3D Terrestrial Laser Scanning for Cadastral and Design Activities - Performing, Data Processing and Analysis. Storage and Backup in the Light of the Nowadays Cloud Possibilities

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key words: laser scanning, measurements, project, cloud storage

SUMMARY

3D terrestrial laser scanning and IT nowadays deliver a number of new possibilities for the geodesists. This paper is focused on the process of performing geodetic measurements using 3D terrestrial laser scanning, quality analysis of the results and safe data storage. The contactless way of measurement gives a lot of advantages as: enormous field productivity, elimination of the possible human-based errors and delivers significant 3D accuracy of the created geodetic product.

The paper studies the implementation of the relevant activities, which are required for the delivery of the necessary spatial information, its processing, analysis and last but not least the safe and encrypted cloud storage of the gathered in the field digital data.

Currently, there are several cloud-storage providers, which deliver online service with various parameters, like: size of the space, transfer quota, security, support, etc. Since the volume of the measured data from 3D terrestrial laser scanning depends on several settings in the scanner's firmware, details on its processing and online storage are further discussed in the paper.

Analysis of the factors for the decision to use the mentioned surveying equipment and IT possibilities for project and cadastral activities are given in the paper.

The necessary assessment of the accuracy of the performed geodetic measurements was done. Graphical examples, which illustrate the performed work are also included in the study.

Conclusions and recommendations for future work are given in the paper.

РЕЗЮМЕ

3D наземното лазерно сканиране и Информационните Технологии (IT) в днешно време предоставят много нови възможности на геодезистите. Този материал е фокусиран върху дейностите при извършване на геодезически измервания чрез използване на 3D наземно лазерно сканиране, анализ на качеството на резултатите и безопасното съхранение на данните. Безконтактния начин на измервания предлага редица предимства като: огромна производителност на полето, елиминиране на възможните операторски грешки и постигане на значителна точност на създадения тримерен геодезически продукт.

Статията анализира изпълнението на съответните дейности, които се изискват при създаване на необходимата пространствена информация, нейната обработка, анализ и не на последно място безопасното и криптирано съхранение в облака на измерените на полето цифрови данни.

Към днешна дата съществуват редица доставчици на облачно съхранение на данни, като услугите се различават по редица параметри, напр.: размер на пространството, квота на трансфер, ниво на сигурност, поддръжка и др. Поради факта, че обема на измерените на полето сурови данни зависи от някои настройки на firmware на скенера, детайли по обработката на информацията и нейното online съхранение се дискутират по-нататък в материала.

Анализ на факторите, повлияли на избора на упоменатото геодезическо оборудване и възможностите на IT за нуждите на кадастъра и проектирането са дадени в материала.

Представена е оценка на точността на извършените геодезически измервания. Също така са приложени графически примери, които илюстрират извършената работа в материала.

Заключения и препоръки за бъдеща работа са дадени в статията.

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1. INTRODUCTION

3D terrestrial laser scanning and IT both deliver nowadays a huge range of new technological possibilities for the geodesists. Laser scanning, as part of LIDAR is one of the fastest and accurate technology for performing of 3D measurements, including in the data the intensity of the returned laser signal in the scanner [Milev, 2012]. In Internet could be found many more examples for applications of the mentioned technology, e.g.: https://blog.lidarnews.com/notre-dame-3d-laser-scanned-2005/,
https://www.researchgate.net/publication/330771641_the_suitability_of_terrestrial_laser_scanning_for_building_survey_and_mapping_applications.

This study is focused on the technical details, which should be followed in the process of performing of laser scanning of objects - buildings for activities in the area of cadastre and forthcoming design, so the surveying data to be used for more than one task.

Another important technological part of the work to be considered after performing the field measurements is the storage, sharing and backup (in the cloud) of the raw and processed laser scanning data. Sharing a link to the created 3D data is convenient and currently may be the only possible way to send large volumes of information in case it is necessary. This part of the project activities, described in details in chapter 6 was done using several cloud storage providers.

This paper is concentrated on several major topics, listed below:
-preparation for performing of geodetic measurements with laser scanner in a villa area;
-conducting productive one-person crew geodetic measurements;
-processing of the raw data;
-georeferencing of the point cloud;
-extraction of the necessary 3D data;
-safe and encrypted online storage of the raw, processed and linked data.

