CIVIL ENGINEERING FACULTY
OVERLAND COMMUNICATION WAYS, FOUNDATIONS AND CADASTRAL SURVEY DEPARTAMENT

Traian Lalescu 2A, 300223, Timişoara, ROMÂNIA

HABILITATION THESIS

Lecturer PhD.eng.ec. Clara – Beatrice Vîlceanu

Civil Engineering Faculty,
Politehnica University Timişoara

Timişoara

2021

CIVIL ENGINEERING FACULTY
OVERLAND COMMUNICATION WAYS,
FOUNDATIONS AND CADASTRAL SURVEY
DEPARTAMENT

Traian Lalescu 2A, 300223, Timişoara, ROMÂNIA

HABILITATION THESIS

GeoData for 3D Modeling and H-BIM development in Urban Planning – current and future practice

Lecturer PhD.eng.ec. Clara – Beatrice Vîlceanu

Civil Engineering Faculty,
Politehnica University Timişoara

Timişoara

2021

ABSTRACT

Intelligence is, perhaps, the most precious gift given to human beings, the result of millions of years of evolution. Education, however, is what gives intelligence rigor, direction and purpose, moral sense and continuity. In vain do we invent wheels, if we do not know where we are going. And if we know, we can use the experience of others to choose the shortest path. Education is based on teachers, personal example and influence, transmitting of values and the awakening of curiosity. Curiosity is innate, but it depends on the school whether it is encouraged or suppressed.

After a long journey on school benches, after a rich experience in academia, I can say that the desire to learn and share what I have learned has become more intense over time, because the more we know, more questions arise, more excited our curiosity becomes. First of all, I would like to emphasize the importance of immersion in academia, together with colleagues and professors equally passionate about geodesy and topography, among friendly discussions and differences, as a fertile ground where the fruits of knowledge are not long in coming and where strong essences are truly valued. Starting from general to individual, to the specialization on certain topics and current issues, each step has its well defined role. In order to better understand the details, it is important to have an overview, and in order to have a more comprehensive overview, it is the details that make the difference. In order to be able to contribute to solving a problem, we must dedicate ourselves completely and we must focus only on it. This is actually tried through the bachelor's, master's and doctoral programs, the last step being the one that allows the concrete, palpable action that we can have on the daily reality, the one that allows us to change, literally, the world. Even if it may be difficult at first, the end results make everything worthwhile and, as with anything, it is important to find the right motivation. Motivation is the engine of any action and without it we can achieve nothing. Thus, whether it is the desire to know more, the desire to do something concrete in the world you live in or just the pure passion for the domain, it is important to establish this from the beginning. And then go on your way. I did it, and I feel more fulfilled as a professional in the field of land measurements and cadastre, but also as a human being.

The habilitation thesis comprises in the research activity undertaken by the candidate after defending the PhD Thesis entitled “Monitoring, modeling and analysis of landslides and reinforced-earth constructions using modern geodetic technologies”, having Prof.dr.eng. Marin Marin as scientific coordinator, at Politehnica University Timisoara. The public defending of the doctoral dissertation took place in 28 February 2014 at the Civil Engineering Faculty, the PhD title being confirmed by Order no. 165, dated 07.04.2014 issued by The Ministry of Education and Research.

The scientific and professional achievements together with the evolution and career development plan, presented during the present habilitation thesis, are structured in four sections, namely:

1. Overview of research conducted during doctoral stage;
2. Scientific, professional and academic achievements in post-doctoral period;
3. Evolution and development of professional, scientific and academic career plan;
4. References.

The first section reviews the research undertaken in the doctoral stage. The most documented section is represented by the second one, in which the most important achievements are presented, in close connection with the current development context of the domain in which the addressed topic in this habilitation thesis is applicable.

The 2nd section which, as stated above, includes both the research activity conducted so far and the achievements, being structured on certain thematic directions:

- the first part synthetizes the deliverables obtained throughout the professional activity, after defending the PhD. thesis, namely: published books and e-books, scientific articles, citations of the articles from the ISI, Scopus and Google Scholar databases, research projects both as manager and team member and other relevant scientific, didactic and professional achievements;
- the second part presents the personal achievements in the context of the current state of scientific research in the thematic field of geodesy, both internationally and nationally, highlighting, in an argumentative and documented way, the relevance and originality of personal contributions.

Given the fact that, in the geodesy field, the advance of technology has an alarming pace, I have always tried to be up-to-date with state-of-the-art and to develop my research in those particular directions, so that the topics covered during the activity professional are based on the evolution of technology, including case studies conducted with LiDAR (Light Detection and Ranging) - terrestrial laser scanning and UAS (Unmanned Aerial Systems) - drones.

It should be noted that the activity of the candidate in the field of geodetic engineering, in particular 3D modeling (11 years of research in this field), from the beginning, September 2010, until the defending of PhD Thesis, and for the postdoctoral period, comes under the scope of the research conducted by the department of Overland Communication Ways, Foundation and Cadastral Survey. Moreover, the scientific research was materialized in numerous grants and projects developed in collaboration with the team from Terrestrial Measurements and Cadastre from Civil Engineering Faculty, Politehnica University Timisoara, but also with private companies from the western part of Romania in the geodetic sector and departments from EU universities.

The new subjects of research in the post-doctoral period can be synthetized in three distinguish themes, each of them related to the following aspects:

- LiDAR applications in the Geodetic Engineering domain;
- Reverse engineering with a view to creating 3D point clouds / mesh models for H-BIM in the cultural heritage domain;
- E-Learning in higher education system – particular case of Geodetic Engineering domain.

REZUMAT

Inteligența este, poate, darul cel mai de preț oferit omului, rezultatul a milioane de ani de evoluție. Educația, însă, este cea care conferă inteligenței rigoare, direcție și scop, simț moral și continuitate. Degeaba inventăm roți, dacă nu știm încotro ne îndreptăm. Și dacă știm, ne putem folosi de experiența altora pentru a alege drumul cel mai scurt. Educația se bazează pe dascăli, pe exemplul personal și pe influențare, pe transmiterea unor valori și pe trezirea curiozității. Curiozitatea este înnăscută, însă depinde de școală dacă ea este încurajată sau înăbușită.

După lungul drum parcurs pe băncile școlii, după o bogată experiență în mediul academic, pot spune că dorința de a învăța și de a împărtăși cunoștințele acumulate a devenit tot mai intensă cu timpul, căci cu cât știm mai multe, cu atât devin mai numeroase întrebările, cu atât ne este ațâțată curiozitatea. În primul rând, doresc să subliniez importanța imersării în mediul academic, alături de colegi și profesori la fel de pasionați de domeniul geodeziei și topografiei, printre discuții și divergențe prietenești, ca pe un sol fertil unde fructele cunoașterii nu se lasă mult așteptate și unde esențele tari sunt cu adevărat prețuite. Pornind de la general către particular, către specializarea pe anumite teme și probleme de actualitate, fiecare pas are rolul său. Pentru a înțelege mai bine detaliile, e importantă privirea de ansamblu, iar pentru a avea o privire de ansamblu mai cuprinzătoare, detaliile sunt cele care fac diferența. Pentru a ne putea aduce aportul la rezolvarea unei probleme, trebuie să ne dedicăm total și trebuie să ne concentrăm doar asupra acesteia, fapt care se încearcă de fapt prin programele de licență, masterat și doctorat, ultimul pas fiind și cel care permite acțiunea concretă, palpabilă pe care o putem avea asupra realității cotidiene, cea care ne permite să schimbăm, la propriu, lumea. Chiar dacă poate fi greu la început, rezultatele finale fac ca totul să merite și, ca în cazul oricărui lucru, e important să ne găsim motivația potrivită. Motivația e motorul oricărei acțiuni și fără ea nu putem realiza nimic. Astfel, fie că este dorința de a ști mai mult, dorința de a face ceva concret în lumea în care trăiești sau doar pasiunea pură pentru domeniu, e important să stabilești asta de la început. Și apoi să mergi pe drumul tău. Eu am făcut-o, și mă simt mai împlinită ca profesionist în domeniul măsurătorilor terestre și al cadastrului, dar și ca om.

Teza de abilitare cuprinde activitatea de cercetare întreprinsă de candidată după susținerea tezei de doctorat intitulată „Utilizarea tehnologiilor geodezice moderne pentru monitorizarea, prelucrarea și analiza unor alunecări de teren și construcţii din pământ armat”, conducător științific Prof.dr.ing. Marin Marin, la Universitatea Politehnica Timișoara. Susținerea publică a tezei de doctorat a avut loc în 28 februarie 2014 la Facultatea de Construcţii, titlul de doctor fiind confirmat prin Ordinul nr. 165, din 07.04.2014 emis de Ministerul Educației și Cercetării.

Realizările științifice și profesionale, împreună cu planul de evoluție și dezvoltare a carierei, prezentate în cadrul prezentei teze de abilitare, sunt structurate în patru secțiuni, și anume:

1. Scurtă descriere a cercetării realizate în timpul stagiului de doctorat;
2. Realizări științifice, profesionale și academic în perioada post-doctorală;
3. Evoluția și dezvoltarea planului de carieră din punct de vedere profesional, științific și academic;
4. Bibliografie.

Prima parte cuprinde o trecere în revistă a cercetărilor întreprinse în stagiul doctoral. Cea mai documentată secțiune este reprezentată de cea de-a doua parte, în cadrul căreia sunt prezentate cele mai importante realizări, în strânsă legătură cu contextul actual de dezvoltare a domeniului în care este aplicabil subiectul abordat în această teză de abilitare.

A doua secțiune care, după cum este menționat mai sus, include atât activitatea de cercetare desfășurată până în prezent, cât și realizările și este structurată pe anumite direcții tematice:

- prima parte sintetizează rezultatele obținute pe parcursul activității profesionale, după susținerea publică a tezei de doctorat, și anume: cărți și cărți electronice publicate, articole științifice, citări ale articolelor din bazele de date ISI, Scopus și Google Scholar, proiecte de cercetare atât ca manager, cât și ca membru al echipei și alte informații relevante realizări științifice, didactice și profesionale;
- partea a doua prezintă realizările personale în contextul stadiului actual al cercetării științifice în domeniul tematic al geodeziei, atât la nivel internațional, cât și la nivel național, evidențiind, într-un mod argumentat și documentat, relevanța și originalitatea contribuțiilor personale.

Având în vedere faptul că, în domeniul geodeziei, avântul tehnologiei are un ritm alerm, am încercat permanent să fiu la curent cu stadiul tehnicii și să îmi dezvolt activitatea de cercetare în direcțiile respective, astfel că subiectele atinse pe parcursul activității profesionale se bazează pe evoluția tehnologiei, cuprinzând studii de caz realizate cu LiDAR (Light Detection and Ranging) – scanare laser terestră și UAS (Unmanned Aerial Systems) – drone.

Trebuie remarcat faptul că activitatea candidatei în domeniul Ingineriei Geodezice, în special modelarea 3D (11 ani de cercetare în acest domeniu), încă de la începutul stagiului doctoral, septembrie 2010, până la susținerea tezei de doctorat și pentru perioada postdoctorală, intră în sfera cercetărilor efectuate de departamentul de Căi de Comunicație Terestre, Fundații și Cadastru. Mai mult, cercetarea științifică s-a concretizat în numeroase granturi și proiecte dezvoltate în colaborare cu echipa de la programul de studii „Măsurători Terestre și Cadastru” de la Facultatea de Construcții, Universitatea Politehnica Timișoara, dar și cu companii private din partea de vest a României din sectorul geodezic și departamente ale unor universități din Uniunea Europeană.

Noile subiecte de cercetare din perioada postdoctorală pot fi sintetizate în trei teme distincte, fiecare dintre ele legate de următoarele aspecte:

- Aplicații LiDAR în domeniul Ingineriei Geodezice;
- Inginerie inversă în vederea realizării de modele 3D cloud / mesh pentru H-BIM în domeniul patrimoniului cultural;
- E-Learning în sistemul de învățământ superior - cazul particular al domeniului Inginerie Geodezice.

1. OVERVIEW OF RESEARCH CONDUCTED DURING DOCTORAL STAGE

In the context of changing demographic, technological, economic conditions, of unplanned urbanization, of insufficient development, irrational use of natural resources, everywhere around the world, as well as in Romania, the consequences of natural hazards will be more and more serious for human civilization. In Romania, the country's various regions have developed differently over the years, this leading to a social and economic imbalance between the levels of development found in different regions. Therefore, a necessity for achieving regional development is ensuring sustainability in all regions of the country, which involves taking into consideration environment factors in the social and economic growth process. (Vîlceanu C.-B. , 2014)

Upon joining the E.U., Romania has set as goal the implementation of development policies based on the sustainability principle. One of these development policies is represented by that present in the environment field which contains, besides requirements for environment protection, both disaster prevention measures and the actions necessary for reconstructing affected areas. Natural disasters that have affected Romania over the years are earthquakes, landslides, floods, soil erosion. Other common problems are: forest health, water pollution from mining and accidental pollution caused by the chemical industry, thermal processes or oil refineries. Sustainability is achieved by means of evaluating the present state of environment factors and the development of new technologies that can ensure management of environment reconstruction and facilitate the adopting of optimal decisions to that purpose. (Vîlceanu, Herban, & Muşat, 2011)

The research I have focused on during my doctoral stage had as goal the presentation of methods and materials specific for geospatial solutions that are in close connection with environmental engineering and have to be used for continuously monitoring areas affected by hazards. Although sometimes the surveyor's contribution to certain projects for hazard risk management, meant to develop early-warning-systems or risk maps, is not adequately appreciated, as he is only seen as supplier of measured geometric data, the surveyor has a significant contribution, through his abilities regarding modeling of dynamic systems like construction or slopes and GIS data interpretation. For all these reasons, the old view must be put aside, and the novel element is brought by underlining the important role that the surveyor has in monitoring the earth surface prone to natural hazards. By means of presenting state of the art technologies, like remote sensing, satellite-based positioning or GIS, the thesis shows its high level of topicality. Moreover, the thesis's originality is given by the proposal that the surveyor should always take part in reaching decisions regarding courses of action in hazard risk management.

The methods and instruments presented indicate the stage researches have reached, they are diverse and cover a wide area, making possible even the monitoring of the entire planet.

The objectives aimed to be achieved by the doctoral dissertation were the following:

- interpretation of the national and global data regarding hazards;
- presenting the fundamental theoretical information with respect to the land sliding phenomena, by detailing their main causes, the geological formations subjected to the sliding phenomena and the specific geotechnical parameters that interfere in the study of the soils massive behaviour;
- the description of the geodesic methods and technologies that are used in problems regarding the monitoring of some surfaces affected by the instability phenomena in order to determine the horizontal and vertical (settlements) displacements, mapping and the execution of the digital models for the respective areas;
- highlighting the importance of interdisciplinary landsliding research in order to obtain some accurate results and establishing the action paths for repairing the damages;
- describing case studies that are based on the land sliding problems that have been made by renowned research teams in order to emphasise how the theme fits into the international, national and regional concerns;
- studying the time behaviour of some objectives affected by land sliding, by executing periodically geodesic measurements using the latest technologies that will allow the processing and analysis of the data obtained by the tri-dimensional system;
- creating the basis for the modeling and optimising the monitoring networks by choosing the optimum research methods.

The innovative elements brought by the doctoral dissertation consisted in proposing a working methodology that can comprise methods and complementary technologies from the geodesic and geotechnical engineering field that can be used in the evaluating and monitoring the processes that lead to risks due to sliding. At the same time, the capabilities of the programs/software specialised for 3D data processing, to generate accurate results regarding the volumetrically calculus have been demonstrated.

Thus, in my doctoral dissertation I have studied several geodetic applications to civil engineering field being structured as follows:

1.1.Hazards and the socio-economical impact over the human activity

The hazards can be classified function of many criteria: forming pattern (genesis), period of emergence, affected area, number of victims, and the complexity of the phenomenon and so on, as it can be shown in table 1.

Table 1. Hazards classification

CRITERION	TYPE OF HAZARD
Genesis	a. Naturals: endogenous and exogenous; b. Anthropic.
Affected area	a. Global, systemically; b. Global with regional effects; c. Regional; d. Local and punctual.
Size of the effects	a. With reduced effects b. With severe effects; c. Disasters (catastrophe).

There are dozens, sometimes hundreds of hazards all over the world, daily. Presently, the losses following hazards are growing constantly (Fig. 1) and are accompanied by serious consequences as regards human survival, dignified life conditions and means of existence and also the loss of goods gathered with difficulty in the development process. Some of these hazards are triggered by people and can also be stopped by them; therefore the human factor has various possibilities to act.

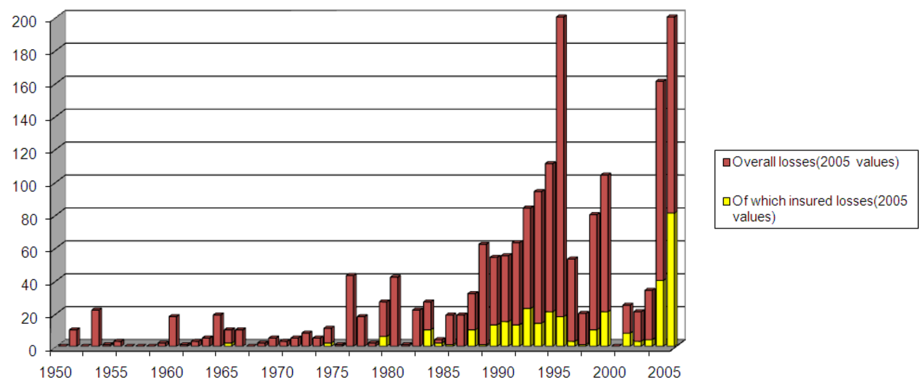


Figure 1. Natural catastrophes 1950 – 2020

In Romania, the country's various regions have developed differently over the years, this leading to a social and economic imbalance between the levels of development found in different regions. Therefore, a necessity for achieving regional development is ensuring sustainability in all regions of the country, which involves taking into consideration environment factors in the social and economic growth process.

Upon joining the E.U., Romania has set as goal the implementation of development policies based on the sustainability principle. One of these development policies is represented by that present in the environment field which contains, besides requirements for environment protection, both hazard prevention measures and the actions necessary for reconstructing affected areas.

The United Nations Organization realizes yearly a word risk report that established the basis of the World Risk Index, which gives the probability with which a country or a region will be hit by a disaster. Four components characterize this basic notion, and they are put into concrete terms by five categories each. In turn, the four components are mathematically combined as modules, thus forming the World Risk Index.

The concept of the World Risk Index, with its modular structure, was developed jointly by scientists and development experts. The calculation of the Index, which the United Nations University Institute for Environment and Human Security, Bonn (UNU-EHS), has been commissioned to perform by Alliance Development Works, is carried out via the four components:

- exposure towards natural hazards such as earthquakes, cyclones, flooding, drought and sea level rise;
- susceptibility depending on infrastructure, nutrition, housing situation and economic framework conditions;
- coping capacities depending on governance, disaster preparedness and early warning, medical services and social and material coverage;
- adaptive capacities relating to forthcoming natural events, to climate change and to other challenges.

The document that gradates 175 countries shows that Romania has a reduced capacity of managing natural hazards, and to adapt after their occurrence, being situated in 2020 on 99th place, comparing to the year 2012, when it has been ranked on the 82th place (Fig. 2).

Rank	Country	WorldRiskIndex	Exposure	Vulnerability	Susceptibility	Lack of coping capacities	Lack of adaptive capacities
87.	Pakistan	6.68	11.74	56.89	33.13	84.81	[illegible]
88.	Colombia	6.65	14.65	45.38	22.73	77.45	35.97
89.	India	6.62	12.51	52.94	32.08	78.15	48.60
90.	Thailand	6.54	14.81	44.13	17.52	78.63	36.25
91.	Swaziland	6.42	11.12	57.72	41.73	83.05	48.38
92.	Peru	6.37	14.14	45.08	26.39	76.03	32.83
92.	South Africa	6.37	13.37	47.65	30.75	72.82	39.38
94.	Namibia	6.21	11.36	54.66	42.50	74.13	47.36
95.	Syrian Arab Republic	6.03	10.80	55.87	27.47	[illegible]	49.13
96.	Iraq	5.99	10.78	55.59	26.60	[illegible]	52.44
97.	Mexico	5.97	14.09	42.39	20.96	73.91	32.30
98.	Samoa	5.87	12.19	48.13	25.40	79.66	39.33
99.	Romania	5.86	15.41	38.03	19.49	64.60	30.00
100.	Cuba	5.84	16.53	35.34	19.48	53.67	32.86
100.	China	5.84	14.30	40.85	20.98	72.07	29.50
102.	Tajikistan	5.83	11.99	48.63	32.00	77.09	36.81
103.	Morocco	5.82	12.14	47.91	24.70	79.02	40.00
104.	North Macedonia	5.81	14.48	40.12	18.88	70.23	31.25
105.	Armenia	5.73	14.55	39.37	20.21	69.22	28.67
106.	Azerbaijan	5.72	14.31	39.98	17.80	71.43	30.71
106.	Georgia	5.72	14.58	39.23	22.56	63.77	31.36
108.	Tunisia	5.70	13.06	43.67	17.73	75.46	37.82
109.	Yemen	5.68	8.33	[illegible]	[illegible]	[illegible]	[illegible]
110.	Turkmenistan	5.66	12.25	46.22	27.29	73.18	38.18
111.	Seychelles	5.31	12.53	42.39	18.07	67.13	41.97
112.	Lebanon	5.27	11.43	46.08	20.31	78.98	38.95
113.	Serbia	5.25	13.41	39.17	22.01	67.80	27.71
114.	New Zealand	5.11	17.73	28.81	16.16	48.57	21.70
115.	Hungary	5.07	15.24	33.28	16.01	58.65	25.19
116.	Islamic Republic of Iran	5.03	10.96	45.85	19.78	83.24	34.53
116.	Turkey	5.03	12.29	40.96	18.17	72.92	31.80
118.	Brazil	4.91	11.33	43.33	22.57	76.28	31.14
119.	Bosnia and Herzegovina	4.80	11.18	42.95	18.65	74.24	35.95
120.	Plurinational State of Bolivia	4.78	9.56	50.01	32.36	79.97	37.71
121.	Nepal	4.77	8.62	55.29	33.70	83.34	48.81
122.	Italy	4.75	15.17	31.29	17.25	59.22	17.41

Figure 2. Classification of the countries that are subjected to risk from the global risk report realized by ONU in 2020

Country	WRI	Rank
Afghanistan	9.79 %	40.
Albania	9.96 %	38.
Algeria	8.15 %	56.
Angola	6.56 %	88.
Argentina	3.80 %	133.
Armenia	7.04 %	79.
Australia	4.57 %	117.
Austria	3.75 %	135.
Azerbaijan	6.10 %	98.
Bahamas	4.17 %	125.
Bahrain	1.81 %	166.
Bangladesh	20.22 %	5.
Barbados	1.15 %	171.
Belarus	3.32 %	145.
Belgium	3.48 %	142.
Belize	6.63 %	86.
Benin	11.42 %	27.
Bhutan	8.17 %	55.
Bolivia	5.13 %	110.
Bosnia and Herzeg.	6.63 %	86.
Botswana	5.21 %	109.
Brazil	4.30 %	124.
Brunei Darussalam	15.92 %	11.
Bulgaria	4.56 %	118.
Burkina Faso	9.74 %	41.
Burma	9.15 %	42.
Burundi	10.49 %	36.
Cambodia	17.17 %	8.
Cameroon	11.50 %	26.
Canada	3.18 %	150.
Cape Verde	10.88 %	32.
Central African Rep.	6.64 %	85.
Chad	11.13 %	28.
Chile	12.26 %	19.
China	7.05 %	78.
Colombia	6.89 %	81.
Comoros	7.45 %	68.
Congo	7.38 %	71.
Costa Rica	17.38 %	7.
Côte d'Ivoire	9.00 %	44.
Croatia	4.35 %	123.
Cuba	6.55 %	89.
Cyprus	2.81 %	152.
Czech Republic	3.67 %	138.
Denmark	3.09 %	151.
Djibouti	9.96 %	37.
Dominican Republic	11.63 %	25.
Ecuador	7.94 %	58.
Egypt	2.33 %	161.
El Salvador	16.89 %	10.
Equatorial Guinea	4.47 %	121.

Country	WRI	Rank
Eritrea	6.44 %	92.
Estonia	2.50 %	159.
Ethiopia	7.81 %	62.
Fiji	13.69 %	15.
Finland	2.24 %	163.
France	2.78 %	153.
Gabon	6.20 %	96.
Gambia	11.84 %	23.
Georgia	6.75 %	84.
Germany	3.27 %	146.
Ghana	8.85 %	45.
Greece	7.35 %	72.
Grenada	1.46 %	169.
Guatemala	20.75 %	4.
Guinea	8.55 %	49.
Guinea-Bissau	13.34 %	17.
Guyana	11.77 %	24.
Haiti	11.96 %	21.
Honduras	11.02 %	30.
Hungary	5.87 %	102.
Iceland	1.53 %	168.
India	7.28 %	73.
Indonesia	10.74 %	33.
Iran	4.98 %	112.
Iraq	4.95 %	113.
Ireland	4.50 %	120.
Israel	2.43 %	160.
Italy	4.82 %	116.
Jamaica	12.15 %	20.
Japan	13.53 %	16.
Jordan	4.90 %	114.
Kazakhstan	3.87 %	128.
Kenya	6.96 %	80.
Kiribati	1.78 %	167.
Korea, Republic of	4.89 %	115.
Kuwait	3.71 %	136.
Kyrgyzstan	8.50 %	50.
Lao P. D. Rep.	5.73 %	103.
Latvia	3.51 %	141.
Lebanon	5.10 %	111.
Lesotho	7.22 %	75.
Liberia	7.86 %	60.
Libyan Arab Jam.	3.80 %	133.
Lithuania	3.23 %	148.
Luxembourg	2.65 %	155.
Madagascar	10.96 %	31.
Malawi	8.18 %	54.
Malaysia	6.53 %	91.
Mali	8.76 %	46.
Malta	0.61 %	172.
Mauritania	8.43 %	52.
Mauritius	15.39 %	13.

Country	WRI	Rank
Mexico	6.39 %	94.
Mongolia	3.24 %	147.
Morocco	7.21 %	76.
Mozambique	9.09 %	43.
Namibia	5.72 %	104.
Nepal	5.69 %	105.
Netherlands	8.49 %	51.
New Zealand	4.44 %	122.
Nicaragua	15.36 %	14.
Niger	11.93 %	22.
Nigeria	8.28 %	53.
Norway	2.31 %	162.
Oman	2.72 %	154.
Pakistan	7.25 %	74.
Panama	7.69 %	64.
Papua New Guinea	15.81 %	12.
Paraguay	3.84 %	129.
Peru	7.18 %	77.
Philippines	27.98 %	3.
Poland	3.53 %	140.
Portugal	3.82 %	131.
Qatar	0.10 %	173.
Rep. of Moldova	5.73 %	108.
Romania	6.78 %	82.
Russia	3.83 %	130.
Rwanda	7.60 %	67.
Samoa	4.51 %	119.
S. Tome a. Principe	3.40 %	143.
Saudi Arabia	1.31 %	170.
Senegal	11.08 %	29.
Serbia	7.67 %	66.
Seychelles	2.60 %	156.
Sierra Leone	10.58 %	35.
Singapore	2.54 %	158.
Slovakia	3.69 %	137.
Slovenia	3.81 %	132.
Solomon Islands	18.15 %	6.
South Africa	5.90 %	100.
Spain	3.40 %	143.
Sri Lanka	7.79 %	63.
Sudan	7.88 %	59.
Suriname	8.62 %	48.
Swaziland	7.84 %	61.
Sweden	2.15 %	164.
Switzerland	2.59 %	157.
Syrian Arab Republic	5.68 %	106.
Tajikistan	7.40 %	70.
Thailand	6.44 %	92.
Rep. of Macedonia	6.25 %	95.
Timor-Leste	17.13 %	9.
Togo	10.64 %	34.

Country	WRI	Rank
Tonga	28.62 %	2.
Trinidad a. Tobago	7.68 %	65.
Tunisia	5.90 %	100.
Turkey	5.68 %	106.
Turkmenistan	6.55 %	89.
Uganda	6.75 %	83.
Ukraine	3.19 %	149.
Uni. Arab Emirates	2.07 %	165.
United Kingdom	3.65 %	139.
U. Rep. o. Tanzania	8.11 %	57.
United States o. A.	3.99 %	127.
Uruguay	4.12 %	126.
Uzbekistan	8.71 %	47.
Vanuatu	36.31 %	1.
Venezuela	6.13 %	97.
Viet Nam	12.88 %	18.
Yemen	5.98 %	99.
Zambia	7.44 %	69.
Zimbabwe	9.87 %	39.

Countries not listed in the WorldRiskIndex
Andorra
Antigua and Barbuda
Dem. People's Republic of Korea
Democratic Republic of the Congo
Dominica
Federated States of Micronesia
Liechtenstein
Maldives
Marshall Islands
Monaco
Montenegro
Nauru
Palau
San Marino
Somalia
St. Kitts and Nevis
St. Lucia
St. Vincent and the Grenadines
Tuvalu

Figure 3. Classification of the countries that are subjected to risk from the global risk report realized by ONU in 2012

Natural hazards that have affected Romania over the years are earthquakes, landslides, floods, soil erosion. Other common problems are: forest health, water pollution from mining and accidental pollution caused by the chemical industry, thermal processes or oil refineries.

Sustainability is achieved by means of evaluating the present state of environment factors and the development of new technologies that can ensure management of environment reconstruction and facilitate the adopting of optimal decisions to that purpose.

The data regarding the type and number of hazards, numbers of victims, which have been affected by them, as well as the supported damages, are collected at the International Federation of the Red Cross Society and Red Half-moon. Taking into consideration the recorded data from the International Data Base for Disasters, EM-DA, from the Research Centre for Hazards Epidemiology (CRED), figures 3-7 offers a global view over the hazards that have affected Romania in the last two centuries.

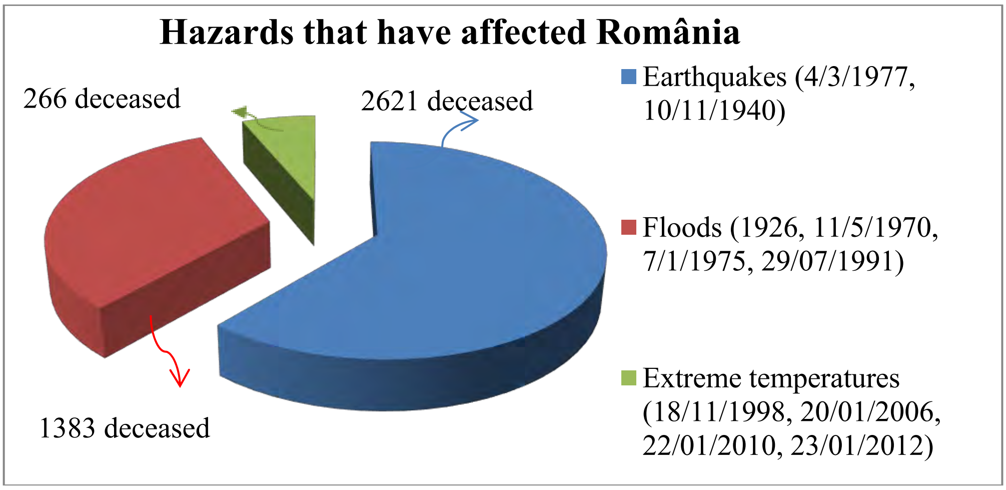


Figure 4. Classification of the 10 most important natural hazards that have affected Romania between 1900 – 2013, function of the number of deceased persons

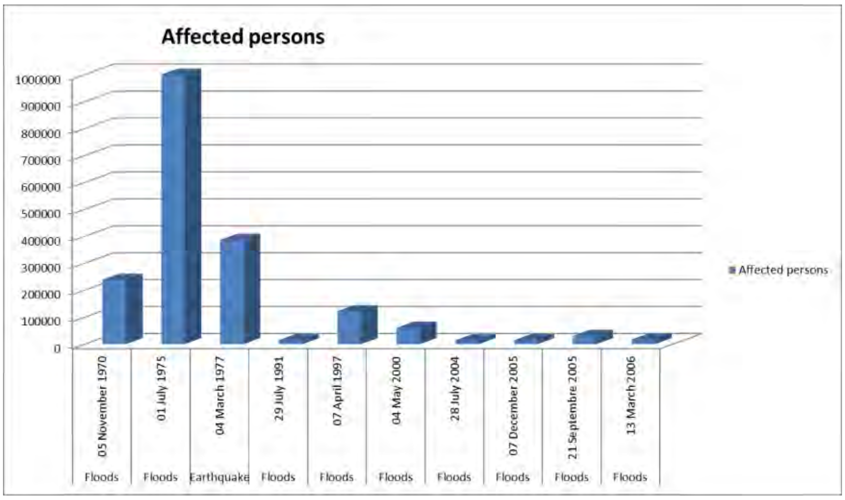


Figure 5. Classification of the 10 most important natural hazards that have affected Romania between 1900 – 2013, function of the number of affected persons

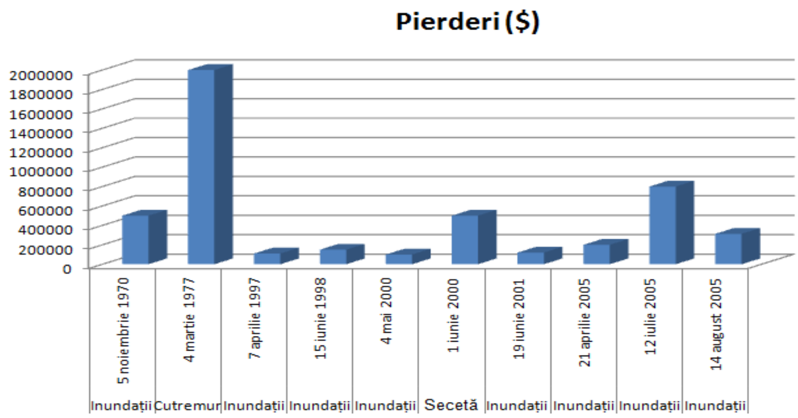


Figure 6. Classification of the 10 most important natural hazards that have affected Romania between 1900 – 2013, function of the number of affected persons

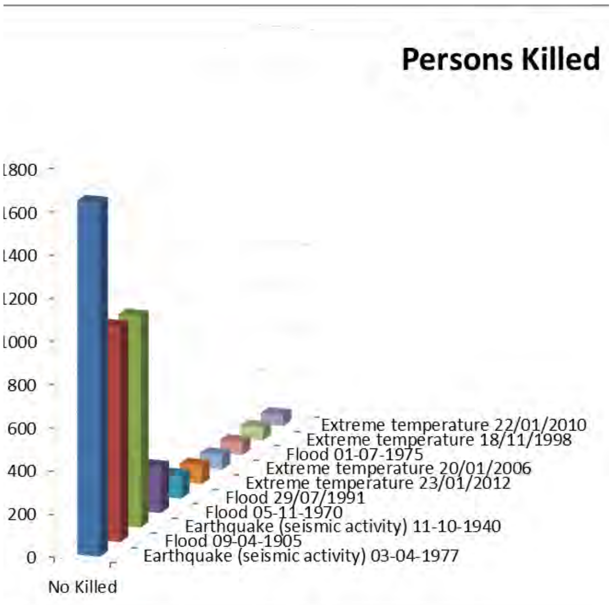


Figure 7. Classification of the 10 most important technological hazards that have affected Romania between 1900 – 2013, function of the number of deceased persons

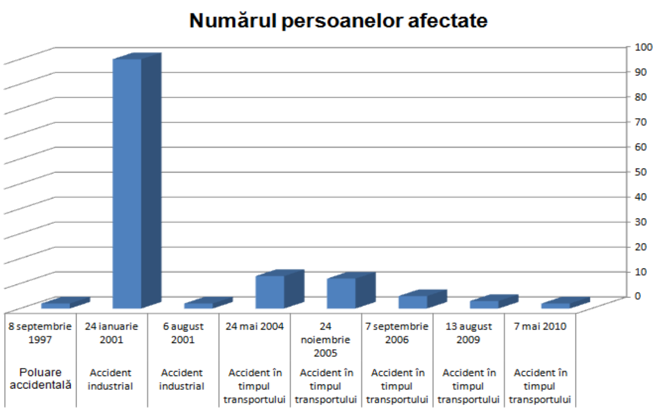


Figure 8. Classification of the 10 most important technological hazards that have affected Romania between 1900 – 2013, function of the number of affected persons

From analysing figures 4 – 8 Romania's susceptibility to natural hazards results and the fact that the authorities are not properly prepared to manage such situations. Excepting the difficulties in implementing the strategies at the European Union level, in our country there must be taken into consideration a series of particular problems, such as consolidating the major city buildings with high risk for collapsing in case of earthquake; thermal and functional refurbishments of the large precast reinforced concrete panels, traffic fluidizations and assembly soundproofing panels, waste selective collecting as well as erecting plants where these can be collected, recycled or incinerated (in a controlled environment) in order to obtain energy (as for polystyrene); relinquishing the generalised embankment of the major riverbeds and of the everglades and execution of polders as "breathing" spaces for the flooding period, executing anti-erosion works, desilting the minor riverbeds and interdicting any type of constructions in their proximity.

