EuroSDR

European Spatial Data Research

Annual Report 2021

www.eurosdr.net

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 (2021)

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

Our Associate Members and their Representatives (2021)

Esri/nFrames	Nick Land & Konrad Wenzel
Hexagon	Simon Musäus
ICGC	Julià Talaya
Informatie Vlaanderen	Jo Van Valckenborgh
Terratec	Leif Erik Blankenberg
Vexcel	Michael Gruber
1Spatial	Dan Warner

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Message from the President

Michael Hovenbitzer

Dear colleagues, fellow delegates, Members of the Executive,

A heartfelt welcome to EuroSDR's 2021 annual report to those of you that have been with us for years and to all new members of EuroSDR.

As current events, be they geopolitical or epidemic, are unfortunately all too present in our minds these days, I think it is important that we make a conscious effort to focus on steady, positive developments in the spirit of collaboration. It gives me great pleasure to see that EuroSDR truly fosters a sense of partnership, cooperation and teamwork – no matter where you are from, which is very much mirrored in your work and contributions to EuroSDR. I invite you to take a look at the numerous activities EuroSDR has been involved in over the past year. I am confident there will be times ahead where a simple foreword will not have to reference current events and will instead touch on more local-level topics, which will seem banal in comparison. I do hope, as I did last year, that with that we can also get back to meeting in person again soon.

Most importantly, I would like to thank each and every one of you for your contributions to the work of EuroSDR throughout the year. A special thank you also goes out to the secretariat, publications staff, and everyone who works tirelessly to ensure that EuroSDR runs smoothly.

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

- Mário Caetano (Direção-Geral do Território) as Prime Delegate of Portugal;
- Paulo Patricio (Direção-Geral do Território) as Second Delegate of Portugal;
- Anna Bober (GUGiK) as Prime Delegate of Poland;
- Anders Rydén (Lantmäteriet) as Second Delegate of Sweden.

I would also like to express my thanks to all of the individual Commission Chairs, where we have seen the appointment of:

- Jon Mills for his third and last term as Chair of Commission 1 'Data Acquisition' (re-appointment);
- Frédéric Cantat as Chair of Commission 4 'Business Models and Operation';
- Anka Lisec as Chair of Commission 5 'Knowledge Transfer'.

The EuroSDR network is constantly expanding, so I am pleased to welcome Cartographic and Geological Institute of Catalonia (ICGC) as a new Associate Member of EuroSDR with Julià Talaya as representative. I am also proud to announce that Portugal is now a member of EuroSDR.

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

- Sally Cooper (Prime Delegate UK)
- Thomas Lithén (Second delegate of Sweden).

Also a special thanks to Markéta Potůčková, who was Chair of the Commission on Education/Knowledge Transfer since 2012.

In executive news, I am very happy that my EuroSDR presidency was extended with one year as no physical meeting could take place so far. I am delighted to be joined by Fabio Remondino who has been re-appointed for his last term as Vice-President of EuroSDR (Autumn 2021 – Autumn 2023).

It is a pleasure for me to present our annual report this year. This report highlights and underscores your work and dedication over the last twelve months, which have not necessarily been easy. I look forward to continuing our work together, hopefully in more calmer times over the coming year.

Message from the Vice-President

Fabio Remondino

Dear EuroSDR friends,

The past year proved to be another successful and intense year for EuroSDR which confirmed, despite the lack of physical meetings like in the past, its leaderships and presence in the geospatial sector through many events, research activities and cooperation with sister organisations. Despite the still unsolved pandemic situation, 2021 was still a productive and successful year for EuroSDR with many research activities concerned with:

- integration of Artificial Intelligence methods in the daily management of geodata, from processing to interpretation
- technical development in geospatial data acquisition, processing, updating and visualization
- use of historical aerial images for territorial mapping and change detection
- BIM/GIS integration and geoBIM
- RPAS for mapping purposes
- point cloud and mesh 3D classification.

In 2021 various interesting **projects** took off, such as the "*Benchmark - TIME - on historical aerial images*", the "*Benchmark - Hessigheim 3D - on semantic segmentation of high-resolution 3D point clouds and textured meshes*" and the "*Benchmark on RPAS geometric survey quality in the absence of ground information*". On the other hand, other projects related to spatial data quality issues, crowdsourcing and open data were finished, either with a publication or with an event.

In terms of **publications**, there have been some scientific and official publication of EuroSDR, such as the report on "*The Use of Volunteer Geographic Information for Producing and Maintaining Authoritative Land Use and Land Cover Data*", the report on the "*EUNET4DBP - Digital Building Permit*" or the report on "*Spatial Linked Data in Europe*".

A new **EuroSDR Research Plan**, approved at the 139th BoD meeting, was issued, including a new structure of the research Commissions which are now five: Data Acquisition; Data Processing, Modelling and Integration; Information Usage and Visualization; Business Models and Operation; Knowledge Transfer.

Following the experiences of 2020, the year 2021 has still seen many remote meetings and basically no physical events. We are all very aware that the pandemic situation has dramatically changed our habits, including travels ad meetings, but EuroSDR believes that delegates should meet again soon and physically.

We wish you all a very successful 2022 with many new research activities, events and educational courses, hopefully all physical or hybrid!

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

1. Supporting the Mapping process by Automated Land Cover Classification
   Federal Office of Metrology and Surveying (Wolfgang Gold)

In the more than 250 years of history of national mapping in BEV (Austrian Institute for Metrology and Surveying) and its parent organization, the institute for military mapping, one always tried making the related processes more efficient. A recent development is the process step from orthoimages to the digital landscape model.

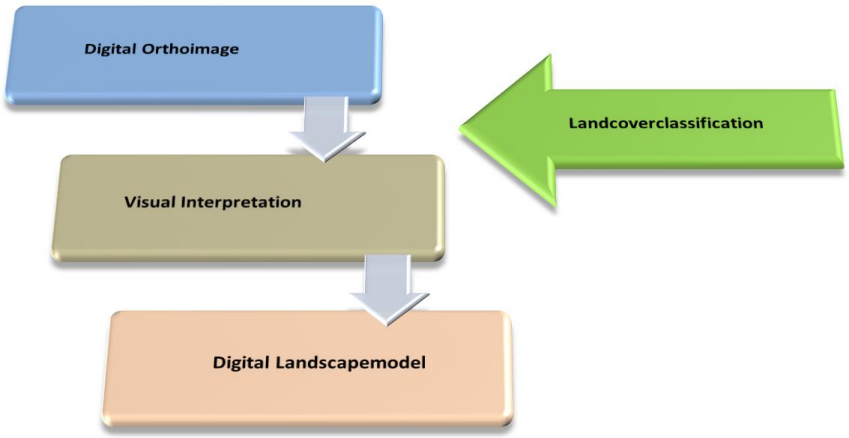


Figure 1: A new process step in the mapping workflow of BEV

In the sequence from pixel based orthoimages to the Landscape model, which is a spatial database dataset in vector format, lots of human interpretation was done until now.

In 2015 BEV started with a land cover classification based on the standardised nationwide available orthoimages, which are produced in a three years cycle with a GSD (ground sampling distance) of 20 cm. Other used data sets are a DSM (digital surface model) generated from the same aerial images as the orthoimages with a resolution of 50 cm and an ALS-DTM (digital terrain model acquired by airborne laser scanning). This input allows a classification in very high granularity but since it is based "only" on four radiometric bands the resulting class scheme is rather simple. Classes that can be reliable determined are: water, buildings, vegetation (high, medium, low) and ground.

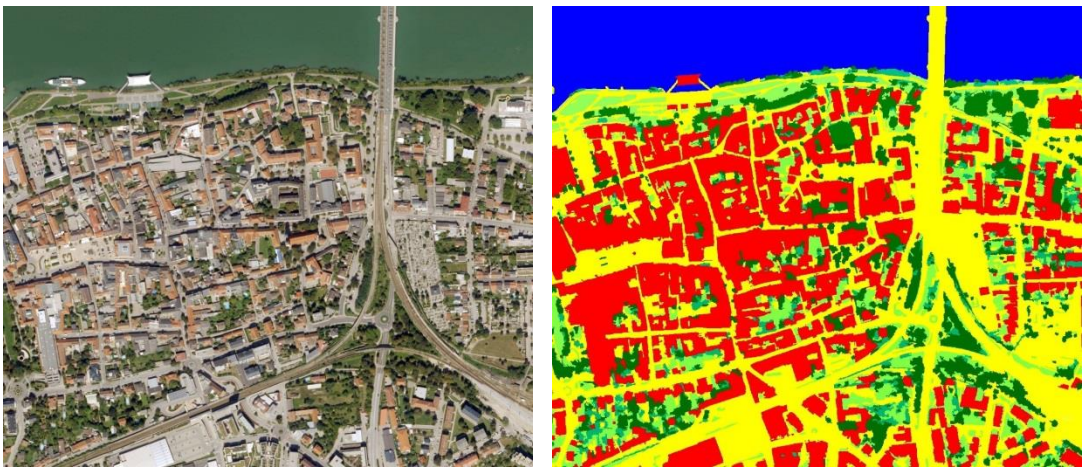


Figure 2: Orthoimage and land cover classification

The classification is executed as an object based image analysis with segmentation relating to radiometric information of the orthoimages. The use of the NDVI (normalised digital vegetation index) leads to a separation of vegetation and non-vegetation classes. DSM and DTM are relevant input for a further differentiation. One of the ideas of this classification process is: “if a computer can check where buildings are, don’t do it yourself”.

The integration of this land cover layer in the mapping process has led to faster and much more reliable results in building up the land scape model of Austria, so it was implemented by default. Having a first nationwide coverage enables change detection algorithms in the upcoming update cycle.

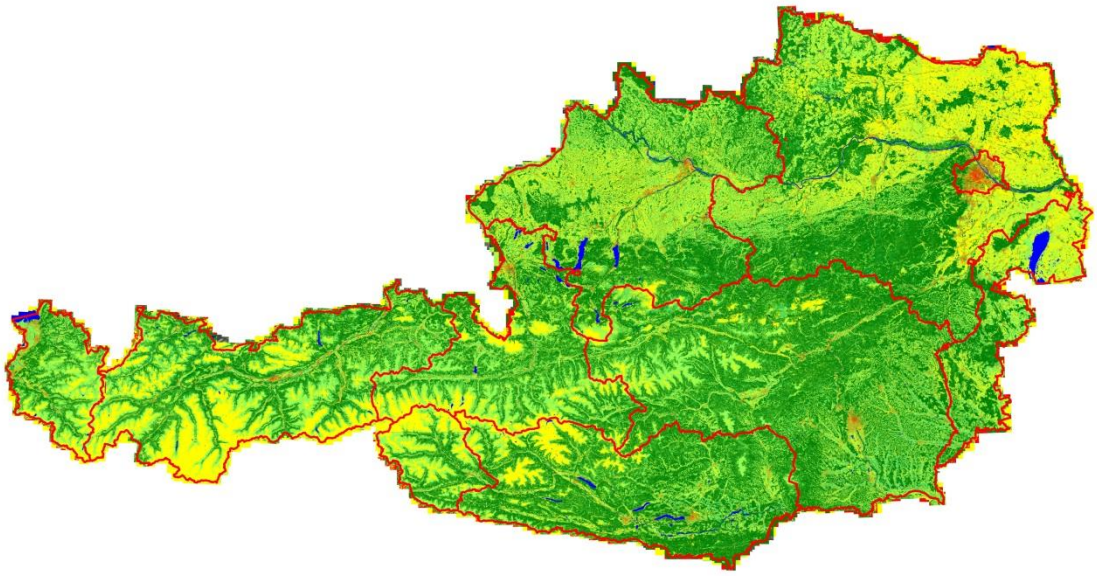


Figure 3: Land Cover of Austria

Further developments will focus on a differentiation of the recent class ground. At the moment we pursue a machine learning strategy. A success will lead to a report.

2. Automatic extraction and change detection of buildings from aerial lidar data in the department of lands and surveys (DLS), Cyprus

Department of Lands and Surveys, Ministry of Interior Cyprus (Georgia Papathoma Economidou - email)

The main objective of this project was to detect building changes using automated processes, so as to reduce time and cost of data capture. The time period, in which the changes took place was between 2014 and 2019. The Photogrammetry and Remote Sensing section of DLS, used aerial laser scanner (ALS) data and aerial image data from the 2019 aerial photography and Lidar project, to compare them with the National Topographic Building Database (2014). The data capture was performed through the purchase of private sector services and covered a total of 550 km² in urban areas. The density of the captured 3D point clouds is 10 points/sqm, with a precision of 20 cm in height. The GSD of the orthophotos is 10cm. The city of Limassol, which is a mixed tourist, commercial and residential area, was selected as a pilot area to evaluate the results of building change detection.