In the project were used the following applications:
-Trimble RealWorks;
-Mega desktop app;
-pCloud desktop app;
-IDrive – within a web browser.
The listed applications are given in the sequence as they were applied in the study.

The information, created for this case consists of:

-raw and processed data in format for Trimble RealWorks;
-digital models in *.dwg and *.dxf formats;
-link to the necessary data for external users.

2. 3D TERRESTRIAL LASER SCANNING - POSSIBLE APPLICATIONS IN SURVEYING

A number of examples could be given for applications of the terrestrial laser scanning in the areas of: surveying, cadastre and design. Here are listed some of them: https://www.iff.fraunhofer.de/content/dam/iff/en/documents/publications/guidelines-on-laser-scanning-in-plant-design.pdf, https://matrixti.com/matrix-on-manufacturing/3d-laser-scanning-industrial-plant-design/ and http://www.geodetic.science/papers,presenation,publications.html#Eng-papers-2018.

Another possible application of 3D terrestrial laser scanning both in cadastre and design, which applies latest IT possibilities, especially optical Internet is studied in this paper. The aims are: performing of contactless geodetic measurements, processing of the data, analysis of the results, usage of cloud storage and linking the necessary information for further sharing.

The study in this paper includes the application of:
- 3D terrestrial laser scanner for performing geodetic measurements;
- Trimble RealWorks;
- Internet;
- contemporary laptop;
- several cloud services for storage of large volume of information.

3. REQUIREMENTS IN THE FIELD AND IN THE AREA OF IT FOR THIS SPECIFIC CASE

The activities in this study include several technical requirements to be fulfilled in order to be gained productivity in the field and to be obtained the expected quality of the results. These requirements are listed below:
- appropriate relation between quality/resolution of the laser scanning data should be chosen;
- the scanner must be placed in a position with the relevant visibility to the object's details before performing of the measurements;
-clear view must be ensured between the scanner and the artificial targets, in our case spheres.

In this case (i.e. villa region, no dangerous objects in the vicinity, no car or pedestrian traffic) there was no need to secure the area next to the scanner and spheres prior performing of the measurements. These circumstances made the work possible with one-person crew in the field, saved labour force and reduced costs.

According to the specific needs of the project, the following requirements in the IT area should be satisfied:
-contemporary powerful laptop;

-fast and stable Internet connection, e.g. optical, without traffic limitations;
-cloud storage service accounts in different providers;
-security of the data.

The applied contactless technology gives the geodesist the following advantages, some of them given below:
- all necessary cadastral details (outdoor and indoor) can be measured in a reasonable time in the field;
- the terrain data around the object is also measured in the same time;
- one person is required to operate in the field in this case;
- enormous productivity can be obtained;
- significant accuracy of the results from processing of the raw data.

These factors led to the decision for choosing exactly 3D terrestrial laser scanning and not to use any other technology for performing of geodetic measurements in our specific case.

4. NECESSARY ACTIVITIES BEFORE PERFORMING OF 3D TERRESTRIAL LASER SCANNING IN OUR CASE

The geometry and the interior of the buildings, subject of geodetic measurements was studied in details. The positions of the scanner were chosen to correspond with the requirements, listed below:
- the area around the scanner and spheres to be unobstructed;
- appropriate distances between: outdoor and indoor details/edges of the objects and each scanner's station;
- the required direct visibility: scanner - artificial targets and scanner - buildings;
- the mutual spatial geometry of the spheres.

The spheres were situated in the relevant positions and distances around the building.

The appropriate settings for outdoor/indoor scans were applied in the firmware in order to be obtained: productivity in the field and density of the point cloud.

5. PROCESSING OF THE RAW DATA. RESULTS. ANALYSIS

The raw scan data was processed and analysed in Trimble RealWorks.

The information from the geodetic measurements was registered, using "Auto-extract Targets and Register" option in the software. For some of the stations the target-less registration was applied to create the point cloud.

The fast registration of the data was possible due to the usage of: artificial targets - spheres and powerful laptop.

The results for the quality assessment and other technical details from the registration process are shown in fig. 1. The indoor scans were registered using spheres, positioned on various levels and ensuring the visibility from more than one station, fig. 1a.

It should be noted, that due to the specific geometry of one of the building, subject of measurements, short distances between the stations and the spheres were necessary to be applied as it can be seen in fig. 1 and fig. 1a.

