Combination of 3D Terrestrial Laser Scanning and GNSS Technologies for Measurement of hard /Impossible/ to Access Objects of Cadastre in the Process of data Acquisition for the Required Update of the Cadastral plan

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1. Introduction

on one hand - **3D Terrestrial laser scanning**

- technology, able to create thorough data set for the measured object

on the other hand - **GNSS**

- is one of the most accurate (*under certain conditions*) and productive technology

In this specific case - **Combination**

For our objects were performed geodetic measurements and data was processed by the relevant software apps.

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1. Introduction

The equipment acquired data for:

- hard /impossible/ to access objects;
- boundary control points;
- georeferencing.

3D information was extracted and digital models were created;

to update the existing, but **incomplete** cadastral plan

Fig. 1 A cadastral plan

2. Aims

a) **Combination** of both technologies – to perform the necessary geodetic measurements for ***specific*** cadastral objects;

- To **gain** field productivity;

- Creation of documentation and its submission in the relevant municipality to update the cadastral plan.

- To process the acquired data and analyse the results;

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3. Key parts of the procedure

a) scan of the object;

b) performing of GNSS measurements in RTK mode, including ***control ones***;

c) **elimination** of any possibilities for human errors;

d) processing of the raw data, incl. - ***georeferencing*** of the point cloud

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3. Key parts of the procedure

e) quality assessment of the results;

f) extraction of information from the point cloud;

g) creation of digital models (incl. *.cad) for the update of the cadastral plan – see fig. 2

Fig. 2 The updated cadastral plan

4. Application of 3D laser scanning in this specific case

Reasons to involve

3D terrestrial laser scanning

a) the objects - inaccessible /hard to access/;

b) the human factor for errors - **excluded** in process of data acquisition;

c) the information (3D coordinates of the edges of the cadastral object) - easy to be extracted from Trimble RealWorks;

d) unsurpassed **productivity**.

5. Application of GNSS equipment in this specific case

a) possibility for enormous **productivity** in the field;

b) **fast** acquisition of the necessary boundary control points;

necessary, due to:

c) very **high accuracy** of the processed data;

d) (almost) **impossible** to deliver erroneous results.

6. Implementation of the Combination of the Technologies on the Terrain

Part 1

3D terrestrial laser scanning

control points were stabilised, artificial targets placed over each control point;

- the visibility of the object from the scanner;

to be observed:

- direct visibility scanner - artificial targets;

- visibility scanner-targets in-between two adjacent stations.

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6. Implementation of the Combination of the Technologies on the Terrain

Part 2

GNSS measurements

a) GNSS equipment was installed on already chosen geodetic network point.

b) The control points - already created and stabilized, were measured using the rover – see fig. 3.

c) The measurements performed for:

- georeferencing of the point cloud;
- the boundary control points.

Fig. 3 The artificial targets on the street

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7. Analysis of the applied procedure

Advantages

a) no need to store additional records in the field. Process was simplified;

b) field crew requires only one high-qualified geodesist (another one not always necessary – depends on the terrain conditions);

c) in case of presence of natural material, the measurements with 3D terrestrial laser scanner were **technically reliable**;

d) **enormous** field productivity;

e) **high accuracy** achieved in the point determination;

7. Analysis of the applied procedure

Technological requirements

- two types of instruments have to be carried in the field.

- meteorological conditions should be observed in advance

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8. Processing of the raw data from 3D Terrestrial Laser scanning and GNSS Measurements

Input of the raw data from GNSS measurements in Geomax Geo Office – fig. 4

Point Id	Point Class	Date/Time	Posn. Qlty
110025	Reference	07/20/2017 15:01:53	0.0000
110024	Measured	07/20/2017 15:03:45	0.0097
110001	Measured	07/20/2017 15:06:12	0.0070
110002	Measured	07/20/2017 15:07:30	0.0077
110003	Measured	07/20/2017 15:07:51	0.0061
110004	Measured	07/20/2017 15:08:12	0.0072
110005	Measured	07/20/2017 15:08:39	0.0072

Fig. 4 List of the measured points and quality assessment

The results from GNSS measurements were converted in the appropriate format /using app *GNSSTransformations* – fig. 5/ and imported in Trimble RealWorks,

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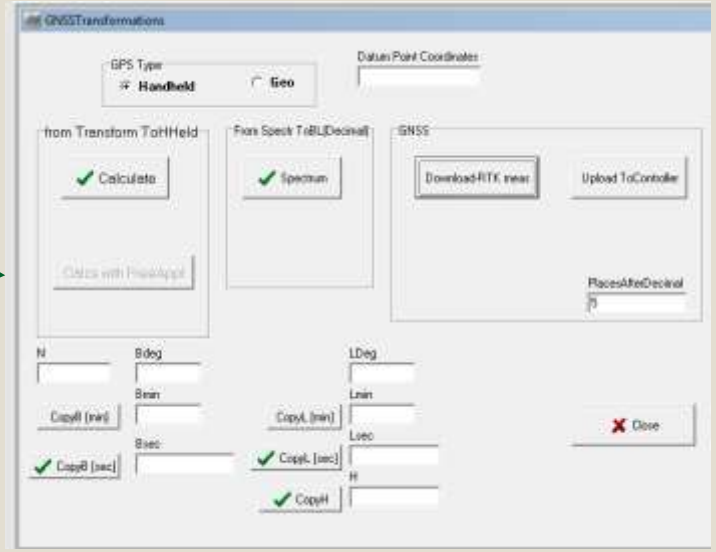

