

# Annual Report 2019

## 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 (2019)

<b>Austria</b>	Michael Franzen	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 (2019)

<b>Esri</b>	Nick Land
<b>Hexagon Leica Geosystems</b>	Poul Noergaard
<b>Informatie Vlaanderen</b>	Jo Van Valckenborgh
<b>nFrames</b>	Konrad Wenzel
<b>Terratec</b>	Leif Erik Blankenberg
<b>Vecxel</b>	Michael Gruber
<b>1Spatial</b>	Dan Warner

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## Message from the President

Paul Kane



Members of the executive, fellow delegates it is my pleasure to once again to introduce the EuroSDR annual report for 2019. As with many other calendar years 2019 was very busy with many international workshops been organised and hosted through the various commission chairs across a variety of focus areas, from New Lidar technology, Point Cloud Processing, Geographical Information Systems, SDI's, Linked Data, Historical Imagery, Remote Sensing and Photogrammetry, GeoBIM to name a few.

In addition to the workshops we very successfully hosted the 17<sup>th</sup> Eduserv knowledge transfer programme which drew a very large number of participants.

I would like to express my thanks to all of the individual Commission Chairs and the local organising committees for their work and assistance in hosting all of the events, and of course to the wider EuroSDR members for their support in attending and participation through providing papers and sharing experiences.

This year was no different to other years in that we had some new delegates joining us and I'm glad of the opportunity to again welcome;

- Austria: Wolfgang Gold and Christine Ressler
- Denmark: Jesper Weng Haar
- Estonia: Tambet Tiits and Artu Ellmann
- Germany: Paul Becker
- Poland: Adam Andrzejewski
- Slovenia: Peter Prešeren and Marjan Čeh

While the introduction of new delegates of course is always welcome, sometimes it means we are saying adieu to old friends, and 2019 saw the retirements of;

- Austria: Michael Franzen
- Poland: Piotr Woźniak
- Slovenia: Tomaž Petek

And I should also mention Mojca Kosmatin Fras, who deputised on occasions on behalf of Slovenia.

We thank them for their commitment and dedication to the EuroSDR organisation and I hope you will forgive a special word of thanks to Michael for his very long association and work on official publications.

The year also saw the extension in the number of Associate members, and joining EuroSDR;

- Hexagon-Leica Geosystems represented by Poul Noergaard
- nFrames represented by Konrad Wenzel
- Terratec represented by Leif Erik Blankenberg
- Vexcel represented by Michael Gruber
- 1Spatial represented by Dan Warner

Having contributed six years as Chair of Commission 3 "Updating and Integration" Jon Arne Trollvik retired to the benches and resumed his role as Prime Delegate of Norway, and in his place Martijn Rijdsdijk of the Netherlands took over this important position. I'm sure on behalf of all delegates I should express our thanks to Jon Arne for his work over the past years as part of the executive, and to Martijn for taking up this new role.

The locations for our board of delegate meetings in 2019 took us to the wonderful cities of Vienna and Cyprus and my thanks to all of the respective delegates for the organisation and hosting of the 134<sup>th</sup> and 135<sup>th</sup> conferences.

Finally on a personal note as this is one of my last duties as President of EuroSDR, I would like to say thank you, firstly to the Executive Team for all of the guidance and patience that was extended to me during my time. As a relative new comer to the organisation, it was only since 2017 that I became a full delegate, to step into the Presidency role was certainly both an honour and a challenge, and it was through the warm welcome of not only the Executive but also the Delegates that I managed to come through it. I must say it was a pleasure and a great opportunity to get to know the members and I hope to continue to be involved with the organisation for as long as I can as Prime Delegate.

My experience of working with the executive and the secretariat that I take away is that I can attest to the hard work and true diligence that they provide on behalf of the organisation and that contributes hugely to the success of EuroSDR.

And so thank you all for the support during my term and I wish good luck to Michael Hovenbitzer and Germany as they take up the next Presidency.

## Message from the Vice-President

Fabio Remondino



2019 was another intense and prosperous year for EuroSDR which confirmed its leaderships and presence through many scientific events, research activities and cooperation with sister organisations.

The main research activities of EuroSDR in 2019 dealt with:

- technical development in data acquisition, processing and visualization;
- integration of Artificial Intelligence methods in the daily practice;
- growing demand for up-to-date spatio-temporal, 3D, multi-scale data and services;
- data integration and quality issues.

Many **projects** have been finalized and new projects have been launched, often based on open questions at workshops or breakout sessions at the Board of Delegates meetings.

In **Commission 1** the activities focused on the new laser technology SPL (Single Photon LiDAR) or Geiger-mode LIDAR. A [workshop](#) was held in March 2019 at ICGC Barcelona (Spain), with some 100 participants. In collaboration with Leica Geospatial a benchmark is under discussion to better understand, analyse and evaluate this new technology. A [benchmark workshop](#) was also organized in Warsaw (Poland) whereas the [EuroCOW](#) workshop was held within the ISPRS Geospatial week.

Within **Commission 2** the focus was moved towards the geometric processing of the geospatial data, in particular point clouds. A successful [workshop](#) was organized in Stuttgart (Germany) with almost 100 participants. Nevertheless the Commission still keeps on-going the activities related to building modelling, in particular the [GeoBIM](#) one, with various tasks and meetings realized in 2019.

In **Commission 3** after a long, fruitful and successful period, Jon Arne Trollvik stepped down and Martijn Rijdsdijk was elected as the new commission chair. Research activities dealt with [SDI](#), the inclusion of modern Artificial Intelligence methods into NMCAs practices and the organization of a [workshop](#) in Paris (France) on Historical Aerial Images.

**Commission 4** continued its activities on [Linked Data](#), the EU project “[TimeMachine](#)” and the establishment of the [EuroSDR infolab](#).

**Commission 5** continued its interesting activities on crowdsourcing in national mapping, uses and needs of SDI, sustainable open data business models for NMCAs and authoritative data.

**Commission 6** organized the 17<sup>th</sup> Educational Service (EduServ) with the pre-courses organized at ICGC Barcelona in March 2019. The four two-week e-learning courses were followed by more than 60 people. The courses had the following topics: (i) Automatic Topographic Mapping through Description and Classification of RS Imagery, (ii) 3D Sensing, Scene Reconstruction and Semantic Interpretation, (iii) Open Spatial Data Infrastructures and (iv) Deep Learning for Remote Sensing. A short course in Photogrammetry was organized in June at Charles University, Prague. The **EuroSDR Award 2019** for the best PhD thesis related to Geoinformation Science awarded the work of Dr. Florent Poux (University of Liège, Belgium) with the work “The Smart Point Cloud - Structuring 3D intelligent point data”.

In terms of **publications**, there have been many scientific and state-of-the-art papers produced during the year. Amongst these, an official publication of EuroSDR “Authoritative Data in a European Context” (publication no. 72), the “International Benchmarking of Terrestrial Laser Scanning Approaches for Forest Inventories: Results, Discussion and Outlooks” (publication no. 71) and the workshop report “Data Linking by Indirect Spatial Referencing Systems” (publication no. 70).

In conclusion, 2019 was a very productive and successful year for EuroSDR with many more new research activities, events and educational courses planned for 2020!!

## Interesting examples of real life practices at NMCA's based on results of existing applied research

### 1. A SATELLITE-BASED GROUND DEFORMATION MONITORING OF DENMARK DANISH AGENCY OF DATA SUPPLY AND EFFICIENCY (JOANNA BALASIS-LEVINSEN)

The Agency of Data Supply and Efficiency is working towards establishing an operational service for monitoring the ground deformation in Denmark using satellite imagery. The service will be based on Sentinel-1 radar images acquired through the EU Commission's Earth Observation program, Copernicus. Such data is used due to the supply of freely available, continuous and uniform satellite images acquired from 2014 and until 2030 at the earliest. With 250 km wide satellite tracks and image acquisitions in Denmark every three days, an unprecedented opportunity for the derivation of uniform deformation maps over large areas has arisen.

The agency's efforts towards an operational service began in 2015 and until now have resulted in the publication of two nationwide maps derived from Sentinel-1 imagery; one published in 2018 and an update in 2019. The maps were derived using all available images from 2014 until the given year. Selected deliverables are:

- Deformations in the satellite's line-of-sight direction,
- Horizontal and vertical deformation rates,
- Vertical rates adjusted to a known reference frame using observations from the agency's network of permanent GNSS stations.

The deformation maps are freely available for any interested users in Denmark. The motivation for this is to support the data adaptation among end-users in the public and private sectors, and to identify end-user requirements for such data if once provided via an operational service. As a result of these efforts, the data are already applied in a wide and growing number of applications, such as:

- Monitoring of infrastructure such as buildings, bridges, highways and ports,
- Monitoring of subsurface gas storages,
- Asset management of subsurface infrastructure (water and wastewater pipelines),
- Climate change adaptation: Where to apply which measures?,
- Planning of geodetic monitoring,
- Maintenance of national, geodetic height infrastructure.

See Figures 1 and 2 for examples of line-of-sight deformations over infrastructure.

Similar works towards operational services for nationwide monitoring are seen in Norway, the Netherlands, Germany, etc. The motivation for establishing one in Denmark is multifold: As a governmental agency, one of our responsibilities is to publish data that can serve as input for an improved basis of decision and support an improved digital growth in Denmark. Further, as an NMA, another responsibility concerns the maintenance of the national geodetic infrastructure. Today, the datasets most commonly used for the latter are leveling and GNSS. With the unprecedented spatio-temporal coverage of Sentinel-1 imagery, an important goal is to use the deformation maps together with the in-situ measurements, to obtain reliable, consistently updated data on the country's horizontal and vertical deformation.





Figure 1. Deformations over the town Skagen in Northwestern Denmark, given in mm/yr. Red shows movement away from the satellite and blue movement towards the satellite. The movement of most infrastructure is resolved: The main road leading to Skagen, buildings, the rock dikes along the coast, the infrastructure on the port, etc. For example, a great subsidence is seen by the port resulting from construction works. Courtesy: TRE Altamira (2020). This work contains modified Copernicus Sentinel data 2014-2019.

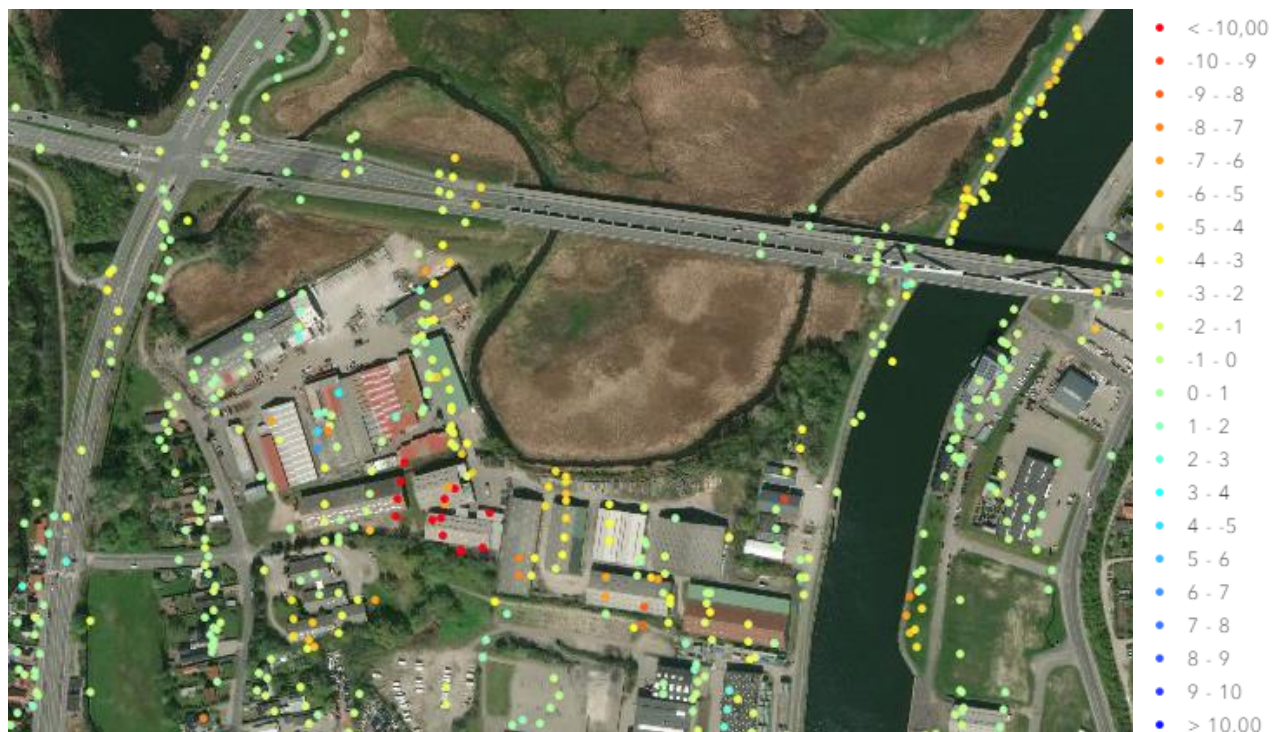


Figure 2. Deformations over the town Odense in central Denmark, given in mm/yr. Here, subsidence occurs along the canal and by a company, e.g. owing to recent developments. The rest of the area appears to be relatively stable. Courtesy: TRE Altamira (2020). This work contains modified Copernicus Sentinel data 2014-2019.



## 2. RESEARCH BASED DEVELOPMENT OF A NEW 5 MM GEOID MODEL FOR ESTONIA MAA-AMET

Since January 01, 2018, a new EVRS (European Vertical Reference System) based height system EH2000 has been enforced in Estonia. This datum change caused the previous heights (belonging to the obsolete 1977 Baltic Height System) to increase from 14 cm to 25 cm in the north-westerly direction. The new height system is supported by the new EST-GEOID2017 model. Geoid model is needed in many surveying and engineering applications for converting GNSS derived ellipsoidal heights into normal heights and vice versa.

EST-GEOID2017 was calculated in research cooperation between the Tallinn Technical University and the Estonian Land Board. The Estonian University of Life Sciences and the Estonian Geological Centre contributed to the project with gravimetric data. Additional input data (i.e. gravity data and elevation models from neighbouring countries) were obtained within the framework of the Nordic Geodetic Commission (NKG) geoid modelling activities and the Nordic-Baltic joint project "NKG2015 geoid".

The local terrestrial gravity anomaly model was combined with a global geopotential model by applying the Least Squares Modification of Stokes' formula with Additive Corrections (LSMSA). Considering the wide spectra of possible practical applications, primarily associated with the use of the GNSS-technology, the resulting gravimetric geoid model was fitted to 131 high-precision GNSS-levelling points. A two stage stochastic spatial prediction was applied to obtain an optimal fit between precise GNSS-levelling data and the geoid model. The location-specific post-fitting uncertainties of the resulting model EST-GEOID2017 revealed StDev of 4.2 mm, i.e. the same level as the uncertainty of the used GNSS-levelling control points.

The geoid model EST-GEOID2017 is distributed free of charge, but a licence agreement must be signed in order to use the geoid model data.

