MODERN TECHNIQUES FOR AUTOMATION OF SYSTEMATIC LAND REGISTRATION IN LIEBLING'S ADMINISTRATIVE TERRITORIAL UNIT

Andana RUS [1], A. SMULEAC [1], Laura ȘMULEAC[1], M. SIMON [1]

[1]Banat's University of Agricultural Sciences and Veterinary Medicine"King Mihai I of Romania" from Arad, 300645, 119, Calea Aradului, Arad, Romania
Corresponding author: adriansmuleac.as@gmail.com

Abstract: *The solutions identified so far in the field of Cadastre and land registration require a careful analysis of the practical way of collecting and integrating data, especially when it comes to the steps necessary for the proper running of the systematic land registration process, the purpose of which is to have complete evidence of lands and buildings in Romania. For these reasons, this paper, respectively, the systematic land registration in Liebling's Administrative-Territorial Unit, located in Timis County, outlines an overall analysis of the techniques and methods used to automate this process, from the perspective of cadastre specialists who actively participate in the systematic land registration of lands and buildings. Within this type of project, 75-80% of the total work volume represents the topographic measurements and data acquisition, as well as processing, respectively integrating this data into a Geographic Information System (GIS). Due to the fact that this share amount is so high, for the operability and shortening of these stages, in the Systematic Land Registration of Liebling's Administrative-Territorial Unit, new modern means, superior to those used in the previous projects of this type, were implemented. For the data acquisition stage, Pegasus Backpack (mobile LiDAR scanning equipment - Mobile Mapping System) and Wingtra One Drone were integrated, in order to obtain a higher performance and precision and as for data manipulation and generating deliverables of Systematic Cadastre projects, GIS software Mapsys 10.0 with CG 3.0, as a relational geographic database manageable in MapSys were correlated. The use of these modern techniques of data acquisition and processing had as main objective to increase the efficiency and simplification of this real estate systematic registration process within reasonable terms while still maintaining a high-quality level. A first beneficial impact due to the short time of data acquisition, was obtained from the first stages of the project such as having a better overview regarding property limits and ownership, but also by having an efficient data management system, that helped make faster and better decisions while being in the documents collecting phase. Due to the fact that this process is of national importance and in a continuous change, the paper is structured around two major concerns, namely, the presentation of the current modern state of the systematic land registration activity while taking into consideration the degree of novelty and also identifying improvement proposals based on the results obtained from this study case. The main purpose of this research is to increase public awareness of the continuous automation in which the Systematic Land Registration System is currently in, while having a strong and beneficial impact, regarding costs, time and professional staff required for a high-level project like this, but also sustain the fact that even though this system has not yet reached its full potential it is definitely ready for "Cadastre" and "Registration of the whole country".*

Key words: *Systematic Land Registration, Automation, Process, Modern techniques, Data, GIS, Analyze*

INTRODUCTION

The degree of systematic land registration of a country reflects its economic and social development (GRECEA ET ALL 2013; ȘMULEAC ET ALL 2019, 2020). The initialization of the systematic land registration process after 2005 and the implementation of the system has encountered several difficulties and obstacles, thereby only after the year 2015 the ANCPI agency has managed to significantly accelerate the systematic registration projects by completing the required legislative and operational measures, and by introducing systematic land registration on a sector level.

Out of the total of 3.181 administrative territorial units (UAT) in Romania, until the 31'st of October 2021, systematic land registration projects were finalized for 122 administrative territorial units (Figure 2), having a total area of 3.325.863,25 ha and projects are ongoing at full scale and on sector level for an additional 1.493 administrative teritorial units which have an estimated area of 4.559.583,44 ha (Figure 1).