Figures 7 and 8 show an increased percentage of the technological hazards, but only until the beginning of the XXI century. This is due to the fact that before, during the communism era, Romania was a high industrialised country. Once with the globalisation, the competitiveness of the industry lowered, without attracting new capital, this segment started its decline, explaining this way the reduction of the industrial accidents.

It is obvious that the engineers, regardless of their speciality, environmental engineers, civil engineers or geodetic engineers, have a key role in assuring sustainable development. The society needs to move towards preventing the environmental problems by developing new proactive solutions, given by engineers.

1.2. General analysis of the landsliding phenomena

It was composed out of 6 subchapters, which approached in detail the land sliding problems. There were discussed the stages and the specific elements of the landslides (Fig. 9), classification criteria, main causes that lead to landslides, geological formations subjected to the sliding phenomena and specific geotechnical parameters used for characterising the behaviour of the earth massive.

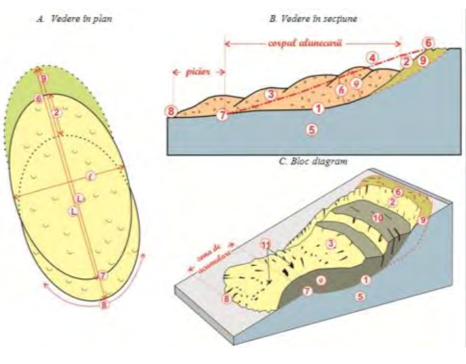


Figure 9. Main elements of a landslide

1.3.Geodetic methods used for landslides monitoring

It was composed out of four subchapters. The first two show specific topographic and geodetic methods for determining the horizontal and vertical displacements. The next subchapter reviews the particularities of the terrain's digital models, methods for obtaining those, domains in which can be applied and international context, as well as national regarding the concerns for creating quality digital terrain models, because the existing ones do not possess sufficient precision, present lacks in information and therefore, induce errors and distortions in the orthorectified images, fact that can affect entire geospatial data bases.

Surface modeling is the process of plotting a natural or artificial surface through one or more mathematical equations. Land surface modeling is therefore a special case of modeling surfaces in which specific issues related to the representation of the Earth, or parts of the Earth, need to be taken into consideration. The product is called a 3D model and it incorporates components, materials, layers that make up a complex structure.

For instance, designing a dynamic framework for planning and development, based on 3D models can help to create the master plan of any populated area. That is why, in recent years, more and more engineers worldwide have approached this relatively new field, the three-dimensional modeling, preferring 3D design systems instead of the traditional 2D drawing.
3D modeling offers multiple advantages, namely correcting heights, interconnecting the object's components, creating a new product based on the primary elements. Thus, the designing process is facilitated together with an effortless manipulation of the complex data.

Creating the digital terrain model through planimetrical and altimetric precise measurements is of high importance because it can also be used for the calculus of:

- thickness and volume of the landslide body;
- length and width of the landslide body;
- partitioning surface area by establishing directions of slip;
- determining the longitudinal and transverse sections etc.

A 3D model is composed of objects, materials, layers forming a complex structure. In it we can visualize certain parts separately or all the elements together. Objects and materials have easy to highlight properties, called visual properties such as colour, light reflection, contrast or albedo. As a final product we can obtain the facade of buildings, their roofs or 3D terrain models.

The three dimensional model offers multiple possibilities for working: correction rates, connecting elements that are part of the creation of a new product starting from the basic elements. Easy handling and complexity of information provided facilitates the design process. Finally, the data can be integrated and exported to other programs specialized in a particular field, such as: design, urban planning, tourism, real estates, police and security etc. Dimensional models can be, in turn, very helpful in specific analysis, but can also be sources for the implementation of another product.
The last subchapter emphasizes the geodesist's contribution to creating and updating of the risk maps which represent a decision tool for adopting hazard prevention measures, in case of landslides, floods, earthquakes etc. Due to the geological and physical-geographical conditions, Romania is among the countries with high risk potential for the occurrence of certain instability phenomena, especially landslides. In the context of protecting the environment, not only the design of a development strategy to limit environmental degradation, human and material losses is responsible for ensuring sustainable development, but also, according to the current and future needs, the quality of applied management.

The multidisciplinary approach of updating the risk map consists in using the information from the geotechnical field – i.e. contour of risk zones using the findings of the geotechnical investigation – and the topo-geodetic measurements, through a permanent landslide monitoring in the affected area.

Landslide engineering-geology mapping is made to identify the affected areas and to study measures to stabilize. The maps have different scales and in Romania the most usual scales are 1:25.000 and 1:10.000. This method is also used to know all the geological factors which generate the landsliding process and to provide information about it, such as geological formations, age and lithologic and tectonic nature, underground waters. There can also be observed in detail all the landsliding elements which can be observed directly, such as: breaking front, sliding terrace, sliding accumulation, longitudinal and transversal cracks, sliding relief, edges and the base of the sliding.

In order to draw up a map for Romania indicating the areas with landslide potential risk, several documents were issued. These are: "The Guide to draw up risk maps for slope sliding to ensure the stability of the constructions"- indicative GT019-98 and approved by H.G. no. 447/ 10.04.2003, "Methodological Norms for the elaboration and the content of the natural risk maps for landsliding". These norms represent the general frame regarding the succession of the stages for drawing up landsliding maps. In Romania, besides the relief conditions, the areas with high potential landsliding risk overlap, in most cases, with the areas with high seismic activity.

Drawing up slope sliding risk maps needs as much accuracy as possible in the correlation of the slope slide occurrence potential with the assessment of the risk elements in the area (Fig. 10).These maps area (Fig. 11) must reflect the effort state of the slopes and the values of the stability factors, in representative sections. They constitute the main parameters on which one can assess how high it is the danger of reaching the collapse limit of the land massif and the occurrence of a landslide.

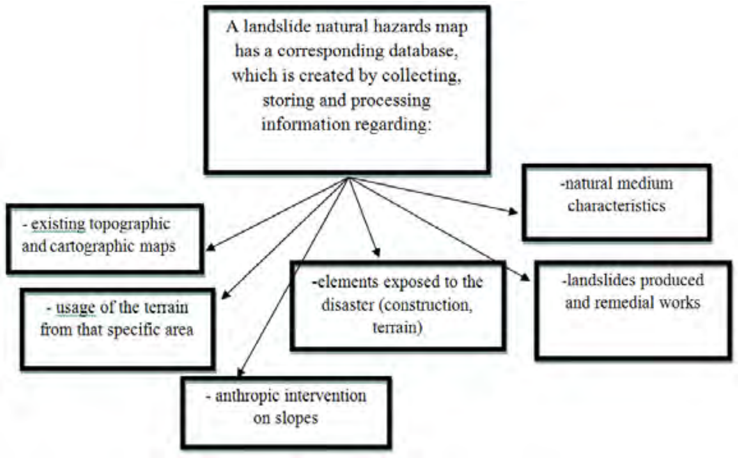


Figure 10. Information contained in the corresponding risk map database

Drawing up a risk map should be conducted in two stages:

Phase I - will include collecting of all types current information: morphological, hydrological, climatic, geological, geotechnical and hydrogeological. This information can be found in the documentation drawn up for various purposes, associated with the researched perimeter, as well as in very detailed geological engineering and hydrogeological mappings.

Phase II –must include, besides the data obtained in the first stage, exploration work (geophysical, drilling, mining, *in situ* tests) and laboratory geotechnical analysis. The data obtained contribute substantially to an increased accuracy of the risk maps which will be produced on more precise calculations and interpretations.

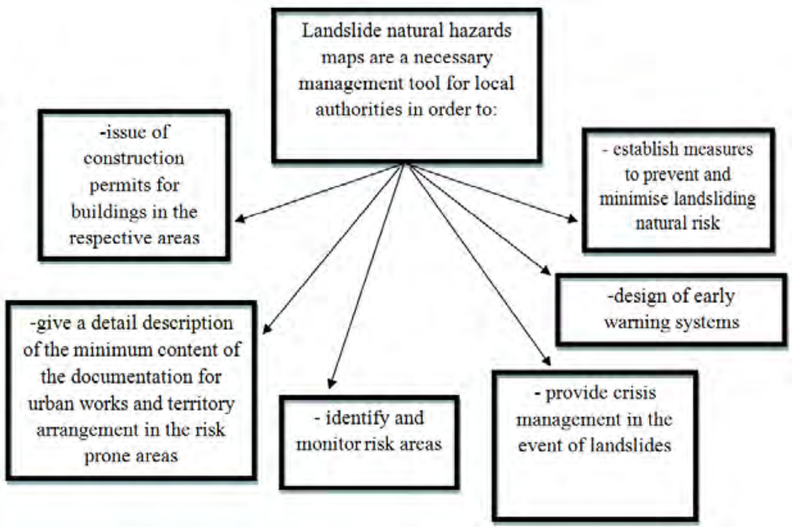


Figure 11. Risk maps - a management tool for local authorities

1.4. Directions towards landslides monitoring using modern geodetic methods aiming to increase the operational safety

It is divided in four subchapters; the first of them highlights the importance of the monitoring concept in geodetic and geotechnical engineering.

About 80% of daily decisions on national or local level, in different fields of activity, like demography, spatial planning, environment, hazard areas, infrastructure, housing, property evaluation etc. are spatially or geo-referenced. The modern surveying engineer assists in acquiring, managing, visualizing and analysing geospatial data related to hazards. Combined with new technologies and methods, the challenging profession delivers the basic principles for hazard risk management within the disciplines geodetic engineering, satellite-based positioning, photogrammetry, remote sensing, geoinformatics and land management (Fig. 12).

Reducing hazard risk can be achieved through monitoring objectives, surfaces, regions or even the entire planet with the purpose of warning the population that could be affected by the hazard at the right time. A very important role in hazard monitoring is played by geodetic methods by means of which catastrophes like: earthquakes, volcano eruptions, landslides, hurricanes, the falling down of hydro dams or bridges can be monitored and anticipated.

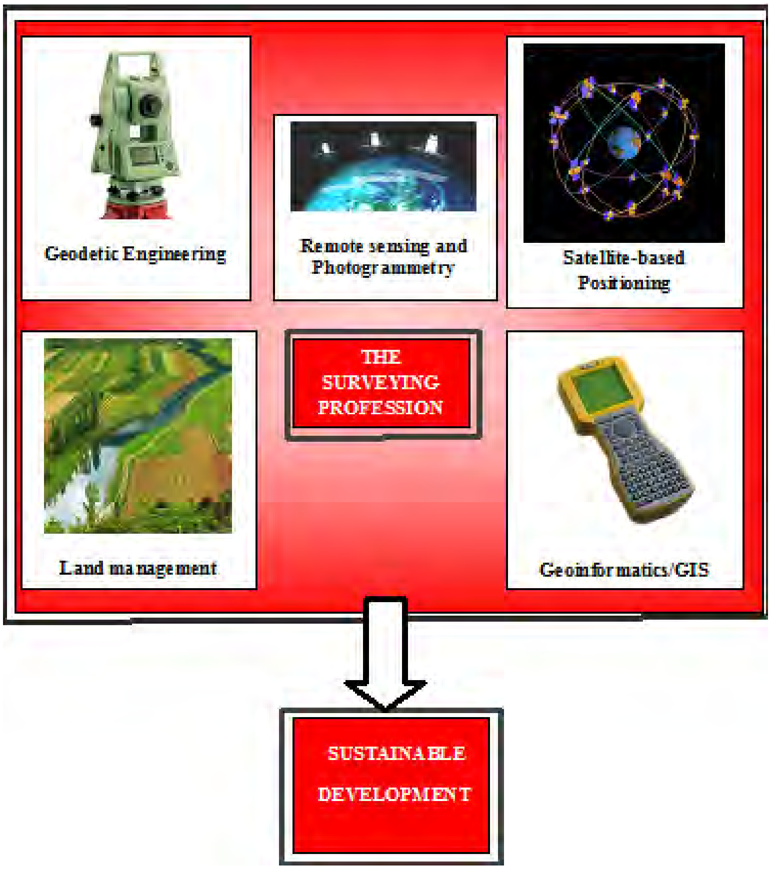


Figure 12. The importance of surveying methods for sustainable development

- **Geodetic Engineering**

Hazards that are monitored and forecasted by geodetic means are earthquake, volcanic eruption, landslide, tsunami, dams or bridge failures, aiming to build up *early warning systems*. Usually, when talking about realizing an early warning system, a team of specialists from various fields is put together, namely civil engineers, geologists, geophysicists, hydrologists. There is an absolute need for a geodetic engineer to cooperate in this multidisciplinary team for delivering the geometric quantities needed – positions of objects in absolute sense or in relation to other objects or in distances between points on one object – and describing the quality of the data.

- **Photogrammetry**

Photogrammetry is an efficient tool in monitoring spatial objects due to location, form and shape. The terrestrial photogrammetric methods have a significant contribution in determining and monitoring, documenting and analysing the damages in the structures after different hazards such as earthquakes or landslides. Through photogrammetry, orthophoto images (Fig. 13) are obtained, one can work both in local and regional systems, terrain digital elevation models are created, the direction and tilt of geological strata and the position of points are determined, thus helping to determine the deformations of the building and helping to decide whether a damaged building will be kept for retrofitting or be demolished.

Figure 13. Timişoara's Orthophotoplan in colours with 11 cm space resolution

The advantages of photogrammetry as compared to classic topographic methods are:

- obtaining a significant amount of data, with the possibility of exploring vast and hard to reach areas;
- quick evaluation of the extent of some hazards and the damage the cause;
- the coordinates of every point can be determined without any effort or additional costs.

- **Remote sensing**

Aerial photogrammetric data acquisition techniques give very accurate data about the damaged area and, by using the latest technology like InSAR and LiDAR, large amount of data is provided very fast, weather and day light independent.

- **InSAR technology** comes in different forms. We have as follows: *Standard InSAR* for DEM generation, *Differential InSAR* (DInSAR) for ground deformation mapping allows the monitoring of slow ground movements which involve large portions of the land surface, such as subsidence phenomena, fault movements and along volcano displacements, tectonic movements and *Permanent/Persistent Scatterer Interferometric Synthetic Aperture Radar* (PS-InSAR) for displacements over individual coherent targets.

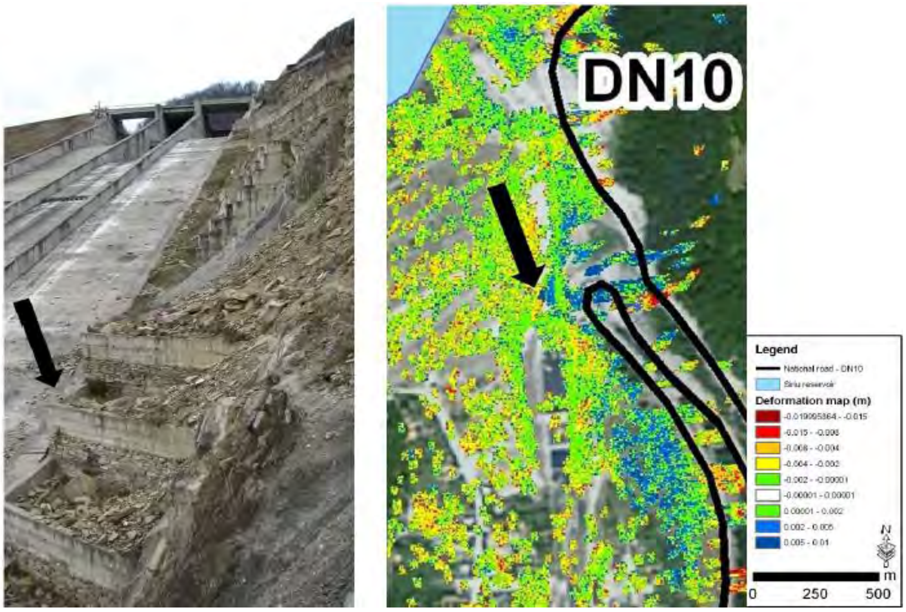


Figure 14. Deformation map for Siriu area spill, Buzau county, Romania, based on the radar measurements

The main benefit of the interpherometric analysis is the possibility to check the effectiveness of the remedial measures that have already been adopted.

- **LIDAR** is an optical remote sensing technology which measures properties of scattered light to find range and/or other information of a distant target.\

Major advantages of Lidar are:

- lots of data points; makes for a very good approximation of the surface;
- can penetrate through gaps in trees and provide detailed topography of bare Earth;
- can provide detailed information of vertical distribution of canopies;
- high resolution submerged topography in relatively clear and shallow water;

- data gathering through LIDAR is not conditioned by weather conditions, just like aerophotography, and it is even possible during winter months, if there is no snow.

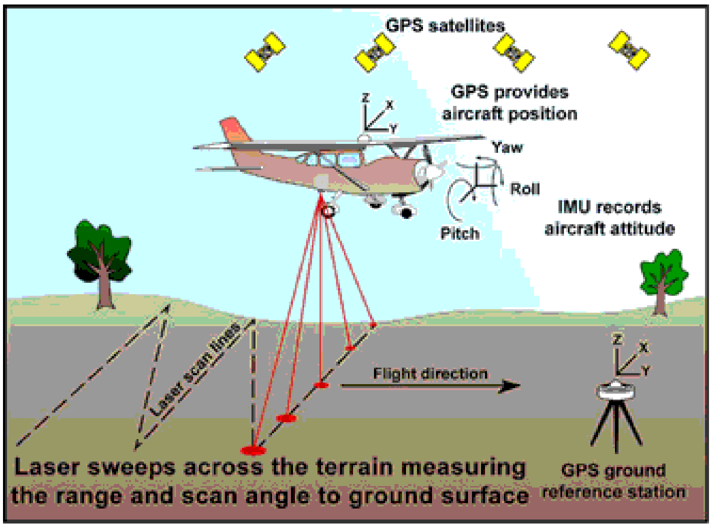


Figure 15. Lidar system (source: https://lidarnews.com/articles/lidar-system-accuracy/)

The main advantages of satellite remote sensing are mainly connected to "real time" work, or work very near to "real time" characteristics, for tracking dynamic phenomena like: evolution of cultures, of environment factors, control of natural calamities and hazards, management of irrigation systems and so on.

Earth observation satellites have demonstrated their utility in providing data for a wide range of applications in hazard risk management. Pre-hazard uses include risk analysis and mapping; hazard warning, such as cyclone tracking, drought monitoring, the extent of damage due to volcanic eruptions, oil spills, forest fires and the spread of desertification; and hazard assessment, including flood monitoring and assessment, estimation of crop and forestry damages, and monitoring of land use/change in the aftermath of hazards. Remotely sensed data also provide a historical database from which hazard maps can be compiled, indicating which areas are potentially vulnerable. Information from satellites is often combined with other relevant data in geographic information systems (GIS) in order to carry out risk analysis and assessment.

- **Laser scanning technology**

The 3D models can be used for publicity purposes as they are accessible and easy to understand because of the force of the visual impact. Model information, such as relative angle and length dimensions, can be extracted from the resulting 3D surface CAD model. Some of the data available with 3D laser scanners are difficult or impossible to measure using traditional surveying instruments. Laser scanners provide thousands of times more information than this traditional approach, and field-work time drops dramatically.

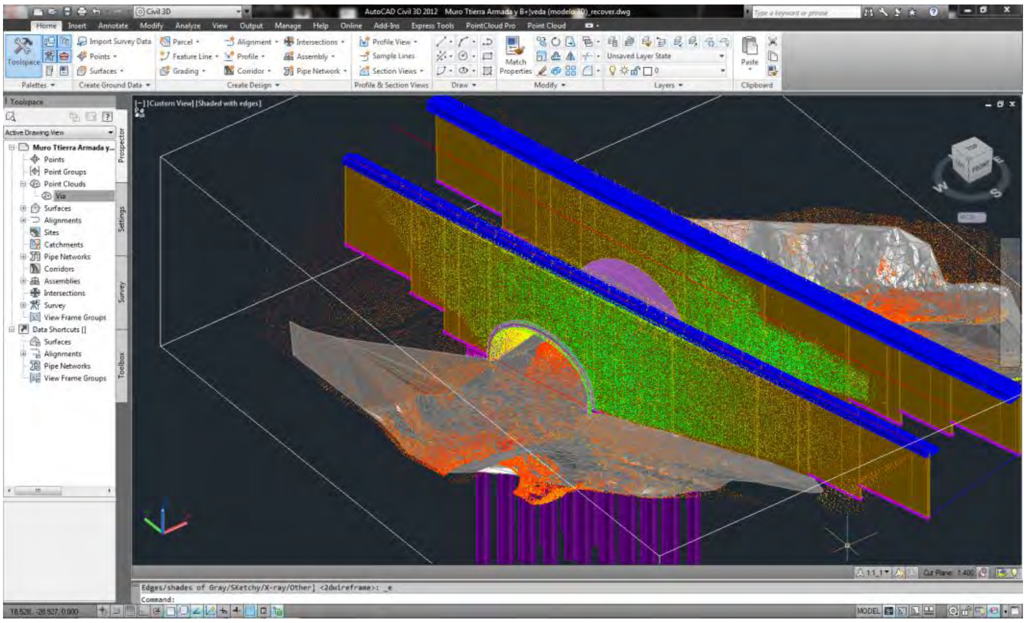


Figure 16. 3D model of a viaduct overlapped to the designed 3D model

3D modeling permits the exportation of the data to different programs that are specialized on a certain field of activity, for example: designing, spatial and urban planning, tourism, real estates, security etc.

Among the benefits of 3D, are the following:

- opportunity of real image acquisition with very realistic 3D models, that are applied in a large variety of fields;
- less time for field work, more time for data processing;
- less cost than airborne technologies on small – and moderate – size reaches;
- the scanner minimizes the probability of unscanned zones due to shadowing effect of roughness elements and overhanging zones due to proximity to the target and the possibility of scanning from different angles and overlapping the scanning results.

This section analyses the complex relationship between hazards, in particular landslides, and the monitoring techniques specific to geodetic domain and leads to the conclusion that sustainable development is directly related to the frequency and intensity of hazards. If all countries would permanently apply risk reduction measures such as raising awareness, educating the population on environmental issues, environmental management, raising the population's living standards, protecting vital utilities, efficient land use, avoiding deforestation, drawing up urban plans, problematic areas monitoring, the risk would be identified, for an early warning of both the population and the authorities, and they would no longer be taken by surprise but would be prepared to manage the hazard impact. The configuration of lands affected by landslides is the indisputable basis for considering geodetic and topographic monitoring.

The international trend is to use spatial data sets for mapping and management of activities in the engineering sectors, surveyed with the monitoring platforms presented. They have a huge role and a real value in hazard management, mitigation, response and socio-economic impact on the environment and also provide safety.

The high level of topicality on 3D technology is demonstrated on one side by the increased interest of both scientific and industrial sectors of producing 3-dimensional models of major cities, and on the other side by the development of solutions to capture, display and manipulate this type of data by the global technology companies. (Styliadis, Honstantinidou, & Tyxola, 2008)

3D models can help to create the master plan of any populated area by designing a dynamic framework for planning and development. While they are generally used to simply visualize the built environment, there are early signs of them being used as 3D interfaces to more sophisticated simulation models. (Grecea & Gridan, Geospatial technology for 3D City and Urban modelling, 2011) That is why, in recent years, more and more engineers worldwide have approached this relatively new field, the three-dimensional modeling, preferring 3D design systems instead of the traditional 2D drawing. (Bălă, Brebu, & Moscovici, Using terrestrial laser scanning echnologies for high construction monitoring, 2012)

A 3D model is composed of objects, materials, layers forming a complex structure. In it we can visualize certain parts separately or all the elements together. Objects and materials have easy to highlight properties, called visual properties such as colour, light reflection, contrast or albedo. As a final product we can obtain the facade of buildings, their roofs or 3D models. A wide variety of applications demonstrate that 3D models allow the user to process different information contents from a digital representation of the reality. (Rusu & Mușat, 2012)

3D modelling represents a first reference for Geo-3D modeling and data analysis, with applicability for studies on many important directions and in various fields, such as: geophysics, mining, hydrology, environmental protection etc. (Didulescu, 2010), (Bălă, Grecea, Brebu, David, & Bota, 2012)

3D modeling offers multiple advantages, namely correcting heights, interconnecting the object's components, creating a new product based on the primary elements. Thus, the designing process is facilitated together with an effortless manipulation of the complex data. Finally, the data can be integrated and exported to other programs specialized in a particular field, such as: design, urban planning, tourism, real estates, police and security etc. (Shashi & Jain, 2007). Dimensional models can be, in turn, very helpful in specific analysis, but can also be sources for the implementation of another product.

2. SCIENTIFIC, PROFESSIONAL AND ACADEMIC ACHIEVEMENTS IN POST-DOCTORAL PERIOD

2.1.Conducted research and its visibility

2.1.1. Books and e-books

Ever since the doctoral stage I was preoccupied with developing teaching materials necessary to support the didactic activity, thus realizing the following:

- ✓ **Beatrice Clara Vîlceanu**, Sorin Ioan Herban, Luisa Izabel Dungan, ***3D printing and scanning***, ISBN 978-973-132-627-6, Eurobit Publishing House, Timisoara.
- ✓ Izabel Dungan, **Clara-Beatrice Vîlceanu**, ***Infrastructura de transport***, 2020, ISBN 978-973-132-622-1, Eurobit Publishing House, Timisoara.
- ✓ **Clara – Beatrice Vîlceanu**, ***Sisteme Informatice Geografice - Concepte şi Aplicaţii***, Politehnica Timisoara Publishing House; ISBN: 978-606-35-0125-8, 2017.
- ✓ Cosmin Muşat, Gheorghe Belea, Dan Pintea, Carmen Grecea, **Beatrice Vîlceanu**, Roberta Gridan, ***Măsurători terestre - concepte, vol.I***, Politehnica Timisoara Publishing House; ISBN: 978-606-554-427-7, 2014.
- ✓ **Clara – Beatrice Vîlceanu**, ***Aplicaţii Practice în Fotogrammetria Digitală***, Available online at: http://www.ct.upt.ro/users/Clara-BeatriceVilceanu/Fotogrammetrie.pdf, 2014.
- ✓ **Clara – Beatrice Vîlceanu**, http://www.ct.upt.ro/users/Clara-BeatriceVilceanu/Laborator_Sisteme_Informatice_Geografice.pdf, 2014.

Regarding the scientific research activity, I can mention that this preoccupation started since the student years with participating in various scientific communication sessions at national and international level, especially in the Geodesy and Topography fields. Namely, I can mention obtaining the "Best paper" award within the 14th edition of the international conference "Student Technical Days" and the second prize at the "Winners in Cadastre" contest, both events held in 2010. After graduating from bachelor and master programmes and enrolment in doctoral courses (2010), I developed as sole author or co-author over 60 scientific articles in the field of Geodetic Engineering, some of this papers being presented at various national and international conferences in the country and abroad (Austria, Bulgaria, Greece, Serbia etc.). In the following sections I will present only the articles published and the achievements obtained after the public defending of the doctoral thesis.

2.1.2. Web of Science indexed articles

1) ***Durable Solutions for Precision Agriculture in Romania***, By: Morarescu, Anca; Herban, Sorin; **Vilceanu, Clara-Beatrice**; et al. Conference: International Conference on Numerical Analysis and Applied Mathematics (ICNAAM) Location: Rhodes, Greece, Date: Sep 23-28, 2019, Sponsor(s): European Soc Computat Methods Sci & Engn, International Conference on Numerical Analysis and Applied Mathematics ICNAAM 2019, Book Series: IP Conference Proceedings, Volume: 2293, Article Number: 350006, DOI: 10.1063/5.0026421, Published: 2020.

   https://www.webofscience.com/wos/woscc/full-record/WOS:000636709500023

2) ***3D Modelling of Cultural Heritage Objective in Timisoara using precise LiDAR***, By: Alionescu, Adrian; Herban, Sorin; **Vilceanu, Clara-Beatrice**, Conference: International Conference on Numerical Analysis and Applied Mathematics (ICNAAM) Location: Rhodes, Greece, Date: Sep 13-18, 2018, Sponsor(s): European Soc Computat Methods Sci & Engn, International Conference on Numerical Analysis and Applied Mathematics (ICNAAM-2018), Book Series: AIP Conference Proceedings, Volume: 2116, Article Number: 370002, DOI: 10.1063/1.5114375, Published: 2019.

   https://www.webofscience.com/wos/woscc/full-record/WOS:000521108600362

3) ***Spatial Data Geoportal for Local Administration - Solution for Smart Cities***, By: Moscovici, A-M; **Vilceanu, C. B.**; Grecea, C.; et al., Journal of Environmental Protection and Ecology, Volume: 20, Issue: 3, Pages: 1374-1383, Accession Number: WOS:000497992700034, Published: 2019.

   https://www.webofscience.com/wos/woscc/full-record/WOS:000497992700034

4) ***Heritage Studies in Spatial Planning; Development and Environmental Policies***, By: **Vilceanu, C. B.;** Alionescu, A.; Grecea, C.; et al., Conference: 18th International Technical-Scientific Conference on Modern Technologies for the 3rd Millennium Location: Oradea, Romania Date: Apr 04-05, 2019, Modern Technologies for the 3rd Millennium, Pages: 79-84, Accession Number: WOS:000617030100014, Published: 2019.

   https://www.webofscience.com/wos/woscc/full-record/WOS:000617030100014

5) ***Structure settlements analysis highlighted by topographic and geotechnical studies***, By: **Vilceanu, C. B.**; Alionescu, A.; Herban, S., Conference: 17th International Technical-Scientific Conference on Modern Technologies for the 3rd Millennium Location: Oradea,

ROMANIA Date: MAR 22-23, 2018, Modern Technologies for the 3rd Millennium, Pages: 123-128, WOS:000491484600022, Published: 2018.

https://www.webofscience.com/wos/woscc/full-record/WOS:000491484600022

6) ***Opportunities and Challenges in Higher Education System: Knowledge Transfer by e-Learning vs. Traditional Methods***, By: **Vilceanu, Clara-Beatrice**; Grecea, Carmen; Herban, Sorin, Conference: 14th International Scientific Conference on eLearning and Software for Education - eLearning Challenges and New Horizons Location: Bucharest, Romania, Date: Apr 19-20, 2018, Sponsor(s): Romanian Adv Distributed Learning Assoc; Univ Natl Aparare Carol I; European Secur & Def Coll; Romania Partnership Ctr, Elearning Challenges and New Horizons, Vol 4, Book Series: eLearning and Software for Education, Pages: 253-258, DOI: 10.12753/2066-026X-18-250, Published: 2018.

   https://www.webofscience.com/wos/woscc/full-record/WOS:000468620000036

7) ***Cultural Heritage Modeling Potential Highlighted by e-Learning Resources***, By: **Vilceanu, Clara-Beatrice**; Herban, Sorin; Banescu, Oana Andreea, Conference: 14th International Scientific Conference on eLearning and Software for Education - eLearning Challenges and New Horizons Location: Bucharest, Romania, Date: Apr 19-20, 2018, Sponsor(s): Romanian Adv Distributed Learning Assoc; Univ Natl Aparare Carol I; European Secur & Def Coll; Romania Partnership Ctr, Elearning Challenges and New Horizons, Vol 4, Book Series: eLearning and Software for Education, Pages: 476-483, DOI: 10.12753/2066-026X-18-282, Published: 2018.

   https://www.webofscience.com/wos/woscc/full-record/WOS:000468620000068

8) ***Using LiDAR for Urban Green Space Monitoring***, By: **Vilceanu, Clara-Beatrice**; Herban, Sorin; Meng, Qingyan; et al., Conference: International Conference of Numerical Analysis and Applied Mathematics (ICNAAM) Location: Thessaloniki, Greece, Date: Sep 25-30, 2017, International Conference of Numerical Analysis and Applied Mathematics (ICNAAM 2017), Book Series: AIP Conference Proceedings, Volume: 1978, Article Number: 390010, DOI: 10.1063/1.5043994, Published: 2018.

   https://www.webofscience.com/wos/woscc/full-record/WOS:000445105400313

9) ***Road-Structure Monitoring with Modern Geodetic Technologies***, By: Herban, Ioan Sorin; **Vilceanu, Clara-Beatrice**; Grecea, Carmen, Journal of Surveying Engineering, Volume 143, Issue: 4, Article Number: 05017004, DOI: 10.1061/(ASCE)SU.1943-5428.0000218, Published: NOV 2017.

https://www.webofscience.com/wos/woscc/full-record/WOS:000416492300001

10) ***Time Structural Behaviour of Buildings Monitored by Topographic Technologies***, By: **Vilceanu, C. B.**; Herban, S.; Musat, C., Conference: 16th National Technical-Scientific Conference on Modern Technologies for the 3rd Millennium Location: Oradea, Romania, Date: Mar 23-24, 2017, Modern Technologies for the 3rd Millennium, Pages: 99-104, Accession Number: WOS:000413420300017, Published: 2017.

https://www.webofscience.com/wos/woscc/full-record/WOS:000413420300017

11) ***Relevancy of Mathematical Support for Geophysics Determinations***, By: **Vilceanu, Clara-Beatrice**; Grecea, Carmen; Musat, Cosmin, Conference: International Conference on Numerical Analysis and Applied Mathematics (ICNAAM) Location: Rhodes, Greece, Date: Sep 19-25, 2016, Proceedings of the International Conference on Numerical Analysis and Applied Mathematics 2016 (ICNAAM-2016), Book Series: AIP Conference Proceedings, Volume: 1863, Article Number: 430008, DOI: 10.1063/1.4992604, Published: 2017.

https://www.webofscience.com/wos/woscc/full-record/WOS:000410159800423

12) ***Geodetic studies with significant contribution to landslide monitoring in south-western Romania - Area with high risk potential***, By: **Vilceanu, CB**; Herban, IS and Grecea, C, Nov 2016, Tehnicki Vjesnik-Technical Gazette 23 (6), pp.1623-1630, DOI: 10.17559/TV-20140304224522, Published: 2016.

https://www.webofscience.com/wos/woscc/full-record/WOS:000388945600011

13) ***WebGIS Solution for Urban Planning Strategies***, By: Grecea, C; Herban, S and **Vilceanu, CB**, World Multidisciplinary Civil Engineering-Architecture-Urban Planning Symposium (WMCAUS) 2016, Vol. 161, pp.1625-1630, DOI: 10.1016/j.proeng.2016.08.637, Published: 2016.

https://www.webofscience.com/wos/woscc/full-record/WOS:000387566500251

14) ***Targeting Displacements' Monitoring of Constructions through Mathematical Methods***, By: Tesila, R; Rusu, G; **Vilceanu, B**; Alionescu, A, International Conference on Numerical Analysis and Applied Mathematics (ICNAAM)2016 | Proceedings of the International Conference on Numerical Analysis and Applied Mathematics 2015 (ICNAAM-2015), Vol. 1738, DOI: 10.1063/1.4952133, Published: 2016.

https://www.webofscience.com/wos/woscc/full-record/WOS:000380803300360

15) ***Using Open Source GIS for the Management of the Administrative Territorial Unit***, By: **Vilceanu, CB**; Herban, S and Alionescu, A, 15th National Technical-Scientific Conference on Modern Technologies for the 3rd Millennium, 2016, pp.73-78, Accession NumberWOS:000378314000013, Published: 2016.

https://www.webofscience.com/wos/woscc/full-record/WOS:000378314000013

16) ***3D Model Tools for Architecture and Archaeology Reconstruction***, By: Vlad, I; Herban, IS; Stoian, M.; **Vilceanu, CB**, International Conference on Numerical Analysis and Applied Mathematics (ICNAAM), 2016 | Proceedings of the International Conference on Numerical Analysis and Applied Mathematics 2015, Vol: 1738, DOI: 10.1063/1.4952128, Published: 2016.

https://www.webofscience.com/wos/woscc/full-record/WOS:000380803300355

17) ***Mathematic Interpolation Methods - Support for an Efficient 3D Modeling of Landslides in the Context of Displacements Monitoring***, By: Alionescu, A; Herban, IS; **Vilceanu, CB**; Musat, CC, International Conference on Numerical Analysis and Applied Mathematics (ICNAAM) 2015 | Proceedings of the International Conference on Numerical Analysis and Applied Mathematics 2014, Vol: 1648, DOI: 10.1063/1.4912897, Published: 2015.

https://www.webofscience.com/wos/woscc/full-record/WOS:000355339704032

18) ***Workflow optimization of immovable's registration in Romanian cadastral system***, By: Herban, S; Grecea, C; Musat, C; **Vilceanu, CB**, 15th International Multidisciplinary Scientific Geoconference (SGEM) 2015 | Informatics, Geoinformatics And Remote Sensing, Vol II, pp.1231-1238, Accession NumberWOS:000371600100153, Published: 2015.

https://www.webofscience.com/wos/woscc/full-record/WOS:000371600100153

19) ***Processing of environmental data using digital terrain models for the western part of Romania***, **Vilceanu, CB**; Herban, S; Alionescu, A; Musat, C, 15th International Multidisciplinary Scientific Geoconference (SGEM), 2015, Informatics, Geoinformatics And Remote Sensing, Vol II, pp.1043-1050, Accession NumberWOS:000371600100130, Published: 2015.

https://www.webofscience.com/wos/woscc/full-record/WOS:000371600100130

20) ***E-learning in engineering - Impact upon the student's mentality and development***, By: **Vilceanu, Clara-Beatrice**; Herban, Sorin; Grecea, Carmen, Conference: 11th International Scientific Conference on eLearning and Software for Education (eLSE) Location: Bucharest,

Romania, Date: Apr 23-24, 2015, Rethinking Education by Leveraging the Elearning Pillar of the Digital Agenda for Europe!, Vol. II Book Series: eLearning and Software for Education, Pages: 584-591, DOI: 10.12753/2066-026X-15-180, Published: 2015.

https://www.webofscience.com/wos/woscc/full-record/WOS:000384470100088

21) ***Comparative overview of cadastre and land information systems in some countries from EUROPE-An efficient tool to understand and manage urban development***, By: Grecea, C.; Moscovici, A. -M.; **Vilceanu, C. -B.**; et al., Journal of Environmental Protection and Ecology, Volume: 15, Issue: 2, Pages: 678-685, Accession Number: WOS:000339362500031, Published: 2014.

https://www.webofscience.com/wos/woscc/full-record/WOS:000339362500031

22) ***Studying the movement of buildings and developing models to determine real settlements***, By: Herban, S. I.; **Vilceanu, C. -B.**; Alionescu, A.; et al., Journal of Environmental Protection and Ecology, Volume: 15, Issue: 2, Pages: 789-796, Accession Number: WOS:000339362500044, Published: 2014.

https://www.webofscience.com/wos/woscc/full-record/WOS:000339362500044

2.1.3. International databases indexed articles

1) ***Geostatistical analysis for landslide prediction in Transilvania, Romania***, By: **C.-B. Vîlceanu**, A. C. Badea, S. Herban, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLII-3/W4, 543–547, 2018, https://doi.org/10.5194/isprs-archives-XLII-3-W4-543-2018

2) ***Urban green space monitoring for climate change mitigation***, By: S. Herban, **C.-B. Vîlceanu**, Rares Halbac-Cotoară-Zamfir, 17th International Multidisciplinary Scientific Geoconference SGEM 2017, Conference Proceedings vol. 17 Energy & Clean Technologies Issue 43, Recycling Air Pollution and Climate Change, Modern Energy and Power Resources, ISBN 978-619-7408-28-7, ISSN 1314-2704, DOI: 10.5593/sgem2017H/43, pp. 595-593.

