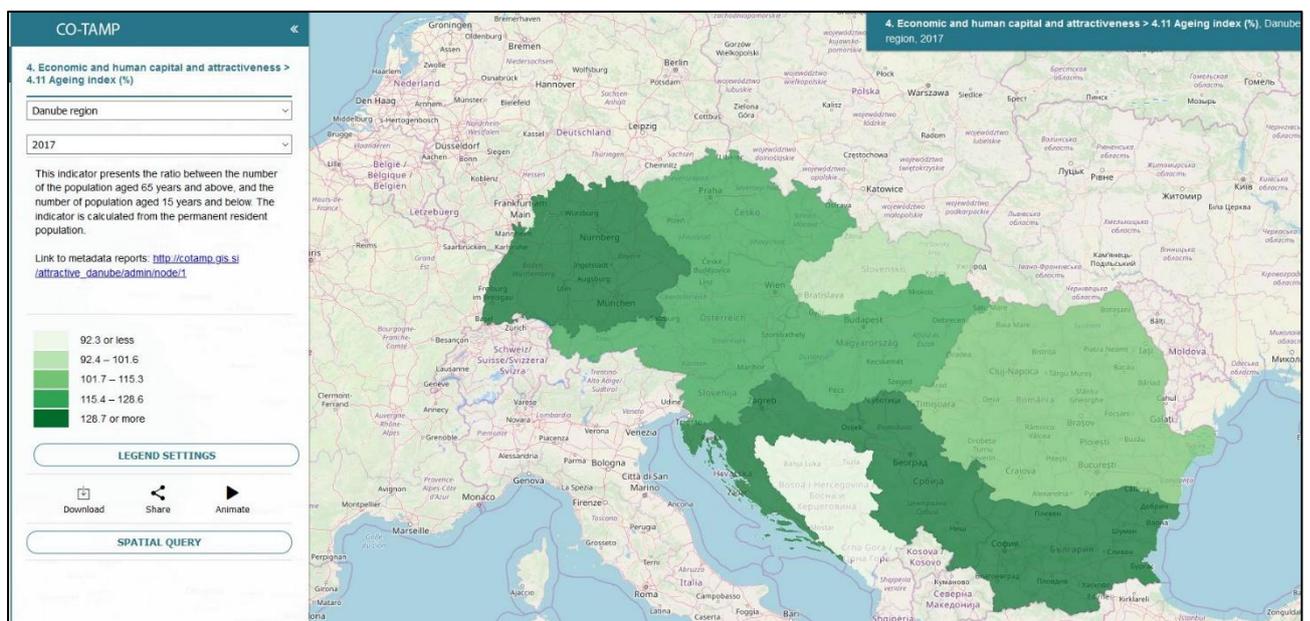


Figure 1: CO-TAMP application: map view; Example indicator: Ageing index (%) in the Danube region in 2017

Each territory has its own set of specific capitals and assets which can make it competitive in comparison to other territories. Through good governance, policies can create conditions for maximising the potentials of territorial assets and capitals for development, thus increasing the attractiveness of territories for its residents, visitors and businesses. The main project objective was to strengthen multilevel and transnational governance and institutional capacities of policy planners involved in territorial development by establishing a permanent common transnational platform for monitoring territorial attractiveness.

Besides the carefully selected set of indicators, geographical visualization or geovisualization is also one of the success factors of any territorial monitoring system. Utilizing the latest GIS-based applications, geovisualization is today more than a plain static visual presentation of the territorial structures and dynamics using the maps and different computer graphics. It is a set of tools, methods and techniques that enables interactivity and exploration capabilities over the monitoring system content, which includes different geospatial data. Deployment of these capabilities results in the various interactive visual analyses, leading to the recognition and presentation of the previously

invisible spatial relations and data patterns, which are of shared importance for the spatial planning stakeholders and territorial development policy decision makers, on all levels. Relying on the rapidly developing interactivity feature, which is being fed by the increasing number of geospatial data from various sources, there is a growing number and variety of the monitoring systems in Europe, from local via national and transnational to European level.

5. PERMANENT GEODETIC MARKERS AS A BASIS FOR THE HIGH-QUALITY PERFORMANCE OF THE GEODETIC PROFESSION (TARGETED RESEARCH PROJECT V2-1924)  
GEODETIC INSTITUTE OF SLOVENIA & UNIVERSITY OF LJUBLJANA - FACULTY OF CIVIL AND GEODETIC ENGINEERING,

**Project funding:** The Slovenian Research Agency and the Surveying and Mapping Authority of the Republic of Slovenia

**Keywords:** permanent surveying markers, geodetic pillars, cultural heritage, Slovenia

Geodetic or surveying markers appear on the Earth surface in various forms, such as square stones, concrete pillars, wooden and metal towers, crosses and holes chiselled in rocks and stones with brass and iron bolts, appropriate markings on various natural and built objects, or even as independent small-sized buildings. Regardless of the age, type and purpose of permanent surveying markers, they are in most cases part of triangulation surveys or levelling networks, i.e., geodetic networks that represent national coordinate systems. The second group of very similar markers are connected with the land ownership relations or different kind of historical borders in a certain area, which are in a considerable amount still used today, i.e., as land cadastral municipality borders, and thus have not only historical value, but also practical value. Slovenia lies on the territory that in the past was a part of various state formations, which is also reflected in various forms of surveying markers.

In this project, we have developed conceptual model of a database for important surveying markers and networks not being in practical use for a certain period of time. The purpose of the developed model is the evaluation of both groups of markers through their possible practical value for modern surveying purposes. Besides their surveying purpose, also their technical, cultural-historical value and tourist potential were evaluated. A pilot database of selected surveying markers was created, based on literature overview and unstructured interviews made with older surveyors. The current status of many old permanent surveying markers identified through interviews was also checked in the field.

A pilot database of important old surveying markers and networks has a potential to give guidelines on the amount and complexity of work needed in future to establish a complete database of important old surveying markers. Such database can be used in studies of changes in physical space with the connection of field data and measurements from the past with the new ones. Selected surveying markers can be proposed to institutions dealing with preservation of technical and cultural heritage for including them into local, national or international lists of important cultural heritage objects. This can emphasize the importance of the geodetic and surveying profession and its history to the general public.





Figure 1: Different types of markers for trigonometric points based on the institution that made its stabilisation in the past.

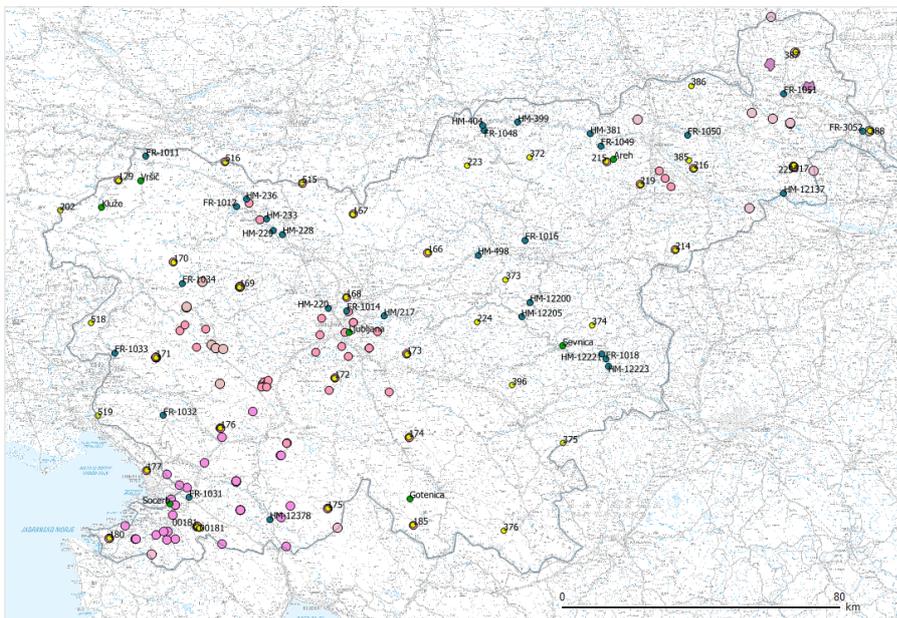


Figure 2: Currently identified locations of interesting geodetic marks with potential for future cultural heritage preservation. Pink – proposals from interviews, blue – benchmarks, green – gravimetric points, yellow – first order trigonometric points.