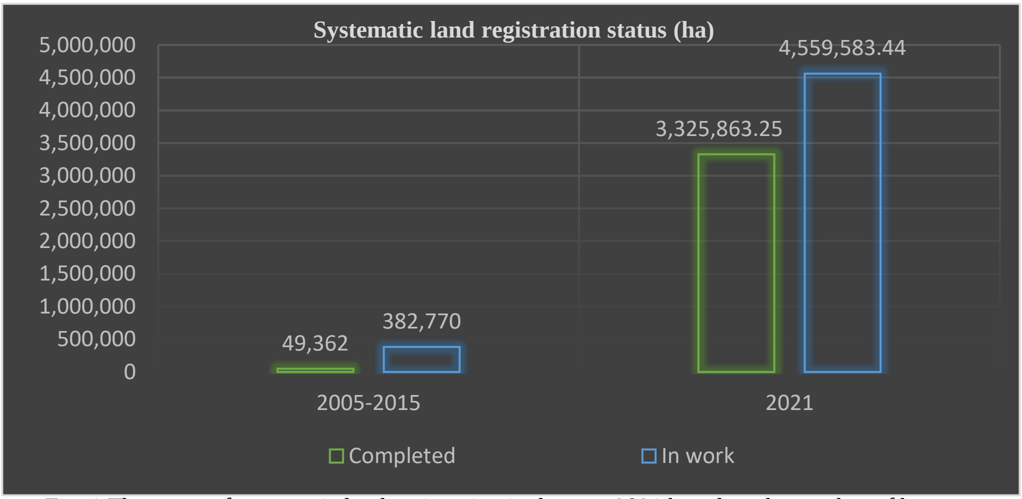

Fig. 1 The status of systematic land registration in the year 2021 based on the number of hectares

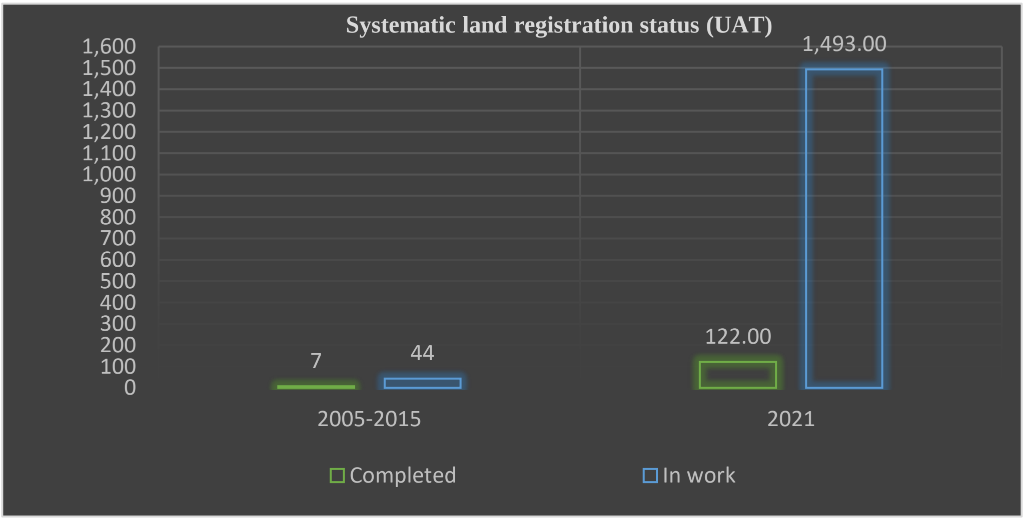

Fig. 2 The status of systematic land registration in the year 2021 based on the number of administrative territorial units

The main quality of a modern systematic land registration is the way it can be automized in any stage of the process (GRECEA, 2013; MITA ET ALL 2020). The dynamic evolution of cadastral surveys implies an ever-increasing volume of data, and the process of updating this data, tasks which would be almost impossible without a continuous automatization process, in which the current systematic land registration system is in(Figure 3). The automatization process is having a strong positive impact on economic aspects, duration and resources required for such a grand project, also thanks to the automated process the system is ready to perform systematic land registration in the entire country.

Fig. 3 National Cadastre and Land Book Program status at 31-10-2021 (ANCPI, 2021)

MATERIAL AND METHODS

In systematic land registration projects the land surveying activities together with the data processing, data aquisition and integration of the complete data in a GIS system, represent the biggest share of activities out of the total volume (75-80%).As this share is so great, to increase the efficiency and to reduce the duration of these steps during the systematic land registration process of administrative territorial unit Liebling, modern and superior methods were used by using drone type Wingtra ONE (Figure 4) and Pegasus Backpack system (mobile LiDAR mapping system).The scanning and land surveying activities were peformed in the towns belonging to the administrative territorial unit Liebling, located in Timis county, respectively Liebling, Cerna and Iosif, with a total area of 360 hectars as target.

