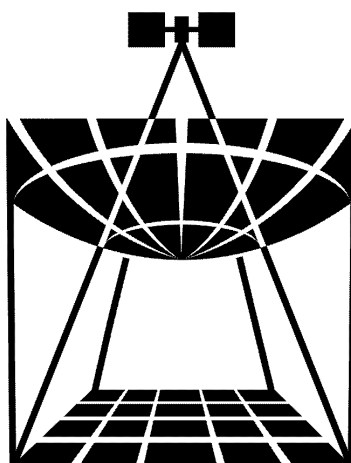


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**4<sup>th</sup> Czech–Polish Symposium  
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***“ACTUAL PROBLEMS OF GEODESY,  
CARTOGRAPHY AND PHOTOGRAMMETRY”***

**ABSTRACTS**

**Łądek-Zdrój, Poland  
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# ALGORITHM FOR FINDING A HAMILTONIAN PATH IN GRAPH

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Key words: Hamiltonian Paths, polynomial-time algorithm, the P versus NP problem

## ABSTRACT

In this paper a polynomial algorithm is presented which finds a Hamiltonian Path in an undirected graph. Determining if a graph is Hamiltonian is well known to be an NP-Complete problem. It first reintroduces the concepts described in previous works and then explains the algorithm. The core of the algorithm is the step by step elimination of nodes that are replaced with composed edges. These edges are a combination of connection of all input and output edges of the given node. Each composed edge is evaluated with incident nodes and the sum of the lengths of the edges of which were composed. Composed edges are gradually sorted by their length. In the last step we obtain single node only. Hamiltonian path is composed edge that contains all the nodes and has a minimum length. The algorithm is tested on several examples e. g. on of Dirac's famous theorem of 1952. The algorithm is implemented in the Borland Delphi. The paper discusses one of the problems of the millennium – P versus NP problem.

# PROCESSING OF ENORMOUS AMOUNTS OF GEOGRAPHICAL DATA

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Key words: image classification, spatial analysis, GIS

## ABSTRACT

The article describes the technology for classification of data about storage of the engineering networks and facilities under certain types of terrain surfaces. Technology solves a data analysis of the storage of underground utilities under certain types of terrain surfaces on extensive territories. This analysis was done in order to determine reproductive values of these utilities and the valuation of costs which would be necessary to spend for building new utilities. The classification uses raster datasets of orthophoto, vector sets of Fundamental Base of Geographic Data (ZABAGED) and vector sets of the route of line of underground engineering networks. The aim is mining the maximum possible information from the image of orthophoto and the transfer to the database and vector form. The advantage of technology is a high degree of automation of the whole process and the efficiency of use especially in large areas. The proposed method was tested in the project of data analysis of storage of gas facilities under certain types of terrain surface in the Czech Republic (CR). The authors solved this project for the GasNet, s.r.o. Company which is a part of a RWE group in the Czech Republic. Input data were datasets of orthophoto with the resolution of 25 cm/pixel, layers of communications of ZABAGED CR and vector sets of the route of line of underground engineering networks. Due to the territorial coverage of the CR with the area of 64,350 km<sup>2</sup>, these were massive tasks with data volume of 500 GB. Processing was carried out in assigned created application in Python language with support for ESRI libraries and also in ArcGIS 10.0 environment. The results demonstrated the efficacy (effectiveness) of this process and the low error rate in the range of 2%–3% was achieved over the whole modeled area.

# CONCLUSIONS FROM LONG-TERM MONITORING OF LARGE SPAN ROOF TIMBER CONSTRUCTION

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Key words: geodetic deformation measurement, large span roof timber construction

## ABSTRACT

The paper includes conclusions from evaluation of results obtained from long-term measuring of innovative atypical roof timber structures. Based on the results of measurements of vertical and horizontal deformation components it is possible to analyze the real behaviour of structures in given conditions. By assessing deformations in various stages, including particularly external and internal environment temperatures, relative air humidity and moisture content of wood, decisive parameters for real structure behaviour can be established. The data are processed from period 2001–2013.

# GEODETIC MONITORING FOR THE DIAGNOSTICS OF A HISTORICAL RAILWAY BRIDGE

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Key words: monitoring, digital level, automatic leveling, historical bridge, load test

## ABSTRACT

This article deals with the long-term (seasonal) and short-term monitoring of “Křenová” historical railway bridge construction in Brno. Leica DNA03 digital leveling system was used for seasonal monitoring. Automatic leveling system was used for the short-term load test monitoring. The automatic leveling system consists of two Leica DNA03 digital levels and one Leica NA3003 digital level. All digital levels are controlled by special software application. Continuous leveling is used to monitor deformations at top of the bridge vault during the load test. The results of the continuous measurement are combined with the result of the epoch measurement.

# TWENTY YEARS OF COOPERATION BETWEEN THE INSTITUTE OF GEODESY – WROCLAW UNIVERSITY OF ENVIRONMENTAL AND LIFE SCIENCE AND THE BRNO UNIVERSITY OF TECHNOLOGY

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Key words: Śnieżnik Massiff, geodynamics, satellite and gravimetric measurements

## ABSTRACT

The academic cooperation between the partners started in 1993 in the Śnieżnik Massiff on both sides of the border within the frames of a Polish research grant package titled “The Śnieżnik Massiff – changes of the natural environment”. The geodesy part concerned the “Geodynamics of the Massiff and adjacent areas”. The epoch observations of the geodynamic network (satellite GPS and gravimetric) have been the foundation of joint publications.

In 1998 the official “scientific cooperation agreement” was signed between the partner faculties focusing on the topic of “geodetic and cartographic studies of changes in the natural environment of the Sudetes”. The effects of these studies include joint publications and processing of results for publications. Each year, the research staff, PhD candidates and students participate in seminars, symposiums and conferences (including international ones) organised by the partner institutes. The presentations are published in scientific papers and conference proceedings.

An important achievement of this cooperation is the alternating organisation of the „Czech–Polish Symposium Brno–Wrocław” focusing on the topic of the „Actual Problems of Geodesy, Cartography and Photogrammetry”. The consecutive symposiums took place in: Dolní Morava – Czech Republic (2005), Łężyce – Poland (2008), Lednice, Czech Republic (2011) and presently in Łądek-Zdrój – Poland (2014).

# CONTACTLESS GEODETIC MEASUREMENTS OF ELONGATED ENGINEERING OBJECTS BY USING LASER BEAMS

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Key words: engineering survey of elongated objects, non-contact position measurement, laser pointer

## ABSTRACT

The deviations from straightness of elongated engineering objects is often necessary to measure in the geodetic measurements. There are many geodetic measurement methods of points that represent an elongated object. The main methods are: alignment surveys (optical, laser, mechanical – stretched wire), trigonometric, geometric leveling, photogrammetric, terrestrial laser scanning. These are the contact and contactless methods, which respectively require or do not require direct access to the object being measured.

The authors have developed the concept of the two methods and have done a set of instruments permitting enforcement of the non-contact position measurement of points representing the alignment object.

Measurement of the first method is based on alignment reference line and device equipped with horizontally set measuring cup and two laser pointers. In the device is used a known method of angular intersection with a fixed angle, which execute the rays emitted by two laser diodes.

The second method is based on polar measuring (bearing and distance) and device equipped with a reflector and two laser pointers that perform intersection with a fixed angle.

