A Shift from 2D Design Paradigm of the 19th Century to 3D/CityGML, BIM, 3D Printing and Some of Smarter Cities in Poland

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1 ABSTRACT

A road from paper-based- administration of the 80-ties to Smart Cities of today is being showed in this paper. Shift from paper do digital environment started with regaining of Polish independence in 1989, 26 years ago. The first e-mail from Poland was sent in 1990 year, 19 years after the first e-mail on the world of Ray Tomlinson (1971). Transfter of legal responsibilities, legal power, competences and finance from the top to local levels resulted in revolution in IT sector, which was the first commercial sector running in apost comunist country, in the 80-ties and the beginning of 90ties.Pressure for changes was visible exspecially in the biggest cities, and were initially connected with process of "mucicipalization" – i.e. – transfering of ownership of land from the state level to the level of municipalities. Signum Tempori of this time, was a process of transfer of state owned land to the city property of the City of Gdansk, where more than 30 000 real estates of of the market value of 750 million US dollars were transferred and became municipal between 1992 and 1994 years.More and more LIS (Land Information Systems) and GIS (Geographic Information Systems) were implemented, without interoperability rules and standards. Lack of ability to adapt centrain common standards between State Surveying and the biggest cities resulted in appearance of more than 20 graphical applications and more then 20 textual databases applications which required later substantial efforts and costs to overcome information chaos. 10 biggest metropolitan Polish Cities spend more then 3 times than the General Office of Geodesy and Cadasrte of Poland, between 1991 and 1994. Gradual implementaion of INSPIRE Directive and the Law of National Infrastrructure of Spatial Information created unprecedented shitf from paper maps and paper records to almost all digital Poland. Expenditures of c.a. 650 million PLN were assigned to creation of digital representaion of all 34 data layers of INSPIRE Directive for the impelmentaion period of 2010 to 2019. Nevertheless, this amount has been almost doubled in the first 3 years, taking into acccount expenditures of only regional and local GIS/SDI Projects.Polish spatial and economic conditions created spatio-economic background, within which more than 65 % of GDP of Poland is located within 12 metropolitan areas, and at the same time around 67 % of Polish GDP is being generated by more than 4 million of micro or small businesses (often small "family" businesses.).Polish Spatial Planning Law of 2003 has weakened spatial planning regulation, allowing for certain "exception from the rule", which became a new rule in itself. Basically, this "door" in the law to obtain building permint outside the borders of local development plan – resulted in issuing of more than 700 000 building permits – all located ouside territories of local spatial development plans between 2003 and 2015.Therefore we observe freely flowing process of urban sprawl on one hand and increased land consumption, expecially in the peri-urban zones of all metropolitan cities, and on the other hand, from the economic point of view – Poland has experienced unprecedented GDP growth in recent 10 or 12 years.Nevertheless several really interesting projects have been kicked-off by metropolitan cities, regions and General Survey of Poland (GUGIK). One of the most interesting projects – ISOK (Informatic System of State Protection against Extraordinary Threads) was impelmented between 2011 and 2015, at the cost of c.a. 300 million PLN, resulting in creation of laser scanning data for 92 % of territory of Poland. Continuation of this project was secured in the autumn of 2015 year, devoting budget of 189 million PLN for the project called CAPAP (acronyme from " Centre of Spatial Analysis of Public Administration), which aim is to provide 3D model of all buildings in Poland, in compliance with CityGML LOD 2 (second Level of Detail), withing the time frame 2016 – 2018. So, all territory of Poland will become 3D in 3 years time in accordance with CityGLM LoD2 and some studies and pilot projects going in this direction are being described in this paper. Some recent exercises with 3D printing of new urban projects are being reported at the end of article.

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2 FIRST 3D MODELS OF CITIES IN POLAND

2.1 Metropolitan Area of Warsaw Project, Centertel, Geosystems Polska, 1997

Revolution in 3D visualization with excellent compter graphics of Silicon Graphic Workstations reached Poland in 1993 and 1994. A lot of Indy, INDIGO2 and O2 workstations were used at this time in Poland. GEOSYSTEMS Poland LLC was established in 1995 and equipped with INDIGO2 and Indy Workstations, with Stereographics Crystal Eyes 3D glasses – started a project for one of mobile phones prodiver company – Centertel. In the result of project, aimed for collection of 3D models of buildings for UMTS network planning (1997), a stunning project for area of Metropolitan Area of Warsaw (ca 2500 km²) has been completed in less than a year, resulting with ca 140 000 models of buildings in 3D, stereodigitized from stereoscopic aerial images.[1]

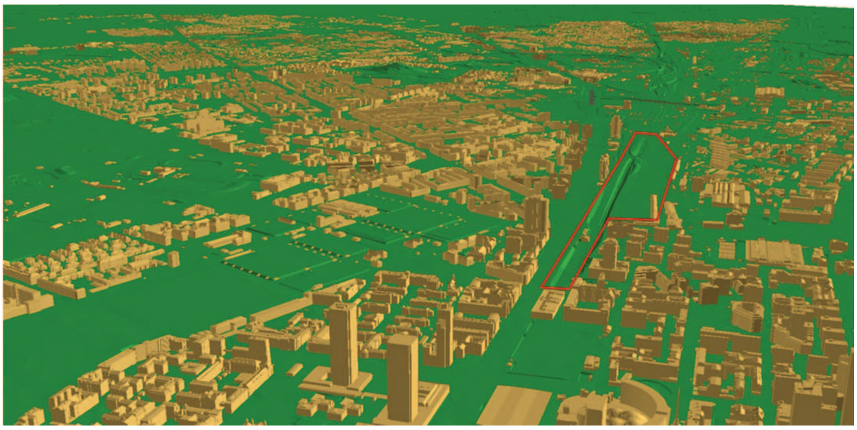

Fig. 1: screenshot from 3D model of Warsaw, build by GEOSYSTEMS Poland in 1997 for Centertel, with red polygon, indicating site for a new development project, to increase compact character of city centre of Warsaw.

2.2 Intelligence meet Geospatial and 3D / Iraq and what this has common with Google KML and Google Earth ?

KML stands for "Keyhole Markup Language" – memorizing Key Hole (KH) reconnaissance US satellites, belonging to KH-series satellites, started to be developed withing the framework of CORONA Project.