Fig. 4 Wingtra ONE RX1RII (SIMON, 2021)

Drone surveillance was performed for each town using Wingtra ONE. The drone is quipped with a fullframe Sony RX1RII 42 MP 35 mm Full Frame photo camera, which is capable of covering 100 – 2500 hectars, depending on the flying altitude, in aproximately 45 minutes. It can reach a maximum altitude of 3000 meters. Due to the integrated GNSS PPK (Șmuleac et all 2017) module the absolute mapping precizion can reach up to 2 cm on the vertial axis and up to 1 cm on the horizontal axis, with a horizontal relative precision up to 0.003%.

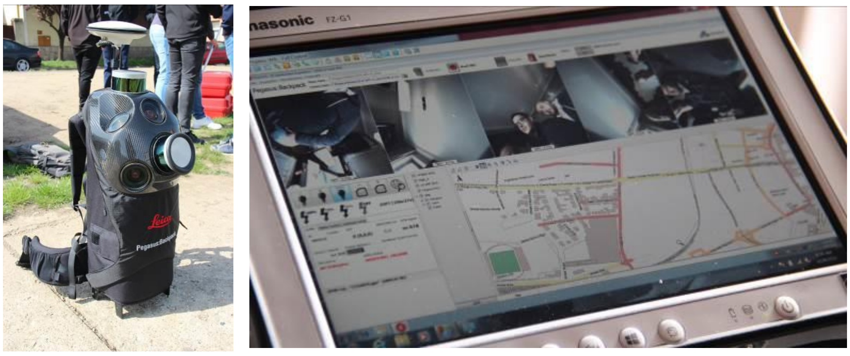

Fig. 5 Leica Pegasus Backpack (SMULEAC, 2019)

The Leica Pegasus Backpack is a system which combines two liniary Velodyne VLP-16 (Mita et all 2020) type scanners (one vertical and one horizontal), five cameras used for data texture, a GNSS / INS Novatel SPAN (Șmuleac et all 2020), integrated system, batteries and a control unit (Leica Pegasus Backpack, 2017). The system is capable of determining 600 thousand points per second at a maximum distance of 50-75 meters on the left and right side. During data acquisition a robust screen shows videos from the cameras, profiles from the two linear scanners, and a diagnostic instrument with data regarding the GNSS and INS sensors (Figure 5).

The Pegasus Backpack was used to perform detailed land surveys to measure the outline of the blocks which contain road fronts and topographic details from urban areas (Figure 6). The data was later combined with the data from aerial photogrammetry gathered using the Wingtra One drone.

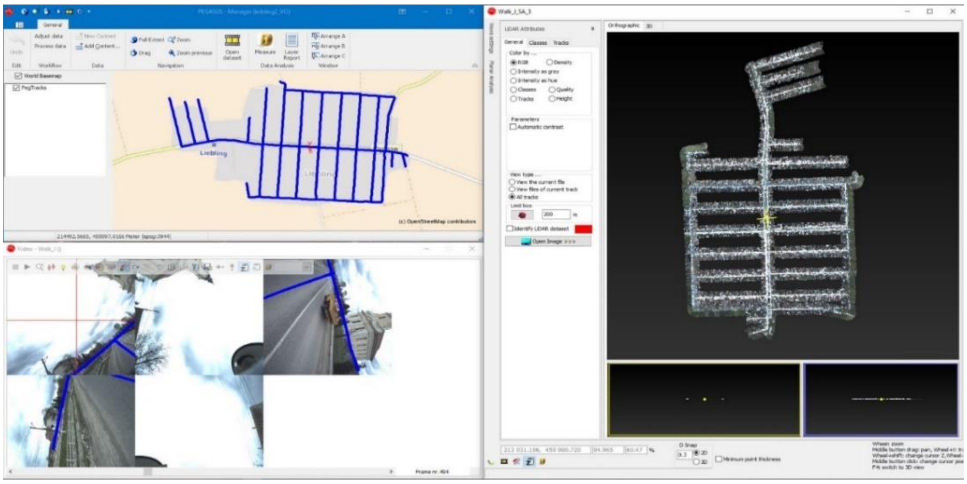

Fig. 6 Trajectories and point clusters obtained using Pegasus backpack (SIMON, 2021)

The usage model of LIDAR – Mobile Mapping technology for detailed land surveying consisted of the following workflow:

1.An area inspection to determine the number of required scanning procedures and mounting position for the reference station – Master Base (SR1).