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 ...	Correspond...	Scan Per Tar...	Residual Error	Delta N	Delta E	Delta El	Fitting Error	Distance to Sca...
MV001	5			**0.001 m**					
003		003	3	0.001 m	0.000 m	0.000 m	0.001 m	0.000 m	6.788 m
Target2		--	--	--	--	--	--	0.000 m	6.730 m
005		005	3	0.001 m	-0.001 m	-0.000 m	-0.000 m	0.000 m	7.911 m
002		002	3	0.001 m	0.001 m	0.000 m	-0.001 m	0.000 m	10.074 m
004		004	3	0.001 m	-0.000 m	0.000 m	0.001 m	0.000 m	7.614 m
MV002	5			**0.001 m**					
001		001	2	0.002 m	0.000 m	0.000 m	-0.002 m	0.000 m	12.650 m
002		002	3	0.001 m	-0.001 m	-0.000 m	0.001 m	0.000 m	4.099 m
003		003	3	0.001 m	0.001 m	-0.000 m	-0.000 m	0.000 m	9.302 m
004		004	3	0.000 m	-0.000 m	-0.000 m	0.000 m	0.000 m	8.087 m
005		005	3	0.001 m	0.000 m	0.000 m	0.001 m	0.000 m	6.339 m
MV003	5			**0.001 m**					
001		001	2	0.002 m	-0.000 m	-0.000 m	0.002 m	0.000 m	7.597 m
004		004	3	0.001 m	0.000 m	-0.000 m	-0.001 m	0.000 m	11.247 m
005		005	3	0.001 m	0.000 m	0.000 m	-0.000 m	0.000 m	8.710 m
003		003	3	0.001 m	-0.001 m	0.000 m	-0.001 m	0.000 m	12.187 m
002		002	3	0.000 m	0.000 m	-0.000 m	0.000 m	0.000 m	7.346 m

Fig. 1 Registration of the stations and quality assessment of the results

Vérification du recalage

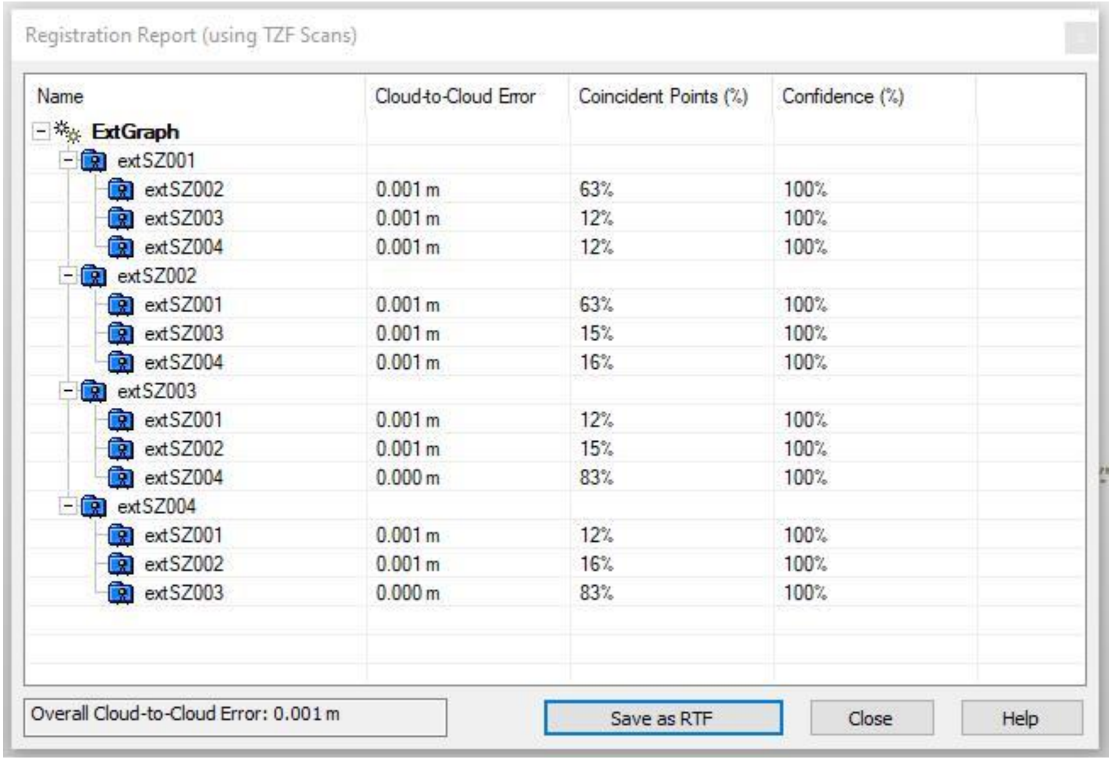
Vue Stations | Avancé | Erreur résiduelle totale : 0.000 m

Apparier avec... | Désapparier | Auto-apparier tout | Auto-apparier la st...