Figure 1: Orthophoto 2019, National Topographic Database 2014

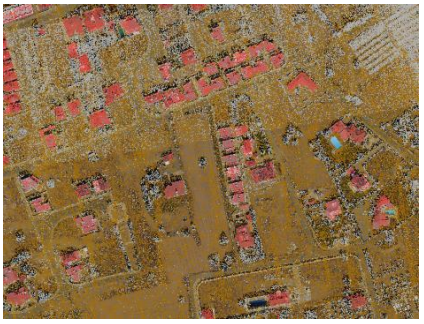


Figure 2: Aerial laser scanner (ALS) data 2019

We used a 3-stage *Classification-Vectorisation-Change Detection* approach to reach the final product. At stage 1, an automated methodology is developed to classify and extract building Lidar points from point cloud data. Some buildings are partially covered by high trees or have high vegetation fences (bushes) alongside the building boundary. Although building constructions are characterized by a regular and well-defined geometry, many building structures in Cyprus have complex shapes with solar water heaters and air-condition units installed on their roofs. To overcome these difficulties, we applied Lidar building extraction techniques, using *ESRI ArcGIS Pro* software. Point cloud data were classified based on their height and shape information, using the aggressive classification method, which as it is stated by the developers, means that points which fit the planar rooftop characteristics with a relatively high tolerance for outliers will be detected. The results are shown in Figure 3.

Figure 3: Classified Building points identified from Lidar data

Figure 4: Converted classified points to polygon features

At stage 2, a sequence of Lidar vectorisation techniques was used for converting the classified (LAS) points to polygon features. The next step was to compare them with orthophoto images of the same time period (2019). QC checks were satisfactory in terms of accuracy and processing time and the results are shown on Figure 4. In order to achieve better results and eliminate false positive cases,

selected polygons with height below 2m and area less than 20 m², were considered as *not-building* entities and were deleted. These cases were vegetation fences, trucks and commercial storage containers.

At stage 3, an automated process was developed to identify building changes within the selected urban geographic area, comparing building polygons of 2019 from stage 2, with the topographic building database polygons of 2014. The results show that the most important changes have been identified and are meeting our mapping specifications.

After validating the successful pilot results, the above process was applied to the whole Area of Interest (AOI).

Figure 5: Detected building changes 2014-2019 (green)

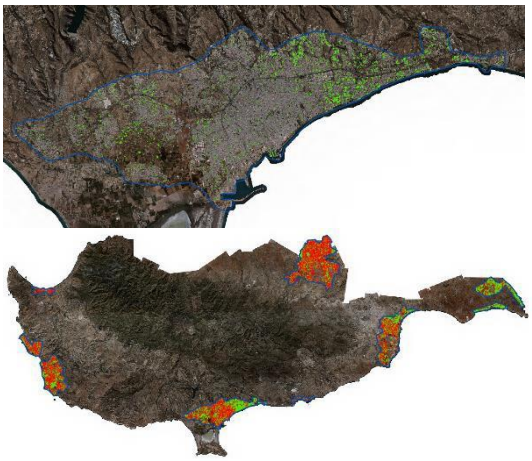


Figure 6 & 7: Change Detection results (green) in Limassol area(above) and AOI (below)

The effective use of Lidar data for National Cartographic Agencies is very important and the implementation of accurate update mechanisms is crucial. The development of automated processes using lidar data will accelerate the identification of building changes and this will have a significant contribution to the economic development of the State.

3. Estonia EstHUB supports decision-making and innovation in remote sensing

National Satellite Data Centre ESTHub (website), Department of Geoinformatics, Estonian Land Board (website) (Martin Menert - email)

Estonia has been a full member of the European Space Agency (ESA) since 2015. According to the co-operation agreement the Estonian Land Board was designated as the national contact point – the National Mapping and Cadastre Agency (NMCA) – for the ESA. The main task of the contact point was the storage and transmission of remote sensing data from the Copernicus program's Sentinel satellites.

The Estonian Land Board produces orthoimagery and mosaic which covers the entire Estonian territory and is composed in two years. The long-term experience gained in the production and enrichment of orthoimagery was also used in the processing of the satellite data. The creation of services (WMS) providing near-real-time remote sensing data started in 2017.

1 July 2018 was a date of significant importance in Estonia, because the Estonian Land Board made the spatial data it manages available to everyone. On 16 May 2019, the national satellite data centre ESTHub was opened. Its first task was the processing and dissemination of open remote sensing data.

Although the satellite data was available to experts through the ESTHub data warehouse, there was no simple and convenient public application for rapid access and visualization of the data. With regard to remote sensing and spatial data, the introduction of data services in both scientific analysis and end-user applications, instead of downloading complete sets of raw data, has been an important trend over the last decade. Remarkably, in 2021 an EstHUB application for the remote sensing service Satiladu was launched.

In this Satiladu service satellite data are combined with the spatial data of Estonia, turning it into an effective tool for improving quality of environmental decisions. In addition, a public API for satellite imagery was created to facilitate the work of professionals and provide a data flow for future remote sensing applications. Today, officials, entrepreneurs, and citizens have the opportunity to get a daily overview of land use and land cover (LULC) at both the state and local government level.

The application also plays an important role in supporting innovation in remote sensing. Compared to previous map products, the focus is on promotion of spectroscopy in earth science. For example, several maps characterising the state of vegetation (NDVI, NDPI, ...) can only be calculated using different parts of the infra-red spectrum measured by the satellite (B8, B12, and others that are invisible to the naked eye). The application allows the user to find a suitable spectral set and weights for calculating the required environmental index. An intuitive and minimalist user interface contributes to user convenience, in which data can be compared with other land use indicators, such as the Estonian topography database or other open data sources.

The creation of the application laid the foundation for the introduction of a data exchange standard for remote sensing applications in Estonia, which supports the principles of Green ICT. At the same time, prototyping is easier for new remote sensing companies, as data services can be used to run design and development cycles faster than with classic file-based solutions.

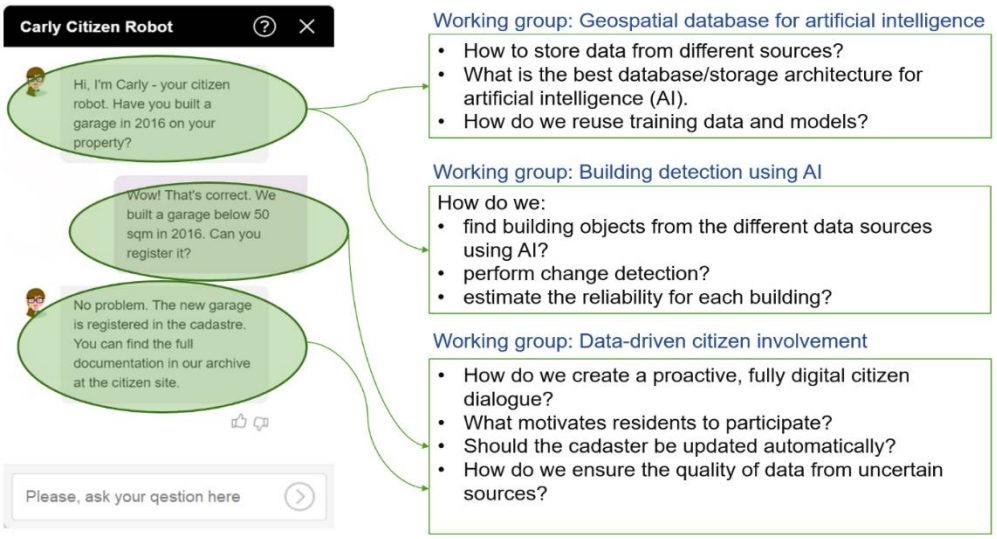
4. Kartai

Kartverket (Ivar Oveland - email)

In Norway the number of building application is declining (-11%). At the same time the operating expenses for the municipalities are increasing (+15%). The project hypothesis is that expenses can be reduced by improving the quality of the cadastre and the national map database. KartAI is a collaboration between academia, national mapping authority, municipality and private industry. Regional Research Fund Agder, Norway, financially supports the project which runs from 2021 to 2023.

KartAI is a research project for raising the quality of the property register (cadastre) and the National Map Database using artificial intelligence (AI), focusing on buildings. The project combines multiple data sources into a common architecture including cadastre, national map database, aerial images, orthophoto, LiDAR and crowd sourcing. The various data sources are handled as independent building observations and are used to establish change detection and reliability for each individual building.

The project is based on the principle that citizen involvement creates better data and a better data democracy. The citizens will automatically and digitally be contacted if the reliability shows a need for additional information. KartAi aims at creating a system for digital participation between Ai, citizens and the formal data registries.



The Figure shows the research question for each working group and shows how the citizen robot can hypothetically be used to contact the building owners.

Using an event source strategy, the concept of finding a truthful representation of the real world, is inherently innovative with respect to the traditional data management routines today.

5. Poland's NMCA activity

Head Office of Geodesy and Cartography (GUGIK)

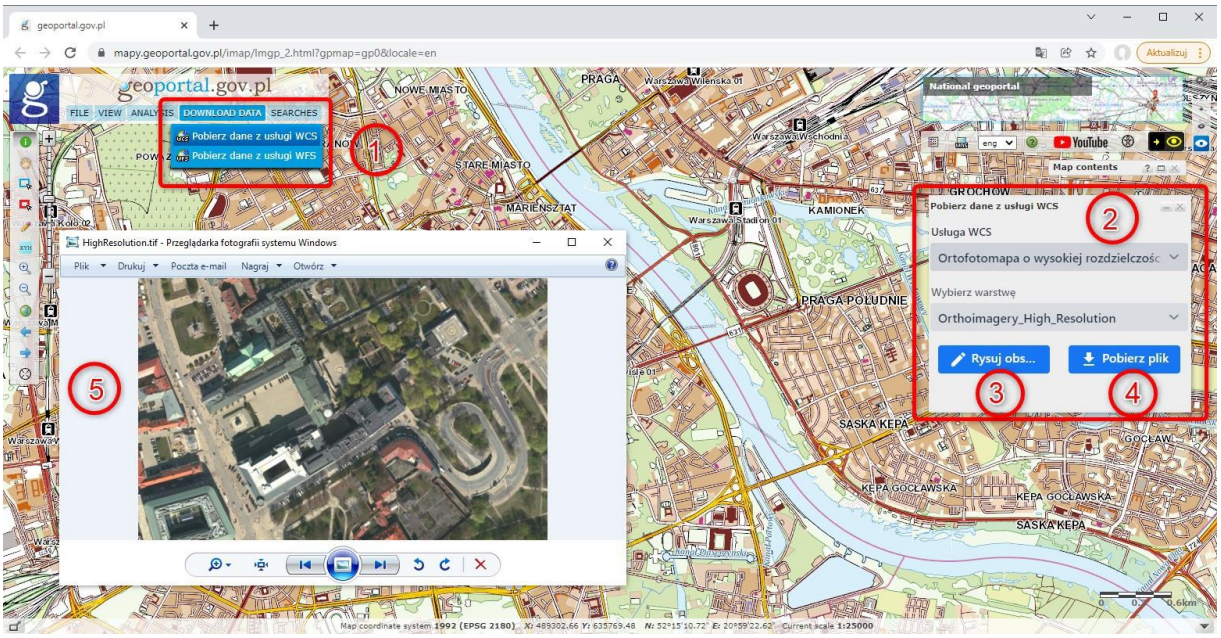
1. DEVELOPMENT OF NATIONAL SERVICE GEOPORTAL.GOV.PL

Following the release and opening of spatial data (now available freely and without any restrictions), the next important step to be taken, was to provide users with reliable data analysis and processing tools. Nearly 10 000 000 users visited the geoportal.gov.pl service in 2021. This is the best result so far and is 25% more than 2020. 605 TB of open spatial data was downloaded in 2021, almost twice as much as in 2020.