2.Scanning the area of interest using Leica Viva GS 08 Plus as Master Base, which gathered Rinex data each second during the scanning process.

3.Determining control points using RTK method with the help of GNSS Leica Viva GS08 Plus, which were verified on the point cluster gathered during the scanning performed in the previous step.

4.Postprocessing with the help of Pegasus Manager v2019.1 software and verifying the precision with the help of Novatel Inertial Explorer v8.8.

5.Extracting topographic data by uploading the point cluster in Leica Cyclone Model v9.3 software.

6.Obtaining a final result with the help of Autodesk AutoCAD Map 3D v2021 software and generating report using Leica Infinity v3 software.

The data obtained after finalizing the steps listed above was verified topologically and updated by adding systematic registration specific base attributes and was later integrated in the geographic informational system MapSys 10 (Figure 7). This software was optimized for verifying, correcting, incremental creation, transforming and data collection, having an GDAL (Geospatial Data Abstraction Library) interface which allows vectorial GIS data transfer by synchronizing with the external Cadastru General (CG) application, specialized in generating data and reports which are required in systematic land registration. Through this synchronization the object attributes (ID's, areas, drawings, lists) are automatically taken over into the CG application database in which they can be extended with additional object specific data (POPESCU ET ALL 2016; ȘMULEAC ET ALL 2012, 2017).

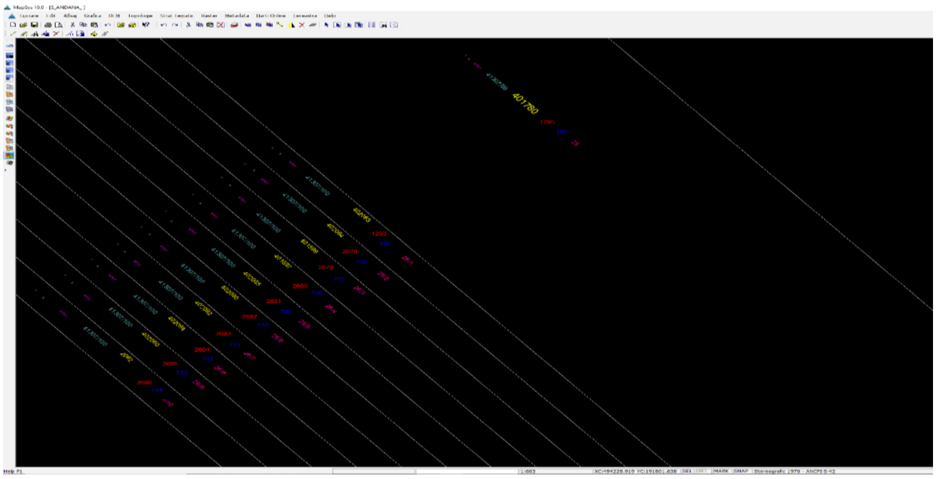

Fig. 7 Main attributes in the geographic informational system MapSys (RUS, 2021)

Main MapSys functions used in the case study:

- Object identifier attribute (Cad number)
- Collecting text attributes in database
- Collecting attributes from neighboring polygons
- Displaying attributes from database in graphical surface

- Overlapping topological layers (overlay) by combining edit object attributes.

CG is an independent application designed to manage systematic land registration data according to the technical specifications required by ANCPI (Figure 8). This application allows the creation, validation and administration of a relational geographic database, and the generation of all the information necessary for the realization of the systematic land registration having as final result the creation of specific vector and cgxml data sets (ŞMULEAC ET ALL 2013, 2015).