3) ***Urban Green Space Monitoring technique with Remote Sensing and its application and urban green space index***, By: S. Herban, Q. Meng, **C.-B. Vîlceanu**, Scientific Bulletin of the Politehnica University of Timisoara, Transaction of Hydrotechnics, Vol. 62 (76), Issue 2, 2017, pp. 23-27.

4) ***Waste Management – Approaches, strategies and differences between Romania and Norway***, By: S. Herban, R. Hălbac-Cotoară-Zamfir, **C. B. Teșilă**, B. Foreid, C. Farkas,

Scientific Bulletin of the Politehnica University of Timisoara, Transaction of Hydrotechnics, Vol. 62 (76), Issue 1, 2017, pp. 27-32.

5) ***Monitoring of Buituri slag dump, Hunedoara county in relation with environmental protection***, By: Moscovici, Bala, Brebu, **Vilceanu**, Csegu, Bulletin UASVM Horticulture 74(1)/2017, ISSN 1843-5254 / 1843-5394, DOI:10.15835/buasvmcn-hort:12300 pp. 110-116.

6) ***Managing Urban Traffic and Road Network using GIS Facilities***, By: A. Alionescu, S. Herban, C. Muşat, **B. Vîlceanu**, Scientific Bulletin of the Politehnica University of Timisoara, Transaction of Hydrotechnics, Vol. 60(74), Issue 1, 2015, pp. 13-17.

7) ***3D models for a sustainable development of cultural heritage***, By: **C.-B. Vîlceanu**, S. I. Herban, O. Grecea, Procedia Environmental Science, Engineering and Management (P - ESEM), ISSN: 2392 – 9537, ISSN-L: 2392 – 9537, eISSN: 2392 – 9545, (2015) (2) pp.157-160.

8) ***Cadastre 2020: A new perspective of Romanian cadastral system***, By: C. C. Muşat, **C. – B. Vîlceanu,** A. M. Moscovici, Advances in Environmental Development, Geomatics Engineering and Tourism, Proceedings of 2nd European Conference of Geodesy & Geomatics Engineering (GENG '14), ISSN 2227-4359, ISBN 978-960-474-385-8, pp. 168-174, 2014.

9) ***Application of close-range photogrammetry to cultural heritage***, By: I.S. Herban, **C.-B. Vîlceanu**, A. Alionescu, RevCad Journal of Geodesy and Cadastre, ISSN 1583-2279, No. 16-2014, pp. 104 – 112.

10) ***Geodetic frame for railways infrastructure works***, By: S. I. Herban, A. Alionescu, C. Grecea, **B. C. Vîlceanu**, International journal of systems applications, engineering & development, ISSN: 2074-1308, vol. 8/2014, pp. 26-32.

2.1.4. Other articles

1) ***Using the laser scanning for conservation of Cultural Heritage buildings***, By: **C.-B. Vîlceanu**, L. Dungan, S. Herban, F. Popescu, the X International conference- Industrial Engineering and Environmental Protection (IIZS 2012), 8th – 9th October 2020, Technical faculty "Mihajlo Pupin" Zrenjanin, Srbija.

2) ***Influence of climate change and urban development on GNSS measurements***, By: A. Bălă, L. Dungan, **C.-B. Vîlceanu**, S. Herban, the X International conference- Industrial Engineering and Environmental Protection (IIZS 2012), 8th – 9th October 2020, Technical faculty "Mihajlo Pupin" Zrenjanin, Srbija.

3) ***Spatial data geoportal – a powerful interface for the local administration***, By: O.-A. Bănescu, **C.–B. Vîlceanu**, A.–D. Hapenciuc, The first Conference on Heritage and Sustainable Innovation, CoHeSION 2018, November 15–17 2018, Timișoara, Romania.

4) ***Management of sporadic registration properties by means of open-source GIS***, By: **C.–B. Vîlceanu**, A.–M. Moscovici, S. Herban, Book of Abstracts no.5/2018, The 17th International Symposium Prospects for the 3rd MillenniumAgriculture, 27th-29th September 2018, Cluj-Napoca, Romania, University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca.

5) ***Spatial data geoportal for Local Administration – smart solution for a secure and valuable cultural heritage***, By: **C.-B. Vîlceanu**; C. Grecea, S. Herban, Journal of Geodesy, Cartography and Cadastre, no. 7 issue 2, 2017, ISSN: 1454-1408.

6) ***TLS and Digital Photogrammetry Studies in Cultural Heritage Domain***, By: S. Herban, **C.-B. Vilceanu**, Conference Proceedings Contemporary Achievements in Civil Engineering, pp. 765-772, DOI:10.14415/konferencijaGFS 2015.097, ISBN 978-86-80297-62-0, Subotica, 2015.

7) ***Systematic registration of properties – a new challenge for the Romanian cadastral system***, By: Muşat C. C., **Vîlceanu C.-B.**, Moscovici A.-M., Journal of Geodesy, Cartography and Cadastre, No 3 / 2015, ISSN: 1454-1408, pp. 15-20.

8) ***Elaborarea hărţilor de risc la alunecări de teren utilizând date geotehnice, topografice şi tehnologia SIG***, By: **C. – B. Vîlceanu**, M. Marin, Revista Construcţiilor, anul XI, nr. 113, April 2015, pp. 50-55.

9) ***Comparative study of TLS and digital photogrammetry for 3D modeling of the Martyr's cross monument***, By: A. Alionescu, S. Herban, C. Grecea, **C. – B. Vîlceanu**, Proceedings of IGIT 2015, International Conference, Integrated geo-spatial information technology and its application to resource and environmental management towards GEOSS, ISBN 978-963-334-211-4, pp. 94-99, Publisher: Nyugat-magyarországi Egyetem Kiadó, Sopron, 2015.

10) ***Studiu De Caz Privind Comportarea Unui Pasaj Din Pământ Armat***, By: M. Marin, P. Pantea, **C. – B. Vîlceanu**, Al XIV-lea Congres Naţional De Drumuri Şi Poduri Din România, Cluj-Napoca, September 10-13, 2014.

11) ***Degradări şi soluţii de condolidare privind rambleele de la Autostrada Nădlac – Arad***, By: M. Marin, P. Pantea, M. Mirea, **C. – B. Vilceanu**, Al XIV-lea Congres Naţional De Drumuri Şi Poduri Din România, Cluj-Napoca, September 10-13, 2014.

2.1.5. *Citations*

I believe that many of my own scientific contributions are relevant and have brought added value to knowledge. Most of the reference articles are cited in various journals by researchers both from Romania and abroad as it can be seen in the following images.

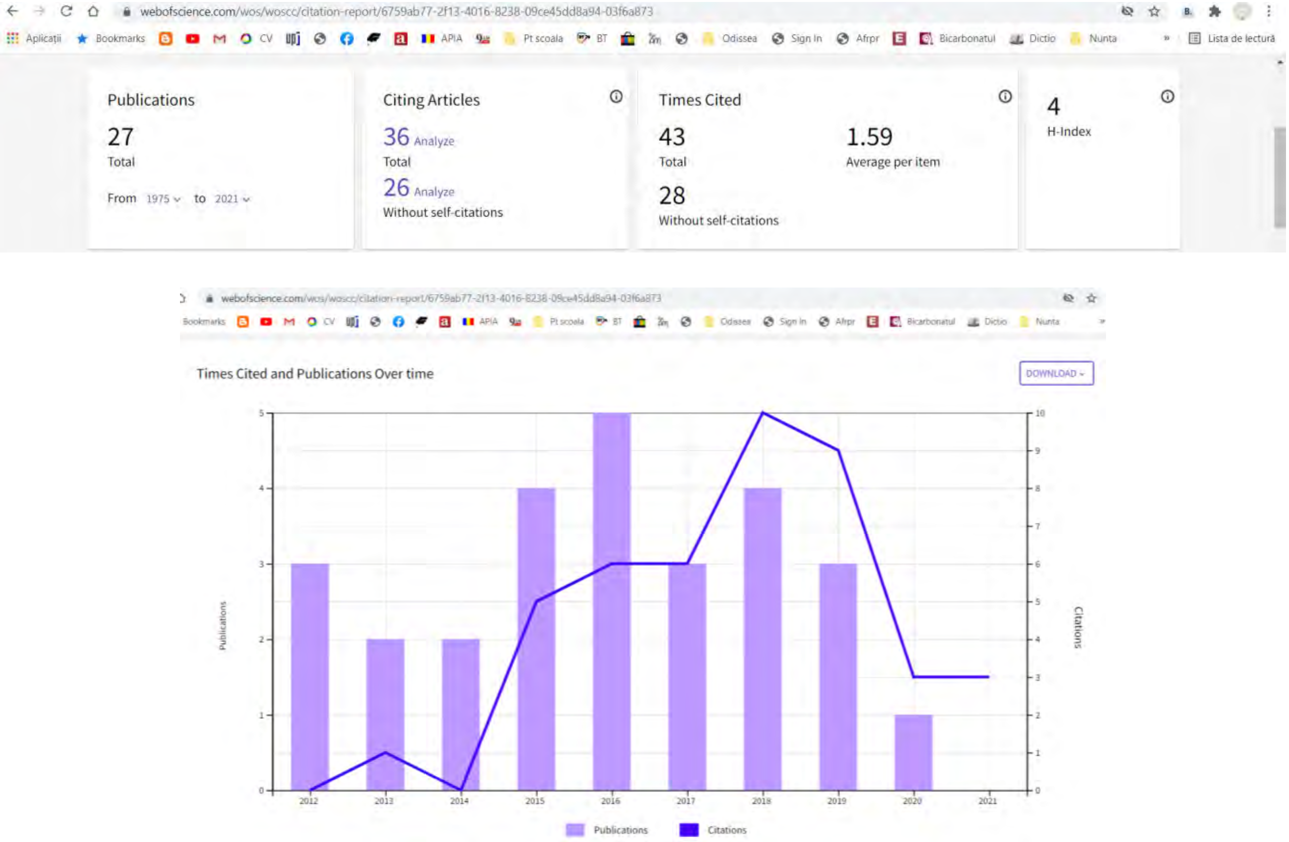


Figure 16. Citation index Web of Science (12.08.2021)

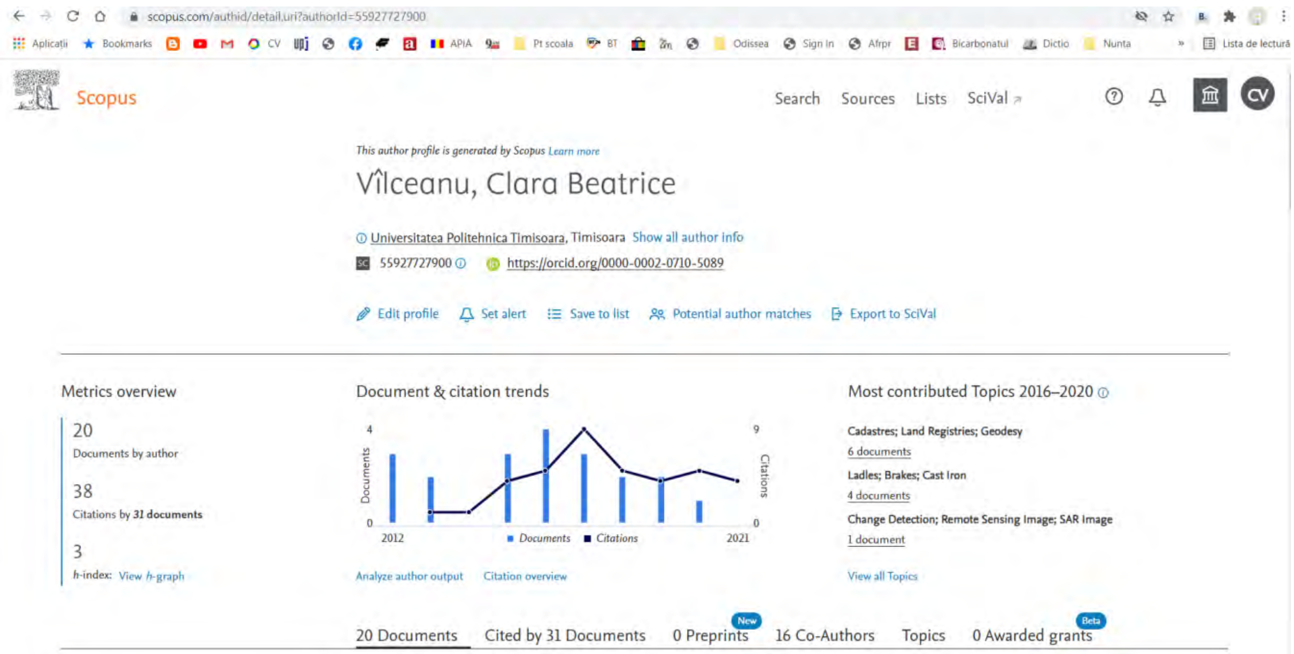


Figure 17. Citation index Scopus (12.08.2021)

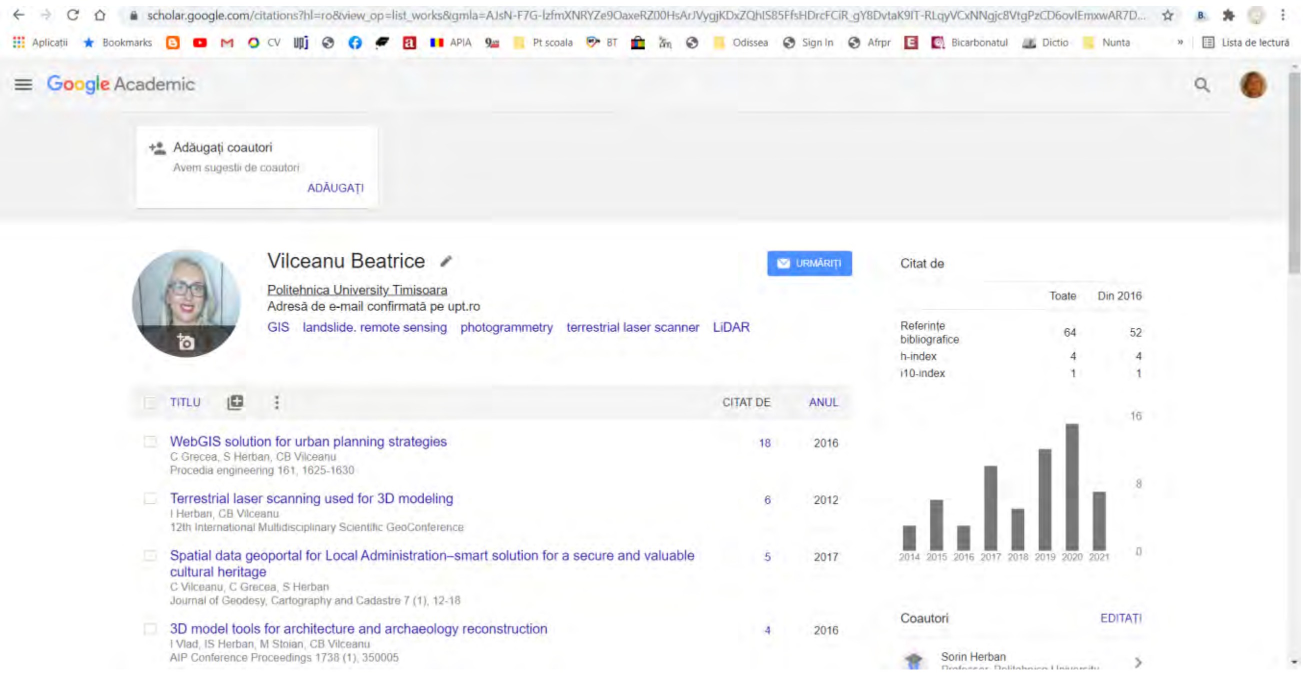


Figure 18. Citation index Google Scholar (12.08.2021)

2.1.6. Research projects

Regarding the implementation of research projects, besides managing several projects, I also participated as member both in research teams of some projects funded by European Union funds, and in research teams of projects carried out in partnership with state authorities or private economic environment. In the following pages I will present in detail the most relevant projects that had a significant research component.

Project manager:

1) PN-III-P1-1.1-MC-2019-0531 mobility project: Training Stage at Warner Surveys Ltd. Company, London between 23th of September and 1st of October 2019 to practice, research and acquire knowledge regarding using fully automated 24/7 active installations, with real time data continuously uploaded to the web.

Warner Surveys Ltd. offers an exceptionally broad range of topographical and engineering surveying services. From topographic and setting out surveys to underground utilities detection and UAV flights. We ensure that all of the customers’ survey requirements from project concept through to completion are provided. Dedicated to survey, our Company Values are Quality and Communication, committing us to the highest of standards and doing whatever it takes to deliver the results the customers need.

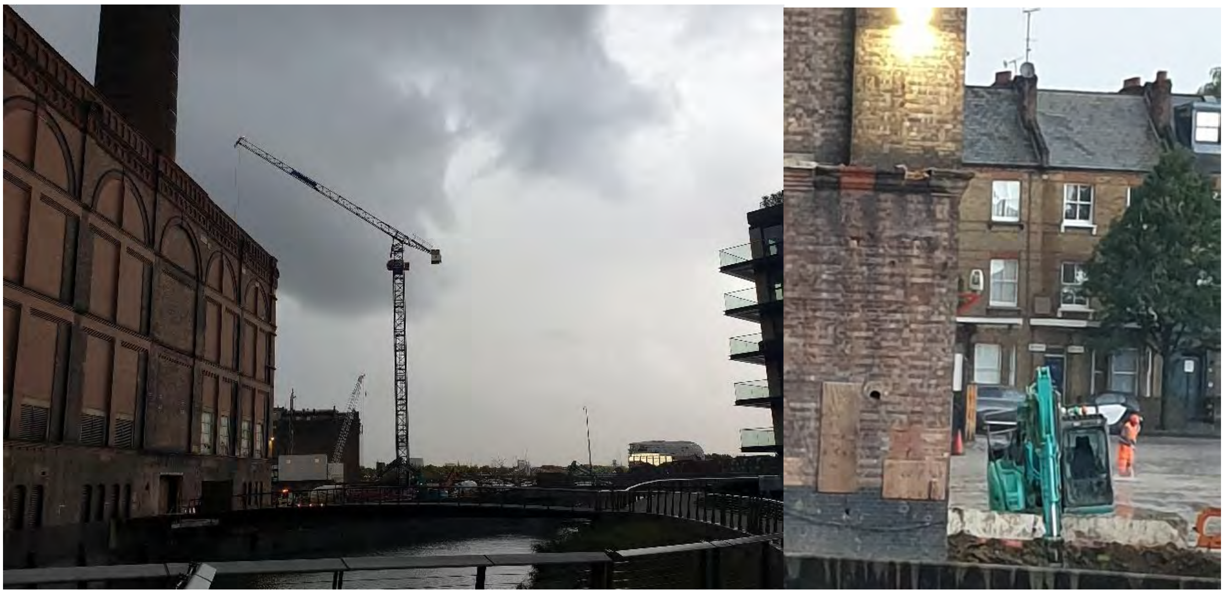


Figure 19. Field visit to Lots Road Power Station Development construction site

2) Mobility to: Reykjavik University, faculty: School of Science and Engineering, SEE Mobility 2018-2019 PROJECT EY-MPO-0083, EEA & Norway Grants.

The main objectives of the mobility aimed to emphasize the importance of implementing ICT (Information and Communications Technology) as current practices in complex issues regarding land to develop tools for an integrated management of the territory, land's potential and hazards that could affect it.

The mobility also targeted developing easy-to-use authoring tools for sustainable development experiences while ensuring increased teaching skills, new educational materials and projects.

The added value of the mobility referred to transfer of experience from the host institution in several fields of activity and the possibility to carry out in the near future joint educational activities that may result in dissertation and PhD thesis coordinated in UPT-RU partnership. For me the main benefits of the mobility have been: creating and developing strong cooperation relationship with Reykjavik University staff, expand the network of international contacts through this university, participate in the preparation and implementation of some educational projects, transfer of expertise in the field of organizing summer schools.

Field visits have been organized during the summer school to two geothermal power plants near Reykjavík city, namely Nesjavellir Geothermal Power Plant and Hellisheidi Geothermal Power Plant, both belonging to ON Power company – a producer and supplier of energy in Iceland.

Figure 20. Field visits to Nesjavellir (left) and Hellisheidi (right) Geothermal Power Plants

Figure 21. Activities realized during the mobility

3) PN-III-P1-1.1-MC-667 mobility project at Universita degli Studi della Basilicata, Department of Civil and Environmental Engineering for access to "HydroLAB" laboratory to practice, research and acquire knowledge regarding using open source software in education of geodetic engineers between 21th and 28th of November 2018.

Research conducted by HydroLAB is focused on the following activities:

- Field measurements for hydrological modeling;
- Distributed model for Runoff, Evapotranspiration, and Antecedent soil Moisture simulation;
- Optimizing the production of electricity from reservoirs and river plants to provide forecast on the potential production of energy at 24-48-72 hours;
- Advances in Hydraulic modeling and flood impact;
- Soil moisture monitoring;
- Vegetation patterns.

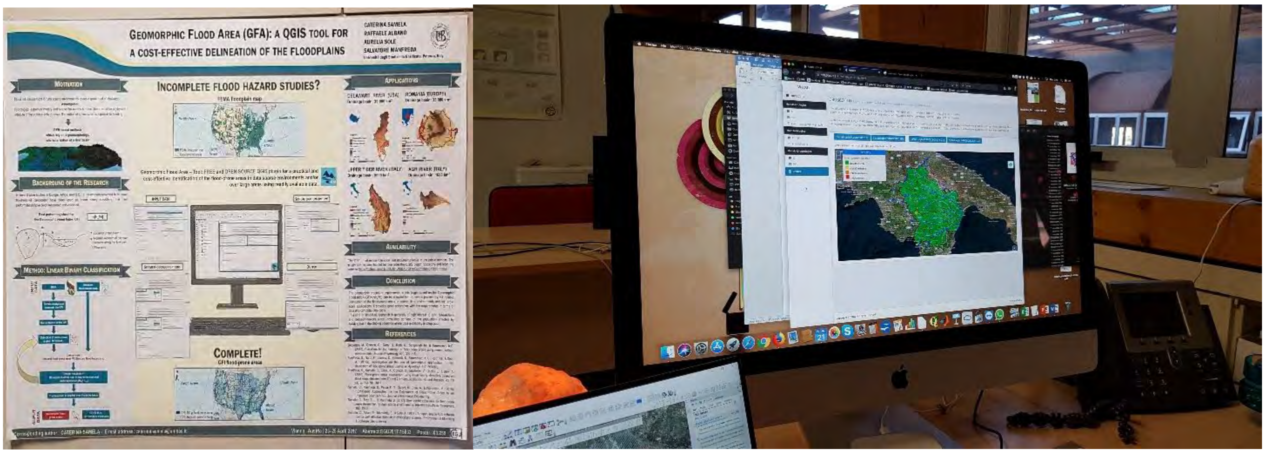


Figure 22. Activities at HydroLAB

One research topic I became familiar with during this mobility refers to the creation of a webGIS for civil protection. This program is being implemented in the Basilicata region, as the Civil Defence institution in the area contracted the university specialists to develop an early-warning-system that allows a real forecast in the area focused on 3 directions: hydrological module, hydraulic module and hydrogeological module.

The webGIS collects the information from the network of hydrological and pluviometric sensors installed in the area, as well as those predicted by the model developed by the specialists from "HydroLab".

4) PRECISI-2018-33183 Awarding research results – Articles. The article entitled "Road-Structure Monitoring with Modern Geodetic Technologies", authors: Ioan Sorin Herban, Clara-Beatrice Vilceanu, Carmen Grecea published in Journal of Surveying Engineering, Vol. 143(4), DOI: 10.1061/(ASCE)SU.1943-5428.0000218, 2017, by "American Society of Civil Engineering", Q2 quartile was rewarded by UEFISCDI public institution under the Romanian Ministry of Education.

5) Optimizing risk reduction strategies for geomorphological hazards by 3D modeling – GEOMOD, Civil Engineering and Equipments, Cadastre and Geodesy Domain, Project code 7, Contract no. 5495/02.05.2018.

Natural hazards, especially landslides, are complex phenomena both regarding their generating causes and also the effects they produce; thus representing a risk factor to be determined and quantified. 3D modeling of geospatial data characteristic to landslides acquired using terrestrial laser scanning technology and UAVs is useful for monitoring and determining the risk potential of certain areas as well as for managing the destructive effects of geomorphologic hazards on the environment and to optimize their forecasting and post-factum approaches.

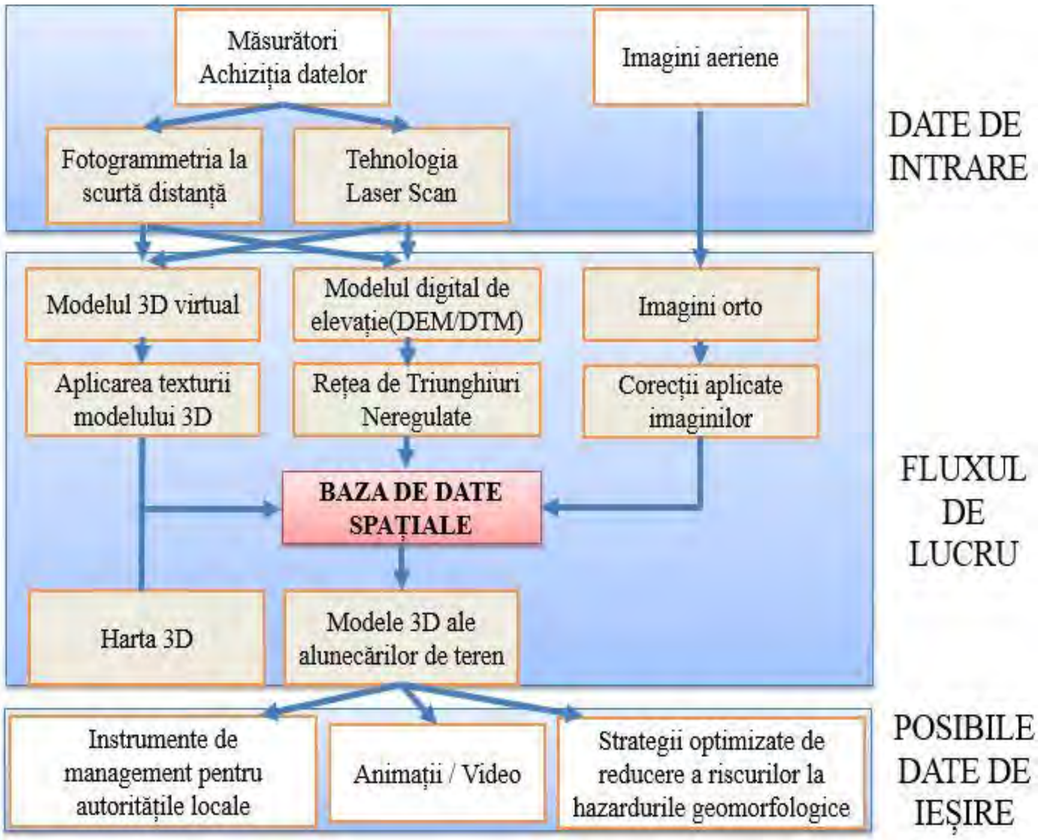


Figure 23. Work methodology for landslides monitoring process

6) PN-III-P1-1.1-MC-2017-1407 mobility project which involved attending „GeoInformation for Disaster Management 2018" international conference held at Istanbul Technical University, Turkey.

7) PN-III-P1-1.1-MC-2017-1686 mobility project to visit the University of Belgrade, Faculty of Civil Engineering, Department of Geodesy and Geoinformatics for access to the "Laboratory for development of open source geospatial technologies" between 26th of February and 2nd of March 2017.

Access to research infrastructure at Open source geospatial technologies – OSGL at the Department of Geodesy and Geoinformatics included the following activities:

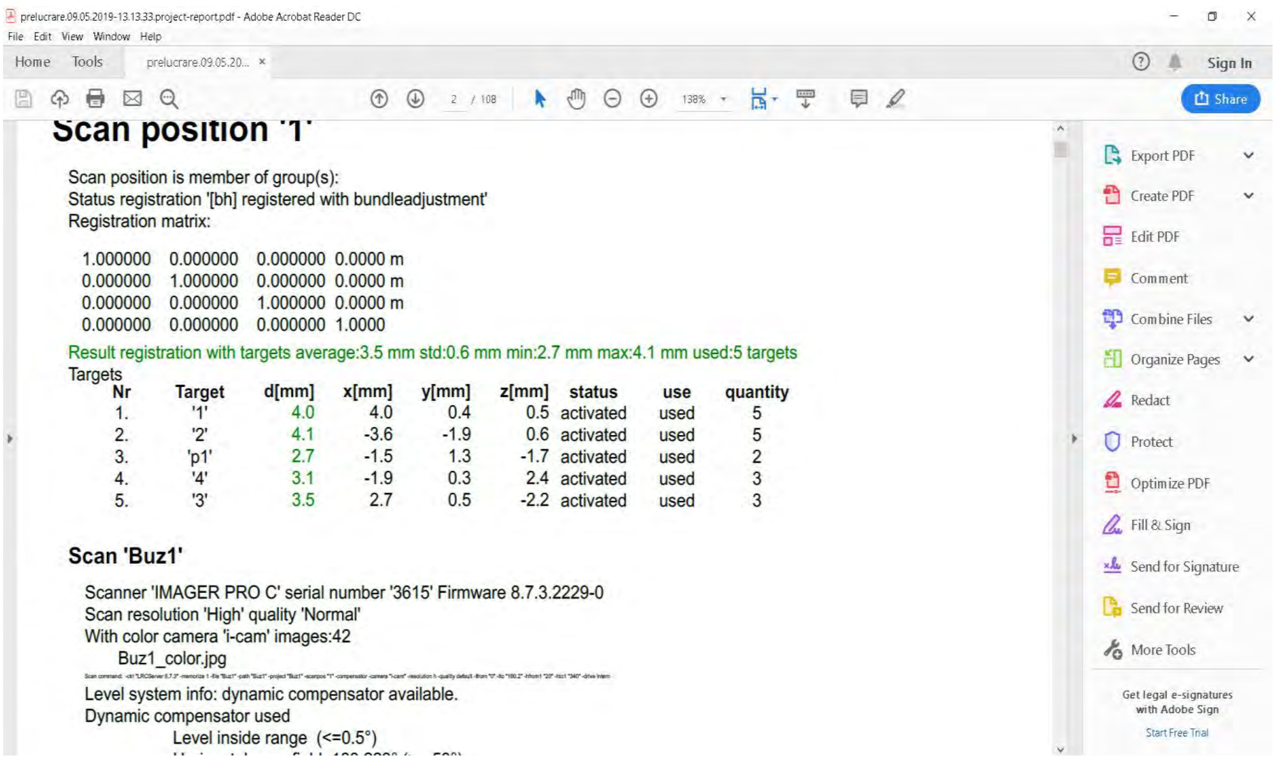
- Automated mapping using geostatistics and machine learning aiming to provide automated mapping solutions in different fields mostly using in-situ measurements in combination with Remote Sensing data;
- Remote Sensing in agriculture: processing of optical Remote Sensing data, as well as for generation of indexes and modelling biophysical parameters;
- Familiarization with international research and scientific projects such as Horizon 2020;

- Implementation and promotion of open source technologies in the domestic and international industry and economy.

8) PN-III-P1-1.1-MC-2017-0683 mobility project at Cadline company, London, for Open Source GIS Integration Training Course Staines 2017, 13th – 14th November 2017. This course has been realized under the dome of The Association for Geographic Information from United Kingdom.

9) Contract no. BC 115/10.12.2018 – Digitization services of the investment objective “CONSOLIDATION AND RESTORATION OF THE COLONADE IN THE CITY OF BUZIAŞ” within the Regional Operational Program 2014-2020, Priority Axis 5 Improving the urban environment and conservation, protection and sustainable capitalization of cultural heritage, Investment priority 5.1 Conservation, protection, promotion and development of natural and cultural heritage, no. call for projects POR 2018/5/5.1 /7.

Considering the fact that the building is a historical monument of national importance, included in the List of Historical Monuments in Timiş County at 169th position with the code TM-II-aA-06191, The “Grand” Hotel and the “Casino”, digitization services of the colonnade in the city of Buziaş have been requested. The works were executed using the Z+F IMAGER 5010C scanner from the endowment of the “Land Measurements and Geoinformatics” laboratory within the Polytechnic University Timisoara.