Stations appariées

Nom	Scan par s...	Cible correspondante	Scan par ...	Erreur résiduelle	Delta N	Delta E	Delta El	Erreur d'ajustement	Distance au Scanner
IntSZm007	5			**0.000 m**					
004		004	3	0.000 m	0.000 m	0.000 m	-0.000 m	0.000 m	2.994 m
005		005	3	0.000 m	0.000 m	0.000 m	-0.000 m	0.000 m	3.282 m
003		003	3	0.001 m	-0.000 m	-0.000 m	0.000 m	0.001 m	2.844 m
002		002	3	0.000 m	0.000 m	0.000 m	-0.000 m	0.000 m	3.320 m
001		001	3	0.001 m	-0.001 m	-0.000 m	0.000 m	0.001 m	2.848 m
IntSZm004	5			**0.000 m**					
001		001	3	0.001 m	0.001 m	-0.000 m	-0.000 m	0.000 m	5.011 m
002		002	3	0.001 m	-0.000 m	-0.000 m	-0.000 m	0.000 m	4.999 m
003		003	3	0.001 m	0.000 m	0.000 m	0.000 m	0.000 m	4.271 m
004		004	3	0.000 m	-0.000 m	-0.000 m	0.000 m	0.000 m	4.621 m
005		005	3	0.001 m	-0.001 m	0.000 m	0.000 m	0.000 m	4.427 m
IntSZm006	5			**0.000 m**					
003		003	3	0.000 m	0.000 m	0.000 m	-0.000 m	0.000 m	2.250 m
001		001	3	0.000 m	0.000 m	0.000 m	-0.000 m	0.000 m	2.132 m
004		004	3	0.000 m	-0.000 m	-0.000 m	0.000 m	0.000 m	2.025 m
005		005	3	0.000 m	0.000 m	-0.000 m	-0.000 m	0.000 m	1.872 m
002		002	3	0.000 m	-0.000 m	0.000 m	0.000 m	0.000 m	1.776 m
IntSZm005	0			--					

Fig. 1a Registration results for the stations in the interior


Registration Report (using TZF Scans)

Name	Cloud-to-Cloud Error	Coincident Points (%)	Confidence (%)
ExtGraph			
extSZ001			
extSZ002	0.001 m	63%	100%
extSZ003	0.001 m	12%	100%
extSZ004	0.001 m	12%	100%
extSZ002			
extSZ001	0.001 m	63%	100%
extSZ003	0.001 m	15%	100%
extSZ004	0.001 m	16%	100%
extSZ003			
extSZ001	0.001 m	12%	100%
extSZ002	0.001 m	15%	100%
extSZ004	0.000 m	83%	100%
extSZ004			
extSZ001	0.001 m	12%	100%
extSZ002	0.001 m	16%	100%
extSZ003	0.000 m	83%	100%

Overall Cloud-to-Cloud Error: 0.001 m

Save as RTF | Close | Help

Fig. 1b Quality control for target-less registration - outdoor scans

The quality control of the outdoor scans is given in fig. 1b. As it was mentioned target-less registration was used, due to various factors, e.g.: type of terrain, direct visibility, etc.

The necessary georeferencing, required for the final results of the created point cloud was done using network control points. The results from the calculations and the average error are given in fig. 2.

In order to improve the overall 3D quality control of the results from the georeferencing one network point was excluded. It should be noted, that the calculated result fully satisfies the accuracy requirements in the area of cadastre and design for this case.