It seems that "First Infomration War on Iraq" from 1991 has been also a battle/test field for a lot of new technologies and the end of certain epoque for other older technologies. Declassified report of one of American generals stated clearly, that generation of older US intelligence satellites was no longer adequate for growing information needs. War in Iraq, Yugoslavia and some other conflicts gave birth for other technologies, namely VHR (Very High Resolution satellites), like of IKONOS, Quickbird, Worldview series (in USA) and Pleiades satellites in Europe. Moreover, the ownership of Keyhole company (2001), initially co-funded by CIA/NGA, Sony , was passed to Google(2004) and already Google has launched Google Earth application and led to much wider usage of KML format.

2.3 3D Models of 55 Cities in Poland, fruits of IKONOS Satellite Ground Station in Poland, 2005

While the creation of 3D model of Warsaw Metropolitan Area within the timeframe of one photogrammetric season was perceived as success in 1997, similar projects could not be treated as success in the beginning of next decade. Mobile network operating companies paid enourmous fees for obtaining of UMTS Licenses in Poland, while their needs for 3D models of all cities could not be met quickly due to too small number of companies with proper experience in 3D a, reaoperating at this time olish market.

With the purchase of IKONOS satellite groundstation in 2003, this situation has dramatically changed. It took 14 months to prepare investment blueprint (6 months) and to physically build and test (8 months) 20 million USD investment into Earth Surveillance Satellite ground Station. and the first image with 82 cm resolution from IKONOS satellite was received directly to the antenna dish on September 30th 2004.

[1] W.FEDOROWICZ-JACKOWSKI, Internal company information from the realization of contract between GEOSYSTEMS Polska, sp. z o.o. and PTK Centertel, Warsaw, 1997

Winter season 2004/2005 was used for the detailed preparation of next photogrammetric season, and within 2005 photogrammetric season images of 42 Polish Cities were acquired in stereographic mode, resulting in 3D models of more than 1,3 million buildings in the same year, with average speed of 3D digitization of. Ca 1000 buildings per person per one working day.

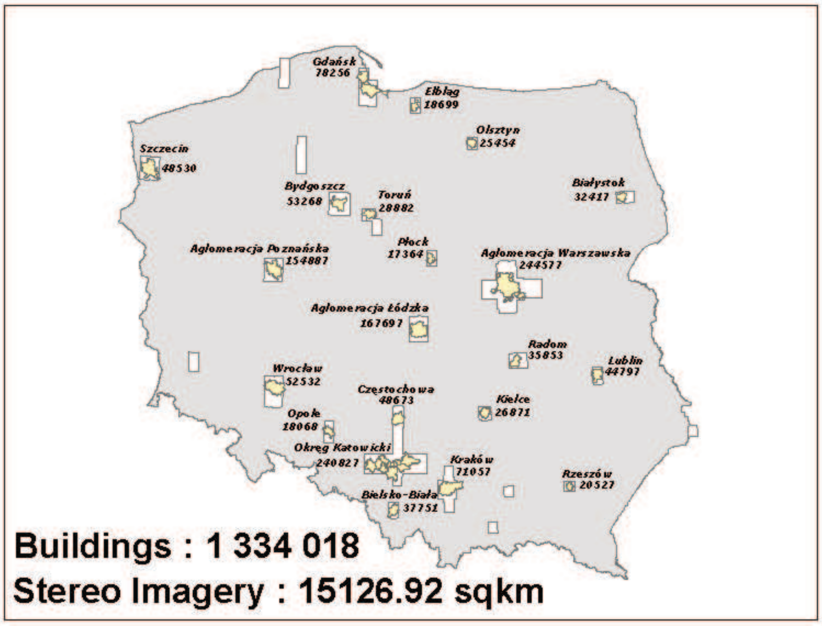

Fig. 2 : Collection of IKONOS satellite srereopairs for 42 cities of Poland by SCOR SA, resulted in acquisition of 15 126,92 km², what allowed for construction of simplified 3D models of 1 334 018 buildings in 2005

Stereodigitizing was realized the same day, mmediately after imagery collection of each IKONOS stereopairs, reducing greatly time (end cancelling the former need do develop regular Kodak 9” x 9” film frames and the time of their scanning). Obviously, accuracy of 3D models, derived from stereodigitizing of satellite imagery was much lower then this of the aerial photogrammetry, but the time-trade-off was very significant.

While in year 2000 there were only 2 companies in Poland, which could deliver 1 or max 2 city models in 2000 year each, executing contracts for mobile operators, the 2005 IKONOS campaign delivered 3D models for 55 cities and lead to creation of more than 1,3 million 3D buildings. The level of detail of therse models of buildings was obviously much lower than the one being achoieved today. Basically, these models were simplified volumes of the buildings, most of them with rectangular 3D shapes. Geometric quality of these models was between submeter accuracy for “x” and “y” axis and around 2 meters for “z” axis. Speed, consistency of this method, rigid process of quality control were important enough to convince owners of all mobile network operating companies – to buy these 3D models from TECHMEX SA – the executing arm of this contract and the owner of the data.[2] The second serious client for 3D models of cities – were the cities alone. Majority of the 3D data models of all collected cities were sold to them in the next years. Cities used this type of data for building of spatial planning applications and took actions to model the noise models, mainly for areas of city centres (according to the noise Directive of the EU)

[2] M.BOROWSKI R.LACH, W.KUZNICKI, A.KOWALCZYK, , Realized project of 3D City Models of 42 Polish Cities, on the basis of extraction of vector data from stereopairs of IKONOS imagery, 26th EARSeL Symposium, New Developments and Challenges in Remote Sensing, 3D Remote Sensing Session, Warsaw, Poland, May 29th – June 2nd, 2006