6. UAV PHOTOGRAMMETRY FOR CADASTRAL MAPPING OF NON-VISIBLE PROPERTY BOUNDARIES  
UNIVERSITY OF LJUBLJANA - FACULTY OF CIVIL AND GEODETIC ENGINEERING

**Project funding:** Surveying and Mapping Authority of the Republic of Slovenia and the Slovenian Research Agency

**Project duration:** November 1, 2019 –October 31, 2021

**Project group:** Anka Lisec (coordinator), Marjan Čeh, Samo Drobne, Dejan Grigillo, Mojca Kosmatin Fras, Klemen Kozmus Trajkovski, Klemen Kregar, Krištof Oštir, Polona Pavlovčič Prešeren, Dušan Petrovič, Jernej Tekavec, Barbara Trobec, Tilen Urbančič, Bujar Fetaj

The Surveying and Mapping Authority of the Republic of Slovenia has initiated the applied research project “*Feasibility study of UAV photogrammetric applications for cadastral mapping*”. The research focus, conducted by the University of Ljubljana, Faculty of Civil and Geodetic Engineering, is on the challenges of using UAV photogrammetry for detection and mapping of non-visible cadastral boundaries.

Photogrammetric cadastral data acquisition is not a novelty, with the first projects in Europe and on a broader international scale dating back to the 1950s. These projects followed the challenges of technological development – at that time in optical geospatial data acquisition by aircraft. In the last decade, the main challenge in photogrammetric cadastral mapping has been the development of new platforms and technologies for aerial geospatial data acquisition using remote-controlled systems, i.e., Unmanned Aerial Systems – UAS. So far, cadastral mapping with UAV photogrammetry has been present mainly in developing regions with low cadastral coverage, where applications focus on detecting and extracting visible land boundaries, e.g. land cover boundaries. However, an effective cadastral system should provide up-to-date land data. In countries with complete cadastral coverage, this up-to-dateness is considered one of the major challenges for cadastral systems, where low-cost and rapid cadastral surveying and mapping techniques are welcome.

The main objective of the project is to investigate the possibilities of using UAV photogrammetry for cadastral mapping. The technological solutions are discussed in different contexts – from preliminary land cover mapping to detect inconsistencies between land possession and cadastral maps within cadastral resurveys or land plot rearrangements to cadastral mapping based on marked land plot boundary points in the field. The research focus is on the until now unexplored area of ground control points and cadastral points marking in the field, which would enable process optimisation and better interpretation of the geospatial data acquired.

One of the project’s objectives is to study and evaluate the suitability of different targets for marking ground control points and cadastral points for UAV photogrammetric cadastral mapping. In the first phase, the study area Kandrše was selected to establish artificial test fields of different targets, taking into account also topographic and vegetation characteristics, e.g. slope, height of grass, etc. (Figure 1).



Figure 1: Test fields with various targets in the study area of Kandrše, Slovenia.

The various possibilities of ground control and cadastral points' marking were examined mainly from the aspects of:

- The possibility of (semi)automatic identification of targets (signals) in image processing of acquired geospatial data,
- The positional accuracy of point clouds and orthophoto, and
- The positional accuracy of cadastral points in the national geodetic reference system D96/TM.

In addition to the characteristics of the targets and topography, various factors affecting the quality of UAV photogrammetric products were investigated in the Kandrše study area (Figure 2). With the aim of ensuring the required positional accuracy of UAV cadastral mapping and providing the guidelines for the practice, three groups of factors were investigated in detail: (a) factors related to camera characteristics and image quality; (b) factors related to mission planning and execution; and (c) factors related to indirect georeferencing of imageries using ground control points. These factors were analysed based on a detailed review of relevant scientific publications. For the selected factors, e.g., flight parameters, illumination, number of control points and their spatial distribution, etc., the influence of factors was studied based on the experiments in the study area.



Figure 2: The study area of Kandrše with the network of grounds control points and »test fields with targets (left) and UAV photogrammetric cloud with labelled control points (right).

The findings from the first study areas are being verified in new study areas where the cadastral survey has recently been conducted. Here, the recognition and positional accuracy of the coordinates for the marked cadastral points, which are determined based on UAV photogrammetrical data processing, will be investigated.

The expected project outcomes are the main findings and recommendations for UAV photogrammetric projects in land cadastre, with the methodology for quality control and quality assessment. The recommendations will include guidelines for planning and implementing UAV-based photogrammetric cadastral surveys, methodological recommendations for image processing and feature extraction, including suggestions for marking ground control points and cadastral points, recommendations for control measurements and quality assessment of the acquired data.

## 7. ORDNANCE SURVEY AND THE OMNICA V PROJECT

### ORDNANCE SURVEY

In 2018 Ordnance Survey was part of a consortium which successfully bid for government funding in a competition run by the Centre for Connected and Autonomous Vehicles (CCAV) and Innovate UK. The aim of the OmniCAV project was to produce a simulation environment in which autonomous vehicle systems (“self-driving cars”) could be tested in a virtual world before they were allowed out onto the streets. Members of the consortium included simulation experts, traffic modelling specialists, an autonomous vehicle systems manufacturer, a local authority and an insurance company; each bringing a different viewpoint of the autonomous driving world. Ordnance Survey’s role in the project was to capture and process real-world data to create a 3D model to be used within the simulation.

For the test track, a 32 km route around the roads of Oxfordshire was chosen, comprising urban, suburban and rural areas, and even a couple of “burger roundabouts” (no, we’d never heard of them before the project either...they are roundabouts which also have a road that goes straight across the roundabout, and they are nicely complicated to model!) To build the model we used data from many sources, including a mobile mapping data set (lidar and imagery), aerial imagery from our standard nadir-pointing cameras, oblique imagery from an XCAM system, and ground survey data. Since several of these systems were new to OS, we employed third party data providers, Korec and GeoXphere, to capture the mobile mapping and oblique imagery, respectively. We wanted to ensure that we had a very high resolution dataset, so the mobile mapping data was captured four times (day and night, both clockwise and anti-clockwise around the road loop). One of the first things we learned on gathering the data was that 32 km of very high resolution mobile mapping was a huge amount of data! We quickly realised that, if we were going to produce 3D models from the data which would be suitable for the simulation software, we would have to thin the point clouds down considerably and use different levels of detail in various regions of the model.

During the production of the 3D model we used many different processes and software packages, to take the raw data and create a textured surface mesh, 3D building and vegetation models, and detailed 3D models of the roadside furniture such as lamp posts, traffic signs and traffic lights. Before the project we all thought we knew what a traffic light looked like – we soon came to know that there are many different types of traffic light, and each had to be modelled separately in order to work in the simulation. Another thing we learnt during the project was that a mapping agency’s notion of a 3D model is not necessarily the same as that of a simulation designer or a traffic modelling expert. Each partner in the consortium had their own idea of the data requirements, and these rarely coincided with each other. This meant that we had to learn many new ways of preparing, integrating and modelling data in order to produce a model suitable for all the parties in the consortium. To create a high-resolution model for the entire road circuit proved to be too ambitious, so a compromise was made in which a slightly lower resolution model was created for the entire loop, together with a set of very detailed models for seven smaller areas of interest along the route.

By the end of the project we had built up a lot of knowledge about 3D data capture and modelling, and we will know next time to spend more time at the start of a project working out exactly what the user requires, rather than assuming that we as a mapping agency know what a 3D model looks like. The image shows a section of the 3D model, rendered within the Unity game engine (and including three types of traffic light!).



## Report by the Secretary-General

Joep Cromptvoets



This report reviews the annual Board of Delegates meetings happening in the framework of EuroSDR in 2020, the appointments of (new) delegates, the activities related to our partner associations and some logistics.

### Meetings

With regret, the State Geodetic Administration had to cancel the 136<sup>th</sup> EuroSDR Board of Delegates meeting in Zagreb from 25 to 27 March 2020 due to the Covid-19 pandemic.

The 137<sup>th</sup> EuroSDR Board of Delegates meeting was organized virtually on 8 and 9 October 2020 and was hosted by Colin Bray and Paul Kane (Ordnance Survey Ireland). The highlights of the meeting were 1) the keynote presentation titled 'Experiences with point cloud classification at a national scale and advances in deep learning' by George Vosselman (University of Twente), 2) the presentations 'Quality evaluation of 3D building models: a scalable approach' by Oussama Ennafii (University of Paris-Est) and 'Exposure and seismic vulnerability assessment using machine learning techniques with remote sensing data: Applications in Lorca (Spain) and Port-au-Prince (Haiti)' by Yolanda Torres Fernández (Universidad Politécnica de Madrid), the two winners of the 2020 EuroSDR Award, and 3) the keynote presentation 'Analysis and Classification of 3D Point Clouds Based on Deep Learning' by Rico Richter (Point Cloud Technology).

