APPLICATION OF 3D TERRESTRIAL LASER SCANNING IN THE PROCESS OF UPDATE OR CORRECTION OF ERRORS IN THE CADASTRAL MAP

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APPLICATION OF 3D TERRESTRIAL LASER SCANNING IN THE PROCESS OF UPDATE OR CORRECTION OF ERRORS IN THE CADASTRAL MAP

1. Introduction

3D Terrestrial laser scanning

delivers **highly accurate** spatial data – needed for the geodesist

online access of the cadastral map in Bulgaria - **https://kais.cadastre.bg**

Fig. 1 Cadastral map online

in our case geodetic measurements and data processing were performed

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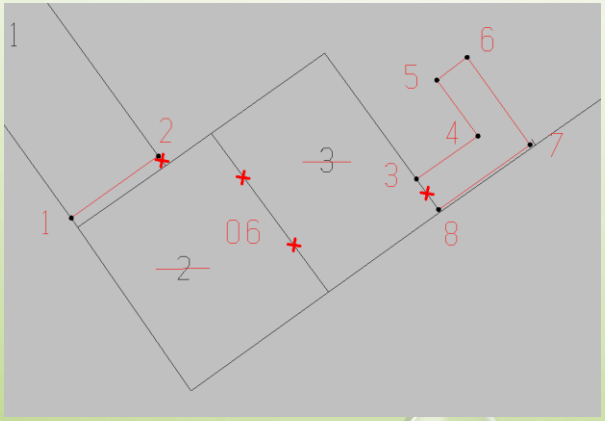

Fig. 2 Graphic for correction of the cadastral map

the errors / incompleteness should **be corrected**

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1. Introduction

In this specific case, digital model and project (fig. 2) were required for the update of the map

In the process of the measurements technical difficulties could be met

object, subject of this paper - located in a high density urban area

the geodetic measurements were processed and documentation was created

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2. Aims of this project

Usage of 3D terrestrial laser scanning for geodetic measurements in high-density urban area, as one contemporary way for **fast gathering** of spatial information

To **maximize** the field **productivity.**

To deliver **cost-competitive** final product.

Creation of documentation, according to the requirements of Ordinance N RD-02-20-5, 2017

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3. Important parts of the study

The implementation of the procedure has these **key sections**

Performing of geodetic measurements – 3D terrestrial laser scanning of the **object and its vicinity**

Creation of **point cloud and data extraction**

The **efficiency of the geodetic activities** - minimization of the work both in the open field (urban area) and in the interior (underground)

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4. Technical issues, which might require update/correction of the cadastral map

missing objects of cadastre (buildings, schemes of the separated objects on the relevant floor of a building, etc.);

incorrect contour of an existing object on the cadastral map.

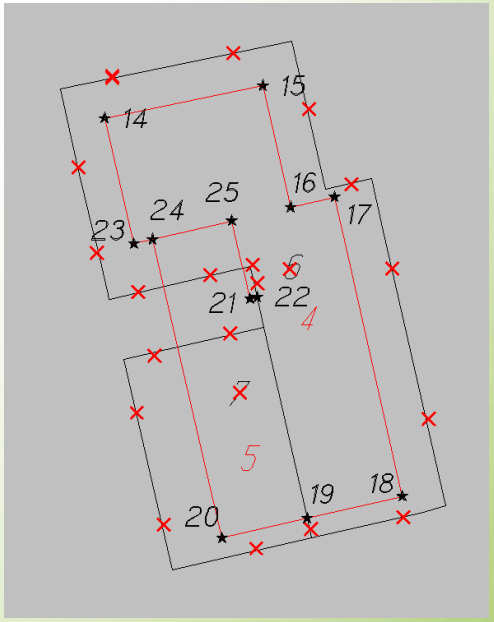

Fig. 3 Screenshot of a project for **correction** of the cadastral map

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5. The focus of the paper

a) conducting of geodetic measurements, using 3D laser scanning - **both in external and internal areas**;

b) creation of **reliable and accurate** 3D digital model;

c) **elimination of** the possibility for **errors** during the survey process and data handling;

d) extraction of the required data in the 2D space (in 2005 Cadastral coordinate system as required);

e) **minimization** of the work of the crew in the field

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5. The focus of the paper

This specific procedure uses:

a) up-to-date digital information (*.cad) from Internet (fig. 1);

b) contemporary surveying technology - 3D terrestrial laser scanning;

c) Trimble RealWorks

d) The viewer of Trimble RealWorks;

e) contemporary GIS software Mkad;