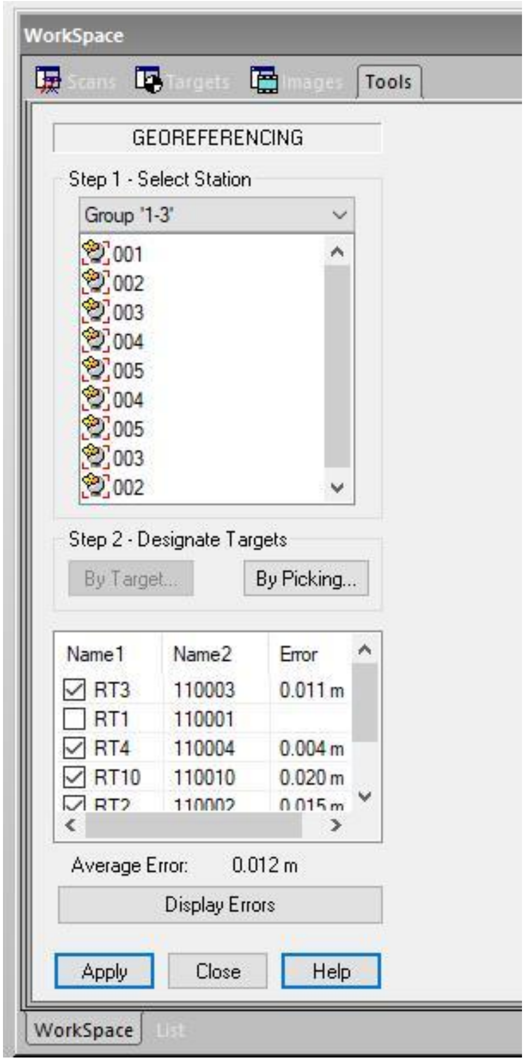


Fig. 2 Georeferencing of the point cloud and results from the quality assessment

The results, given in this chapter show very high quality of the processed raw data:
- 0 mm overall residual error from the registration of four stations in the interior of the building – fig. 1a;
- 1 mm overall residual error in the registration results for exterior stations, derived from three stations of the scanner – fig. 1;
- 1 mm overall cloud-to-cloud error - calculated from data, measured from four stations of the instrument. It should be noted that the information was processed with 100 % confidence for every station - fig. 1b;
- the final processing of the point cloud – its georeferencing was calculated with 12 mm average error. The last includes a number of possible sources, falling beyond the scope of this paper.

The value of this average error meets the accuracy requirements of both fields of activities in this paper – cadastral and design.

6. CLOUD STORAGE AND BACKUP BOTH OF THE RAW DATA AND PROCESSED INFORMATION

Nowadays the storage and backup of large volume of data is too risky to be kept on external hard drive, due to a number of reasons like:
- possibility for bad sectors (physical damage);
- dropping of the HDD;
- its loss, stealing, etc.

External SSD is another option for storage, but its usage might not be a good decision for the purposes of this study, due to several reasons like:
- impossibility to compare the parameters (e.g. price, capacity, speed, etc.) with the relevant HDD;
- risk of stealing/loss;
- constantly changing standards for volume in the area of IT.

Currently, it is a practice to work with one and the same information on various laptops and/or places, to send data to other users or give access to folder and last but not least to backup the updated data. One possible and also contemporary technical solution to accomplish this is to use cloud storage.

The above mentioned facts led to the decision for application of current IT possibilities for the needs of cadastre and design in this specific case.

The cloud storage is offered by a number of companies on the Internet, providing a service with various parameters /volume of space, volume of a single file to be transferred, transfer quota, etc./.

In our specific case - working with hundreds of MB or GB, the selection of appropriate /free or paid/ cloud storage provider should be done very carefully. Here are some reasons to take care of:
a) the file formats of the information of 3D terrestrial laser scanning raw data;
b) the attributes of the files in the raw data;
c) the volume of the files in the data.

According to www.techradar.com and www.itproportal.com IDrive, pCloud and Mega are listed as “Best cloud storage of 2020”, see fig. 3 and fig. 4.

In this study the above mentioned service providers were used to store raw data and backup GB of information of the processed laser scanning project. It should be noted that the following issues were encountered:

- for IDrive: – after upload of the raw data *.fls file was missing in the cloud, fig. 5 and fig. 7
-two step verification was required, which slows down the user’s work;

-sharing of the information requires the recipient to be IDrive user, which is a significant limitation.

- for Mega – in the raw data, after upload was missing the file with .classid extension, fig. 6 and fig. 7. It should be noted, that transfers of the information with slow/unstable speed were observed over excellent Internet connection.