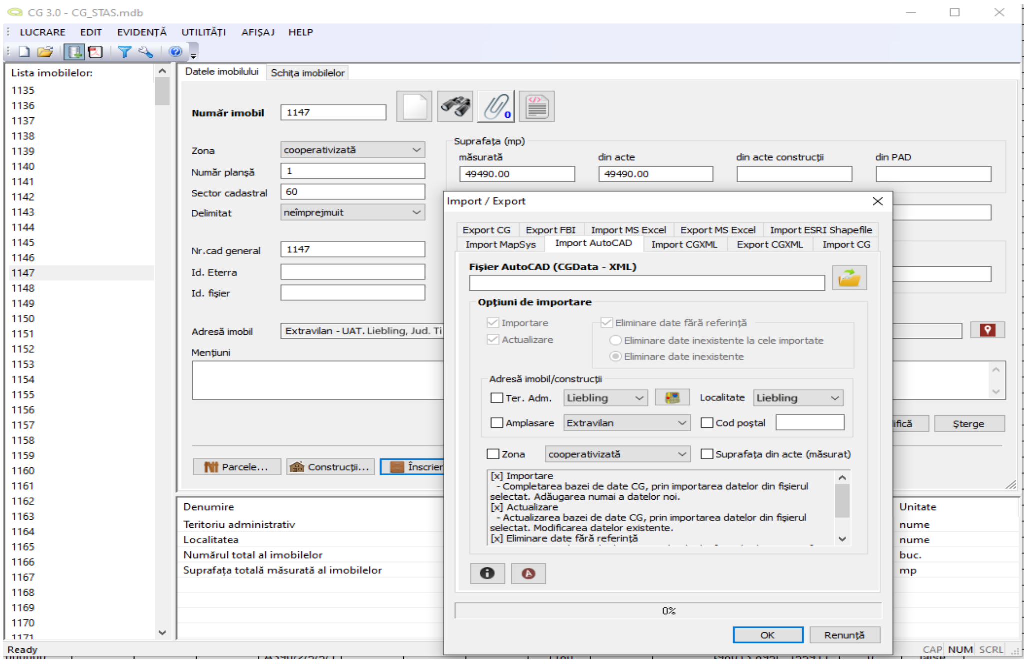

Figure 8 CG application interface (RUS,2021)

Main CG application functions used in the case study:

- Data entry: building / parcel / constructions / individual units / registration;
- Database validation (missing or duplicated data);
- Relational database generation using MapSys topological functions;
- Import / Export MapSys vector formats;
- Import CGXML / CPXML / CG;
- Export CGXML/MS Excel/ CG;
- Generation of technical documents (Cadastral Register of Real Estate and Owners, Interview Form, Alphabetical Index of Owners);

RESULTS AND DISCUSSIONS

The use of these modern techniques for data acquisition and processing had as main objective to increase efficiency of Liebling's Administrative Territorial Unit systematic land registration process, in order to complete it in reasonable terms and at an appropriate quality level.

Results obtained by automating data acquisition

Performing topographic measurements for planimetry within the built-up area, using the Leica Pegasus Backpack system and aerial photogrammetric flights reduced by about 70%

(or even more according to Table 1 data) parameters such as time, costs and needed personnel through speed and accuracy in obtaining 3D data (Figure 9).

Table 1

Parameters obtained in Liebling's urban area

Liebling's urban area Surface - 211ha	Leica Pegasus Backpack	Wingtra One
Scanning	5 h	45 min
Processing	5 days	3h
People	3	2
Precision	2cm	2cm

The use of equipment such as total stations and GPS technology for the same investigated area, respectively Liebling Locality, would have taken around 30 days, with a need of 10 people and a lower complexity purchased data compared to a system that uses LIDAR technology - Mobile Mapping.

Fig. 9 Results obtained from data processing (RUS, 2021)

Results obtained through efficient data management

An important factor when we refer to a project that includes a large number of data is the management of specialized software for processing, storing and sorting this data. Due to the large volume of information needed in the systematic land registration of Liebling's administrative territorial unit, emphasis was placed on the automation in all stages of the project, resulting in a more efficient management of databases, with increased accuracy and thus obtaining a faster final cartographic product. The main approaches in order to increase efficiency were:

- Retrieving cadastral data (cpxml files) and creating a database file (.mdb) using CG, Microsoft Access and Microsoft Excel to identify all the incomplete land books in terms of required information and with no graphics in Eterra 3 (ANCPI registration platform), in order to proceed with the land registration process.

- Database integration and sorting using CG and Microsoft Excel applications, obtaining a quick identification of all property titles that were issued whitin and outside the urban areas and also obtaining a filter in order to verify the number of the title deed needed for the attributes association made in Mapsys (Figure 10).