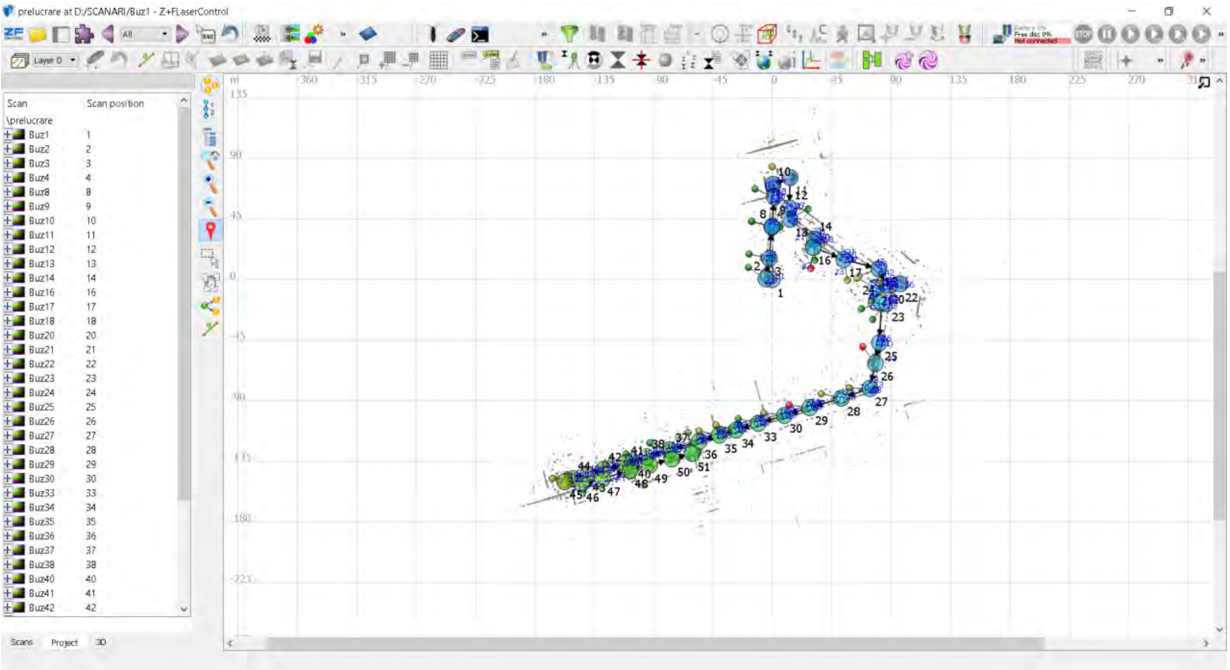


Figure 24. Position of the scanning stations

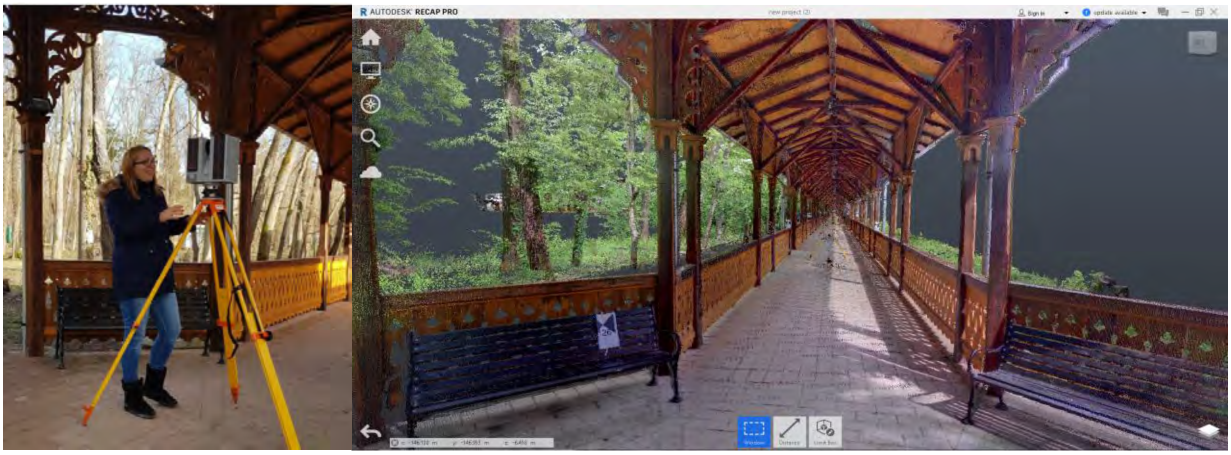
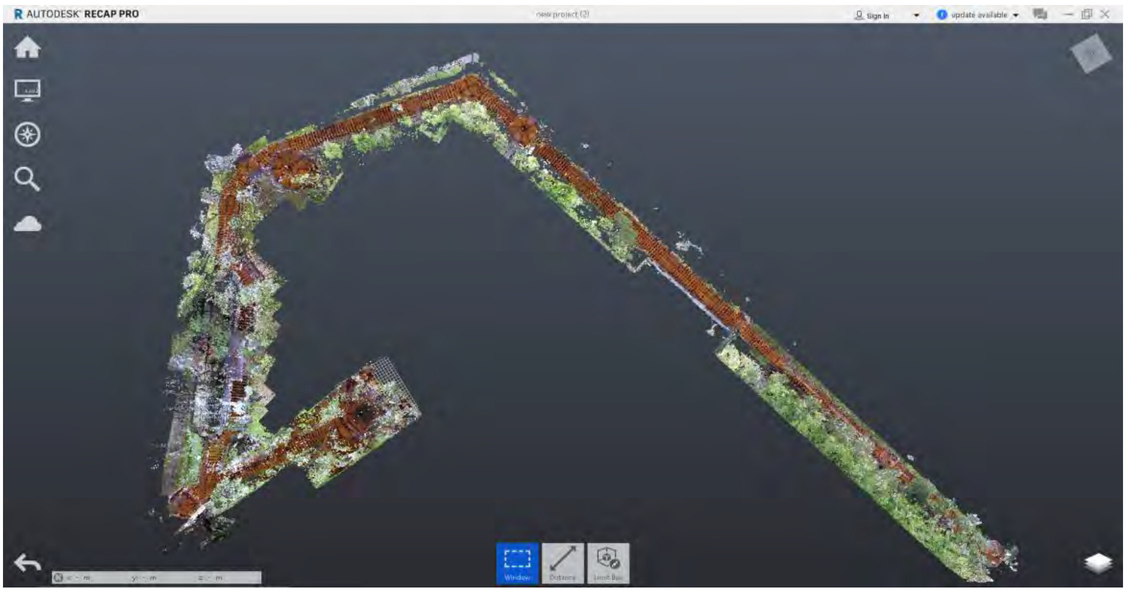


Figure 25. Field work (left image) and capture from the point cloud processing (right image)



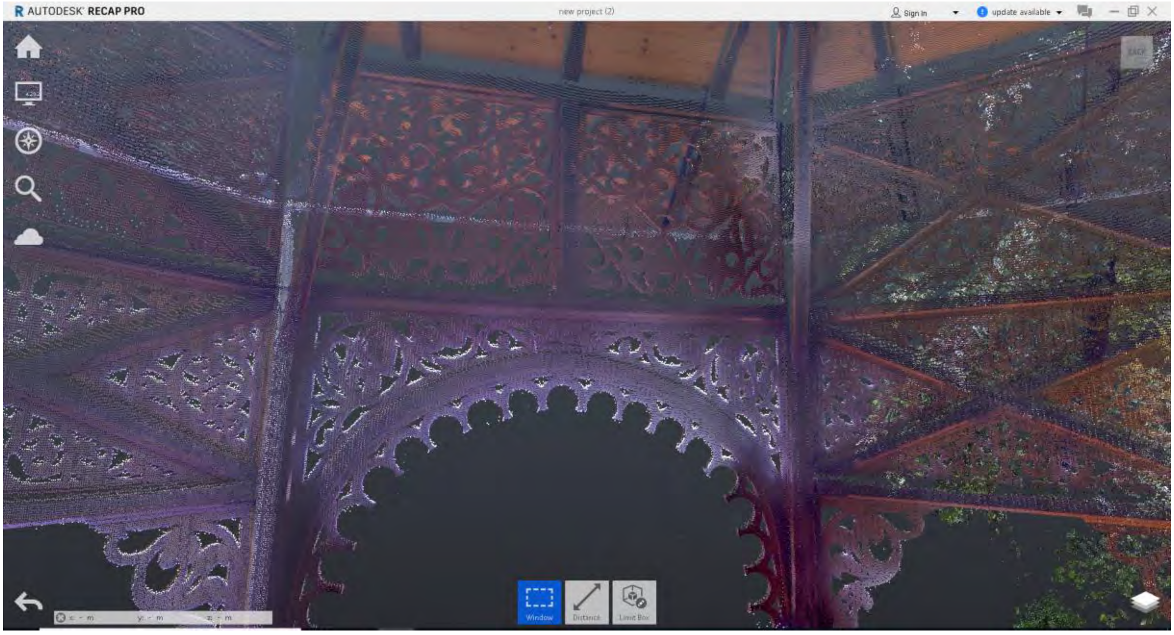


Figure 26. Pointcloud views of the colonnade after noise reduction

For three-dimensional modeling of complex surfaces it is necessary to connect all the points in the set of points. This union is an interpolation of points in three dimensions creating a complete representation of the surface. For an easy visualization and an integration of the spatial information in the database of Buziaș City, the primary information was compressed resulting in an optimal number of points according to the attached figures. This has been communicated to the beneficiary.

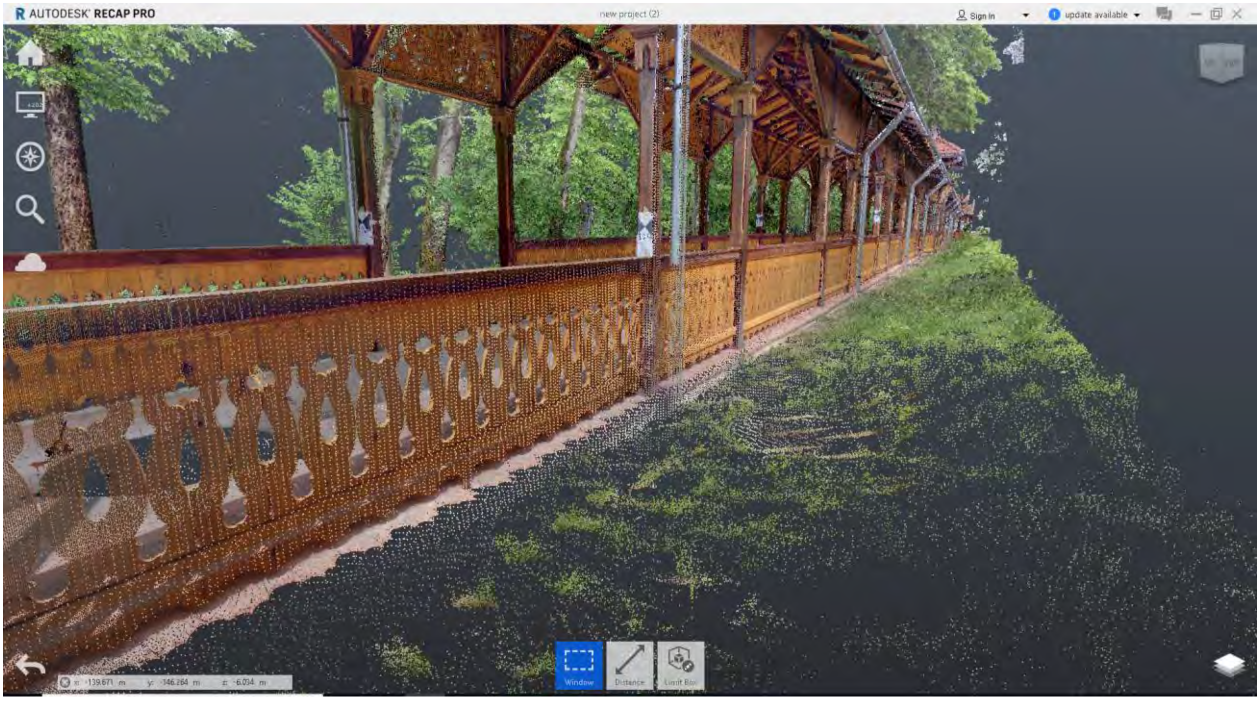


Figure 27. View of the 3D model of the colonnade

A movie we have realized within this project showing a fly through the 3D model can be found online at https://www.primariabuzias.ro/proiecte-in-implementare.

Research team member:

1) Asigura-ti Viitorul prin Educatie si Antreprenoriat – AVEA, (Ensure your future through Education and Entrepreneurship) 2019-2021, POCU/379/6/21/6.7/6.9/6.10/123900/ project.

2) Centru de învățare în științe inginerești (Engineering sciences learning centre) (CISI), 105/SGU/CI-II ROSE project, 2019-2022.

3) RO SRB "Through knowledge to business and smart development of Banat", cod ems RORS 394, Interreg IPA Cross Border project, 2020-2021.

4) Construieşte-ţi viitorul prin stagii de practică! – CONPrACT, (Build your future through practical stages) 2018-2020, POCU 107330 project.

5) Development of Urban Green Space Monitoring Technique with Remote Sensing and its Application. Case Study Timisoara Romania and Beijing-China http://uefiscdi.gov.ro/userfiles/file/CAPACITATI/Bilaterale/RO-CH/Competitie%202014/Rezultate%20comisie%20mixta%20RO_CH%202016.pdf.

Remote sensing imagery enables rapid and efficient quantification urban eco-environment and it gives a new insight for urban environmental research. A wide range of urban remote sensing applications is available. With the availability of super high resolution remotely sensed imageries and multi-source remote sensing data, there is a great need to transform remote sensing data into useful information that we need for urban studies.

There are few special studies on the urban green space monitoring based on modeling the proximity of buildings to green space with remote sensing using multi-source satellite images. The study achievement would provide reference for the measurements of green space, serving the urban eco-environment quality monitoring. At the same time, it was of great theory and practical significance to improve utility efficiency of satellite data and eco-environment monitoring precision.

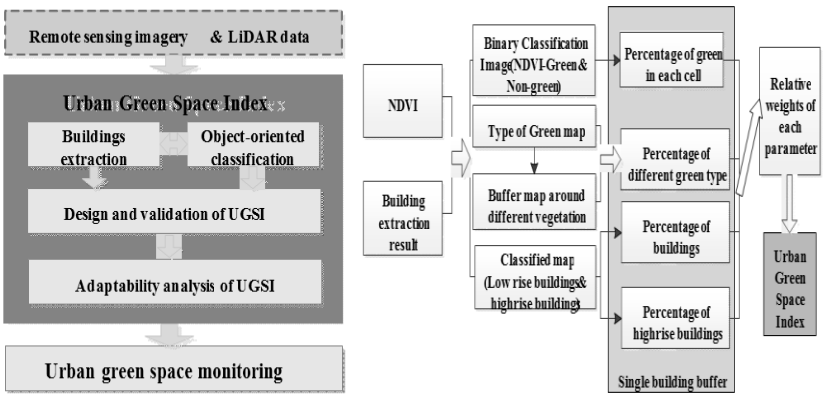


Figure 28. Urban green space index and its applications

6) Waste management – Adaptation strategies to climate changes, "Research in Priority Sectors" programme financed by SEE 2009-2014.

An important aspect of environmental protection is represented by the strategies and approaches regarding waste deposits. European Union has established standards and regulations of waste management and deposits. In some cases those orders can be taken into consideration with all the aspects but there are some deposits which have been rehabilitated from the ecological point of view in the past. For those areas, all the effects of waste upon the environment and population are important to be understood. Related to solid waste management issue, Romania has made significant progress, but challenges remain; primarily weak capacity to implement and manage projects.

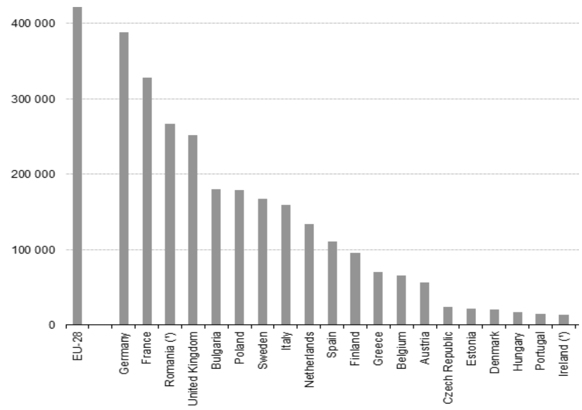


Figure 29. Total waste in Europe according to EUROSAT – Romania on the 3rd place

The economy develops proportionally with the consumption's expanding, waste volumes grow steadily but landfill expansion has not kept pace. Unfortunately, rural areas lack adequate solid waste management infrastructure, and even where infrastructure exists, success has been elusive. In 2010 less than 5.0 percent of waste was recycled, so reaching a waste recycling target of 55 percent by 2013 was not accomplished, leading to the conclusion that household recycling adoption rates have been low even in the largest urban centres. Therefore, comprehensive public awareness and communication efforts in addition to improvements in infrastructure are required.

Figure 30. Făget landfill and data acquisition on field using GNSS technology

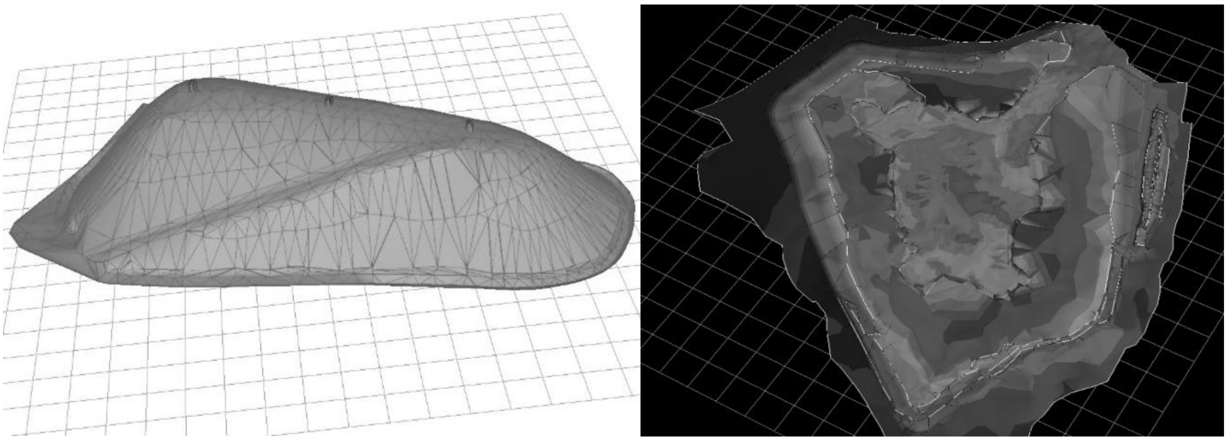


Figure 31. Făget landfill digital model

7) Contract no. BC 68/16.06.2015 Studies and research in the surveying engineering area for 3D modeling and representation of under pressure vessels' entrances – beneficiary SC PRESAFFE SRL.

The determination and precise representation of three-dimensional coordinates, the realization of 3D models of the inlets of pressure vessels can be achieved only by topo-geodetic precision measurements. This process of 3D modeling of the contact elements is part of the quality control and assurance process of the parameters designed after the execution of the objects themselves.

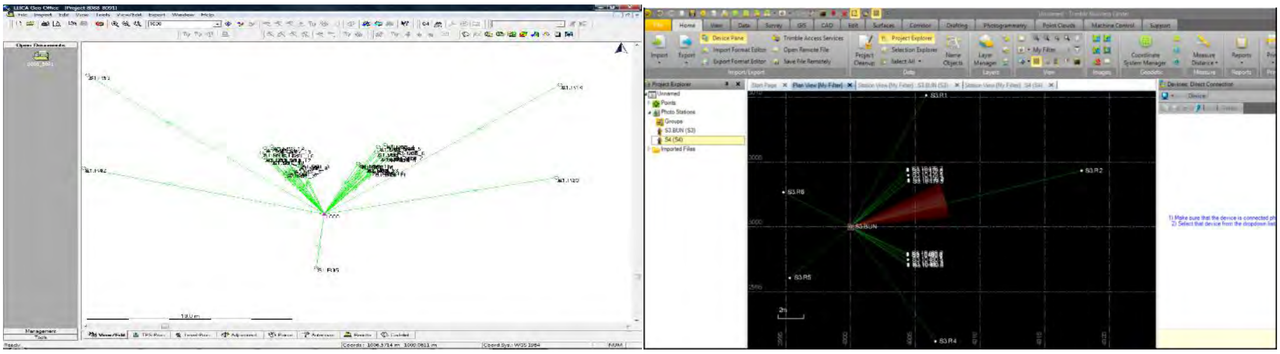


Figure 32. Data processing with different specialized software: Leica (left) and Trimble (right)

The selection and marking of discretization points is a laborious process that requires increased attention from the beneficiary and is coordinated by the specialist in terrestrial measurements.

The positioning of the object points and the support points must respect the principle of perpendicularity in order to reduce the effects of measurement errors.

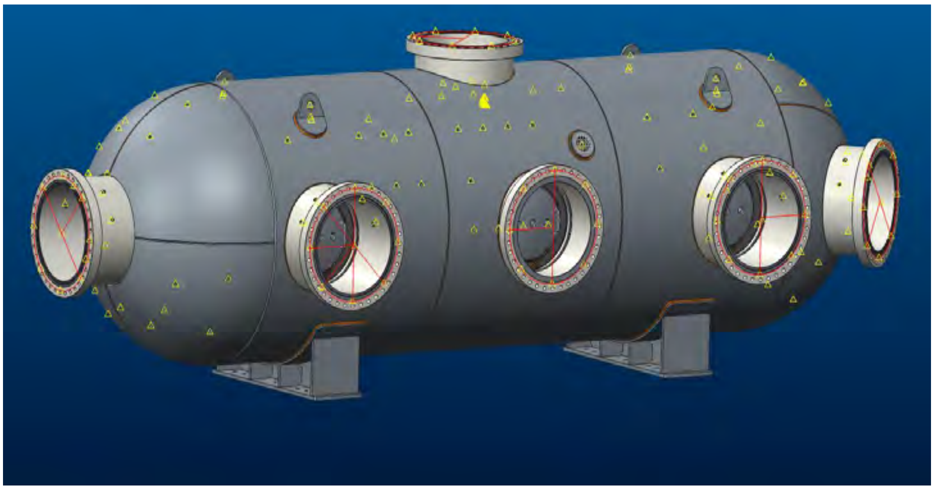


Figure 33. Control points on the 3D model – spatial representation

8) Monitoring the passages' earthworks: SEBEŞ, km 4+725 – A2 (C2) ledge; POTOC, km 5+512 – A1(C1) ledge and A2(C2); VALEA MARE, km 7+107 –A1(C1) ledge and A2(C2); VALEA MICĂ, km 7+375 – reinforced earth passage from Caransebeș bypass.

The topographic measurements aimed to determine the absolute values of displacements both at the level of the road and at the level of infrastructure elements, using the methods of high precision geometric levelling and precision trigonometric levelling in compliance with the provisions of STAS 2745/90 and STAS 3300 / 2-85. Measurement campaign dates: October 20-25, 2014; and in the year 2015: January 5-16; March 14-20; June 15-20; September 23-October 4. The elements measured in the field were subjected to processing and compensation processes.

9) Technical expertise for TMD Friction hall and administrative building in Caransebeș.

The object of the contract consisted in monitoring the movements and the resistance elements of the hall structure and the administrative building for the TMD FRICTION objective located in Caransebeş municipality. As general working methodology, the high-precision geometric levelling method was used because it ensures the highest accuracy in measuring the vertical displacements of constructions, being used both in the experimental test of constructions on models or on a natural scale, in tracking behaviour over time, and in the operation phase.

The process of determining the control points displacements (compaction marks) included the following steps:

- on field levelling measurements for each measurement cycle;
- measurement processing for the calculation of construction displacements and accuracy assessment which included:
  - testing the stability of the fixed landmarks of the reference network;

- calculation of the control points displacements placed on the construction under study;
- accuracy assessment for displacements determinations;
- elaboration of the technical documentation of the research.

Anexa 1 - Tabel Centralizator Tasare Mărci – Valoarea tasării (s) este în metri [m]

Marca	C0: 14.03.15	C1: 08.05.15	C2: 05.07.15	C3: 12.09.15	C4: 07.11.15	C5: 06.02.16	C6: 16.04.16
s: Ma: A-3 [m]	0.0000	0.0014	0.0038	0.0050	0.0073	0.0087	0.0093
s: Ma: A-6 [m]	0.0000	0.0011	0.0033	0.0040	0.0077	0.0084	0.0085
s: Ma: A-10 [m]	0.0000	0.0010	0.0039	0.0058	0.0067	0.0091	0.0109
s: Ma: C-11 [m]	0.0000	0.0004	0.0016	0.0027	0.0035	0.0035	0.0035
s: Ma: C-15 [m]	0.0000	0.0026	0.0040	0.0049	0.0053	0.0057	0.0058
s: Ma: G-1 [m]	0.0000	0.0002	0.0008	0.0010	0.0020	0.0020	0.0022
s: Ma: G-7 [m]	0.0000	0.0009	0.0028	0.0040	0.0045	0.0045	0.0051
s: Ma: G-11 [m]	0.0000	0.0016	0.0041	0.0064	0.0072	0.0074	0.0075
s: Ma: G-15 [m]	0.0000	0.0006	0.0015	0.0021	0.0037	0.0043	0.0044
s: Ma: G-21 [m]	0.0000	0.0002	0.0006	0.0014	0.0016	0.0015	0.0017
s: Ma: L-1 [m]	0.0000	0.0007	0.0024	0.0027	0.0029	0.0031	0.0033
s: Ma: L-7 [m]	0.0000	0.0013	0.0022	0.0037	0.0044	0.0043	0.0044
s: Ma: L-11 [m]	0.0000	0.0052	0.0075	0.0090	0.0092	0.0098	0.0105
s: Ma: L-15 [m]	0.0000	0.0019	0.0022	0.0023	0.0028	0.0031	0.0033
s: Ma: L-21 [m]	0.0000	0.0009	0.0010	0.0010	0.0023	0.0024	0.0024
s: Ma: P-7 [m]	0.0000	0.0008	0.0008	0.0011	0.0015	0.0020	0.0022
s: Ma: P-11 [m]	0.0000	0.0002	0.0005	0.0006	0.0021	0.0022	0.0022
s: Ma: P-15 [m]	0.0000	0.0005	0.0007	0.0011	0.0014	0.0016	0.0018

Anexa 2 - Tabel Centralizator Tasare Buloane Parter – Valoarea tasării (s) este în metri [m]

Bulonul	C0: 14.03.15	C1: 08.05.15	C2: 05.07.15	C3: 12.09.15	C4: 07.11.15	C5: 06.02.16	C6: 16.04.16
Bl 1 [m]	0.0000	0.0022	0.0038	0.0042	0.0046	0.0082	0.0086
Bl 2[m]	0.0000	0.0012	0.0064	0.0071	0.0081	0.0097	0.0112
Bl 3 [m]	0.0000	0.0022	0.0055	0.0082	0.0099	0.0118	0.0130
Bl 4 [m]	0.0000	0.0013	0.0044	0.0076	0.0091	0.0098	0.0111
Bl 5 [m]	0.0000	0.0074	0.0106	0.0128	0.0136	0.0144	0.0155
Bl 6 [m]	0.0000	0.0049	0.0079	0.0082	0.0099	0.0102	0.0108
Bl 7 [m]	0.0000	0.0036	0.0043	0.0053	0.0068	0.0073	0.0074
Bl 8 [m]	0.0000	0.0002	0.0004	0.0012	0.0023	0.0040	0.0063
Bl 9 [m]	0.0000	0.0012	0.0016	0.0037	0.0041	0.0052	0.0061

Anexa 3 - Tabel Centralizator Tasare Buloane Etaj (Sala Mese) – Valoarea tasării (s) este în metri [m]

Bulonul	C0: 14.03.15	C1: 08.05.15	C2: 05.07.15	C3: 12.09.15	C4: 07.11.15	C5: 06.02.16	C6: 16.04.16
B1 [m]	0.0000	0.0001	0.0000	0.0001	0.0002	-0.0003	-0.0003
B2 [m]	0.0000	0.0006	0.0009	0.0010	0.0011	-0.0013	-0.0014
B3 [m]	0.0000	0.0001	0.0003	0.0004	0.0005	-0.0015	-0.0023
B4 [m]	0.0000	0.0001	0.0001	0.0001	0.0003	-0.0005	-0.0007
B5 [m]	0.0000	0.0002	0.0000	0.0003	0.0006	-0.0006	-0.0006

Figure 34. The value of the determined displacements

The topographic measurements aimed to determine the absolute values of the displacements both at the level of the roadway and at the level of the infrastructure elements. The measurement calendar was carried out as follows: 14.03.2015; 08.05.2015; 5.07.2015; 12.09.2015; 7.11.2015. The elements measured in the field were subjected to processing and compensation processes.

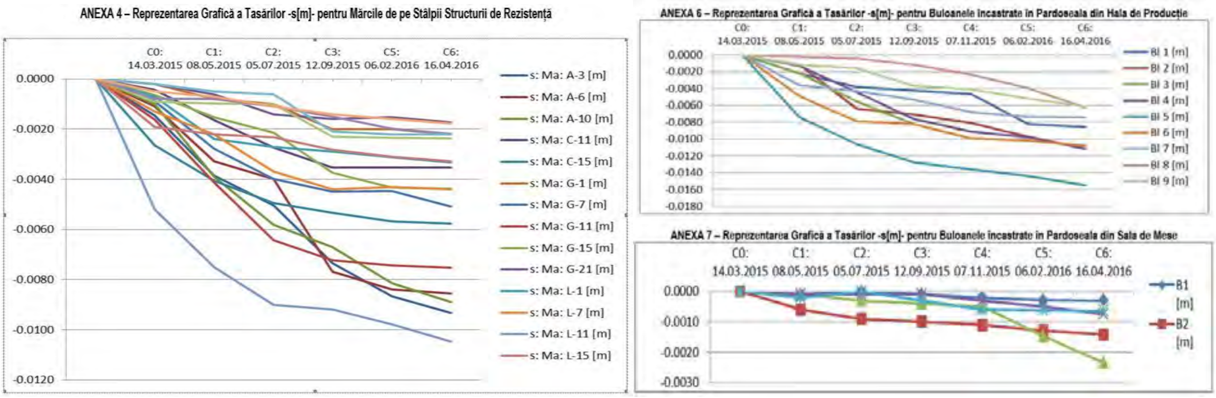


Figure 35. Graphical representation of the displacements

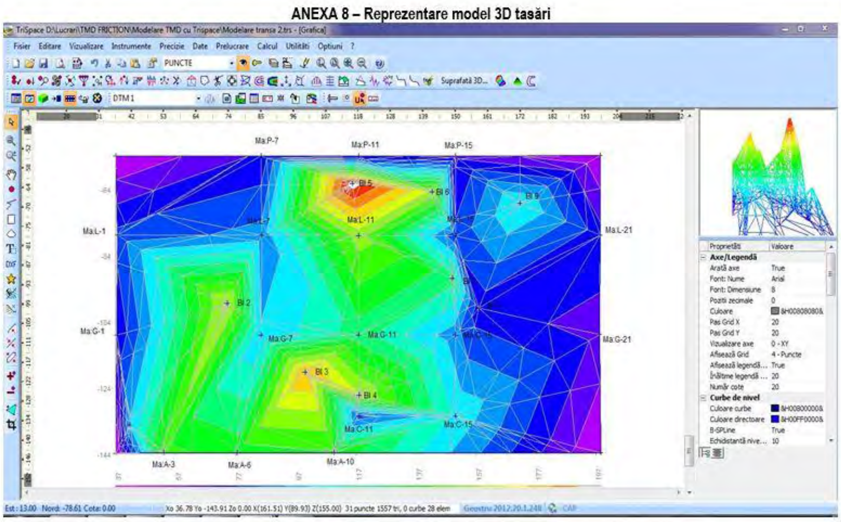


Figure 36. 3D representation of the displacements

10) Contract no. BC 27/17.02.2014 for Sibiu International Airport: Technical economical assessment for the objective Sibiu International Airport.

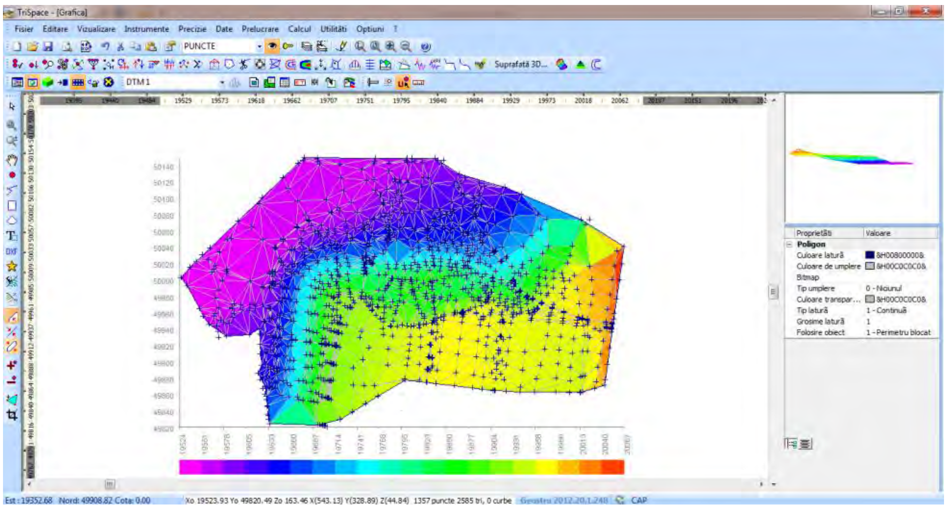


Figure 37. Realizing the triangulation as part of the processing stage of the survey realized at Sibiu International Airport

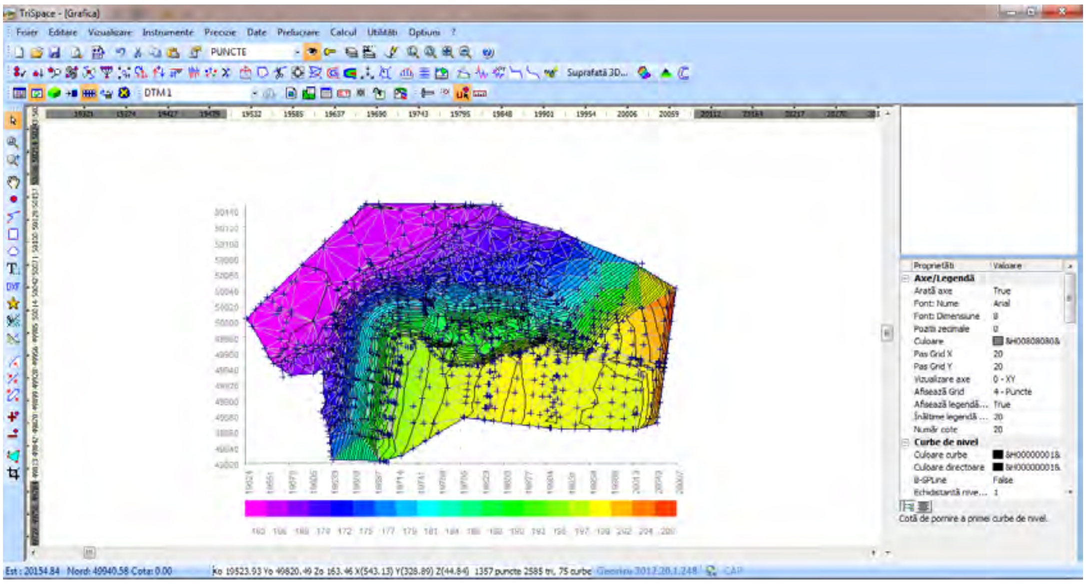


Figure 38. Generating contour lines within the surface

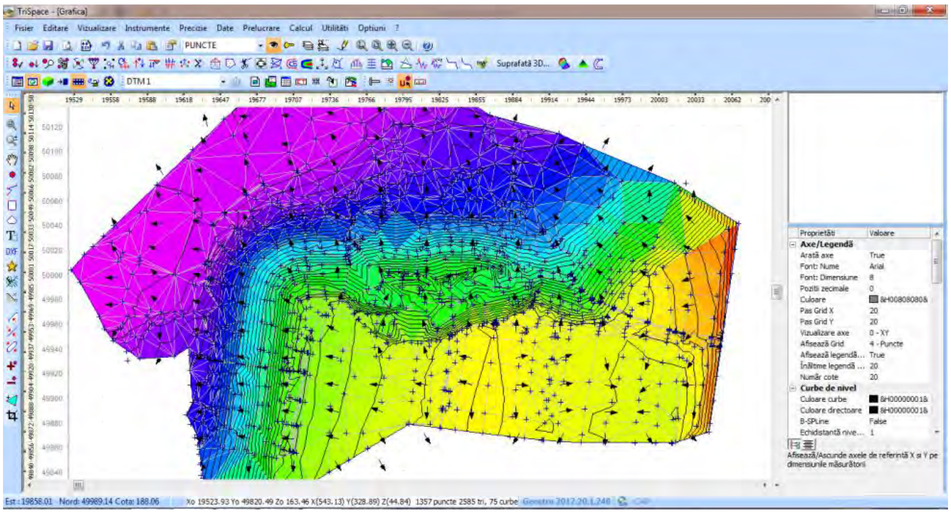


Figure 39. Inclination vectors represented together with the contour lines

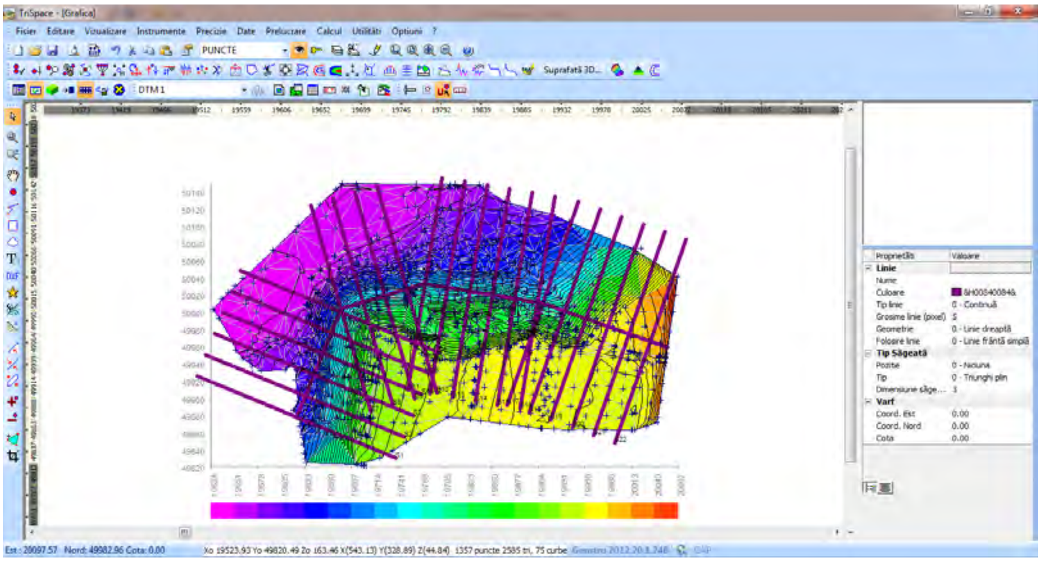


Figure 40. Directions for profile generation

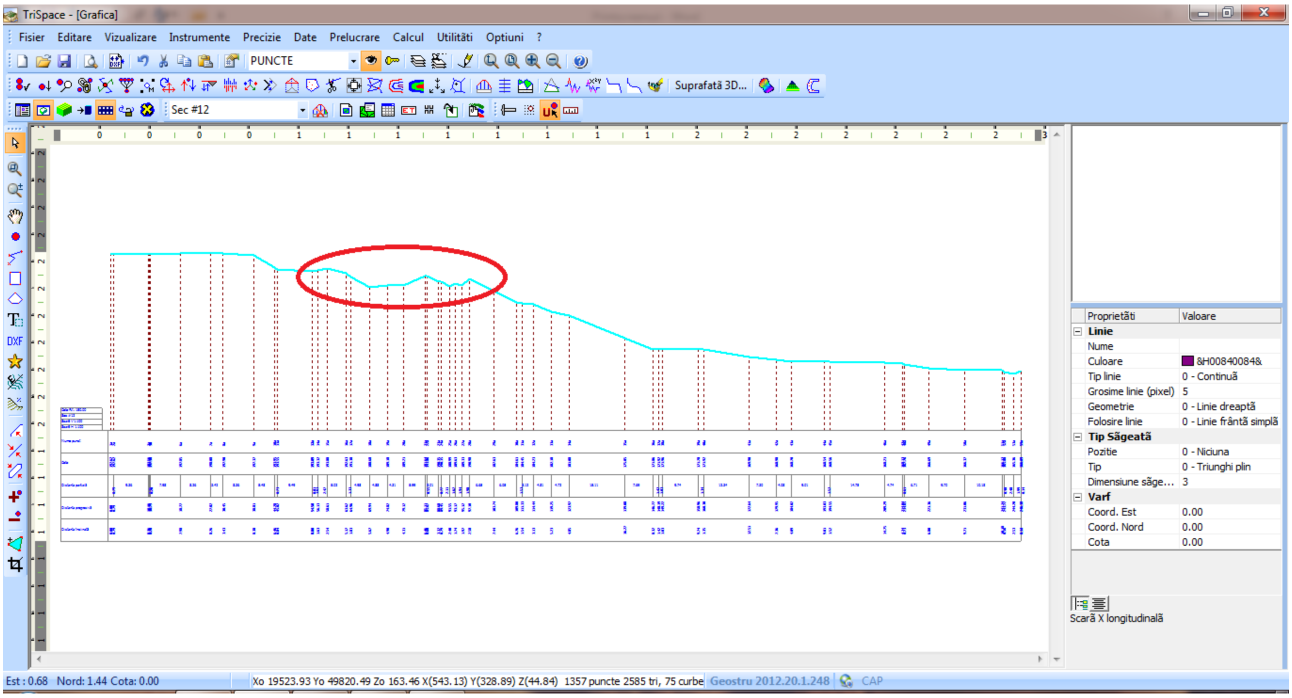


Figure 41. Example of profile generation with landslide highlighting

2.1.7. Other relevant scientific, didactic and professional achievements

The recognition of my activity is reflected in the professional organisations I am part of, namely: Uniunea Geodezilor din România (Romanian Geodesists Union), Ordinul Geodezilor din România, (Romanian Geodesists Order), Societatea Română de Geotehnică și Fundații (Romanian Society of Geotechnics and Foundations).