Last year, the national geoportal was developed and enriched with tools, as follows:

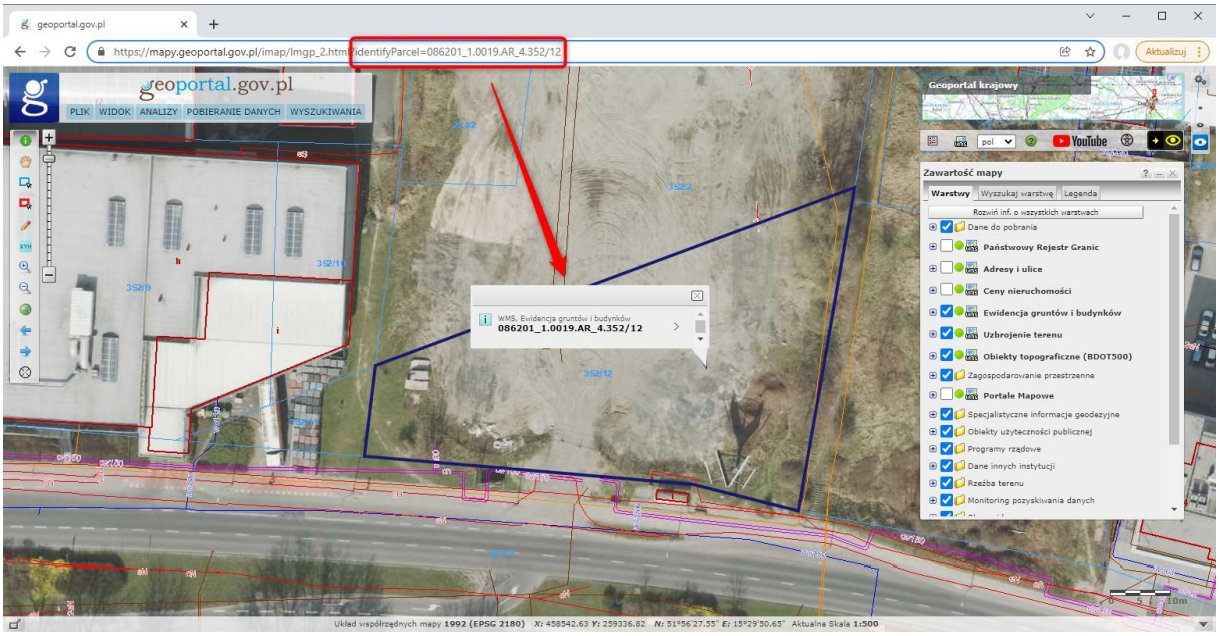
- DATA DOWNLOADING - USING WCS AND WFS SERVICES

New simple graphic interface for downloading open geospatial data from predefined WFS and from WCS services has been developed. The tool offers downloading both raster (in tiff format from 7 WCS services) and vector data (in GML formatfrom 13 WFS services). Even less advanced users can download orthophotomaps, elevation data and land cover data by marking the area of interest.



- CALLING GEOPORTAL.GOV.PL WITH DEFINED PARAMETERS

Another new useful functionality of the geoportal is calling it with defined parameters. The example of its use (with the *identifyParcel* parameter) is launching the geoportal map application, centered on the specified by the user cadastral parcel. Knowing the given unique parcel identifier, the user can create a dedicated direct link. This functionality allows for wider integration of geoportal.gov.pl and other systems. The functionality is used for example in the Electronic Land Register System or on commercial websites with real estate advertisements.



- SEARCHING ROUTE

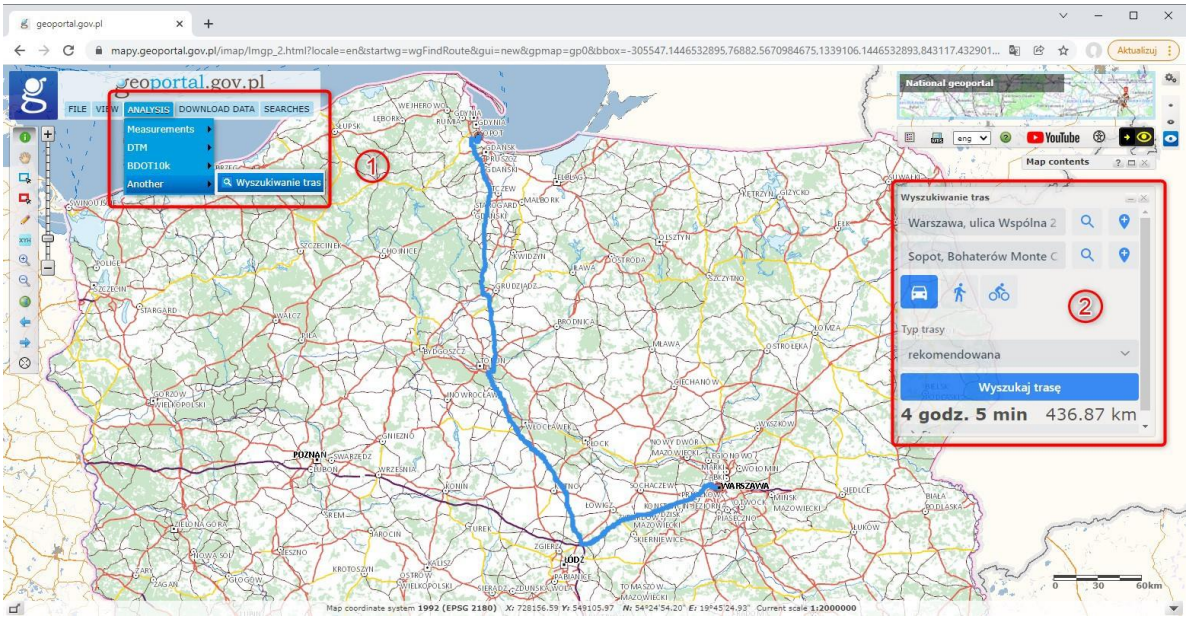
Finding the route, based on geospatial data from National Geodetic and Cartographic Resource, is realized by indicating the start and end point, using the following parameters:

- marker identification,
- or address lookup.

After a while, the user gets 3 possible options:

- the fastest,
- the most comfortable,
- the shortest.

The solution is based on Open Street Map services.



2. NEW QUASI-GEOID MODEL (2021) FOR THE AREA OF POLAND

Head Office of Geodesy and Cartography (GUGIK) has gained a new quasi-geoid model (2021) for the area of Poland. The new model was developed by the Wroclaw University of Environmental and Life Sciences.

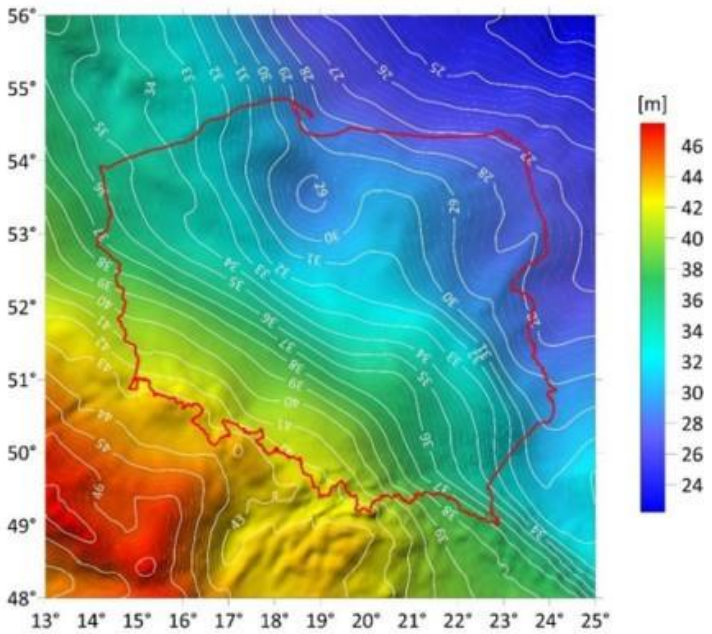
The quasi-geoid model with its specification is published in the geoid repository on the International Service for the Geoid.

The quasi-geoid *PL_quasi-geoid2021* was computed for the area: lat <48°N; 56°N> and lon <13°E; 25°E>, with a resolution of 0.01° x 0.01° by using GGI method.

The model was elaborated on the basis of:

- SGG-UGM-2 global geopotential model,
- currently available gravimetric data,
- SRTM V 4.1. digital terrain model with a resolution of 3".

The final height anomalies at points on the territory of Poland were adopted as average values from two models: A and B. Procedure A involves developing a gravimetric quasi-geoid modeland fitting this model by a transformation function to GPS/leveling data (ASG-EUPOS network points). Procedure B involves building a model fitted to GNSS/leveling data (selected POLREF points). Provided height anomalies are the differences between geodetic heights in the PL-ETRF2000-GRS80h system and normal heights in the PL-EVRF2007-NH system. The reference ellipsoid for this model is GRS80.



The PL_quasi-geoid2021 quasi-geoid model developed by the GGI method.

The standard deviation of the heights difference at the GPS/leveling points is 1.9 cm. The table below presents the model's statistics for individual networks.

network designation	$min(\Delta\zeta)$	$max(\Delta\zeta)$	R	$\Delta\zeta$mean	$stdev(\Delta\zeta)$
	[cm]				
ASG_Stacje	-3.0	2.5	5.5	0.1	1.16
ASG_Excentry	3.3	1.9	5.2	-0.1	0.95
EUVN	-3.4	1.6	5.0	-0.7	1.16
POLREF*	-5.6	2.3	7.9	-0.8	1.17

3. DEEP LEARNING FOR AUTOMATIC DETECTION OF ERRORS IN AERIAL IMAGERY

The number of aerial images taken is growing in an exponential rate due to the lowerGSD, more frequent data acquisitions, new aerial platforms and sensors. This creates new operational challenges in verifying the quality of the thousands of images, acquired every year and included to the National Geodetic and Cartographic Resource in Poland. Since it is governmental, the data must be authoritative. Any errors, such as blurs, clouds, shadows, smokes cannot appear on the aerial images constituting the National Geodetic and Cartographic Resource.

Using the power of deep learning and dedicated methods of training data, it is possible to perform radiometric quality assurance (QA) of images in a fast and reliable way. Thanks to that, controllers can spend their valuable time focusing on evaluating images with errors and their impact on the quality of delivered products, not on verifying correctly captured images.

Key technical challenges, faced when doing automatic radiometric QA of aerial survey images, are as follows:

- huge diversity of aerial images, which makes it even more difficult to develop a universal solution for this type of image,
- the requirement for the solution to be effective for all photos taken, regardless of the pixel size, type of land cover, season, or the angle of the sun's rays,
- errors occurring in the photos also vary in appearances (e.g. clouds can have any shape, size and thickness, which means that the image of the Earth's surface may be completely obscured or partially visible through the clouds),
- lack of large-scale training data (more than 98% of images delivered are without errors).

Traditional algorithms fail, due to multiple edge cases that happen when combining camera quality problems with different land cover types visible on aerial images. Therefore it was decided to use deep learning methods. This approach is implemented by using a mix of deep learning models (for detection of the clouds, clouds shadows, blur, discoloration and smoke) and traditional computer vision algorithms (for burn-in and glare detection). CertiflAI software was commissioned by the Head Office of Geodesy and Cartography and implemented by the company Opegieka. The software detects the following errors:

- blur - deep learning model uses full resolution of the image to detect even small blurs,
- radiometric errors - detection of discoloration, burn-in and glare,
- clouds, cloud shadows and smoke - important feature can be obstructed by such elements, so it is important to correctly reduce their impact on the datasets.

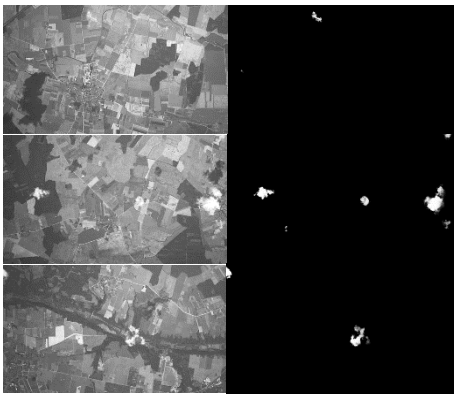
The basic condition for the development of an effective model of radiometric QA in aerial photos based on machine learning techniques, is the preparation of a sufficiently large and varied set of training data. Training, of the convolutional neural networks, was done on more than 10 000 aerial

images. Different types of errors commonly occurring on aerial images (e.g. clouds, blur, discoloration) were simulated on error-free images. In addition, the errors were subjected to random modifications such as scaling or rotation. This way, an exceptionally large and varied set of training data was obtained. After the training process was completed, the neural networks were ready to make predictions of the presence of errors on photos.

The software runs on a workstation with an Nvidia Gaming GPU. The image processing time is ~20s per image. It is possible to obtain metadata from the folder structure and batch processing. An adjustable confidence threshold to change the detection sensitivity and user defined reporting has been implemented.