After performing a test upload, it was noticed, that if the information was stored as *.zip archive, these issues were eliminated. Unfortunately, this was a limitation due to the necessity for storage of the original project, not archived one.

According to the published information, concerning the security of the stored data, Mega provides end-to-end encryption, while for pCloud the user has to pay additionally in order to use "Files, protected by pCLoud Crypto" on the device, fig. 8.

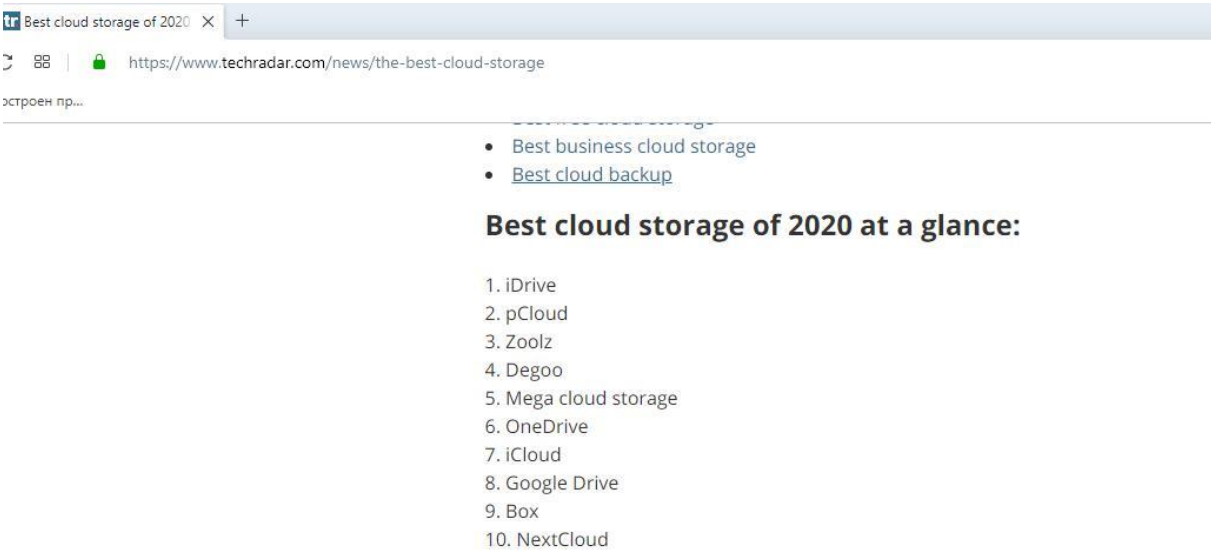


Fig. 3 List of "Best cloud storage of 2020" from www.techradar.com

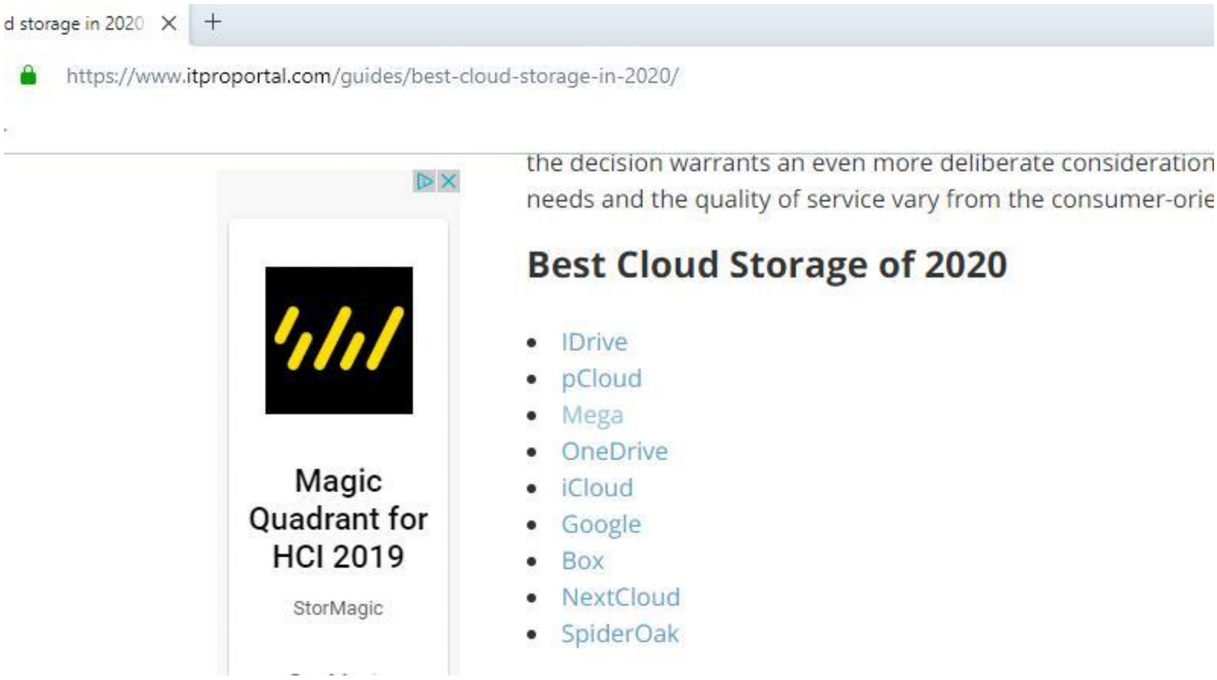


Fig. 4 List of “Best Cloud Storage” of 2020 from www.itproportal.com

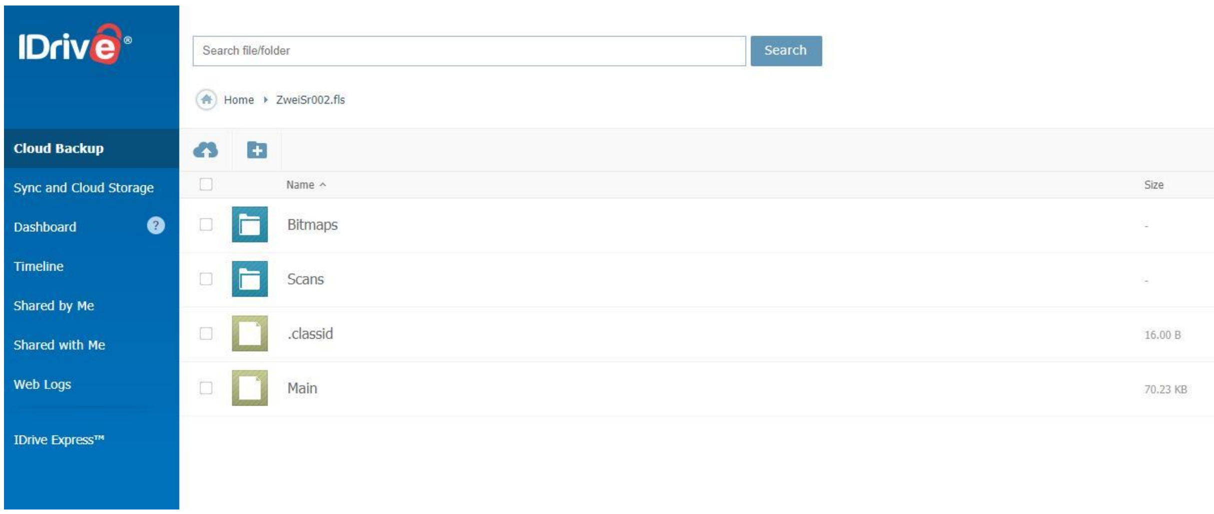


Fig. 5 Missing *.fls file in IDrive

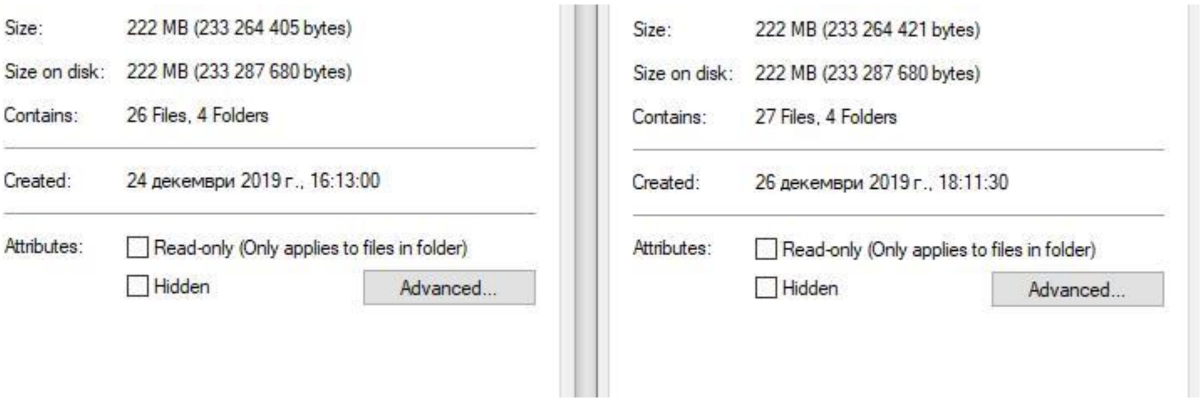


Fig. 6 Missing .classid file in Mega's cloud storage after sync and view from another PC.

