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# 3D GIS TECHNOLOGY MORE ACCURATE GIS EVERY-DAY-REALITY

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***Географическое пространство может быть описано с помощью Географических информационных систем (ГИС). В них входят программное обеспечение, оборудование, данные, алгоритмы, процедуры для обработки информации и обеспечения доступа к ней, а также люди, которые используют систему, и юридические, технологические и организационные процедуры. ГИС широко применяется в таких исследованиях, как «Программы защиты окружающей среды», в многочисленных отчетах и документах по пространственному планированию, тематическим задачам, моделированию природных явлений и других действиях, связанных с менеджментом (Zero, 2011). Это ощутимая помощь для специалистов и политиков для лучшего понимания некоторых явлений.***

***Geographical space can be described with the Geographic Information System (GIS). It consists of software, hardware, data, algorithms, procedures for processing information and accessibility, as well as the people who use the system and the legal, technological and organisational procedures. GIS is commonly applied in such studies as "Environmental Protection Programmes", and in numerous reports and documents regarding spatial planning, thematic tasks, modelling of natural phenomena and other management-associated actions (Żero, 2011). It is a significant help for specialist and policymarkers to better understand some phenomena.***

**Introduction** Production of advanced surveying instruments and the dynamic development of the Information Technology (IT) have a huge impact on extending the possibilities of GIS (Geographic Information System) technology, in particular in the field of acquisition, gathering, processing and visualization of spatial data. The greater emphasis on unification of data standards, the greater opportunity to automate processing and visualization of spatial data. The initiative to create a spatial data infrastructure, allows easy access via the Internet, by means of a variety of geospatial web services to a richer spatial data resources (Chojka, 2011). The purposes of this article are as follows: to present laser scanning technology which allows for very rapid acquisition of 3D information and to review current technologies and standards for 3D GIS.

**Geoinformation systems** is a technology that has many practical applications in spatial analysis in many different areas. It enables to get information about the spatial objects. Rapidly grows need for 3D information as well as the ability to visualize spatial data, especially the possibility of presenting them in the spatial and temporal context (Stoter and Zlatanova, 2003). 2D GIS solutions have limitations in the analysis of certain events. For example, changes in the models of natural phenomena like changes in the water level (flooding), or in the monitoring of air pollution and etc.

**3D Technology Geographic Information Systems – GIS 3D (3D Graphical Information System).** Nowadays, 3D GIS is used in many areas of the economy: in architecture, urban planning, cartography, environmental protection, etc. The use of 3D GIS technology allows to make a transition from a flat paper map to the virtual map and build three-dimensional models of the real world. Such models let to conduct simulations of processes and events of different types. They are increasingly replace two-dimensional maps and databases (Tymków et al, 2010). Creating spatial models requires high-speed measurement methods for acquiring reliable

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data about terrain and objects geometry as well as fast and reliable algorithms for modeling. For data acquisition now is used airborne and terrestrial laser scanning technology. Terrestrial laser scanning technology, thanks to its precision and spatial resolution enables to reconstruct the geometry of the objects in macrostructural approach where its shape is modeled as an external contour and in microstructural approach, where the object of the modeling is the shape and topology (Wieczorek, 2013). Scanning technology allows to quickly deliver a large dataset called “point cloud”. "Point cloud" is then a subject of the processing by means of the specialized software (Kaminski, 2008).

**Overview of laser scanning technologies.** Laser scanning provides discrete (point) information about the earth's surface and all objects located on it (Borkowski, Jóźków, 2006). Result of scanning is the set of points, each of which has coordinates XYZ, and collateral information such as intensity or number of subsequent reflection. An overview of laser scanning technology is presented below. The criteria are the location of the scanner in the space and the manner of performing the measurements.

**Satellite Laser Scanning SLS** is performed by systems located on the satellite orbits. SLS is mainly used in monitoring of ice cover, monitoring of atmospheric changes and changes in the dynamics of urbanization.

**Airborne Laser Scanning ALS** is executed from the aircraft, manned and unmanned. ALS is applied for creating highly accurate 3D models of large areas, in modeling engineering structures, mapping of the linear objects such as power lines, stations, in forest inventory and monitoring. ALS enables to generate DTM (Digital Terrain Model) and DSM (Digital Surface Model). Data from ALS can be visualized and edited in Esri GIS overlay software such LP360.

**Mobile Laser Scanning MLS** is an example of the laser scanner integrated with a digital camera mounted on the mobile platform (e.g.car). It is primarily used to inventory infrastructure such as roads or railways.

**Terrestrial Laser Scanning TLS** is performed in static mode from one or more positions. It is mainly used to determine the precise shape of individual objects in space (e.g.: architectural inventory). Data from TLS usually are processed in software supplied by terrestial scanner producers such as Leica Cyclone, CloudWorx.