In preparation for these two Board of Delegates meetings, the Executive Management Team met in Trento, Italy, on 4 February 2020, and virtually on 11 and 25 March, 19 June, 20 August, 3 and 4 September 2020.

### Delegates

In 2020, the following appointments were approved: 1) Simon Musaeus as representative of Hexagon (replacing Poul Noergaard) 2) Gottfried Mandlbürger as academic representative for Austria (replacing Norbert Pfeifer), 3) Juha Kareinen as second delegate of Finland (replacing Jurkka Tuokko), 4) Michael Hovenbitzer as prime delegate of Germany (replacing Paul Becker), and 5) Evelyn Uemaa as academic representative for Estonia.

Norbert Haala and Bénédicte Bucher were also re-appointed for their second and last term as chair of Commission 2 and 4, respectively.

### Partnerships

EuroSDR continued collaborating with its key partner associations in 2020: EuroGeographics, Association of Geographic Information Laboratories for Europe (AGILE), Open Geospatial Consortium (OGC), International Society for Photogrammetry and Remote Sensing (ISPRS), Council of European Geodetic Surveyors (CLGE) and International Cartographic Association (ICA).

Some examples indicating our successful collaborations with our partner associations are the following:

- General Assembly of EuroGeographics (15 October 2020) – Virtual
- 7th Plenary meeting of UN-GGIM Europe (22 – 23 June 2020) – Virtual
- Meeting with Bart de Lathouwer (OGC) (16 September 2020)
- EuroGeographics EuroSDR Spatial Data Quality workshop (Valetta, Malta, 27 – 29 January 2020)
- 7th Plenary meeting of UN GGIM Europe (22 – 23 June 2020) – Virtual
- Webinars EuroGeographics: Further Reading materials on Open Data (16 April 2020), Digital transformation in Cadastre (23 April 2020), GNSS (30 April 2020), Interoperability and use of authoritative Data (7 May 2020), Geoportals (14 May 2020), Quality (28 May 2020), Business

transformation in Cadastre and Land Registry (4 June 2020), Covid-19 mapping and spatial analyses (11 June 2020), Digital transformation (18 June 2020) – Virtual

### **Logistics**

Regarding the associated logistics, the secretariat was among others strongly involved in preparing the meetings, processing the minutes, decisions and actions of each meeting, organising EuroSDR events (e.g. workshops, webinars, EduServ e-learning courses), editing publications and the annual report, financial accounting, auditing, updating the EuroSDR website, managing social media, etc.

On behalf of the secretariat, I would like to express that we really look forward to continue cooperating with our members and associate members, Commission Chairs, President, Vice-President, representatives of our partner associations and those that are simply interested in the activities of EuroSDR in the (near) future.

## Commission I: Data Acquisition

Jon Mills



*The mission of Commission 1 is to investigate, test and validate platforms, sensors and algorithms to acquire geospatial data, with emphasis on precision, accuracy, reliability and standardization of data acquisition and pre-processing procedures.*

### Single Photon and Geiger-Mode lidar

Following the successful 2019 EuroSDR workshop on Single Photon (SP) and Geiger-Mode (GM) lidar at the Institut Cartogràfic i Geològic de Catalunya (ICGC) in Barcelona, Spain, a lidar benchmarking project was discussed and developed at subsequent BoD meetings. The EuroSDR lidar benchmark project aims to collect different datasets over a test site in Innsbruck, Austria, with the support of commercial providers in order to perform detailed investigations and analyses. The Innsbruck site has the support of the local and national mapping agencies, as well as local academics to facilitate ground truth. Unfortunately, there presently remains no suitable SP or GM lidar sensor based in Europe with which to capture data of the Innsbruck site and the COVID-19 pandemic derailed all plans to achieve this using US-based sensors in 2020. The project is therefore on hold, but negotiations with the major manufacturers of suitable lidar sensors are ongoing with the ambition of flying the test site in late 2021.

### EuroSDR participation in 2020 ISPRS Congress

EuroSDR teamed up with the ISPRS IPAC (International Policy Advisory Committee) to organize a EuroSDR National Mapping and Cadastral Agency (NMCA) and ISPRS Space Agency (SA) Forum at the ISPRS Congress in Nice 2020. Unfortunately the COVID-19 pandemic meant that the Congress was postponed until 2021, with only a shortened virtual event held in August/September 2020, and the forum was therefore delayed by 12 months. Following the subsequent announcement that the 2021 Congress will now be online only, EuroSDR recently took the decision to cancel the 2021 Forum. With an in-person Congress planned for 2022, EuroSDR agreed to revisit the idea of hosting a Forum together with IPAC at the Congress at the appropriate future time. Several technical papers were also submitted and published as part of EuroSDR Theme Sessions at the 2020 and 2021 virtual events. Further details on the ISPRS Congress can be found at <http://www.isprs2020-nice.com/>.

### Centre for Doctoral Training (CDT) in Geospatial Systems

The Commission 1 Chair became Director of the UK's £6.7M Engineering and Physical Sciences Research Council (EPSRC) Centre for Doctoral Training (CDT) in Geospatial Systems in April 2020. The Centre will train five annual cohorts of c. 10x 4-year PhD students per year in all aspects of geospatial systems. The Centre has the support of EuroSDR and a number of its members, including Ordnance Survey, Finnish Geospatial Research Institute, IGN France. Various opportunities exist for NMCA collaboration with the centre, further details of which are available at <https://research.ncl.ac.uk/geospatial-systems/>.

### Future Commission 1 projects

With the COVID-19 pandemic causing disruption to planned Commission 1 events and activities throughout 2020, and still ongoing, alternative projects and activities have been discussed and will be presented at a future BoD meeting.

## Commission II: Modelling and Processing

Norbert Haala

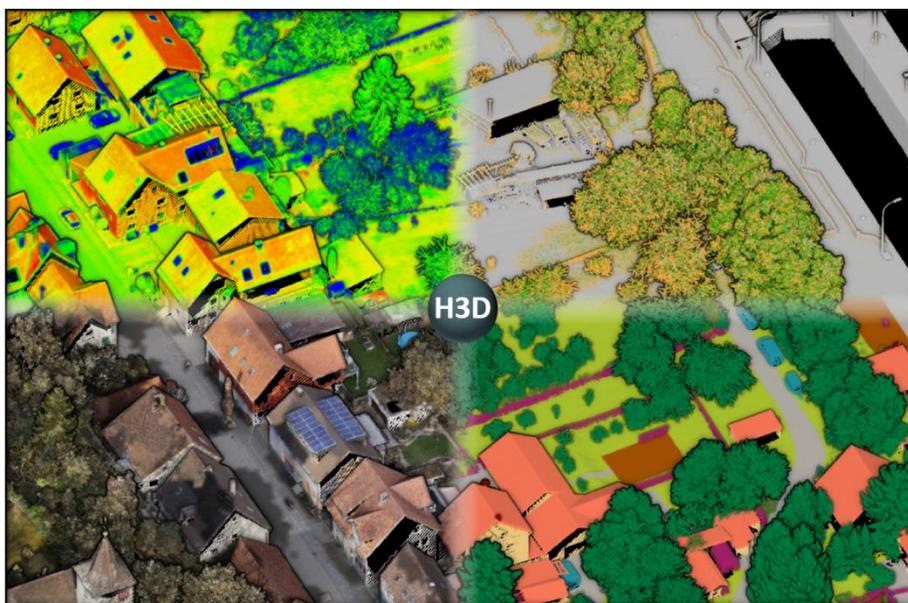


*The mission of Commission 2 is to investigate, demonstrate and evaluate the generation, processing, structuring, maintenance and distribution of spatial information. The focus is on algorithms, including machine learning, Cloud-computing and upscaling..*

### Recent research initiatives and developments

In view of the growing interest on semantic analysis of 3D point clouds within EuroSDR, the Hessigheim 3D - Benchmark (H3D) on Semantic Segmentation of High-Resolution 3D Point Clouds and Meshes was established as a joint EuroSDR/ISPRS scientific initiative. The data set consists of both an Unmanned Aerial Vehicle (UAV) laser scanning point cloud and a 3D textured mesh captured at the village of Hessigheim (Germany). The point cloud features a mean point density of about 800 pts/m<sup>2</sup> and the oblique imagery used for 3D mesh texturing realizes a ground sampling distance of about 2-3 cm. This enables the identification of fine-grained structures and represents the state of the art in UAV-based mapping. The respective point clouds are manually labeled into 11 classes and are used to derive labeled textured 3D meshes as an alternative representation. Ultimately, data sets from three different epochs will be made available, currently the first epoch can be accessed by the benchmark webpage <https://ifpwww.ifp.uni-stuttgart.de/benchmark/hessigheim/default.aspx>. Interested researchers can use these state-of-the-art data sets to test their methods and algorithms on semantic segmentation of 3D point clouds for geospatial applications. Detailed information on the data, the participation and the submission of results for the H3D benchmark is also available in the accompanying paper <https://arxiv.org/abs/2102.05346>

To further trigger the collaboration within EuroSDR, we plan to organize a workshop for interested participants this summer.