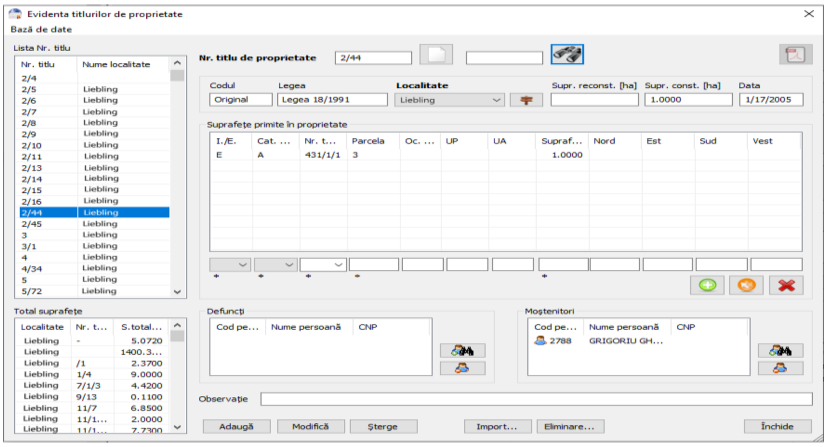

Fig. 10 Associating Title Deeds from the Database (RUS, 2021)

- Using MapSys Geographic Information System to collect text attributes in the database and subsequent querying on each layer, resulting in multiple data insertions and also eliminating as much as possible in an early stage of the process, the errors created through human data manipulation.

- Decreasing the cgxml files execution time, by automatic record creation using the CG application, for property titles that were initially integrated as data into the database, but also for all the buildings for wich no deed of ownership was identified.

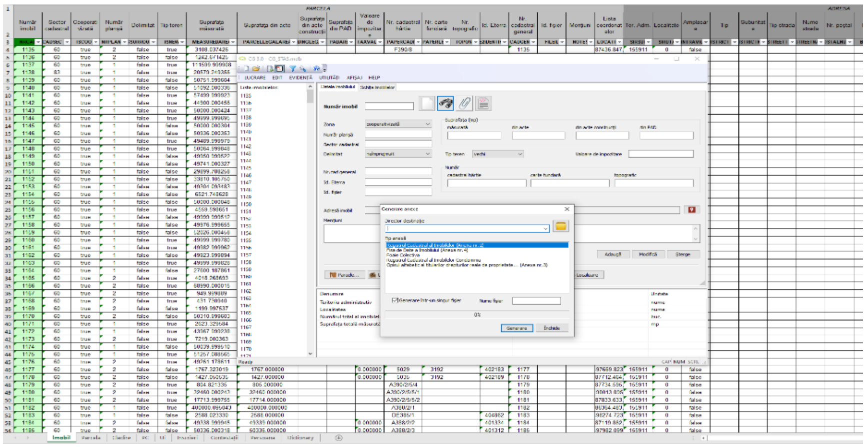
Fig. 11 CG Database management in Microsoft Excel (RUS, 2021)

- A major impact on the data processing stage is the way the CG application works by synchronizing the object attributes, which are automatically retrieved in the databases in

Mapsys and by the possibility to export this database as a .xls file resulting in a much faster and simpler management that significantly reduces processing time (Figure 11).

CONCLUSIONS

The structure of the paper was outlined around two major concerns:

- Presenting the current modern state by which the systematic land registration activity is regulated through the chosen case study, that takes place within the territorial administrative unit of Liebling, Timis County, between 2021 and 2022;
- identifying parts of the process that can still be improved or automated, in order to successfully fulfill all of the activities required from the National Cadastre and Land Book Registration Program;

The optimization solutions that were implemented in this study case's process focused on two main categories:

- Detailed topographic surveys within the built-up areas due to the higher degree of difficulty
- Optimizing the use of support software in the management and processing of the necessary data within the systematic registration.

Integrating the use of Mobile Mapping technology – LIDAR into the detailed topographic surveys, usually made by GNSS equipment and total stations, is a real advantage, by reducing working time and the surface of the investigated area, with a high complexity of data acquired, while obtaining an accuracy similar to the usual equipment.

Advantages and applicability of using the proposed model:

- Execution time (for detailed topographic surveys);
- Obtaining point clouds and a detailed image in coordinates of the studied area;
- The precision and accuracy of the data obtained;
- High degree of detail with the option to further use the obtained images;
- The possibility of using the data obtained in the GIS environment which allows "combining" with other geospatial data or creating non-graphical databases;

Improvement proposals regarding data acquisition step:

- Replacement of classical measurements, within the boundaries of buildings located in urban areas, by integrating a solution consisting of a drone and a Lidar sensor (Figure 12), that could reduce the execution time but also significantly increases the accuracy of determining a construction's position.