**3D Object Modelling**. On the basis of airborne laser scanning technology and by means of various software tools (e.g.: LP360), models of buildings at three levels of detail (LoD0, LoD1, LoD2) can be generated. LoD0 is a DSM with optional added texture from aerial photos, suitable for the representation of the landscape. Modeling buildings at LoD1 is identified as a simple block model buildings with flat roofs. Buildings at LoD2 are most often built-up areas of the city and are characterized by the ability to distinguish the orientation and shape of the roof (Wężyk, Maślanka, 2012).

**Example of ALS in ISOK Poland 2010-2013.** Airborne laser scanning was made for ISOK project (Informatyczny System Osłony Kraju – National Guards Computer System). Data was obtained according to standard I and II. 20% od standard I (4 points/ m2, 6 points/ m2; area outside the cities) and 86% of standard II (12 points/ m2, urban area). ISOK product obtained from ALS is presented in figure 1.

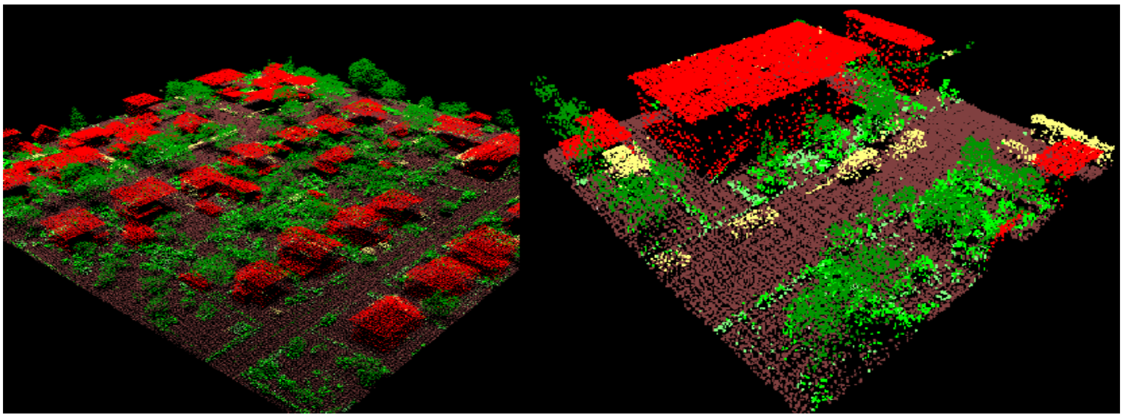

*Fig. 1. ISOK product obtained from ALS (Source: Matusiak, 2012. www.furgo.com)*

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**An example of a 3D model.** Potentialities of using geoinformation technologies and terrestrial laser scanning for monitoring of meandering section of the river were evaluated in study in 2012. Results from measurement by means of Scanner Scan Station C10 in a station JAJKOWO, Drwęca river, is presented in figure 2.

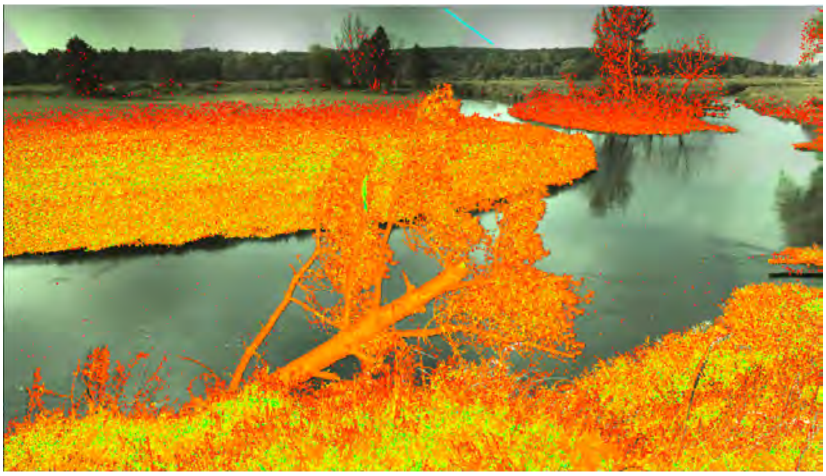

*Fig. 2.Graphical representation of measurement in a station JAJKOWO*

Obtaining 3D model from TLS requires a few stages of data processing. One of them is initial automatic point filtration (Figure 3), and then correction in interactive mode.

*Fig. 3. Point cloud from TLS after the initial filtration (Own work)*

**Overview of 3D technologies and standards in the GIS.** The most popular 3D technologies and standards that can be used in conjunction with GIS technology are presented below. **CityGML** (OGC, 2008) is a standard OpenGIS ®. It is an open data model and XML-based format for the storage and exchange of virtual 3D city models (http://www.opengeospatial.org). CityGML is an application schema for the Geography Markup Language (GML3). It was the extendible international standard for spatial data exchange 'issued by the Open Geospatial Consortium (OGC) and the ISO TC211. The aim of the development of CityGML is a common definition and reach of the basic entities, attributes, and relations of a 3D city model. This is especially important with Respect to the cost-effective sustainable maintenance of 3D city models, allowing the reuse of the same data in different application fields. CityGML allows to create 3D models, depending on needs and their destination, at different levels of detail LoD. There are five levels of detail (Figure 4).