### 3D GeoInfo 2020 and BIM GIS Integration Workshop

UCL and Ordnance Survey hosted the 3D GeoInfo 2020 Conference as virtual/online event from 7th until 11th September 2020. 3D GeoInfo which included the BIM GIS Integration Workshop covers all aspects of 3D geoinformation, with a particular focus on 3D city modelling. The organisers Claire Ellul and Jantien Stoter issued a sub-call for papers of particular interest and relevance to NMCAs. The organizing committee compiled 16 sessions from 45 accepted submissions covering topics like

Applications of BIM and GIS integration, AR/VR, Visualisation, Point Clouds, Indoor 3D and 3D Data Creation. Further information, including the link to the papers and abstracts can be found at the conference web-page <https://www.ucl.ac.uk/3dgeoinfo/>

## Commission III: Updating and Integration

Martijn Rijdsdijk



*The mission of Commission 3 is to investigate, demonstrate and evaluate advanced methods of archiving, updating, semantically enriching and integrating geo-information with spatial (sub)elements. The Commission's focus lies at the exploitation of these methods and its applications applied to geospatial data and for the benefits for national mapping and cadastre agencies (NMCAs).*

### Overview activities 2020

Although the Covid-19 crisis had some impact on the Commission 3 activities, many results were made. First, there was the official takeover of the legacy and continuing the good work from Commission Jon Arne Trollvik from Norway. As Commission Chair he organised many activities and projects last years. We are very grateful for this. Mr Trollvik is still involved as an active member, for example in the organising committee of the workshop on Sentinels in Europe in October 2020.

During the Executive Management Team meeting in Trento, there were discussions about topics that should be part of the Commission 3 scope. Machine Learning and Deep Learning is one of the topics that will be adopted in the commission's domain in the next years. Machine Learning got priority by EuroSDR in its research programme. As a result, a questionnaire was made to get a clear insight in the NMCA's activities in this domain. The questionnaire will be sent to all EuroSDR members. Next to that, the topic was discussed during the Board of Delegate meetings. Also, a first e-learning course about this topic is organised. Another aspect decided during the Executive Management Team meeting was to involve the project of historical and photogrammetric data of Fabio Remondino (Vice-President of EuroSDR) in this commission. It was decided that Commission 3 should be hardly involved in further activities around this project as the leading commission. Unfortunately, because of the Covid-19 crisis, there is some small delay in running this project. Hopefully the project will be finished in 2021. The highlight of this commission in 2020 was the workshop "Sentinels in Europe".

### Workshop Scaling up sentinels in Europe

The workshop about Sentinels was the latest in a series of four; the last one was held in 2018 and was a very successful event. As a result of its success, a new workshop was planned to be organised in Tonsberg, Norway. However, during the preparations, we were forced to transform the workshop to a webinar caused by the Covid-19 travel restrictions. The workshop was a cooperation between EuroSDR (Kadaster/Kartverket) and the Norwegian Space Agency. It was scheduled on October 26 and 27. Around 120 participants took part in the event. After the two-days programme, the following conclusions could be defined:

- Data and Information Access Services (each DIAS has a slightly different business plan and target group, and offers different commercial satellite data and other data sets);
- More national data portals for Copernicus data around Europe. We've seen demos from the Swedish data cube, the Finnish collaborative ground segment - the Artic Space Centre, and the Norwegian data portal;
- The Nordic national ground segments are working on some identical topics, and are facing similar difficulties in processing the products;
- Maybe further coordination and exchange of experiences between the national hubs could be beneficial.

Next, a nice recommendation was that tutorials on how to make the best use of national hubs are also wanted. Looking back, it was a very successful webinar with an average of 85 participants online during the two days. Interesting aspect was also that some participants from outside Europe wanted to be involved and registered themselves. At the end of the workshop it was recommended to organise a follow up within two years.

**Futher activities**

Some activities of 2020 are postponed or still under construction in the year 2021 as we will still have to deal with the Covid-19 restrictions. However, Commission 3 already has some projects and activities in store for 2021 like a workshop about feedback systems, follow-up webinars about Machine Learning and Artificial Intelligence and will support the other commissions in their activities and their mission.

## Commission IV: Information Usage

Bénédicte Bucher



*The mission of Commission 4 is to explore, demonstrate and contribute to further increase the usage, access and visualization of authorized geodata as well as to investigate better mechanisms for the dissemination of geodata from database to end-users.*

### Overview

Commission 4 tackles information usage, information infrastructures (GeoWeb, INSPIRE), interoperability and visualization.

The two first items in this report relate to the valorization of historical data, defined as data that have been replaced by newer ones. We wish to consider geodata with a *continuous* historical perspective, i.e. to remove existing barriers between data at different time period and in different places. This is an opportunity to add longer term perspectives in applications, and to account for a European history related to land use and land cover based on data. This is also an opportunity to co-design solutions to cope with data heterogeneities in information infrastructures with new communities, the humanities.

The three next items relate to the Linked Data Group activities. In this group, the activity is fostered towards enhancing collaboration with Linked Data specialists and the assessment of LD value from mapping agencies and addressing unsolved issues in SDIs thanks to more collaboration with semantic Web designers.

The next activity relates to engaging with a specific user community: urban climate services designers.

Last, the Geo-immersive reality workshop has been postponed due to the COVID-19 outbreak.

### Distribution of historical data on the Web: survey

Commission 4 has circulated late 2020 a survey on the distribution of historical data on the Web. There were 11 answers from land surveys and mapping agencies (Cyprus, Switzerland, France, Denmark, Spain, Great Britain, Germany) and academics (the Geodetic Institute of Slovenia, TU Wien research in natural science and engineering, CNRS consortium in digital humanities, University of Zagreb faculty of geodesy). The answers will be presented at the spring Board of Delegates, BoD138. Interests varies from mere distribution of archives to a better distribution of geographical data in general, and to the exploitation of these data either for scientific work or more operational applications, for example surveying changes and developments of a landscape. With respect to data and metadata services for such data, ISO and OGC standards are quoted as well as national standards specific to archives. It is unsure whether a specific standard is needed for adding this historical perspective on geodata. The respondents underlined different kinds of limits in their work, for example the economic means necessary to digitize archives and to fund an infrastructure, the numerous heterogeneities, the difficulty to contextualize data and evaluate quality, the lack of accurate referencing to make the data usable beyond mere visualization, or the lack of user' awareness that these data exist. Participants agree that a European approach to the field could be useful at least for knowledge exchange and raising awareness, for sharing standardization and infrastructure costs, but also for ambitious goals like providing a trans-European historical vision. Current discussions aim at scoping a workshop on the topic, during 2021 fall.

## The Time Machine Organization

The Time Machine project funded by the European commission (March 2019 – Feb 2020) finished early 2020. Since the Horizon Europe stopped funding FET flagship, the consortium moved to the **Time Machine Organisation** (TMO): <https://www.timemachine.eu/time-machine-organisation/>.

The purpose of the Time Machine Organisation is roughly to carry out the CSA Time Machine roadmaps based on the dynamic of the CSA and on European and national funding. This consists in particular in developing reusable technologies and an infrastructure to organize archives into a seamless Big Data of the Past. The TMO website references existing initiatives to serve historical data, called Local Time Machines, which usually are associated to a city.

During this first year of TMO, EuroSDR was a de facto associate member to TMO because being an associate partner to the CSA Time Machine. TMO has defined three levels of memberships: associate member, regular member and founding member (<https://dev.timemachine.eu/membership-details/>). A specific service proposed to the TMO regular and founding members is a project scouting service.