Sample errors and user interface

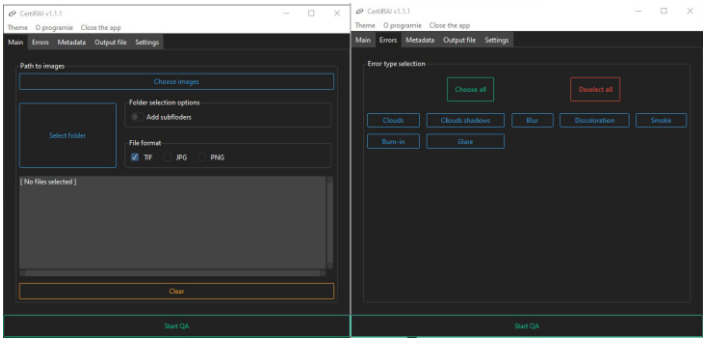
Examples of images with clouds (left) and corresponding probability images that predict the artificial neural network (right).



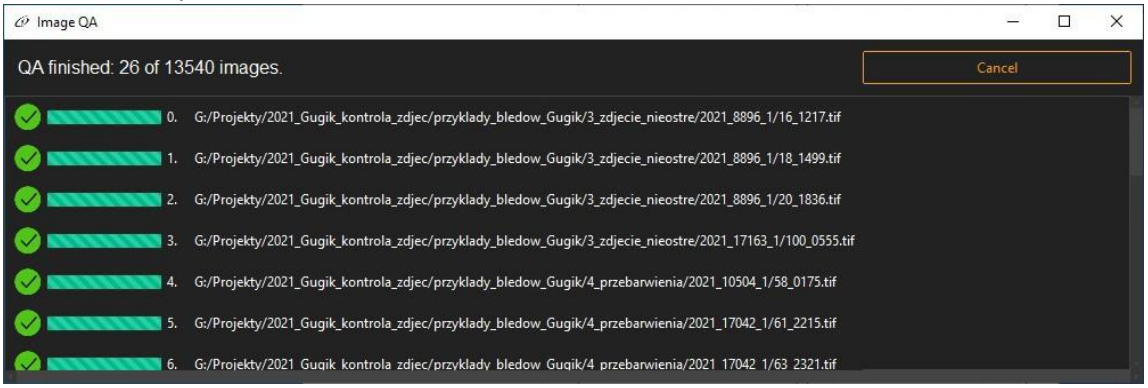
Examples of photos with discoloration

Example of a blurred image detected (left)

Main window of the software:



Process status report:



4. AUTOMATIC PRODUCTION OF THE GENERAL GEOGRAPHIC OBJECTSDATABASE (BDOO)

The basic and main source of data for the General Geographic Objects Database (BDOO) is the Topographic Objects Database (BDOT10k) - developed with the level of detail typical for 1:10000 scale studies.

The first version of the BDOO was created in 2015 using semi-automatic data generalization of the BDOT10k. In 2021, thanks to a modification of the processes, the generalization (quantitative and qualitative) became fully automatic. Improved rules and parameters of generalization made its effect the closest to the manual editing of the cartographic studies.

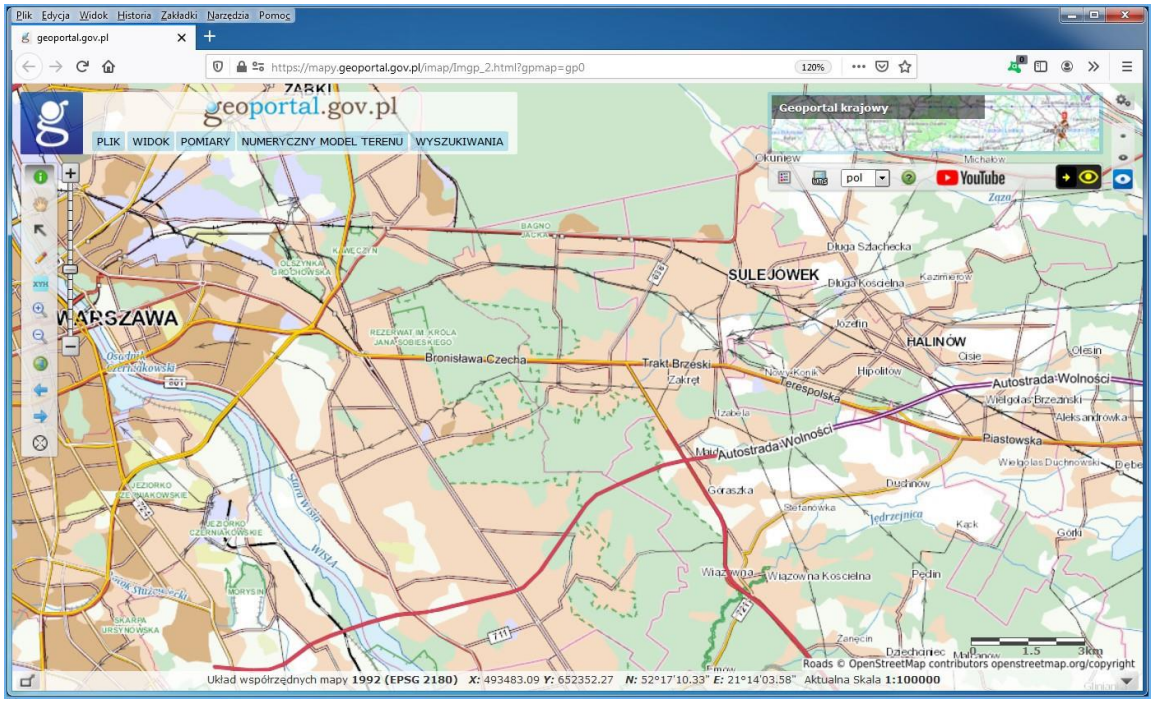
The processes needed for the automatic generalization have been prepared using the FME Desktop software of Safe Software and operate using FME transformers, as well as the pythonlibrary - ArcPy from Esri. The automatic generalization of BDOT10k to BDOO is controlled by the main process triggered in the FME Server software.

The automatic generalization can be performed simultaneously for many voivodships (takes two days to process the entire country).

To mention some changes implemented:

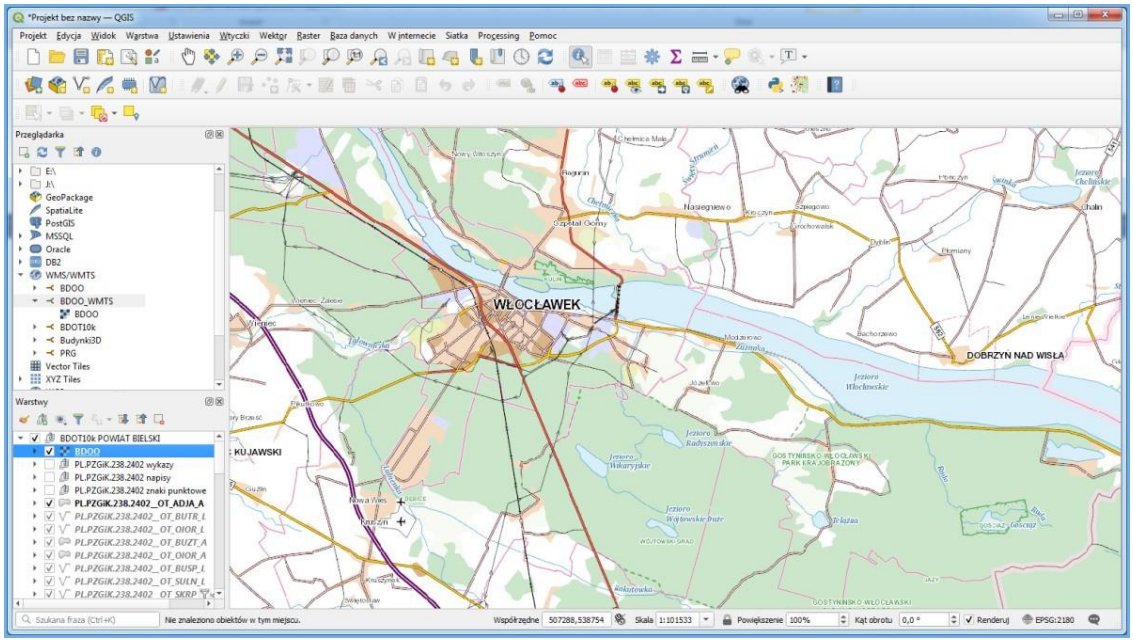
- the geometry of the objects and their course - corrected by, among other operations, selection - assortment, aggregation - combining, simplification, restoring right angles, displacement and changing orientation of objects, stretching the boundaries of built-up areas according to given criteria,
- the water course networks - generalization based, among others, on the length criterion (for example, for lowland areas the minimum length is 4 km, for mountain areas - 3 km),
- the generalization of the road network is about pre-processing data, merging road segments and running process of qualitative and quantitative generalization on it.

At the moment, BDOO contains ca. 600,000 objects and features. The cartographic image of this database is used at geoportal.gov.pl as a one of the base maps for scales under 1:50 000.



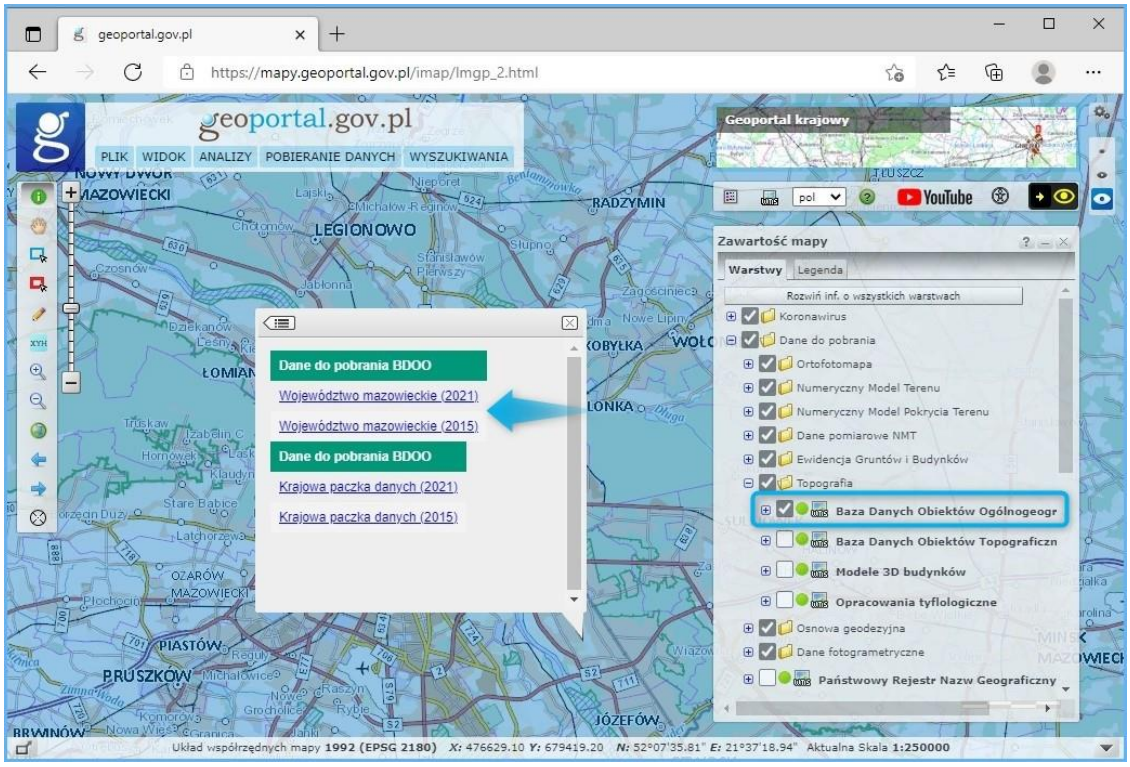
Free QGIS software is a great tool for BDOO data visualization and analysis. Due to the broad range of topics covered by BDOO data, it is recommended to use the BDOO_GML plug-in provided by the Head Office of Geodesy and Cartography (GUGiK) for the important presentation of this data. It provides a representative image of a downloaded BDOO collection similar to a traditional geographical map.

BDOO data can be browsed using WMTS which is by default connected to geoportal.gov.pl. The service can also be connected to any software that supports such standard (link). The results obtained by connecting the service in QGIS are shown below.



Apart from the WMTS displaying BDOO data, a WMS is available to display particular BDOO layers (link). Moreover, the display of archive BDOO data from 2015, is also available (link).

BDOO data is provided free of charge and can be used for any purpose. It can be downloaded from geoportal.gov.pl, section „Data for download", group "Topography", layer „BDOO data" (Fig below). Both 2015 and current data obtained as a result of automatic generalization is accessible.