I also consider worth mentioning the following:

- ✓ Obtaining the license for D category issued by National Agency of Cadastre and Land Registration in Romania, Series RO-B-F No. 2299, 2020.
- ✓ Participating to ICT 2018: Imagine Digital - Connect Europe, Vienna, Austria, 3-6 December, organized by the European Commission, https://ec.europa.eu/digital-single-market/en/events/ict-2018-imagine-digital-connect-europe as COST (European Cooperation in Science & Technology) representative.

Managerial activities in the educational process:

- ✓ Head of the Civil Engineering Faculty Student Counselling Office;
- ✓ Member of the Admission Commission of the Civil Engineering Faculty;
- ✓ Tutor for the 1st year students enrolled at the “Land Measurements and Cadastre” study programme;

- ✓ Responsible for the second year's student practice from the "Land Measurements and Cadastre" study programme;
- ✓ Secretary of the bachelor thesis commission for the "Land Measurements and Cadastre" study programme;
- ✓ Member of the commission for dissertations for the "Cadastre and the Evaluation of Immovables" master programme;
- ✓ Member of doctoral guidance committees;
- ✓ Member of the team for the preparation of the ARACIS evaluation documentation regarding "Cadastre and the Evaluation of Immovables" master programme – 2021.

2.2. Research impact

2.2.1. 10 most relevant scientific articles

The impact of the research carried out after defending the doctoral dissertation is reflected in the 10 most representative articles that constitute the basis for the elaboration of the habilitation thesis. These articles include research characteristic to the Geodesy domain, as well as studies conducted in interdisciplinary fields:

1) ***Heritage Studies in Spatial Planning; Development and Environmental Policies***, By: **Vilceanu, C. B.**; Alionescu, A.; Grecea, C.; et al., Conference: 18th International Technical-Scientific Conference on Modern Technologies for the 3rd Millennium, Location: Oradea, Romania, Date: Apr 04-05, 2019, Modern Technologies for the 3rd Millennium, Pages: 79-84, Accession Number: WOS:000617030100014, Published: 2019.

   https://www.webofscience.com/wos/woscc/full-record/WOS:000617030100014

2) ***3D Modelling of Cultural Heritage Objective in Timisoara using precise LiDAR***, By: Alionescu, Adrian; Herban, Sorin; **Vilceanu, Clara-Beatrice**, Conference: International Conference on Numerical Analysis and Applied Mathematics (ICNAAM) Location: Rhodes, Greece, Date: Sep 13-18, 2018, Sponsor(s): European Soc Computat Methods Sci & Engn, International Conference on Numerical Analysis and Applied Mathematics (ICNAAM-2018), Book Series: AIP Conference Proceedings, Volume: 2116, Article Number: 370002, DOI: 10.1063/1.5114375, Published: 2019.

   https://www.webofscience.com/wos/woscc/full-record/WOS:000521108600362

3) ***WebGIS Solution for Urban Planning Strategies***, By: Grecea, C; Herban, S and **Vilceanu, CB**, World Multidisciplinary Civil Engineering-Architecture-Urban Planning Symposium (WMCAUS) 2016, Vol. 161, pp.1625-1630, DOI: 10.1016/j.proeng.2016.08.637, Published: 2016.

https://www.webofscience.com/wos/woscc/full-record/WOS:000387566500251

4) ***Using LiDAR for Urban Green Space Monitoring***, By: **Vilceanu, Clara-Beatrice**; Herban, Sorin; Meng, Qingyan; et al., Conference: International Conference of Numerical Analysis and Applied Mathematics (ICNAAM) Location: Thessaloniki, Greece, Date: Sep 25-30, 2017, International Conference of Numerical Analysis and Applied Mathematics (ICNAAM 2017), Book Series: AIP Conference Proceedings, Volume: 1978, Article Number: 390010, DOI: 10.1063/1.5043994, Published: 2018.

https://www.webofscience.com/wos/woscc/full-record/WOS:000445105400313

5) ***Urban Green Space Monitoring technique with Remote Sensing and its application and urban green space index***, By: S. Herban, Q. Meng, **C.-B. Vîlceanu**, Scientific Bulletin of the Politehnica University of Timisoara, Transaction of Hydrotechnics, Vol. 62 (76), Issue 2, 2017, pp. 23-27.

https://www.ct.upt.ro/buletinhidro/2017-2/0005Herban_Meng_etc_FINAL.pdf

6) ***Targeting Displacements' Monitoring of Constructions through Mathematical Methods***, By: Tesila, R; Rusu, G; **Vilceanu, B**; Alionescu, A, International Conference on Numerical Analysis and Applied Mathematics (ICNAAM)2016 | Proceedings of the International Conference on Numerical Analysis and Applied Mathematics 2015 (ICNAAM-2015), Vol. 1738, DOI: 10.1063/1.4952133, Published: 2016.

https://www.webofscience.com/wos/woscc/full-record/WOS:000380803300360

7) ***Structure settlements analysis highlighted by topographic and geotechnical studies***, By: **Vilceanu, C. B.**; Alionescu, A.; Herban, S., Conference: 17th International Technical-Scientific Conference on Modern Technologies for the 3rd Millennium Location: Oradea, ROMANIA Date: MAR 22-23, 2018, Modern Technologies for the 3rd Millennium, Pages: 123-128, WOS:000491484600022, Published: 2018.

https://www.webofscience.com/wos/woscc/full-record/WOS:000491484600022

8) ***Mathematic Interpolation Methods - Support for an Efficient 3D Modeling of Landslides in the Context of Displacements Monitoring***, By: Alionescu, A; Herban, IS; **Vilceanu, CB**;

Musat, CC, International Conference on Numerical Analysis and Applied Mathematics (ICNAAM) 2015 | Proceedings of the International Conference on Numerical Analysis and Applied Mathematics 2014, Vol: 1648, DOI: 10.1063/1.4912897, Published: 2015.

https://www.webofscience.com/wos/woscc/full-record/WOS:000355339704032

9) ***Opportunities and Challenges in Higher Education System: Knowledge Transfer by e-Learning vs. Traditional Methods***, By: **Vilceanu, Clara-Beatrice**; Grecea, Carmen; Herban, Sorin, Conference: 14th International Scientific Conference on eLearning and Software for Education - eLearning Challenges and New Horizons Location: Bucharest, Romania, Date: Apr 19-20, 2018, Sponsor(s): Romanian Adv Distributed Learning Assoc; Univ Natl Aparare Carol I; European Secur & Def Coll; Romania Partnership Ctr, Elearning Challenges and New Horizons, Vol 4, Book Series: eLearning and Software for Education, Pages: 253-258, DOI: 10.12753/2066-026X-18-250, Published: 2018.

https://www.webofscience.com/wos/woscc/full-record/WOS:000468620000036

10) ***Cultural Heritage Modeling Potential Highlighted by e-Learning Resources***, By: **Vilceanu, Clara-Beatrice**; Herban, Sorin; Banescu, Oana Andreea, Conference: 14th International Scientific Conference on eLearning and Software for Education - eLearning Challenges and New Horizons Location: Bucharest, Romania, Date: Apr 19-20, 2018, Sponsor(s): Romanian Adv Distributed Learning Assoc; Univ Natl Aparare Carol I; European Secur & Def Coll; Romania Partnership Ctr, Elearning Challenges and New Horizons, Vol 4, Book Series: eLearning and Software for Education, Pages: 476-483, DOI: 10.12753/2066-026X-18-282, Published: 2018.

https://www.webofscience.com/wos/woscc/full-record/WOS:000468620000068

The relevance and originality of personal contributions in the context of the current state of scientific research in the field of geodesy and cadastre, is part of the specialists' concerns, both internationally and nationally for 3D modeling of various objectives. This vast field of 3D modeling involves, on the one hand, the use of modern data acquisition technologies, such as Lidar either terrestrial or airborne, and, on the other hand, the geospatial data processing in order to obtain the desired 3D models.

2.2.2. Lidar applications in the Geodetic Engineering domain

2.2.2.1. General considerations

Electromagnetic radiation (including light) exhibits the properties of waves and particles. It is characterized by wave length, frequency and intensity.

Equation (1) expresses the light formed out of photons which have no mass but have the energy E in inverse ratio to the wave length λ.

$$E = \frac{h \cdot c}{\lambda} \tag{1}$$

where h – Planck constant (6,6262) and c – velocity of light (299.792.458m/s).

The visible spectrum lies between 400mm and 700mm wavelengths. The laser interval stretches between ultraviolet and infrared area of the electromagnetic spectrum. The light is emitted on different trajectories; when it reaches the object, a part of the electromagnetic radiation is reflected from its surface.

The ratio between the reflected and received radiation by the surface defines the reflection. A reflecting surface (Ri) transmits (T_λ) and/or absorbs (A_λ) the energy (E) of the incoming incident radiation (I_λ) according to equation (2).

$$E_{I_\lambda} = E_{T_\lambda} + E_{A_\lambda} + E_{R_\lambda} \tag{2}$$

where λ - wavelength of the electromagnetic radiation.

For most surfaces, the angle of incidence increases directly proportional with the amount of light reflected. This effect is more pronounced for reflective or smooth surfaces (example: at sunrise or sunset when the sunlight hits the surface of the water). Analysing equation (2) it becomes evident that the degree of reflection depends on the wavelength. Surfaces absorb certain parts of the electromagnetic spectrum while reflecting certain wavelengths (Fig. 42). The results of the absorption and reflectance are the colours that we see in the visible spectrum.

LIDAR (Light Detection And Ranging/detection of electromagnetic waves (light) and determining the distance) is a remote sensing technique that uses the properties of scattered light to determine certain characteristics of objects located at distance. (Synge, 1930) was the first who said that one can determine the density of a beam of light by sensing its dispersion into the atmosphere.

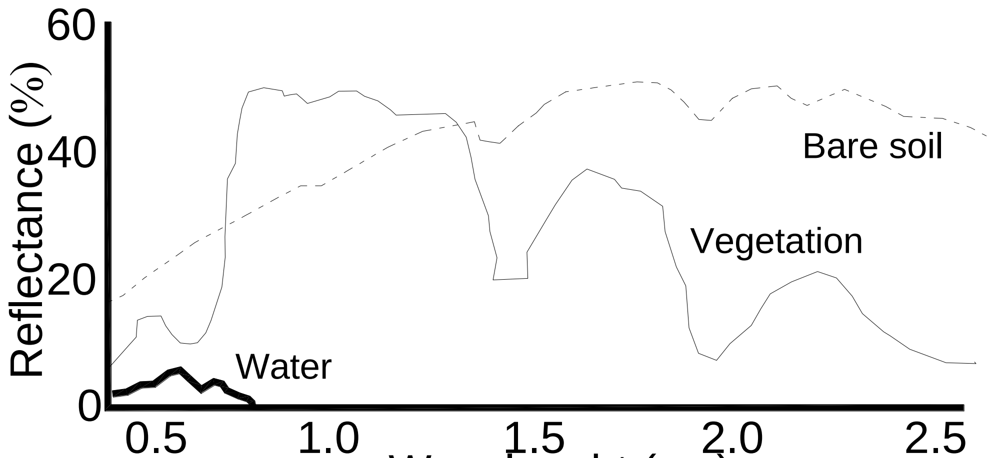


Figure 42. Bare soil, water and mixed vegetation reflectance

There are two active basic methods for the optic measurement of a 3D surfaces: transit time estimation of light and triangulation. Light waves travel with a known speed in a certain environment. Thus, measuring the time delay created by light moving from a source to a target reflective surface and back to a light detector offers a very convenient method for distance estimation. These systems are also known as time-of-flight systems or LiDAR. (Heritage & Large, 2009) Quantification of the time-of-flight can also be done indirectly by means of continuous measurement of laser wavelength phase – CW (continuous wave). Using the cosine and triangulation law, a triangle using a lighting direction (angle) directed toward a reflective surface and an observation direction from the source of illumination is build.

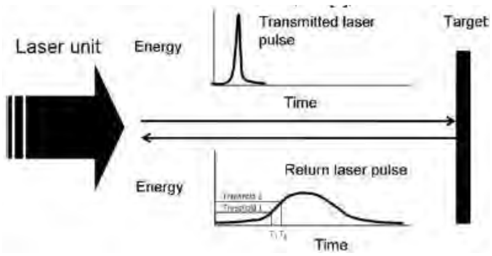
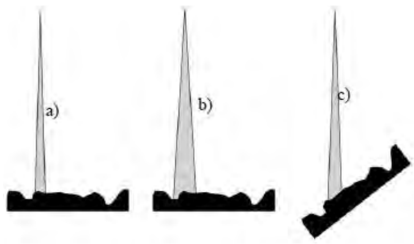


Figure 43. Laser pulse influence upon the time of flight for LiDAR pulse systems



Influence of the beam divergence upon
a) Small aperture beam on horizontal terrain
b) Greater aperture on horizontal terrain
c) Smaller aperture on downgrade terrain – for systems with LiDAR pulses (Goulden, 2009)

Scanner systems can be classified into three types having different functions:

1. Differential absorption LiDAR (DIAL): measures the concentration of chemical elements in the atmosphere using two wavelengths of laser light;
2. Doppler LiDAR: measures the velocity of an object on the basis of changes in wavelength and frequency for the signal returned by the object located in motion;
3. Retrograde Scattering LiDAR: refers to particles or waves reflection in the direction of the beam emission; a portion of the laser pulse returns to the instrument determining the round flight time of the signal together with equation (3) and the optical-geometric information of the instrument, the 3D position of the object is determined.

$$d = \frac{c \cdot t}{2} \quad (3)$$

where c- constant, velocity of light and t – round flight time of the emitted pulse.

LiDAR Terrestrial Equipment

LiDAR technology-based instruments have the designation of 3D laser scanners. A 3D laser scanner with a computer and data processing and transfer software form the scanning equipment. Scanning equipment can operate as a dynamic or static. Table 2 presents the main features of two scanners using different measurement technology.

Table 2. Main characteristics of two scanners using different measurement technology

Characteristics	**ScanStation 2 (time-of-flight)**	**Leica HDS 6200 (phase shift)**
Laser class	3R	3R
Minimum scanning distance	300m with 90% reflectance	79m with 90% reflectance
Data acquisition speed	50.000points/sec	1.000.000points/sec
Diameter of laser beam	4mm for a 50m distance	8mm for a 25m distance
Accuracy of distance measuring	4mm for a 50m distance	4mm for a 25m distance
Weight	18.5kg without batteries	14kg battery included

The 3D scanner acquires a "point cloud" of geometric samples on the objective's surface. (Grădinaru, Herban, & Gabor, 2016) These points can then be used to extrapolate the shape of the objective (a process called reconstruction). Except for the RGB, colour information is collected for each point, in order to be draped on the objective's surface for its real representation.

Static mode laser scanning means that the instrument's position is fixed during data acquisition. The most important advantages of this method are high accuracy of the results, high density of the points taken, finding easy solutions to registration issues or bringing into the same coordinate system and the calculation of X, Y, Z coordinates.

The mathematical model takes into account primary measurements of the laser scanner, i.e. range r and scan angle D, with the time-dependent exterior orientation of the sensor system, expressed by the position of the antenna phase centre (x0, y0, z0) and the sensor attitude angles Z, M, and N, to the ground point (x, y, z) is:

$$\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} x_0 \\ y_0 \\ z_0 \end{pmatrix} + R_{\omega\varphi\alpha}\left(t + R_m \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\alpha & \sin\alpha \\ 0 & -\sin\alpha & \cos\alpha \end{pmatrix} \begin{pmatrix} 0 \\ 0 \\ -r \end{pmatrix} \right) \tag{4}$$

In the above equation t is the GPS antenna offset and R_m is the IMU misalignment. The rotation angles are summarized in the matrix $R_{\omega\varphi\alpha}$accounting for the rotation of the body frame to the global frame. All measurements acquired by the multi sensor system have to be synchronized, which is possible with the GPS time signal.

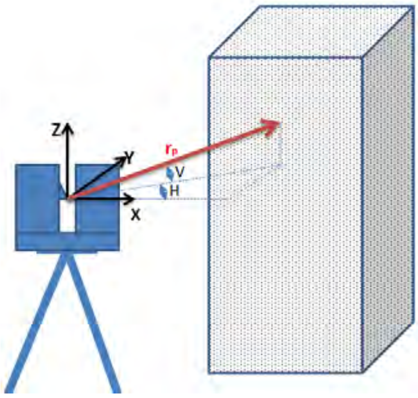


Figure 44. Laser scanning principle used for the application

This principle is found in the specialty literature as time-of-fight (TOF) or "Laser pulsed". In this case, the distance from the instrument to the object is determined according to the time between the issuance and reception of the laser beam. In principle, a diode emits a laser impulse with a known frequency to an object in the field. (Herbei, Sala, & Boldea, 2015) This wave is reflected diffusely from the surface of the object and – a part of it – returns to the receiver. For each impulse the time between issuance and reception is measured.

It is well known that in the case of terrestrial laser scan technology, which is the technology we have used, the relative orientation between two laser scans can be computed by using 2 different methods. One of this methods bears a close resemblance to relative orientation of images which uses tie points. Because of the fact that laser scanners do not measure distinct points, i.e. intersection of geometric or radiometric edges directly, but scan the surface irrespective of the location of features, firstly, the specialists have to extract the points. Characteristic to the second method, is the fact that it does not require identical points and performs the orientation of two scans, given approximate values of sufficient quality, entirely automatically. These algorithms constitute the basis of the registration process, nowadays used synonymously with relative orientation. Other scientists use the terms (co-) alignment and consolidation. The procedure of unifying two scans starts with transforming the slave scan onto the master scan by a congruency or Euclidean transform, i.e. a shift and a rotation. With the use of artificial targets on field, extraction of distinct points becomes especially simple.

To acquire a city model, including additionally the roof forms, the geometry of the facades, terrestrial laser scanning is an interesting option. Typically, imagery is acquired as well, so that the geometric model can be textured. In documentation cultural heritage laser scanning is applied not only in research, but also in practice, ranging from small artefacts with a few centimetres diameter, to statues and monuments with a height of one or a few meters, up to entire buildings and castles. As the precision and measurement volume requirements are very diverse, not one laser scanner alone can be used to cover all applications in cultural heritage. Figure 43 shows an example of a historic room in

Schönbrunn castle, Austria, which was acquired by a scanner with a pulsed laser scanner (Riegl LMS-Q420i (Riegl, 2007)). The texture was acquired with a Canon Eos1Ds digital camera mounted on top of the scanner.

Figure 45. Left: boundary representation (black) and triangulated surfaces (grey) of an indoor room; right: vrml visualisation of the textured model (Dorninger & Briese, 2005)

3D Modeling

3D scanning as a high-resolution and accurate recording of the objects in 3D space is of high importance for many subjects of different domains of interest such as cultural heritage, monitoring landslides, archaeology etc. Traditional techniques for 3D data acquisition either restrict the size of the scanned objects or impose demands on the stability and structure of the surface.

On the other hand, various society fields demand realistic 3D city models. For urban planning (Moscovici & Grecea, Geomatics, Support for an Efficient Urban Planning) or historical buildings even ancient fortresses, analysing in a 3D virtual reality world is much more efficient than imaging the 2D information on maps. For public security, accurate 3D building models are indispensable to make strategies during emergency situations. Navigation systems and virtual tourism also benefit from realistic city models. Manual creation of city models is undoubtedly a rather slow and expensive procedure, because of the enormous number of buildings and complexity of building shapes. The rapid development of cities also adds to the cost of manual city model updating. Nowadays, a lot of research has been done to automate the procedure of city reconstruction, and a number of approaches have been proposed. These approaches differ with respect to input data, automation level, and object representation. In this context, terrestrial 3D imaging laser scanning forms a method to acquire a large number of precise data points in 3D space representing the surface of the objects under investigation. These scanners are an effective tool for the collection of data to create a digital elevation model of the topography of a site as well as of the surface of a single archaeological deposit.

The acquired data can be used for documentation purposes only, but the further processing provides the possibility for virtual reality modelling for public presentation, restoration planning or virtual reconstruction. Laser scanning technology and the final deliverable, materialized as the three dimensional model of the terrain, emphasises the importance and the applicability of geodesy in giving proactive solutions to architectural and engineering problems.

Creating 3D objects using laser scan technology (LiDAR) that is one of the most important techniques used to acquire spatial data has several advantages, namely: it scans quickly the architecture point by point; registers and joints point cloud to digitally simulate the object's shape; finally, it reconstructs the 3D model accurately. It also produces construction drawing including ichnography, elevation, and cutaway. In addition, detailed structure and vignette can be acquired by close-range photogrammetry method, which produces orthoimages and linear drawings. This method is especially fit for surveying historical architecture that lacks construction records.

2.2.2.2. 3D modeling for Cultural Heritage

Romania has an important number of cultural heritage objects. Some of them date from ancient history like the geto dacian fortress, some of them date from the Ottoman Empire period and, at least in the western part of Romania, from Austrian Hungarian Empire. This empire has left its imprint both on the architecture of this region and on religion. So, between the years 1867-1918, the Transilvania region was under austro-hungarian occupation. In this period a preoccupation was to build Catholic Churches. During the communist regime this churches were left behind. After communist revolution in 1991 there was a lack of interest and of finances for the rehabilitation of these old churches. On the opposite, recently there is a lot of interest from authorities to start rehabilitation programs for cultural heritage objects. Historical buildings play an important role in cultural heritage scenario: their main value is due overall to age, artistic and structural features and to surrounding environment.

In particular, Timisoara, the city with most numerous number of historical building from Romania has won the competition for European Cultural Capital in 2021. In this sense there is a complex and important program of rehabilitation of those buildings and also a large program of integrating the historical and geospatial information in webGIS platforms. This fact is in accordance with the European Commission recommendation regarding i2020 an informatics society. Buildings rehabilitation implies more than their outer coating. The rehabilitation program (Alionescu, Bălă, Brebu, & Moscovici, 2017) is more complex, including tasks such as strengthening and renovation of buildings (strengthening the resistance elements of the building and, if necessary, restoration of the roof), better interior comfort, (replacement of windows, equipped with the minimum utility necessary) and improving interior and exterior appearance (renovation of the ornaments, particularly facades, architectural style and restoration of the original building's colour).

- **Wooden church inside the Village Museum in Timisoara**

Except for the optimum scanner locations, the target type and locations and/or their geometric configurations are also important. The targets are mainly used to register scans collected from different scan stations. At the moment, there is a great variety of available targets: retro-reflecting, spherical, paper targets, prismatic targets. For the studied objective, paper targets have been used, thus offering the possibility of automated registration.

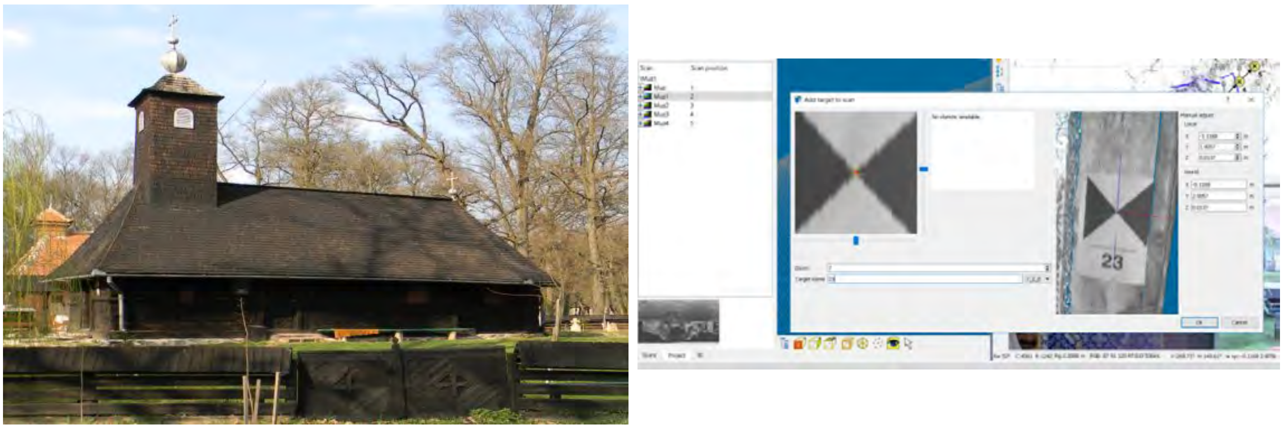


Figure 46. The studied objective (left) and automated recognition of the paper targets (right)

In most situations, a single scan station is not enough in order to produce a complete digital model of a certain objective. Multiple scan stations (sometimes even hundreds), at different angles, are usually necessary to collect information for each part of the studied objective. All these scans must be brought together into a common reference system, process defined as alignment or registration, further processed to create a complete digital model. For this reason, namely a complete coverage of the studied objective, we have used 5 scanning stations.

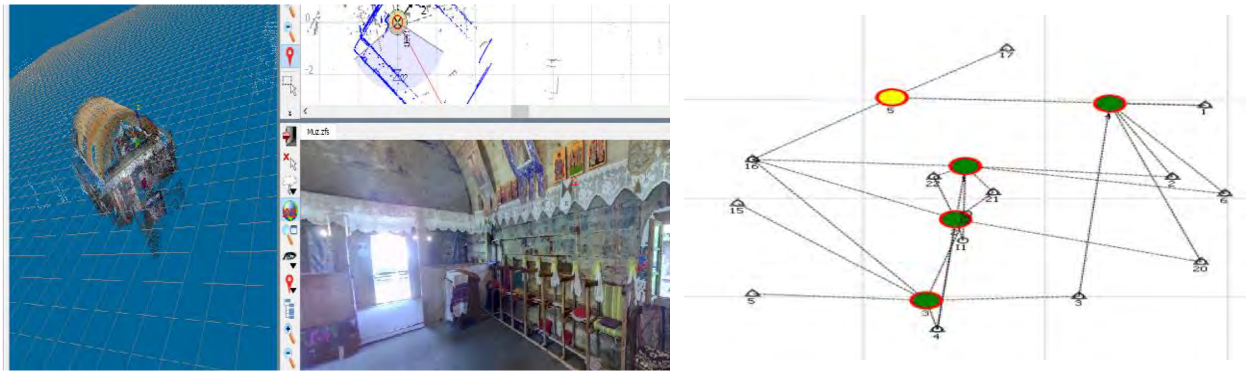


Figure 47. Scanning process / Georeferencing stations

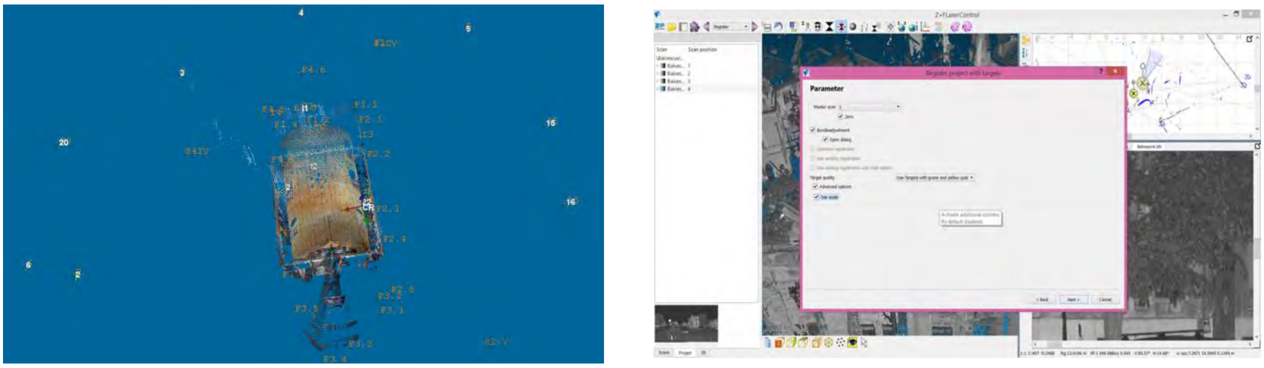


Figure 48. Point cloud georeferencing and setting the parameters for enhancing the model's accuracy

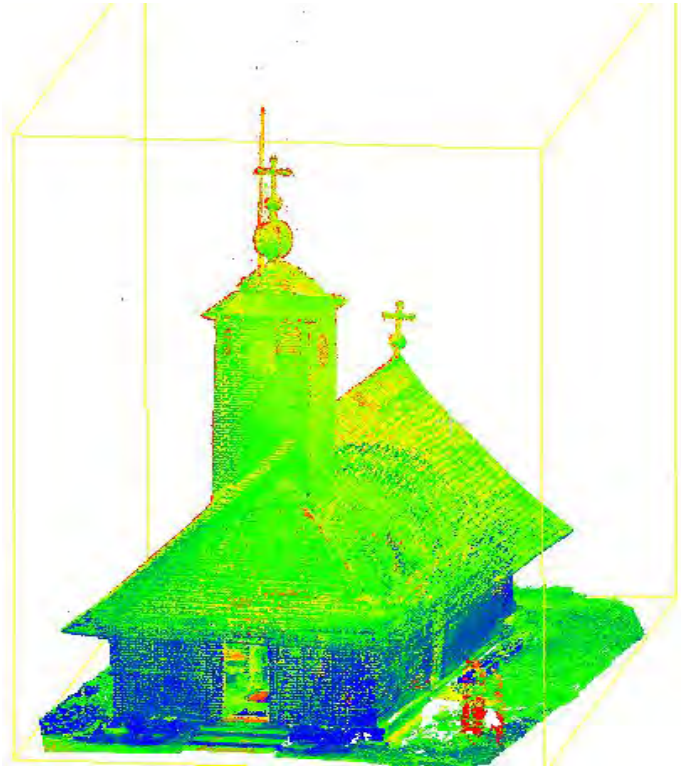


Figure 49. 3D model of the studied objective

Conclusions

This case study has summarized the technology of laser scanning, i.e. the different range measurement principles and scanning mechanisms. For terrestrial laser scanning, rigorous calibration is necessary in order to improve the geometric quality of the laser scanning point cloud.

Concerning applications of laser scanning, a short overview, by no means comprehensive, was given. Laser scanning can play an important role in many photogrammetric tasks. The authors expect that we will see in future integrated sensor systems, possibly integrated devices, capable of recording range and colour information simultaneously. This means that photogrammetry specialists will have to extend their mathematical concepts for optimally using synergies in both data sources.

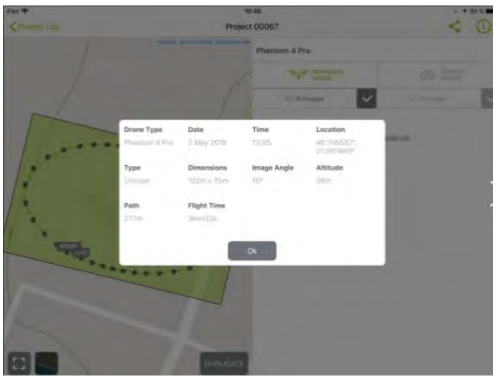
❖ **Pecica Roman Catholic Church**

Another case study refers to Roman Catholic Church from Pecica city, Arad County. As this church has been declared historical monument, the rehabilitation project also involved creating its 3D model. Thus, by using the IMAGER (Zoller & Fröhlich) 5010 C Laser Scanner and a Phantom 4 Pro 20Mp UAV as data collection technologies and Metashape Agisoft Photoscan Z&F Laser Control and Geoverse softwares for data processing, the final product was realized. This also implied further processing of the church's point cloud with SolidSCAN, CloudCompare, GlobalMapper, Autocad, Arhicad and ReCap3D specialized software.

In the scientific literature, there are many studies and determinations related to the realization of 3D models for cultural heritage objects. There are also studies that have used either terrestrial or aerial photogrammetry and combined this techniques with terrestrial scanning technology. What makes the research we have done unique is, first of all, the geometry of the object, the state of degradation and the need for the 3D model to be used to rehabilitate this objective. In order to acquire this, in this study we propose a modern approach using a precise terrestrial laser scan and digital airborne photogrammetry to create a digital object of the church. The scanning process was realized both outdoor and indoor to generate the thickness of the walls, columns, structural elements etc.. Evaluation the precision of the object it was a demand and a purpose because the 3D object was used both for touristic and digital documentation and also for a large program of rehabilitation and design. For a better understanding of the whole object or of the construction, as well for rebuilding purposes, our approach aimed to realizing a 3D model that renders the object as accurate as possible. This was done by means of merging the two point clouds, separately obtained from ground and aerial images by the SfM technique.

Another challenge was the optimal choice of both scanning stations and flight plan for data collection, especially as there is a lot of vegetation in the areas adjacent to the church, which obscures the scenes and the visible areas of the lens become smaller.

The photogrammetric data collection included 850 digital images and 16 Ground Control Points both natural and artificial.