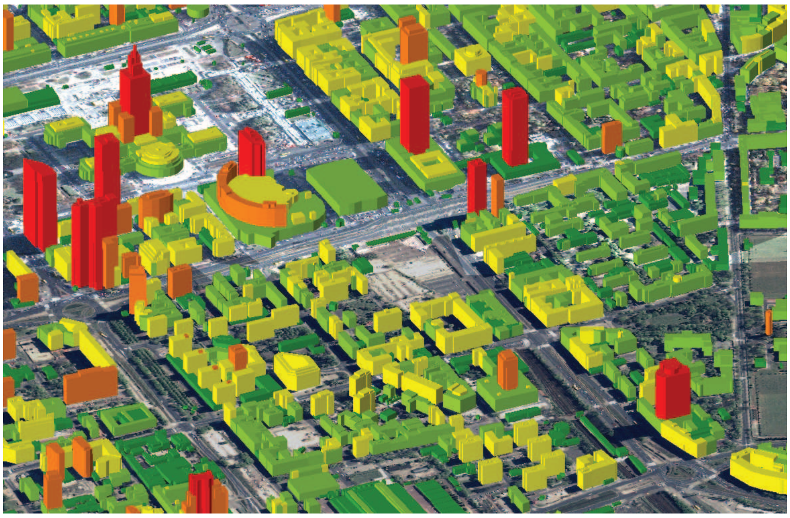

Fig. 3: 3D model of centre of Warsaw, derived from stereopais of IKONOS satellite, 2005

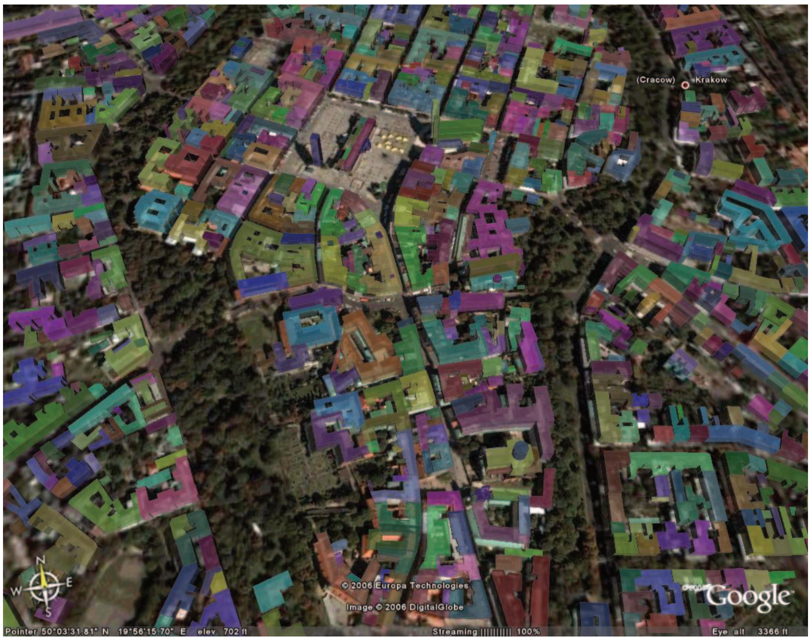

Fig. 4. 3D Model of the City of Krakow from stereodigitization of IKONOS satellite imagery, exported to KML format, shown in Google Earth,2005

2.4 3D Models of Polish Cities, in time frame 2006 to 2014

Invention of first digital photogrammetric cameras (UltraCamD, Vexcel, DMC) provided next boost for development of 3D models and applications. First photogrammetric aerial camera was purchased by MGGP Aero in 2007. MGGP Aero was earlier present at traditional Polish market. Gradually more and more companies were using digital photogrammetric cameras.

Variety of 3D models of Warsaw exists, and it’s natural in the market driven economy, that various forces try to position themselves on rich-geospatial content market. Architects and developers used to build 3D models of buildings of new buildings, mainly, high-scrapers in the centre of Warsaw, using most often SketchUp tool (by Trimble) often also used for visualization of ancient monuments and/or historical buildings. Cities alone announced more and more public tenders with aim to produce 3D models of cities, consisting of Digital Elevation and Digital Terrain, Digital SurfaceModels (DEMs, DTMs, DSMs), vegetation models, road/railway/metro and 3D building models.

Obviously, as each city developed ita own TOR/SOW(Terms of Refference/Scope of Works) specifications, resulting city models differ one from the other and obviously you could not pick 2 cities and have the same information backbone of their 3D models. Most of Polish bigger cities built their own 3D models, but all of them have various x,y,z accuracies, various level of details as well as various semantic content.There are some cases and some characreristics of 3D models of some biggest cities of Poland, described below.

Fig. 5: 3D Model of historical centre of Warsaw, built in 2006

2.4.1 Warsaw

First 3D model of Warsaw was built in 1997, however its aim, as described at the beginning – was to satisfy the needs of mobile network operating company for Warsaw metro area. First, more detailed 3D model of the centre of Warsaw was acquired in 2006.

This 3D model was built from strereodigitizing of new aerial photos. Textures were acquired from terrestrial photos, which were processed further and drapped over 3D wireframe model. Cost of this model was at the level of ca 8258,06 PLN /1 km²

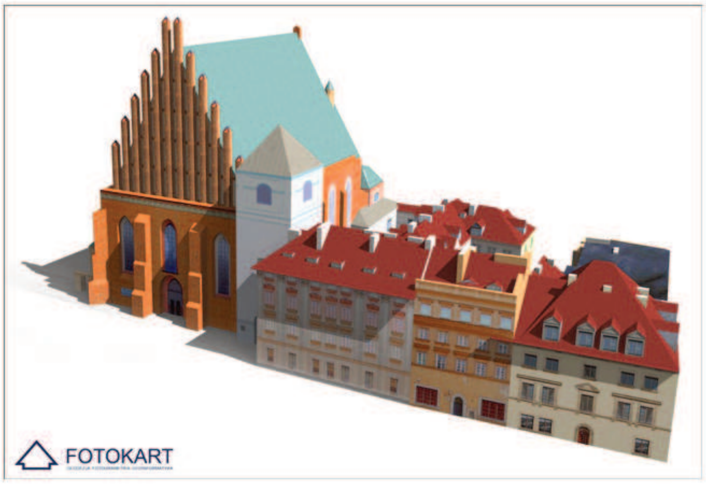

Fig. 6: Example of the level of details of 3D model of historic city centre of Warsaw. One of blocks., 2006