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6. The application of 3D laser scanning in our specific case

Key reasons to use the laser scanning in this project

a) object was situated underground, where the usage of other surveying equipment would be unreasonable;

b) object was “sealed” as it is at the moment;

c) It is almost impossible to be produced error/s/ in the final results;

d) possibility for creation of cross-section (fig. 9) of the object.

e) data was easy to be captured and delivered;

7. Reasons, which led to exclusion of other surveying equipment

a) object under study was situated in **high-density** urban area;

b) points from the national geodetic network were not existing;

c) **high productivity was required** as the trade activities in the object were cancelled during the measurements

d) distances between the instrument and the objects were short.

e) the human factor for errors **was eliminated**

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8. Advantages and disadvantages of the used technology, explicitly in our case

Advantages

possibility to capture all objects in full horizon within a short time period;

no need to keep a record for the description of the points – information could be structured in layers

highly-productive technology

easy to measure the necessary control points from other objects.

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8. Advantages and disadvantages of the used technology, explicitly in our case

Disadvantages

requirement for direct visibility between scanner-object;

the scanner's position must be very carefully considered;

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9. Technical difficulties - in the high density urban area and in internal places

Potential danger – risk from **falling natural material** (e.g. small branches or big leaves) from the tree onto the scanner.

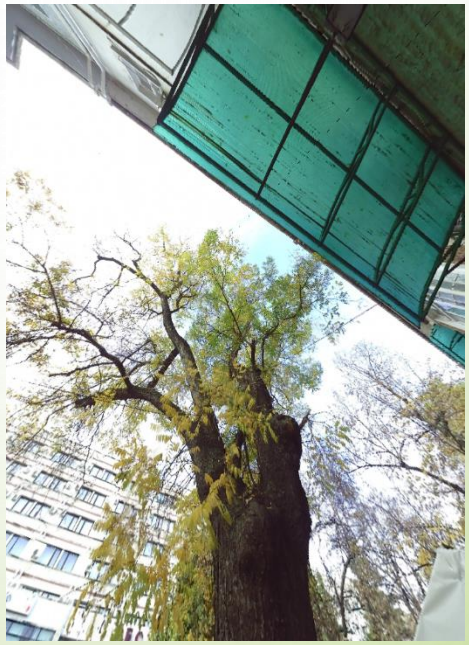

Fig. 4 The tall trees, situated next to the object

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9. Technical difficulties - in the high density urban area and in internal places

The photos were required for the further geodetic activities

→ The area in-between the scanner and the object should be **kept clear.**

slippery floor indoors imposed work in **dangerous environment**

→ / accessory required for stable fixing of the tripod in the extreme conditions

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10. Processing of the raw data. Final results from the geodetic measurements.

Registration Details

Station View | Advanced | Overall residual error: 0.000 m

Match with... | Unmatch | Auto-match all | Auto-match Station

Matched Station

Name	Scan Per Station	Corresponding Target	Scan Per ...	Residual Error	Delta N	Delta E	Delta El	Fitting Error	Distance to Scanner
Changer00	6			0.000 m					
001		001	2	0.000 m	-0.000 m	-0.000 m	0.000 m	0.000 m	5.659 m
002		002	2	0.000 m	-0.000 m	-0.000 m	-0.000 m	0.000 m	7.640 m
003		003	2	0.001 m	0.001 m	-0.000 m	0.000 m	0.000 m	6.156 m
004		004	2	0.000 m	-0.000 m	-0.000 m	-0.000 m	0.000 m	9.741 m
005		005	2	0.000 m	0.000 m	0.000 m	0.000 m	0.000 m	7.496 m
Target12		--	--	--	--	--	--	0.001 m	7.611 m
Changer00	6			0.000 m					
002		002	2	0.000 m	0.000 m	0.000 m	0.000 m	0.000 m	2.013 m
001		001	2	0.000 m	0.000 m	0.000 m	-0.000 m	0.000 m	2.424 m
004		004	2	0.000 m	0.000 m	0.000 m	0.000 m	0.000 m	3.477 m
003		003	2	0.001 m	-0.001 m	0.000 m	-0.000 m	0.000 m	1.455 m
005		005	2	0.000 m	-0.000 m	-0.000 m	-0.000 m	0.000 m	1.728 m
Target6		--	--	--	--	--	--	0.001 m	5.906 m

Fig. 5 Registration of the external stations

The scans were registered, using the **"Auto-extract Targets and Register"** menu option

maximum overall residual error 0.001 m.

fast and accurate registration process

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10. Processing of the raw data. Final results from the geodetic measurements.