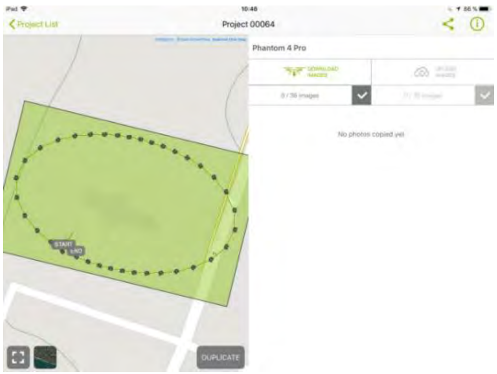


Figure 50. Settings of the realized flights with the UAV

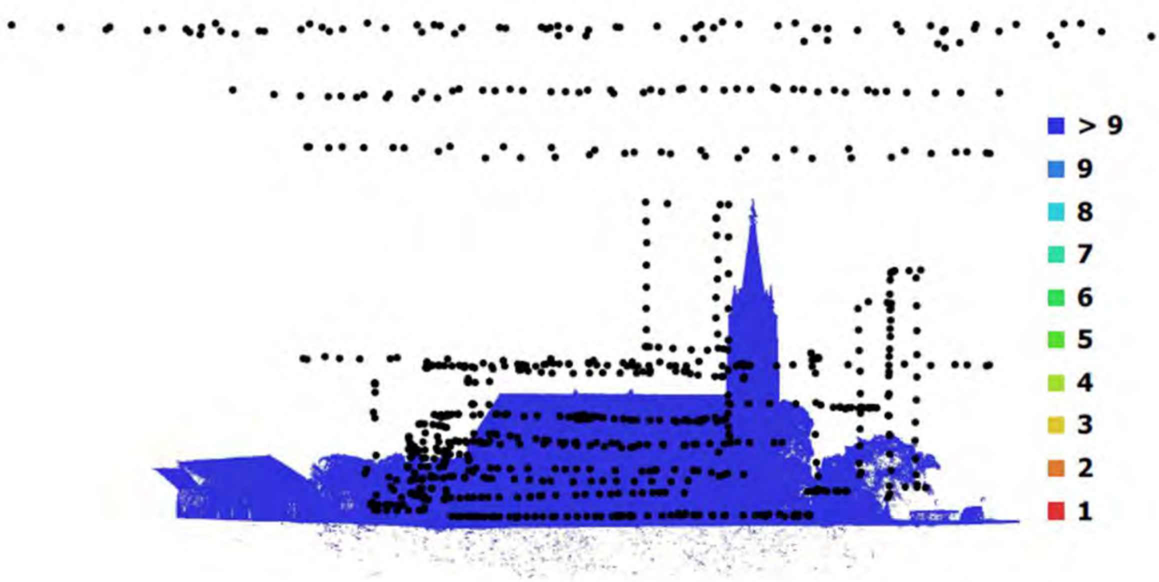


Figure 51. Camera locations and image overlap

The contributions we consider significant are: generating and bringing point clouds from the two techniques in the same coordinate system; generating facades mainly in places where objects were vertical and elongated, such as the church tower; joining the two categories of point clouds, namely outdoor and indoor; generating the attic structure and creating the 3D model of the roof truss as well as extracting technical information (vertical, horizontal sections and facades) for technical rehabilitation; highlighting areas with cracks and considerable fissures to achieve adequate consolidation of the building.

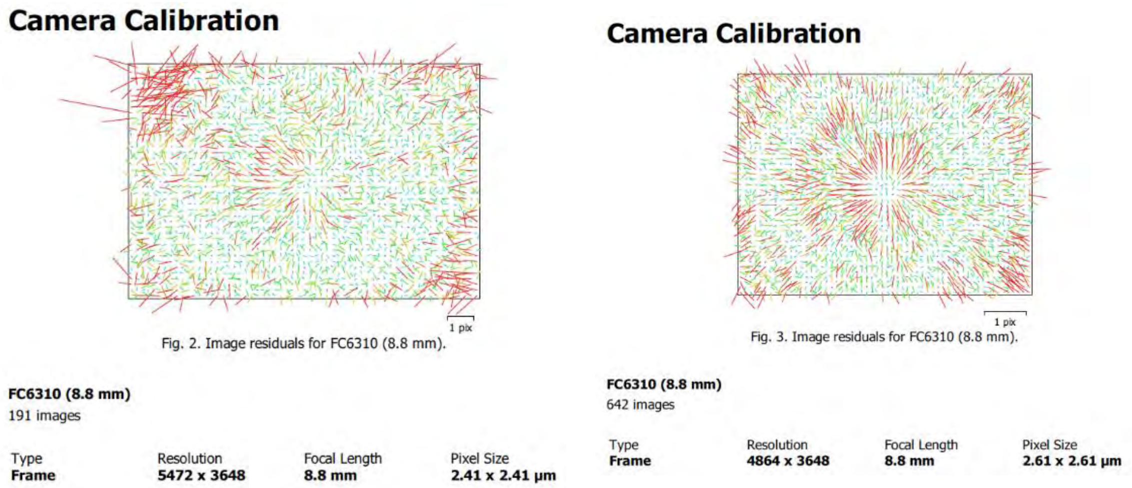
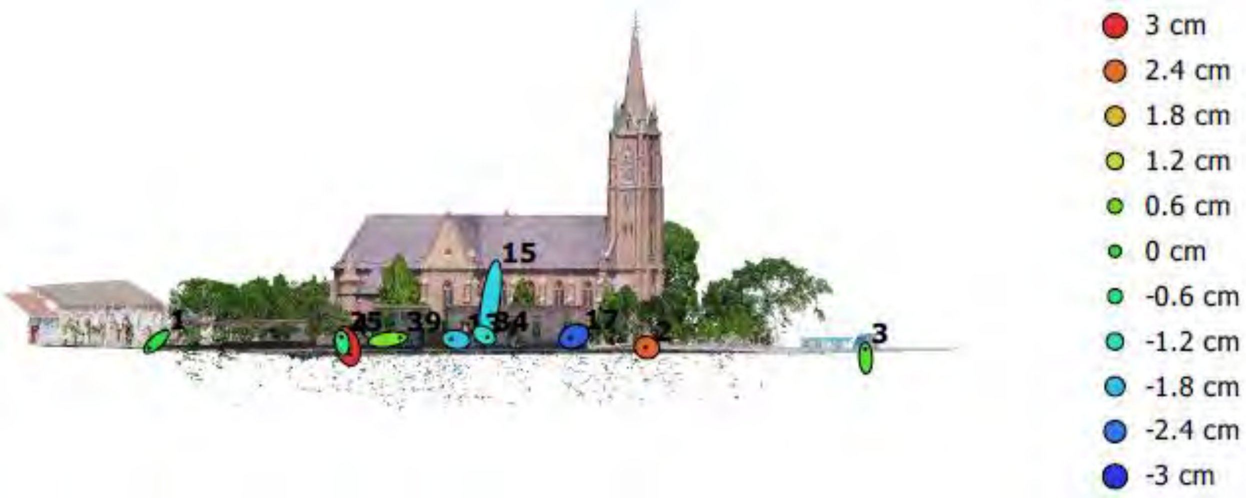


Figure 52. Camera calibration process and residual errors



Count	X error (cm)	Y error (cm)	Z error (cm)	XY error (cm)	Total (cm)
9	0.814487	0.75174	1.75399	1.10838	2.07484
34	0.494773	-0.306505	-1.22046	1.35213	0.188 (4)
39	1.88327	0.254297	0.659442	2.01153	0.269 (3)
Total	**0.814487**	**0.75174**	**1.75399**	**2.07484**	**0.796**

Figure 53. GCP locations and error estimation

The reconstructed digital elevation model of the Pecica Roman Catholic church in RGB can be seen in the following image:

Figure 54. Digital Elevation Model of the church in RGB

The Terrestrial Laser Scanned collected data was realized with the Z+F LaserControl specialized software as illustrated below. For the scanning, more than 60 scanning stations have been materialized in order to acquire data both from outside the church and inside (ground floor, stairway including the attic with all its framework and quarter which support the roof).

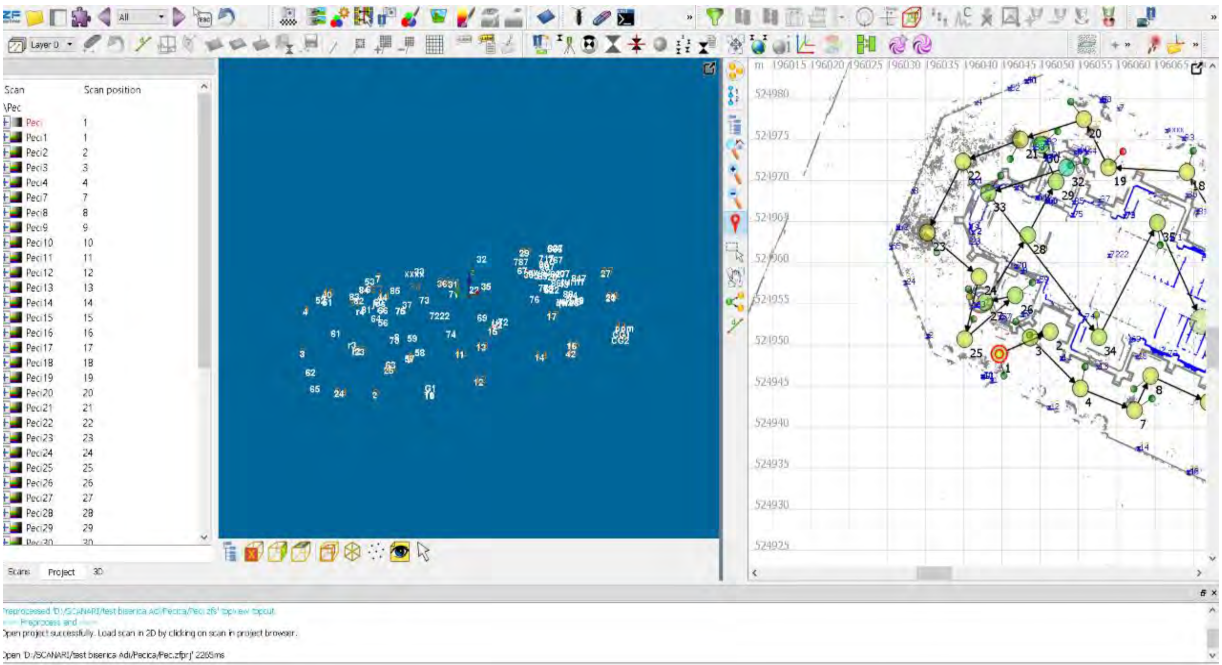


Figure 55. TLS stations

The processing and calculation of data, respectively their integration in a model can be observed in the adjacent images.

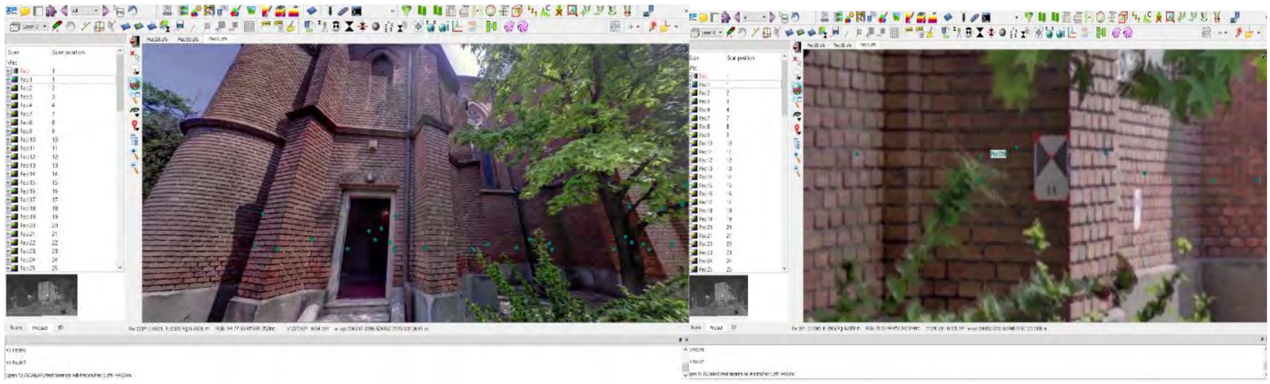


Figure 56. Stages of the TLS data processing

In the context in which we had photogrammetric data for which Ground Control Points (GCP) were determined both using GNSS technology and using the traverse method, we understood that in the process of integration and overlapping photogrammetric data with those from scanning we need common coordinate points. Or rather, a network of points is needed that can be used for both digital photogrammetry and scanning. Thus, we have determined the targets' coordinates needed in the scanning process and we have generated scans that are georeferenced.

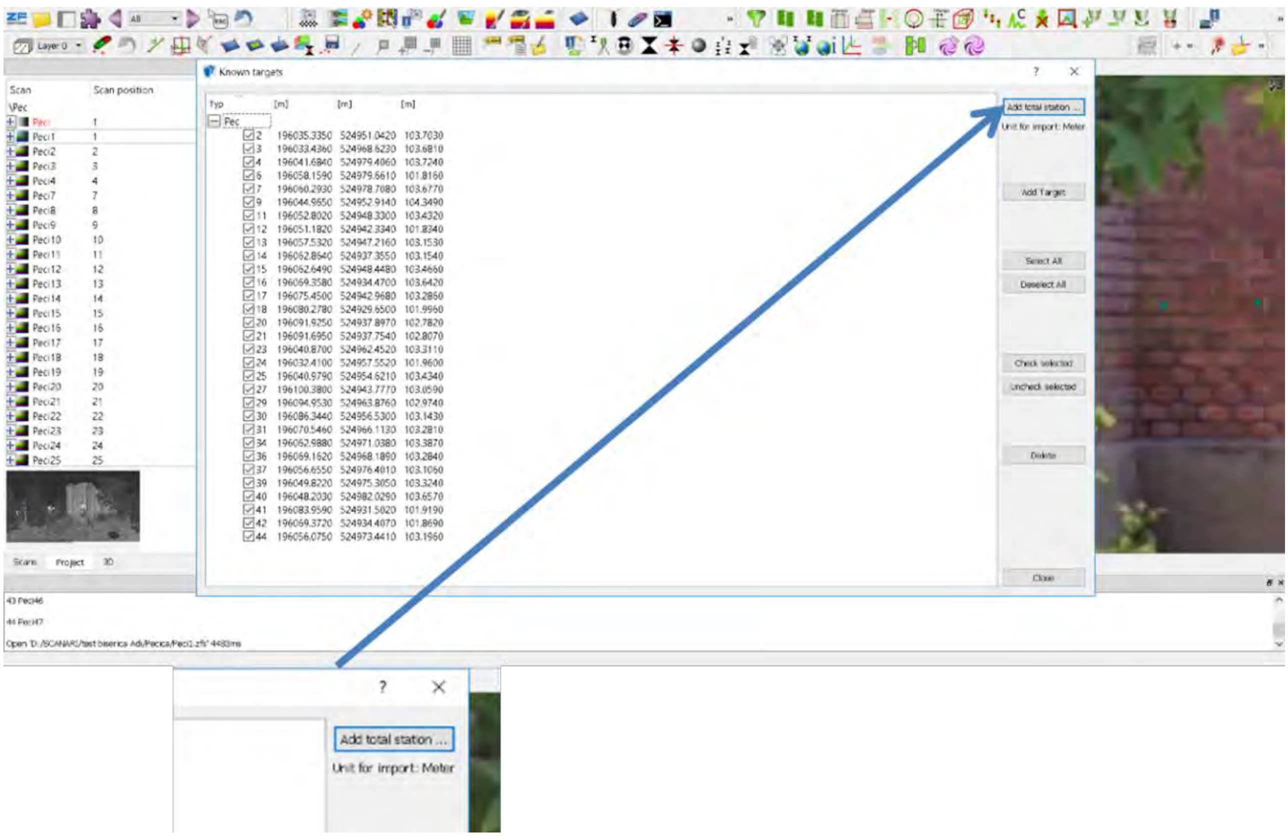


Figure 57. Local Network to determine GCP (DP) and Paper Targets (TLS)

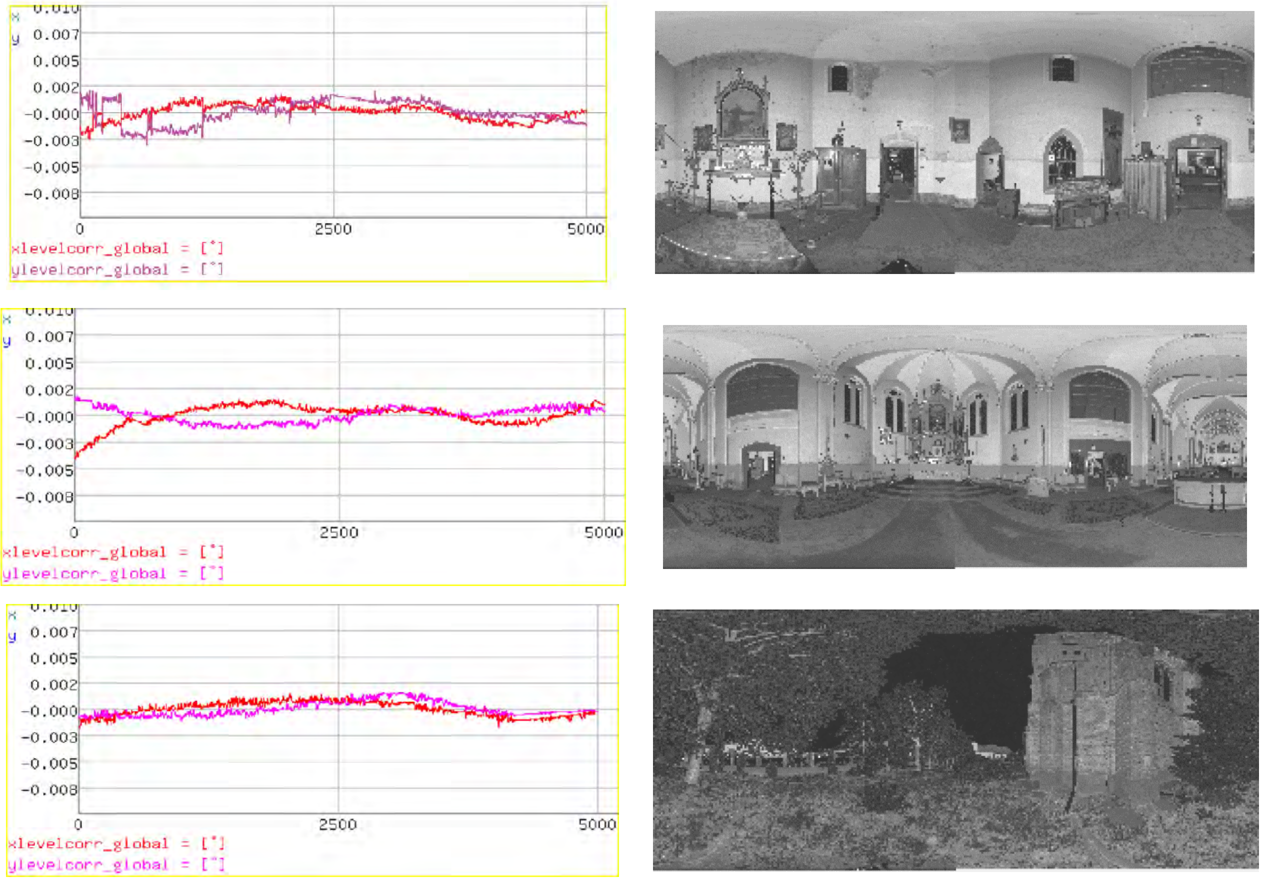


Figure 58. Residual errors of the scanning stations and their values

It can be observed that the values of the residual errors do not exceed 2...3mm for each scanning station.

Result registration with targets average:4.1 mm std:1.8 mm min:1.2 mm max:7.4 mm used:8 targets

Targets

Nr	Target	d[mm]	x[mm]	y[mm]	z[mm]	status	use	quantity
1.	'1'	4.0	-2.1	1.8	-2.9	activated	used	3
2.	'11'	2.7	-0.2	0.2	2.7	activated	used	4
3.	'10'	3.5	-0.6	1.9	-2.9	activated	used	3
4.	'2'	3.9	2.1	0.6	3.3	activated	used	6
5.	'G1'	4.9	-3.3	2.9	-2.3	activated	used	3
6.	'T1'	4.8	3.2	-3.1	1.9	activated	used	2
7.	'8'	1.2	1.0	-0.4	0.6	activated	used	2
8.	'24'	7.4	0.9	-7.4	-0.3	activated	used	2
9.	'9'	-	-	-	-	activated	not used	1

Result registration with targets average:3.4 mm std:1.0 mm min:2.3 mm max:5.1 mm used:6 targets

Targets

Nr	Target	d[mm]	x[mm]	y[mm]	z[mm]	status	use	quantity
1.	'21'	2.8	-0.3	-0.3	2.8	activated	used	3
2.	'20'	3.3	-1.1	-0.3	-3.0	activated	used	4
3.	'27'	3.7	0.0	3.2	-1.9	activated	used	4
4.	'43'	3.1	1.8	-2.4	-0.4	activated	used	3
5.	'19'	5.1	2.0	0.3	4.7	activated	used	2
6.	'CG2'	2.3	-2.2	-0.3	-0.6	activated	used	3

Result registration with targets average:3.4 mm std:2.0 mm min:1.2 mm max:7.5 mm used:9 targets

Targets

Nr	Target	d[mm]	x[mm]	y[mm]	z[mm]	status	use	quantity
1.	'57'	7.5	-1.3	2.1	-7.1	activated	used	2
2.	'58'	4.3	1.6	-1.6	-3.7	activated	used	2
3.	'59'	1.4	1.0	0.1	1.0	activated	used	2
4.	'8'	1.2	-1.0	0.4	-0.6	activated	used	2
5.	'63'	1.5	-1.0	-0.1	-1.1	activated	used	2
6.	'64'	3.9	2.8	-2.0	1.9	activated	used	4
7.	'66'	4.1	-2.3	1.9	2.8	activated	used	4
8.	'1'	3.0	2.4	-1.2	1.2	activated	used	3
9.	'10'	3.5	-2.3	0.6	2.6	activated	used	3

1.2-2.3 minimum error

Figure 59. Residual errors' values

In the centralizing table after performing and generating the 3D model, a scanning accuracy that does not exceeds 2…3mm can be observed. Control points with errors larger than 4mm have been removed from the process of generating the 3D model.

The next step consisted in combining the 2 models obtained.

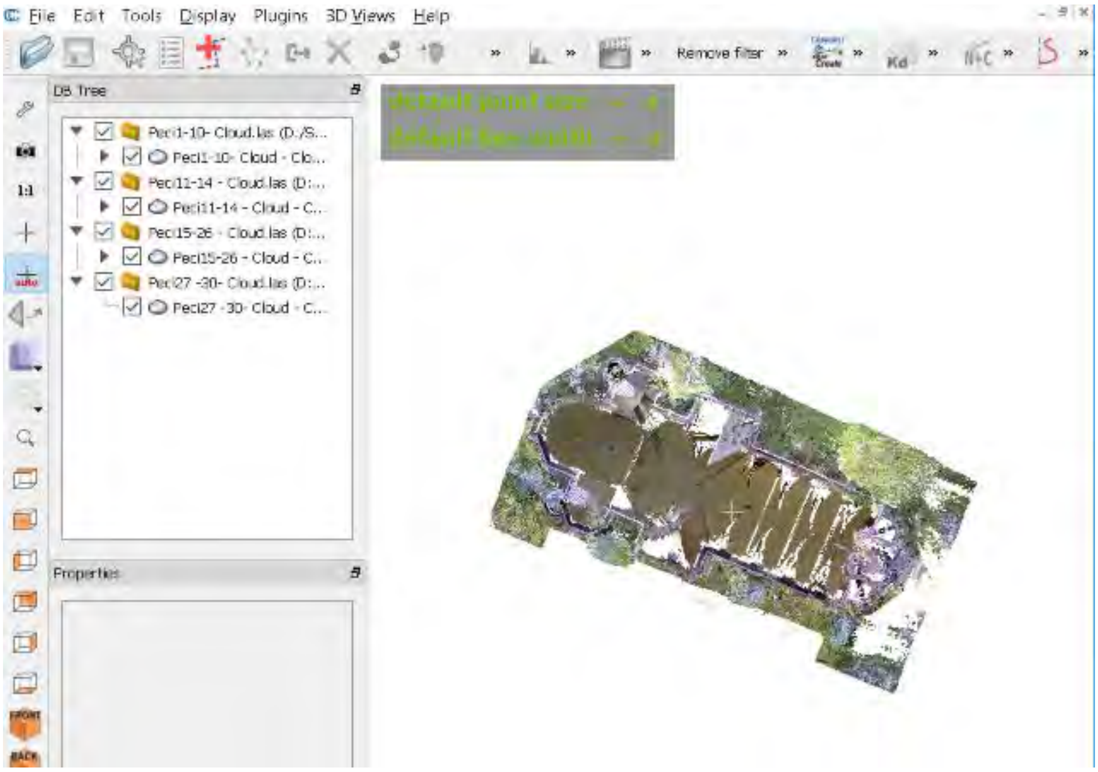


Figure 60. Combing and integrating the Models

The combination and integration of the models obtained by means of the 2 technologies, namely Terrestrial Laser Scanning and Digital Photogrammetry was realized in Cloud Compare, an open source resource.

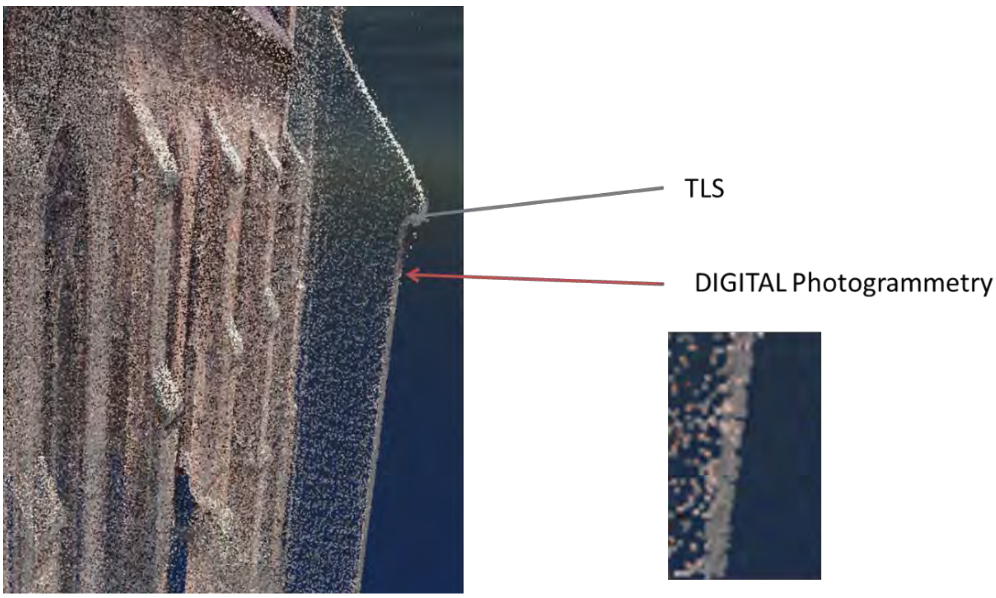


Figure 61. Differences between the Models

Figure 62. Differences between /overlapping of the Point Clouds

As it can be seen in figure 62, the 2 point clouds resulting from data collection realized with the 2 different technologies are generated. However, even though we obtained very good mathematical values in the overlapping process, we chose to present the 2 models separately. Thus, the TLS model is represented by grey colour and the DP model is represented by natural colours.

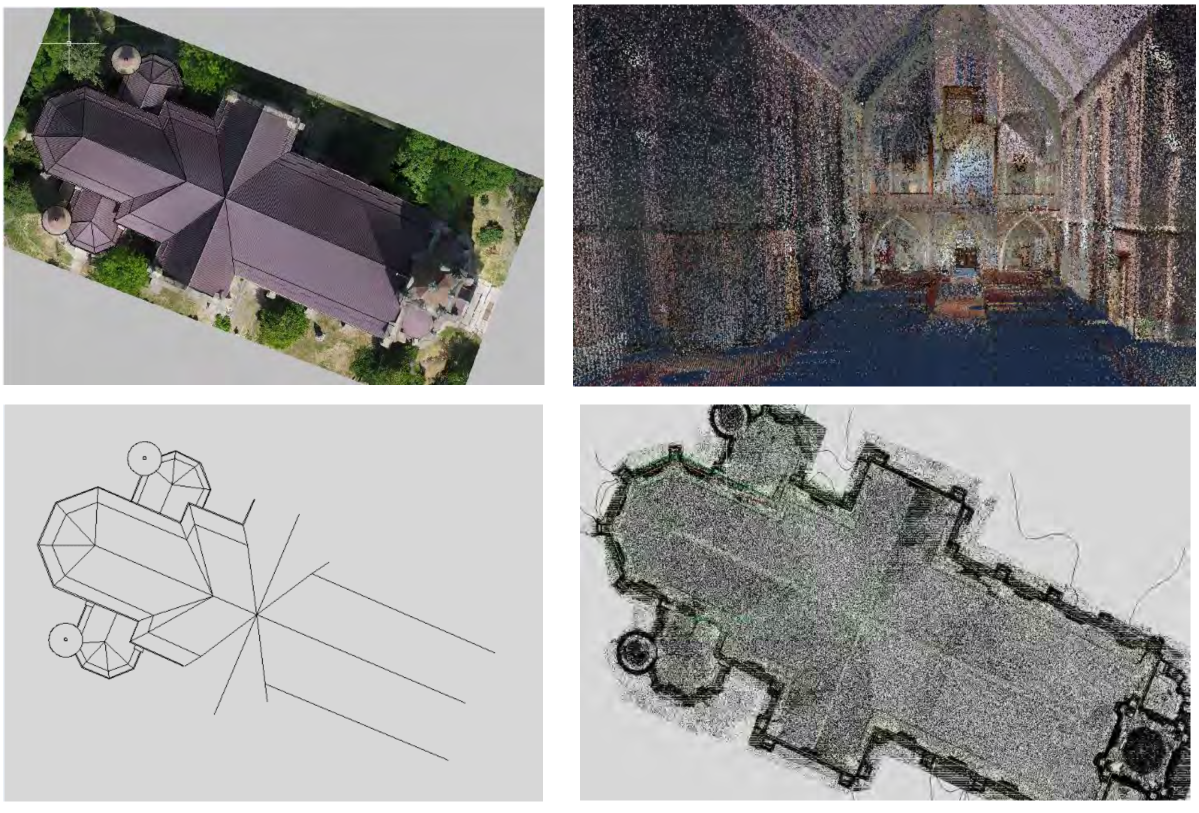


Figure 63. Extracting the buildings / structural elements

Finally, we extracted the geometric elements that are important for survey and the generation of facades, horizontal, vertical sections etc..

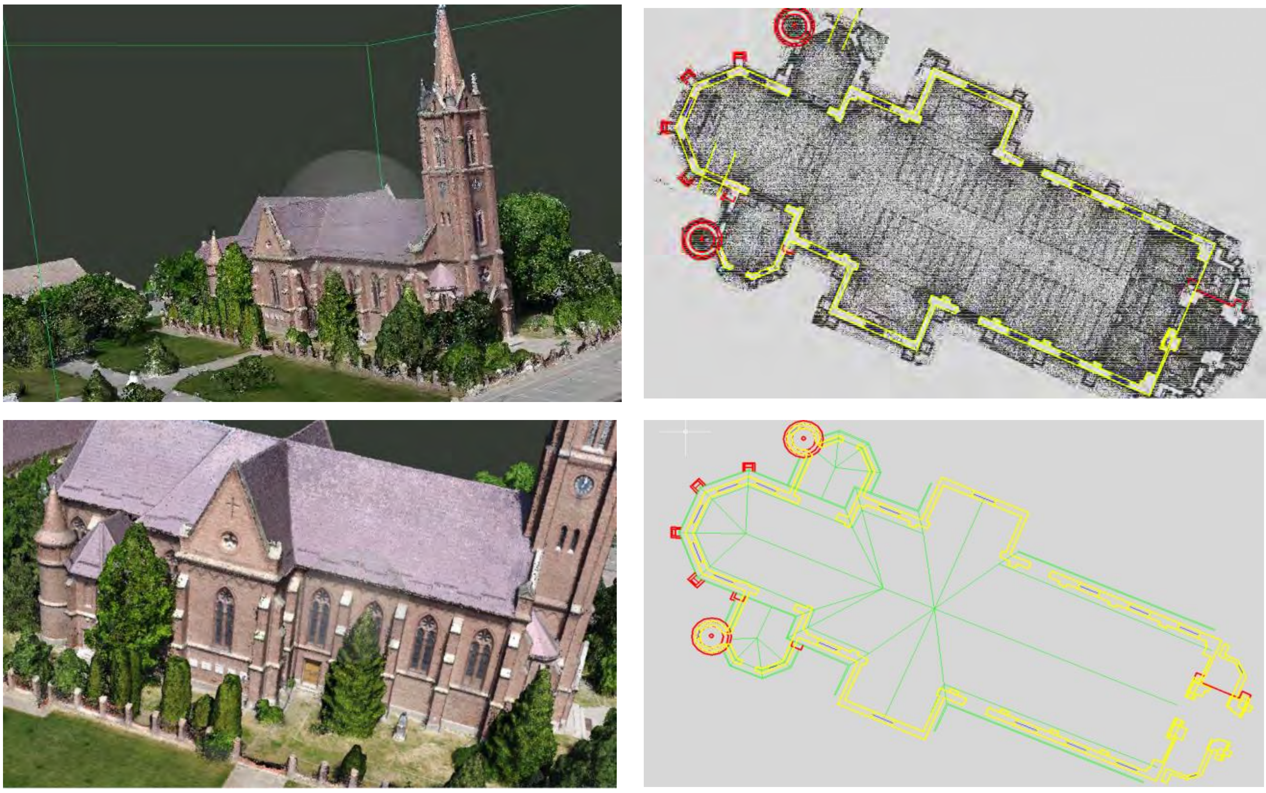


Figure 64. Extracting the buildings / structural elements

Conclusions

The urban planning and the territorial management aim to establish not only the spatial development directions, but also the general targets, such as: the social and economical development of the regions, a responsible utilization of human resources and the environmental protection or the reasonable and efficient utilization of the territory. Preserving cultural heritage and historic sites is also an important issue that must be taken into account when urban planning projects are required for developing the model of urban growth.

The case studies emphasize the importance of using state-of-the art technologies as current practices in cultural heritage aiming to develop tools for an integrated management of the metadata related to 3D buildings. In this context, it is obvious that an efficacious urban planning must include 3D modeling of heritage sites for purposes such as: documenting historic buildings and monuments for reconstruction or restoration if they are destroyed, creating education resources for history and culture students and researchers, simulation of new buildings, updating and keeping cadastral databases current, visualization from viewpoints that are impossible in real world due to size or accessibility, interaction with objects without risk of damage and virtual tourism.

2.2.2.3. Using LiDAR for Urban Green Space Monitoring

The aim of this case study involves urban green spaces monitoring with a view to inventorying urban wooded areas and the trees inside the cities using LiDAR technology. As study area, a park near the “Dan Păltinișanu” stadium, Timișoara, Romania was chosen. There were two sets of data collected at different speeds of approximately 10km/h, respectively 30km/h. For data processing, corrections are needed either given by a reference station either by a permanent GNSS station. In the second case, the correction are ordered and paid according to the number of hours requested to the Cadastre and Land Registration Office. For the present study, corrections from our own reference station have been used.

The measurements have been realized using Trimble MX2, a mobile laser scanning system that combines high resolution laser scanning and precise positioning to collect georeferenced point cloud that is useful to projects with vast requirements. (Grădinaru, Herban, & Gabor, 2016) Trimble MX2 is an integrated system which captures, processes, and analyses point clouds for mobile applications using spatial images. The system has three main elements: the sensor, operator console and analysis software. As optional equipment, Trimble MX2 mobile scanning system can be equipped with a DMI-Distance Measurement Indicator which calculates the rotation of the wheels to help positioning the vehicle and with a G360 panoramic camera system.

The platform used for data collection is composed of a Ford vehicle on which the Trimble MX2 scanner has been mounted. As performance, the system has the following characteristics: operating temperature: –10°C to +50°C; laser type: dual SLM -250 Class 1 lasers; range up to 250m; accuracy ±1cm to 50m; field of view 360degrees, measuring rate 72.000points/second.