2.4.2 Gliwice

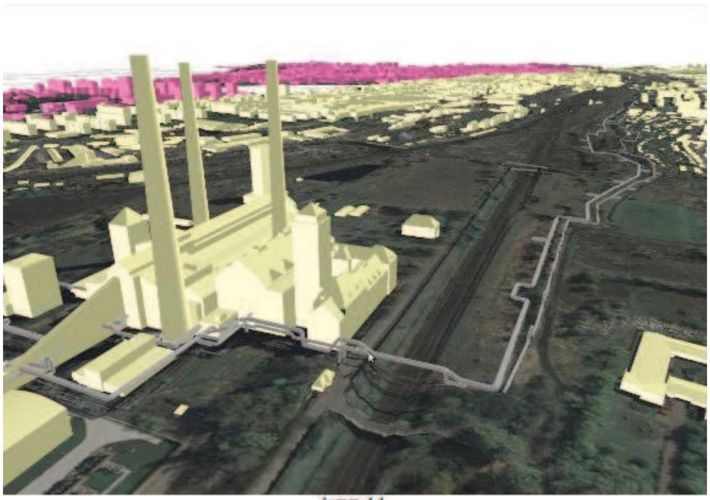

Fig. 7: Screenshot from Aurora application, industrial building, 3D model of Gliwice, 2007

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3D Model of Gliwice was built with greater accuracy in the very centre of the City, and the smaller accuracy for the rest of the city, coverig area of 133,88 km².

Cost of this model was 2906,93 PLN/ 1 km²

2.4.3 Toruń

The City of Torun has requested the elaboration of 3D model in 2013. Detailed model of historic centre of Torun was created, allowing for some basic database operations. While you open webpage with 3D model you can adjust your graphical user interface, selecting desired layers of data for display and manipulation, set up some basic viewing properties, etc.

Interesting approach was taken in the City of Toruń, where data from several sources were combined and merged. 3D models of buildings were elaborated, taking the data from aerial photos and existing databases. It may be observer however, that there is a lot discrepancies between true geometry of the newly acquired LIDAR data (aerial laser scanning data with denstity of 12 points/1m²)

Cost of the model 3966,90 PLN/1 km².

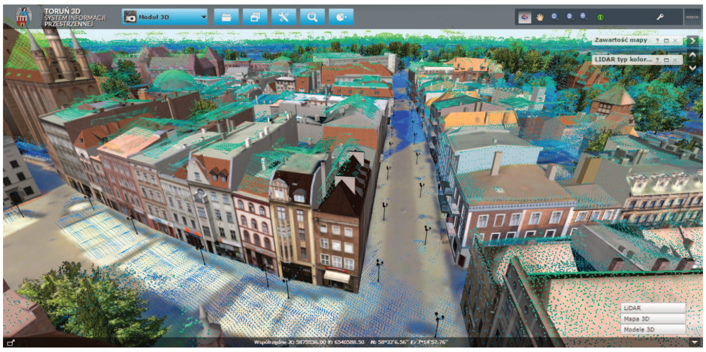

Fig. 8: Combining detalied building models of historical centre of Toruń with LIDAR point clouds, 3D module of Toruń's City geoportal.

2.4.4 Wrocław

City of Wrocław didn't organize any tender for execution of 3D model of the City. 3D model of the City has been worked out instead by the offic staff of the City of Wrocław, with LoD 0 and LoD 1 levels, mostly with the use of ESRI software environment.

Fig. 9 3D model of the City of Wrocław, a 3D module of the city geoportal.

City of Wrocław invested recently (2015) into acquisition of new digital photos and orthophoto of 5 cm resolution which provides a lot of details, previously not able fod precise identification.

Fig.10 Ortophoto of Wrocław with 5 cm resolution, acquired in 2015, displayed in urban geoportal of Wrocław.

2.4.5 <u>Lublin</u>

City of Lublin intends to complete its 3D Model until the end of 2017 year and curently some test works with usage of digital photogrammetry and the use of the LIDAR data were executed in 2015. The City of Lublin has also acquired two coverages of the LIDAR data for the entire City territory, in 2013 and 2014 years. The first LIDAR data coverage was acquired from Main Office of Geodesy and Cartography of Poland with density of 12 points/ 1 m² . Next coverage of LIDAR data was acquired in 2014, with the density of ca 25 points/1m². Both these LIDAR coverages of Lublin have also images collected from digital cameras.

Department of Architecture of the City promoted the use of the LIDAR data among the city officers and more then 50 persons were trained in usage of LIDAR data LiMON Viewer from DEPHOS Software company. Since LIDAR point cloud data of Lublin were installed in Server/Desktops architecture with LiMON Server and 70 LiMON Viewer licenses – a growth of 3D analyses became gradually visible in recent 2 years. Moreove, cooperation of the city administration with Lublin Faculty of Architecture and with Supercomputing Centre of Swierk (NCBJ) created som eadditinal spin-off effects. Usually these are surveyors, who specialize in 3D laser scannning services in Poland, while in Lublin a series of 3D scanning projects arose from architectural society at the Faculty of Architecture of Lublin Polytechnic.

TESTS of EFFICIENCY and of ACCURACY of 3 D model of LUBLIN in 2015.

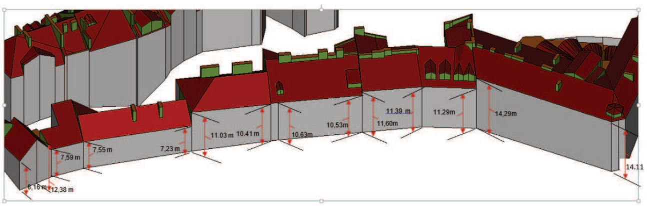

Fig.11 : 3D model of the Test area 1, derived from stereodigitizing of aerial photos, 2014

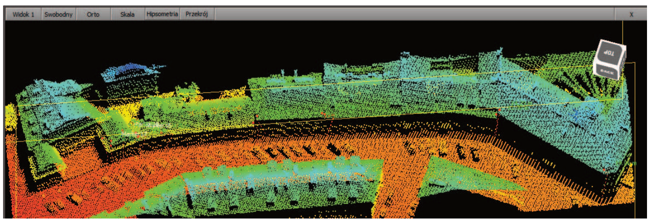

Fig. 12: 3D point cloud from laser aerial scanning (LIDAR data) of ISOK project, Test area 1

3 Test areas were selected in Lublin in order to determine best methods of data collection and processing, aiming to create CityGML standard compliant 3D models, at Level 2 and Level 3 of the detail of CityGML specification.