6. Lidar facilitated volunteered geographic information for topographic change detection (Applied research project L2-1826)
   Geodetic Institute of Slovenia & University of Maribor, Faculty of Electrical Engineering and Computer Science

Project funding: The Slovenian Research Agency, the Surveying and Mapping Authority of the Republic Slovenia and the Ministry of Defense

Keywords: volunteered geographic information, topographic changes, response of volunteers

Acquisition of *volunteered geographic information (VGI)* or geographic crowdsourcing has gained increased attention in the last decade, especially for topographic change detection, collaborative mapping and natural hazard monitoring. When VGI, especially amateur volunteered photographs, are facilitated by complementary georeferenced big data, e. g. LiDAR point clouds, photogrammetrically derived digital surface models (lidar-like data) of the entire countries, or by satellite images, the whole new area of research emerges. Topographic map updating is usually done by photogrammetric survey, where imagery used to detect changes is professional, i.e. metric, orientated, stereo (in pair) and vertical (aerial – from an airplane).

The main objective of this project is to develop an optimal methodology for a topographic map updating based on a mashup of volunteered geographic data, volunteered amateur photographs and professional lidar or lidar-like data.

Trough an online survey we studied the willingness of volunteers to report changes on topographic maps. The survey was answered by 653 Slovenian respondents who use various online or classic topographic maps in their time or at work and are willing to report their knowledge of spatial changes or errors in maps to the map-updating institution (Triglav Čekada in Radovan, 2021).[1]

Some of the main findings of the survey helped us with the organisation of a pilot case study of collecting volunteered geographic information. Three controlled campaigns of collecting voluntary photographs of topographic changes took place during 2020-2022 (Figure 1). We collected photographs of spatial changes that may be useful for the maintenance of the 1:5000 scale topographic map or the data of the so-called national topographic model. A total of 195 potential volunteers took part in those three campaigns: all employees of the Geodetic Institute of Slovenia, three classes of students on UL FGG and two classes of students of UM FERI. A total of 62 volunteers responded to the call with 567 photographs showing 358 spatial changes (some individual changes were captured by several photographs; some changes were photographed by several volunteers). The analysis of response showed that the groups where the participants were given no bonus, 26 % of the potential volunteers responded, and in the groups, where they received a certain smaller bonus, the response rate was as high as 40 %. We were also interested to get an answer to the question "How would you prefer to report a topographic change (through which application/platform)?". This question was answered only by the participants which sent us photographs of topographic changes. Twelve options were offered and the most popular answers were: *I could use more applications: list which ones (33 %), e-mail (18 %) and WeTransfer (11 %).* We were surprised that only 8 % of the participants chose an option *A dedicated application to report changes*.

[1] http://www.geodetski-vestnik.com/65/3/gv65-3_cekada.pdf

The analysis of the potential usefulness of the single photographs for capturing vector data (interactive orientation) and/or for extracting only attribute data showed that 92 % of the photographs are potentially useful for updating the content of the 1:5000 scale topographic map.

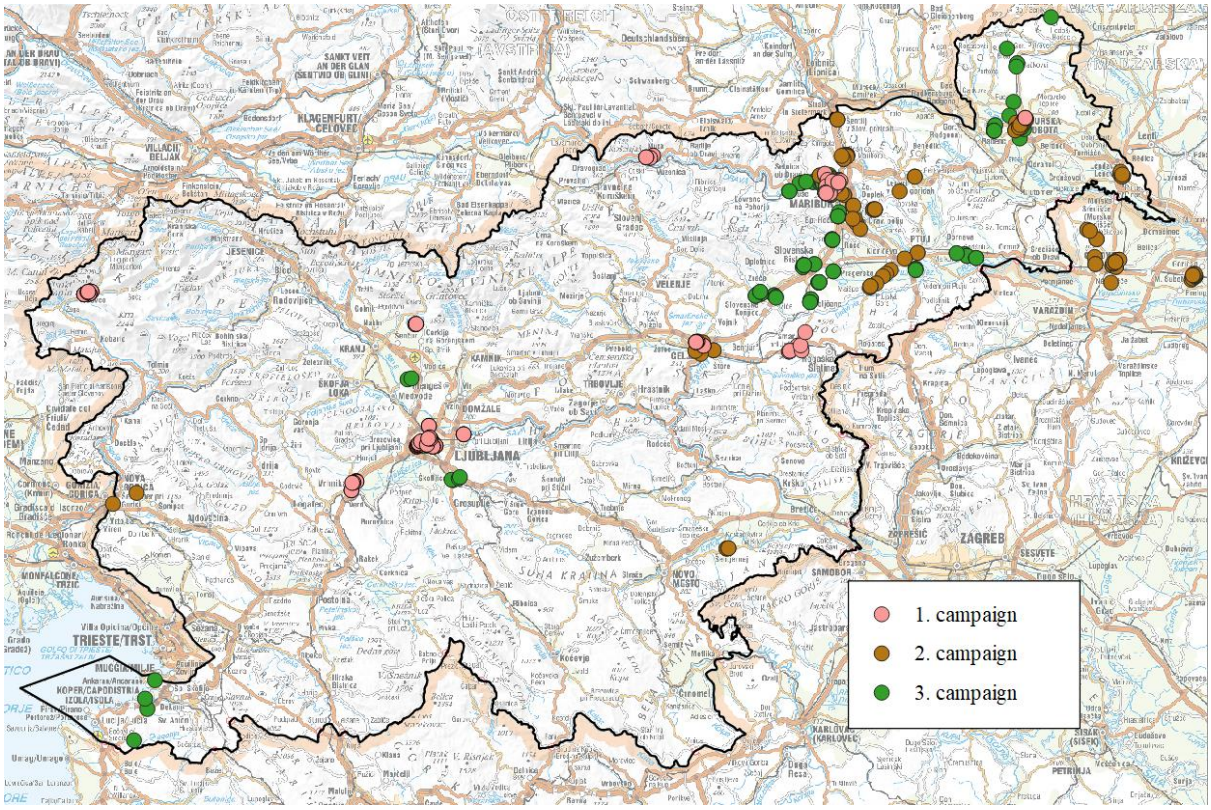


Figure 1: Locations where the photographs of topographic changes were taken. 1. campaing – winter 2020/2021, 2. campaign – summer semester 2020/2021, 3. campaign – winter semester 2021/2022 (Basemap source: National large scale map DPK 1:1.000.000, GURS)

7. Geospatial Reference Information on Hydrography

IGN Spain

The current users' needs, together with new technological improvements and the regulations in terms of geographic information have led to a change in the productive system of Geospatial Reference Information of Hydrography (GRI-HY) at the National Geographic Institute of Spain (IGN-ES).

The main objective of the GRI-HY project is to provide any hydrographic phenomenon of interest in a precise, unique and standardized way, for becoming the basic data handled for all users in many fields of application. These data must be produced by an authoritative organization to ensure their maintenance over time and guarantee their quality, homogeneity and official status.

This objective involves achieving coordination of national organizations and meeting the INSPIRE Directive (2007/2/CE), the Water Framework Directive (2000/60/EC) and national requirements. These requirements imply not only a political, administrative and economic justification, but also the technical conditions and its feasibility.

To this aim, the IGN-ES began the automatic or semi-automatic production of a vector river network for the GRI-HY, based on a 2m grid Digital Terrain Models (DTM) obtained from the LiDAR coverage of the Spanish territory with a density of a point every each 2 m^2. This river network has been produced following these main steps:

1. Gathering and analysis of users' needs, INSPIRE and WFD directives.
2. Definition of the IGR-HY data model based on INSPIRE Data Specifications schema: physical waters and network model, also including WFD model requirements.
3. Producing an Automatic Hydrographic Network (RHA) from the LiDAR DTM, in two consecutive processes:
    a. DTM correction by adding buildings, removing bridges and dams, rectifying terrain lifts, etc.
    b. Hydrographic network extraction by flow accumulation combing hydrographic and hydrological criteria.
4. Transferring attributes from reference river networks of different national organization to the RHA resulting in the Basic Hydrographic Network (RHB).
5. Quality control, verification and validation of the RHB. Several quality controls have been developed in ETL technologies, and visual inspections are based on the most updated orthophotographs from PNOA (Spanish acronym for Aerial Orthophotography National Plan), 3D orthorectification, shadowed MDT, and other network references. This includes a xyz accuracy control with several field-captured section to assure a difference lower than 3-5 m on xy and 0.5 m on z.
6. For reservoirs, contours were extracted from LiDAR data at a constant z value taken as the normalized maximum level (NMN), together with a 3D orthorectification with the NMN.

In figure 1, all these steps are shown resumed in one image, from the beginning with the LiDAR MDT until the validation.

During the last 3 years, a big effort has been done together with the General Water Directorate of Spain and the River Basin Districts Authorities in order to harmonize the geometries of the Surface Water Bodies (polygons, lines and network) for the next WFD report. This means the consolidation of 20% of the hydrographic network at the national level.

In the next two years, the objective will be to achieve full harmonization. In order to have a proper coordination between all the agencies involved, a new GIS web tool named HYSIG platform has been

developed, based on ESRI technology, where producers and collaborators can interact with the geospatial database, showing changes in real time.

Finally, with the aim of disseminating the information to users, a new simplified viewer has been developed, in which the information is displayed in real time as it is also connected to the centralized database (Figure 2). This viewer is accessible to the public here.

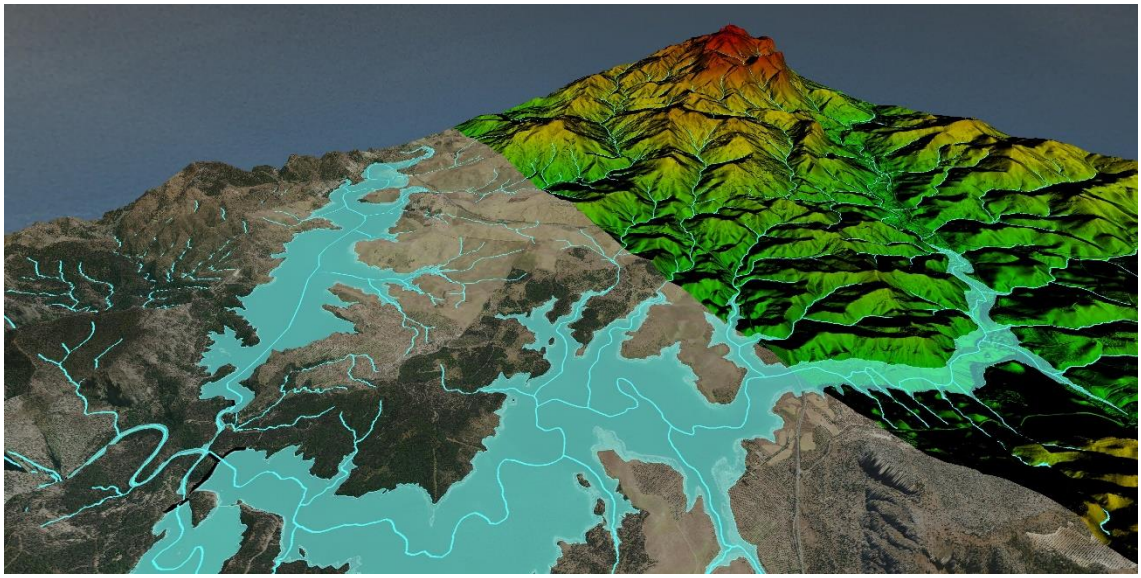


Figure 1: LiDAR MDT, 3D orthophoto, river network and reservoirs at the junction between Guadalhorce and Gudalteba River (Andalucia. Spain)

Figure 2: IGR-HI viewer at the junction between Guadalhorce and Gudalteba River (Andalucia. Spain)

Report by the Secretary-General

Joep Crompvoets

This report reviews the annual Board of Delegates meetings happening in the framework of EuroSDR in 2021, the appointments of (new) delegates, the activities related to our partner associations and some logistics.

Meetings

The 138th Board of Delegates meeting was virtually hosted by Bundesamt für Landestopografie swisstopo and École Polytechnique Fédérale de Lausanne on 6 and 7 May 2021. 51 persons attended this meeting. Highlights of this meeting were 1) the keynote presentation 'Digital Twin from a Geospatial Perspective' by Jantien Stoter (TU Delft), and 2) the keynote presentation 'Navigating without a Navigator: GNSS Developments + Positioning and Navigation for UAVs' by Terry Moore (University of Nottingham).