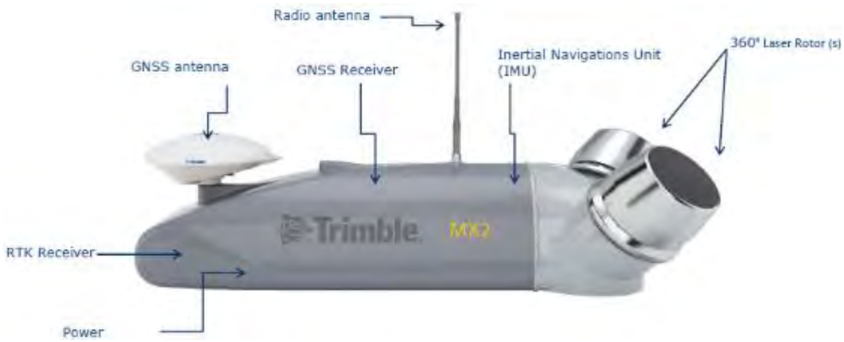


Figure 65. Trimble MX2 scanning system (www.trimble.com/imaging/Trimble-MX2.aspx, n.d.)

The Trident software is used for data acquisition. Because it is a mobile platform, the system needs initialization to facilitate subsequent post-processing. This takes about 5 minutes after which the measurement itself is realized in about 30 minutes. There were two sets of data collected at different speeds of approximately 10km/h, respectively 30km/h. The resulting measurement consists of the files containing the entire trajectory of the car – POS, files containing the actual measurement –

TRIDB along with the point cloud and images taken by the camera – CAM. The measurements have been carried out between 9:58-10:18 AM, 11/05/2017 and the corrections have been recorded for the whole day. The park chosen as study areas is located in plain area, the terrain height is between 86 and 91m.

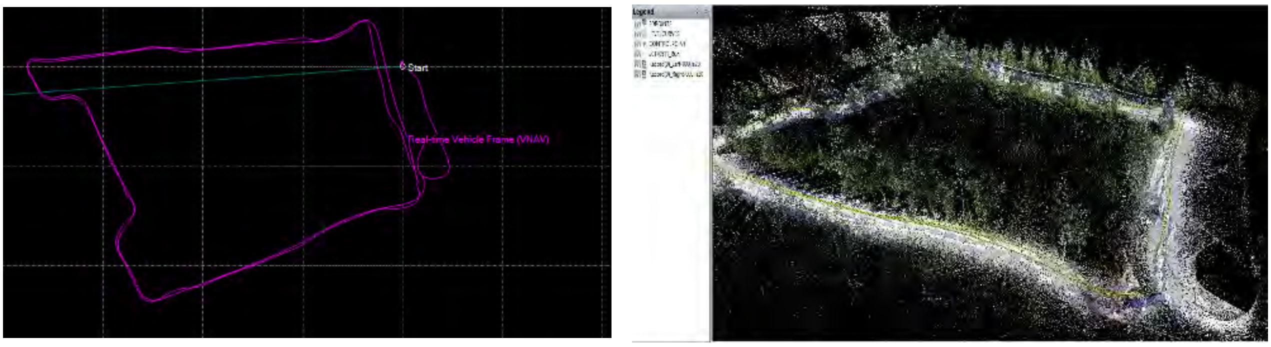


Figure 66. a) Trajectory processing b) Processed point cloud

As a result of data processing, the following resulted for the two sets of measurements:

- a point cloud consisting of 10 million points and a distance of 10cm between them for 10km/h speed,
- a point cloud consisting of 4.5 million points and a distance of 35cm between them for 30km/h speed.

It can be concluded that a higher speed of movement of the platform leads to reducing the number of points and their density.

Digital terrain model DTM is carried out on the basis of ground points, as TIN (Triangulated Irregular Networks) and determines the terrain's slope. Digital surface model DSM is carried out on the basis of all points by removing points with heights greater than 110 m, considered as errors and determines the wooded areas or those in which trees have heights lower or higher.

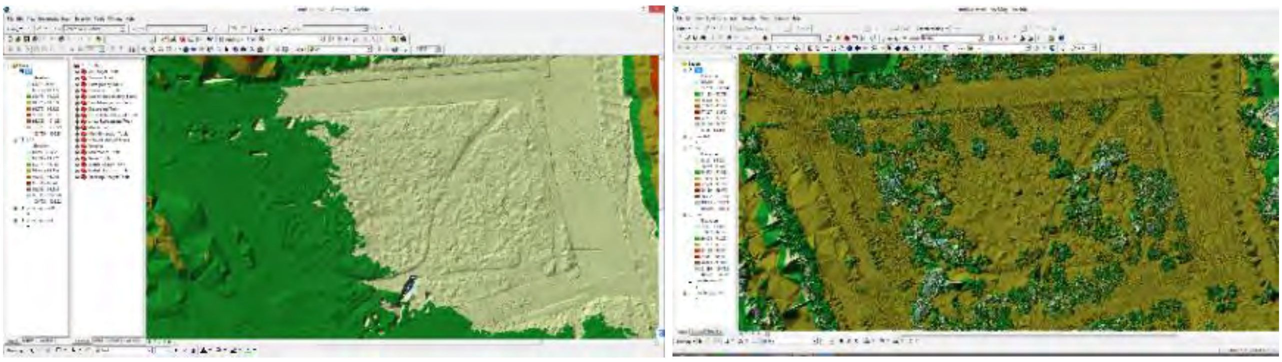
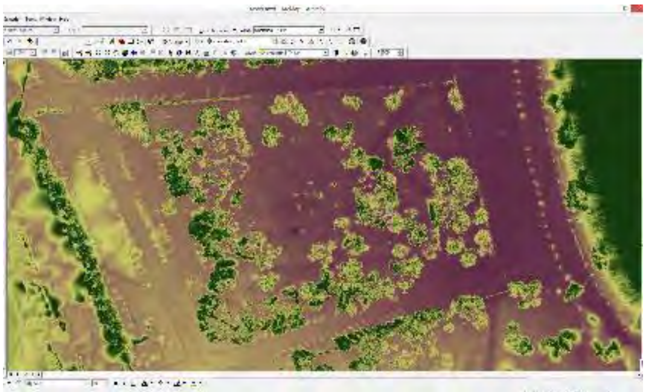


Figure 67. a) Digital Terrain Model b) Digital Surface Model

For a more explicit graphic representation we have created DSM for data set containing 10 million points in a raster with 0.05 pixel size. In figure 67 a) it is observed that for planar areas Brown colour was used and the areas where trees have the greatest heights are represented by green colour. To determine the effectiveness of the technology for studying forested areas, we realized both manual and automated inventory of trees from this park. Manual inventory has been undertaken with the Trimble Trident software by vectorising on the images collected by the camera mounted on a mobile platform. A number of 129 trees resulted. Automated inventorying was realized using Global Mapper software; for the data set with a higher density of the point cloud, 81 trees were identified and for the point cloud with a smaller density, a number of 75 trees resulted.



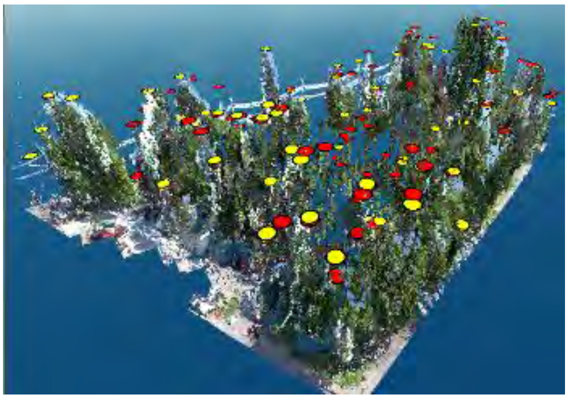


Figure 68. a) Raster DSM b) Automated inventorying of trees

Conclusions

Sustainable urban planning uses a conscious approach to energy and ecological conservation in the design of the built environment with a view of stimulating investments, attracting tourists and increasing the living standards of inhabitants. Green space monitoring is considered a key instrument for urban environmental management and will facilitate the development of local urban ecological environment policies by local authorities.

Following the study, it was found that terrestrial LiDAR technology can be used to automatically inventory the trees from an urban wooded area. By means of using the Trimble MX2 device with a speed of about 30km/h, the authors obtained a point cloud composed of 4.5 million points with a distance of 35cm between them and a 58% percentage of automatic inventorying of trees. The second scenario, which involved the minimum speed of 10km/h, led to a point cloud consisting of 10 million points with a distance of 10cm between them and a 63% percentage of automatic inventorying of trees. In order to obtain an automated percentage for trees inventory a more precise mobile Laser scanner which collects a greater number of points/second is needed.

2.2.3. Reverse Engineering

Nowadays, as a great accent is placed on digital recording of cultural heritage objects for conservation purposes and taking into consideration technology advances, the most suitable process is represented by reverse engineering (RE) as it consists in acquiring the geometry and shape of an objective's part and reconstructing its digital model. Reverse engineering finds its applicability in the CH domain for purposes such as maintenance (e.g. computer-aided repair), reproduction (e.g. via rapid prototyping), multimedia tools for education and dissemination (e.g. virtual museums), to artefact condition monitoring (e.g. computer-aided inspection) and many more.

In 2017 the member states of the European Union adopted "Recommendation CM/Rec (2017) to member States on the "European Cultural Heritage Strategy for the 21st century" and in May 2018 a new agenda regarding Cultural Heritage has been adopted.

The "Paris Agreement" (2015) and the 13th objective for sustainable development goal on climate action of United Nations also brought together the identification of good practices and innovative measures for their transformation into sustainable buildings. Another approach implies protecting these buildings as well as historic objectives from the effects of climate change.

The information from the Horizon 2020 scientific projects will be shared with the EU and the "Disaster Patrimony Survey" will be considered.

Romania, as a member state, has aligned its priorities to the EU and is constantly trying to develop smart solutions regarding the issue of preserving its Cultural Heritage. (Vîlceanu, Alionescu, Grecea, Herban, & Moscovici, 2019) 3D modeling of cultural heritage objects is an expanding application and can be easily combined with other technologies. (Vîlceanu, Herban, & Grecea, Creating 3D Models of Heritage Objects Using Photogrammetric Image Processing, 2013)

When taking into account the 21 Agenda for culture – initiative of the Cultural Committee of United Cities and Local Governments, the increased interest is for the Section D referring to territorial and economic development. Within this strategy, 11 recommendations were made, namely:

- D1 promote cultural heritage as a resource and facilitate financial investment;
- D2 support and promote the heritage sector as a means of creating jobs and business opportunities;
- D3 promote heritage skills and professionals;
- D4 produce heritage impact studies for rehabilitation, construction, planning and infrastructure projects;
- D5 encourage the reuse of heritage and use of traditional knowledge and practice;
- D6 ensure that heritage is taken into account in development, spatial planning, environmental and energy policies;
- D7 give consideration to heritage in sustainable tourism development policies;
- D8 protect, restore and enhance heritage, making greater use of new technologies;

- D9 use innovative techniques to present cultural heritage to the public, while preserving its integrity;
- D10 use the cultural heritage as a means of giving the region a distinctive character and making it more attractive and better known;
- D11 develop new management models to ensure that heritage benefits from the economic spinoffs that it generates. (www.coe.int/en/web/culture-and-heritage/strategy-21, 2019)

2.2.3.1. Heritage studies in Spatial Planning; Development and Environmental Policies

I. Concepts and Methods

The case study referring to such an objective in Timisoara, Romania can be integrated within D4 and D8 recommendations. Other rehabilitation projects that have made a contribution to changing the perception of historical monuments only with a past without a functional future are also presented. For example, images with a historical building from the Union Square (Fig. 69) and the Michelangelo bridge (Fig. 70) are presented after rehabilitation.


Figure 69. Historic building in Union Square before and after renovation (www.primariatm.ro, 2018)


Figure 70. Michelangelo bridge

Basically, Timișoara is an important economical centre, an important cultural centre, it has a wide and interesting architectural heritage (with 3 poles, unique in our country), it currently is an important migration magnet, a smart city wannabe and an upcoming tourist magnet. (Bănescu, Vîlceanu, & Hapenciuc, 2018)

Timișoara Municipality has set its goal to become one of Europe's smart cities and communities, taking into account both, cultural and ecological strategies. These are very much supported by winning the title for "European capital of culture" in 2021, thus involving the entire community in embarking socio-economic and infrastructure projects and databases which ensure efficient management for the municipality.

In 2023 Timisoara will be the European Capital of Culture, but the budget for this project does not include investments for infrastructure or rehabilitation of buildings. Moreover, by winning the title of this initiative, the context for implementation of several policies for the buildings' rehabilitation, consolidation and infrastructure by the city hall and the county council is created.

By recognizing the role of culture for development and quality of life, contemporary cultural policies call attention to the need to inherently integrate the cultural sector in other areas of public life. (Grecea, Herban, & Vilceanu, WebGIS Solution for Urban Planning Strategies, 2016) Concern for the cultural life of the city of Timişoara implies a strong relationship between culture and urbanism, architecture, environment, education and contributes to local and regional development.

Bridges in Timișoara are important in two aspects, one aspect would be their functionality (Moscovici, Păunescu, Sălăgean, & M. Călin, 2019) and the other aspect would be their historical importance (Fig. 4). In Timisoara there are ten bridges, two passages and four pedestrian walkways. In the image below we have marked these bridges and walkways on the map of Timisoara where they can be seen as belonging to the category of historical monuments. The natural disasters (Bonazza, 2018) that primarily affect this type of monument are floods. That is why we consider that our case study demonstrates the complexity of the measurements (Dinca, et al., 2017) and the importance of the 3D model (also necessary for a possible reconstruction), of the elevation model of the terrain and the orthophotoplan.

The case study refers to a pedestrian walkway on the Bega River which, because of climate change and the fact that the constructor's warranty has expired, finds itself in need of a structural consolidation, but because it is a historic objective, its identity from this point of view must be preserved. The pedestrian bridge (Fig. 71) at the end of the Chrysanthemum Street, which connects with Gelu Street, is situated in the area of Dâmboviţa-Iosefin neighbourhoods. It is the first bridge in Timişoara, which is under repair, 70 years after its construction.

Figure 71. Map of protected bridges in Timisoara

The bridge connecting the streets of Chrysanthemums and Gelu was built in 1949 and has never been completely rehabilitated ever since. It is currently being used by people who shorten their way from one side of the Bega River to the other, without having to circumnavigate more than one kilometre to the nearest bridge.

Figure 72. The pedestrian bridge under study (https://mapio.net/s/62770987/ , 2018)

The technical project to upgrade the aforementioned bridge linking the watersides of the Bega River is at a stage of consultation with local authorities and architects. Our contribution to the project consists in conducting topographic surveys by using two methods in order to acquire geospatial data and have a real image of the field situation with a view to obtaining as much details as possible. The two methods are:

- Surveying engineering using GNSS technology and the total station;
- Photogrammetric measurements using UAVs – drones. (Tóth, Balázsik, & Kiss, 2018)

The topographic survey was made using GNSS equipment. In order to measure the inaccessible elements of the bridge (bridge abutments, beams etc.), the total station was used.

In the image below the topographical plan containing field details and the orthophotoplan are presented.

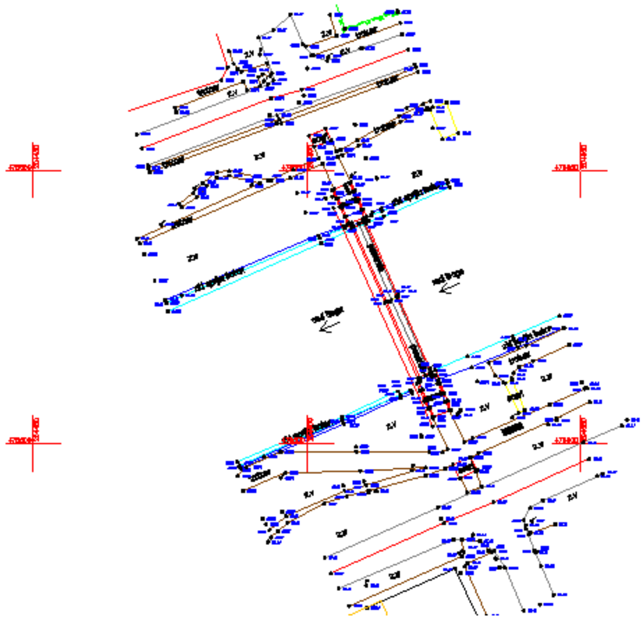


Figure 73. Site plan, scale 1:500

II. Results and discussions

For photogrammetric measurements, a smart drone with 5 directions sensors system composed of vision and infrared sensors, which allows it to avoid obstacles during the flight was used. Its camera delivers unprecedented image quality with improved clarity, less image noise, and greater photo and video resolution (20 Megapixels). The remote control supports dual frequencies, making video transmission more efficient and stable. To carry out the measurement, the Pix4DCapture application, available for free for any Android or iOS user, was used. This application turns the drones into a professional mapping tool. 2 flights have been performed, the first flight at an altitude of 60m with 90 degrees inclination. The duration of the flight was about 4 minutes and 55 images were taken. Image overlap was 80% -70% as grid. For the second one, the flight altitude was 30m with 60 degrees camera inclination. The flight duration was 8 minutes and 189 images were taken.

Further, we used a data processing program that allows users to create orthographic, georeferenced, high resolution images (up to 5cm using ground reference points) and highly detailed digital terrain models stored in irregular polygonal and textured structures. The application provides high-quality combined and rectified images even when alignment is used without coordinates being assigned to images previously.

On the field, 7 Ground Control Point have been materialized as seen in the figure below in order to be identified on the images acquired by the drone (Fig. 73).

Markers	Easting (m)	Northing (m)	Altitude (m)	Accuracy (m)	Error (m)	Projections	Error (pix)
☑ 1	204533.187900	478580.382100	87.463300	0.005000	0.001157	4	0.036
☐ 2	204492.249200	478597.599100	85.775500	0.005000		1	0.000
☑ 3	204551.262300	478610.096500	88.925500	0.005000	0.002293	11	0.033
☑ 5	204522.015900	478661.427900	88.310000	0.005000	0.002983	7	0.038
☑ 6	204503.256000	478655.245500	89.004000	0.005000	0.002145	4	0.051
☑ 7	204477.097900	478627.114800	85.549400	0.005000	0.041465	1	0.000
Total Error							
Control points					0.018652		0.038
Check points							0.000

Figure 74. Description of the Ground Control Points

The totally automated workflow enables ordinary users to process, in a natural language without the need for advanced modelling knowledge, thousands of aerial or terrestrial images only by using a computer to obtain end products that consist of professional photogrammetric data (Fig. 74). Image alignment and reconstruction 3D models are totally automated.

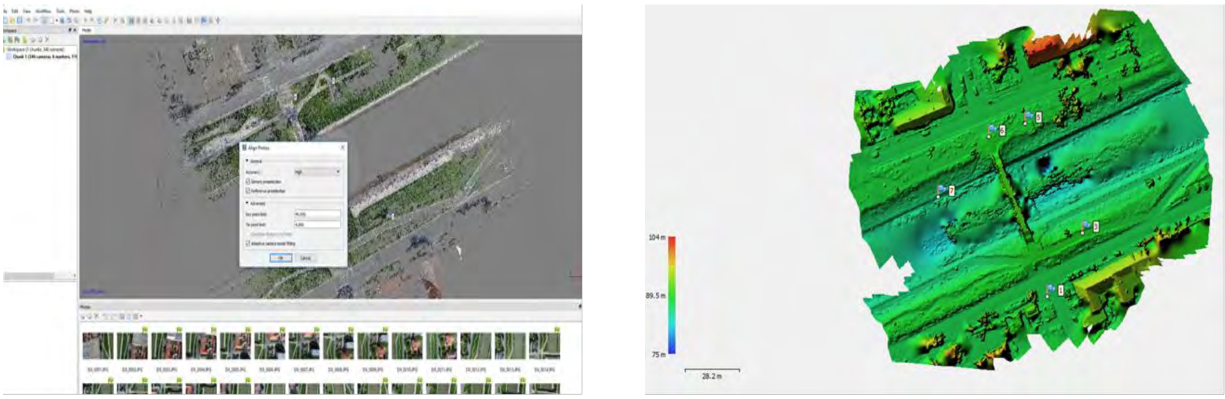


Figure 75. Image alignment and Elevation model with GCP

Photogrammetric analysis can create a virtual 3D model of the bridge to be rebuilt after a flood of water or it can be illustrating for architects dealing with its rehabilitation. A realistic impression of geometric 3D data can be generated by draping real colour textures simultaneously captured by a colour camera images. (Moscovici, Brebu, & Bălă, Geospatial Data Acquisitions Using 3D Laser Scanning Technology in the Context of Monitoring Mines, 2017)

III. Conclusions

The documentation of cultural heritage through the acquisition of digital data and the realization of 3D models currently can count on many procedures and survey instruments which have been developed in the last decades and still more specialized for the acquisition of metrical information with high resolution levels, reliability and precision. The conducted studies prove that photogrammetric technologies are nowadays used at a large scale for obtaining the 3D model of cultural heritage objects, efficient in their assessment and monitoring, thus contributing to historic conservation.

All its aspects play an important contribution to recording and perceptual monitoring of cultural heritage, to preservation and restoration of any valuable architectural or other cultural monument, object or site, as a support to architectural, archaeological and different art-historical research. 3D modelling has much functionality: the possibility of creating sections for a thorough analysis, collaborative work between specialists in different countries, calculating cost of restoration before actually doing the work, allowing virtually visits of objects in order to evaluate them, being the most important advantage.

Timişoara, as a European city and more importantly, as an upcoming European Capital of Culture, needs a modern interface, which organizes built environment and appeals both to locals and tourists. In this context, the study case can also serve as a basis for implementing a spatial data geoportal at Local Administration level (Timişoara City Hall) to streamline the data workflow and provide easy access to it in order to increase the visibility of cultural and historical heritage of the municipality, to contribute to efficient urban transportation and infrastructure monitoring.

2.2.3.2. Creating 3D point cloud / mesh models for H-BIM type digital platforms

The constructions field is in the midst of a revolution triggered by the transition from 2D documentation and delivery processes for digital prototypes and collaborative workflows.

This transition is due, first of all, to the technological evolution of the last 15 years, but also due to the increasingly complex works in the constructions field which, despite their complexity, it is intended to achieve maximum efficiency and overall performance.

Rigorous conditions of performance and efficiency of works, ensuring the fulfilment of all the legislative provisions but also the full satisfaction of the investor's needs cannot be met successfully by descriptive representations of the construction process. There is a need for a wider vision, more precise but at the same time more intuitive, easier to be perceived and put into practice by the workers on the construction sites that should come to the beneficiary’s aid facilitating, facilitating the decision-

making process. It is necessary to establish a framework in which the specialists participating in the project to carry out a much more efficient communication and to have access to all the information related to the entire project.
Analysing the above, we can say that meeting these needs and requirements it requires more than the realization of a high-performance model, namely it requires the implementation of one whole process, a process called BIM. (www.united-bim.com/bim-maturity-levels-explained-level-0-1-2-3/, 2021)
This process has become an increasingly present reality in many countries around the world. Although in many countries, BIM is still at a low level of implementation, in countries such as The United Kingdom and Singapore, the use of the BIM has become mandatory in order to carry out constructions projects. (Arschcraft, 2008)
Studying the evolution of BIM implementation over the last years, globally, but also the results obtained from its use so far, one can conclude that it is only a matter of time until BIM will completely revolutionize the field of construction, becoming a normalcy and not an option. (Kensek & Noble, 2014)

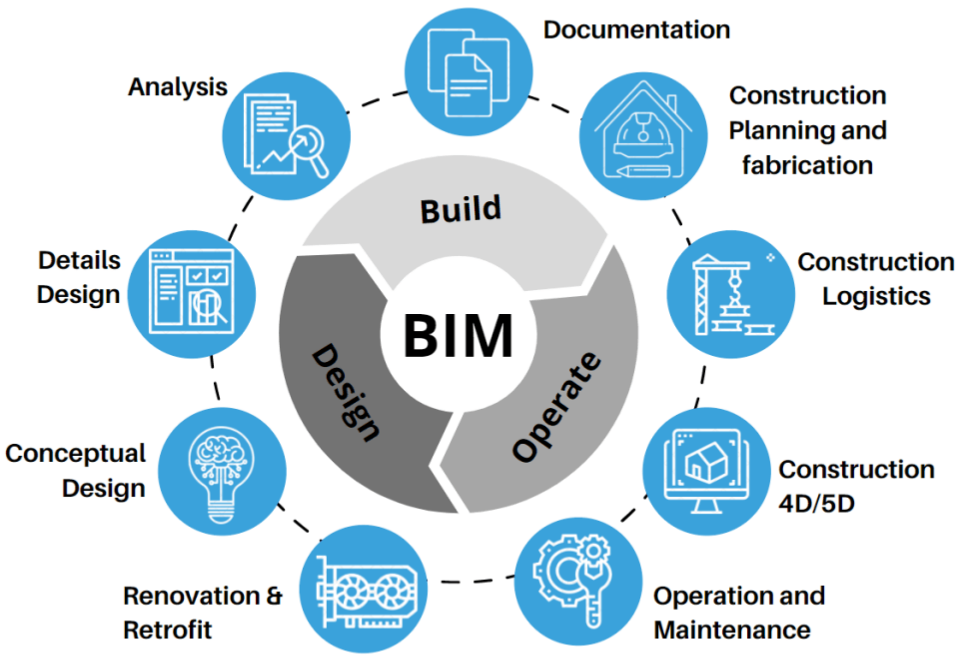


Figure 76. BIM as a basis for decision making (source: https://fsixsolution.com/blog-what-is-scan-to-bim)

Due to the significant advantages that the use of BIM offers, the companies that opt for the implementation of this process are in a privileged position from the competitiveness point of view. (www.advenser.ae/bim-services/, 2021), (www.thenbs.com/knowledge/bim-levels-explained, 2021)
The World Heritage Site is made up of a number of places around the world that have a remarkable universal value for humanity and have therefore been inscribed on the World Heritage List in order to protect them in order to give future generations the opportunity to appreciate them. According to

UNESCO, world heritage is made up of natural heritage, cultural heritage and underwater heritage. As the term “heritage” suggests, world heritage is in itself universal values that need to be passed down from one generation to the next. In turn, cultural heritage can be divided into two categories: tangible cultural heritage and intangible cultural heritage.

The intersection between BIM and cultural heritage takes place in the tangible heritage sphere, more precisely, in terms of real estate. This category includes: groups of isolated or grouped buildings which, due to their architecture, unity and integration into the landscape, have an exceptional universal value from a historical, artistic or scientific point of view, works of architecture, sculpture or monumental paintings, archaeological elements or structures, inscriptions, caves. (Wang, Pan, & Luo, 2019)

Due to the high importance of historic buildings, it is essential to include the stage of their conservation during their life cycle by carrying out modernization and restoration works.

The term H-BIM comes from Historic Building Information Modelling and describes a solution by which interactive parametric objects that represent architectural elements are constructed from historical data. Thus, while the use of BIM is dedicated to the constructions to be made, H-BIM is a process that runs in the opposite direction, namely, it is a technology that allows the reproduction of an existing building and the creation of a model that can simulate real construction and which, in the end, offers most of its features in the most feasible way. Since in the context of H-BIM the operations are found in reverse order to BIM, it is natural to say that in the case of H-BIM the project begins with the analysis of the existing situation in the field and collection of the necessary data regarding the construction. The most used method to obtain the necessary information from the field in order to perform an H-BIM is laser scanning. This concept is found in the scientific literature under the name of Scan-To-BIM (from scan to BIM).

Figure 77. Scan-to-BIM concept

Contrary to their importance, historical buildings lack complete documentation and efficient administration. In case of buildings belonging to cultural heritage, the responsible team for the realization of the project is made up of specialists from various fields, due to the interdisciplinary character that such a project possesses. Because of the fact that each category of specialists uses different tools, applications and standards, all the information related to construction will take the form of a collection composed of individual documents, reports, drawings, files resulting from computer-aided design (2D and 3D renderings). Therefore, from this perspective, all the information regarding the construction that belongs to the cultural heritage is not concentrated in one place, in the form of a unitary database, nor is it presented under the same type of formats. This is a major disadvantage in terms of administrative activity and decision-making process.

The heritage sector involves not only the construction, but also planning, historical asset management, preventive maintenance, documentation, investigation and research. H-BIM can provide new tools for this sector to support all these activities through digital collaboration and efficient information management. The 3D (geometry) and 4D (time-based) modeling capabilities of H-BIM technology can be useful for heritage interpretation, presentation and simulation applications.

In terms of cultural heritage, H-BIM presents a wide range of applications whose adoption decision will depend on the project's objective. The applications are the following: data and information storage, monitoring the condition of the heritage, planning the conservation process, preventive maintenance, heritage management, scheduling intervention sessions, security, fire safety, safety and health of visitors.

I. Necessity of the study

Research regarding the issue of integrating three-dimensional models in H-BIM is exemplified in the following case study involving the realization of a three-dimensional model of point cloud type and later, the realization of the mesh of the wooden church inside the Village Museum in Timisoara.

The church dates from 1746 and was built in the village of Remetea Luncă. Due to the fact that a new church was later built, the wooden church was moved to Topla village in Timiș County, in 1806, with the help of oak rollers pulled by 24 pairs of oxen. Due to the depopulation of Topla village and the danger of degradation, in 1987 the church was demolished, and in 1992 it was transferred to the Village Museum in Timișoara. Between 1994 and 1996, the assembly and restoration works took place.

The 3D models integrated in H-BIM will contribute to the study of the state of the church and to the identification and analysis of the best conservation and restoration solutions.

In order to collect spatial data from the field, a laser scanning of the church was carried out, which resulted in a point cloud. The point cloud obtained is at the foundation of the development of an H-BIM because it is the most complex and precise product that can be obtained in the context of reverse engineering. This point cloud is the image of the church made up of millions of points endowed with three-dimensional geographical coordinates and chromatic characteristics of the area it represents.

In order to finally obtain the faithful representation of the church through the point cloud for its further H-BIM integration, it is possible to proceed in two manners. (England, 2017)

The first solution involves importing the point cloud into a BIM platform, such as Revit. Based on the point cloud, manual modeling of construction elements and architectural elements is needed. However, this method brings a wide range of disadvantages.

The most important disadvantage is the high volume of time required for manual modeling of architectural elements. If for new constructions such as office buildings, made mainly of prefabricated materials, manual modeling of the elements does not raise problems, due to their common character and their presence in families of elements, in the case of buildings belonging to cultural heritage, unique elements are not found in pre-established families, being necessary to model them taking into account all the details of the respective element. This, of course, also involves a much higher cost of realization.

This method was not suitable for the case study carried out because even in the case of the church most of the constituent elements have a unique, special character (walls, windows, doors, crosses, altar).

The second method, which I have used, is to create a mesh based on the point cloud. Mesh represents a network of triangles obtained by joining all the points in the point cloud. Thus, by the process of obtaining a mesh, a connection will be created between the points in the point cloud, forming a surface. The Romanian equivalent of the English term "mesh" would be the word "net". I consider, however, that this Romanian correspondent cannot fully comprehend and express the meaning of the term “mesh” which, over time, has become familiar as an universal word being used by all experts in the field regardless of the language they speak.

To visually exemplify the difference between point cloud and mesh, I have used two captures made from the same angle and from the same distance, of the representation of the church under study.

Figure 77 shows the church in the form of a point cloud and one can see the church’s roof but also the elements behind it such as the bridge, the icons inside, even the curtain. This is possible due to the distances between the points that work like windows, ensuring the visibility of all points that do not overlap, from the same perspective.

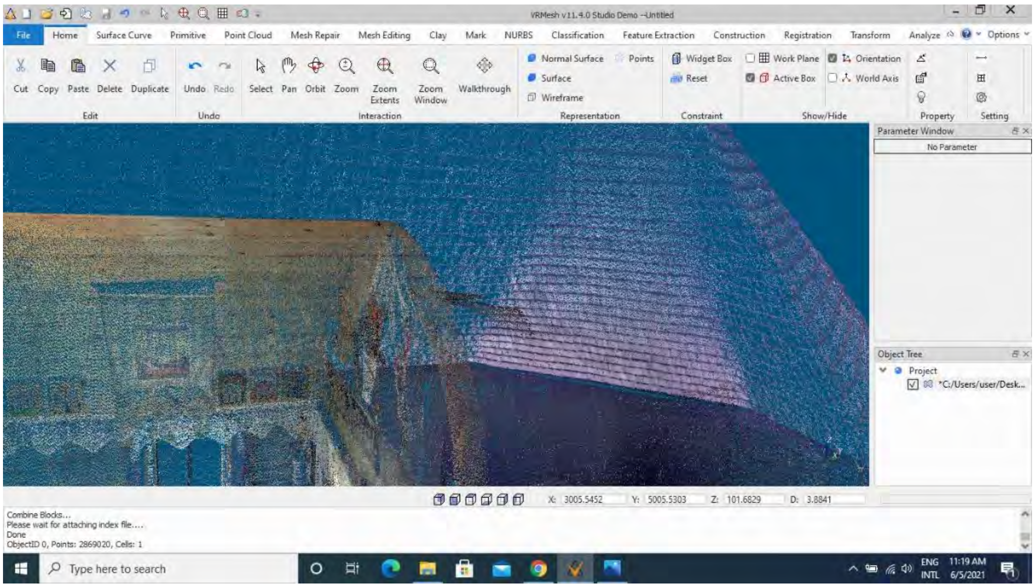


Figure 78. The point cloud of the church

Figure 78 shows the church in the form of a mesh from exactly the same angle and from the same distance. In this image one can see only the roof of the church, not the elements behind it, as was possible in the case of the point cloud. This is due to the fact that making a mesh involves generating surfaces by joining the points obtained from the scan.

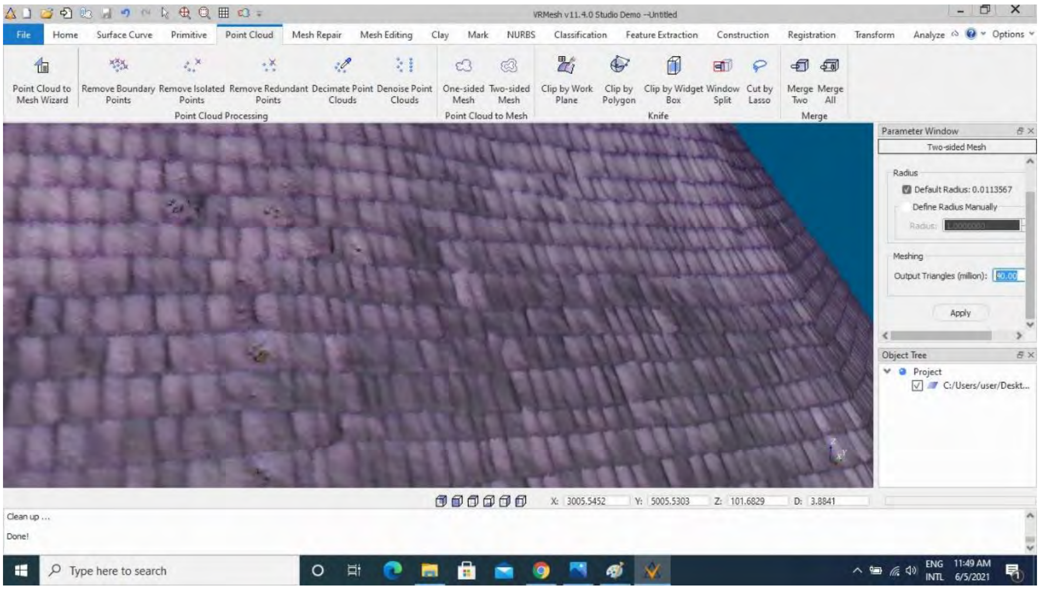


Figure 79. Mesh realization from the point cloud

Unlike figure 77, in figure 78 one can distinguish the details of the roof, more precisely, the shape and position of each tile. This can help specialists to identify alleged damage to the roof by providing the opportunity to intervene in time and avoid possible destruction. The simple representation of a cultural heritage object through the point cloud does not have this advantage and such an analysis is not possible. For this reason, the manual modeling of the digital object or the realization of a mesh arise.

Analysing the two mentioned methods, I considered that the most efficient and accurate method by which we can obtain a 3D model that can be succesfully integrated into H-BIM is that of creating a mesh.

II. Results and discussions

In order to obtain the mesh from the point cloud, I tried to identify the software solution that can offer all the prerequisites for creating a quality product.

The first software solution I opted for is Cloud Compare. Cloud Compare is a software for processing 3D points, as are those obtained by laser scanning. The specialized program also allows users to work with meshes and calibrated images. It can be downloaded for free from various sources on the internet.

The first step in obtaining the mesh is to import the point cloud into Cloud Compare. The point cloud is contained in an e57 file and was imported without difficulty because Cloud Compare supports a variety of formats such as (e57, ply, obj, shp, vtk, ascii and others).

In order to shorten the processing time, I performed a noise reduction on the point cloud (Fig. 79), keeping only the points in the area of interest, i.e. those that form the image of the church.