Fig. 11 shows 3D model derived from stereopairs of aerial photos of Lublin, acquired by MGGP Aero in 2014, Fig. 12 shows the same test area by LIDAR dataset of ISOK project, with density of 12 points/1m². Relative hights of buildings elevation were measured independently in Bentley V8 viewer (for model derived from stereodigitizing) and in LiMON Viewer (for measurements from point cloud data). Result of these measurements were compared in a table below :

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No of point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Relative height Measured on model	8,61	11,56	13,31	11,34	8,19	8,16	12,38	7,59	7,55	7,23	11,03	10,41	10,63	10,53	11,60	11,39	11,29	14,29	14,11
Relative height Measured on ISOK LIDAR point cloud	8,62	11,31	13,38	11,33	8,15	7,64	12,58	7,,63	7,75	7.50	11,09	10,70	10,74	10,47	11,73	11,45	11,30	14,29	14,06
Δ h = difference in height measurements in[cm]	**1**	**25**	**7**	**3**	**4**	**48**	**20**	**4**	**20**	**27**	**6**	**29**	**10**	**6**	**13**	**6**	**1**	**0**	**5**

Table 1: Comparizon of relative hight of the buildings from stereodigitizing anf from LIDAR measurement

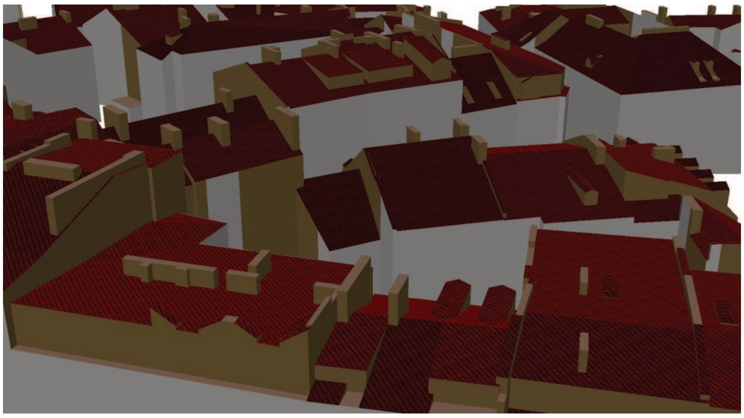

Fig.13: sample model 3D, CityGML LoD 2, with roof details from stereodigitizing

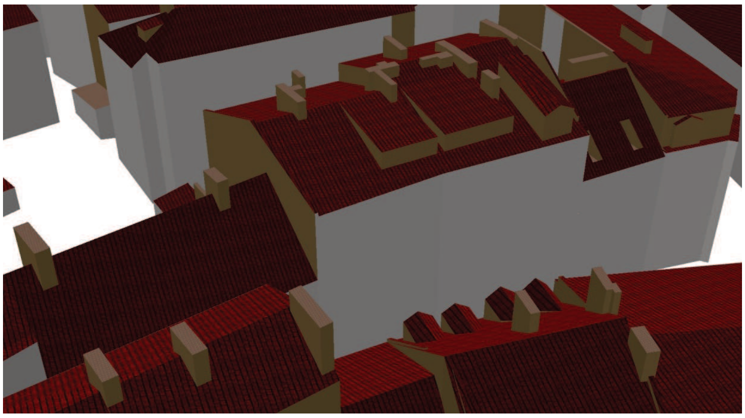

Fig.14: sample model 3D, CityGML LoD 2, with roof details from stereodigitizing

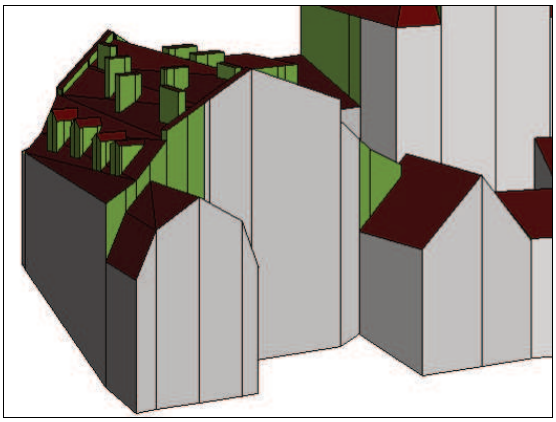

Fig.15: source data(aerial), Fig.16: Model 3D derived from stereodigitizing

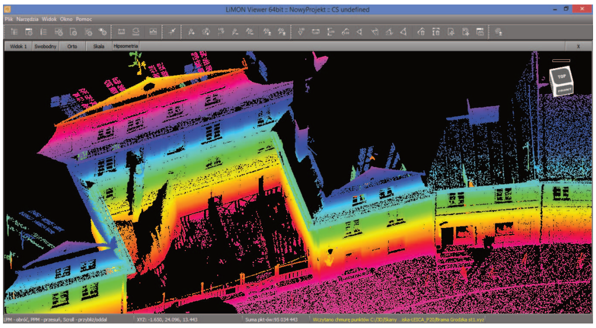

Fig.17: LIDAR from terrestrial scanning are excellent data source for buildings elevation details

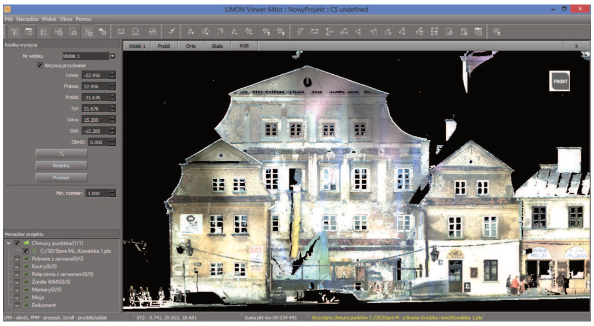

Fig. 18. Result of terrestrial laser scanning, PTS format (z,y,z + color data), scan by LEICA P20

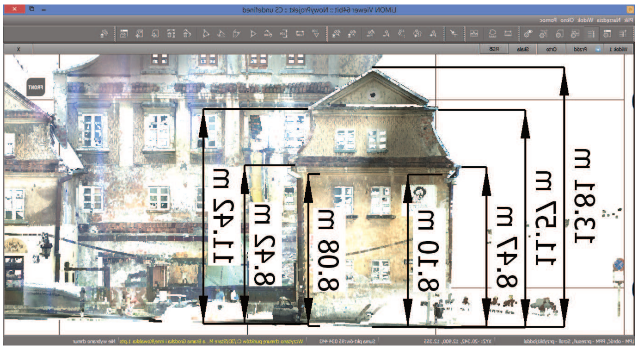

Fig.19: Terrestrial laser scan of the building, Leica P20, PTS format – idea tool for measurement