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Bundesamt für Landestopografie swisstopo
Office fédéral de topographie swisstopo
Ufficio federale di topografia swisstopo
Uffizi federal da topografia swisstopo

EPFL

The 139th Board of Delegates meeting was virtually organized on 21 and 22 October 2021 by the Estonian Land Board. At this meeting, the following interesting topics were presented: 1) the keynote presentation titled 'Next Level Geospatial: Geiger-Mode Review for EuroSDR' by Paolo Colombi (VeriDaaS), 2) the presentations 'Development and analysis of land-use/land-cover spatio-temporal metrics in urban environments: Exploring urban growth patterns and linkages to socio-economic factors' by Marta Sapena Moll (Politechnical University of Valencia) and 'Geospatial data and knowledge on the Web: Knowledge-based geospatial data integration and visualisation with Semantic Web technologies' by Weiming Huang (Lund University), the two winners of the 2021 EuroSDR Award, and 3) the keynote presentation 'Forecasting the Future of Data Interoperability in Europe' by Ville Sirviö (Nordic Institute for Interoperability).

REPUBLIC OF ESTONIA
LAND BOARD

In preparation for these two Board of Delegates meetings, the Executive Management Team organized two virtual meetings on 24 – 25 February 2021 and 1 – 2 September 2021.

Delegates

In 2021, the following appointments were approved: 1) Mário Caetano as Prime Delegate of Portugal 2) Paulo Patricio as Second Delegate of Portugal, 3) Anna Bober as Prime Delegate of Poland, 4) Anders Rydén as Second Delegate of Sweden, 5) Frédéric Cantat as Chair of Commission 4 'Business Models and Operation', Anka Lisec as Chair of Commission 5 'Knowledge Transfer', Conor Cahalane for his first term as Secretary-General of EuroSDR as from Autumn 2023 until Autumn 2027

Fabio Remondino was re-appointed for his last term as Vice-President of EuroSDR (Autumn 2021 – Autumn 2023) and Jon Mills for his third and last term as Chair of Commission 1 'Data Acquisition, Michael Hovenbitzer's term of Presidency was extended with one year as no physical meeting has taken place under his presidency so far. (Markéta Potůčková will act as observer in future meetings as the Czech Republic is not an official member of EuroSDR.)

Partnerships
EuroSDR continued collaborating with its key partner associations in 2021: 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:

- EuroSDR/EuroGeographics Workshop on Artificial Intelligence (AI) for National Mapping and Cadastral Agencies (NMCAs) (3 – 4 February 2021) – Virtual meeting (± 250 attendees from National Mapping and Cadastral Agencies, companies, universities and research institutes)
- EuroSDR/EuroGeographics Artificial Intelligence (AI) & (Sub)National Mapping Workshop (23 June 2021) – Virtual meeting as part of the FIG eWorking Week 2021 (± 90 attendees from land surveying companies, (sub)national mapping agencies, public sector and academia)
- Participation to General Assembly of EuroGeographics (17 May 2021) – Virtual
- Meetings with Léa Bodossian, Secretary-General of EuroGeographics (Summer 2021)
- UN-GGIM Europe meeting (13 – 14 October 2021, Brussels, Belgium)
- AGILE – EuroSDR Collaboration meeting (16 September 2021)

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, algorithms and human sources to acquire geospatial data, with emphasis on precision, accuracy, reliability and standardisation of primary data acquisition procedures.

Commission 1 RPAS benchmark project

With the COVID-19 pandemic causing disruption to planned Commission 1 events and activities throughout 2020, a new EuroSDR benchmark initiative was proposed at the first Board of Delegates (BoD) meeting of 2021 with the aim of independently evaluating the true geometric quality of real-world survey data generated from remotely piloted aircraft systems (RPAS). A 2018 survey of the EuroSDR BoD had placed RPAS at the forefront off research topics that members would like to see Commission 1 investigate. The new benchmark therefore proposed to focus primarily on the geometric quality of data generated in the absence of ground control and local GNSS base station information.

Commencing in mid-2021, the chart below reports the current progress and revised planned timescale to deliver the benchmark by the scheduled date of the autumn 2022 BoD meeting.

Task	**2021**								**2022**									
	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O
T0: EuroSDR BoD meeting	X																	
T1: Specification / survey		X	X	X														
T2: RPAS missions				X														
T3: Project setup					X	X												
T4: Project announcement							X											
T5-1: Phase 1 processing								X	X	X								
T5-2: Phase 2 processing											X	X						
T5-3: Phase 3 processing													X					
T6: Independent analysis										X	X	X	X	X	X	X		
T7: Project workshop																	X	
T8: Paper and reporting																		X

Task 1: Guided by a task force of NMCA experts and academics, a coordinated test field of ground control points (GCPs), independent checkpoints (CPs), test objects and profiles was established at a disused limestone quarry in Northumberland, UK (Figure 1).

Figure 1: Wards Hill Quarry, Northumberland UK

Task 2: The 350 x 250 m study area (Figure 2) was simultaneously surveyed using different RPAS mounted instruments, each limited to a single survey flight to represent "real-world" operation. Commission 1 would like to acknowledge DJI, Heliguy and Routescene for assisting the data collection exercise, and Leica Geosystems for provision of surveying equipment used in the ground exercise.

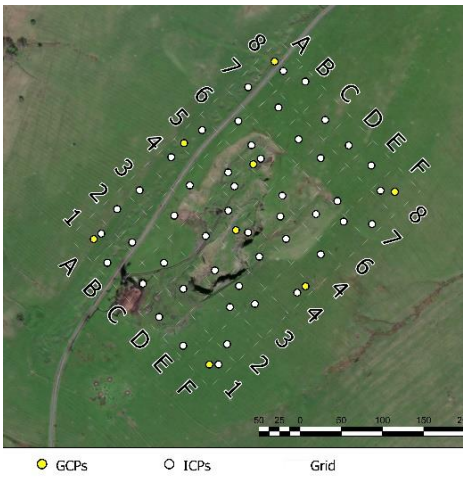


Figure 2: Test field target distribution

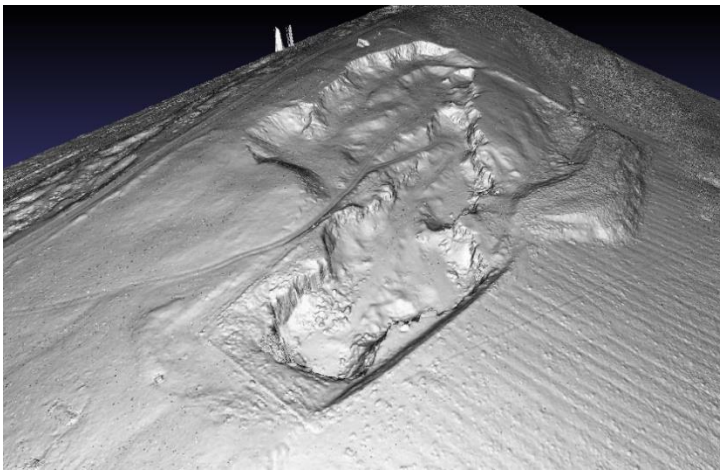


Figure 3: Example processing of test field imagery

Tasks 3-5: The project was announced and Phase 1 data (no ground control or local base station) was released to project participants in November 2021 for processing by end of February 2022. Preliminary results (e.g. see Figure 3) will be reported to the BoD in spring 2022. Further details on the EuroSDR RPAS Benchmark, including joining and participation instructions, can be found here.

Single Photon and Geiger-Mode lidar

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, but the lack of any European-based sensors and the COVID-19 pandemic meant the project did not proceed as planned in 2020. Unfortunately, the ongoing pandemic continued to hamper any plans for the lidar benchmark throughout 2021 and, despite establishing a new link with VeriDaaS (GM lidar) and a Hexagon SP sensor known to be active in Europe during the autumn, data acquisition over Innsbruck has so far not proven possible. It remains an ambition of Commission 1 to proceed with the benchmark if data acquisition proves feasible in 2022.

EuroSDR participation in 2020/21/22 ISPRS Congress

Following postponements of the ISPRS Congress in 2020 and 2021, the planned EuroSDR National Mapping and Cadastral Agency (NMCA) and ISPRS Space Agency (SA) Forum at the ISPRS Congress was cancelled. However, EuroSDR aims to run an in-person Theme Session on National Mapping at the 2022 Congress, and papers are currently under review. Several papers were also published as a result of EuroSDR Theme Session calls for the 2020 and 2021 virtual events. Further details on the ISPRS Congress can be found here.

Centre for Doctoral Training (CDT) in Geospatial Systems

The Engineering and Physical Sciences Research Council (EPSRC) Centre for Doctoral Training (CDT) in Geospatial Systems will train 50 PhD students per year in all aspects of geospatial systems by 2028. The Centre has the support of EuroSDR and a number of its members, including Ordnance Survey, Finnish Geospatial Research Institute, IGN France. Continual opportunities exist for NMCA collaboration, further details of which are available here.

Commission II: Modelling, Integration and Processing

Norbert Haala

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

Recent research initiatives and developments

The semantic segmentation of 3D point clouds for automatic geospatial information extraction has become a topic of major interest for users and providers of geospatial data. Either provided by airborne laser scanning (ALS) or multi-view-stereo, 3D textured meshes are becoming increasingly popular. Compared to the well-established standard 3D point clouds, a surface representation in the form of a textured 3D mesh has multiple advantages especially due to its well-defined topological structures. This is especially beneficial for the analysis of complex urban scenes. In view of these developments, EuroSDR is currently involved in two benchmark initiatives on automatic information extraction from such meshes.

SUM: A benchmark dataset of Semantic Urban Meshes

This benchmark was initiated by the 3D geoinformation research group at the Delft University of Technology. The 3D texture meshes were generated from aerial images that have about a 7.5cm ground sampling distance (GSD) using the software system ContextCapture. The entire data set covers 4 km^2 of the city of Helsinki and has been annotated into the six classes: Terrain, Vegetation, Building, Water, Vehicle, and Boat. The mesh is then sampled into a coloured point clouds with a density of about 30 pts/m^2 to also use standard 3D point cloud representations as input for current state-of-the-art 3D deep learning methods. In addition to the benchmark dataset, this EuroSDR funded project also provides the semi-automatic annotation framework used to label the semantic-rich urban mesh as required ground truth. This framework consists of a pipeline for semantic mesh segmentation and an annotation tool for semantic refinement.

Further information can be found at the accompanying paper and the benchmark homepage:

SUM: A Benchmark Dataset of Semantic Urban Meshes, Weixiao Gao, Liangliang Nan, Bas Boom and Hugo Ledoux. ISPRS Journal of Photogrammetry and Remote Sensing 179 (2021) 108-120. https://doi.org/10.1016/j.isprsjprs.2021.07.008.

Hessigheim 3D - Benchmark (H3D) on Semantic Segmentation of High-Resolution 3D Point Clouds and Meshes from Airborne LiDAR and Multi-View-Stereo-Image-Matching

This benchmark 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^2 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.

The data as captured with the same high-resolution sensor configuration is available for 3 different epochs (March 2018, November 2018 and March 2019). Thus, the benchmark additionally provides state-of-the-art multi-temporal data sets to the community, which can be used to test own methods and algorithms on semantic segmentation of (meshed) point clouds for geospatial applications. More information is available in the accompanying paper and the benchmark webpage.

Kölle, M., Laupheimer, D., Schmohl, S. , Haala, N. Rottensteiner, F. , Wegner, J.D. & Ledoux, H. (2021) The Hessigheim 3D (H3D) benchmark on semantic segmentation of high-resolution 3D point clouds and textured meshes from UAV LiDAR and Multi-View-Stereo, ISPRS Open Journal of Photogrammetry and Remote Sensing, Volume 1, 2021, https://doi.org/10.1016/j.ophoto.2021.100001.

EduSERV Course on 3D Point Cloud Classification for Mapping Purposes

In view of the considerable interest in semantic segmentation of 3D point clouds, an EduServ course on 3D Point Cloud Classification for Mapping Purposes has been initiated in cooperation with EuroSDR Commission 5. The course will take place from May 23 to June 3, 2022. Tutors are Eleonora Grilli and Fabio Remondino from the 3D Optical Metrology unit of the Fondazione Bruno Kessler and Michael Kölle and Norbert Haala from the Institute for Photogrammetry at the University of Stuttgart.

Commission III: Information Usage and Visualization


Martijn Rijsdijk & Bénédicte Bucher

The mission of Commission 3 is to explore, demonstrate and contribute to further increase the usage, access, distribution and visualisation of authorised geospatial data as well as to investigate better service mechanisms for the dissemination of geodata from database to end-users.