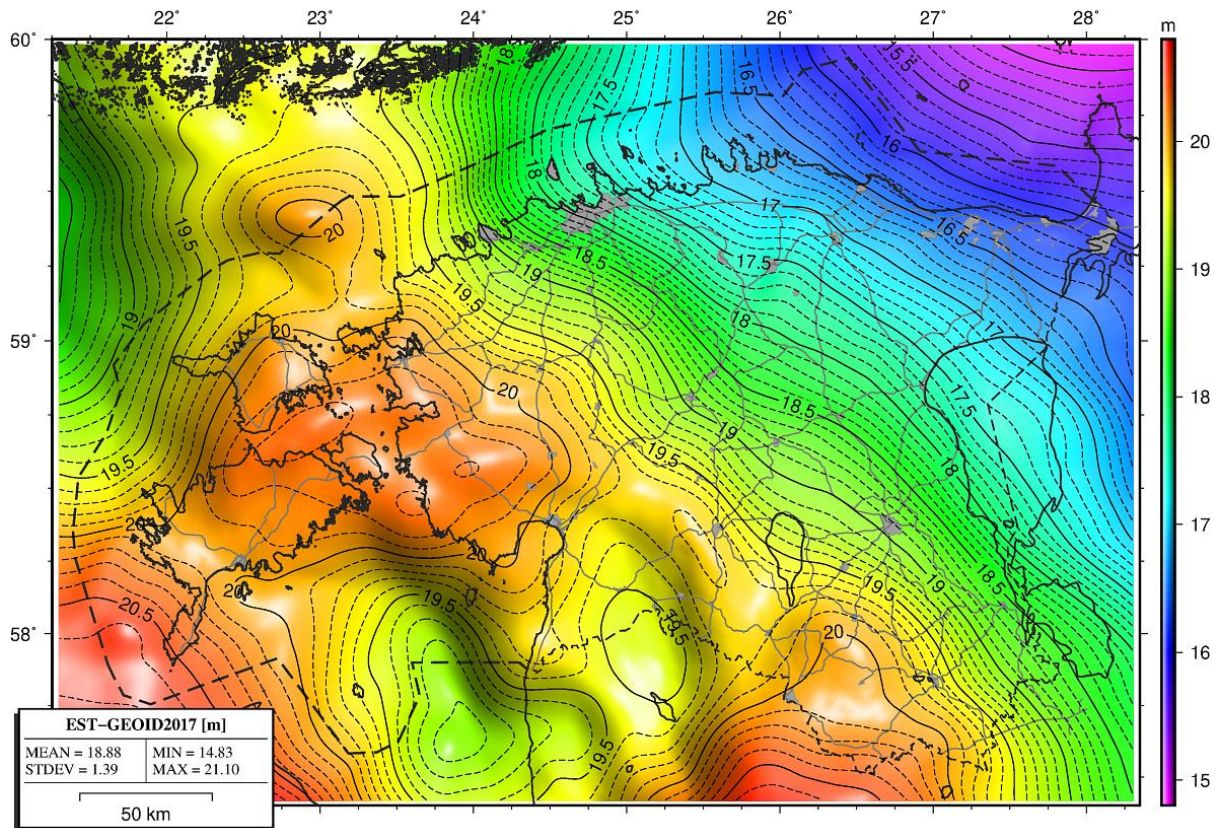


Figure. Estonian geoid model EST-GEOID2017

### 3. OSI: CHANGE DETECTION AND CLASSIFICATION PRODUCED AS PART OF THE OSI RESEARCH INITIATIVE

ORDNANCE SURVEY IRELAND (SEAN O' RIOGAIN, JOANNA CHRACHOL, AIDAN BURKE, GERARD HAMILTON, DERMOT WARREN, CONOR CAHALANE, PAUL KANE)

#### Introduction

In May 2016 Ordnance Survey Ireland (OSi) launched the OSi Research policy initiative. A priority research theme identified by OSi was a need to determine the difference between remotely sensed imagery and the OSi spatial data holding (PRIME2) while conforming to the PRIME2 data model. The output would deliver the physical geometry of change and also assist in identifying the type of change. This collaborative research project, funded by OSi and partnered with the National Centre for Geocomputation and the Department of Geography at Maynooth University (MU), is currently exploring the suitability of a three stage, segmentation – classification - change detection approach. Open source Computer Vision (CV) and Machine Learning (ML) python libraries have been harnessed to enable a computer to 'read' multispectral aerial photographs, such as those used by OSi.

#### Data Capture and Pre-processing

Stage 1 initiated a literature review to catalogue data capture methodologies and established best-practice for minimising spectral errors during airborne surveys. These are important for minimising errors in classification/change detection. Subsequent portions of this Stage 1 included identifying suitable pre-processing examples in the literature and identifying suitable open source libraries for Stage 2: Segmentation (Figure 1).

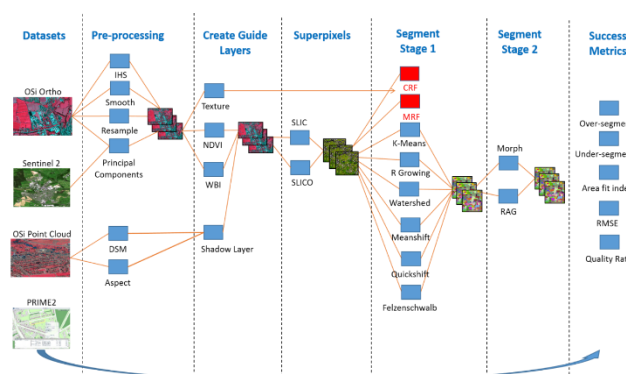


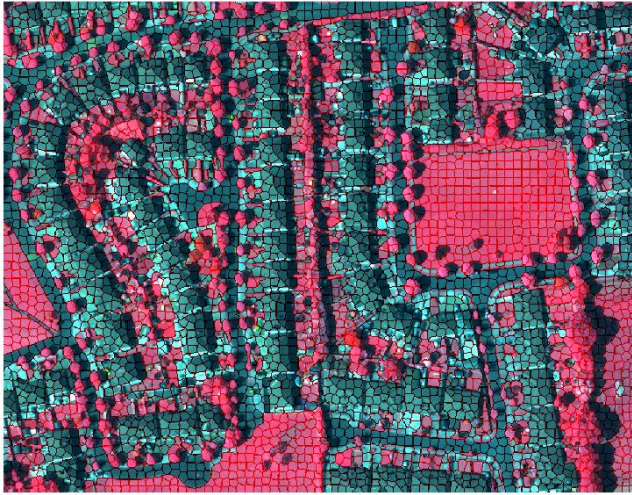
Figure 3. Pre-processing/Segmentation/Tidying Workflow

#### Segmentation/OBIA

In Stage 2 - that project team developed a highly-configurable research tool, written in the Python programming language, which can use the following image segmentation algorithms, either individually or in combination, to segment images of different types: Simple Linear Iterative Clustering (SLIC), Felzenszwalb, Quickshift and Watershed. The work completed to date has also identified a variant of the SLIC algorithm, commonly known as SLICO, as the one that provides promising results at moderate levels of segmentation in terms of accuracy and processing time.

The tool also allows those segmentation algorithms to be used in combination with various band reduction techniques, such as Principle Component Analysis (PCA), as well as with Gaussian filtering for image smoothing, and Region Adjacency Graphs (RAG) to minimise over-segmentation. It also outputs modified copies of the input image to visualise the results achieved at key stages of the segmentation-classification process. For example, Figure 2 shows how it visualises the results of segmentation by marking the segment boundaries on a copy of the original image.





*Figure 2. Visualising the results of Segmentation*

### **Classification**

Stage 3 has explored suitability of Random Forest (RF), an ML algorithm, to classify the resultant image segments in accordance with the following agreed priority land cover classes: Building, Road, Vegetation and Waterway. In this context, it automates the pre-classification of the segmented images used to train (and create) and test the RF classifier using a variety of techniques, including leveraging the relevant OSi Prime2 vector layer datasets as the source of 'ground truth'.

As well as the four priority classes referred to above, the RF classifier is also designed to detect image segments which fall into the following ancillary classes: Shadow, High-Reflection and Semi-Vegetated (e.g. where a segment contains the front garden of a dwelling that is partly paved and partly grassed). In the case of the first two of those classes, the tool uses configurable grayscale thresholds to identify segments of those types, while a configurable Normalised Difference Vegetation Index (NDVI)-based thresholding technique is used to identify segments in the third class.

Figure 3 shows how the tool uses colour-coding to visualise the classification of the segmented image that was featured in Figure 2, where segments in the Building class are coloured in red, the Road class in grey, the Vegetation class in green, the Semi-Veg. class in yellow, the Shadow class in black, and the High-Reflection class in white (usually due to relief displacement).



*Figure 3. Visualising the results of Classification*

### Current Focus

The project is currently exploring how OSi's point cloud data (Figure 3) might be used to improve the accuracy of the classification process by using the elevation information that it contains as an additional ML predictor. The final stage of the project – Stage 4 - will incorporate change detection between classified datasets exploring different temporal intervals for a test area in North Kildare, profiling processing performance as we scale the process and project reporting.



*Figure 4. Image derived point clouds provide additional 'elevation' predictor class for RF.*

#### 4. THE CENTRAL COMMON MAP DATABASE FOR NORWAY NORWEGIAN MAPPING AUTHORITY (NILS IVAR NES)

This document describes an example of a real life practice from the Norwegian Mapping Authority; the central FKB database.

##### **Background: Geovekst and FKB**

*Geovekst* is the name of a Norwegian public cooperation for spatial data. The cooperation consist of the municipalities of Norway, The Norwegian Mapping Authority, The Norwegian Public Roads Administration and other public agencies. The cooperation was established in 1992. Former public agencies for telecom and power supplies are now privatized but are still part of the cooperation.

Geovekst are responsible for the FKB product specifications. FKB is a list of data specifications for detailed map data for different themes. The principle of FKB is to meet all the Geovekst members need for detailed map data. The cost for establishing and maintaining the data is spilt to the members of the cooperation and all the partners have full access to the data.

The data specifications is part of the Norwegian SOSI standard for spatial data. The SOSI standard is based on UML data models in compliance with the ISO principles.

The FKB product specifications also consist of detailed instructions for photogrammetric production of FKB-maps. Most of the FKB-data is captured by photogrammetry from aerial photographs with pixel size from 8 – 25 cm.

FKB and other product specifications from Geovekst (in Norwegian): <https://kartverket.no/geodataarbeid/Geovekst/geovekst-produktspesifikasjoner/>

The SOSI standard (in Norwegian): <https://kartverket.no/geodataarbeid/Standarder/SOSI/>

##### **Technical description of the central FKB database**

The central FKB database is based on two open APIs. This is the *NGIS-API* for updating the data in the database and the *Geosynkronisering-API* for synchronizing the updated data to copies. The municipalities are intensive updaters and users of the FKB-data and a part of the concept is that all the municipalities have a copy of the central database for their area.

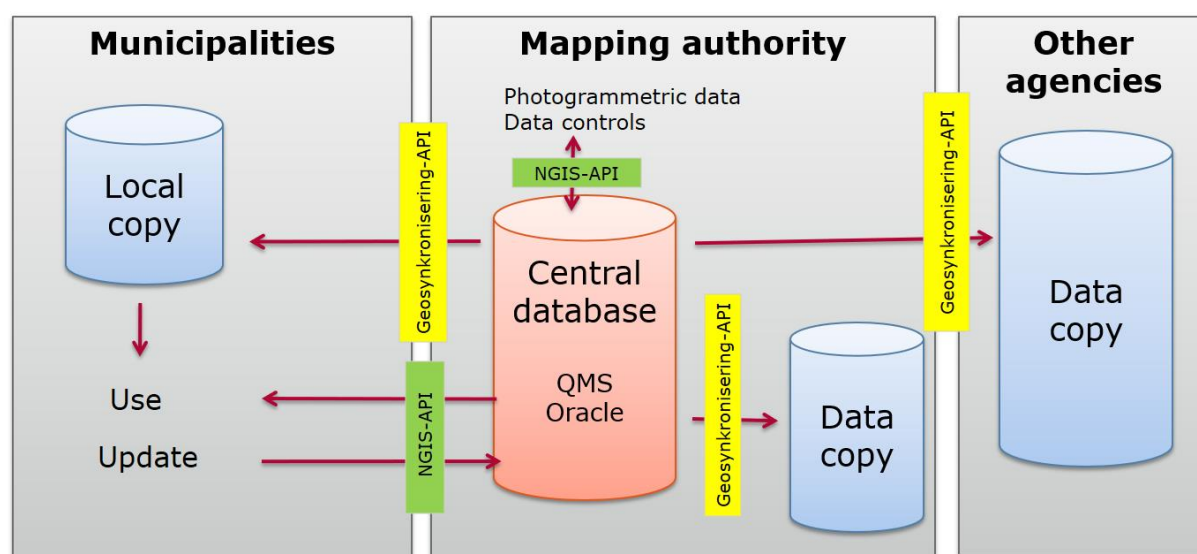


Figure 1. Showing the dataflow of the system. When the municipalities update the central database using NGIS-API, the local copy is immediately updated using Geosynkronisering-API.

The central database is based on the software Quadri Map Server (QMS) which handles the mapping between the APIs and the database. The database itself is currently based on Oracle. The QMS software is developed in a partnership between Norwegian Mapping Authority and the company Norkart AS. The Norwegian Mapping Authority uses an own developed software for updating the system while municipalities and other agencies can choose between client software from two competing software companies (Norkart AS and Norconsult Informasjonssystemer AS).

Both the APIs and the structure of the database are based on UML-models. That means it is easy to extend the content of the management system simply by making a new UML data model and export setup information from the model.

The standard Geosynkronisering (in Norwegian):

<https://kartverket.no/globalassets/standard/bransjestandarder-utover-sosi/geosynkronisering-standard-versjon-1.pdf>

The website for the project (in Norwegian): <https://kartverket.no/Prosjekter/Sentral-felles-kartdatabase/>

### **The national geoportal – Geonorge.no**

The national geoportal in Norway is named geonorge.no. Here you can find metadata about and download most of the spatial data available in Norway.

FKB-data is the core detailed basis geospatial data in Norway. Updated data from the central FKB database is a significant part of Geonorge.no. WMS-services and downloadable files for each municipality is updated on a daily basis.

The national geoportal (English version): <https://www.geonorge.no/en/>

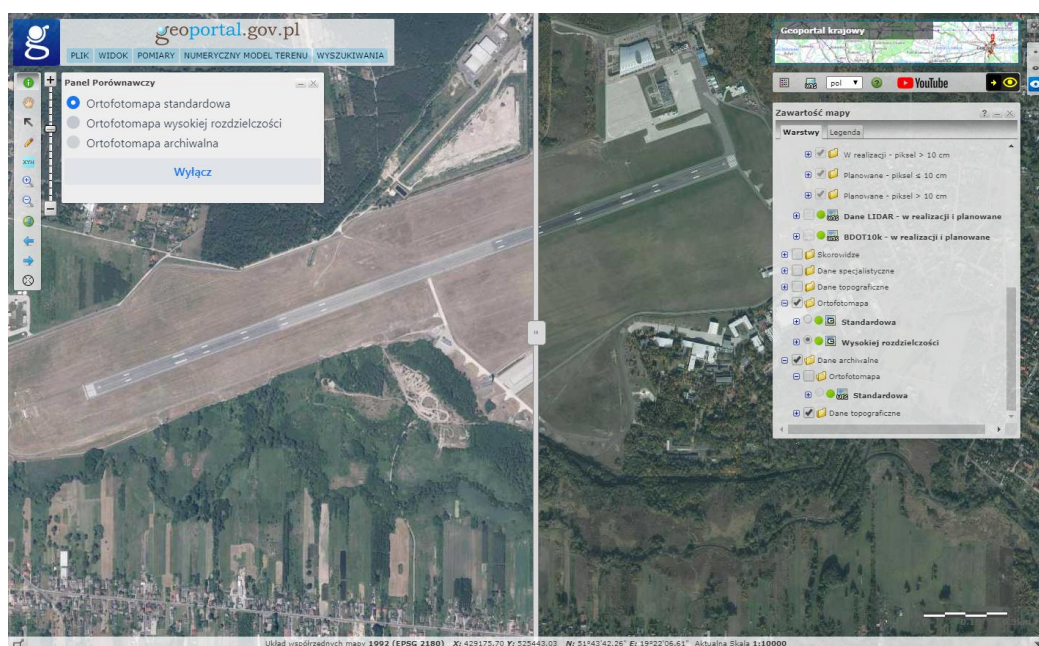


## 5. BUILDING REFERENCE DATABASES

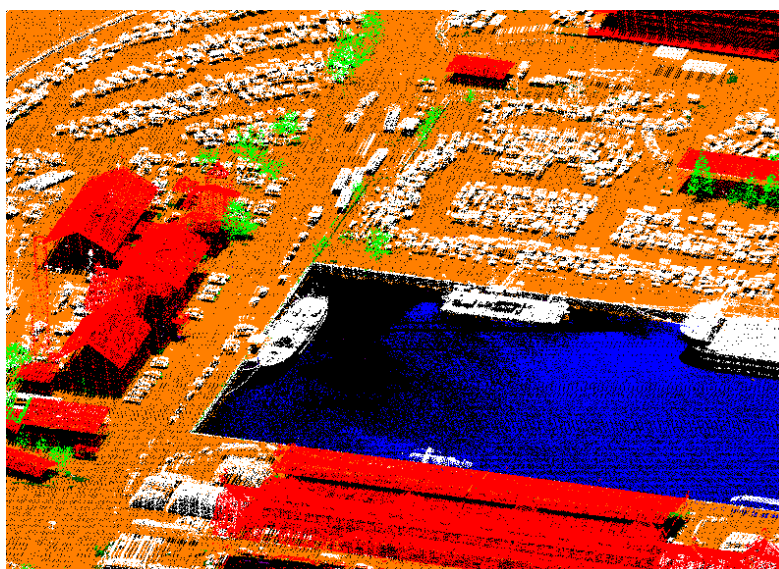
### HEAD OFFICE OF GEODESY AND CARTOGRAPHY (GUGIK)

During 2019 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 GUGiK ordered the following photogrammetric data:

1. Aerial images and orthophotomaps with GSD 10 cm (for cities - 7 289 km<sup>2</sup>) and 25 cm (69 391 km<sup>2</sup>). Digital elevation model is also provided with this data, properly 1m and 5m ESRI GRID. Orthophotomaps for the whole country are available in web services ([WMS and WMTS](#)) and also published in the national broker [geoportal.gov.pl](#). In addition, GUGiK have implemented new functionality in the [geoportal.gov.pl](#) that allows to compare published orthophotomaps by using the "Comparison panel" tool:

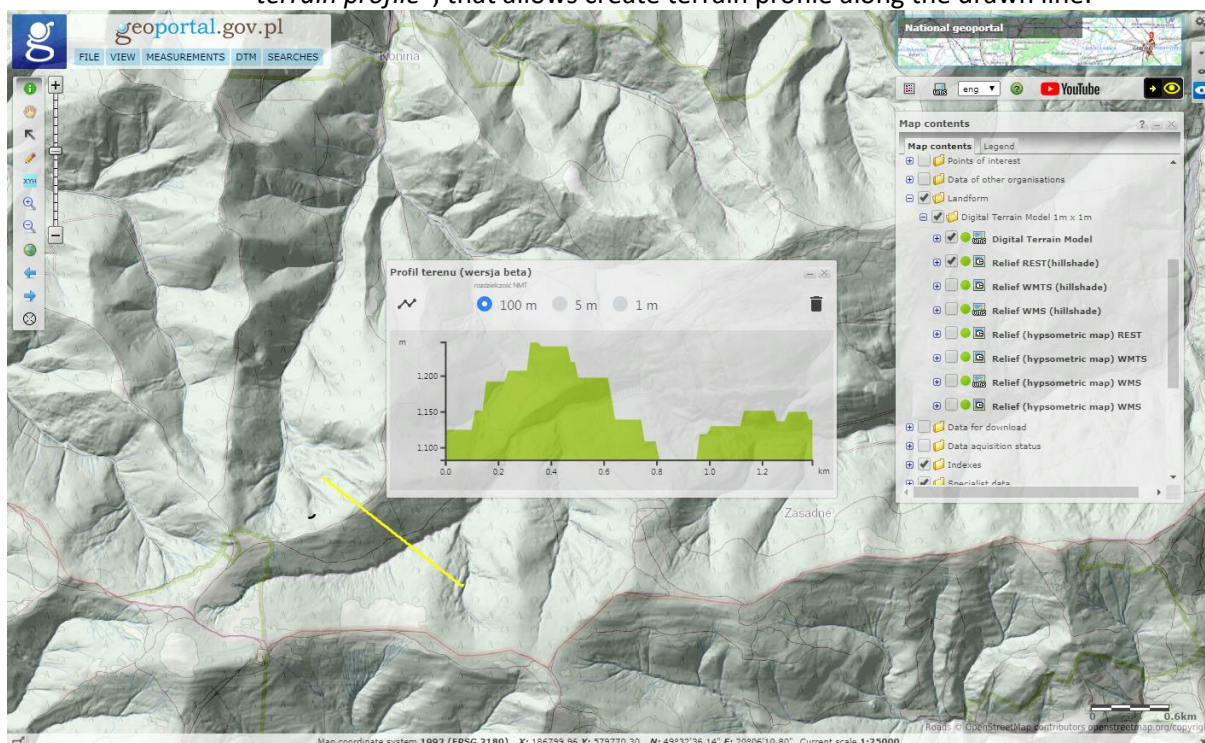


2. ALS data with a density of 4 points/m<sup>2</sup> (31 570 km<sup>2</sup>) and 12 points/m<sup>2</sup> (for cities - 4 779 km<sup>2</sup>) for a total area of 36 349 km<sup>2</sup>. In addition, based on data ALS, GUGiK has developed DTM (1m ESRI GRID) and DSM (1m ESRI GRID outside cities, 0.5m ESRI GRID in cities).

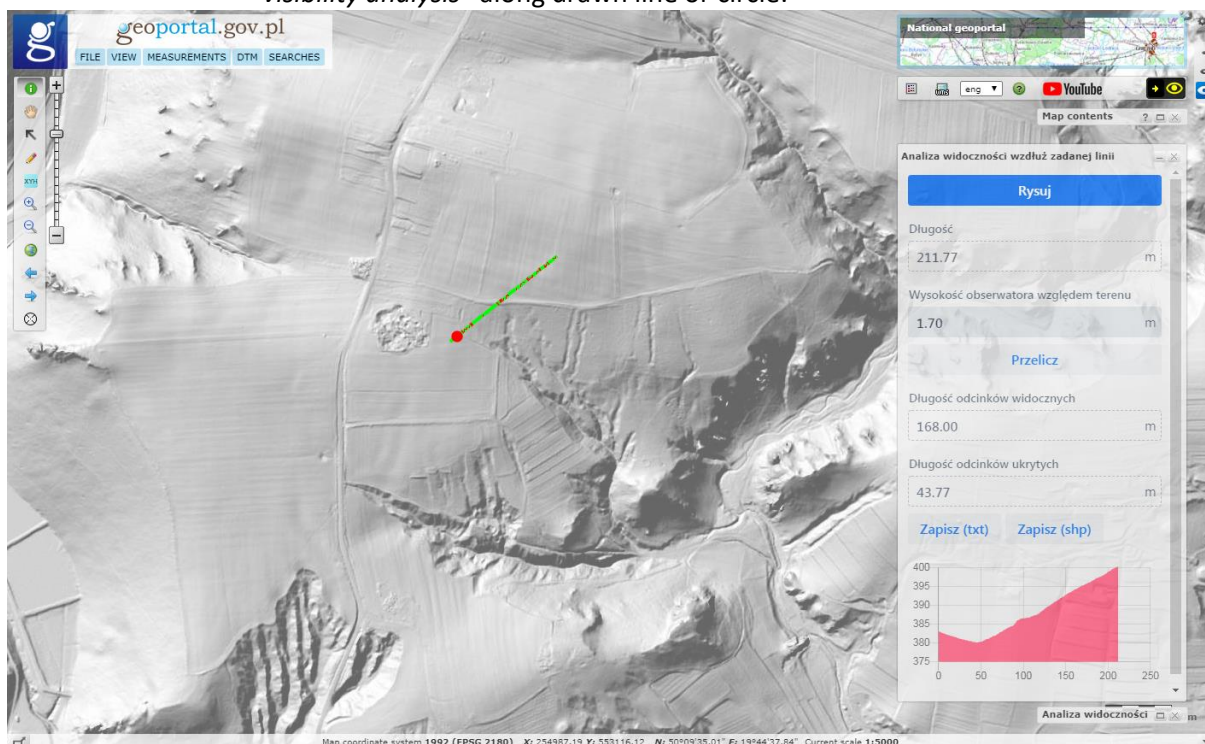


DTM for the whole country, in the form of hillshade, is available in web services ([WMS and WMTS](#)) and also published at [geoportal.gov.pl](#). In addition, GUGiK have implemented in the [geoportal.gov.pl](#) the following tools based on 1m DTM:

- “terrain profile”, that allows create terrain profile along the drawn line:



- “visibility analysis” along drawn line or circle:





Additionally GUGIK has launched a new [Digital elevation model](#) service, based on 1m DTM, that allows :

- determine the height (vertical coordinate system PL-KRON-86) for xy coordinates (PL-1992, EPSG:2180)
- determine the height (vertical coordinate system PL-KRON-86) for list of points (xy in PL-1992, EPSG:2180)
- lowest and highest point for area described as polygon (WKT format, PL-1992, EPSG:2180)
- volume of earth mass

The tools are also available in the [geoportal.gov.pl](http://geoportal.gov.pl).

Beside to the above-mentioned tasks GUGiK, as part of its own activities, prepared building models in the CityGML LOD1 format obtained using building outlines from the topographic database (BDOT10k) and ALS data.



The data is prepared for the entire country and available without restrictions at [geoportal.gov.pl](http://geoportal.gov.pl):

## 6. POSITIONAL ACCURACY IMPROVEMENT OF LAND CADASTRE INDEX MAPS IN THE REPUBLIC OF SLOVENIA

MINISTRY OF THE ENVIRONMENT AND SPATIAL PLANNING - THE SURVEYING AND MAPPING  
AUTHORITY OF THE REPUBLIC OF SLOVENIA

### Introduction

Due to the increasing use of digital land cadastral data in the administration of the state, it is necessary to ensure adequate quality improvement of the land cadastral positional data. The Surveying and Mapping Authority of the Republic of Slovenia (GURS) will provide positional accuracy improvement (PAI) of the land cadastral data with the project named "Positional Accuracy Improvement of Land cadastre Index Maps", managed within the Ministry of the Environment's project package "The Programme of eProstor (eSpace) Projects".

In the Republic of Slovenia, the cadastral database is divided into a geometric data section and a descriptive (attributive) data section. In the geometric section of the land cadastre, two digital geometric presentations of land are managed: land cadastral index maps (ZKP) and land cadastre maps (ZKN).

The main objective of the project is to make the graphic data layer of the ZKN continuous when the project is completed, so that it can replace the existing ZKP in the procedures of efficient spatial management, thus providing better quality support to decisions and spatial management. The operational objective of the project is the positioning accuracy improvement of the ZKP in the territory of the entire country. The improved data on the positions of land boundary points and land cadastral points will be recorded in the cadastral database with coordinates in the D96/TM (E, N) state coordinate system.

### Work method

The adjustment membrane method facilitates the transfer of positional accuracy improvement of the measured LCPs (land cadastral points) with high-quality coordinates, to the ZKP model in a continuous mode. The method is based on a mechanical analogy of Hooke's Law that superimposes the ZKP geometry on the elastic membrane formed by a triangular irregular network (TIN). High-quality measured LCPs represent the points on which this elastic membrane is tensioned (heterogeneous cadastral geometry is printed on it before the improvement), which is improved in the neighbourhood of tensioning points, based on the improved positions of measured LCPs and the introduction of additional geometric constraints (orthogonality and collinearity, measured distances from fieldbook data, etc.). The method provides for proximity fitting, based on the model of mechanical membrane. GURS obtained a licence for *Systra* software of the German company Technet GmbH from Berlin for the operational computer implementation of the positional accuracy improvement of land cadastre index maps. The *Systra* represents a powerful software tool allowing the geometric integration of geodetic observations and various data layers of geographic information systems (GIS) through the procedure of geodetic adjustment. In order to automate the process, the GURS, assisted by the domestic contractor, Geodetska družba, d. d., developed the *SysGeoProTM* software, which is an interface for the transfer and preparation of data between the land cadastre database and the *Systra* software.

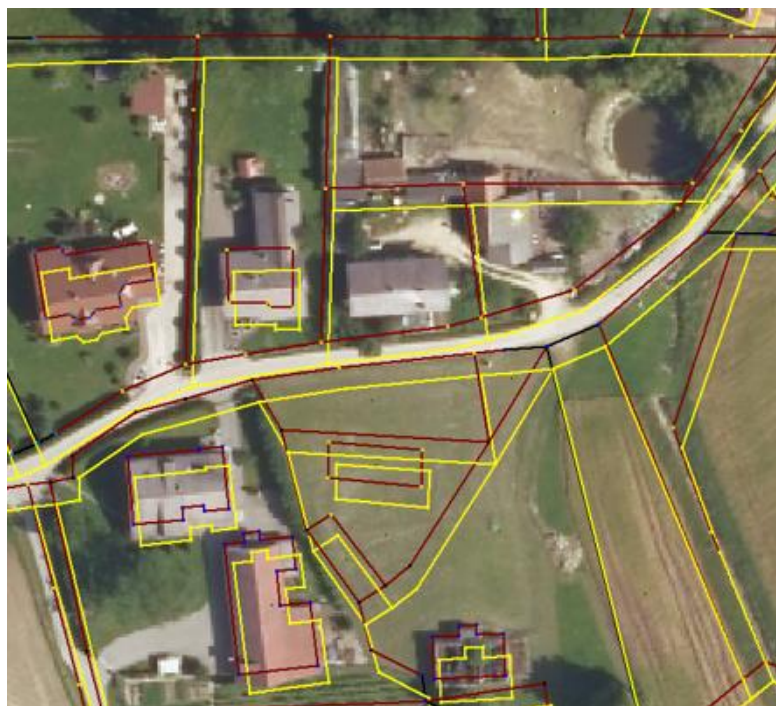
### Results

The database with adjusted and homogenised point coordinates is transferred from the *Systra* to the *SysGeoProTM*. The results are carefully analysed (examination of the *Systra* output databases) and converted into an appropriate format for import into the land cadastre database.

The result of the positional accuracy improvement of land cadastre index map will be the improved positional accuracy of the ZKP for the whole territory of Slovenia. This will provide us with an integrated, continuous and topologically correct data layer of the land cadastre geometry.

In the current land cadastre information system, the ZKP will remain unchanged and the existing ZKN will be supplemented (integrated) with the data from the improved (in terms of positional accuracy) ZKP, and will thus become a continuous geometric data layer. Due to the continuous and improved

positional accuracy, the ZKN data layer has replaced/will replace the existing continuous graphical data layer of the ZKP in serving the needs of users (Figures).



*Figure. The result of the improved positional accuracy of the ZKP. KEY: ZKP lines before positional accuracy improvement – yellow; ZKP lines after positional accuracy improvement – red, black (ZKN)*

## **Conclusion**

At the GURS, the procedure of the positional accuracy improvement of the ZKP is considered to be a process rather than a one-time effort. By obtaining additional data from the maintenance procedures applied to land cadastre graphical data or additional data that would be collected with the intention to serve in the positional accuracy improvement process in the future, the number of connection points and geometric constraints is increasing continuously.

The implementation of the Positional Accuracy Improvement of Land Cadastre Index Map project has been in progress since February 2018 and is expected to be completed in October 2020. The project is being implemented in individual cadastral municipalities.

By February 2020, this project will be completed in approximately 1,840 of the 2,698 cadastral municipalities in the territory of the Republic of Slovenia, accounting for approx. 68 % of all cadastral municipalities. The results of the improvement are registered on an ongoing basis in the land cadastre database and are immediately applied to other land administration procedures.

## 7. HIGH RESOLUTION SIOSE

### IGN SPAIN

SIOSE (Sistema de Información sobre Ocupación del Suelo en España) is the Land Cover and Land Use information system of Spain. The SIOSE's objective is to generate a LC/LU vector polygonal database for describing all landscape typologies for whole country integrating the information available from the Regional and National Public Administrations to fulfil national and international requirements (e.g. INSPIRE, EIONET, Copernicus). Instituto Geográfico Nacional (IGN Spain), as EIONET National Reference Centre of Land Cover, Land Use and Spatial Planning, is the coordinator of the project.

Minimum mapping unit (MMU) for SIOSE was initially defined in the first version of 2005 equal to 2ha (and 0.5 ha for water and artificial classes), however in the last years there has been a growing increase in the needs of the main users of SIOSE. More specifically, users demand greater geometric, thematic and temporal detailed data. On the other hand, nowadays there are accessible, better than epochs before in Spain, greater amount of reference information available from official digital sources, such as LiDAR data, cadastral geometries, land parcel information systems, forestry inventories, etc.

All of this leads to the development of a new strategy in which the production of the SIOSE must take into account these needs to be satisfied. The new High Resolution SIOSE is defined by the following key aspects:

- Continuation of the SIOSE data model, to give continuity to the previous data and to adapt to the European Copernicus EIONET EAGLE data model.
- To be obtained by integrating official reference data.
- Improvement of the geometric and thematic resolution according to the reference sources used.
- To be based on a high level of automation that guarantees the maintenance of an objectivity in the integration of data, reduction of costs and higher frequencies for updating

During last years, IGN Spain in collaboration with others agents, finalised the development of the new SIOSE production strategy, much based in the automatic integration of data than in photointerpretation like traditional LC/LU systems. Last January, the first version of the product was completed, which represents a national and international milestone in the automatic integration of reference vector geospatial data. This product with reference date of 2014 is essential to establish methodological and statistical parallels with the traditional SIOSE of 2014. Pure automatic result needs a complementation with revisions tasks over particular well-known sites where automatic algorithms can fail. This additional revision work looks for fine-tune of the product, reduce possible automatic mistakes and involves of rest project partners, such as Regional or other National Public Administration not belonged in the automatic process. Due to the massive number of elements in High Resolution SIOSE, the revision work must be guided in practical and economical terms.

The High Resolution SIOSE structures the information on land cover and land use individually, as INSPIRE recommends, and in line with other sets of geographic reference information fundamental from the National and Regional Governments.