Registration Details

Station View | Advanced | Overall residual error: 0.001 m

Match with... | Unmatch | Auto-match all | Auto-match Station

Matched Station

Name	Scan Per Station	Corresponding Target	Scan Per ...	Residual Error	Delta N	Delta E	Delta El	Fitting Error	Distance to Scanner
Changer003	**5**			**0.001 m**					
006		006	2	0.001 m	-0.000 m	-0.000 m	-0.001 m	0.000 m	2.751 m
007		007	2	0.001 m	0.001 m	-0.001 m	-0.001 m	0.000 m	3.125 m
008		008	2	0.001 m	0.001 m	0.000 m	0.001 m	0.000 m	2.558 m
009		009	2	0.002 m	-0.001 m	0.001 m	0.000 m	0.000 m	2.712 m
Target22		--	--	--	--	--	--	0.000 m	2.934 m
Changer004	**4**			**0.001 m**					
006		006	2	0.001 m	0.000 m	0.000 m	0.001 m	0.000 m	0.843 m
007		007	2	0.001 m	-0.001 m	0.001 m	0.001 m	0.000 m	0.938 m
008		008	2	0.001 m	-0.001 m	-0.000 m	-0.001 m	0.001 m	1.444 m
009		009	2	0.002 m	0.001 m	-0.001 m	-0.000 m	0.000 m	0.865 m

Fig. 6 Registration of the internal (underground) stations

overall residual error 0.001 m.

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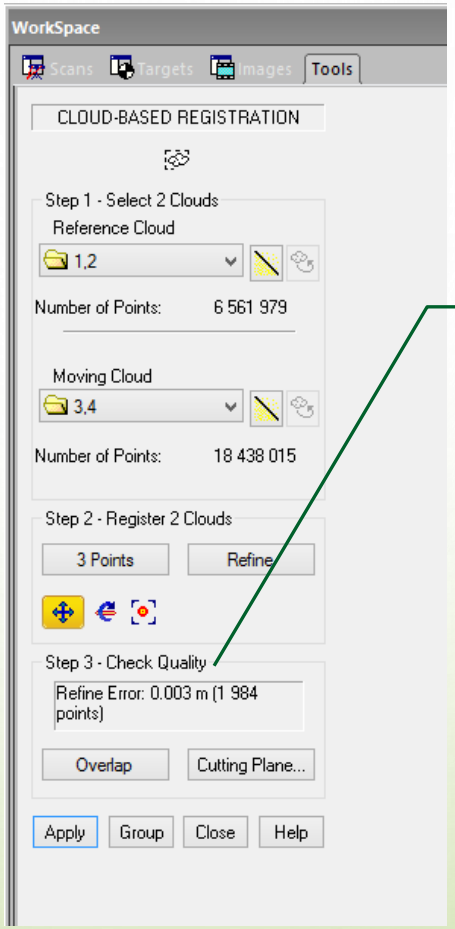
10. Processing of the raw data. Final results from the geodetic measurements.

"Cloud based registration"
was used -
due to the unique cadastral situation
– narrow entrance and steep stairs.



A refine error of 0.03 m. was calculated.

Fig. 7 Cloud based registration of the external and internal parts of the object

11. Application of the data from the laser scanning in our case

The point cloud of the united model

the cloud was used **further more** for data extraction

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Fig. 8 The underground object