Workshop on Digital Twins for NMCAs and other governmental organisations

The aim of the webinar on Digital Twins was to exchange experiences and plans from NMCAs and other governmental organisations on Digital Twin-related activities, to discuss the impact of the Digital Twin concept for them and to identify remaining issues, challenges as well as opportunities. It was not the aim to come to a shared definition on the concept Digital Twin but rather to discuss the meaning of the concept for governmental organisations: what are the ongoing DT-activities, what are the use cases, lessons learned, uncertainties, opportunities etc.

In the programme various topics were included related to digital twins; a national Digital twin programme overview of the different countries, different activities and research topics. Also some speakers outside Europe (Japan, UK) supported and enriched the programme. The webinar was finally hold in January 2022 (postponed from November ’21), but the extra time was well used to define different hypotheses to be tested during the webinar. Examples are: is there a common definition for Digital Twins and NMCAs, is there a different approach in relation to Digital Twins and their experiments, use cases and co-operations; what is Digital Twin thinking and is it more an approach or a concept.

For this webinar, EuroSDR cooperated with several organisations and partners like Kadaster, Swisstopo and KU Leuven. During the programme committee discussion it became clear that there are very different views on Digital Twins. The workshop discussions made these differences even more visible.

Workshop on Data Science for NMCAs

The other workshop about Data Science for NMCAs is still under construction. The first ideas about it were developed in 2021. Together with the NMCAs of Poland, Finland and France a programme was set up featuring presentations about the role of Data Science for NMCAs, how data science is being organised, show and use cases and the different stories and problems in relation to culture.

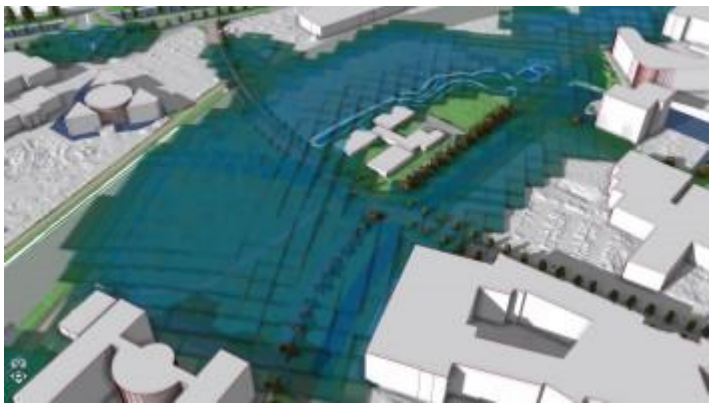


Figure: Digital Twin Zwolle city, to get insight the consequences from flooding, cooperation between RIVM and Kadaster, 2019

The main objective should be sharing experiences and finding overlaps and differences between all organisations. The webinar will be organised in spring 2022.

EuroSDR Open Knowledge Graph

During the first semester of 2021, the EuroSDR Linked Data group regularly met to engage participants in the collaborative creation of a EuroSDR Open Knowledge Graph (KG). The purpose of this KG is to describe digital assets in Europe that have a spatial component. The added value compared to catalogues is to comprehend links between metadata depicting different assets. These links can be used to discover and compare assets but also to bear relevant information for the joint usage of the assets.

A first result of 2021 is a well-documented and user-friendly procedure for any expert who knows digital assets but who be novice to linked data to create nodes in the KG. A second result is the analysis of categories of links that exist between such nodes, i.e. the kind of links that exist between digital assets.

Workshop on Urban Climate Indicators

In May 2021, EuroSDR co-organized the 1st European Workshop on Urban Climate Indicators (EWUCI), online. The topic of the workshop was the design of indicators to study and adapt cities to climate change, thanks to a better access to and better sharing of data and with a concern to scale these indicators in space and in time. It was co-organised with the support of the national mapping agencies, statistical institutes and meteorological institutes of France and of Finland (IGN, INSEE, MétéoFrance, Statistics Finland, FMI, NLS), as well as the Finnish environment institute (SYKE) and the European project ERA4CS URCLIM on urban climate services. The workshop gathered up to 60 participants. The slides are available on the workshop website.

The workshop started with a presentation from Julia Hidalgo, scientist in an interdisciplinary lab who analyzed what are required data to manage summer comfort in urban planning based on different research projects and expertise. Urban data are required not only for geographical and urbanistic analysis but also for downscaling regional climate data to more local climate modelling. On the shelves urban data are not sufficient. Climatic data are needed at several temporal and spatial scales, including long term scenarios. Besides, other data are needed that relate to governance and planning tools.

Her presentation was followed by a presentation from Berger-Levrault company who designs software solutions for municipalities. Christophe Bortolaso underlined the potential of open data to combine data together and have a more systemic approach of city modelling and in particular to integrate human activities and flows.

Guillaume Dumas presented his PhD work on the setting of a network of meteorological stations in Toulouse agglomeration to monitor the urban heat island and develop climate services, i.e. services dedicated to transfer scientific knowledge to non-scientists.

Maren Koehlmann from the German Institut for Research and Development in Federal Statistics analysed the potential of satellite imagery to acquire objective and reliable data to produce environmental and urban indicators, without any burden of respondents.

Tarek Habib from the company Murmuration also analysed the potential of satellite imagery to acquire reliable data, related to Greenhouse Gases monitoring, and correlate that with human activity, like for example tourism.

Alban Mallet from the greater Nantes administration presented current work and need to design public space and anticipate future climate conditions when doing so, that relies on research data from different projects that are integrated together based on a GIS.

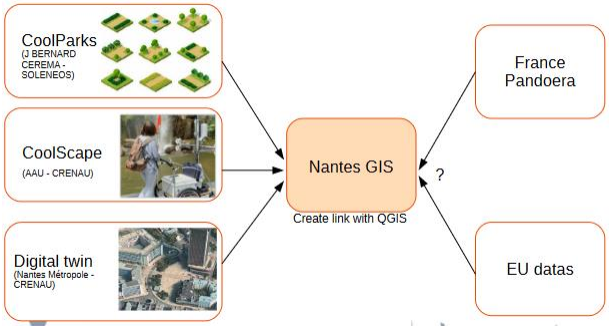


Figure: © Mallet. Integration of research datas to support the design of sustainable public spaces

Gwendolin Seidner-Schötz, Patrick Knoefel, and Jeanette Kretz, from BKG presented the use of remote sensing data to compute SDGs indicators and highlighted the necessity for more collaborations between different geospatial and statistical authorities.

Athanasios Votsis, University of Twente, Adriaan Perrels, Finnish Meteorological Institute, Valéry Masson, Météo France, Rina Tammisto Statistics Finland and Bénédicte Bucher, IGN-France, presented perspective from the URCLIM project related to designing Urban Climate Services using open urban data and regional climatic data. Pending challenges were presented:

- designing indicators accounting for urban adaptation,
- revising urban concepts and definition used in Europe to be more relevant for urban climate studies,
- adding environmental indicators to the European grid LAEA to account for biodiversity, ecosystem goods and services, temperature extremes, etc.

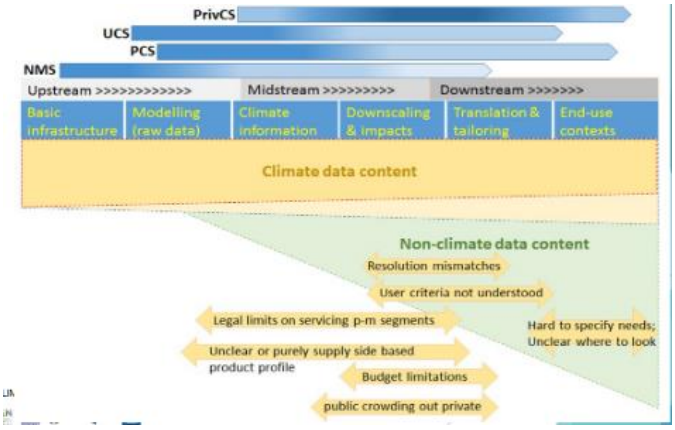


Figure: © Votsis et al. Obstacles to the urban climate services value chain

Commission IV: Business Models and Operation

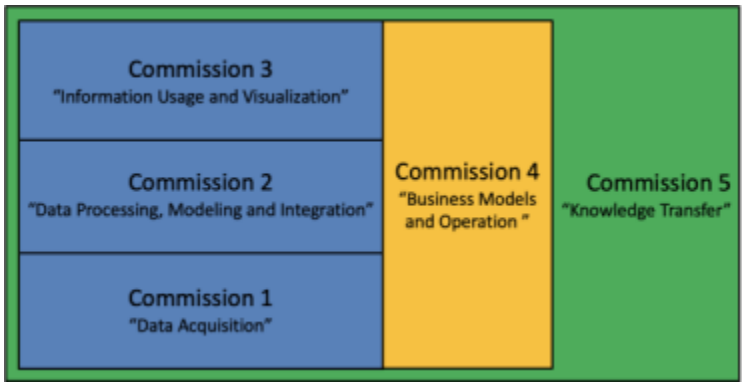
Joep Crompvoets & Frédéric Cantat

The mission of Commission 4 is to contribute to the development and implementation of business models describing the rationale of how mapping and cadastral agencies can create, deliver and capture value, in economic, legal, social, governance, cultural, sustainable or other contexts.

As chair of Commission 4 'Business Models and Operation' (former Commission 5, as established at the 139th Board of Delegates meeting in October 2021), it is my pleasure to contribute to the EuroSDR annual reports series. I am very honored to take over from Joep Crompvoets, after being appointed at the 138th Board of Delegates meeting (online, May 2021). This commission was established at the 126th Board of Delegates meeting in Tønsberg (Norway, May 2015). Joep Crompvoets chaired the commission for six years and did a very excellent work, running the following workshops/projects:

- Project Preservation of the Geographic Production Process (2015 – 2016)
- Project Economic Value of 3D + Workshop + Publication (2015 – 2016)
- Workshop Valuing the Societal Benefit of Geo-Information (2016)
- Workshop INSPIRE Validation (2016)
- Project + Workshop Marine Spatial Data Infrastructure (2016 – 2017)
- 2 Projects/Workshops Crowdsourcing & National Mapping + Publications (2017/20)
- 2 Workshops Spatial Data Data Quality (2017/2020)
- Workshop Sustainable Open Data Business Models + Survey + Publication (2017)
- Workshop Disruptive Geo-technologies (2018)
- Survey Future research topics on Spatial Data Infrastructures (2018)
- EduServ Course Open Data Infrastructure (2018 – 2019)
- Workshop/Project Authoritative Geospatial Data + Publication (2018 – 2019)
- Workshop Use and needs of Spatial Data Infrastructures + Publication (2019)
- Survey Resources for Education and Research + Publication (2019 – 2020)
- Workshop VGI for Land Use and Land Cover data (2020)
- Workshop Artificial Intelligence for NMCAs (2021)

The role of Commission 4 within EuroSDR commissions works is transverse, as is Commission 5.



Socio-economics benefits of Geospatial information and systems course

The second EuroSDR course on Socio-economics benefits of Geospatial information and systems was a joint action in collaboration with ConsultingWhere and Enumanation. This free course was delivered in two parts in May 2021. Part 1 was a self-paced e-learning module describing how to build a business case. The participants learned to:

- List key economic and social benefits of geospatial information and systems;
- Identify the policy objectives that geospatial information and systems align to;
- Explain how to quantify the costs and benefits of geospatial information systems;
- Describe how to build a business case for geospatial information systems.

Part 2 was a webinar (19th May 2021) that built on the content of the e-learning through a question-and-answer session with a panel of three specialists (Joep Crompvoets, Professor KU Leuven and Secretary-General of EuroSDR; Andrew Coote, CEO of ConsultingWhere; Davor Duran, Republic Geodetic Authority of the Republic of Serbia), allowing delegates to gain insights relevant to their challenges gaining executive-level buy-in for investment plans.

62 people were registered: 26 from NMCAs, 21 from Academics, 15 from Industry. They were coming from 22 countries: Belgium, China, Croatia, Cyprus, Denmark, England, Finland, France, Germany, Iran, Ireland, Italy, Moldova, Norway, Romania, Serbia, Slovenia, Spain, Sweden, Turkey, Ukraine and the USA.

Among the key takeaways of the course, attendees could have learned that:

- a standards-based, repeatable approach to assessing the Socio-economic impacts of geospatial is now available;
- the best business cases combine qualitative and quantitative (financial) benefits;
- in Republic of Serbia, thanks to a study which main objective was to present a clear and concise analysis of the socio-economic benefits of the National Spatial Data Infrastructure

(NSDI), aligned with the UN-IGIF and the EU INSPIRE Directive, it appears that 1. Main organizational benefits for the future NSDI are improved data quality, increased efficiency and meeting the legal requirements; and 2. Cost and time savings and process simplifications are considered as key societal benefits of the future NSDI.