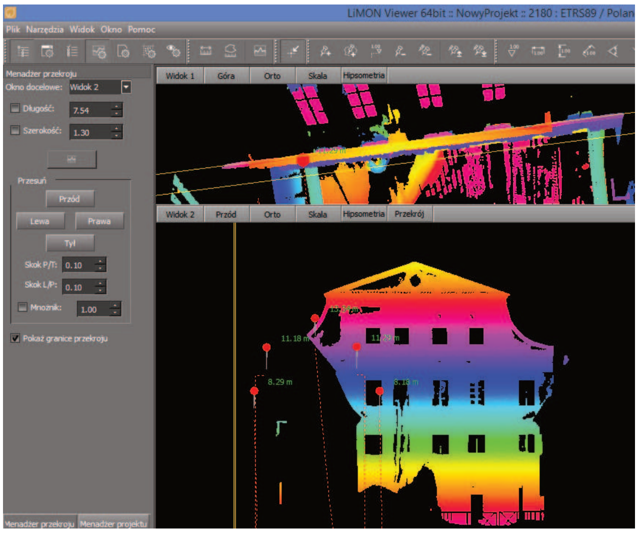

Fig.20: 3D data of terrestrial laser scans are ideal complementary data source for aerial scannning or data derived from stereodigitizing of aerial photos.

As it can be seen on Fig. 15-Fig.20 – terrestrial scanning data are ideally complementary to aerial data. When relying on aerial data while stereodigitizing complex roof shapes of the buildings, especially in the dense environment of historical city centres – operators of stareodigitizing stations often can have problems with exact interpretation of particular details of roof. Fig 15 and Fig.16 ilustrate the case, when operator of

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digitizing station made a mistake, while digitizing the building roof. The building on the right side is digitized with mistake. Adding terrestrial laser scan data, one can achieve complimentary data source, which is ideal for completion of the full CityGML model in 3D, with LoD 3 – the third level of detail of the buildings.

A state-wide projects of 3D buildings are usually picking up the second level of detail, since the third level of detail requires adding the windows, doors of the buildings, and this alone – without adding data from terrestrial laser scans – might be very difficult, if not the impossible.

3 REAL EFFICIENCY AND ECONOMY OF SCALE – ISOK PROJECT (2011-2015)

It took almost 1,5 year for Main Office of Geodesy and Cartography of Poland to prepare Executive Study of the ISOK Project. ISOK is the acronyme for : “Informatic System for Extraordinary Threats of the State”. ISOK Project was and answer for anti-flood activities, and taking into account 2007 floods (cost over 4 billion PLN, more than 15 lives lost), the State authorities decided to spend ca 300 million of PLN (around 75 million USD) to implement the system.

The King died, Long live the next King. Since era of Very High Resolution has beed captured by Google (Google Earth) and era of digital cameras was used by Microsoft (BING) a new phonomenon has been born and more widely used in geospatial world – the world of LIDAR.

Almost whole Poland’s territory was covered by LIDAR data coverage with density of 4 LIDAR points per 1m² in rural areas and with density of 12 points/1m² in the areas of 203 Polish Cities within timeframe of 2011-2015.[3]

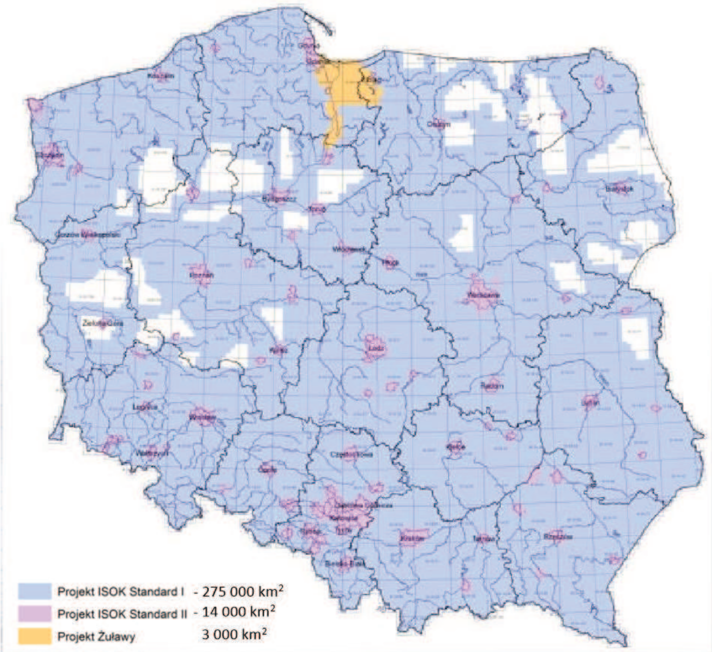

Fig. 21: Areas of ISOK Project. Blue : LIDAR Coverage 4p/1m²(rural) , Pink : 12 p/1m² (203 cities)

4 BENEFITS AND CONSTRAINTS OF CITYGML STANDARD

4.1 Benefits

Its good that CityGML standard was approved by OGS as OGC standard. One could get a headache from monitoring the evolution of 3D data file formats. Starting from the early times of prof. Greenberg experiments at 70-ties and 80-ties at the Cornell University, Silicon Graphics development impulse (early 90-ties), SIGGRAPH heritage, and the “volcanic” eruption of various 3D file formats. This has created

development and adoption by OGC the CityGML standard – we can observe gradual growth of interoperability in the 3D environment, between various user groups.

[3] P.WOŹNIAK, Status of Distribution of LIDAR/DEM/DSM data of ISOK Project, Main Office of Geodesy and Cartography, Warsaw, 2014

As observed by SOM (Skidmore, Owings & Merill) and others, there are no single universal software tools, which could fit the requirements of all participants of the design/planning process. Using even more sophisticated packages, like Revit from Autodesk, it is usually required to use whole range of various applications, applied for construction calculations, AM/FM applications, sun/shading, modelling, visualization, investment planning, project management, so usually it takes from 9 to 15 various project packages, involved into the whole planning/execution cycle. Obviously – this is possible only for bigger planning/development companies, since "one-man show" or "family" businesses – still can not afford the purchase of expensive software toools. The majority of the Polish small design beauros, architectural ateliers, still uses either 2D version of Autocad (LT) or Archicad, - withius sophisticated 3D funcionalities.