## The conference “Knowledge Graph in Action”

The Knowledge Graph in Action (KGiA) online conference was organized as a joint event gathering three annual events with a common interest on producing, consolidating data, and supporting their joint reuse and different specific focuses within this common interest: the DBpedia day which more specifically focuses on advancing DBpedia, the EuroSDR Spatial Linked Data day which more specifically focuses on spatial linked data, and the EuroSDR VGI event which more specifically focuses on volunteered geographic information. Within the spatial linked data track, there were updates presented by different agencies or partners on latest developments, focusing on a given territory (The Netherlands, Norway, Germany, Belgium, Spain, Ireland, Switzerland). These presentations revealed the maturity of the Linked Data technology. They demonstrated their added value to interconnect data from multiple authorities, and develop solutions for user-centered access to these data, typically by providing feature level information, either through a chatbot like in Kadaster approach or through an interface compiling informations provided from various authoritative databases like in BKG approach, see figure 1. GeoPubby implements a fuzzy search, a map application.

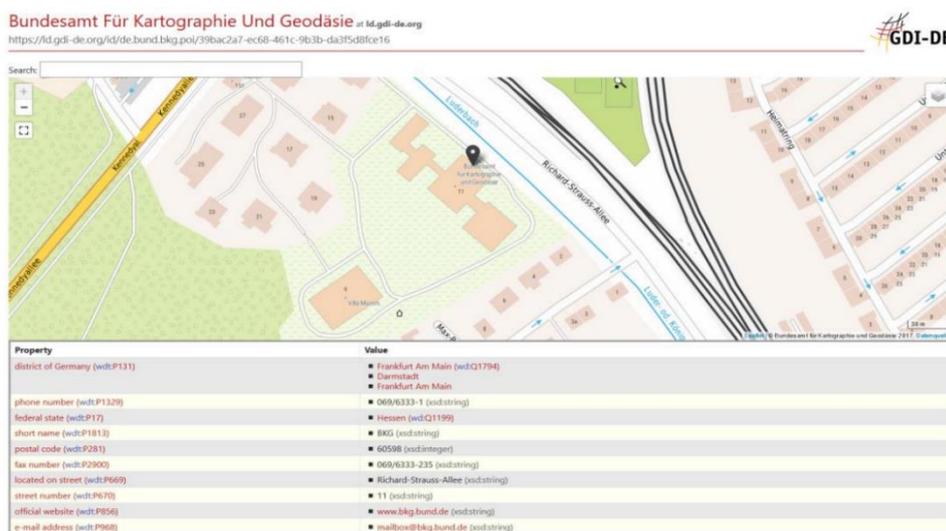


Figure 1: GeoPubby interface to serve data at the level of features, <https://github.com/i3mainz/geopubby>

Quality management and data governance, including vocabularies, was a raising theme during KGiA presentations. The Irish experience demonstrates in particular how URI are useful to manage authorities and ensure trust in the data and the possibility to develop specific quality management processes across different authorities based on Linked Data, as was experienced during the application of Geohive platform to the COVID-19 outbreak, see figure 2.

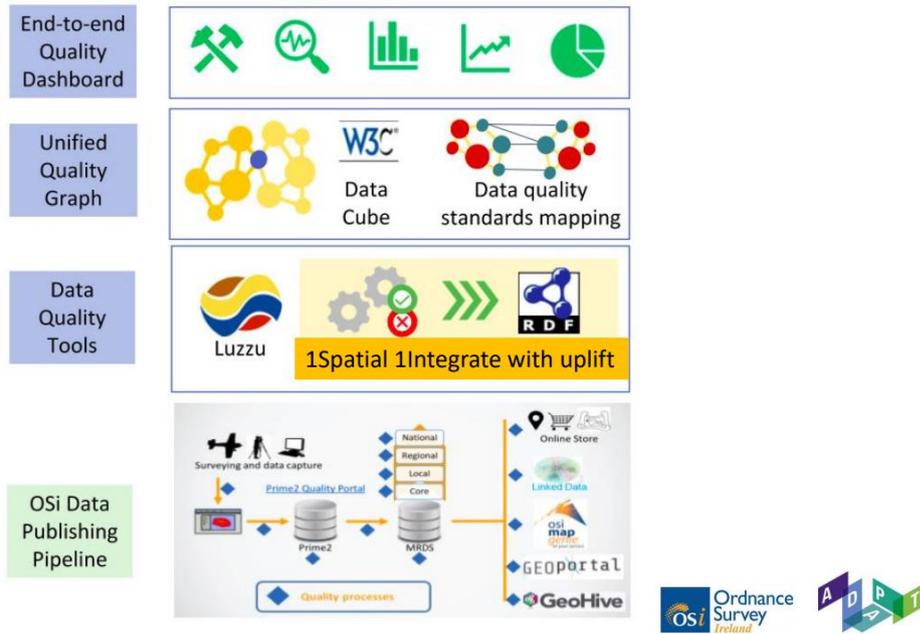


Figure 2: Linked Data for Governance of Geospatial Data

The report of the spatial linked data sessions of the KGiA conference was written, reviewed and published early 2021: “Spatial Linked Data in Europe: Report from Spatial Linked Data Session at Knowledge Graph in Action”, 2021, Bénédicte Bucher, Erwin Folmer, Rob Brennan, Wouter Beek, Elio Hbeich, Falk Würriehausen, Lexi Rowland, Ricardo Alonso Maturana, Elena Alvarado, Raf Buyle, Pasquale Di Donato, EuroSDR Official Publication n°73, [http://eurocdr.net/sites/default/files/uploaded\\_files/eurocdr\\_publication\\_ndeg\\_73.pdf](http://eurocdr.net/sites/default/files/uploaded_files/eurocdr_publication_ndeg_73.pdf)

### Advancing GeoSparQL technology on EuroSDR LD sandbox

EuroSDR LD sandbox is hosted on PLDN, the Dutch Platform for Linked Data. It is a place where participants to EuroSDR LD group can publish and process data as linked data thanks to a user friendly interface.

One activity of the Linked Data Group is to follow up the implementation of LD standards and possibly benchmark technologies. A specific standard is GeoSPARQL. It was created by the Open Geospatial Consortium and comprehends a model for describing complex geospatial information in linked data, and specific spatial queries. The implementation of the standard on EuroSDR sandbox was subcontracted to Triply B.V. with EuroSDR funding. Triply is a linked data startup that has experience with publishing large GeoSPARQL datasets and is the software for the Dutch Platform for Linked Data (PLDN). For this implementation of GeoSPARQL, benchmark data from the most recently published literature are used, representations and queries, figure 3.

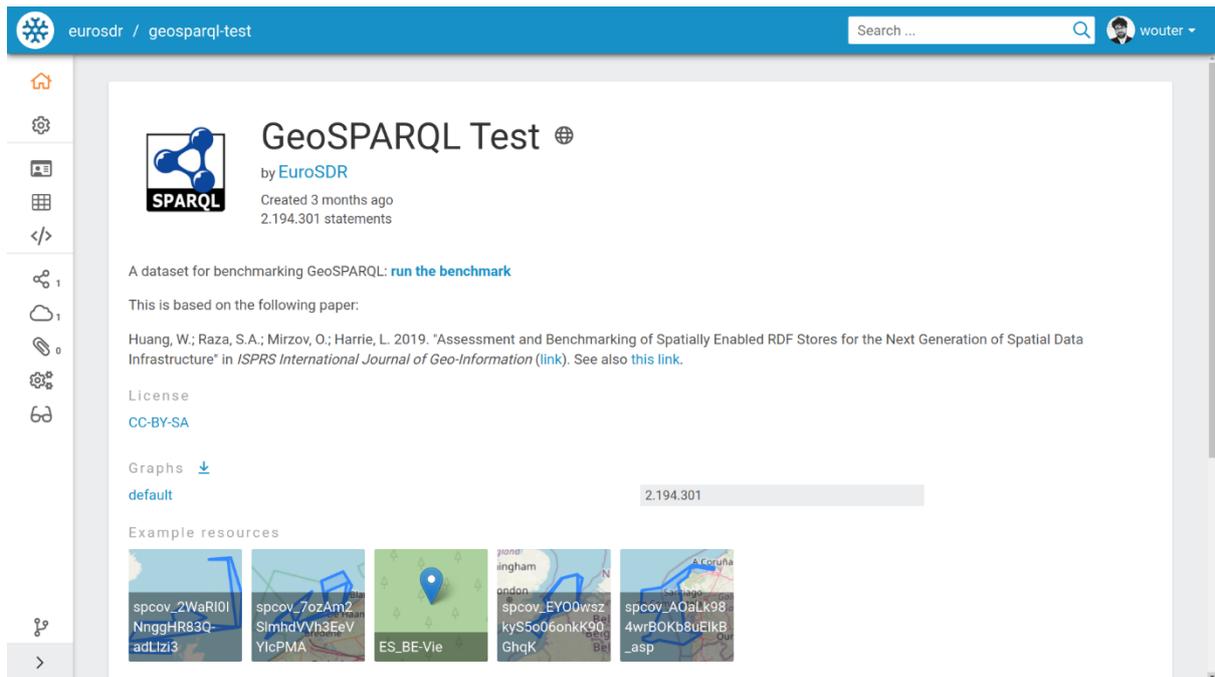


Figure 3: The GeoSPARQL test dataset published under the EuroSDR account in the linked data environment of PLDN (<https://data.pldn.nl/eurosd/geosparql-test>)

The GeoSPARQL Test environment provides several functionalities like:

- The dataset can be browsed in a low-level table to see the underlying data patterns, and in a more visually appealing browser that shows geometries and applies quality-printing of various value types.
- The dataset includes a public GeoSPARQL endpoint that everybody can use. The GeoSPARQL endpoint comes with a feature-rich IDE that supports writing queries and visualizing their results. Specifically, geospatial results can be directly plotted on a 2D or 3D map.