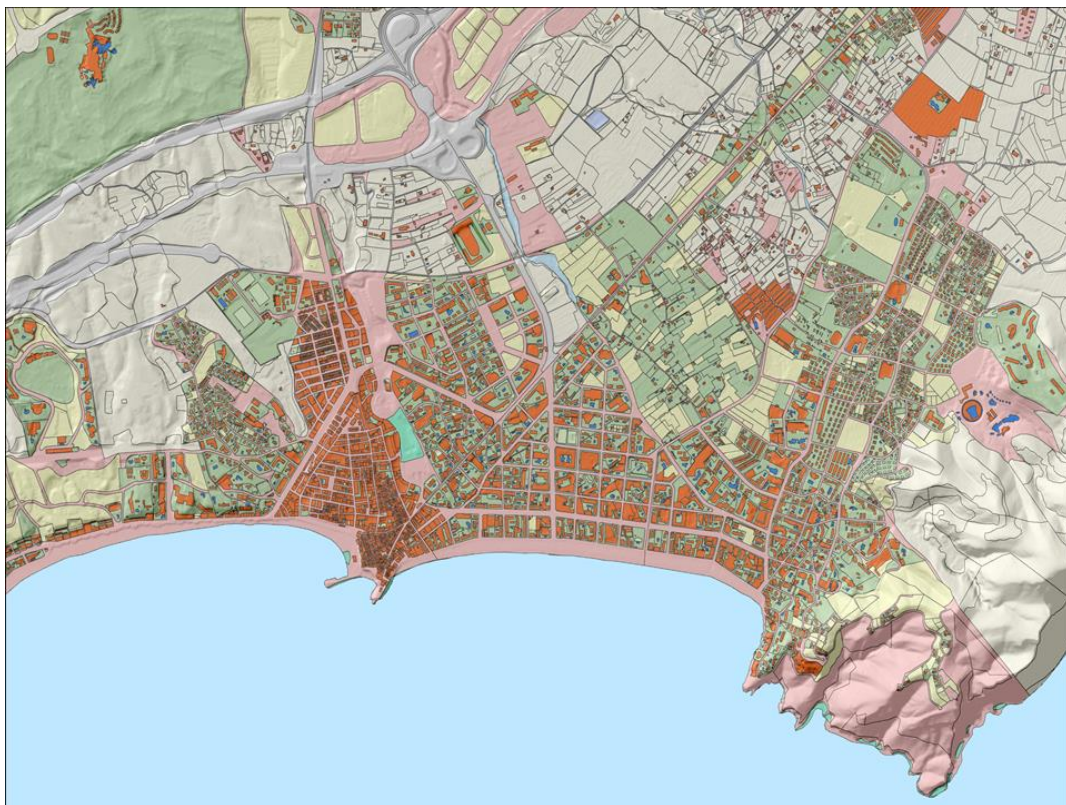
Technical characteristics:

- Cooperative productive scheme between the National and Regional Governments
- Automation in the integration of sources, which allows an objectivity, cost reduction, higher frequency of updating and maintenance of geometries and themes
- No actual minimum mapping unit (inherited scale from integrated information 1: 1,000-1: 5,000) for practical reasons, polygons smaller than 1 m<sup>2</sup> are collapsed
- Sources of information:
  - o Cadastre
  - o SIGPAC - Land Parcel Information Systems (LPIS)
  - o Farmers declaration of the Common Agricultural Policy



- National Forest Map of Spain
- Geographic Reference Information on Transportation and Hydrography
- LiDAR (0.5 – 1 p/m<sup>2</sup>)
- National Topographic Database 1:25.000
- Traditional SIOSE and other inventories
- Object-oriented data model and compatible with traditional SIOSE and with European data models EIONET Copernicus EAGLE and INSPIRE.
- Vector polygonal database
  - Land cover table (with 100 million polygons)
  - Percentages land covers table (with 130 million elements linked to land cover polygons 1:M)
  - Land use table (with 54 million polygons).

More information at: <https://www.siose.es/web/guest/siose-alta-resolucion> ([siose@fomento.es](mailto:siose@fomento.es))



*Figure. High Resolution SIOSE of Benidorm (Spain)*

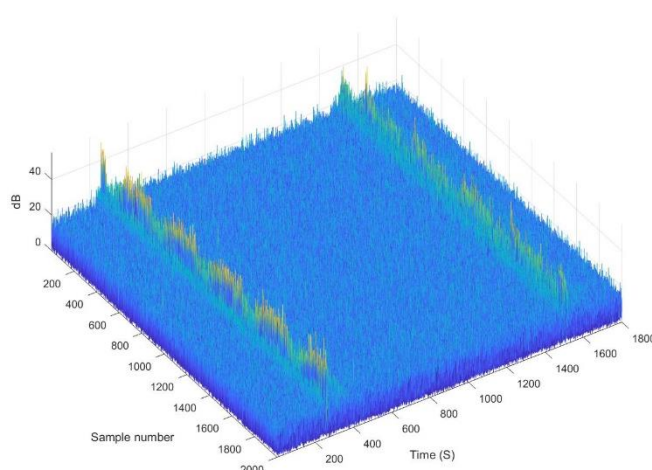
## 8. UNDERSTANDING THE IMPACT OF NATURAL AND MANMADE INTERFERENCE ON A NATIONAL GNSS NETWORK

### ORDNANCE SURVEY UK

OS Net is Ordnance Survey's highly accurate and resilient Continuously Operating Reference Station (CORS) network, made up of 115 Global Navigation Satellite System (GNSS) base stations across Great Britain. It is the infrastructure for realising our national 3d coordinate system across the country and is used by a vast array of communities. These include surveyors who take real time GNSS correction services that enable them to position to a couple of centimeters, the Meteorological Office who use the data to measure the amount of water vapor in the atmosphere and academia who use the data in over 80 projects a year. OS Net is also critical to Ordnance Survey operations, supporting both our field surveyors and remote sensing capability.



For a number of years however, OS has been concerned with both the perceived and real impact on this infrastructure from both natural and manmade GNSS interference sources. With such a wide user community, understanding the effects of issues such as malicious jamming to solar storms is really important.



At the national level, the 2018 UK Government report on Satellite-derived Time and Position: A Study of Critical Dependencies (the Blackett report<sup>1</sup>) looked at service provision, impact and risk mitigation and made recommendations to improve resilience across a wide variety of GNSS user communities. Ordnance Survey however also sees itself as having a strong role in this field and has carried out work in this area for over ten years. For example, the GemNet project<sup>2</sup> both characterised the issue of GPS jamming and started to look at developing mitigation. It captured GNSS

jamming occurrences and, just as importantly, replayed the captured interference profile under laboratory conditions back through a variety of survey and consumer grade GNSS receivers to examine the impact. At that time, clear evidence of GNSS interference from intentional jamming was collected, although just as importantly, the actual impact when the jamming signals were played back through the receivers, was generally negligible.

This is a developing picture however as both the issue and ways of understanding it are changing rapidly. Building on research OS has carried out over the years, we are planning to develop capability along with partners to research and develop a proof of concept deployment of a system that will capture, correlate, characterise, store and disseminate GNSS interference events and their observed impact. This will provide a powerful resource for OS as we continually strive to build more resiliency into our CORS network as well as be a resource that will enable many areas of government to understand the challenge.

<sup>1</sup> <https://www.gov.uk/government/publications/satellite-derived-time-and-position-blackett-review>

<sup>2</sup> "GNSS threat quantification in the United Kingdom in 2015" (Coordinates Magazine, January 2016)

## 9. MINECRAFT® ON DEMAND TO PREPARE THE FUTURE

### IGN FRANCE (FRANÇOIS LECORDIX)

The French national mapping agency launched a new web service in June 2016, called Minecraft® on Demand (Fremont *et al.*, 2016) (Lecordix *et al.*, 2017). This free web service (available at [www.ign.fr/minecraft](http://www.ign.fr/minecraft)) is designed to provide Minecraft® maps, the world's most popular video game, computed on the fly from different geographic databases that IGN produces and publishes, which are:

- RGE ALTI®, providing a digital terrain model (DTM) with a 1 meter resolution to generate the topographic relief;
- BDCARTO®, a vector database, providing a continuous land cover on the whole French territory with a 10 m resolution;
- Registre parcellaire graphique (RPG), a non-continuous vector database, with all the different cultures in agricultural areas, hence providing more information than BD CARTO® to distinguish them;
- BD TOPO®, a topographic vector database, with a resolution of 1 meter and 3D information, to generate road, river, forest, building,...
- And others for particular information.

After selecting the center of any desired area in France on the service, the player can easily import a corresponding map of 5 km long and 5 km wide, at the scale of 1 block for 1 meter into Minecraft®. This service was specifically developed for young people to discover IGN data and geography. Since its launch in June 2016, 62000 Minecraft maps have been delivered in end of 2019, with an average of 50 maps a day.

In addition to this attraction of young audiences, the Minecraft® on Demand service has interested two French ministries, which would also like to reach out to the new generation:

- the Ministry of Territorial Cohesion (MCT) used this web service for a national Minecraft® contest;
- the Ministry of National Education launched, in March 2018, a project proposed by IGN based on this service to develop new educational tools on Minetest, which is an open source voxel game inspired from Minecraft, with the geographic data produced by IGN and introduced into the game.

The results of these projects were obtained in 2019 and are presented below.

### **National contest Cities and Territories of Tomorrow**

In 2018, the MCT wanted to raise awareness and to consult a large audience for citizens to imagine their future cities and territories, with the objective to address challenges like improving the quality of life of citizens, contributing to a more inclusive society, designing, building and renovating buildings and neighbourhoods, developing urban nature and urban mobility while limiting pollution, providing solutions to climate change and the ecological transition of society, optimizing the management of water and energy...But for this kind of consultation, it is generally difficult to reach a young audience. That is why the MCT decided to try an original experiment with the *national Minecraft contest Cities and territories of Tomorrow*<sup>3</sup>.

This national contest, which was organized to encourage people to imagine the evolution of their familiar environment by creating better places to live in, took place from October 5, 2018 to January 31, 2019. Projects had to be based on Minecraft® or Minetest and to use maps initially produced by IGN service Minecraft® on Demand. This constraint to use Minecraft® on Demand was intended to encourage the imagination of the evolution of the territories in 2050, and not to create a new city from scratch with no connection to the present. A 3-minute video presentation had to be submitted to validate the entry.

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<sup>3</sup> <https://villesterritoires-minecraft.gouv.fr/>

1200 people registered on the contest website. As of February 2019, 27 contest applications had been submitted. It turned out yet that the requirement to produce a video presentation to participate proved too difficult for the younger participants. Associated with a theme that was difficult for children to address, this explains the large gap between the number of people registered on the ministry website and the final number of candidates.

Applications came from very different audiences: young children alone on their own, a group of 80 pupils from a school, students from an architecture schools, etc... Various ecological solutions have been proposed in terms of energy (solar panels, wind and hydro turbines...), transport and buildings. All the videos are available on the MCT website<sup>4</sup> and all the feedbacks on the contest are written in (Lecordix *et al.*, 2020) (fig. 1).



Figure 1. A proposition for the contest: *Carrière du Boulonnais*, by *Play-Minecraft.fr* (Source *Play-Minecraft.fr*)

### New educational tools on Minetest

Quickly after the creation of Minecraft® on Demand, IGN wished to use this service for educational purposes. As part of a call for projects from the Ministry of Education to create innovative digital services, IGN proposed to develop new educational tools based on Minetest, using the geographical data provided by IGN to produce Minetest maps. Funded by the Ministry of Education through a specific funding program PIA (Programme d'Investissements d'Avenir), this project aims to develop an innovative approach to multidisciplinary digital learning. With Minetest maps, two main themes were addressed, which would link the geographical data and some parts of the National Education programs: orientation around home and natural hazard prevention.

The project development was divided in two parts:

- Improving the Minecraft® on Demand service that IGN developed internally:
  - Adding new territories in the service: French overseas territories through IGN data, test on Belgium through the Service Public of Wallonia data, test on the world through OSM data.
  - Adding new formats of maps delivery, in particular Minetest to answer of the ministry request to use free open source software.

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<sup>4</sup> <https://villesterritoires-minecraft.gouv.fr/projets>



- Introducing new geometric parameters for the map: a scale factor (and not only one block for one meter), different areas up to 5 km long and 5 km wide, different orientations, ...
- Introducing new map thematic selections: possibility to add snow (for avalanches risks), and to select some key elements (roads, buildings ...).

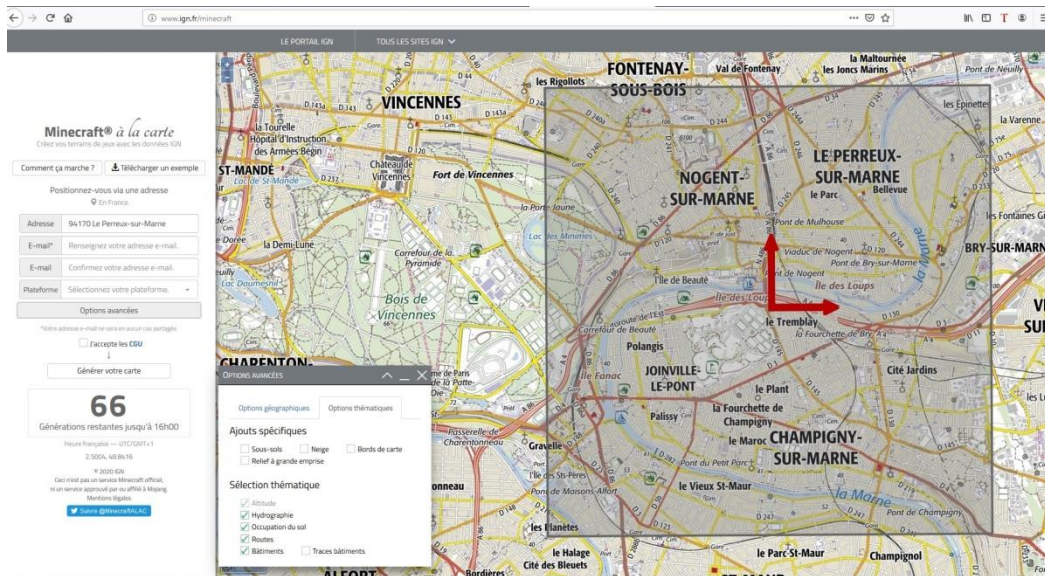
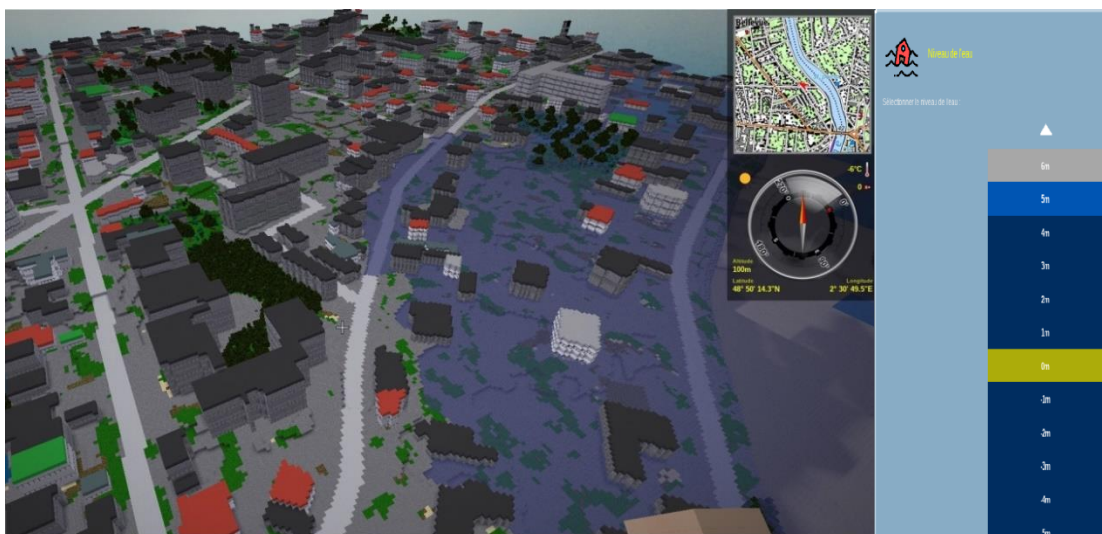
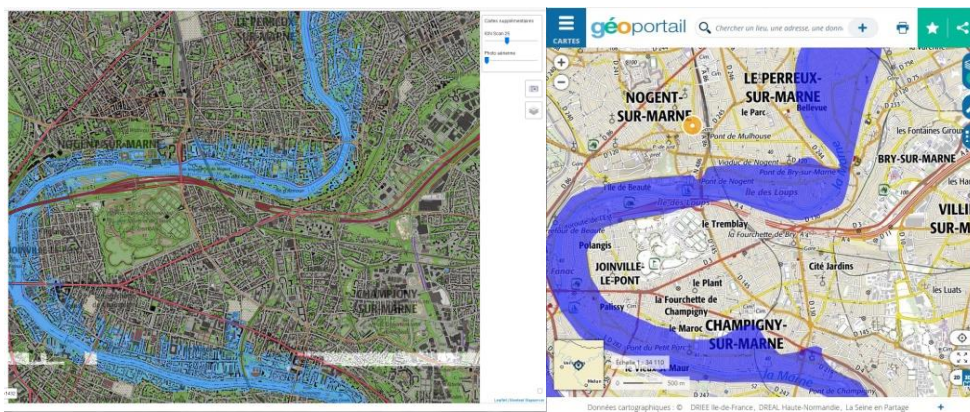


Figure 2. Interface of the service Minecrat@ on Demand

- Developments of pedagogic tools in Minetest engine that IGN subcontracted to the start-up EvidenceBkidscode:
  - Tools to work on spatial orientation, in 2D and in 3D;
  - Tools to simulate natural hazard in a 3D environment: floods, avalanches, mudslides, tornadoes, volcanic eruptions. For instance, the user can observe the effect of the rising waters in a Minetest map and can detect the buildings and areas that will be flooded (fig. 2a) on his own territory depending on the height of the flood.
  - Tools to visualize and to map in a 2D environment the consequences of floods or avalanches simulations (fig 2b) which can be compared to a past event (fig 2c).