In the work will be presented the results of test measurements made in the laboratory and field. The results obtained with developed the measuring equipments has shown that the proposed methods have comparable accuracy with conventional measuring methods.



# INTEGRATED SUPPORT FOR COMPLEX DECISION MAKING IN RELATION TO THE PRICE-SETTING FACTORS

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Key words: Price-setting factors, Decision making, Spatial analysis, GIS

## ABSTRACT

The article deals with the issues of the decision making theory which effectively contributes with the aid of spatial analysis in a geographic information system for the decision-making process between the stakeholders in the real estate market. It was created a mathematical model in the context of this article where the individual parameters represent different functional groups taking into account the price-setting factors. Multi-criteria analysis methods are integrated into a mathematical model. These methods evaluate the impact of different price-setting criteria comprehensively. The most commercially attractive is the market with building plots designated for residential housing. It is furthermore possible to consider such as parameters realized sales of plots in the commercial areas, manufacturing and industrial areas. These parameters were established as key areas for defining the main price-setting factors and criteria for the mathematical model. The range of considered price-setting factors allows the use of the groups of similar plots with realized price for their comparison with the groups of plots with analogous characteristics. Consideration of plots with analogous characteristics can be taken as verification of input factors in a mathematical model. The primary effort of implementation to the mathematical model was precise classification of plots into groups with identical end-use property with respect to the amount of price-setting factors. Generally, the decision-making process includes heterogeneous parameters that are necessary to competently assess. This problem is solved by a process of quantification, which represents the spatial analysis in comparison of several variants. The combination of a mathematical model, multi-criteria decision analysis (MCDA) and their implementation in a geographic information system is a new approach for the comprehensive evaluation in the decision-making process of the real estate market. They are used the tools of the expert system to support spatial decision making for final evaluation which contains two essential components: a multi-criteria decision making model and GIS environment.

# ACQUISITION OF DIGITAL WATER SURFACE MODEL FROM ISOK FLOOD HAZARD MAPS

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Keywords: GIS 3D, ISOK, digital water surface model

## ABSTRACT

The ongoing climate change is one of the factors causing more common and severe occurrence of flood events. Some existing internet GIS systems allows to simply visualize this phenomena in 3D. In this case the water surface is flat, the DTM is highly generalized and terrain obstacles do not influence the flood extent, which may lead to incorrect interpretation of flood risk.

We developed a concept of integrated GIS system supporting flood modeling and 3D visualization of its result. The system is based on products from ISOK (system of the country's protection against extreme hazards), existing spatial databases and LIDAR data. The target functionality of this system is to present the real or simulated state of flood wave in 3D.

In this presentation, we compare the different methods of retrieving the up component from two dimensional ISOK flood hazard maps, thus creating a digital model of water surface. Generally, two different ways to develop such a model are presented. The first utilize the water heights placed discretely along the river. The water surface model is bounded by the intersection of cross-sections with DTM. The second method uses the flood extent presented on flood hazard maps, and the height of the water on its boundary is retrieved from the DTM. Because of the digitalization error and height error of DTM, the point heights are averaged in specified radius. The methods are validated and finally we present a model which is a combination of both.

# IN HOUSE DEVELOPED SOFTWARE FOR GNSS PPP REAL-TIME POSITIONING – GNSS-WARP

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Keywords: GNSS, PPP, software, real-time

## ABSTRACT

Precise Point Positioning (PPP) is a positioning technique of autonomous GNSS receiver. To remove main error sources, precise orbits and clocks are introduced into equation system. The effect of the ionosphere delay is eliminated by linear combination L3 (iono-free) of phase and code observation. Such approach utilize the computational potential of global GNSS network analysis. PPP technique is worldwide established as postprocessing solution, and is successfully used to estimate position, troposphere delay and analyze GNSS signal.

Since the International GNSS Service (IGS) officially run the real-time service (RTS), PPP can also be used in real-time mode, becoming a very powerful technique to process GNSS signals. At the same time, the existing PPP software are very limited in their functionality and require redevelopment in order to fit the scientific requirements. This becomes the impulse to developed original software, that will be easy to modify and apply original algorithms.

GNSS-WARP (Wrocław Algorithms for Real-Time Positioning) software is developed from scratch. It is implemented entirely in Matlab Environment, using additional Instrument Control Toolbox to establish connection with RTS stream decoder and GNSS receiver over TCP/IP port. Currently the software is enable to process GPS and GLONASS data, both in real-time and postprocessing mode (the second one simulates the real-time conditions) for static and kinematic data. In this presentation the software ant its functions are briefly described, as well as some exemplary results are presented that are mainly related with the application of IGS RTS products together with various external troposphere models.

# COMPARISON OF RADIOSONDE AND GPS-RO PROFILES OVER POLAND

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Key words: COSMIC, GPS, radio occultation, radiosonde, RO

## ABSTRACT

Global Positioning System (GPS) Radio Occultation (RO) technique applied in Taiwan/US FORMOSAT-3/COSMIC (FORMOSA SATellite mission – 3/ Constellation Observing System for Meteorology, Ionosphere and Climate) joint project allows to collect meteorological parameters of global range by probing the atmosphere with satellite microwaves. While COSMIC mission provides approximately 2,500 daily profiles, with measurements based on time delays, it appears to be a useful complement for radiosonde data – a crucial component of numerical weather prediction models. In this paper, traditional radiosonde observations are utilized to evaluate the quality of GPS-RO profiles in a comparative analysis for the area of Poland. This includes the error assessment of vertical profiles, but also deals with collocation criteria and data characteristics. Observations of regularly scheduled weather balloons, launched twice daily, for three Polish stations are used together with wetPrf product of COSMIC provided by CDAAC/TAAC processing center. The comparison is made for refractivity, pressure and temperature in a function of height for four months of 2014 – from January to April. The results show that COSMIC parameters agree well with those of radiosonde data, especially for high altitudes. Due to high vertical resolution of RO profile, COSMIC provides a good representation of atmospheric layers. The technique may still require improvements in the lower troposphere, where high moisture conditions dominates and disrupts the signal path.

# WILKANÓW FRAMEWORK FAULT BASED ON GEOPHYSICAL DATA, SUDETY MTS., SW POLAND

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Key words: gravimetric profiles, geophysical investigation, Upper Nysa Kłodzka Graben, Wilkanów fault

## ABSTRACT

Wilkanow framework fault separates the Śnieżnik Massif from the inner mountain depression, which is tectonic Upper Nysa Kłodzka Graben. Already since the 20-ies of XX century Closs (1922) presented it as a steep reversed fault. Only in few sections it had a vertical fault character. Frąckiewicz (1968) confirmed Closs' observations in two locations, finding gneisses overthrust on marls and Upper Cretaceous limestones (in the research excavations). The author identified collapse angles indicating the occurrence of thrusts. Fault plane in Nowa Wieś falls at an angle of 40° and 55–60° in Wilkanów. In turn, Rode (1936) and Rawański (1975), followed by an almost all the authors of geological maps, assumed the presence of steep flexures along which Late Cretaceous formations were arranged vertically. A lot of geoelectrical research activities were focused on the Cretaceous sediments of the Upper Nysa Kłodzka Graben. The purpose of these studies were searching for mineral and curative waters so probing distance was too large to reliable conclude about the fault surface slope (Jodłowski, 1999; Farbisz, 1993).

Only two electro-resistance profiles with 50 m probing distance made in the north part of Wilkanow fault indicate vertical contact gneiss and Late Cretaceous rocks (Badura et al., 2002).