These are 27 queries, each of them makes use of a different aspect of the GeoSPARQL standard. Together, these 27 queries provide a good overview of GeoSPARQL compliance. The online publication in the PLDN environment lowers the threshold for starting to experiment with GeoSPARQL.

### Building EuroSDR Knowledge Graph

During 2020, the LD group started a new initiative related to the creation of a EuroSDR Knowledge Graph that describes available geodata in Europe. Real world use cases of such a KG have been identified and are listed below. They are fostering the design of the KG. These use cases are considered as unsolved issues on current SDIs.

A first use case is that of a scientist/SME has developed an application on some place, for example on the French city Toulouse, and would like to adapt it to another place, for example the city Bucharest, or to another epoque, for example Toulouse 10 years ago. He/she searches the KG for datasets similar to the datasets he/she already used but with a scope covering Bucharest or covering Toulouse in 2010.

A second use case is that of a company that searches for data to answer a specific call for tender of the European Environment Agency, like for example producing a specific land cover product reusing available data, possibly from authoritative providers.

A third use case is that of a domain expert who contribute to defining a European regulation that can be monitored based on existing national data.

A fourth use case is an operator of a national geo-platform who need to integrate different datasets and needs in particular to understand the id policies of different authoritative datasets on a given theme (eg: administrative units) to use them consistently.

The proposed process for the KG creation is firstly to create nodes for some geodigital assets relevant to the use cases as well as “same as” links between them. The creation is investigated so far by participants to the LD group and documented on our infolab, <https://geometadatalabs.eu/index.php?title=EuroSDRKG>.

#### **A European workshop on urban climate indicators EWUCI (May 17<sup>th</sup> 2021)**

The European Workshop on Urban Climate Indicators tackles the design of relevant and computable urban climate indicators to study and adapt to climate change, specifically indicators that can be scaled in space and in time throughout Europe thanks to a better access to and better sharing of data. It is organised with the support of EuroSDR, of the national mapping agencies, statistical institutes and meteorological institutes of France and of Finland (IGN, INSEE, MétéoFrance, Statistics Finland, FMI, NLS), of the Finnish environment institute (SYKE) and of the European project ERA4CS URCLIM on urban climate services.

Targeted audience is scientists and experts who specify, prototype or produce indicators relevant to urban climate study, scientists and experts who advance the field of information infrastructure to support this application.

<https://easychair.org/cfp/ewuci2021>

## Commission V: Business Models and Operation

Joep Cromptvoets



*The mission of Commission 5 is to contribute to the development and implementation of business models describing the rationale of how mapping and cadastre agencies can create, deliver and capture value, in economic, legal, social, governance, cultural or other contexts.*

As chair of Commission V ‘Business Models and Operation’, it is my pleasure to contribute to the EuroSDR annual reports series. This commission was established at the 126th Board of Delegates meeting in Tønsberg (Norway, May 2015). In the fifth year of the existence of the Commission, it run the following workshops/projects:

- Crowdsourcing and National Mapping
- The Use of Volunteered Geographic Information for producing and maintaining authoritative Land Use and Land Cover data
- Authoritative Data in an European Context
- EuroGeographics Webinars
- Spatial Data Quality 2020 Workshop
- Use and needs of Spatial Data Infrastructures
- Survey on resources for education and research

The objective of the Commission V is to contribute to the development and implementation of business models in terms of describing the rationale of how mapping and cadastre agencies can create, deliver, and capture value, in economic, legal, social, governance contexts.

### **Crowdsourcing and National Mapping**

Commission 5 organized a third EuroSDR workshop on Crowdsourcing in National Mapping in 2020. This ‘physical’ workshop entitled “VGI Map of Europe: The State of Play” took place in Leuven, on 16 (Full) and 17 (Half a day) January 2020. 23 professionals and researchers from National Mapping and Cadastral Agencies and universities participated the workshop.

In the past number of years, use of crowdsourcing by National Mapping and Cadastral Agencies (NMCAs) has grown from being a disruptive technological idea to a mainstream source of geographic data and information. Today, many NMCAs and companies within the geospatial technologies industry use crowdsourcing to update databases and registries. However, it is often difficult to find information about what projects or initiatives are currently in operation or have been used in the past. Where has crowdsourcing being used? What role did crowdsourcing play in collecting, editing or updating data and information for NMCAs, companies or other institutions?

In this context, submissions were welcomed from participants who were willing to share their experiences, knowledge, expectations, use cases, future planning, etc., for Volunteered GeoInformation (VGI) and crowdsourced geospatial data.

The workshop served two principal aims:

- Create VGI-ME (the VGI Map of Europe). We gathered information and examples on projects and initiatives in European National Mapping and Cadastral Agencies and geospatial companies/SMEs where crowdsourcing has been successfully implemented. VGI-ME will be a conceptual ‘map’ of projects from around Europe which used crowdsourcing as a means of collecting geospatial data and information.
- Plan the design and delivery of a VGI Hackathon event in the second half of 2020 which will feature the creation of new crowdsourcing applications (mobile and web) and extending/improving existing

ones. For this part of the workshop we actively encouraged the participation of developers from NMCAs, universities, research institutions and companies who were/are active in developing crowdsourcing applications. We invited them to present their software, the data produced with it and its use in the organization's workflow and discuss extensions/new ideas which can be developed as proof of concept in a hackathon with other developers and creative thinkers, in order to make VGI apps more versatile, more user-friendly, and more effective.

The workshop engaged with stakeholders from NMCAs, the Geomatics Industry, academic research, software developers, citizens involved in geographic crowdsourcing and VGI, leaders or managers of crowdsourcing or VGI projects over 1.5 days to understand the most prominent and pressing questions related to crowdsourcing and national mapping in Europe (and beyond) today and to begin building the inventory of projects for VGI-ME.

The main conclusions of this workshop were that the research topic Crowdsourcing/VGI covers multiple disciplinary areas such as geomatics, computer science, law, ethics and governance. NMCAs are currently under pressure to consider/use crowdsourced data in their production flows, a possible divergence between research community and NMCAs on future VGI focus. More attention is needed for state of the art examples of the use of crowdsourcing at NMCAs and the legal and ethical issues involved in deploying them.

A workshop report has been published as an EuroSDR Official Publication.



As a follow-up of the Workshop, an online event on Crowdsourcing & Mapping took place as part of the 'Knowledge Graphs in Action: DBpedia, Linked Geodata and Geo-information Integration - SEMANTiCS Satellite event (6 October 2021). The online event was divided into two different sessions: Session 1: VGI country presentations (Estonia, Finland, Netherlands, Poland, and Session 2: EuroSDR VGI Datathon results.

## The Use of Volunteered Geographic Information for producing and maintaining authoritative Land Use and Land Cover data



This EuroSDR/Landsense/IGN France online workshop was organized (24-25 November 2020) on behalf of EuroSDR and the LandSense project (A Citizen Observatory and Innovation Marketplace for Land Use and Land Cover Monitoring). LandSense goal is to build a citizen observatory for land use and land cover (LULC) monitoring by proposing innovative technologies for data collection, change detection, data quality assessment and offering tools and systems to empower different communities (e.g., private companies, NGOs, NMAs, research, public authorities) to monitor and report on the use of the use of Volunteered Geographic Information (VGI) for producing and maintaining authoritative Land Use and Land Cover (LULC). The workshop was attended by ± 70 attendees from universities, research institutes and national mapping agencies.

LULC data are necessary for different applications (e.g., urbanization growth, biodiversity conservation, climate change) in monitoring our environment at national, regional and local scales. Different European initiatives such as CORINE Land Cover, Copernicus, Urban Atlas exist allowing to produce LULC data in vector format (i.e. feature-based LULC). The National Mapping Agencies (NMAs) also produce feature based LULC data at regional or national scales based on demand and available resources.