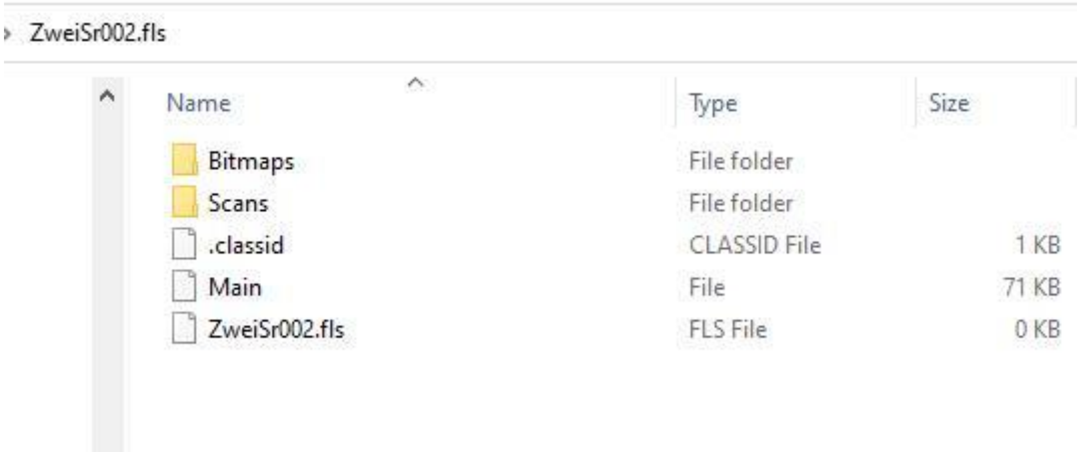


Fig. 7 Original source of the raw scanner data with .classid and *.fls files inside

Fig. 8 Paid options for pCLoud Crypto as given at https://www.pcloud.com/fr/encrypted-cloud-storage.html

7. CONCLUSION. RECOMMENDATIONS. OUTLOOK

This paper described the application of 3D terrestrial laser scanning in the fields of cadastre and design for objects, situated in villa area in the light of contemporary possibilities of the IT.

In the study were noted the practical issues, which encountered in the process of online storage and backup of laser scanning data.

3D terrestrial laser scanning was used as technology, which eliminated any possibilities for human errors. The scanner was used for measurements of both interior and exterior parts of objects with various spatial geometry. In this case the task required forthcoming design activities for the objects.

The applied surveying equipment achieved enormous field productivity, provided significant simplicity in the data processing and its extraction after completing of the geodetic measurements.

The IT involved in this case was a look ahead to a union of two productive technologies: 3D terrestrial laser scanning and online storage of both raw and processed data.

The given in chapter 5 quality assessment of the results from the performed laser scanning and georeferencing, shows the achieved high quality of the processed and created final data:
- overall residual error for the target-based registration – 1 mm;
- average error for the georeferencing - 12 mm.

Based on the field productivity and the listed results for the quality control (both for creation of the point cloud and its georeferencing) the used technology, applied for both cadastral and design activities was successfully implemented for hard to measure objects in surveying practice.

The combined usage of modern technologies:
- in the area of surveying – 3D terrestrial laser scanning;
- in the area of IT - cloud storage services,
in the way they exist nowadays led to one contemporary and refined model of geodetic activities in the area of cadastre and design.

Based on the given in chapter 6 information, the above mentioned technologies could be highly recommended in nowadays geodetic practice.

Future work. It should be noted, that obviously the technical side of the services of the cloud storage providers should be updated in the means of fixing the issues with specific laser scanner data formats and their handling in the cloud.

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DESKTOP APPS

Mega Desktop App
pCloud Drive
Trimble RealWorks;

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