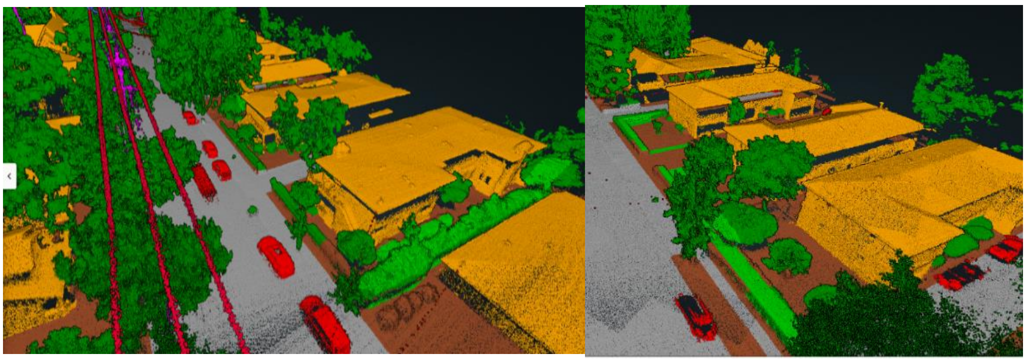

Fig. 12 Points cloud scanned with DJI Zenmuse L1 drone, LiDAR sensor

- Addition of aerial photogrammetric flights that also cover the terrain outside the built-up areas, using a drone with a longer flight time and a longer surface coverage that can equal Wingtra One's absolute accuracy of 2 cm.

GIS (Geographic Information System) and the applications used in order to obtain a fast and efficient data management, provide a framework for organizing, identifying problems and making decisions in real time, all of which help users achieve a common goal, namely to gain intelligence from all types of data (Herbei et all 2018). The main advantages in using an integrated GIS system with integrated applications were the visualization, storage, manipulation and analysis of data in a more efficient way and with a significantly reduced execution time.

Improvement proposals in order to optimize the workflow:

- Automatic correlation of scanned property deeds to the database according to the unique identifier assigned (ID);
- Export cadastral plans from Mapsys with customed specifications;
- Adding a cross-topology filter;
- Adding digital signature and stamp information;
- Eliminating verification filters such as "Documents and documents without reference";
- Automatically delete and renumber document entries according to certain given parameters;

In order to accelerate the process of systematic land registration, all of the methods applied in the study case and all of the improvement proposals have the purpose to optimize the workflow and to support a complex and complete automation, as much as possible in the current real estate registration activity.

BIBLIOGRAPHY

ERGHELEGIU B., (2013), Automation of Cadastral Works, București;

GRECEA C., HERBAN I.S., (2008) Present Experiences in Romanian Cadastral Engineering, GIS Open 2008 Conference-Szekesfehervar, Hungary(www.geo.info.hu/gisopen/ gisopen2008);

GRECEA, C., RUSU, G., MUȘAT, C. C., & MOSCOVICI, A. M. (2013), Challenges in implementing the systematic land registration in Romania. Recent Advances in Geodesy and Geomatics Engineering, 98-105.

GRIGORE V. M., (2015), Contribuții la perfecționarea Sistemului informațional pentru Înregistrarea sistematică a Proprietăților imobiliare, Teza de doctorat, București;

HERBEI, M., HERBEI, R., DRAGOMIR, L., & SMULEAC, A. (2013). The analysis of cartographic projections used in Romania. Research Journal of Agricultural Science, 45(2), 127-136.

HERBEI, M., ȘMULEAC, A., & POPESCU, C. (2018). Cartografie digitală și mobile GIS, Ed. Mirton, Timișoara.

MIȚA, R., SIMON, M., COPACEAN, L., ȘMULEAC, A., HERBEI, M., & POPESCU, G. (2020). Using geographical information systems in order to achieve the urban cadastre in the subcetate neighborhood of arad with the help of modern technologies. Research Journal of Agricultural Science, 52(4).

PASOLEA M. E., MOCAN M., (2017), Strategia logistică şi aspecte ale evoluţiei cadastrului general în România, Lucrare de disertatie, Timișoara;

POPESCU, G., POPESCU, C. A., HERBEI, M., & SMULEAC, A. (2016). Measuring the parameters that influence the phenomenon of displacement and deformation of the ground at

ȘMULEAC, A., HERBEI, M., & POPESCU, C. (2012). Creating the digital terrain model of the USAMVB area using modern technology. Research Journal of Agricultural Science, 44(3), 282-287.