This problem has been studied in the project NN 526 223335 „Geodetic monitoring of the Waliszów–Morawa tectonic zone recent activity” by detailed gravimetric profiling. Gravimetric measurements were made in two profiles (Idzików and Wilkanów profiles) using Autograv Scintrex CG-5 instrument. The measurement points in the both profiles (intersecting Wilkanów fault) were taken every 100 m. Points were positioned by a GNSS technique.

The attempt to explain the inclination angle and direction of the Wilkanów fault plane using gravimetric profiling partially confirmed the vertical collapse of this fault.

Numerous variants of gravimetric profiles modeling in order to prove his overthrust character gave results incompatible with the basic geological data. The problem was a similar (nearly identical) density of gneisses and Late Cretaceous rocks amounting to  $2.61 \text{ g/cm}^3$  in borehole Pisary IG-1 (Rosowiecka et al., PGI-NRI, 2013). To construct a model that meets the criterion of compliance measurements of gravity and geology was possible only after taking into account the relatively high density of Late Cretaceous rocks.

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# 3D BUILDING MODELING USING ROOF TOPOLOGY GRAPHS

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Key words: building, reconstruction, roof topology, LIDAR, point cloud

## ABSTRACT

This paper presents a method for automatic reconstruction of 3D polyhedral building models using airborne laser scanner (ALS) data. The main research problem of the study is to recognize building roof structure and associate each detected roof plane with appropriate semantic information. For this purpose, the algorithm uses the concept of roof topology graph that enables to relate specific features found in the data with general knowledge about buildings. The graph describes a topological structure of a roof so that each planar face is represented by a vertex and each pair of neighboring faces is reflected by an edge connecting two vertices. Presented reconstruction approach follows the idea that even very complex shape of a building may be represented by a set of simple structures. Such 3D blocks can be seen as pieces stucked together for building construction according to the information found in the data. Hence, the core process of model generation is based on the identification of predefined shapes and their logic combination.

The data input contains 3D point cloud segmented into subsets of points that represent individual planes of building roof. The first stage of modeling algorithm is to establish spatial relation between detected patches. This lets to create a roof topology graph for reconstructed building. Then, identified topological relationships are compared with predefined structures. For this purpose, it is necessary to develop a library of parametric shapes and their corresponding graphs. The task of structure recognition is performed by matching of pieces of a building graph with simple sub-graphs associated with base elements from the library. Final 3D reconstruction is applied only to those planes that have been identified as combinations of predefined structures. In contrast to the typical data driven methods, where each surface is reconstructed individually, the presented algorithm allows for modeling of all building elements in terms of their mutual relationships. The final stage of the research is to determine parameter values of the models, in order to obtain the best fit between recognized structures and data source.

The algorithm is tested against an ALS data set that depicts various residential buildings. The results demonstrates the validity of the presented approach for generation of reliable polyhedral models. Structure recognition applied to the algorithm prevents from frequent modeling difficulties related to gaps within LIDAR data and false conclusions during automatic interpretation. Another advantage of the presented method is a full applicability in the case of low density point clouds and the topological correctness, implicitly provided by predefined parametric structures.

# CYCLE PATH GIS OF MORAVIAN WINE TRAILS

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Key words: Geographic information system, ArcGIS, database, analysis, Moravian Wine Trails, cyclotourism

## ABSTRACT

The paper deals with the development of a geographic information system with the focus on its use in the bicycle touring domain.

Is decribed data collection, obtaining maps and their processing and transformation to S-JTSK. Besides that, the import of geodata and the creation of geodatabase are set forth and the draft of graphic representation of the cycleway and infrastructure is offered. The conclusion consists of the real use of the GIS – selecting and querying tasks and output analysis. Finally, the possibilities of exporting GIS to different formats (e.g. ArcReader, ArcPad, ArcScene and GeoPDF) and platforms (e.g. PDA, tablet, web map server) are discussed.



# ALTNET – CREATION OF HOMOGENOUS SET OF ALTIMETRY DATA FOR LONG-TERM ANALYSIS

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Key words: Altimetry satellite, geographical coordinates, geoidal height, programming language FORTRAN, neighbourhood of point

## ABSTRACT

Altimetry satellites are artificial devices on the Earth orbit. They are equipped with systems for determination of satellite height above the Earth surface and devices for determination of satellite position in 3D coordinates. The accuracy of measured data on sealevel is one order better than on continents. For that reason, the data are mostly used for sealevel description. If we have a long-period data set, we will be able to describe the time-dependent changes on the sealevel.

The paper focuses on software creation for altimetry data processing and result analysis from altimetry satellite measurements. The software is designed to work with all altimetry satellites data from missions TOPEX/POSEIDON, JASON-1, JASON-2 and JASON-3 and it is usable for long-time analysis of the data.

The satellites orbit around the Earth in planned tracks. Due to influence of powers which ones have disturbed projected tracks, we can extract data set of measurement in slightly different points. This is the problem which one forbid us to process a homogenous long-term analysis on the raw data.

Software ALTNET is designed to work with the altimetry data mentioned above and it is developed in programming language FORTRAN. The set of raw data contain points with their latitude, longitude and ellipsoidal height. The purpose of the software is creating or insertion a network of pseudomessurred points on sea level which ones are close to distribution of the raw data set. In other words, either the software calculate latitude and longitude of intersections of footprint of satellites, or one can insert precalculated coordinates. In this fixed coordinates, the software can calculate sea level heights using statistical analysis of neighbourhoods. The software also provide error characteristics.

The software provide us values of ellipsoidal height in fixed points suitable for analysis. When we correct this data by suitable sealevel topography model, the input data could be used for evaluation of geopotential models.

# THE POTENTIAL OF REMOTELY-SENSED DATA FOR SUPPLYING CHOSEN LAYERS OF SOZOLOGICAL MAP – THE STUDY CASE IN SUDETY MOUNTAINS

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Key words: remote sensing, GIS, sozological map, vegetation indices

## ABSTRACT

A sozological map is a thematic map that presents the natural environment state, as well as the causes and effects of both negative and positive transformations occurring in the environment. The official sozological map is prepared in the scale of 1:50 000 in an analogue and numerical form according to technical guidelines GIS-4 (*Wytyczne techniczne GIS-4 Mapa sozologiczna Polski skala 1:50 000 w formie analogowej i numerycznej*). There is no doubt that the SOZO database should be the important source data in all environmental studies and monitoring issues. However, the analysis of chosen layers of this thematic map led to conclusion that content of the database seems to be insufficient for conducting spatial analysis. The problems faced by Authors refer to class of forest damage. The phenomena – according to technical guidelines GIS-4 – is indicated as a marker (point feature in a database) without delineating its range. This type of presentation is rather useless in spatial studies of the environment. Hence, the Authors propose application of remotely sensed data in supplying sozological database. The aim of the research is to present possibility of determining class of forest damage based on the satellite images and thereby make a sozological map a fully useful product in any kind of spatial analysis.

# GEOMETRICAL AND TEMPORAL CHARACTERISTICS DETERMINATION OF DEVICE FOR ANTENNA CALIBRATION

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Key words: antenna calibration, StAnCa, geometrical properties, temporal synchronization

## ABSTRACT

StAnCa (Station Antenna Calibration) is a device developed at Brno University of Technology, Faculty of Civil Engineering, Institute of Geodesy for the purpose of absolute calibration of geodetic GNSS antennae. It consists of two main parts, a moveable arm, which can be placed on classic geodetic pillar, and a processing unit, which drives movement of the arm. Movement of the device rely on two step motors, the first one for horizontal and the second one for vertical movement. Top of the arm is equipped by the mounting screw in order to carry calibrated antenna.