The feature-based LULC data are generally cyclically produced every 3 to 6 years, which is not always adequate. Moreover, producing LULC data is costly and a lack of *in-situ* information can generate incompleteness or inaccuracies. Recent research shows that LULC databases may take advantages of the use of Volunteer Geographic Information (VGI) to produce or improve update LULC data. For example, different approaches allowing to derive LULC data from OpenStreetMap are proposed. Thus, in this context the objective of the workshop was to bring together different actors (e.g., National mapping agencies, academic communities, private companies) having experiences in feature-based LULC data production or change detection in order to 1) dress an exhaustive list of the current practices and issues in mapping feature-based LULC data and 2) share innovative approaches allowing to produce, monitor and update LULC data.

### **Sustainable Open Data Business Models for NMCA's**

As a follow-up of the successful workshop in Delft, The Netherlands (September 2017), a second workshop on sustainable business models on Open Data was prepared. It is the intention to organize this event during Fall of 2021. The topic Open Data is very topical as Directive 2003/98/EC on the re-use of public sector information, otherwise known as the PSI Directive was subsequently replaced by the Open Data Directive (EU) 2019/1024 which entered into force on 16 July 2019. Member states have until 16 July 2021 to transpose the new directive into national law. According the new directive Geospatial data is considered as a High-Value dataset meaning that geospatial data are subject to a separate set of rules ensuring their availability free of charge, in machine readable formats, provided via Application Programming Interfaces (APIs) and, where relevant, as bulk download. It is expected that the implementation of this Directive will have a high impact on the business models of NMCA's. Preparation includes a questionnaire on Open data business models sent to members of EuroSDR and EuroGeographics. The questionnaire results will form the basis for the workshop.

### **Authoritative Data in an European context**

EuroSDR, EuroGeographics and KU Leuven initiated this a small project on the meaning of authoritative data last year. The result of this initiative is the report 'Authoritative Data in European context' (EuroSDR Official Publication #72) written by Joep Crompvoets, Stijn Wouters, Maxim Chantillon, Dominik Kopczewski, Mick Cory, Carol Agius, and Stephan Grimmelikhuisen. The highlights of this report were presented during the EuroSDR Board of Delegates meeting in Vienna and discussed during a follow-up break-out session. In addition, the results were also presented at Extraordinary General Assembly of EuroGeographics in Leuven (May) and European Forum for Geography and Statistics (Manchester, October). Finally, a paper with the main results was submitted to Spatial Data Quality 2020 workshop (Malta, January 2020).

### **EuroGeographics Webinars**

The chair of Commission 5 contributed to the weekly organized webinars of EuroGeographics by providing further reading material on a specific topic. The webinar series referred to topics of Open Data (16 April 2020), Digital Transformation in Cadastres (23 April 2020), Positioning/GNSS (30 April 2020), Interoperability (7 May 2020), Geoportals (14 May 2020), Quality (28 May 2020), Business transformation in Cadastre and Land Registry (4 June 2020), COVID-19 mapping and spatial analyses (11 June 2020), Digital transformation (18 June 2020). In general, ± 65 persons attended each webinar mainly from national mapping and cadastre agencies.

### **SDQ 2020 - Spatial Data Quality**



Demands for spatial data are ever increasing, outstripping the capabilities of the methods by which they have traditionally been provided. New capture methods, improved technology and an increasingly diverse customer base are driving the geospatial industry forward at an alarming rate. Consumers of data recognise the importance of location and expect geospatial information to be readily available, accurate, trustworthy and free.

This fast-evolving landscape necessitates that data quality and quality management must evolve to embrace the new technologies, methods of data capture and date use. To maintain their long-standing role of providers of trusted official data, National Mapping and Cadastral Agencies (NMCAs) have to keep up with these evolving needs and trends.

The international workshops on Spatial Data Quality are organised specifically to bring together producers, users, academia and software suppliers into one event to provide innovative and original contributions to the ongoing debate on spatial data quality. They are organised and hosted by two notfor profit entities: EuroGeographics, the association for Europe's National Mapping, Cadastral and Land Registry Authorities, and EuroSDR, the network of European geographic information organisations and research institutes.

Following previous successful workshops in 2015 and 2018, EuroGeographics and EuroSDR, in conjunction with OGC, ISO and ICA, organized the third workshop on spatial data quality held in Valletta, Malta on 28<sup>th</sup> and 29<sup>th</sup> January 2020. 35 participants webinar mainly from national mapping and cadastre agencies attended this physical event.

The topics presented at the workshop were many and varied, as demonstrated by the papers and abstracts provided in this publication. The richness of the discussion and debate is illustrated by the

broad scope of the topics and subject matter of these papers. Quality issues are varied and must be considered from different points of view.

Highlights included examples of how national data providers are meeting the challenge of managing quality from multiple suppliers and how new methods are enabling them to do so. Several presentations covered these areas. Users are interested in locating and using data and we have examples of how data suppliers can communicate this information to end-users in new and informative ways. Authoritative data and its provenance are discussions close to the hearts of both national geospatial data providers and users were also demonstrated. Also included were case studies of good practice in implementing quality at the heart of production, whilst contributions provided an overview of data quality perspectives in e-Government. No discussion covering spatial data quality is complete unless it touches on standards, the topic here was the motivation for revising ISO 19157:2013 Geographic Information – Data Quality. All the presentations together provided as illustration of the rich and broad conversation around quality which is engaging data providers, researchers and users of geospatial data.



## Use and needs of Spatial Data Infrastructures

In the scope of Erasmus+ Cooperation for innovation and the exchange of good practices project “BESTSDI – Western Balkans Academic Education Evolution and Professional’s Sustainable Training for Spatial Data Infrastructures”, there was a request to organize a workshop on the usage and needs of Spatial Data Infrastructures. In this context, a survey was launched and a workshop was organized in Sarajevo, 3 September 2019. The associated survey and workshop report was published in 2020.



## EuroSDR survey on resources for education and research

Commission 5 contributed to execution of the Survey on resources for education and research together with the commission chairs of commissions 4 and 6.

Three commission chairs of EuroSDR (Commission 4 Information usage, Commission 5 Business models and operations and Commission 6 Knowledge transfer) launched a survey on the provision of data and tools for research and education purposes on 13th May 2019. The objective of the survey was to study existing initiatives in terms of practices and projects at EuroSDR organizations to provide data and tools to pupils, students, teachers, and scientists for research and/or education purposes.

A questionnaire was sent to all the delegates of EuroSDR who represent national mapping and cadastral agencies (NMCAs). The respondents were asked to describe their potential initiatives by using a standardized template format. The respondents could describe as many initiatives as relevant for the provision of their data and tools. The deadline was set for 1st July 2019. The answers were compiled and reported in a first draft. As the response rate was rather low, the draft report was circulated in Spring 2020 again. The associated survey report was published in 2020.



Finally, the commission chair also contributed to the EuroSDR Webinar 4<sup>th</sup> Scaling up the Sentinels in Europe (26-27 October 2020) with ± 120 attendees from national mapping and cadastre agencies, companies, universities and research institutes. See report of Commission 3.

## Commission VI: Knowledge Transfer

Markéta Potůčková



*The mission of Commission 6 is to provide education services in order to support the transfer of knowledge from EuroSDR research projects to national mapping and cadastre agencies (NMCAs), academia and industry. The Commission also focus on fulfilling specific NMCAs demands for knowledge update, collecting and disseminating methodologies, developed tools and other research outcomes in the form of EuroSDR's official publications and via EuroSDR's homepage.*

In 2020, the EuroSDR Commission 6 on Knowledge Transfer continued with organising the EuroSDR Educational Service (EduServ) – a series of e-learning courses reflecting new trends in geographic information science in connection with the needs of research, development and practice within NMCAs and industry. The 18<sup>th</sup> series of EduServ offered four e-learning courses on the following topics:

- **Deep Learning for Remote Sensing** (9<sup>th</sup> – 20<sup>th</sup> March 2020)  
Tutors: Loic Landrieu (IGN France), Sébastien Lefevre (IRISA/Université Bretagne Sud)
- **3D Sensing, Scene Reconstruction and Semantic Interpretation** (30<sup>th</sup> March – 20<sup>th</sup> April 2020)  
Tutors: Martin Weinmann (Karlsruhe Institute of Technology), Michael Weinmann (University of Bonn), Franz Rottensteiner (Leibniz Universität Hannover), Boris Jutzi (Karlsruhe Institute of Technology)
- **Spatial Linked (Open) Data** (11<sup>th</sup> – 22<sup>nd</sup> May 2020)  
Tutors: Erwin Folmer (Kadaster and University of Twente), Stanislav Ronzhin (ITC, University of Twente, Kadaster), Rob Lemmens (ITC, University of Twente), Wouter Beek (Triply, VU University, Kadaster)
- **GeoBIM – Basic Principles and Use Cases** (1<sup>st</sup> – 12<sup>th</sup> June 2020)  
Tutors: Lars Harrie (Lund University), Claire Ellul (University College London)

The EduServ opened with a pre-course seminar hosted by Dr. Didier Richard at the premises of Ecole Nationale des Sciences Géographiques (ENSG) in Marne-la-Vallée, France from 2<sup>nd</sup> to 3<sup>rd</sup> March 2020. The possibility of listening to introductory lectures to the courses, meeting the teachers, and exchanging experience with other colleagues attracted 25 participants. Some last-minute cancellations appeared due to the upcoming COVID-19 pandemic. In total, 66 participants followed the e-learning courses. The table below summarises the number of participants attending each course and the number of participants who successfully completed the courses and received the certificates from EuroSDR.