(a)



(b) (c)  
 Figure 3. 3D Simulation in Minetest of the river Marne flooding the city of Le Perreux; (a) Top down view and cartography of the results of 3D simulation; (b) Comparison with the historical flood wick occurred in 1910.

### Future work

IGN wishes to continue introducing geospatial data in serious games to develop new digital applications. The author invites other national mapping agencies in Europe to collaborate to publish their data in a service Minecraft® on Demand and to use simulations tools to reach young people of their country.

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- Lecordix, F, Kriat, S. et Lekhnati, M., « Le concours villes et territoires de demain avec Minecraft® à la carte », Géographie et Culture n°109, L'urbanisme, l'architecture et le jeu vidéo. Que fabrique le game design ? de Prévot, M. et Buyck, J., édition l'Harmatan, Janvier 2020



## Workshop in the picture

### EUROSDR ONE-DAY WORKSHOP ON SINGLE PHOTON AND GEIGER-MODE LIDAR

LUIGI PARENTE (SCHOOL OF ARCHITECTURE, BUILDING AND CIVIL ENGINEERING, LOUGHBOROUGH UNIVERSITY)

On the 6<sup>th</sup> March, 2019 I attended a workshop on Single Photon Lidar (SPL) and Geiger-Mode LiDAR (GML) held at the 'Institut Cartogràfic i Geològic de Catalunya' in Barcelona, Spain. This meeting was organized by the EuroSDR (formerly OEEPE), a pan-European organisation composed by a network of delegates from European Geographic Information organisations and research institutes. EuroSDR members and partners work together on research projects, international workshops and courses focussing on developments and key issues related to the acquisition, management and delivery of geo-spatial data and services.

The workshop in Barcelona brought together over 60 participants interested in 3D mapping methods to discuss a revolutionary change in the capability of new LiDAR technologies. The event was opened at 9.00am with an introduction and welcome speech given by Julià Talaya (ICGC, Spain). A total of 14 talks were given during the day to learn more about the capabilities and results achieved to date with the SPL and GML technologies. The hot topics debated, focused on advantages and drawbacks of the two related techniques with respect to traditional linear LiDAR.

The chairman of the 'Commission 1: Data Acquisition' (EuroSDR) Jon Mills (Newcastle University, UK), analysed 120 responses from a questionnaire conducted between 13<sup>th</sup> August and 30<sup>th</sup> September 2018 and pointed out that there is poor practical experience and lack of benchmark for the SPL and GML. As a consequence, he observed a general confusion over the status, capabilities and drawbacks of the two techniques.

Following presentations focused on state of the art and lesson learnt from practical experience using data from the innovative LiDAR techniques. Charly Bernard (ENSG/IGN, France) presented the potential of SPL working with a dataset captured in 2017 at Easton, Maryland (USA). His study revealed a data density of 55pts/m<sup>2</sup> (flying height: 3750m; speed of acquisition: 750km<sup>2</sup>/h) with a precision of about 2-3cm and suggested to carry out analysis of water composition to improve understanding of data quality of ray penetration into water. Further talks addressing the potential of SPL were given by Gottfried Mandlbauer (TU Wien and University of Stuttgart) who presented a critical review of technological differences and point cloud properties of SPL and full waveform LiDAR and Jeroen Leusink (Het Waterschapshuis, The Netherlands) who compared SPL to traditional and other high performances laser systems. A talk about recent SPL development achieved at FGI was given by Xinlian Liang (FGI, Finland).



Some recent applications of SPL were presented also. Simon Musäus (COWI, Denmark) talked about European projects in 2017-2018 which involved the use of SPL, André Wästlund (Swedish University of Agricultural Sciences, Sweden) presented results achieved with SPL in forestry applications, while experiences of the national mapping agency of the United Kingdom with SPL data were discussed by Hannah Hunt (Ordnance Survey, UK).

A technical overview on the GML technique was presented by Mark Romano, Director of Geospatial Product Strategy at Harris Corporation. In his presentation he showed benefits of GML versus

conventional (linear) LiDAR data that included higher data resolution, reduced time for data collection, wider area of coverage and need for lower power.

As well as presentation describing capabilities and applications of the new LiDAR techniques, several talks looked at other technical aspects including SPL data classification. A workflow for classifying SPL data using Machine Learning and Open Source tools was described by Victor Garcia Morales (Tracasa, Spain), while Guillaume Koehl (IGN, France) conferred the SPL classification for DTM and automatic vector production. Furthermore, Nicolas Riviere and Paul Edouard Dupouy (ONERA, France) presented physical modelling approaches for SPL and GML systems.

From Leica Geosystem, Poul Nørgård (Chief Product Manager) and Ron Roth (Product Manager Lidar) talked about the use of high-density LiDAR for building models and introduced the Leica HxMap software for filtering and quality control, respectively.

At 5.30pm, the closing presentation given by Jon Mills focused on some critical questions to be answered to define a benchmark project in SPL and GML. Participants were eager to engage in further discussion on the potential for application of the new LiDAR techniques and definition of the ideal dataset. Furthermore, it was suggested that data processing and analysis is open to participants that can contribute using a common framework for reporting.



On the evening, all participants were invited to join a complimentary social dinner, kindly hosted by Hexagon/Leica Geosystems at Café de la Pedrera in Barcelona.

This EuroSDR workshop represented a unique opportunity to learn more about the latest LiDAR potential and achievements. A PhD student like me, working with photogrammetric methods, is constantly interested in identifying strengths and weakness of other technologies able to provide 3D spatial measurements. I really appreciate the support I received from the RSPSoc (Travel Bursary Award) and I express my gratitude to the workshop organizers including Jon Mills, Fabio Remondino (FBK Trento, Italy) and Julià Talaya, as I went away having learnt something new and useful for my future career.

Luigi Parente is a third year PhD student at the School of Architecture, Building and Civil Engineering, Loughborough University, UK. He is a geoscientist with interest in slope instabilities and monitoring techniques including photogrammetry and remote sensing. Currently his research is orientated at developing a low-cost monitoring system for geomorphic change based on the use of SfM photogrammetry. For more information about his work visit <https://www.lboro.ac.uk/departments/abce/staff/phd-students/luigi-parente/> or email him ([l.parente@lboro.ac.uk](mailto:l.parente@lboro.ac.uk)).

*This article was originally published in Sensed (issue 72) from RSPSoc (Remote Sensing & Photogrammetry Society).*

## Report by the Secretary-General

Joep Crompvoets



This report reviews the annual Board of Delegates meetings happening in the framework of EuroSDR in 2019, the appointments of (new) delegates, the activities related to our partner associations and some logistics.

### Meetings

The 134<sup>th</sup> EuroSDR Board of Delegates meetings took place in Vienna, Austria, from 22<sup>nd</sup> until 24<sup>th</sup> May 2019. These meetings were hosted by Werner Hoffmann (Federal Office of Metrology and Surveying), Michael Franzen (Federal Office of Metrology and Surveying), Norbert Pfeifer (Vienna University of Technology), Wolfgang Gold (Federal Office of Metrology and Surveying) and Christine Ressler (Federal Office of Metrology and Surveying). 43 persons attended this event. BOD 134 started with an overview of excellent examples of Geographical Information research, education and professional activities in Austria. The highlights of the meetings were 1) the keynote presentation about Copernicus for NMAs by Stéphan Ourevitch, 2) the presentation 'NMAs connections with Copernicus in the Land Monitoring Service and the In Situ Component' by Julián Delgado Hernández, and 3) the keynote presentation 'Deep Learning in Remote Sensing: Applications for NMAs' by Franz Rottensteiner.

EuroSDR also invited Dan Warner from 1Spatial and Øyvind Aase from Terratec to give a presentation about their organisation as they both showed interested to become Associate Member of EuroSDR.

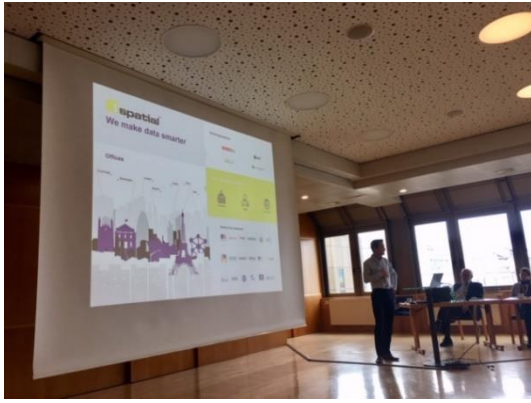


Figure 1. Group photo at the 134th Board of Delegates meeting in Vienna, Austria



Figures 2-4. Presentations by Stéphan Ourevitch, Franz Rottensteiner and Julián Delgado Hernández



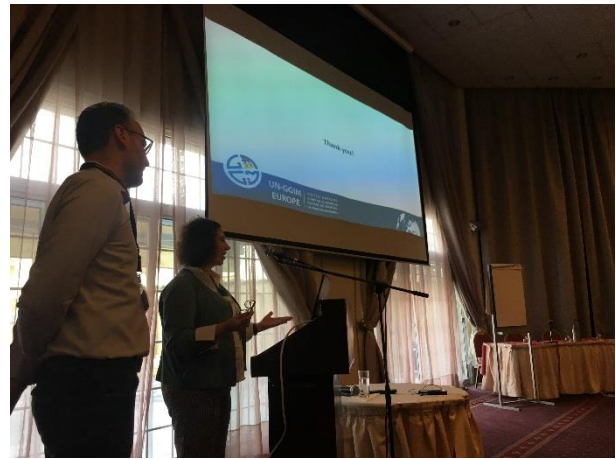


Figures 5-6. Presentations by Dan Warner and Øyvind Aase

The 135<sup>th</sup> EuroSDR Board of Delegates meetings took place in Nicosia, Cyprus, from 13<sup>th</sup> until 15<sup>th</sup> November 2019 and was hosted by Andreas Sokratous (Department of Lands and Sureys), Georgia Papathoma Economidou, Andreas Hadjiraftis (Department of Lands and Sureys) and Dimitrios Skarlatos (Cyprus University of Technology). 40 persons attended the meetings which started with an excellent overview of relevant research innovations happening in Cyprus at the national mapping agencies, companies, universities and research institutes. The highlights of the meeting were 1) the presentation titled ‘The Smart Point Cloud’ by Florent Poux (University of Liège), the winner of the 2019 EuroSDR Award, 2) the keynote presentation about Sustainable Development Goals by Carol Agius (UN-GGIM Europe/EuroGeographics), 3) the keynote presentation by Nick Land (Esri) about innovative projects dealing with deep learning techniques and 4) the keynote presentation about geoprocessing of historical aerial images by Fabio Remondino (FBK).



Figure 7. Group photo at the 135<sup>th</sup> Board of Delegates meeting in Nicosia, Cyprus



Figures 8-11. Presentations by Florent Poux, Carol Agius, Nick Land and Fabio Remondino

In preparation for these two Board of Delegates meetings, the Executive Team met twice in 2019: on 4 and 5 March 2019 at ICGC in Barcelona, Spain and on 26 July 2019 at FRAM centre in Tromsø, Norway.

## Delegates

At the **134<sup>th</sup> Board of Delegates meeting**, the delegates approved the following appointments:

1) Tambet Tiits as Prime Delegate of Estonia, 2) Artu Ellmann as Second Delegate of Estonia, 3) Jesper Weng Haar as Prime Delegate of Denmark (replacing Thorben Hansen), 4) Paul Becker as Prime Delegate of Germany (replacing Hansjorg Kutterer), 5) Peter Prešeren as Second Delegate of Slovenia (replacing Tomaž Petek), and 6) Marjan Čeh as Third Delegate of Slovenia (replacing Mojca Kosmatin Fras).

Joep Cromptvoets and Marketa Potůčková were also re-appointed for their third and last term as chair of Commission 5 and 6, respectively.

At this meeting, four new Associate Members were appointed: 1) nFrames, with Konrad Wenzel as the representative delegate, 2) Vexcel with Michael Gruber as the representative delegate, 3) Terratec with Leif Erik Blankenberg as the representative delegate, and 4) 1Spatial with Dan Warner as the representative delegate.

Finally, the delegates re-appointed Joep Cromptvoets for his last term as Secretary-General and Tatjana Van Huyck as his assistant.

An important decision made at the **135<sup>th</sup> Board of Delegates meeting** was the appointment of Hexagon Leica Geosystems as our 7<sup>th</sup> Associate Member, with Poul Noergaard as the representative delegate.

As usual, the prime delegates appointed and re-appointed some delegates during the meeting. Fabio Remondino and Jon Mills were re-appointed for their second term as Vice-President and Commission Chair 1 'Data Acquisition'.

As Michael Franzen would retire soon, he had to step down as Prime Delegate of Austria after almost 20 years. He was also Treasurer of EuroSDR for 10 years and Representative of the Office of Publications for 6 years. At BOD 134 his successors were appointed: Wolfgang Gold as Prime Delegate of Austria and Treasurer, and Christine Ressler as Representative of the Office of Publications. Furthermore, Adam Andrzejewski was appointed as Prime Delegate of Poland, succeeding Piotr Woźniak, and Martijn Rijdsdijk was appointed as Chair of Commission 3 'Updating and Integration' replacing Jon Arne Trollvik who stepped down as Commission Chair after 6 years.

### **Partnerships**

In 2019, EuroSDR continued collaborating with its key partner associations, e.g. 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:

- Extraordinary General Assembly of EuroGeographics (Leuven, 14 - 16 May)
- 6th Plenary meeting of UN-GGIM Europe (Brussels, Belgium, 5 – 6 June 2019)
- ISPRS Geospatial Week (Enschede, The Netherlands, 10 – 14 June 2019)
- 22nd AGILE conference 'Geo-Information Science' (Limassol, Cyprus, 17 – 20 June 2019)
- 18th General Assembly of the International Cartographic Association (Tokyo, Japan, 15 – 20 July 2019)
- 12th Regional Conference on cadastre and spatial data infrastructure (Neum, Bosnia & Herzegovina, 4 – 6 September 2019)
- Workshop 'Evaluation and Benchmarking of Sensors, Systems and Geospatial Data in Photogrammetry and Remote Sensing' (Warsaw, Poland, 16 – 17 September 2019)
- EuroGeographics General Assembly (Manchester, UK, 6 – 9 October 2019)
- European Forum for Geography and Statistics Conference (Manchester, UK, 10 – 11 October 2019)
- 2019 Time Machine Conference (10 – 11 October 2019, Dresden, Germany)
- EuroSDR/ISPRS GeoBIM Benchmark Workshop (Amsterdam, The Netherlands, 2 – 3 December 2019)

### **Logistics**

Regarding the associated logistics, the Secretariat was among others strongly involved in preparing the meetings, processing the meetings' minutes, decisions and actions, registering for EuroSDR events (e.g. workshops, EduServ), editing the annual report, financial accounting, auditing, managing websites, etc.

On behalf of the secretariat, I would like to express that we really look forward to continue cooperating with our 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

A EuroSDR workshop on Single Photon (SP) and Geiger-Mode (GM) lidar was held at the Institut Cartogràfic i Geològic de Catalunya (ICGC) in Barcelona, Spain, on 6<sup>th</sup> March 2019. The one-day workshop brought together 65 researchers, developers and practitioners from the global mapping sector to discuss this new technology and results achieved to date (Figure 1). 15 presentations were made, many of which can be downloaded from the EuroSDR workshop webpage (<http://www.eurosd.net/workshops/eurosd-one-day-workshop-single-photon-and-geiger-mode-lidar>). The lack of available public datasets for critical evaluation, together with the heavy reliance on pre-processing performed by the data provider, were two of the reasons cited by attendees for adopting a somewhat cautious approach to the adoption of SP and GM lidar technologies. The workshop concluded with a wonderful evening meal at Café Pedrera, Barcelona, kindly sponsored by Hexagon Geosystems (Figure 2).