Knowledge of the mounting screw precise positions (i.e. antenna reference point) in the time of GNSS observations is crucial for the following numerical processing that leads to desired values of phase center offsets and variations. Therefore several testing measurements have already been carried out.

The first set of measurements was focused on small deviations and axes irregularities in construction of the moveable arm. Classic geodetic methods utilizing theodolites were used and the deviations were determined at the 0.1 mm level of precision. Detected values are used for computation of corrected position of the arm.

The second type of measurement was devoted to temporal synchronization of arm's movement. The processing unit incorporates a PC synchronized with UTC via NTP. Movement of the arm is at current stage of the device development designed to stop for a while at the GNSS measurement time. Proper temporal synchronization of the PC and absence of considerable signal delay in whole driving electronics have been successfully verified.

Independent method utilizing state of the art astronomical device MAAS-1 was used, especially it's 25 fps camera and GNSS temporal synchronization device.



# TRANSFORMATION OF PLANE COORDINATES BASED ON A REGULAR GRID OF IDENTICAL POINTS ON THE TERRITORY OF THE CZECH REPUBLIC

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Key words: Datum grid transformation, Helmert transformation, position deviation of a point, trionometric point, net densification point, minor geodetic control

## ABSTRACT

The work contains the description of the algorithm and the results of the transformation horizontal coordinates between ETRF 2000 and S-JTSK systems on the territory of the Czech Republic. The aim was to find a procedure that will provide with a probability of 95%, the position (horizontal) a deviation of less than 0.06 m without the need for repeated search of identical point in both coordinate systems.

For this purpose, were drawn up with the grid square step  $2.5 \times 2.5$  [km] and using the data from the database DATAZ ([http://bodovapole.cuzk.cz/\\_mapTop.aspx](http://bodovapole.cuzk.cz/_mapTop.aspx)) calculated coordinates grid nodes in the Křovák's universal conformal conical projection view on the GRS 80 ellipsoid. Each node in the grid was transformed using at least eight identical points. In such a procedure have two files with the coordinates of the nodes of the grid:

- first, with the coordinates in the Křovák's projection, S-JTSK system (the Bessel ellipsoid),
- second, coordinades in the Křovák's projection, ETRF 2000 (GRS 80 ellipsoid).

The whole territory of the Czech Republic was covered with square networks  $2.5 \times 2.5$  [km] of identical points (nodes) that could be used for the transformation of coordinates.

The results of cross-validation of the quality of the transformation are summarized in the table (deviations are given in metres).

*Table Radial deviations to TB and ZhB (grid  $2.5 \text{ km} \times 2.5 \text{ km}$ )*

<b>39.3%</b>	<b>63.2%</b>	<b>95%</b>	<b>99%</b>	<b>99.5%</b>	<b>99.9%</b>
0.008	0.012	0.032	0.050	0.059	0.077

From the size of the radial deviation implies that the hashing algorithm it fully meets the requirements for the transformation of the points detailed position point field, for which it is enabled, the error limit  $u_{xy} = 0.12$  m.

# EVALUATION OF QUASIGEOID MODEL CREATED BY GNSS/LEVELLING METHOD

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Key words: quasigeoid, height, GNSS, levelling

## ABSTRACT

The paper describes local model of quasigeoid created by GNSS/levelling method on locality within the Brno city. The GNSS technology is frequently used in many geodetic applications in present time. The accuracy of GNSS heights is still worse than accuracy of heights gained by levelling measurements. In present time national, continental or global models of geoid or quasigeoid are available. Accuracy of such models is around 0,03 m and becomes better and better.

On the territory of the Brno city the experimental network of height points called AGNES was build. The satellite measurements, levelling measurements and astronomical observations were realised on all points of the network. The measurement enables to compute height undulation of quasigeoid by GNSS/levelling method and by astronomical levelling method.

The quasigeoid model created by GNSS/levelling method was compared with model created by astronomical levelling method. The latter was select as reference model, because the accuracy of this model is approximately 0,003 m. Standard error of GNSS/levelling model was determined from differences between this two models. The accuracy of determined local GNSS/levelling model was found approximately 0,017 m. With respect to accuracy of heights from levelling measurement we can conclude, that the accuracy of GNSS heights is about 2 cm. The accuracy of the GNSS/levelling model of local quasigeoid is limited by the accuracy of GNSS heights.

# IDENTIFICATION OF EVENTS AND PROCESSES IN LINKED OPEN DATA GENERATED FROM SDI RESOURCES

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Key words: semantic web, ontologies, formal ontologies, spatio-temporal modeling, spatial planning

## ABSTRACT

Semantic data generated from Spatial Data Infrastructure (SDI) resources in the form of Linked Open Data (LOD) can include temporal information. This can be done by using annotated RDF (aRDF), temporal RDF graphs or named graphs. It is possible to represent temporal information directly in an RDF structure as additional triples using an appropriate vocabulary dedicated to modeling spatio-temporal phenomena.

SDI resources can be considered the best source of spatial LOD data. There are various well tested methods of generating semantic data from SDI data sets provided as an object model. There are also various manners of representing the dynamic nature of such data. In the most basic situation, SDI resources are updated in time, in accordance with the change in the entities which they reflect. Therefore, if we want to register changes we should acquire the provided data repeatedly with some appropriate frequency corresponding to the nature of the phenomena. However, the most common situation is when SDI resources are versioned. Another way to provide temporal description about data reflecting changes in reality is preparing data models involving the history of objects. The approaches mentioned above give us data sets embedding (in various forms) time series describing states of objects in selected moments. A crosscut through the whole data set in a given point in time is called a “snapshot”. LOD data generated from SDI can be retrieved in a similar form: the selected named graph encompasses a set of resources with their mutual relations in a given “snapshot”.

If we want to analyze the rules responsible for shaping spatial systems in time, we need to discover the causes of changes and their impact on the state of objects. Therefore, among the changes we have to identify the events and the processes as well as their relationships with particular entities. Such a task demands specialized tools. In the domain of Semantic Web, appropriate instruments are provided by formal ontologies such as DOLCE, BFO, GFO, OCHRE, etc. Among them are structures which give: the distinction between persistent objects (*endurants*) and objects “happening” in time (*perdurants*, e.g. *events* and *processes*), the classification of persistent objects due to their behavior in time (e.g. if the persistent substantial object is *dissective* and/or *cumulative*), the pedigree (known sometimes as *genidentity*, describing which entities are predecessors or successors to others),

the *object history* (describing crucial moments when the nature of an object is changed), *process profile* (describing properties of a process). Persistent objects are bearers of *perdurants* (*processes* and *events*). *Processes* and *events* affect the state of *endurants*. Changes of state could be interpreted as a *Qualitative Change*, *Substantial Change*, *Spatial and Locational Change* resulting in the reclassification of objects.