	Standard/Criterion	VRML	X3D	KML	COLLADA	IFC	GML3	CityGML	DXF	SHP	3D PDF
1	Geometry	++	++	+	++	++	+	+	++	+	++
2	Topology	0	0	-	+	+	+	+	-	-	-
3	Texture	++	++	0	++	-	+	+	-	0	+
4	LOD	+	+	-	-	-	-	+	-	-	-
5	Objects	+	+	-	-	+	+	+	0	+	+
6	Semantic	0	0	0	0	++	0	++	+	+	+
7	Attributes	0	0	0	-	+	+	+	-	+	+
8	XML based	-	+	-	-	+	++	+	-	-	-
9	Web	+	++	++	+	-	-	+	-	-	0
10	Georeferencing	-	+	+	-	-	+	+	+	+	+
11	Acceptance	++	0	++	+	0	0	+	++	++	++

- not supported; 0 basic; + supported; ++ extended support

Table 1 Comparison of various features of 3D data formats.

Nevertheless, earlier formats CAD formats (*.DGN, *.DXF, *.DWG) have their own strong limitations. Visible shift towards IFC and B.I.M. takes place in some EU countries. With the visible shift to more opened data policies its getting easier and easier to use Open Data layers, bacground landscape information (DEMs, DSMs) as required surrounding environment of the architectural / urban objects.

Deep implementation of INSPIRE Directive, and earlier proces of implementain of various LIS/GIS solutions came to a point, where the entire Poland will go "digital" up to 2020, including more than 32 million of digital cadastral parcels and more than 25 million of buildings. Last year announcement of the authorities of Operational Programme "Digital Poland" about funding of CAPAP project, gives a hope, that all the buildings in Poland will be converted to CityGML (LoD2) within timeframe of 2016-2018.

So far, 3D models of the biggest cities of Poland were built with various accuracy requirements, in different timeframe, with various scopes of semantic information, and mainly for historical city centres. Recent decision on funding of CAPAP Project (Earlier Acronyme "Polska 3D+") – gives a hope, that all models of buildings will have the same semantics, the same accuracy, the same level of detail, and that it will be posisble to make searches across the Internet, due to the fact, that WebGL and object thinking about buildings must be finally applied.

4.2 Constraints

CityGML overcomes all former problems of various 3D formats, and its most complete, ie provides all aspects of 3D information, like : geometric, semantic and topological. CityGML is however relatively complex[4], with its detailed requirements. Majority of self-governments in Poland do not know yet how to deal with CityGML. Provided that even the whole Poland will be converted to 3D buildings within 3-4 years from today, the biggest problem seems - the willingness of adoption of the new 3D standard in all the units of selv-governments. There are around 100 biggest cities, 379 counties (powiats) and 2479 municipalities. Without the proper implementaion environment, tools to control proper creation of CityhGML- compliant buiildings it will take at least 4-5 years time before existing 2D reality will convert into 3D dream. Although CityGML is the best standard, taking into account its geometrical, semantic, and topological contexts, the mental adoption of CityGML will take at least several years in Poland.

[4] S.ZLATANOVA J.STOTER, U.ISIKDAG, Standards for Exchange and Storage of 3D Information: Challenges and Opportunities for Emergency Response, 2012

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5 RECENT PROJECTS OF AERIAL, TERRESTRIAL AND MOBILE LASER SCANNING

There are some Interesting projects going on in several cities. The City of Lublin trained more than 50 officers in usage of LIDAR – point cloud data, with the use of LiMON Viewer/LiMON Server solution.

Since the City asked the Main Office of Geodesy and Cartography – for delivering point cloud data of ISOK project (2013) and acquired new point cloud data (aerial laser scanning campaign) in 2014, as well as experimented with terrestrial laser scanning of the Old City, its level of preparation to implement CityGML standard grew up significantly in the recent 2 years. The City of Lublin requested the elaboration of 3D Model, acting together with the Main Office of Geodesy and Cadastre in Poland, as well as experimenting with first initial CityGML effort in some test areas of the city.

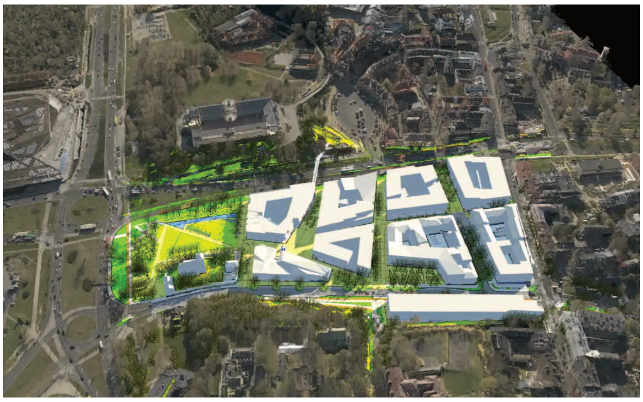

Fig.22. 3D model of "Podzamcze" district in the very centre of Lublin with backgound of LIDAR data

Fig. 22 is one of frames of animation of the new Spatial Development Plan of Podzamcze District, elaborated by PA NOVA SA (a planning & development company from Gliwice), approved at the City Council Meeting of the City of Lublin on May 21st, 2015. It must be explained here that Podzamcze area was very problematic, since this is a huge knot of various problems and various priorities of different groups of interests. However, due to very explanatory nature of 3D data and its animation, with synergy of the up-to-date LIDAR data – the Spatial Development Plan of Podzamcze District was approved, after rejection of 191 ammendments – to the plan – voted at the session of the city Council on May 21st, 2015. Complex knot of various problems was re-solved due to usage of 3D planning data and merged LIDAR point cloud data, (cooperation with DEPHOS Software and the use of their LiMON Viewer/LiMON Server solution. Ability to undertand complex 3D relations, ability to review all the project details by City Council Members, helped a lot. Thanks to this techniques, problem, which could not be solved from several years, has been effectively solved, provide the grounds for new investments, which will shape the new centre of Lublin in coming years. The City of Lublin is recently investing into a lot of development projects. Usage of various 3D data took place in recent 3 years in Lublin, starting with the use of original data from ISOK project, acquired in 2013, to new aerial laser scanning campaign of 2014 (with density of 25 points/1 m.sq.) to terrestrial laser scanning from Leica and Riegl (respectively P20 and VZ400 scanners) and the plans to use light helicopters to scan some more important – investment zones, to acquire newest coverages, later to be integrated from the various data sources and with usageof various data capturing technologies (stereodigitizing of aerial photos, autometic conversion of LIDAR data into 3D models, integration of data from terrestrial laser scanners).