Figure 1. Delegates at the EuroSDR One Day Workshop on SP and GM lidar, Barcelona, Spain.



Figure 2. Delegates enjoying dinner, kindly sponsored by Hexagon Geosystems, at Café Pedrera, Barcelona.

Following feedback on the need for more detailed analysis and understanding into the capabilities of SP and GM lidar, and in conjunction with the promising analysis previously conducted and reported, a lidar benchmarking project was discussed at the Barcelona workshop. The EuroSDR lidar benchmark project aims to collect different datasets with the support of commercial providers in order to perform detailed investigations and analyses. A potentially suitable site was identified as Innsbruck, Austria. The Innsbruck site has the support of the local and national mapping agencies, as well as local academics to facilitate ground truth. An online questionnaire, seeking to evaluate the suitability of Innsbruck or identify an alternative, ran during the summer of 2019 and revealed broad support for the study site, as well as defining priorities for the study (Figure 3). Unfortunately, there presently remains no suitable SP or GM lidar sensor in Europe with which to capture data of the Innsbruck site. Negotiations with the major manufacturers of suitable lidar sensors are ongoing with the ambition of flying the study site in 2020.

Once data has been collected, which of the following activities would you like to see prioritised in the Benchmark (select up to three options)?

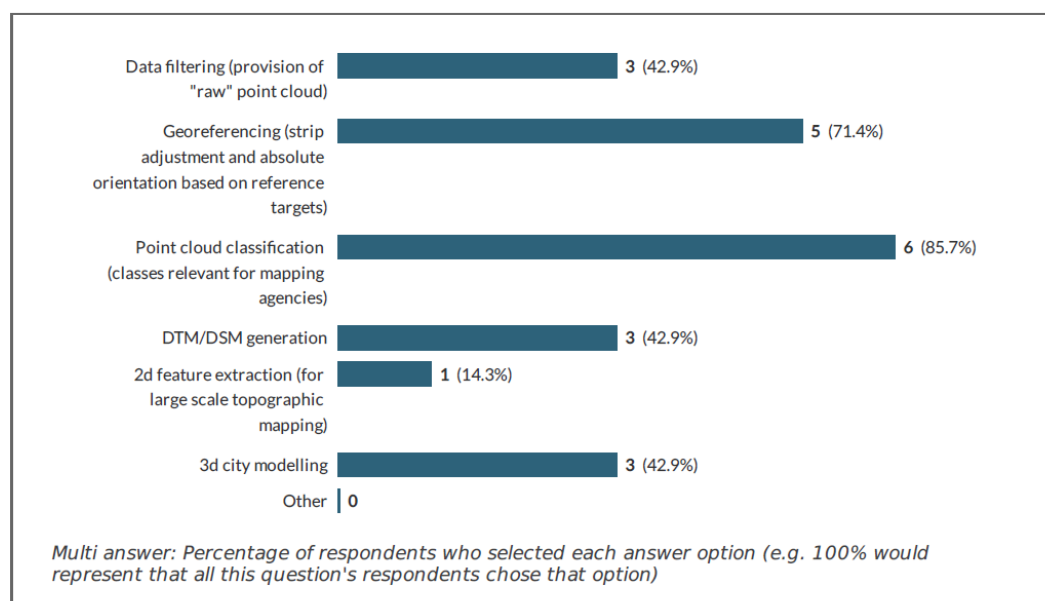


Figure 3. Questionnaire responses – opinion on benchmark priorities.

## EuroCOW 2019

EuroCOW 2019 (<http://www.eurocow.org/index.php/11-news/43-eurocow2019-afterwork>) was held as a standalone workshop as part of the 2019 ISPRS Geospatial Week (<https://www.gsw2019.org/>) at the University of Twente, the Netherlands, from 10<sup>th</sup> to 14<sup>th</sup> June 2019. Results of the EuroSDR Commission 1 SP and GM lidar activity were presented orally at EuroCOW on 13<sup>th</sup> June 2019 (Bernard et al., 2019). Full papers from EuroCOW are available from <https://www.int-arch-photogramm-remote-sens-spatial-inf-sci.net/XLII-2-W13/>.



Figure 4. Closing of the successful 2019 EuroCOW Workshop.

#### **Volta Summer School and ISPRS / EuroSDR Benchmarking Workshop**

The 2<sup>nd</sup> annual Volta Summer School and Joint ISPRS-EuroSDR Workshop on “Evaluation and benchmarking sensors, systems and geospatial data in photogrammetry & remote sensing” was held from 16<sup>th</sup> to 20<sup>th</sup> September 2019 in Warsaw, Poland (Figure 5). Further details of the event are available at <http://volta.uw.edu.pl/>. Papers from the Workshop, including a review of Benchmarking in Photogrammetry and Remote Sensing (Bakuła et al., 2019), form a volume of the ISPRS Archives and can be found at <https://www.int-arch-photogramm-remote-sens-spatial-inf-sci.net/XLII-1-W2/>.



Figure 5. Speakers at the ISPRS / EuroSDR benchmarking workshop in Warsaw, Poland.

### **Centre for Doctoral Training in Geospatial Systems**

In early 2019, Newcastle and Nottingham Universities discovered that they were successful in their joint bid to the UK's Engineering and Physical Sciences Research Council (EPSRC) for a £6.7M Centre for Doctoral Training (CDT) in Geospatial Systems. The Centre will train an annual cohort of c. 10 PhD students per year over five intakes in all aspects of geospatial systems, with the first eight students embarking on their programmes of study in September 2019. The Centre has the support of EuroSDR and a number of its members, including Ordnance Survey, Finnish Geospatial Research Institute, IGN France. Details of the CDT are available at <https://research.ncl.ac.uk/geospatial-systems/>.

### **References**

- BAKUŁA, K., MILLS, J. P. and REMONDINO, F., 2019. A review of benchmarking in photogrammetry and remote sensing. *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, 42(1/W2): 1–8.
- BERNARD, C., MILLS, J. P., TALAYA, J. and REMONDINO, F., 2019. Investigation into the potential of single photon lidar technology. *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, 42(2/W13): 927–934.



## 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 potential and thus impact of Deep Learning and Machine Learning approaches also for geo-data collection, EuroSDR organized the 2<sup>nd</sup> International Workshop on Point Cloud Processing on December 4<sup>th</sup> and 5<sup>th</sup> at Stuttgart University. Overall, there were 20 presentations in five sessions. The number of 90 participants with 21 nationalities shows that the organizers were able to attract a considerable audience with a good mix of participants from academia, industry and NMAs. All slides are available at <http://pcp2019.ifp.uni-stuttgart.de>. The sessions covered topics like data collection and processing, Deep Learning for 3D point clouds as well as the practicability of different data structures and achievable classification accuracies. Presented applications aimed on the classification of objects like buildings, trees, bridges, buildings, power-lines and point cloud visualisation. Processing mainly focused on data from airborne and mobile mapping LiDAR systems, frequently with added RGB colour values. A clear trend to hybrid sensor systems aiming at a fusion of LiDAR mapping and image based photogrammetric data collection could be observed. While in past experimental results were sometimes limited to smaller areas, meanwhile data processing is feasible at large with quantities of several TB. This makes Deep Learning for semantic segmentation of 3D point clouds very interesting for mainstream applications of National Mapping Agencies. Current representations of 3D data in the context of semantic segmentation seem to be pretty divers. They range from point clouds represented by hierarchical trees, sparse voxel grids, graphs and meshes. Available toolkits for classification are clearly dominated by Deep Learning frameworks like PointNet++, EdgeConv, PointCNN, SuperPointGraph and Sparse 3D CNN.

In general, Deep Learning is very data hungry. Thus, the availability and generation of labelled training data is of vital importance for the whole community. Thus, there is considerable interest in “open data” like the Dutch AHN data sets, which provide such information. Typically, semi-automatic labelling provides the required training and evaluation data. In this context, cadaster data can provide valuable information to support label generation.



Crowdsourcing seems to be a very promising approach, especially in the context of active learning. In this respect, joint initiatives from EuroSDR to link groups from academia and industry to NMAs who provide and maintain huge data sources seem to be highly promising for further developments. Open questions refer to transferability of the approaches for different environments as well as practicality considering data sizes and difficult object classes, which, however, might be of interest for NMAs. In view of these rapid developments, EuroSDR will organize a 3<sup>rd</sup> workshop in Point Cloud Processing in autumn 2020. Forces will also be joined by a common initiative with Commission III on Machine Learning and Deep Learning.

## Commission III: Updating and Integration

Jon Arne Trollvik & Martijn Rijdsdijk

*The mission of Commission 3 is to investigate, demonstrate and evaluate advanced methods of archiving, updating, semantically enriching and integrating spatial information. The focus is on the exploitation of these methods applied to geospatial data and for the benefit of national mapping and cadastre agencies (NMCAs).*



### Workshop on Geoprocessing and Archiving of Historical Aerial Images

In 2019, activities within Commission 3 covers completion of a workshop on Geoprocessing and Archiving of Historical Aerial Images arranged at IGN France 2 days in early June. 57 specialists from 21 countries took part in the event, and the workshop gathered people from both the archiving and the photogrammetry part of the GI business.

The goal of this workshop was first of all to gather people interested in both the methodical and thematic sides of historical aerial images. Of course networking, but also to identify possible R&D topics within this field.

The program was partly built up by invited speakers and partly by a “call for papers”. There was great interest for giving presentations within, and 20 speakers from NMCAs, industry and academia contributed to the comprehensive program.

The presentations started with a summary of the survey leading to the workshop. The report is available here: <http://www.eurosdrr.net/publications/official-publication-no-70-2019>.

The 2 days were divided into 5 sessions:

**1) The process of digitizing and archiving of historical images** – This session focused on the huge number of analogue images available through historical surveys, the process of scanning and the build-up of digital historical archives. Several national institutions explained their motivation, the adopted pipeline and reported the current status of the digitization process.

### Key NCAP Holdings: ACIU Collection



- Over 10 of the 30 million images held, date from the Second World War.
- 5.5 million of those are uniquely held as contact prints in the ACIU Collection.
- The ACIU holdings reflect the inter-Allied nature of the Photographic Reconnaissance effort during the war.

Photographic technicians of the US 7th Photographic Reconnaissance Group, surrounded by air cameras, RAF Mount Farm (Source: Museum of the Mighty Eighth).

Figure 1. National Collection of Aerial Photography (NCAP), Dr Allan Williams, Head of NCAP



**2) R&D in geoprocessing historical images, archiving and geoprocessing.** In this session the focus was more in the direction of automated processes on historical images, e.g. automated production of orthophotos and DSM using automatic extraction of Ground Control Points with standard photogrammetric techniques or machine learning. In particular, one study handled directly point clouds from historical images for estimating site index in forestry.

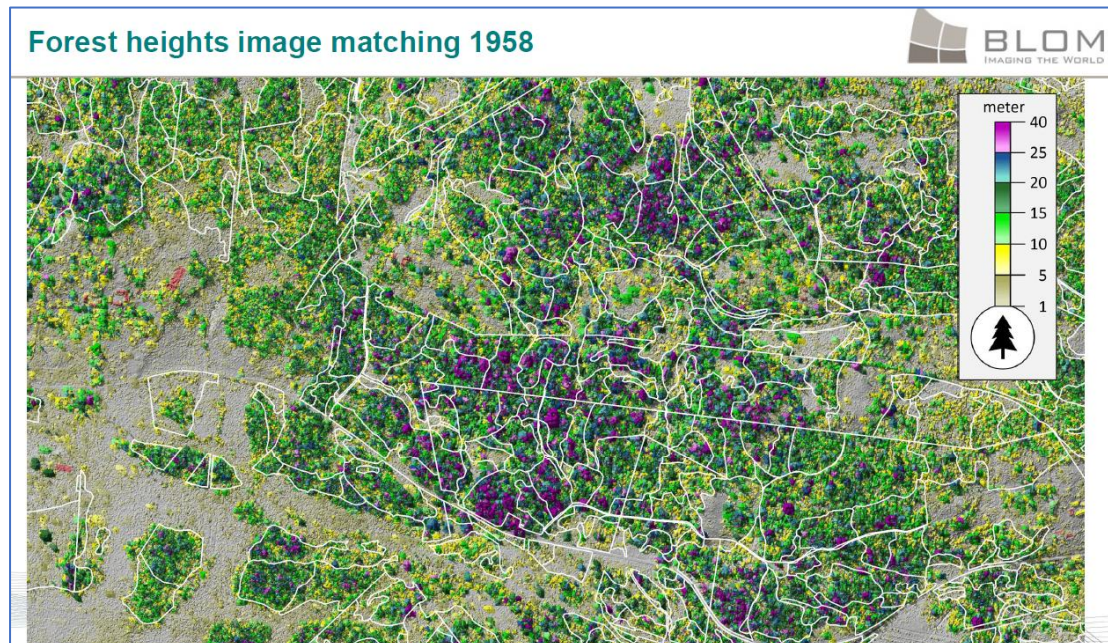


Figure 2. Using point clouds from historical imagery for estimating site index in forestry, Myklebust and Groesz, Blom Norway.

**3) and 4) Geoprocessing and use cases.** These sessions focused on the different use cases on historical data – From the digitizing of historical images, through safe storage, different applications like glacier change monitoring, making orthophotos from historical images to different kinds of distribution and geo-visualisation services.

**5) R&D in geoprocessing historical images.** The fifth and last session gathered presentations related to research on historical images; e.g. land-cover mapping using machine learning, object detection in order to find bomb craters in wartime images.

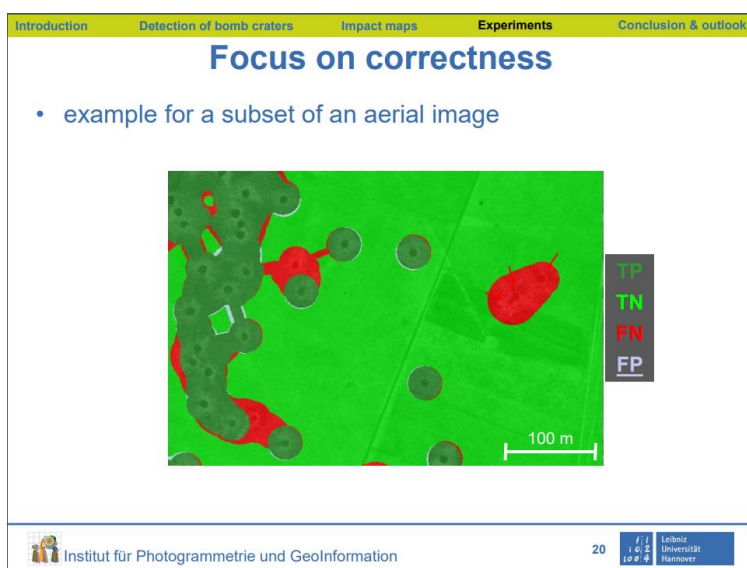


Figure 3. Marked point processes for the automatic detection of bomb craters in aerial wartime images. Christian Kruse, Leibniz University Hannover

Main conclusions and actions: There is a large range of thematic applications that were ignored in the workshop and are ignored by the end-user community. Both scientific communities and practitioners will be stimulated when automatic algorithms will be set up for orthoimages, DSM generation and also probably land-cover maps.

Conclusions and recommendations are:

- Many initiatives and people working on this domain did not attend the workshop since they were not aware of it. Thanks to the respective networks of the attendees, next questionnaires and workshop calls for presentation should be released to a larger audience.
- With a better knowledge on the technical bottlenecks and current initiatives in European countries, new questionnaires should be proposed with more accurate questions.
- The 2017 questionnaire was written without any prerequisite on the type of community (NMA, academia, industry). Probably 3 questionnaires on digitization/archiving, geoprocessing, and exploitation should be set up.
- One missing link is setting up international benchmark datasets for specific issues (geo-referencing, radiometric equalization, crater detection, etc.). Depending on the case studies, data will be released with various time ranges, number of dates, size, etc. Attendees will be invited to propose case studies.
- Probably a new workshop around 2020 would allow to summarize the outputs of the new questionnaires, to gather a larger and more diverse type of people, and discuss current issues.

A report from the event and all presentations are available from Eurosdrr homepages: <http://www.eurosdrr.net/workshops/geoprocessing-and-archiving-historical-aerial-images>



Figure 4. Workshop participants (photo: Ewelina Rupnik IGN-France)



## 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.*

### Theme 1: Historical and time stamped data

This theme addresses data that have been replaced by newer ones. It includes old archives. It also includes time-stamped data like our current data. These induce specific challenges in terms of information usage, information infrastructures and interoperability as well as visualization. They also correspond to specific opportunities we believe, like for example to add longer term perspectives in applications thanks to integration of archives in infrastructures. Another example of opportunity is to develop our expertise and methods to simulate missing data based on available references (for other places or other times) and on geographical knowledge.