Such an approach is very fruitful in the spatial planning domain. Identifying events and processes is *sine qua non* for understanding the dynamics of the behavior of persistent objects, from *creation*, through mutual interactions such as *budding*, *absorption*, *separation*, *unification* to their eventual *destruction*. The pedigree of objects is equally important. In such a way we can describe the changes in the state of a spatial development. Using cadastral data, land cover data as well as spatial development plans (zoning plans), we can monitor if the pace of changes involving cadastral division and building distribution impact land cover in a manner which conforms to the spatial development plan. Spatio-temporal structures deriving from formal ontologies help to find correlations between land use designation in the zoning plan and actual development.

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# MAAS-1 – MODERN MEASURING SYSTEM FOR DETERMINATION OF ASTROGEODETTIC VERTICAL DEFLECTIONS

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Key words: geodetic astronomy, astronomical positioning, vertical deflections, total station

## ABSTRACT

Astronomical positioning has been experiencing a kind of renaissance in the last decade. The main reason is the Earth's gravity field research. Vertical deflections determined by astronomical observations can be used for testing of Earth's global gravity models as well as for creation of local gravity models with high resolution and precision.

Field observations for astronomical vertical deflection determination is a specific part of geodetic astronomy, which needs special instrumentation. Mobile Automatic Astronomical System No 1. (MAAS-1) was developed on Brno University of Technology. It is based on motorized total station Topcon GPT 9001A supplemented by external CCD camera and portable computer. MAAS-1 measuring system is designed for fast and precise determination of astronomical coordinates intended for vertical deflections computation.





# **A DETERMINATION OF SUBSIDENCE OF BUILDINGS BELONGED TO THE WROCLAW UNIVERSITY OF ENVIRONMENTAL AND LIFE SCIENCES**

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Key words: deformation measurements, vertical displacements

## **ABSTRACT**

Correctly determination of (mostly vertical) displacements of buildings and other engineering facilities is necessary to define changes in the structure of these objects. It is also needed for development of rules and methods, which can help to avoid construction disaster. Results of geodetic measurements are the basis for making decision to reinforcement of measured object structures.

Geodetic measurements of displacement are realized with high accuracy, and have a short lead time. Unfortunately, surveyors have to deal with plenty of difficulties, which are result of working in adverse field conditions (traffic, pedestrians, variable lighting conditions). Therefore for realization of displacement measurements, especially on the measured object, high precision equipment should be used.

Speech presents results of 6 measurement cycles of vertical deformations of Wrocław University of Environmental and Life Sciences buildings, located nearby Grunwaldzki Square. Measurements have been conducted in the years: 2006–2010 and 2013.

# COMPARISON OF ALPHA SHAPE AND DRAW POLYGONS ALGORITHMS FOR DELINEATION OF WATER BODIES IN AIRBORNE LASER SCANNING POINT CLOUDS

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Key words: airborne laser scanning, the Topographic Objects Database (BDOT10k), alpha shape, draw polygons, water bodies, detection

## ABSTRACT

Airborne laser scanning (ALS) is one of the modern geomatic technologies for acquiring in a short period of time large amount of topographic information, as three-dimensional point cloud. Spatial data gained by LiDAR measurement is used for many applications and also for geometric modeling of topographic objects. Because of the fact that topographic LiDAR systems operate mainly in near-infrared range of the electromagnetic spectrum, the laser beam is significantly absorbed by water. As a result, water bodies are registered as empty regions in point clouds. This fact can be used for delineation of water bodies.

The paper presents a comparison of two algorithms used to build geometric models of water bodies for updating the Topographic Objects Database (BDOT10k).

Automatic identification of water bodies has been conducted by means of the alpha shape and draw polygons algorithms, with the use of ground laser point cloud of the 4 points/m<sup>2</sup> nominal density. No other information or datasets have been taken into account. The experiments have been performed for 18 testing objects (water bodies). The effectiveness of boundary identification has been evaluated by comparison the generated models with the orthophoto of a 0.10 m resolution. Based on the received results, there has been stated that both algorithms characterize the high effectiveness of water bodies delineation, which is 95% for the alpha shape and 96% for the draw polygons. The alpha shape algorithm has identified 61% of the testing objects with 100% efficiency and the draw polygons respectively 56%. The average of maximum deviation values for the testing algorithms is 1 m and the RMSE error is not higher than 0.9 m. Performed numerical tests showed that, both algorithms can be used for identification and modelling of water bodies. Moreover, thanks to the proposed methodology the accuracy of the geometric representation of the BDOT10k objects would increase, especially in forest areas, where their unambiguous identification on orthophoto is difficult or even impossible.

# TOWARDS AUTOMATIC URBAN LANDSCAPE CHARACTER ASSESSMENT USING GEOTAGGED IMAGES

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Key words: geotagged images, image processing, semantic enrichment, urban landscape, landscape assessment, photo sharing, machine learning

## ABSTRACT

With the ubiquity of mobile location-aware electronic devices, a new type of geographic information has emerged. GPS-equipped cameras, smartphones or tablets permit users to create geo-localized content and to share it instantly in the Web. Current rapid development in the number and capabilities of gadgets, and prognoses about the future market leave no doubt about importance of this segment for the community. In this view, processing and integration of such information constitute a vital problem in geoinformatics.

Socially shared pictures, possessing geographic coordinates, provide additional information about the place, where they are taken. In parallel, advances in techniques of digital image processing, computer vision and pattern recognition enable researchers to use machines to extract information from geotagged visual sources. It can trigger synergistic effect when combining it with other types of geoinformation, coming from map services like OpenStreetMap.

We propose a new approach to assessment of urban landscape character using pictures publically shared in the web, coming from Flickr and Panoramio. This scheme can be viewed as an example of automatic semantic enrichment of geographic data. On the other hand, some of the methods used for this task can be used for developing full semantic description of landscape images, which can be obtained by linking extracted information to the existing structures of knowledge.

The experiments reported in this paper were conducted in the area of Wrocław, Poland, based on the set of around 7000 publically accessible images. However, developed methods are universal for urban areas. We use descriptive characteristics of photos, which establish input to the previously trained classifier and (together with information obtained from map services) base for ground tessellation.

Extracting latent information from the group of pictures leads to assigning values to areas, which in turn can be transformed to evaluative categories possible to be used in landscape character assessment.

This research was supported in part by PL-Grid Infrastructure, where necessary computations were made.

# THE EFFECT OF DIGITAL ELEVATION MODEL SOURCE ON HYDROLOGICAL APPLICATIONS

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Key words: digital elevation model, hydrology

## ABSTRACT

Many of hydrological models needs coefficients calculated from the DEM (digital elevation model). For example, TOPMODEL (topography based rainfall-runoff model) requires calculation of TWI (Topographic Wetness Index) to quantify the control of local topography on hydrological processes and indicate the spatial distribution of soil moisture and surface saturation. Currently, elevation data are available from several major sources and at different spatial resolutions: aerial images, topographic maps, and the Light Detection and Ranging (LIDAR) data. The latter measurement campaign was organized for about 70% of the territory of Poland. It provided a grid DEM with the resolution of 1 meter with the vertical accuracy of  $\pm 0.15$  m ( $\pm 0.30$  m some areas). These may represent a substantial opportunity for hydrological modeling. Using higher resolution DEMs can derive more accurate information, but the computational and economical costs may overwhelm the gains in terms of representation of hydrological feature in a river catchment scale. This article shows the variability of TWI analysis results from different DEM sources performed for the selected subcatchments of Nysa Klodzka river. Results obtained from available free digital surface models are evaluated in reference to 1-meter resolution model.