Sustainable Open Data Business Models for National Mapping and Cadastral Agencies (NMCAs) : survey and workshop

Switching to an open data policy may pose a challenge to the business model of National Mapping and Cadastral Agencies (NMCAs), especially if they are required to generate revenues to cover a substantial part of their operating costs. EuroSDR and TU Delft led in 2017 a research on this topic: *Adapting National Mapping & Cadastral Agencies business models to open data supply: the survey results* by F.M. Welle Donker, J. Crompvoets and B. van Loenen (EuroSDR's Official publication n° 67 – 2017).

In 2019, an important milestone was the publication of the Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and the re-use of public sector information. This directive provides (article 14) that publications and re-use of specific high-value datasets such as geospatial or earth observation and environment (annex 1) shall be free of charge from mid-2023 onward.

Therefore, EuroSDR decided to lead a follow-up, as a repetition of the 2017's action, this time in association with EuroGeographics. This follow-up had two parts once again: a survey and a workshop.

The survey was online from mid-October to mid-November 2021.

Questionnaire dissemination has "targeted" EuroGeographics' permanent correspondents aiming that respondents did it on behalf of their organization and not as an expert.

36 exploitable responses have been registered, all from NMCAs (except one from a university) from 27 countries: Albania, Austria, Belgium, Croatia, Cyprus, Czech Rep, Denmark, Estonia, Finland, France, Georgia, Germany, Great Britain, Hungary, Iceland, Ireland, Latvia, Lithuania, Netherlands, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland and Ukraine.

The main learnings from the 2021 survey, and noticeable trends from the 2017 one, are:

- A huge majority of NMCAs are engaged in Open Data even if the EU directive is not transposed yet in their country: 39 % of the answers saying “the Open Data directive is not transposed in my country yet” whereas only 5.5 % stating that “we do not have opened our data yet”.
- Open Data is here to stay, more than ever (but not without sustainable (co)fundings): 67 % saying that “Open Data will be full or more important than currently in the future days”.
- The top 3 “very important” motivations for Open Data are 1. legal obligations, 2. more economic growth, and 3. more societal benefits.

The main results of the survey were presented by the chair of commission 4 on Day 1 of the online workshop that ran on February 2nd and 3rd 2022. An official detailed report will be published in Spring 2022.

The workshop brought together NMCAs, researchers and policy makers to present, discuss and share their experiences of open data.

Here are the first facts about the workshop: 110 people registered, 80 attendees on Day 1 and 50 on Day 2. 66 % belonged to NMCAs, 13 % to Academia, 11 % to Public Authority (non-NMCA), 4 % to NGO and 2 % to the private sector. It gathered speakers and panelists from DG Connect (European Commission), EuroSDR, University of Delft, IGN France, SDFE Denmark, Czech Office for Surveying, Mapping and Cadastre, Swisstopo, National Land Survey of Finland, University of Zagreb, KU Leuven, Spanish Cadastre, Ordnance Survey Ireland, Ordnance Survey GB, GUGIK Poland, and Kadaster Netherlands.

EuroSDR and EuroGeographics will publish documents about it in Spring 2022.

EuroSDR Proposal Advancing “FELA – Framework for Effective Land Administration”
An important and significant milestone for land administration globally arrived when the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) welcomed and adopted the Framework for Effective Land Administration (FELA) at its 10th session in 2020.

EuroSDR, with the support of EuroGeographics and the UN Expert Group on Land Administration and Management (EG-LAM), initiates a project to raise awareness of the merits and benefits of effective land administration and share knowledge and experience leveraging the FELA as the overarching policy guidance. In addition, the project seeks to support FELA, as a ‘living document’, cognizant of the changing and evolving societal, economic, environmental, political, and technological landscapes and national circumstances.

The chairs of commission 4 and commission 5 (knowledge transfer) contributed to the initialization of the project. The first step was to design the questionnaire of an online survey.

Commission V: Knowledge Transfer

Markéta Potůčková & Anka Lisec

The mission of Commission 5 is to provide educational services to support the transfer of knowledge from EuroSDR research projects to national mapping and cadastral agencies (NMCAs), academia and industry. The Commission also focuses on fulfilling specific NMCAs' demands for knowledge update, collection and dissemination methodologies, developed tools and other research outcomes in the form of EuroSDR's official publications and via EuroSDR's homepage.

2021 was a kind of transition year for EuroSDR Commission 5, with Anka Lisec taking over the chairmanship of the Commission from Markéta Potůčková. In addition, due to the restructuring of the EuroSDR commissions, knowledge transfer activities are now under Commission 5 (previously it was Commission 6). The newly defined terms of reference, as well as the action items of the five EuroSDR Commissions, are described in the EuroSDR rolling research plan 2021–2024. The main purpose of this new EuroSDR rolling research plan, adopted in 2021, is to adequately structure the work of the EuroSDR for the coming years while leaving sufficient flexibility to respond to unforeseen developments.

Despite these transitional challenges and the pandemic, which have had a strong impact on our work, we have realised most of the planned activities.

EduServ19

In 2021, EuroSDR Commission 5 for Knowledge Transfer continued to organise the EuroSDR Educational Service (EduServ) – a series of e-learning courses that reflect new trends in geospatial information science related to the needs of research, development and practice within NMCAs and industry.

The 19th series of EduServ e-learning courses opened on March 1-2, 2021, with the EduServ pre-course seminar, which was organised as an online version due to the pandemic situation in Europe. The online pre-course seminar was attended by 64 participants, including teachers and guests. EduServ19 offered four e-learning courses from March to June 2021 on the following topics:

- **Spatial Linked (Open) Data** (March 8-19, 2021)
  Tutors: Erwin Folmer (Kadaster and University of Twente), Stanislav Ronzhin (ITC, University of Twente, Kadaster), Rob Lemmens (ITC, University of Twente) and Wouter Beek (Triply, VU University, Kadaster)

  This was an introductory course in Spatial Linked Open Data. The course covered the basic theory of Linked Data and an introduction to the most important standards in the domain, such as RDF. More in-depth, the topic of data modelling, vocabularies and ontologies were elaborated as one of the key concepts of Linked Data, with a special focus on geospatial data. The second part of the course was split into a technical module and a business module. The business module was dedicated to the business case for linked data implementations. The technical module provided best practices on how to convert data into linked data, with practical hands-on creating SPARQL queries.

- **GeoBIM – Basic Principles and Use Cases** (April 12-23, 2021)
  Tutors: Claire Ellul (University College London), Lars Harrie and Per-Ola Olsson (Lund University)

  The course addressed the challenges of the geospatial and Architecture Engineering and Construction (AEC) communities in the context of interoperability and integration of data from these two domains. Taking a data-driven perspective on interoperability and integration, i.e. looking at the integration of Building Information Modelling (BIM) and geospatial data, the course provided a comprehensive overview of GeoBIM, starting from first principles, identifying opportunities for using integrated data and challenges arising. Two case studies were available to explore the topic more in-depth. The course concluded by exploring GeoBIM in a wider context, as a location-enabled foundation for digital twins, smart cities and the IoT.

- **Recent LiDAR technologies** (May 3-14, 2021)
  Tutor: Gottfried Mandlburger (TU Vienna)

  The course tackled the recent progress in Airborne Laser Scanning (ALS), the state-of-the technique for 3D mapping of topography and shallow water bathymetry, including the following topics: (i) point density and spatial resolution; (ii) full waveform analysis with state-of-the-art FWF processing techniques; (iii) multispectral laser scanning; (iv) hybrid sensors; (v) single Photon LiDAR; (vi) topo-bathymetric LiDAR for high-resolution mapping of the littoral area; (viii) UAV-LiDAR with new close-range airborne applications due to the integration of lightweight LiDAR sensors on Unmanned Aerial Vehicles.

- **Working with Volunteered and Crowdsourced Geographic Information** (May 24 - June 4, 2021)
  Tutors: Peter Mooney (Maynooth University) and Levente Juhász (Florida International University)

  Volunteered Geographic Information (VGI) and Crowdsourced Geographic Information (CGI) have transformed from being considered 'disruptive' and poor quality to well-known mainstream data sources used widely in industry, research, and other applications. The goal of the course was to introduce participants to VGI and CGI, the state-of-the-art research in these areas, methods for obtaining and processing VGI/CGI data (API sources, processing GeoJSON, etc.), and advanced topics such as assessment of the quality of the data.

A total of 55 participants attended the e-learning courses. The following table gives an overview of the number of participants who attended each course and the number of participants who successfully completed the courses and received a certificate from EuroSDR.

Course title	Number of	
	active participants	issued certificates
Spatial Linked (Open) Data	22	14
GeoBIM – Basic Principles and Use Cases	20	11
Recent LiDAR Technologies	41	21
Working with VGI and CGI	23	12

EuroSDR PhD award

To enhance collaboration between European academia and NMCAs, as well as to engage young scientists in its research endeavours, EuroSDR introduced in 2016 an annual competition for the best PhD thesis in the fields related to geoinformation science. At the end of March 2021, the call for applications for the 2021 EuroSDR PhD Award was announced.

We received 14 applications from candidates holding PhDs from universities in Croatia, France, Germany, Greece, Italy, Slovenia, Spain, Sweden, and The Netherlands. The evaluation committee (Krzysztof Bakula, Joep Crompvoets, Jon Mills, Krištof Oštir, Markéta Potůčkova, Fabio Remondino, Julián Delgado Hernández) reviewed the applications, and two winners were announced in September 2021:

- Dr. **Marta Sapena Moll:** *Development and analysis of land-use/land-cover spatio-temporal metrics in urban environments: Exploring urban growth patterns and linkages to socio-economic factors*, Universitat Politècnica de València, Spain.
- Dr. **Weiming Huang**: *Geospatial data and knowledge on the Web: Knowledge-based geospatial data integration and visualisation with Semantic Web technologies,* Lund University, Sweden.

The winners gave a presentation on the key findings of their research during the online 139th Board of Delegates meeting in October 2021.

Survey on Resources for Education and Research

In collaboration with EuroSDR Commissions 3 and 4, we continued activities related to the survey from 2020 on "Data and tools for research and education". In collaboration with other organisations and associations dealing with education in the geospatial data domain, we are planning to organise a workshop in 2022 with the objective to exploit and improve the value of geospatial data for education and research.

Workshops

- EuroSDR/EuroGeographics workshop 'Artificial Intelligence for NMCAs' (3 – 4 February 2021) – Virtual
- EduServ19 pre-course seminar (1 – 2 March 2021) – Virtual
- I EUnet4DBP International workshop 'Digital Building Permit' (25 – 26 March 2021) – Virtual
- European Workshop 'Urban Climate Indicators' (Paris, France, 17 May 2021)
- 1Spatial/EuroSDR Workshop 'Common Problems in the Data Supply Chain' (16 June 2021) – Virtual
- FIG e Working Week (20 – 25 June 2021) – Virtual

Publications

WR Olteanu-Raimond, A., Crompvoets, J., Moorthy, I., Mallet, C., & Bucher, B. (eds.): The Use of Volunteer Geographic Information for Producing and Maintaining Authoritative Land Use and Land Cover Data, 2022, 40 pages.

WR Noardo, F., Malacarne, G. (eds.): Digital Building Permit: A State of Play. 1 EUnet4DBP International workshop on Digital Building Permit. 2021, 103 pages.

73 Bucher, B., Folmer, E., Brennan, R., Beek, W., Hbeich, E., Würriehausen, F., Rowland, L., Alonso Maturana, R., Alvarado, E., Buyle, R., Di Donato, P.: Spatial Linked Data in Europe: Report from Spatial Linked Data Session at Knowledge Graph in Action. 2021, 26 pages.

WR Holmes, J., Agius, C., Crompvoets, J.: Spatial Data Quality. 2020, 84 pages.

SR Bucher, B., Potůčková, M., Crompvoets, J.: Initiatives for Providing Data and Tools for Research and Education. 2020, 22 pages.

WR Lemmens, R., Mooney, P., Crompvoets, C.: Crowdsourcing in National Mapping. 2020, 22 pages.

SR Crompvoets, J., Bačič, Z., Poslončec-Petrić, V.: Academia-Business Survey on Needs and Cooperation in Field of Spatial Data Infrastructures. 2020, 36 pages.

72 Crompvoets, J.; Wouters, S.; Chantillon, M.; Kopczewski, D.; Cory, M.; Agius, C.; Grimmelikhuijsen, 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 Outlooks. 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.

All publications can be downloaded on the EuroSDR website.

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