Commission 4 launched a call for interest to constitute a group on **tools to distribute historical data on the Web**. Despite a second call, only two members showed interest to the group, IGN-France and SwissTopo. Hence, instead of creating a group, a survey will circulate in 2020 to learn about existing solutions designed in EuroSDR organisations as well as in our network to distribute and interact with historical as well as time stamped and versioned data on the Web.



Figure. The CSA Time Machine proposal targeting a seamless browsing and querying of data across time –and across space–

During 2019, within the context of the **CSA Time Machine project** funded by the European commission (march 2019-feb2020), <https://timemachineproject.eu>, we contributed to the proposal of European research and innovation roadmaps for a Big Data of the Past. This project brings together experts from the humanities and social sciences, computer science, the cultural heritage field, industry, NGO's and societal partners. The main idea is to use advances in digital technology (AI, VR) to *unlock* 5.000 years of historical data present in cultural heritage repositories and sites and repurpose that data for Europe's present-day challenges and for developing scenarios for a sustainable future. From an economic perspective, the challenge also is that Europe takes a leading part in the technological disruption of digital twins by integrating data from the past as well as humanities in their design.

Whereas CSA project were initially intended to deliver candidate flagship projects, i.e. 10 years research and innovation projects with a budget of 1B€. With the transition to Horizon Europe, the

commission adopted a new strategy and required that CSA project, selected within H2020 framework, align their roadmap with the emerging missions of Horizon Europe.

During 2019, commission 4 involvement in CSA Time Machine concentrated on promoting the use cases beyond traditional culture heritage applications: applications of a Big Data of the Past to smart cities, urban planning, land use and territorial policies, together with humanities scientists from University of Amsterdam and from TU Delft. In these specific application domains, pressing issues have been identified with representative stakeholders that should benefit from a Big Data of the Past technologies. One of the distinctive characteristics of current Smart Cities projects is the central role of data collection and processing as a means for improving the city's functions, enhancing environmental sustainability and increasing living standards for citizens. So far, in the debate about Smart Cities, little attention is given to the data that document the 'soft values' of urban living, such as the history and experience of specific urban localities. At the same time, the data-driven approach of contemporary city governance is met with resistance and critique by inhabitants and local social groups. Given its historic specificities, European smart cities are challenged to incorporate meaning-making, culture and history in their policies, in order to prevent further apathy, resistance and criticism towards Smart Cities. With respect to land use and territorial policies, given its diversity of past land use, Europe is challenged to understand land use dynamics and to manage land use. The Time Machine project will yield innovative solutions to support people in understanding their environment dynamics, identifying what are the choices they have to make when they design their environment (incl. European, regional and local regulations), to support their debating other hypotheses, connecting to other inspiring experiences and people, adopting a critical perspective on figures and learning to use data and state of the art knowledge.

The proposed 10 years approach identified during 2019 to foster the development of Time Machine technologies by the applications for Smart Cities, urban planning, land use and territorial policies is articulated around the following deliverables:

- A sandbox for a new implementation of European culture friendly spatial data infrastructure articulated with existing European, national, regional, local portals. It will be used to investigate broker technologies able to cope with member states heterogeneities, to investigate documentation of uncertainty of patchwork European data products and eventually to investigate search functionalities to retrieve "similar" places or "situations" in European history thanks to a European knowledge graph.
- Iterative production of key reference datasets specification and content including a European spatiotemporal knowledge graph, as well as associated guidelines and cookbook: spatiotemporal gazetteers, addresses, land registers, buildings, elevation models, networks, administrative units, cadaster, land cover, ontologies.
- Identification of thematic Time Machines, use cases defined and shared between key stakeholders in domains related to Smart Cities or to Land Use : e.g; agroforestry, energy transition, water reservoirs survey, polluted soils assessment, African forests.
- Calls for proposals:
  - "TM Land Use Digitalisation Proposals", which will invite submissions of projects asking Time Machine to support (subcontract) the digitisation and structuring of precisely identified archives that the project partners commit to exploit in a way to contribute to a European Big Data of the Past. Selection criteria will include the involvement of humanities in the project.
  - "TM Land Use Learning from the Past Missions" which will invite proposals describing current issues that could be solved by learning from the past and that set up machine learning experience. These must include partners who have the competence to identify where to learn from –usually humanities-, and partners who have the competence to evaluate the results. Time Machine will then select proposals, possibly

suggest consolidations between them, and mobilise artificial intelligence communities on the selected proposals.

- A challenge platform, similar to (or extending) the Kaggle platform operated by Google, to design, publish and manage applied challenges or benchmarks relating to “real world” problems encountered by representative users and that can be shared with scientists and developers.
- A collaborative semi-structured multilingual platform, similar to (or extending) Wikipedia and wikidata, that connect concepts (categories) used in datasets or in regulation related to cities and to land use to textual description and to illustration from the real world meaningful to all citizens, 1) to support user appropriation of data and of regulation, 2) to engage collaborative curation of these concepts expressiveness and semantic uncertainties. A URI policy for objects and for links will be needed and established in an iterative way during the project.
- European master programs to train students capable of undertaking Phds on scientific bottlenecks underpinning these domains.
- Workshops with key scientists will be organised at the beginning of the project to foster scientific communities around these application specific bottlenecks. Thematics for these workshops will be: uncertainties in decisions based on data, similarities and dissimilarities between different cities or territories -across space and time-, comparing strategic measures and their impacts, including soft values in regulation.
- Glue and connectors to integrate existing information systems in place to Time Machine data and technology in a seamless enough way for the user.

Framework conditions to support this 10 years program also have been analyzed. They mainly relate to the Public Sector Information reuse directive: will high value datasets (geography, meteorology, statistics) also embrace archives? Will Europe promotes or regulates for the consistency of existing open licenses, at least for data which are produced during projects funded by Europe?

## **Theme 2: Information infrastructures (INSPIRE, Geoweb, Linked data).**

This theme addresses information infrastructures in general. Our activity in this domain is oriented towards establishing efficient collaborations with complementary actors:

- Linked Data and Information Retrieval domains.
- Other data providers than national mapping and cadastral agencies, like national libraries, statistical institutes, geological survey, or also collaborative web content like wikidata.
- Users of infrastructures who will bring use cases of information infrastructures

During 2019, the **report of the workshop Data Linking by Indirect Spatial Referencing Systems** co-organized with Eurogeographics KEN INSPIRE has been published: Bucher, B., Tianen, E., Ellett, T., Acheson, E., Laurent, D., Boissel, S., 2019, Data Linking by Indirect Spatial Referencing Systems, EuroSDR report

[http://eurocdr.net/sites/default/files/uploaded\\_files/eurocdr\\_data\\_linking\\_by\\_indirect\\_spatial\\_referencing\\_systems.pdf](http://eurocdr.net/sites/default/files/uploaded_files/eurocdr_data_linking_by_indirect_spatial_referencing_systems.pdf)

A **peer reviewed paper** has also been prepared and submitted with volunteers from past EuroSDR Linked data events to be submitted to ISPRS International Journal of Geo-Information special issue on SDI and the Revolutionary Technological Trends. This paper presents conclusions from EuroSDR activity on Linked data as well as perspectives for future activity. It was accepted early 2020 and published as an open access publication.

Bucher, B., Tianen, E., Ellett von Brasch, T., Janssen, P., Kotzinos, D., Čeh, M., Rijdsdijk, M., Folmer, E., Van Damme, M.-D., Zhral, M., 2020. Conciliating Perspectives from Mapping Agencies and Web of Data on Successful European SDIs: Toward a European Geographic Knowledge Graph, in *ISPRS Int. J. Geo-Inf.* 2020, 9(2), 62; <https://doi.org/10.3390/ijgi9020062>

Paper abstract : Spatial Data Infrastructures (SDIs) are a key asset for Europe. This paper concentrates on unsolved issues in SDIs in Europe related to the management of semantic heterogeneities. It studies contributions and competences from two communities in this field: cartographers, authoritative data providers, and geographic information scientists on the one hand, and computer scientists working on the Web of Data on the other. During several workshops organized by the EuroSDR and Eurogeographics organizations, the authors analyzed their complementarity and discovered reasons for the difficult collaboration between these communities. They have different and sometimes conflicting perspectives on what successful SDIs should look like, as well as on priorities. We developed a proposal to integrate both perspectives, which is centered on the elaboration of an open European Geographical Knowledge Graph. Its structure reuses results from the literature on geographical information ontologies. It is associated with a multifaceted roadmap addressing interrelated aspects of SDIs.

The Kick off webinar of **EuroSDR Linked Data Group** took place in February 2019. The attendees identified the main objectives of the group: 1) exchange information about mature enough solutions to publish our data as linked data, 2) design harmonization solution for linked data and using linked data, typically to bridge the gap between current SDI components and usage, 3) reach out users of our data served as Linked data.

A second webinar took place in June 2019 where participants discussed about relevant challenges to address together or to share with linked data community. Favourite topics for challenges mentioned in the webinar: align data and schemas from different sources, especially with Wikipedia, wikidata, OSM, generate and reuse Knowledge Graph, propose a method to feed a European backbone for Land Cover product with official and non official data. We also reviewed the idea of designing a Eduserv course to foster adoption of linked data by our sister organisations and Erwin Folmer has been solicited to coordinate it. Participants express lots of interest about this idea. Last the group agreed during this seminar on having an 'internal' workshop before the end of the year 2019, and a 'bigger' event in 2020 hosted by Kadaster and Geonovum.

The Eduserv course on Linked Data has been prepared in 2019 under the coordination of Erwin Folmer from Kadaster and University of Twente for the 2020 edition of Eduserv.

An internal seminar of the Linked Data Group was organised in December 2019 in Paris to review concrete actions needed to take the idea of challenges one step further :

*Action 1 - Setting up a sandbox:* a solution to have a semantic sandbox was proposed by Kadaster and adopted: the pldn platform (<https://triplify.cc/docs/triply-db-getting-started>). The group also prioritized during this seminar which technology development should be funded by EuroSDR for this sandbox : a GeoSPARQL support.

*Action 2 - Technology benchmarks :* specifications for GeoSPARQL support and more generally benchmark will be designed by the group, including specifically how different distances are supported in different triple stores.

*Action 3 – Sharing reusable guidelines :* Specific topics have been identified for which some EuroSDR members have already implemented mature prototypes and others are eager to do so. For these topics, guidelines will be prepared by advanced members and used by others who need to develop similar prototypes:

- the support of semantic feature search (with attribute filtering)
- the publication and interlinking of statistical data with topographic data
- the generation of ergonomic data-cards for different types of resources



*Action 4 – common challenges.* Specific topics have also been identified for challenges where some participants volunteer to prepare datasets:

- managing metadata with different scopes, especially related to buildings
- digital assets management
- smarter datacards
- knowledge graph production

More participants have joined the group during 2019. Registration is done through the group wiki page: [https://geometadatalabs.eu/Linked\\_data\\_main\\_page](https://geometadatalabs.eu/Linked_data_main_page)

Last, as a follow up of the workshop on the Use of INSPIRE Data co—organized with Eurogeographics KEN INSPIRE in November 2018, the work has also progressed on the design of a **benchmark on solutions to broker heterogeneous authoritative and non authoritative data**. A first activity to progress on this initiative was to narrow down possible applications that would require such patchwork datasets and ensure we can involve representative users in the process. The following applications have been identified:

- producing urban climatic indicators (this requires high resolution data about morphology, buildings, vegetation, but also soil sealing, social activity), because we have now collaborations with meteorological institutes. This topic would also be an opportunity to work with statistical institutes.
- providing a backbone for European land use land cover products, here the user would be EEA. EEA has expressed interest for such an experiment.
- providing spatial datasets for humanities scientists, in particular gazetteers used to reference documents.

Criteria identified so far are: capacity to document quality metadata (specifications, quality criteria, and lineage information), scalability in space and in time.

### **Theme 3: Digital natives.**

During 2019, Ordnance Survey GB prepared a **workshop on the theme “Geo Immersive Reality - the use of geospatial data in augmented and virtual reality technologies”**. It aims to offer knowledge exchange with discussion panels assessing the obstacles, benefits and weaknesses of the immersive reality environment. More specific topics have been identified:

- Public Engagement
- Digital Twins and Infrastructure Visualisation
- Challenges and opportunities in Geo augmented reality
- Challenges for data providers

<http://eurocdr.net/workshops/geo-immersive-reality-use-geospatial-data-augmented-and-virtual-reality-technologies>

## 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.*

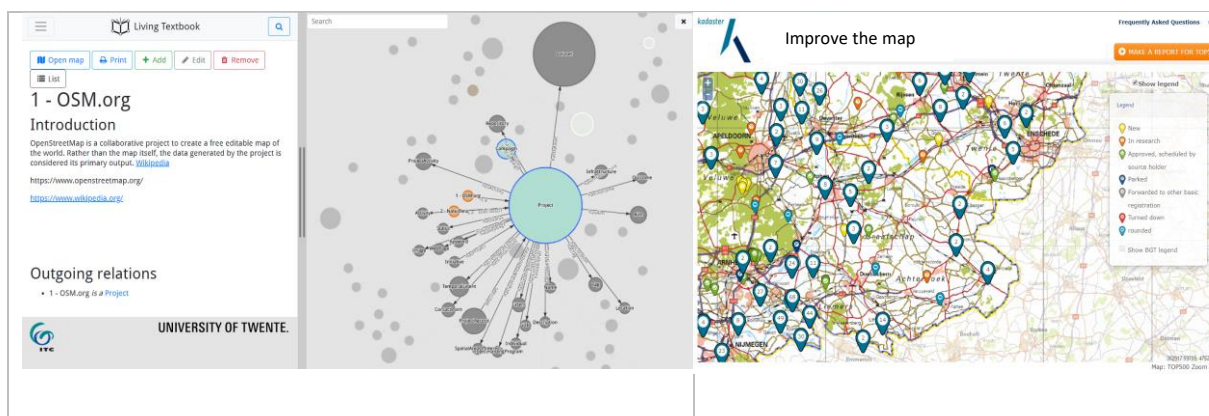
As chair of Commission V 'Business Models and Operation', it is my pleasure to contribute to the EuroSDR annual reports series. This commission was established at the 126th Board of Delegates meeting in Tønsberg (Norway, May 2015). In the fourth year of the existence of the Commission, it run the following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

- Crowdsourcing and National Mapping
- Sustainable Open Data Business Models for NMCAs
- Open SDI EduServ course
- Authoritative Data in an European Context
- 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

The workshop entitled Crowdsourcing in National Mapping – Building a VGI Map of Europe 2020 was prepared. This event will be organized at the Leuven Institute for Ireland in Europe (Leuven, Belgium, 16-17 January 2020). The organisers are the commission chair of Commission 5, Peter Mooney (Maynooth University, Ireland) and Rob Lemmens (University of Twente, The Netherlands) \*



\* The figure shows a prototype of the VGI conceptual map (left) and an example VGI application (right)

In the past years use of crowdsourcing by National Mapping and Cadastral Agencies (NMCA) 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. The workshop has two principal aims:

- Create VGI-ME (the VGI Map of Europe) forming a conceptual 'map' describing projects at NMCAs from around Europe.
- Plan the design and delivery of a VGI Hackathon which will feature the creation of new crowdsourcing applications (mobile and web) and extending/improving existing ones.

### Sustainable Open Data Business Models for NMCAs

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 a follow-up event in Leuven. 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 NMCAs. 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.

### Open SDI EduServ Course

Universities Delft University of Technology (The Netherlands) and KU Leuven (Belgium) run the EduServ 2019 course on “Open Spatial Data Infrastructures” (SDI). This introductory course aimed to provide a comprehensive overview on the state-of-the art in Open SDI and its key components, and introduce participants to the underlying principles of Open SDI, and let them experience hands-on what it means to establish and maintain an Open SDI. A number of topics were tackled: spatial data infrastructures as well open data principles, key standards, architectures, (network) services, relevant EU-regulations and policies, governance strategies, and key institutions. At the end of the course, participants are: informed about Open SDI strategies around the world, aware of the main strengths, weaknesses, opportunities and threats of Open SDI, familiar with the latest technological developments, capable to facilitate the opening of open data using latest developed tools, and able to evaluate Open SDIs. This course was introduced during the pre-course seminar of EduServ (5 March 2019) and undertaken in June 2019. 16 persons participated to the course.

### 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 Grimmelikhuijsen. 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).

The main conclusions of this project are presented below.