## **GPS NETWORKS, GEOPHYSICS AND REMOTE SENSING – TOOLS FOR MORE DETAIL COMMON COOPERATION**

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Key words: Bohemian Massif, geodynamics, GPS, multidisciplinary interpretation

### **ABSTRACT**

In last 15 years several research projects of GPS campaigns and detail measurements were realized along the Czech-Polish border. The results presented are pointing at important geodynamically active territory of the Bohemian Massif which is not yet fully evaluated, and in some cases even ambiguously interpreted from the point of view of further analyses.

The paper shows possibilities of further methodology not only for following geodetic measurements, but also for complex evaluation of the data for purposes of geological interpretation.

In present time it is possible to integrate the results of geodetic activities with geophysics and remote sensing results, and thus unify the multidisciplinary outputs to get unified regional interpretation of the territory/area of interest.

Such results can not only improve level of doctoral and diploma theses, but present important benefits for practice and also for basic and applied research.

# **AN ATTEMPT TO IDENTIFY THE MOVEMENTS OF SELECTED POLISH TECTONIC STRUCTURES ON THE BASIS OF VELOCITIES OF ASG-EUPOS PERMANENT STATIONS**

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Keywords: displacement identification, tectonic structures

## **ABSTRACT**

Geodynamic research in the area of Poland, designed to identify the tectonic movements of selected structures are carried out for many years, and with various methods. The method which allows for the study of movement in the whole territory of Poland and provides information about the movements – and what is more important – about velocity of the measured points are geodetic satellite measurements. In Poland for this purpose observations from reference stations of ASG-EUPOS may be used. ASG-EUPOS works continuously since 2008 and provides data about movements of network points.

Author uses data from ASG-EUPOS about stations displacement velocities (components N and E), and various tectonic divisions (variable number of divided structures) of Poland, to identify the movements of individual structures. Graphical analysis were made, as well as statistical and quantitative. Attempt to eliminate from the set of observation points located in the areas where their movements could be caused by anthropogenic factors was made too.

# SPATIAL FEATURE CHARACTERISTICS EXTRACTION FOR ONTOLOGY CREATION PROCESS

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Key words: SDI, spatial data harmonization, spatial ontology, Semantic Web, feature extraction

## ABSTRACT

Spatial data integration is still one of the main challenges associated with effective management and use of data sets published within Spatial Data Infrastructures. The problem concerns mostly vector data sets in form of layers with spatial features – objects with attributes and spatial reference (usually as geometry attribute). To link heterogeneous spatial data sets, their representation must be compatible – data must be harmonized. Harmonization process is usually conducted by domain experts and it also requires a deep knowledge of harmonized data sets. It is based mainly on proper interpretation of spatial features and their classes, comparison and matching with features from another set. Automation of matching process is a challenge which requires applicable method for spatial feature interpretation, on the level of syntax and semantics as well. It is crucial to extract appropriate features (characteristics) from spatial features to be able to interpret and then match elements from one data set to another. It is a process of creating exploitation metadata which describes data sets on feature level for the purpose of usage and integration. For a formal representation of this information it is possible to use ontologies based on description logic.

Ontology in computer science is defined as an explicit specification of a conceptualization. It is a tool for describing knowledge or fragments of reality in a formal way, and it is used mostly for knowledge base creation. To create such ontology authors propose the use of Semantic Web technologies: RDF data model, OWL2 ontology language and SWRL rule language. Ontology describing spatial data set can be generated from data set and compliant application schema, but it is essential to create a tool capable of retrieving features from those spatial data sets.

Characteristics extraction from spatial features can be compared to feature extraction from raster images for the purpose of object identification and classification. In this case it is important to focus on characteristics supplementing generated ontology, which will be used in the spatial feature interpretation for the purpose of data integration. Information about feature classes, such as names (labels), type and multiplicity of their attributes, can be extracted directly from the application schema. This applies also to geometry attribute, because it can be used to identify objects from this feature class as point object, line object or surface object. More interesting issue is the process of extraction characteristics from spatial features,

which have their shape and are placed in space among other features. It is important to perform analyzes of topological relations between features. Beside common relations such as overlapping, touching, intersecting or disjoining it is necessary to define and analyze relations closer to human perception (on left, above, under, between). It is also important to measure distance from other features with along with discretization of measurements (near, far, next to). Another characteristics of spatial feature are the shape and values like length (for line features) and area (for surface features). Based on the results it is important to define feature class restrictions – classification conditions. Those restrictions will supplement generated ontology which will be the base for heterogeneous spatial feature matching process.



# TPS AND GNSS MONITORING OF INTERACTION BETWEEN RAILWAY TRACK AND BRIDGE CONSTRUCTION

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Key words: railway track, deformation monitoring, GPS

## ABSTRACT

Three years period of deformation monitoring on two Moravian railway bridges is going on since 2013. Subject of research is interaction between bridge deck and railway superstructure induced by traffic and temperature changes. Both bridges of interest have steel deck construction supported by concrete pillars. Measuring points are marked directly on rails and on steel deck surface. For the purpose of geodetic deformation monitoring a special measuring carriage with carriers of reflecting prisms and GNSS antenna was designed and manufactured. The carriage can be precisely centered at measured rail points, with possibility to measure differences in positions of both rails.

On basis of up to now analyzed results it is possible to get information about mutual movements of railway track and bridge construction, and also to evaluate real accuracy relations between TPS and GNSS monitoring methods.

# ACCURACY OF GRAVITY DATA PREDICTION AND ITS EFFECT ON THE ACCURACY OF LOCAL QUASIGEOID MODELLING – CASE STUDY FOR THE AREA OF POLAND

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Key words: gravity data prediction, local quasigeoid modelling, geodetic application  
of the geophysical techniques, disturbing potential model

## ABSTRACT

The paper analyses the problems associated with local quasigeoid modelling for areas with a low density of terrestrial gravity data. It was assumed that in the study area there is a sparse network of integrated geodetic points, which have determined normal and ellipsoidal heights, so in those points GNSS/levelling height anomalies are defined. It was also assumed that for this area, gravity measurements were also done in a rare network of points. A dense network of gravity data, necessary for local, precise quasigeoid modelling, is then determined by prediction of free air gravity anomalies. Prediction of gravity data was carried out in three stages. In the first stage at the measured points the Bouguer and isostatic anomalies were calculated. These anomalies, in the second stage, were predicted using various interpolation techniques. In the third stage, on the basis of the predicted at new points Bouguer and isostatic anomalies, free air anomalies were calculated. Both predicted as well as measured gravity data and GNSS/levelling height anomalies were then used for local quasigeoid modelling. The study investigated the accuracy of the used gravity data prediction technique. There were also evaluated the accuracy of the quasigeoid models built based on rare (measured) and dense (predicted) gravity data. Computational work was carried out based on the data from the territory of Poland. In the calculations, built only on the basis of satellite data, global geopotential model TUMGOCE02S was used.