Fig. 5 App GNSSTransformations

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8. Processing of the raw data from 3D Terrestrial Laser Scanning and GNSS 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
Bast001	**5**			**0.000 m**					
003		003	2	0.000 m	-0.000 m	0.000 m	-0.000 m	0.000 m	10.901 m
004		004	2	0.001 m	-0.000 m	-0.001 m	0.000 m	0.000 m	7.216 m
002		002	2	0.000 m	-0.000 m	-0.000 m	-0.000 m	0.000 m	9.129 m
001		001	2	0.001 m	0.000 m	0.000 m	-0.000 m	0.000 m	9.747 m
005		005	2	0.000 m	-0.000 m	0.000 m	0.000 m	0.000 m	6.179 m
Bast002	**5**			**0.000 m**					
001		001	2	0.001 m	-0.000 m	-0.000 m	0.000 m	0.000 m	3.747 m
002		002	2	0.000 m	0.000 m	0.000 m	0.000 m	0.000 m	4.566 m
003		003	2	0.000 m	0.000 m	-0.000 m	0.000 m	0.000 m	2.864 m
004		004	2	0.001 m	0.000 m	0.001 m	-0.000 m	0.000 m	6.175 m
005		005	2	0.000 m	0.000 m	-0.000 m	-0.000 m	0.000 m	7.342 m

Fig. 6 Registration of the scans. Quality assessment of the results

high accuracy obtained - overall residual error - **0.000 m.**

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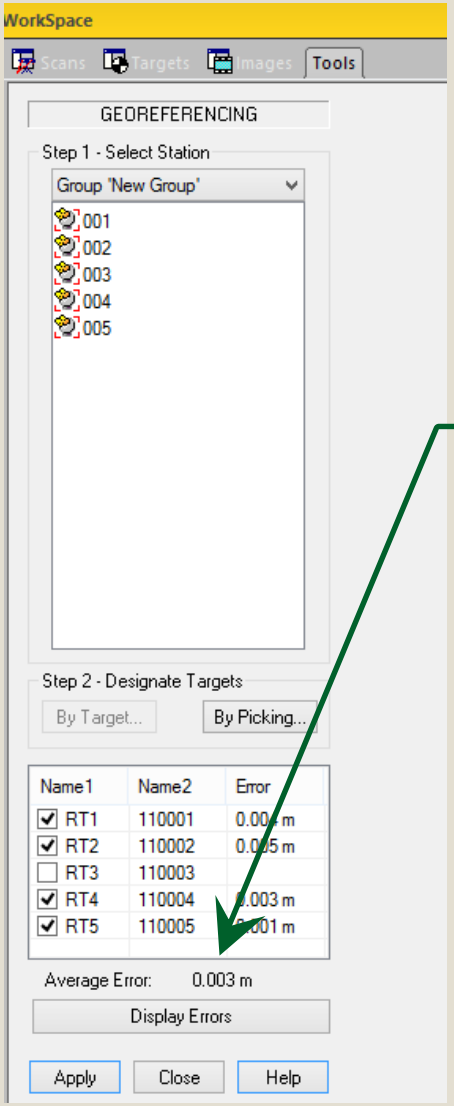
8. Processing of the raw data from 3D Terrestrial Laser Scanning and GNSS Measurements



Average error of **0.003 m**. was achieved.

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Fig. 7 Georeferencing of the point cloud.