11. Application of the data from the laser scanning in our case

One part of the digital product – the extracted horizontal cross section

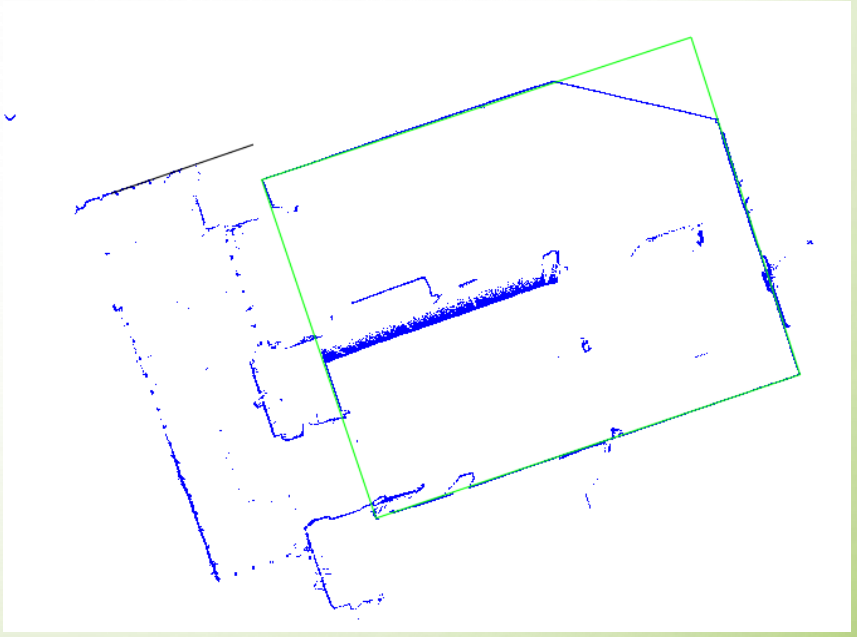

Fig. 9 The extracted contour of the object

The model was used to be created the so called *scheme of a separated object* on the relevant floor of the building

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11. Application of the data from the laser scanning in our case

The geometric information given in fig. 9 - used further on in software Mkad for creation of the *.cad file, required for the update of the cadastral map (fig. 10).

The final “shape” of the object with its ID, placed on the existing cadastral map

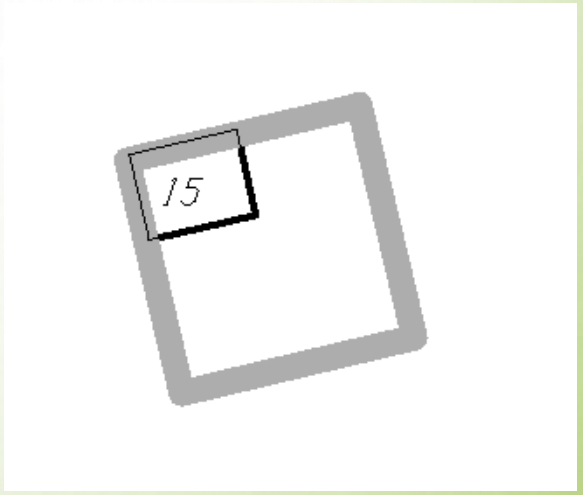

Fig. 10 Screenshot from the updated cadastral map

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12. Content of the final product

The digital geodetic production consists of:

- base information in *.cad format, bought from the Agency of Geodesy, Cartography and Cadastre;
- File in *.cad format with the required information for the update/correction of the cadastral map, **according to the requirements** of [Ordinance N RD-02-20-5, 2017].
- the data from the geodetic measurements, their processing and quality assessment.
- the coordinates of the new-determined points given in fig. 11.

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12. Content of the final product