### 3D SPATIAL DATABASE SUPPLYING IN ASPECT OF CITYGML STANDARD

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Key words: 3D GIS, 3D spatial databases, CityGML, Level of Details (LOD), automatic modeling, building

#### ABSTRACT

The use of databases containing spatial objects in the part of the 3D geometric information is now becoming commonplace. Examples are numerous websites that contain the geometry of buildings, structures and vegetation embedded in digital terrain models. Also in the research and GIS analysis a 3D geometry is widely used. Cubature features are important information for modeling spatial phenomena such as floods, the spread of contamination or search escape routes. And although the use of 3D geometry in these studies is not common, it can be observed rapid development in this field. This implies the need for standardization. OGC, an international industry consortium of companies, government agencies and universities participating in a consensus process to develop publicly available interface standards, adopted and introduced a common information model for the representation of sets of 3D urban objects called CityGML. This standard defines the classes and their relations for the most relevant objects on urban areas with respect to their geometrical, topological, semantical and appearance properties. It introduces generalization hierarchies, aggregations, associations between objects, and spatial properties. This presentation outlines the requirements for standardization of describing the geometry of the buildings in the 3D GIS databases. Summarizes the opportunities for acquiring geometrical data of buildings in terms of LOD (Level of Details) generalization. Numerical solutions have been proposed to supply databases uses CityGML standard on the basis of measurements of laser scanning. The results are presented on the example 3D GIS database of Widawa valley being developed for the hydrodynamic modeling in NCN project No. 2011/01/D/ST10/07671.

# VERTICAL SHIFT OF THE KRONSTADT HEIGHT DATUM TO GLOBAL VERTICAL REFERENCE FRAME IN CENTRAL PART OF EUROPE (CZECH REPUBLIC, POLAND)

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Key words: Global Vertical Reference Frame, local vertical datum, vertical shift, geopotential value, Kronstadt Height Datum

## ABSTRACT

The establishment or improvement of Global Vertical Reference Frame (GVRF) is an actual topic to be solved recently in a very close cooperation by the IAG/IUGG. Some preliminary attempts in this line have been yet achieved by the Czech Republic.

A preliminary Global Vertical Reference Frame has been realized by means of several regional and local vertical datums (LVD) distributed world-wide: the North American Vertical Datum 1988 (NAVD 88), Australian Height Datum 1971 (AHD 71), LVD France, Institute Géographique National 1969 (IGN 69) and Brazilian Height Datum 1957 (BHD 57). The vertical shifts of the above LVD origins have been related to the adopted reference geopotential value  $W_0 = (62\,636\,856.0 \pm 0.5) \text{ m}^2\cdot\text{s}^{-2}$  and they were determined at the 2–3 cm level.

However, because of the lack of the GPS/levelling data over the territories where the Kronstadt Height Datum (KHD) was adopted in levellings, the KHD could not be included into the GVRF above. Preliminary values of the vertical shift of the KHD in central part of the Europe is presented.

The effective mutual cooperation (EUREF, IAG etc.) of the participating countries is needed for to be able to compute the geopotential value  $W_0$  (Kronstadt) specifying the KHD and, consequently, to be able to include the KHD into the GVRF.

# ACTIVITIES OF INSTITUTE OF GEODESY BRNO UNIVERSITY OF TECHNOLOGY IN MORAVIAN KARST

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Key words: Moravian Karst, Speleological Mapping, Cave, Býčí skála

## ABSTRACT

The Landscape Protected Area of the Moravian Karst is a region with best karst phenomena in the Czech Republic. The Moravian Karst extends from the city of Brno in the south and occupies a S–N belt of Devonian limestones, 3 to 6 km wide and 25 km long. The area could be divided from the point of view of recent hydrography into 3 parts – the southern, the central and the northern part, which are accompanied by numerous karst caves and cave system (~ 1100). The Amatérská Cave together with the other caves of the Punkva system are the longest cave system of Czech Republic (~ 35 km) where is the Macocha Abyss too, the world wide known 138,4 m deep abyss, one of the symbols of Moravian Karst. The Býčí skála Cave and Rudické propadání Cave is the second longest cave system, which is situated in the Central part of Moravian Karst.

Due to close location of Moravian Karst area there is long-term cooperation of the Institute of Geodesy with many organizations operating in this area. The most significant cooperation there is with The Landscape Protected Area of the Moravian Karst, Czech Administration of the Czech Republic and Czech Speleological Society. Theses of some the bachelor and diploma theses are situated to these parts of the karst every year. The students of last year of Geodesy and Cartography study program can attend in the subject Speleological Mapping. The practical part of this subject is situated in Býčí skála Cave. The other activities are concentrated to terrain training in second and third years of bachelor studies, which are situated in Jedovnice village in Moravian Karst.

# MODERN MEASUREMENT TECHNIQUES IN SAFETY ISSUES OF THE CONSTRUCTION ELEMENTS

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Key words: displacements, deformations, MEMS

## ABSTRACT

Geodetic measurements are the basis for determining the of deformation and displacement of building elements, which change over time their characteristics as a result of applied loads. A variety of surveying methods can be used to determine the geometric state of this components. But to make them effective in the warning against the threat should be: characterized by a continuity of measurements, control the relevant points (often unavailable), automatically transfer measurement data to a PC. Many of methods used did not fulfill these conditions, therefore, the authors propose solutions that support the surveying of building elements, while satisfying the specified parameters. These solutions use of such elements as accelerometers, gyroscopes, magnetometers, barometers, as well as laser diodes and CCD. In the case of wooden structures are extended by a humidity sensor, and in the case of steel – temperature sensor. These tools extend the capabilities of surveying technology in the study of the geometry state of the engineering components.

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# ACCURACY ANALYSIS ON 3D BUILDING MODELS RECONSTRUCTED FROM CO-REGISTERED TERRESTRIAL AND AIRBORNE LASER SCANNING POINT CLOUDS

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Key words: terrestrial laser scanning (TLS), airborne laser scanning (ALS), ICP algorithm, 3D modelling accuracy

## ABSTRACT

The reconstructing of buildings in 3D models has been a challenging research topic in recent years. 3D building models are used in many professional applications, such as urban planning, spatial analysis, inventories of historical and cultural heritage, promotion of tourist places, etc. The tendency is that the reconstructed 3D building models become more realistic and more detailed.

This work presents the accuracy analysis on 3D building models created from combined airborne and terrestrial laser scanning data. The LiDAR point clouds were acquired using terrestrial Leica ScanStation C10 and airborne Riegl LMS-Q680i scanners. Co-registration of TLS and ALS was simplified by transforming the ALS data into TLS data coordinate system. To reduce systematic errors and offset between TLS and ALS point clouds the Iterative Closest Point (ICP) algorithm was applied. Co-registered point cloud was the basis data for 3D building modelling. Textures mapping was applied, whereby textures were created from digital images taken with a camera Canon 40D. Modelling process was performed semi-automatically using the commercial software Leica Cyclone, free software CloudCompare.

The accuracy of models was assessed by comparing the coordinates of characteristic 3D building models points and the corresponding coordinates of these points measured on the real objects, obtained by using total station Leica TCR407Power. The points measured on the real objects were treated as error-free reference points. In result, the studies shows that the planimetric offsets for 3D building models are below 10 cm, and the vertical offsets are at the zero level.