Course title	Number of active participants	issued certificates
Deep Learning for Remote Sensing	48	27
3D Sensing, Scene Reconstruction and Semantic Interpretation	30	11
Spatial Linked (Open) Data	31	16
GeoBIM – Basic Principles and Use Cases	21	11

A call for entries for the 2020 EuroSDR PhD Award opened in March 2020. Out of 11 evaluated applications, two winners were chosen - Dr. Yolanda Torres Fernandez from the Technical University of Madrid with her thesis titled “Exposure and seismic vulnerability assessment using machine learning techniques with remote sensing data: Applications in Lorca (Spain) and Port-au-Prince (Haiti)” and Dr. Oussama Ennafii from the University of Paris-Est with his thesis titled “Quality evaluation of 3D

building models: a scalable approach”. Both winners gave a presentation about the main outcomes of their research work during the on-line 137<sup>th</sup> Board of Delegates meeting in October 2020.

In collaboration with the EuroSDR Commissions 4 and 5, results of the survey on “Data and tools for research and education” were summarised and after reviewing published within the [EuroSDR survey report series](#).

## Workshops

- 2<sup>nd</sup> Workshop 'Crowdsourcing in National Mapping' (Leuven, Belgium, 15 – 16 January 2020)
- EuroGeographics/EuroSDR 'Spatial Data Quality' workshop (Valetta, Malta, 27 – 29 January 2020)
- EduServ18 pre-course seminar (Marne la Vallée, France, 2 – 3 March 2020)
- Webinars EuroGeographics 'Further Reading materials on Open Data' (16 April 2020), 'Digital transformation in Cadastre' (23 April 2020), 'GNSS' (30 April 2020), 'Interoperability and use of authoritative Data' (7 May 2020), 'Geoportals' (14 May 2020), 'Quality' (28 May 2020), 'Business transformation in Cadastre and Land Registry' (4 June 2020), 'Covid-19 mapping and spatial analyses' (11 June 2020), 'Digital transformation' (18 June 2020) – Virtual
- Webinar 1Spatial 'How can National Mapping Agencies manage data quality from third party suppliers?' (21 April 2020) – Virtual
- Webinar Esri 'GIS for Covid-19 Response & Recovery' (20 May 2020) – Virtual
- Webinar ConsultingWhere 'Influencing Decision Makers: A Tutorial on Developing Winning Geospatial Value Propositions' (15 June 2020) – Virtual
- Webinar 1Spatial 'Research and Development focus update in light of Covid-19' (24 June 2020) – Virtual
- Conference '3D Geo Info 2020' (9 – 11 September 2020) – Virtual
- Webinar 1Spatial 'Accessing Data You Can Trust' (29 September 2020) – Virtual
- 'Knowledge Graph in Action' DBpedia, Linked Geodata and Geo information Integration SEMANTICS Satellite event (6 October 2020) – Virtual
- Webinar 1Spatial 'Transforming Authoritative 2D Data to a 3D World' (22 October 2020) – Virtual
- Webinar 'Scaling up the Sentinels in Europe' (26 – 27 October 2020)– Virtual
- EuroSDR/Landsense/IGN France workshop 'The Use of Volunteered Geographic Information for producing and maintaining authoritative Land Use and Land Cover data' (24 – 25 November 2020 – Virtual

## Publications

- WR Holmes, J., Agius, C. & Cromptvoets, J.: Spatial Data Quality. 2020, 84 pages.
- SR Bucher, B., Potůčková, M. & Cromptvoets, J.: Initiatives for Providing Data and Tools for Research and Education. 2020, 22 pages.
- WR Lemmens, R., Mooney, P. & Cromptvoets, C.: Crowdsourcing in National Mapping. 2020, 22 pages.
- SR Cromptvoets, J., Bačič, Z., Poslončec-Petrić, V.: Academia-Business Survey on Needs and Cooperation in Field of Spatial Data Infrastructures. 2020, 36 pages.
- 72 Cromptvoets, J.; Wouters, S.; Chantillon, M.; Kopczewski, D.; Cory, M.; Agius, C.; Grimmeliikhuijsen, S.: Authoritative Data in a European Context. 2019, 32 pages.
- 71b Liang, X.; Hyyppä, J.; Kaartinen, H.; Lehtomäki, M.; Pyörälä, J.; Yu, X.; Pfeifer, N.; Brolly, G.; Francesco, P.; Hackenberg, J.; Huang, H.; Jo, H.W.; Katoh, M.; Liu, L.; Mokroš, M.; Morel, J.; Olofsson, K.; Poveda-Lopez, J.; Trochta, J.; Wang, D.; Wang, J.; Xi, Z.; Yang, B.; Zheng, G.; Kankare, V.; Vastaranta, M.; Wang, Y.: International Benchmarking of Terrestrial Laser Scanning Approaches for Forest Inventories. Part II: Results, Discussion and Outlook. 2019, 54 pages.
- 71a Liang, X.; Hyyppä, J.; Kaartinen, H.; Pyörälä, J.; Lehtomäki, M.; Holopainen, M.; Kankare, V.; Luoma, V.; Saarinen, N.; Chen, L.; Wang, Y.: International Benchmarking of Terrestrial Laser Scanning Approaches for Forest Inventories. Part I: Objective, Datasets, Evaluation Criteria and Methods. 2019, 30 pages.
- WR Bucher, B; Tiainen, E.; Ellett, T.; Acheson, E.; Laurant, D.; Boissel, S.: Data Linking by Indirect Spatial Referencing Systems. 2019, 26 pages.
- 70 Giordano, S.; Mallet, C.: Archiving and geoprocessing of historical aerial images: Current status in Europe. 2019, 36 pages.
- WR Bucher, B.; Laurent, D.; Jansen, P.: INSPIRE Data Extension. 2019, 19 pages.
- WR Mooney, P.; Cromptvoets, J.; Lemmens, R.: Crowdsourcing in National Mapping. 2018, 26 pages.
- WR Bucher, B.; Schlieder, C.; Cantat, F.; Kavouras, M.; Streilein, A.; Severo, M.: Mapping Places for Digital Natives and Other Generations. 2018, 16 pages.
- 69 Kruk, R. W.; Demeyer, P.; Decoene, K.: Preserving the Geographical Production Process. 2018, 24 pages.
- 68 Coote, A.; Knight, P.; Colding, T.S.; Home, R.; Fröjdenlund, J.; Lysell, G.; Streilein, A.; Kane, P.; Brady, K.; Wozniak, P.; Plá, M.; Bayers, E.; Ilves, R.; Tuokko, J.; Rijdsdijk, M.; Witmer, R.; Cantat, F.; Cromptvoets, J.; Stoter, J: Assessing the Economic Value of 3D Geo-Information. 2017, 128 pages.
- 67 Donker, F.W.; Cromptvoets, J.; van Loenen, B.: Adapting NMCAs Business Models to Open Data Supply: the Survey Results. 2017, 36 pages.
- WR Bucher, B.; Golay, F: Graphical Interfaces for Historical Data. 2017, 16 pages.
- 66 EuroSDR contributions to the ISPRS Congress XXIII, Special Session 12 – EuroSDR, 12 – 19 July 2016, Prague, Czech Republic. 2017, 129 pages.
- 65 Cromptvoets, J.; Streilein, A.; Masser, I.: How should NMCAs adapt to alternative sources for NMCA data? 2016, 9 pages.

All publications can be downloaded on the EuroSDR website ([www.eurosd.net](http://www.eurosd.net)).

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