The point cloud and the **extracted coordinates** of the contour of the object

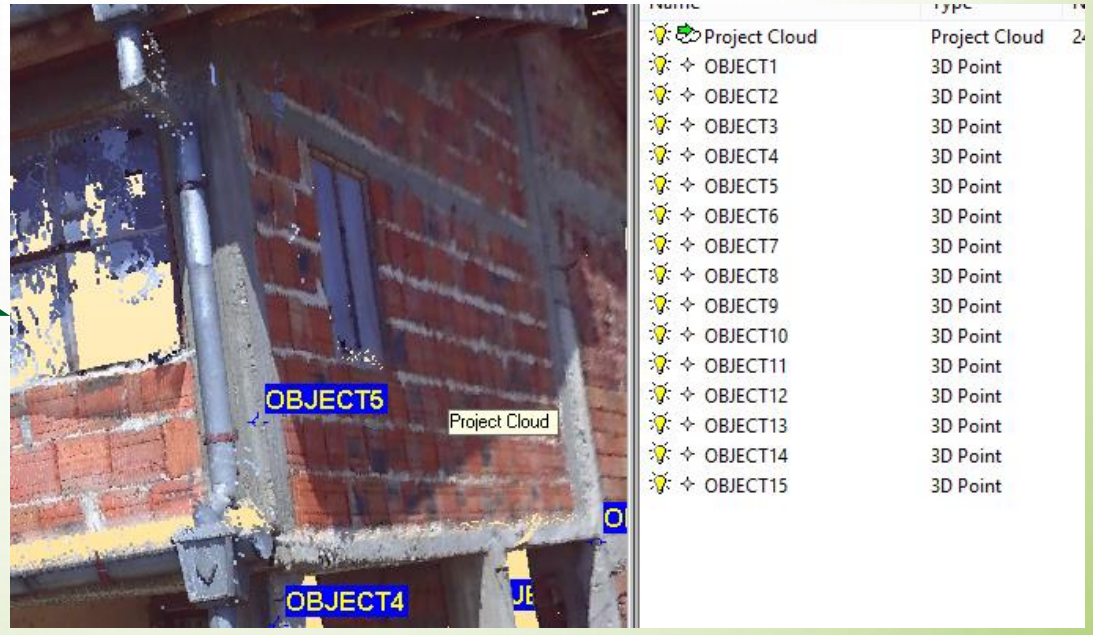

Fig. 11 The object and its coordinates

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13. Conclusion. Recommendations.

Ordinance N RD-02-20-5, 2017 requires performing of measurements in order to submit a **project for update/correction** of errors of the cadastral map

In the annex N 8 to article N 36 (2) of the above Ordinance the technology of laser scanning **was nowhere mentioned**, even though it satisfies completely the requirements for accuracy of the listed types of surveying methods for performing of geodetic measurements.

The update of the cadastral map was successfully completed, using:
-3D terrestrial laser scanning;
-the possibilities of the cited software;
-the described specific procedure.

The mentioned disadvantages and the difficulties met **did not reflect on the overall productivity** and reliability of the conducted geodetic measurements.

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13. Conclusion. Recommendations.

3D terrestrial laser scanning **eliminated the possibility for errors**, which might occur (if using the conventional surveying methods).

The applied surveying equipment **maximized the field productivity** - of **major importance** in the high density urban area.

The applied technology was a reliable one for geodetic activities **in this specific case**, taking in mind the nature of the object (**situated underground**).

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The application of other way for measurements was technically **ill-founded**.

13. Conclusion. Recommendations

Last, but not least the involved IT created a **step forward** to a **more productive procedure**, accurate and reliable final product based on the applied in our case 3D terrestrial laser scanning.

High quality of the digital model was obtained,
as shown from the final results:

- residual error in the target-based registration - **max. 0.002 m.**;
- overall residual error for the target-based registration – **max. 0.001 m**.;
- refine error of the cloud based registration - **0.03 m**.

13. Conclusion. Recommendations

It should be noted that:
-the **high productivity** in the field;
-the results from the **quality control**;
-the applied **technology** for update/correction of the cadastral map

were essential for the successful and reliable completion of the task.

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From the given information and final results it could be concluded:

- to be **proposed** an update of the normative documents, concerning the geodetic measurements /*especially in the area of the subject of this paper*/, taking in mind the **technical possibilities of the nowadays IT in land surveying**.

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14. Outlook

It would be recommended the **explicit addition** of 3D terrestrial laser scanning in the normative documentation, as **contemporary and precise surveying technology**, if update or correction of the cadastral map is required.

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1. Kostov, G. 2015, Application, Specifics and Technical Implementation of the 3D Terrestrial Laser Scanning for Measurement and Analysis of the Spatial Geometry of a Steel Construction. paper no 7625, pp 5. FIG Working week 2015. From the wisdom of the ages to the challenges of the modern world. Sofia, Bulgaria.

2. Milev, G. 2012, Laser and Radar Scanning. Magazine, pp 5-6, 3-12, "GKZ" issue 2012 - in Bulgarian.

3. Ministry of Regional Development and Public Works, 2017. Ordinance N RD-02-20-5 from 15 December 2016 for the Content, Creation and Maintenance of the Cadastral Map and Cadastral Registers, Pp 76-77 – Published in State Newspaper Issue 4/13.1.2017 - in Bulgarian.

4. http://tinyurl.com/pmz2hf6

5. http://tinyurl.com/pttjzxh - in French

6. http://tinyurl.com/pnqqabg

7. https://tinyurl.com/zgbs4nj

8. http://tinyurl.com/z2jpaqj

9. https://tinyurl.com/glxva27

10. http://tinyurl.com/gqk9d4t

11. http://tinyurl.com/hjv785u

12. https://kais.cadastre.bg - in Bulgarian

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REFERENCES:

USED SOFTWARE

1. Autocad (http://tinyurl.com/zc9mot3);

2. Mkad (http://kolma.bg/download.php);

3. Trimble Realworks (http://tinyurl.com/pdckrlr).

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