## Contents

(in alphabetical order)

<i>Dalibor Bartoněk</i>	
ALGORITHM FOR FINDING A HAMILTONIAN PATH IN GRAPH.....	3
<i>Dalibor Bartoněk, Jiří Bureš, Irena Opatřilová</i>	
PROCESSING OF ENORMOUS AMOUNTS OF GEOGRAPHICAL DATA.....	4
<i>Jiří Bureš, Otakar Švábenský, Marek Kalina</i>	
CONCLUSIONS FROM LONG-TERM MONITORING OF LARGE SPAN ROOF TIMBER CONSTRUCTION .....	5
<i>Jiří Bureš, Otakar Švábenský, Alexej Vítula, Zdeněk Fišer, Michal Vojkůvka</i>	
GEODETTIC MONITORING FOR THE DIAGNOSTICS OF A HISTORICAL RAILWAY BRIDGE .....	6
<i>Stefan Cacoń, Josef Weigel</i>	
TWENTY YEARS OF COOPERATION BETWEEN THE INSTITUTE OF GEODESY – WROCLAW UNIVERSITY OF ENVIRONMENTAL AND LIFE SCIENCE AND THE BRNO UNIVERSITY OF TECHNOLOGY.....	7
<i>Kazimierz Ćmielewski, Janusz Kuchmister, Piotr Gołuch</i>	
CONTACTLESS GEODETTIC MEASUREMENTS OF ELONGATED ENGINEERING OBJECTS BY USING LASER BEAMS.....	8
<i>Stanislava Dermeková, Dalibor Bartoněk</i>	
INTEGRATED SUPPORT FOR COMPLEX DECISION MAKING IN RELATION TO THE PRICE-SETTING FACTORS .....	9
<i>Edyta Hadaś</i>	
ACQUISITION OF DIGITAL WATER SURFACE MODEL FROM ISOK FLOOD HAZARD MAPS.....	10
<i>Tomasz Hadaś</i>	
IN HOUSE DEVELOPED SOFTWARE FOR GNSS PPP REAL-TIME POSITIONING – GNSS-WARP .....	11
<i>Paweł Hordyniec, Witold Rohm</i>	
COMPARISON OF RADIOSONDE AND GPS-RO PROFILES OVER POLAND .....	12
<i>Olgierd Jamroz, Janusz Badura, Monika Łój, Sławomir Porzucek</i>	
WILKANÓW FRAMEWORK FAULT BASED ON GEOPHYSICAL DATA, SUDETY MTS., SW POLAND .....	13
<i>Małgorzata Jarzabek-Rychard</i>	
3D BUILDING MODELING USING ROOF TOPOLOGY GRAPHS .....	15
<i>Jiří Ježek</i>	
CYCLE PATH GIS OF MORAVIAN WINE TRAILS .....	16
<i>Josef Jurčík</i>	
ALTNET – CREATION OF HOMOGENOUS SET OF ALTIMETRY DATA FOR LONG-TERM ANALYSIS .....	17

<i>Katarzyna Kopańczyk, Magdalena Fitrzyk</i>	
THE POTENTIAL OF REMOTELY-SENSED DATA FOR SUPPLYING CHOSEN LAYERS OF SOZOLOGICAL MAP – THE STUDY CASE IN SUDETY MOUNTAINS .....	18
<i>Radim Kratochvíl, Kateřina Brátová, Tereza Hynčicová</i>	
GEOMETRICAL AND TEMPORAL CHARACTERISTICS DETERMINATION OF DEVICE FOR ANTENNA CALIBRATION .....	19
<i>Vlastimil Kratochvíl</i>	
TRANSFORMATION OF PLANE COORDINATES BASED ON A REGULAR GRID OF IDENTICAL POINTS ON THE TERRITORY OF THE CZECH REPUBLIC.....	20
<i>Michal Kuruc, Radovan Machotka, Tomáš Volařík</i>	
EVALUATION OF QUASIGEOID MODEL CREATED BY GNSS/LEVELLING METHOD .....	21
<i>Jaromar Łukowicz, Adam Iwaniak</i>	
IDENTIFICATION OF EVENTS AND PROCESSES IN LINKED OPEN DATA GENERATED FROM SDI RESOURCES .....	22
<i>Radovan Machotka, Richard Kratochvíl</i>	
MAAS-1 – MODERN MEASURING SYSTEM FOR DETERMINATION OF ASTROGEODETTIC VERTICAL DEFLECTIONS .....	24
<i>Krzysztof Małkowski, Janusz Kuchmister, Kazimierz Ćmielewski, Piotr Gołuch</i>	
A DETERMINATION OF SUBSIDENCE OF BUILDINGS BELONGED TO THE WROCLAW UNIVERSITY OF ENVIRONMENTAL AND LIFE SCIENCES.....	25
<i>Małgorzata Mendela, Andrzej Borkowski</i>	
COMPARISON OF ALPHA SHAPE AND DRAW POLYGONS ALGORITHMS FOR DELINEATION OF WATER BODIES IN AIRBORNE LASER SCANNING POINT CLOUDS.....	26
<i>Grzegorz Mianowski, Adam Iwaniak</i>	
TOWARDS AUTOMATIC URBAN LANDSCAPE CHARACTER ASSESSMENT USING GEOTAGGED IMAGES.....	27
<i>Adam Michalski, Wiwiana Szalińska, Tamara Tokarczyk</i>	
THE EFFECT OF DIGITAL ELEVATION MODEL SOURCE ON HYDROLOGICAL APPLICATIONS.....	28
<i>Lubomil Pospíšil, Otakar Švábenský, Josef Weigel</i>	
GPS NETWORKS, GEOPHYSICS AND REMOTE SENSING – TOOLS FOR MORE DETAIL COMMON COOPERATION .....	29
<i>Wojciech Sowa</i>	
AN ATTEMPT TO IDENTIFY THE MOVEMENTS OF SELECTED POLISH TECTONIC STRUCTURES ON THE BASIS OF VELOCITIES OF ASG-EUPOS PERMANENT STATIONS.....	30
<i>Marek Strzelecki, Adam Iwaniak</i>	
SPATIAL FEATURE CHARACTERISTICS EXTRACTION FOR ONTOLOGY CREATION PROCESS.....	31

<i>Otakar Švábenský</i>	
TPS AND GNSS MONITORING OF INTERACTION BETWEEN RAILWAY TRACK AND BRIDGE CONSTRUCTION .....	33
<i>Marek Trojanowicz, Krzysztof Gawron, Edward Osada</i>	
ACCURACY OF GRAVITY DATA PREDICTION AND ITS EFFECT ON THE ACCURACY OF LOCAL QUASIGEOID MODELLING – CASE STUDY FOR THE AREA OF POLAND .....	34
<i>Przemysław Tymków, Mateusz Karpina, Edyta Hadaś, Małgorzata Jarząbek-Rychard, Andrzej Borkowski, Anna Bogoliubova</i>	
3D SPATIAL DATABASE SUPPLYING IN ASPECT OF CITYGML STANDARD.....	35
<i>Viliam Vatrt, Josef Jurčík</i>	
VERTICAL SHIFT OF THE KRONSTADT HEIGHT DATUM TO GLOBAL VERTICAL REFERENCE FRAME IN CENTRAL PART OF EUROPE (CZECH REPUBLIC, POLAND) .....	36
<i>Josef Weigel, Radim Kratochvíl</i>	
ACTIVITIES OF INSTITUTE OF GEODESY BRNO UNIVERSITY OF TECHNOLOGY IN MORAVIAN KARST .....	37
<i>Izabela Anna Wilczyńska, Kazimierz Ćmielewski</i>	
MODERN MEASUREMENT TECHNIQUES IN SAFETY ISSUES OF THE CONSTRUCTION ELEMENTS .....	38
<i>Marcin Ziąja, Andrzej Borkowski</i>	
ACCURACY ANALYSIS ON 3D BUILDING MODELS RECONSTRUCTED FROM CO-REGISTERED TERRESTRIAL AND AIRBORNE LASER SCANNING POINT CLOUDS.....	39