ȘMULEAC, A., HERBEI, M., POPESCU, G., POPESCU, T., POPESCU, C. A., BARLIBA, C., & ȘMULEAC, L. (2019). 3D Modeling of Patrimonium Objectives Using Laser Technology. Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Horticulture, 76(1), 106-113.

ȘMULEAC, A., NEMES, I., CRETAN, I. A., NEMES, N. S., & ȘMULEAC, L. (2017, OCTOBER). Comparative Study of the Volumetric Methods Calculation Using GNSS Measurements. In IOP Conference Series: Materials Science and Engineering (Vol. 245, No. 5, p. 052020). IOP Publishing.

ȘMULEAC, A., ONCIA, S., ȘMULEAC, L. I., POPESCU, C., & BARLIBA, C. (2014). Topo-cadastral works to determine the exploitation perimeter of mineral aggregates on the Nera River, Naidas, Romania. In 14th International Multidisciplinary Scientific GeoConference SGEM 2014 (pp. 599-606).

ȘMULEAC, A., POPESCU, C., BĂRLIBA, L., CIOLAC, V., & HERBEI, M. (2017). Using the GNSS technology tothicken geodesic network in Secaș, Timiș county, Romania. Research Journal of Agricultural Science, 49(3).

SMULEAC, A., POPESCU, C., HERBEI, M., BARLIBA, L. L., & SMULEAC, L. I. topographic surveys and compensations with Toposys applied at the BUASVM Timisoara, Romania, DOI: 10.5593. Sgem2014.

ȘMULEAC, A., POPESCU, C., ȘMULEAC, L., & PEPTAN, C. A. (2015). Processing Lidar Information To Increase Precision In Field Numerical Models. Research Journal of Agricultural Science, 47(2).

ȘMULEAC, A., ȘMULEAC, L., MAN, T. E., POPESCU, C. A., IMBREA, F., RADULOV, I., & PAȘCALĂU, R. (2020). Use of Modern Technologies for the Conservation of Historical Heritage in Water Management. Water, 12(10), 2895.

ȘMULEAC, L., IMBREA, F., CORODAN, I., IENCIU, A., ȘMULEAC, A., & MANEA, D. (2017). The influence of anthropic activity on Somes River water quality. AgroLife Scientific Journal, 6(2), 178-182.

ȘMULEAC, L., ONCIA, S., IENCIU, A., BERTICI, R., ȘMULEAC, A., & PIȚIGA, C. (2013). A study on the possibilities of using groundwater in rural communities in south-western Banat plain. Research journal of agricultural science, 45(2), 287-293.

ȘMULEAC, L., RUJESCU, C., ȘMULEAC, A., IMBREA, F., RADULOV, I., MANEA, D., & PAȘCALĂU, R. (2020). Impact of Climate Change in the Banat Plain, Western Romania, on the Accessibility of Water for Crop Production in Agriculture.

ȘMULEAC, L., SIMONA, N., IENCIU, A., & SMULEAC, A. DICU DANIEL-Topographic survey for the monitoring of the impact of the brua/rohuat pipe on water flow in the irrigation system at Fвntвnele. In Arad county, Romania, International Scientific Conferences on Earth and Geo Sciences-SGEM VIENNA GREEN HOFBURG, ISSN (pp. 1314-2704).

***HTTP://EN.WIKIPEDIA.ORG/WIKI/INFRASTRUCTURE_FOR_

***SPATIAL_INFORMATION_IN_THE_EUROPEAN_COMMUNITY

***HTTP://INSPIRE.JRC.EC.EUROPA.EU/INDEX.CFM/PAGEID

***HTTPS://GEOTOP.RO/

***HTTPS://LEICA-GEOSYSTEMS.COM/PRODUCTS/MOBILE-SENSOR-PLATFORMS/CAPTURE-PLATFORMS/LEICA-PEGASUS-BACKPACK

***HTTP://WWW.ANCPI.RO/PNCCF/

***HTTP://WWW.ESRI.COM

***HTTPS://WWW.DELTAQUAD.COM

***HTTPS://NOVATEL.COM/

***HTTPS://WWW.THEINDIANADRONES.COM/

*** VELODYNE (2014), VELODYNE HIGH-DEFINITION LIDAR.