8. Processing of the raw data from 3D Terrestrial Laser Scanning and GNSS Measurements

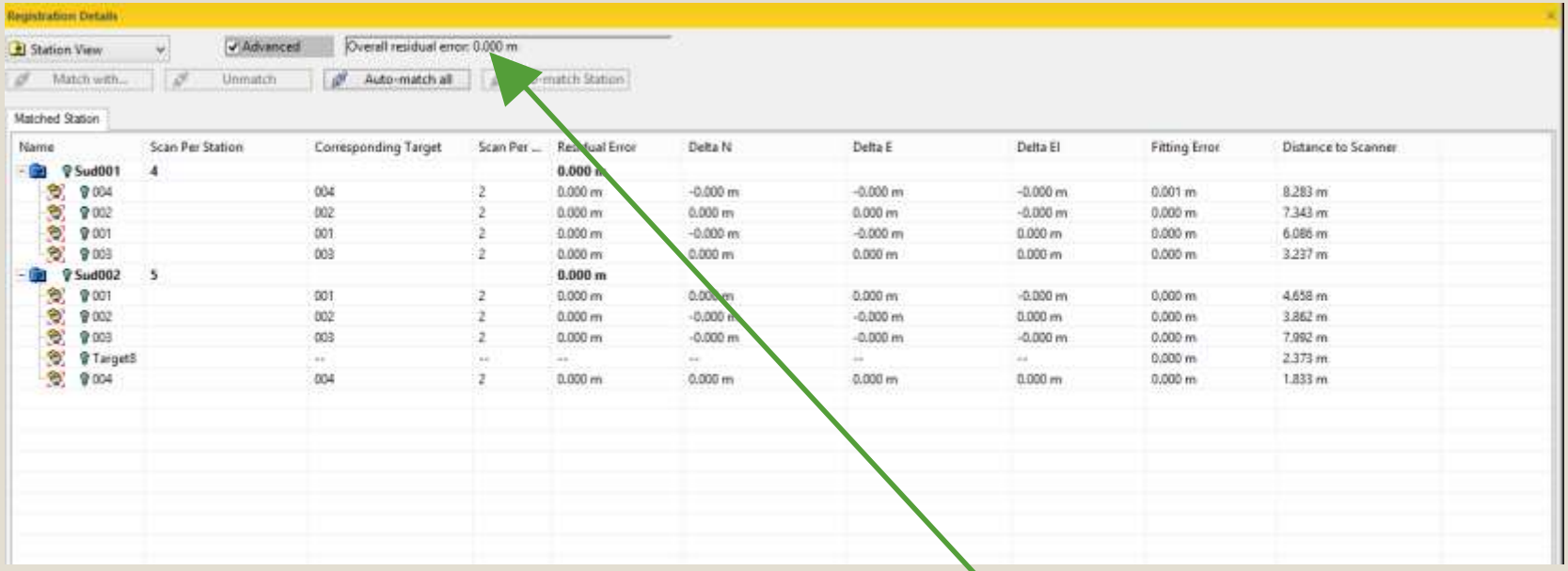

Fig. 8 Results from the registration of the scans - *another object*

Overall residual error - **0.000 m**.

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9. Graphical examples of the objects, subject of update of the cadastral plan

Note:

- "thick" environment around each object
- presence of various natural material

This **excluded** the possibility for application of classical surveying equipment.

Fig. 9 Scanning of impossible to access object "A"

The circumstances:

- hard to access front part and inaccessible rear part;
- the object - surrounded by green area;
- no possibility for **safe positioning** of the geodetic equipment next to the object;
- Control points - stabilised on the street, see fig 9.

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9. Graphical examples of the objects, subject of update of the cadastral plan

The edges of the building - acquired by the laser scanner using **two positions** of the scanner.

The direct access to the object - **not safe and not possible** - existence of tall green plants.

Fig. 10 The second station of the scanner – for the inaccessible rear part of object “A”

Note:

- the point cloud contains a number of **missing parts of the object** (fig. 10);

- existence of **huge quantity of natural material** on the terrain and in the space around the object.

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10. Usage of the information from LIDAR in this case

The existing situation on the terrain - fig. 11

Note:

The **enormous amount** of precisely measured spatial information and **photo realistic data** made the point extraction **possible**.

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Fig. 11 View from above - hard to access object “B”

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11. 3D laser scanning - video material

Fig. 12 Object “A”

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12. Conclusion. Recommendations

a) This possible combination of the technologies could be of significant importance for the geodesist in the terms of:
1. **time saving**;
2. **minimization** of the personnel in the field;
3. **productivity, accuracy** achieved, etc.

b) The calculated results show **no compromise** in the overall quality of the data for the shown hard terrain conditions.

It was achieved extremely high accuracy in the processing of the laser scanning data - **overall residual error of 0.000 m**. - for the both objects – “A” and “B”.

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12. Conclusion. Recommendations

c) Excellent quality results were calculated for the position quality parameter of the GNSS measurements – in the **range of (6 mm, 9 mm).**

d) the point cloud was georeferenced with average **error of 3 mm**.

e) With the combination of the technologies it was achieved:

- **unsurpassed accuracy** in the final results from the geodetic measurements;
- **very high productivity** in the field.

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12. Conclusion. Recommendations

f) Based on the numerical results and the analysis of the applied procedure it could be highly recommended the application of the proposed combination of 3D Terrestrial Laser Scanning and GNSS Technologies **in such specific cases in surveying**.

The described procedure could be of **significant benefit** for the geodesist, especially under the described circumstances – for measurements of **hard or impossible to access** objects of cadastre.

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13. Outlook

Future work. The proposed application of combination of 3D Terrestrial Laser Scanning and GNSS Technologies could be **more productive**, if:

-better accuracy was available from GNSS permanent networks;

- the necessary coverage existed in some regions by the mobile operators.

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USED SOFTWARE

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2. GNSSTransformations [https://tinyurl.com/y83qp2l2];
3. Mkad (http://tinyurl.com/hapgj9l - in Bulgarian);
4. Trimble RealWorks (http://tinyurl.com/pdckrlr);

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