The new era of 3D design and planning is well under way in Poland, and CAPAP Project will give huge additional boost, to make a significant shift from old design in 2D, of XIX-centrury paradigm to 3D/4D methodologies, ending up with 3D printing of the new development projects and delivering both CityGML and printed 3D Models of various development projects.

One os such an examples is given below, showing new urban development project oF PA NOVA SA in the Centre of Gliwice, Poland, modelled with CityGML (with usage of recent aerial and terrestrial laser scanning data) and printed with 3D printer.

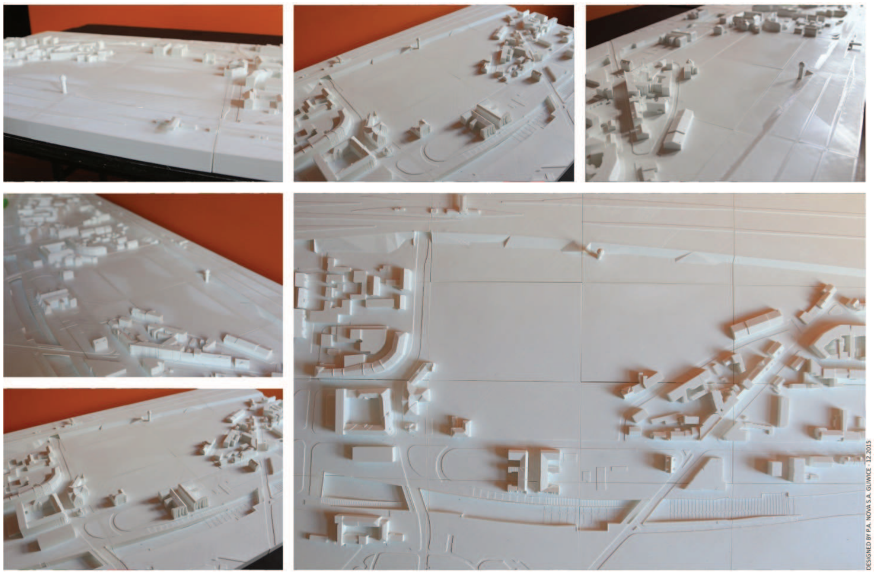

Fig. 23: 3D-print of 3D model of the City of Gliwice, courtesy of PA NOVA SA.

6 CAPAP PROJECT

Following big success of ISOK project -

CAPAP (is the acronyme for Center of Sptial Analysis of Spatial Information). CAPAP ss the follow-up project of ISOK Project due to big success of its predecessor.. The scope of this project includes – finishing the collection of LIDAR data collection for the entire Polsih Territory. Currently the coverage of the LIDAR data for Poland is at the level of 92 % of the whole Poland’s teritory. (for comparison LIDAR data for England scored for 72 % of England’s territory in September of 2015 year).

Collection of new LIDAR point could sets for 100 biggest cities is also scheduled within the project scope.

Creation of 3D buildings for 25 million buildings in Poland in accordance with CityGML Level 2, is also scheduled within the project scope between 2016 and 2018.

7 CONCLUSION

Completeness, accuracy, cost, funcjonality and new applications areas of 3D modelling of buildings and other complimentary data sets will strenghten Polish cities on their road to Smart Cities- behavioural patterns, in e fee years from now, along the production cycle of 3 dimensional information of the entire country. Poland in 3D will carry out next generation applications, even hard to imagine today. The proces has already started.

7.1 Completeness

Production of 3D datasets of buildings will provide whole country coverage of 25 million 3D buildings. The data on cadastral parcels, topographic database BDOT10k and CityGML LoD2 datasets will be available for the whole area of Poland (ca 312 000 km²)

7.2 Accuracy

Accuracy of 3D models of the Cities will be in the range from 20 cm to 40 cm. Planimetric accuracy might be very accurate for x/y coordinates, since mor ethan 200 cities have been mapped with 10 cm resolution orthophotos. “Z” accuracy – of the exisitng aerial scanning campaing of ISOK project proved to be in the range of 7 to 12 cm in th emajority of cases.

7.3 Cost

As explained above various cities generated their 3D models with various costs withing timeframe from 1997 to 2015. Comparing various independent projects – being carried out by the cities alone, and knowing cost factors of the CAPAP project it seems that the cost of creation of 3D model for particular Polish cities will be at least 5 times less expensive then earlier induvidual projects.

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7.4 Functionality

Is seems that recent developments of the CityGML test projects provide the hope that 3D City Models will be available directly on the Internet (like CityGML model of The New York, by T.Kolbe et al.[5]). 3D data of buildings will be accessible to browse and search through regular web browser.

Clicking on each building will open its attribute table, stored at the municipal database.

Semantic-rich data from BDOT10k databases will assist in serach and analyses of the required records.

7.5 New Applications Area

Its hard to invent various application fields, but ad other important projects already have showed (Berlin, Paris, Barcelona, Graz, The New York and dozens of others) each city can apply various features of 3D models for various application areas. Be it "Atlas of Energy"- like in the Berlin case, be it – sustainable development, be it "solar roofs potential", - or any other area. One could imagine, that the availability of 3D models not only possible on mainframes of the past, but also at regular servers, smartphones and tablets will open quite new applications areas, like augmented reality and others. One could imagine, being called from the boss to stay in particular city and manage few more action items. You could just see the surrounding 3D environment through your smartphone or tablet, /where are the nearest free places in nice hotels/ or maybe even use QR code to pay for the room – bought right from the street.

Imagination is the only limit.

[5] KOLBE, CityGML goes to Broadway, 2015