Data are the bedrock of public and private service provision. Digitalization exposes the need for a common approach towards data, through a higher demand for data within and across both the public and private sector (and the so-called third sector including academia and not-for-profit organizations), but also through the development of innovative services. A common approach within countries, but also across borders, is necessary to ensure high data quality, to invigorate trust between stakeholders, to reduce inefficiencies, to stimulate innovation and to allow for a user-centric service provision. Authoritative data are a means to define and organize data, but also to coordinate the roles of all the

involved stakeholders. However, the term itself is defined and operationalized in various ways, depending on institutional, legal and cultural characteristics of countries and public administrations.

To understand the phenomenon, this project applied a two-step methodology, making use of (1) an online survey, and (2) focus group meetings based on roundtable discussions, both with the members of EuroGeographics. Both steps were followed by a triangulation with the academic literature surrounding the subject.

The results of this report underline the need for a systematic and harmonized approach towards authoritative data. The survey revealed three main conclusions:

1. There are a variety of definitions and approaches applied by the different member organizations of EuroGeographics, as well as different opinions on which data should be considered as authoritative.
2. Most of the EuroGeographics Member organizations underlined that their country has a formalised approach towards authoritative data, as well as an obligation to use authoritative data.
3. The survey results indicated that there is consensus concerning the central role of public organizations in the organization and use of authoritative data.

Through the focus groups, the results of the survey were corroborated and several additional elements could be added on the topic of authoritative data. The main conclusions of the focus groups are the following.

1. From a methodological point of view it is important to underline that the key conclusions of the survey, as described above, were indeed confirmed.
2. Related to the first conclusion, it is necessary to underline that several additional conditions and characteristics of authoritative data were added to the (existing) organizational conditions for authoritative data mentioned in the survey: Legally binding, accountability, uniqueness, having a mandate, mandatory use (within the public sector), liability, official, (public) authority provision, reference data, trust, harmonization and standardization, continuity, high quality, the need for adequate quality management system, certification, traceability, maintenance, use and understanding.
3. The NMCAs underlined that data that is validated as authoritative data is considered to be of very high quality. This does, in turn necessitates adequate resources for ensuring data quality and up-to-dateness
4. It was also underlined that the obligation to use authoritative data depends on the situation at hand. More effort should be put in making authoritative data available and recognizable by other public organizations as well as private actors.
5. The participating NMCAs underlined that there is a need for organizations within the public sector to take up a central role in the governance of authoritative data.

Based on these results, from both the survey and the focus groups, the research team took the liberty to formulate the following four recommendations in relation to authoritative data in a European context:

1. Inter-organizational, cross-sector and cross-border exchange of authoritative data necessitates the need for transparency about the characteristics of the authoritative data that is shared and accepted as authoritative by other stakeholders. A commonly agreed meta-level description methodology, to be developed by the European NMCAs grouped under EuroGeographics could be a step in this direction.
2. A harmonization of definitions and criteria is necessary at both country and European level. At the latter level, this could take the form of a broad framework concerning the dimensions, definitions and barriers to exchange and use of authoritative data, mirroring the network-approach of the European Interoperability Framework or the more hierarchical approach of the INSPIRE directive. Additionally, a governance approach of authoritative data between all stakeholders and their representatives should be organized at the European level. Given the



broad membership of EuroGeographics and the diversity in legal, organizational, semantic and technical approaches, we advise for the development of such a governance approach which makes use of a combination of network and hierarchical instruments. However, given that it was underlined by several NMCA that also private sector organisations can play a role in the further development of authoritative data, we strongly encourage reflections on the potential use of market instruments as well.

3. Within this context, it is necessary that the role of public organizations is re-evaluated. Datasets have to be classified according to their importance (either authoritative or not) and governance schemes have to be developed accordingly. First, for core authoritative datasets, authoritative public organizations will be in charge of the governance, whilst other public sector organizations and the private sector will only play a supporting role (for example in a decentralized data gathering setting), depending on the country. Second, other data could be governed by other public organizations or the private sector. Here, authoritative public organizations could take up a role of control, certification and a leading role concerning the governance of data, including harmonization, standardization and interoperability in general. Third, for other data, authoritative public organizations have a role to work towards harmonization and standardization, but based on network instruments (i.e. '(more or less) stable patterns of cooperative interaction between mutually dependent actors around specific issues of policy' – examples are the development of an advisory body or information exchange through voluntary negotiation and norms), whereas the former two categories also include hierarchical instruments (i.e. instruments which are based on authority and power 'as fundamental processes and resources' – examples are regulations and laws achieved via a process of authority and/or power).
4. As a final, and more general recommendation, we think that further research on the specific use of authoritative data(sets) in a policy context would be helpful to deepen the understanding of the topic. This would not only be useful from an academic point of view, but even more so from a practical point of view. Indeed, by researching specific cases that make use of authoritative data(sets), the added value of the 'authoritative' element can be demonstrated in practice thereby stimulating other administrations to work on this topic.

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

Following previous successful workshops in 2015 and 2018, EuroGeographics and EuroSDR, in conjunction with OGC, ISO and ICA, was preparing for the third workshop on spatial data quality to be held in Valletta, Malta on 28th and 29th January 2020.

Technology is driving the Geospatial industry forward at an alarming rate with the introduction of new capture methods, improved technology and an increasing customer base that not only recognises the importance of spatial data but expects it to be readily available, accurate, trustworthy and free. Traditional methods of checking quality are now regarded as too expensive and the focus has shifted into ways of ensuring that quality is built into a method or process from the very beginning. Many of the users know little about how data is produced but they have an expectation that the data is correct – almost to the point where they will blindly follow a satellite navigation system, even though the road signs may indicate that a route is unsuitable. The onus is therefore on producers of traditional geospatial information to be able to produce high quality, authoritative data and communicate the trust, quality, provenance, relevance and content to all potential users – not just those in the professional community. By bringing together producers, users, academia and software suppliers this two-day event aims at providing innovative and original contributions to the ongoing debate on spatial data quality.

## 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. The project leader of BESTSDI is Prof. Željko Bačić. The wider objectives of BESTSDI project is to improve the quality of higher education in Geographical Information Science and Technology field, Spatial Data Infrastructure (SDI) and Geodesy, to enhance its relevance for the labour market and society and to improve the level of competences and skills in Higher Education Institutions by developing new and innovative education programmes within the field of Spatial Data Infrastructures. The specific project objectives are to develop, test and adapt new curricula, courses, learning material and tools within the field of SDI. In this context, it would be good to better understand the current usage as well as needs of SDIs. In this context, a small project was set up including the organization of a survey as well as a workshop. A survey on Academia – Business cooperation was undertaken in June 2019 and a questionnaire was sent to numerous stakeholders. The results of the European-wide conducted survey on Academia-Business needs in education and cooperation in field of SDI was presented in a workshop (Sarajevo, 3 September 2019). In total 123 responses were received. The main conclusions from the survey are the following:

- SDI-competences and necessary (in particular basic SDI knowledge) and in demand
- Academia – Business cooperation is (very) important
- Academic SDI-education is (very) relevant for labor market – but better alignment with technological developments is needed
- Academic SDI-education is (very) relevant for business companies (by workshops, collaboration, experiences exchange, better communication, joint projects)
- Necessities + Relevances significant higher for Western Balkan
- Hampering factors for past and future (Lack of qualified personnel)
- Positive attitude about future development of SDI, but without clear picture in which direction



The survey results were presented at the beginning of the workshop and followed by three presentations from business (Alma Taba-ković), academic (Prof. Medžida Mulić) and governmental (Dr. Slobodanka Ključanin) sector providing specific view about this topic. Further, an EU view was given on academia-business cooperation by Andreas Wytzisk and about broader scope and future of SDI by Danny Vandenbroucke. At the end a discussion took place.

#### **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.

Finally, the commission chair contributed to the international workshop of VirtualArch (Visualise to Valorise – For a better utilisation of hidden archaeological heritage in Central Europe) by giving the presentation ‘Valuing cultural heritage in monetary terms’ (Trento, 25 September 2019). The basis of this presentation was the EuroSDR project on the economic value of 3D data (2015 – 2017).

## 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 wants also to fulfil specific NMCAs demands for knowledge update, to collect and disseminate methodologies, developed tools and other research outcomes in the form of EuroSDR's official publications and via EuroSDR's homepage. The Commission also seeks to contribute to the development of curricula in GeoInformation (GI).*

The EuroSDR Commission 6 on Knowledge Transfer organised two educational events in 2019 – the 17<sup>th</sup> series of the EuroSDR Educational Service (EduServ17) and the 2<sup>nd</sup> short course in photogrammetry.

The Eduserv17 offered four e-learning courses on following topics:

- **Automatic Topographic Mapping through Description and Classification of Remotely Sensed Imagery and Cartographic Enhancement** (11<sup>th</sup>-22<sup>nd</sup> March 2019)  
Tutors: Joachim Höhle (Aalborg University), Sébastien Lefèvre & Bharath Bhushan Damodaran (IRISA/Université Bretagne Sud)
- **3D Sensing, Scene Reconstruction and Semantic Interpretation** (1<sup>st</sup>-12<sup>th</sup> April 2019)  
Tutors: Martin Weinmann (Karlsruhe Institute of Technology), Michael Weinmann (University of Bonn), Franz Rottensteiner (Leibniz Universität Hannover), Boris Jutzi (Karlsruhe Institute of Technology)
- **Open Spatial Data Infrastructures** (6<sup>th</sup>-17<sup>th</sup> May 2019)  
Tutors: Bastiaan van Loenen (TU Delft), Joep Cromptoets (KU Leuven)
- **Deep Learning for Remote Sensing** (3<sup>rd</sup>-14<sup>th</sup> June 2019)  
Tutors: Loic Landrieu (IGN France), Sébastien Lefevre (IRISA/Université Bretagne Sud), Bertrand Le Saux (ONERA)

64 participants followed the e-learning courses in total. The courses on Deep Learning and 3D Sensing were the most attended ones with 45 and 32 participants, respectively. Prior to the e-learning, a pre-course seminar was hosted by Dr. Julià Talaya at the premises of Institut Cartogràfic i Geològic de Catalunya, Barcelona on 4<sup>th</sup> and 5<sup>th</sup> March 2019. 31 participants listened to introductory lectures of the four EduServ topics. Moreover, they had an opportunity to extend their stay in Barcelona and follow the EuroSDR workshop on Single Photon and Geiger-Mode LiDAR on 6<sup>th</sup> March 2019.

High attendance of the EduServ courses confirms a need for such focused, distance education that reflects new trends in geoinformation science and industry. The Fig. 1 shows the number of EduServ participants in the last 8 years.

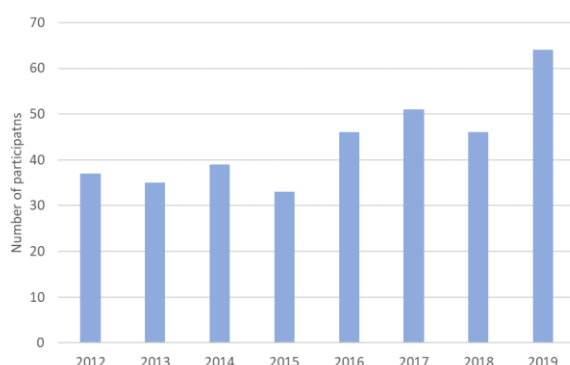


Figure 1. Participation in EduServ courses between 2012 and 2019.



The 2<sup>nd</sup> short course in photogrammetry was hosted by the Faculty of Science, Charles University, Prague from 24<sup>th</sup> to 26<sup>th</sup> June 2019. Dr. Michael Cramer and Prof. Norbert Haala from the Institute of Photogrammetry of the Stuttgart University hold 10 lectures on photogrammetric image processing including topics like camera calibration, GNSS/INS supported aerotriangulation, image matching, combination of LiDAR and image point clouds. The lectures were supported with practical exercises in the Pix4D and Opals software packages. The course was attended by 20 participants from 11 countries. Most of them were involved in the photogrammetric production. The lectures were followed with interesting discussions of practical aspects of presented topics. The participants received a large set of explanatory presentations covering different aspects of image and LiDAR data acquisition and processing. In addition, they could download two data sets that were used during the exercises and they got instructions regarding the available software tools for datasets processing. The feedback received from participants was very positive and encouraging in organizing new series of short courses combining theory, hands on exercises, examples of successful projects and best practices in photogrammetry or other fields related to current research or production tasks of national mapping and cadastral agencies.



*Figure 2. Second short course in photogrammetry, Charles University, Prague, 24<sup>th</sup> – 26<sup>th</sup> June 2019*

Annual EuroSDR Ph.D. award was announced in March 2019. A 6-member commission, where 5 were from academia and 1 from national mapping agency, evaluated 11 applications. Among them the PhD thesis of Dr. Florent Poux from the University of Liège titled “The smart point cloud: Structuring 3D intelligent point data” was selected as the best one. Dr. Poux presented his thesis at the 135<sup>th</sup> Board of Delegates meeting in Nicosia, Cyprus. The award was handed over to him after his presentation.

In collaboration with the EuroSDR Commissions 4 and 5 a survey on “Data and tools for research and education” was distributed among EuroSDR delegates in May 2019. Twelve organisations, mainly national mapping agencies, contributed to the survey. Results summarising available data and tool sources were presented at 135<sup>th</sup> Board of Delegates meeting in Nicosia and further elaborated to a draft report. After receiving comments from the participating organisations and other potential respondents, the final report will be published in spring 2020.

## Workshops

- One-Day Workshop on Single Photon and Geiger-Mode LiDAR (Barcelona, Spain, 6 March 2019)
- EuroSDR workshop SDI.NEXXT, the State-of-the-Art of Spatial Linked Data Implementations in Europe” (Amersfoort, the Netherlands, 12 March 2019)
- CSA Time Machine kick-off meeting (Brussels, Belgium, 18 – 19 March 2019)
- Flagship Time Machine CSA workshop (Amsterdam, The Netherlands, 9 – 10 May 2019)
- Extraordinary General Assembly of EuroGeographics (Leuven, Belgium, 14 - 16 May)
- Workshop ‘Geoprocessing and Archiving of Historical Aerial Images’ (Saint-Mandé, France, 3 – 4 June 2019)
- 6th Plenary meeting of UN-GGIM Europe (Brussels, Belgium, 5 – 6 June 2019)
- ISPRS Geospatial Week (Enschede, The Netherlands, 10 – 14 June 2019)
- EuroCOW 2019 (Enschede, The Netherlands, 13 – 14 June 2019)
- 22nd AGILE conference ‘Geo-Information Science’ (Limassol, Cyprus, 17 – 20 June 2019)
- Short Course in Photogrammetry (Prague, Czech Republic, 24 – 26 June 2019)
- 18th ICC General Assembly (Tokyo, Japan, 15 – 20 July 2019)
- BESTSDI.EuroSDR workshop ‘Academia-Business cooperation requirements towards establishment of efficient SDI’ (Sarajevo, Bosnia & Herzegovina, 3 September 2019)
- 12th Regional Conference on cadastre and spatial data infrastructure (Neum, Bosnia & Herzegovina, 4 – 6 September 2019)
- Workshop ‘Evaluation and Benchmarking of Sensors, Systems and Geospatial Data in Photogrammetry and Remote Sensing’ (Warsaw, Poland, 16 – 17 September 2019)
- Photogrammetric Image Analysis 2019 (Munich, Germany, 18 – 20 September 2019)
- Digitally Enabled Development for a Sustainable Future in Eastern Europe (Vrdnik, Serbia, 18 – 20 September 2019)
- Munich Remote Sensing Symposium (Munich, Germany, 18 – 20 September 2019)
- 8th FIG Land Administration Domain Model Workshop (Kuala Lumpur, Malaysia, 1 – 3 October 2019)
- EuroGeographics General Assembly (Manchester, UK, 6 – 9 October 2019)
- European Forum for Geography and Statistics Conference (Manchester, UK, 10 – 11 October 2019)
- 2019 Time Machine Conference (10 – 11 October 2019, Dresden, Germany)
- EuroSDR/ISPRS GeoBIM Benchmark Workshop (Amsterdam, The Netherlands, 2 – 3 December 2019)
- Workshop ‘Point Cloud Processing’ (Stuttgart, Germany, 4 – 5 December 2019)
- International Land Use Symposium (Paris, France, 4 – 6 December 2019)
- Linked Data Group Seminar (Paris, France, 11 December 2019)

## Publications

- 72 Cromptvoets, 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.
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- WR Bucher, B.; Schlieder, C.; Cantat, F.; Kavouras, M.; Streilein, A.; Severo, M.: *Mapping Places for Digital Natives and Other Generations*. 2018, 16 pages.
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- 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 NMCA's 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 NMCA's adapt to alternative sources for NMCA data?* 2016, 9 pages.

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

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