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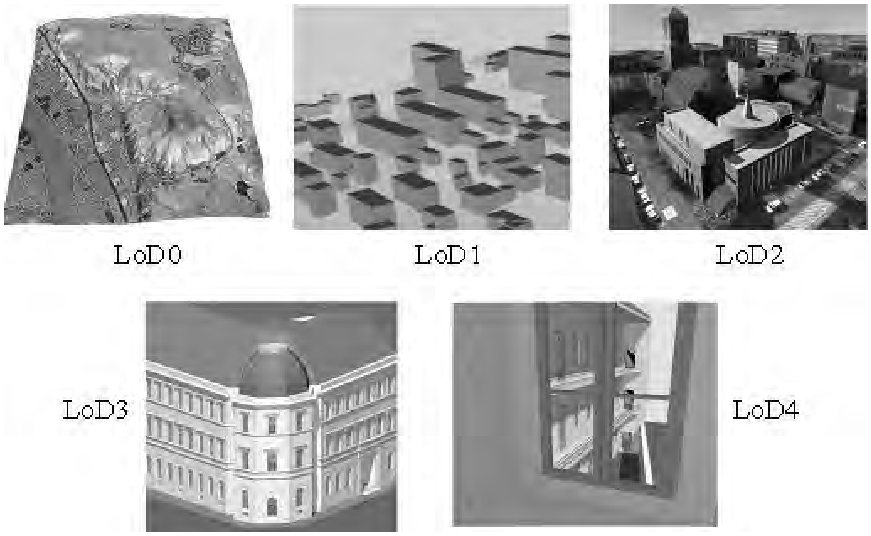


*Fig. 4. Accuracy of five levels defined in CityGML (Source: Kolbe, Bacharach, 2006)*

CityGML defines the classes and relations of the major topographic features with emphasis on their geometrical, topological and external properties. It includes generalization hierarchies between thematic classes. CityGML comprise of a core module and several extension modules. The core module contains the basic concepts and elements of the virtual city. Expansion modules deal with specific parts of the expansions. Extensions do not need the whole data model, but use the parts that suit current needs.

**KML** (ang. Keyhole Markup Language) is an XML language, is an international standard maintained by the Open Geospatial Consortium focused on geographic visualization, including annotation of maps and images. Geographic visualization includes not only the presentation of graphical data on the globe, but also the control of the user's navigation in the sense of where to go and where to look. KML is a file format used to display geographic data in an Earth browser, such as Google Earth, Google Maps, and Google Maps for mobile (https://developers.google.com).

**Web 3D Service** (W3DS) is a portrayal service for three-dimensional geodata, such as landscape models, city models, textured building models, vegetation objects, and street furniture. Geodata is delivered as scenes that are comprised of display elements, optimized for efficient real time rendering at high frame rates. 3D Scenes can be interactively displayed and explored by internet browsers with 3D plugins, or loaded into virtual globe applications. A W3DS is capable of handling data sets of a wide range of scales, from full globes down to smaller immobile objects such as lanterns which are still of geographic relevance. It can handle data sets consisting of multiple Levels of Detail for each object, thereby greatly increasing performance without sacrificing quality (Draft for Candidate OpenGIS® Web 3D Service Interface Standard, 2010).

**X3D** is a scalable and open software standard for defining and communicating real-time, interactive 3D content for visual effects and behavioral modeling. It can be used across hardware devices and in a broad range of applications including CAD, visual simulation, medical visualization, GIS, entertainment, educational, and multimedia presentations. X3D provides both the XML-encoding and the Scene Authoring Interface (SAI) to enable both web and non-web applications to incorporate real-time 3D data, presentations and controls into non-3D content. X3D is the successor to the Virtual Reality Modeling Language (VRML). It improves upon VRML with new features, advanced APIs, additional data encoding formats, stricter conformance, and a componentized architecture using profiles that allows for a modular approach to supporting the standard and permits backward compatibility with legacy VRML data (http://www.web3d.org).

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**Conclusion.** The fourth dimension in geoinformation systems is achieved by adding a parameter describing the time, but it's not real time, but only a simulation taking into account the change of spatial objects in the specified time interval, for example, changes in land-use and climate change. The challenge for the development in GIS technology are tools capable of displaying 4D GIS spatial information dynamically, in real time. Using these applications you can keep track on the effects of flooding, traffic growth, the development of fire or other emergencies dynamics and etc. The fifth dimension allows to consider in the GIS cost factor. The future of GIS is the development of 5D, 6D and 7D. The last one would reflect so faithfully the reality that user does not only get information about the spatial location of an object that interests him, but also be able to hear and feel (texture, temperature, pressure, humidity) and get to know the flavor of the surrounding area (Chojka, 2011).

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