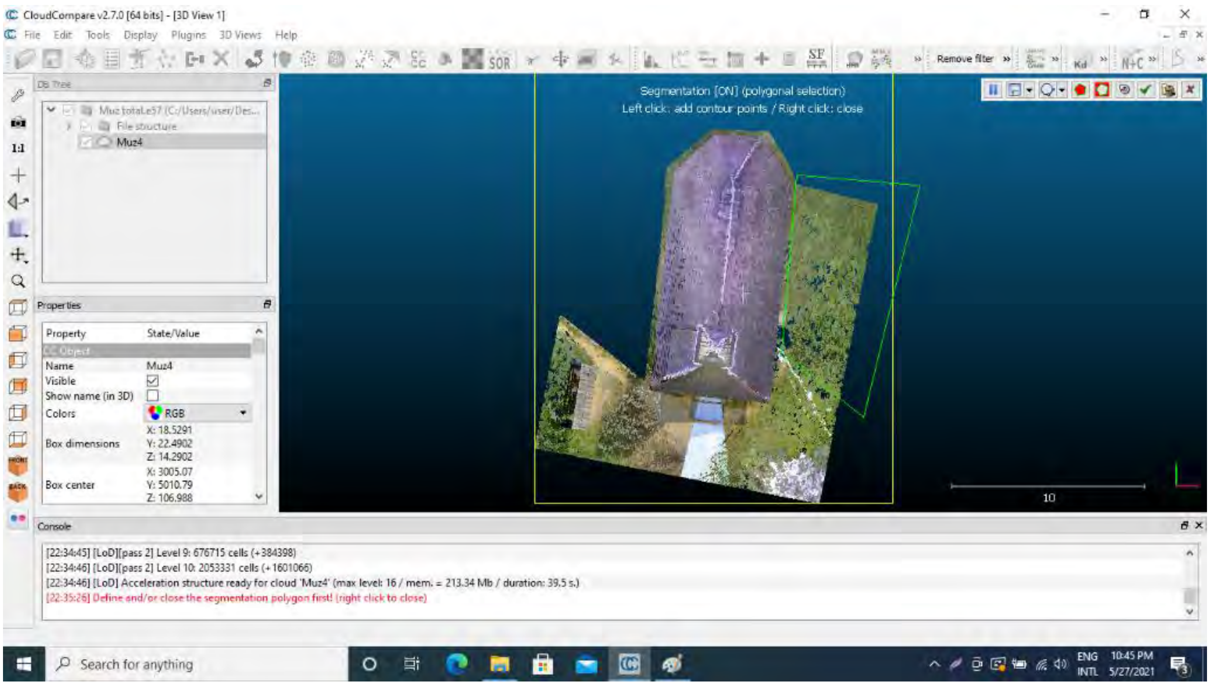


Figure 80. Noise reduction in the point cloud

Creating the mesh involves pre-calculating the surface normals at each point. For this purpose it is necessary to estimate the local area represented by a point and its neighbours. After calculating the normals, I proceeded to mesh generation through the “Poisson Surface Reconstruction” plugin.

In figure 80 the mesh generated in Cloud Compare is illustrated. As it can be seen, the product obtained is affected by a number of errors and distortions. The mainly affected areas are the dome area, the lower area of the roof but also of the walls. This is caused by the complexity of the inserted point cloud. Smaller objects that are represented by a smaller number of points or objects with fewer faces can be successfully modelled in Cloud Compare. In order to model more complex objects, it is necessary to study all the characteristics that can influence the mesh and identify the settings in order to obtain the optimal result.

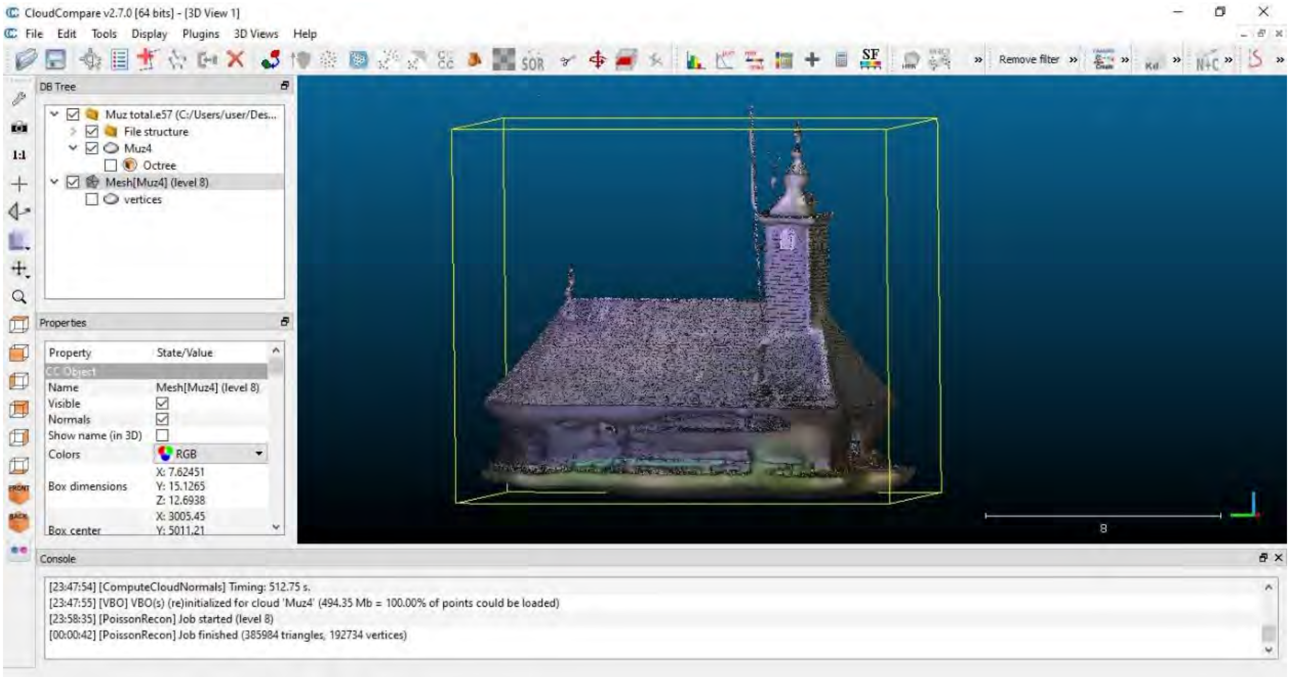


Figure 81. The mesh realized in Cloud Compare software

The second software solution I opted for is VRMesh. VRMesh is a software program that is equipped with state-of-the-art technologies in point cloud classification, feature extraction and mesh making. VRMesh is a software solution that can be purchased at a price of $3000/month.

The first step in obtaining the mesh is to import the point cloud into VRMesh. The point cloud is contained in an e57 file and was imported without difficulty because VRMesh supports a variety of formats such as (e57, las, laz, zlas, ptx, pts, asc, obj, dxf, shp, ply, 3ds , vtk, csv, rcp / rcs and others).

In VRMesh the generation of a mesh is realized depending on the point cloud's quality. In case of high-density point clouds, the mesh is realized by the "one-sided mesh" command. In case of lower quality point clouds with a lower point cloud density, the "two-sided mesh" command is used.

Because the church's point cloud consists of a relatively small number of points, compared to the size of the objective studied, we considered it appropriate to make the mesh by using "two-sided mesh" command.

The result obtained after creating the mesh by the "two-sided mesh" command can be analysed in figure 81. This figure depicts the entrance to the church. It can be seen how the program successfully managed to homogeneously represent the construction, including details such as the girdle carved in wood and the joints of the wooden elements that make up the walls.

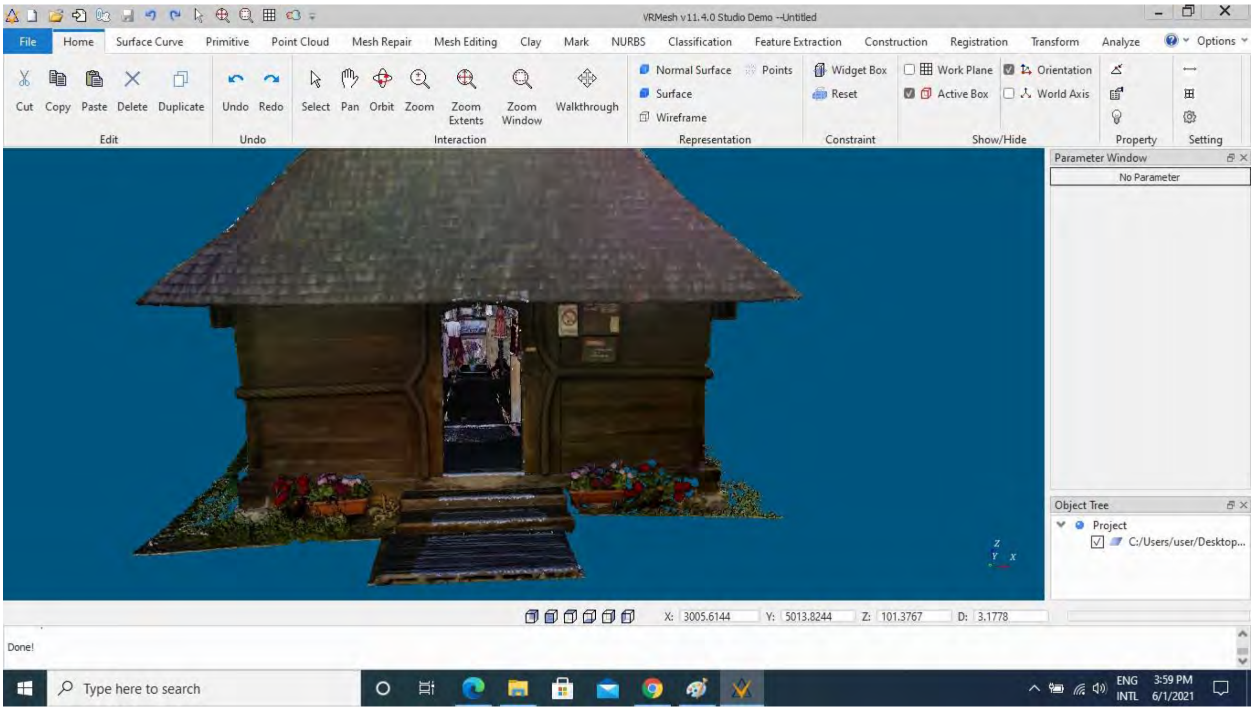


Figure 82. The entrance to the church

By changing the angle, we can also analyse the back of the church. Figure 82 shows the mesh portion depicting the altar area, viewed from the outside. It can be seen how the program reconstructed based on the point cloud elements such as the altar room window, the ribs of the wood that makes up the wall and even a portion of the electrical installation.

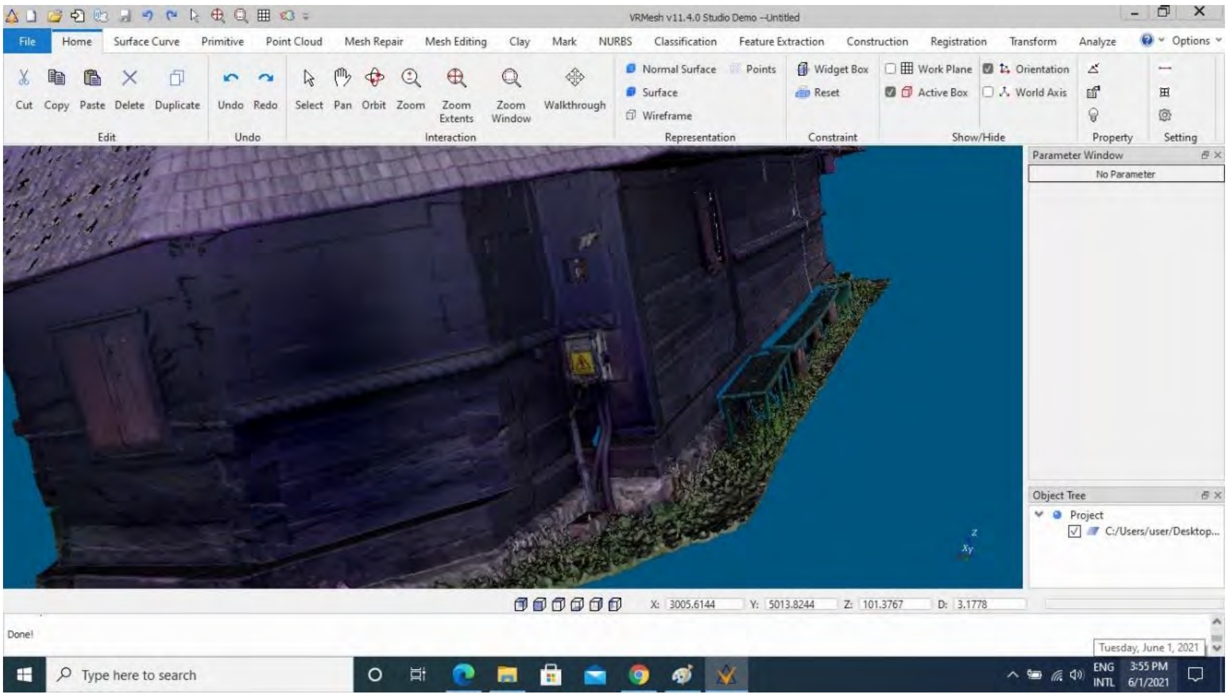


Figure 83. Wall and electrical installation details

Also in figure 82 one can see an area coloured in blue, behind the benches positioned along the church's wall. The scanner mounted in the station point collects information on the points in the immediate vicinity and whose visibility in the field is ensured. Because the bench is positioned in front of the wall, the points that make up the bench will overlap with some points that make up the wall, from a certain position of the scanner. Thus, the covered points will not be able to be registered and represented by the scanner. The blue areas encountered in the mesh represent the overlapping areas, where the acquisition of points was not made and consequently the mesh was not generated. To avoid such areas, it is possible to scan from a larger number of stations, which will improve the accuracy of the model but will extend the processing time.

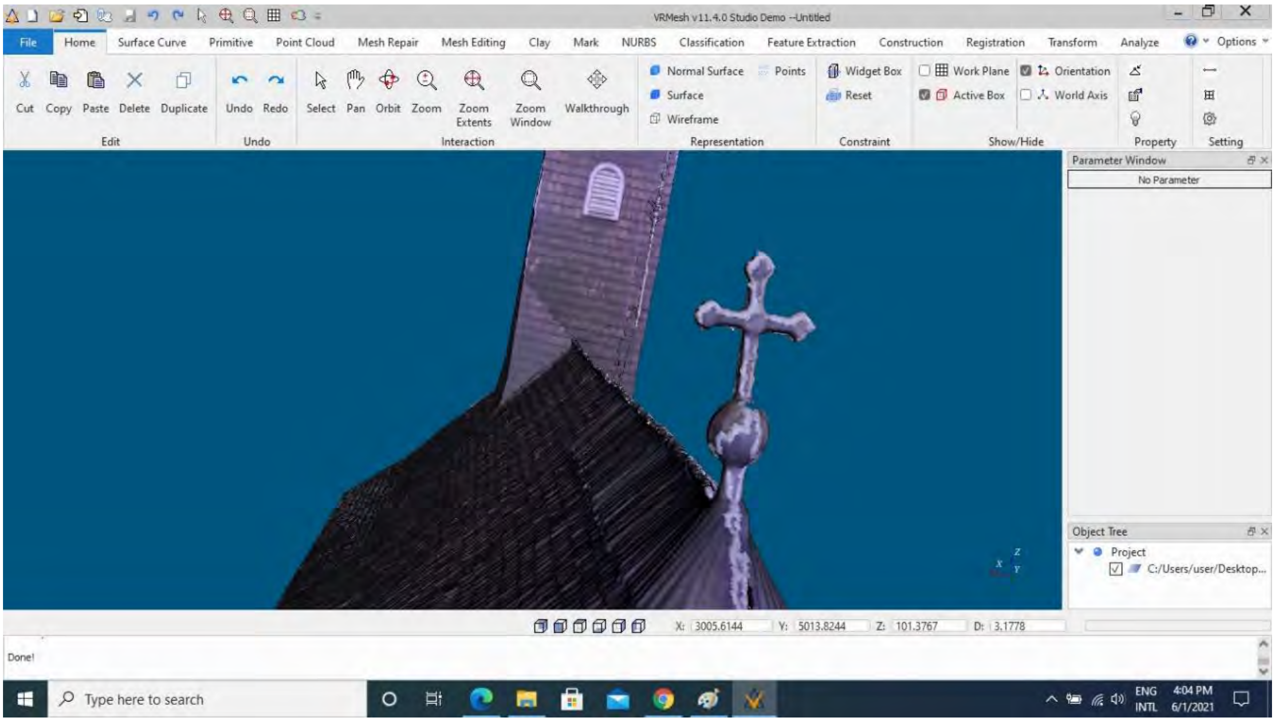


Figure 84. Cross detail

Figure 83 shows the ridge of the roof, the church tower, the lightning rod and, in the foreground, the cross. The cross was modelled in its entirety as well as the existing spherical support at the base.

A chromatic discrepancy can also be observed at the level of the church tower compared to the roof. This is due to the variation in light intensity at different times of the day determined by the changing position of the Sun in the sky due to the rotational motion of the Earth.

With the help of the VRMesh program, we also made two sections of the church, namely, a longitudinal section and a cross section. To make the two sections, the “Widget Box” command. This command places the church in a rectangle that allows to change its size by stretching or reducing the edges. When the length of the rectangle is reduced, the face that intersects the church will determine a cross section.

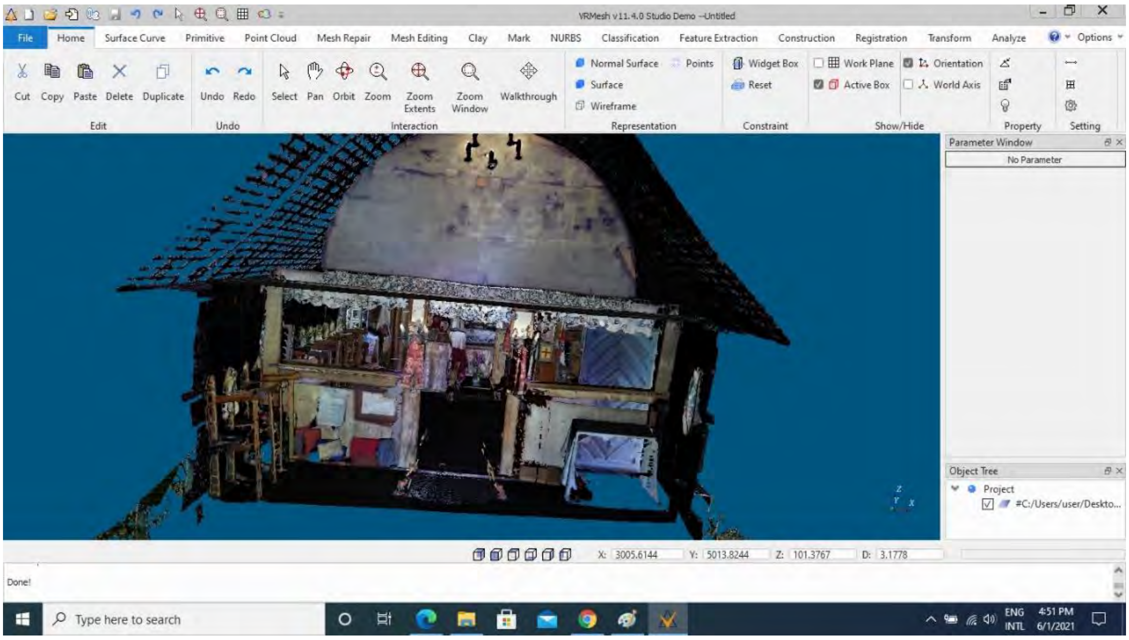


Figure 85. Cross section of the church

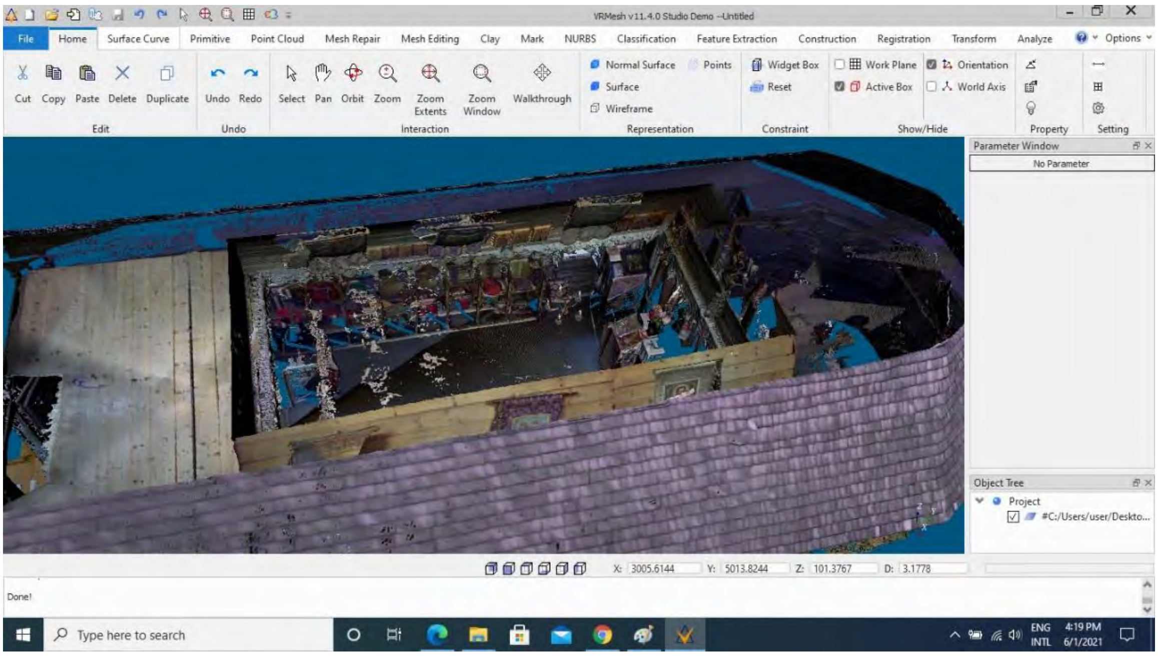


Figure 86. Longitudinal section of the church

When the height of the rectangle is reduced, the face that intersects the church will determine a longitudinal section. Figure 85 shows a longitudinal section of the church. Through this section one can see the bridge of the church but also the interior of the church.

Due to the fact that the laser scanner also acquired points inside the church, it was possible to generate the mesh inside as well. The obtained model is coloured due to the fact that the registered points contain chromatic information. In order for the points to contain chromatic information, the scanner takes pictures during the scan. The points take on the chromatic characteristics of the corresponding areas in the image.

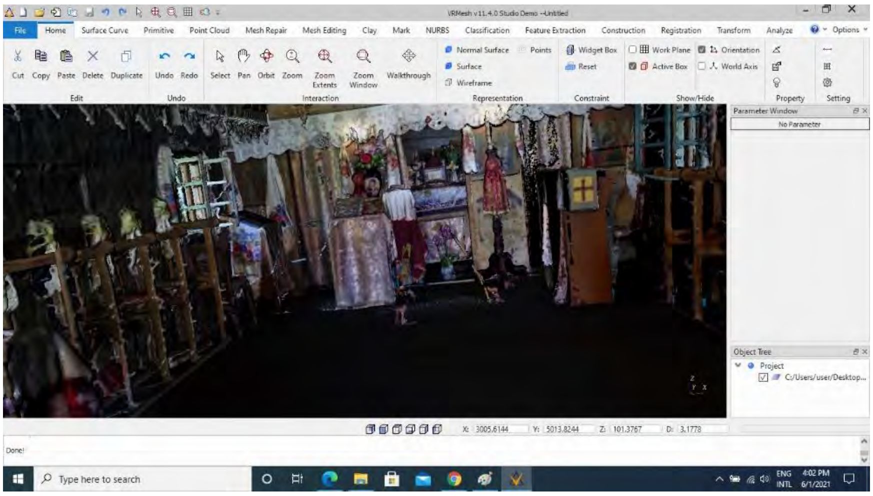


Figure 87. Representation of the church’s interior through mesh

In order to improve the obtained mesh, it is possible to repair it by filling the gaps by interpolation, eliminating the unused points, eliminating the parts that are not next to the main model.

Regarding the integration of the point cloud in the H-BIM type digital platform, we tried to import both the point cloud and the mesh obtained in the Revit specialized program.

The Revit program for BIM and H-BIM allows the import of point clouds in .rcp and .rcs formats. Because the point cloud obtained is in format. e57, it had to be saved in one of the extensions supported by Revit. In order to get the .rcp format I used the Autodesk Recap application. Thus, the point cloud was imported into Revit by the “Insert point cloud” command and can be analysed in Figure 87.

Regarding the import of the 3D mesh model into Revit, following the research we found that this is possible through a plug-in available in the Autodesk online store that can be purchased for $50.

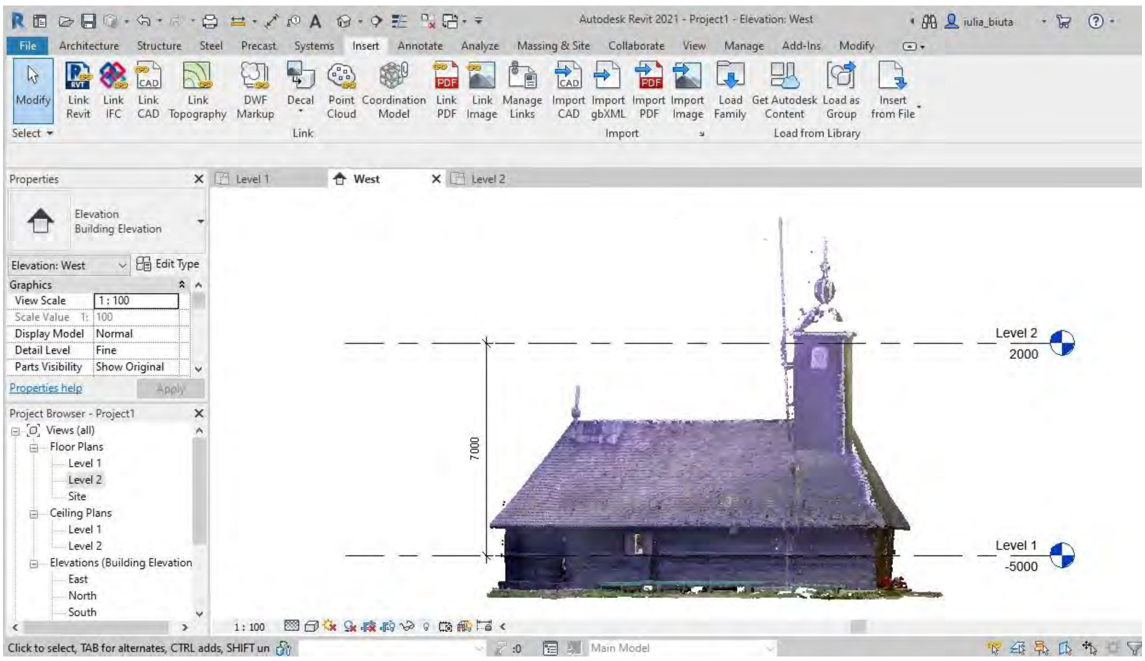


Figure 88. The point cloud inserted into Revit program

III. Conclusions

BIM and H-BIM are processes whose future use is inevitable due to the undeniable advantages they bring in the construction and cultural heritage domains. By adopting them, the manner in which specialists work in these areas today will evolve, guaranteeing high quality products delivered in record time.

The choice of the BIM and H-BIM solution must be weighed from several perspectives and adopted according to the purpose and objectives of the project in order to benefit from an efficient workflow and an optimal cost.

Following the case study, I conclude that, in order to create an H-BIM, the concept that is suitable to be put into practice is that of Scan-To-BIM, due to the complexity and uniqueness of the objects belonging to the cultural heritage.

Although BIM programs allow us to work directly with the point cloud obtained by scanning, following the study, I believe that the use of a 3D mesh model provides more favourable premises for a more accurate result and allow a wider applicability.

The software programs on the market that allow the generation of the 3D mesh model are diverse. To study how they work and to identify the software solution equipped with a newer technology and a more intuitive interface, we performed simulations in several specialized programs: Cloud Compare, VRMesh, MeshLab, Autodesk Recap. Of these programs, the most promising results were obtained in Cloud Compare and VRMesh, which is why I chose to present in the thesis only the processing realized with these software.

Following the analysis of the results obtained in Cloud Compare and VRMesh, we concluded that the mesh in Cloud Compare is affected by a series of errors and distortions, VRMesh being a better option.

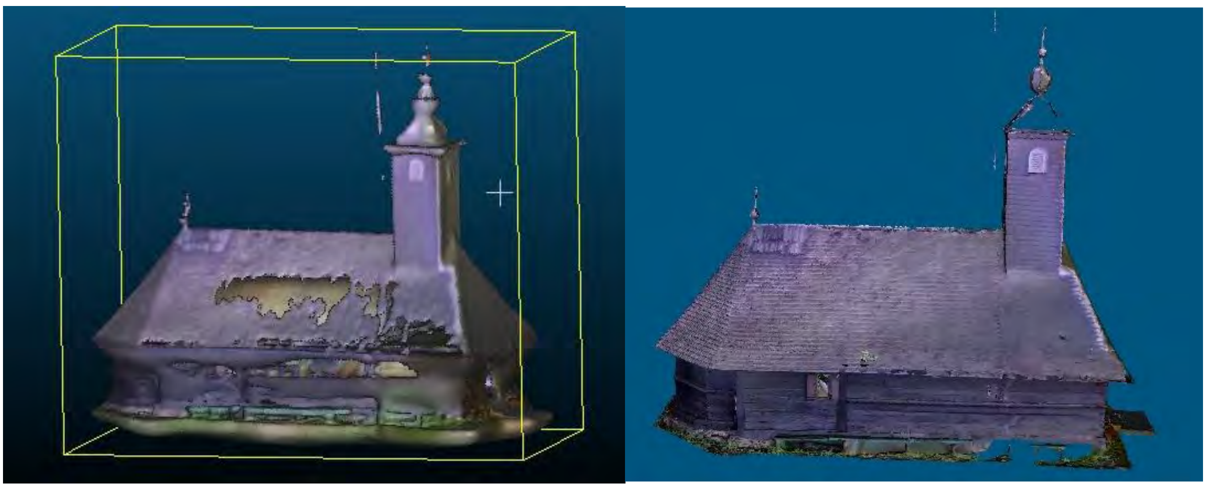


Figure 89. Comparison between the mesh obtained in Cloud Compare and the one obtained in VRMesh

Although the best results of the study were obtained using VRMesh, its use was limited due to the cost of purchasing this program, which determined the need to work in a demo version that did not allow saving and integrating the product obtained in an H-BIM program. We also found that Revit allows the import of 3D mesh models in .obj format through a plug-in that can be purchased from the Autodesk online store.

Concluding, H-BIM represents a saving solution of cultural heritage, the realization of an H-BIM outperforming the realm of science, more precisely, is found where science and art meet. I consider that H-BIM represents the hope for the conservation of architectural jewellery, the price of an H-BIM cannot be limited to the cost of its realization, the value itself being invaluable.

2.2.4. E-learning in higher education system – particular case of Geodetic Engineering domain

Even before the pandemic context, the need to implement modern learning techniques in the Geodetic Engineering domain emerged. Thus, together with fellow researchers conducted studies and presented 2 articles to the 14th International Scientific Conference on eLearning and Software for Education - eLearning Challenges and New Horizons, 2018, further published in the Elearning Challenges and New Horizons, Vol 4, Book Series: eLearning and Software for Education.

New learning environments aim to developing abilities and skills for students through the use of information and communication technologies (ICT). The new strategies for restructuring the higher education system involve continuous improvement of the curriculum and educational programmes, in line with the evolution of technology and continually referring to similar institutions in the country (regional development) and in the European Union.

The actual international context of developing people's digital skills and competences imply using intelligent, adaptive and personalized e-Learning platforms. The latter should come in support of students and represent both an efficient alternative for the individual study and resources for team-work. The purpose of the following studies is to highlight the importance of using an e-Learning resource implemented by Politehnica University Timisoara through which students can load the results of their projects and work.

2.2.4.1. Opportunities and challenges in higher education system: knowledge transfer by e-Learning vs. traditional methods

Starting with the vision of acquiring in-depth knowledge of Geodesy and cadastre in the e-Learning System by students or anyone interested, an online network was implemented for university collaboration to develop the capacity of providing superior competences in Geodesy, mainly for harmonization and standardization of a training program at multi-regional level. This network constitutes an integrated informatics solution that consolidates existing relationships as well as their expansion, between universities, businesses and research centres, developing at the same time the capabilities of working in collaboration, highly acclaimed skill by employers. The authors present a comparative study regarding the overall results of students (development, skills acquired, theory assimilated, progress) using e-Learning technologies (platform mentioned above) versus the traditional method. The subjects belong to the 2nd and the 4th year of study, Bachelor cycle, as the study also focused on differences between students situated at the beginning of their studies and students that are close to graduation. The e-Learning platform used represents a smart additional tool to work, characterized by efficiency and capacity to adapt and is used successfully since 2012, facilitating collaboration between sets of graduates, students and teachers. It allows viewing and managing complex educational content types, such as interactive materials, tutorials, exercises, simulations, educational games and provides a user-friendly interface for all users, both professors and students.

I. Integrating e-Learning and geodesy: the educational opportunities

Over the last decade considerable emphasis has been placed on developing new and innovative ways of delivering digital competences education. Both students and professors are now finding that a knowledge of information and communication technologies (ICT) on its own may no longer be sufficient to ensure professional development, or even a first job. Those now wanting to outperform see ICT skills as part of a more extensive portfolio which includes the other elements that define digital literacies in the scientific literature, namely:

- media literacy: critically read and creatively produce academic and professional communications in a range of media;
- communications and collaboration: participate in digital networks for learning and research;
- career and identity management: manage digital reputation and online identity;
- ICT literacy: adopt, adapt and use digital devices applications and services;
- learning skills: study and learn effectively in technology-rich environments, formal and informal;
- digital scholarships: participate in emerging academic professional and research practices that depend on digital systems;
- information literacy: find, interpret, evaluate, manage and share information. (www.jisc.ac.uk/guides/developing-students-digital-literacy , 2018)

One of the priorities of the Commission of the European Parliament Council regarding "i2010 – A European Information Society for growth and employment" says, quote: "In launching the partnership for growth and jobs as a new start for the Lisbon strategy, the 2005 Spring European Council called knowledge and innovation as engines of sustainable growth and stated that it is essential to build a fully inclusive information society, based on the widespread use of information and communication technologies (ICT) in public services, SMEs and households)". More than that, the document shows that ICT can strongly contribute to improvements in the quality of life. ICT are capable of improving the health of our citizens via new ICT enabled medical and welfare services. In light of the demographic challenges facing Europe, ICT can help make public health and welfare systems more efficient and effective. ICT can be a strong force for reinforcing Europe's cultural diversity by making our heritage and our cultural creations available to a wider number of citizens. ICT are also a tool for environmental sustainability, i.e. through monitoring and disaster management and through clean, low energy and efficient production processes. ICT can help to make transport safer, cleaner and more energy efficient. (http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52005DC0229, 2018)

In this context, where the need for geodesy is obvious, geodetic educationalists in the higher education system have been faced with the challenge to develop a learning environment which is capable of providing a broad skills base, yet flexible enough to allow individual students to specialise.

For some of the Romanian technical universities, the solution was represented by a virtual platform used by professors and students for the exchange of information and knowledge in geodesy and cadastre domain using e-Learning system. (Vîlceanu, Herban, & Grecea, E-Learning in engineering - Impact upon the student's mentality and development, 2015) General and specific objectives of e-Learning platforms for geodetic engineering concern a step forward in the promotion of innovative techniques and technologies, based on the virtual system of learning. The new methods involve experimental learning based on scenarios, alternatives solutions and direct interaction between the student, the subject of learning and the learning environment.

Specific experience of E-Learning in Geodesy at Politehnica University Timisoara

The "Land Measurements and Cadastre" study programme from Politehnica University Timişoara aimed, for the Bachelor cycle, to develop new abilities and skills through the use of information and communication technologies (ICT). With the help of European funding, a project was realized by means of which Geodesy-Instruct was created, a virtual platform that can be used by students or anyone interested to acquire in-depth knowledge of Geodesy and cadastre in the e-Learning System.

The platform (www.geodesy-instruct.ro, 2018) represents a smart additional tool to work, characterized by efficiency and capacity to adapt (Badea, Badea, & Clinci, 2012), (Badea, Badea, & Clinci, E-Learning using educational software – a feasible alternative for training and learning, 2012) and is used successfully since 2012, facilitating collaboration between sets of graduates, students and teachers. The impact of using the e-Learning platform Geodesy-Instruct (Fig. 90) can be seen in the student's membership to a community interested in the subject in question or in the same discipline, as well as in the increasing rate of people who have a stable and durable job due to the deployment of on-line training activities.

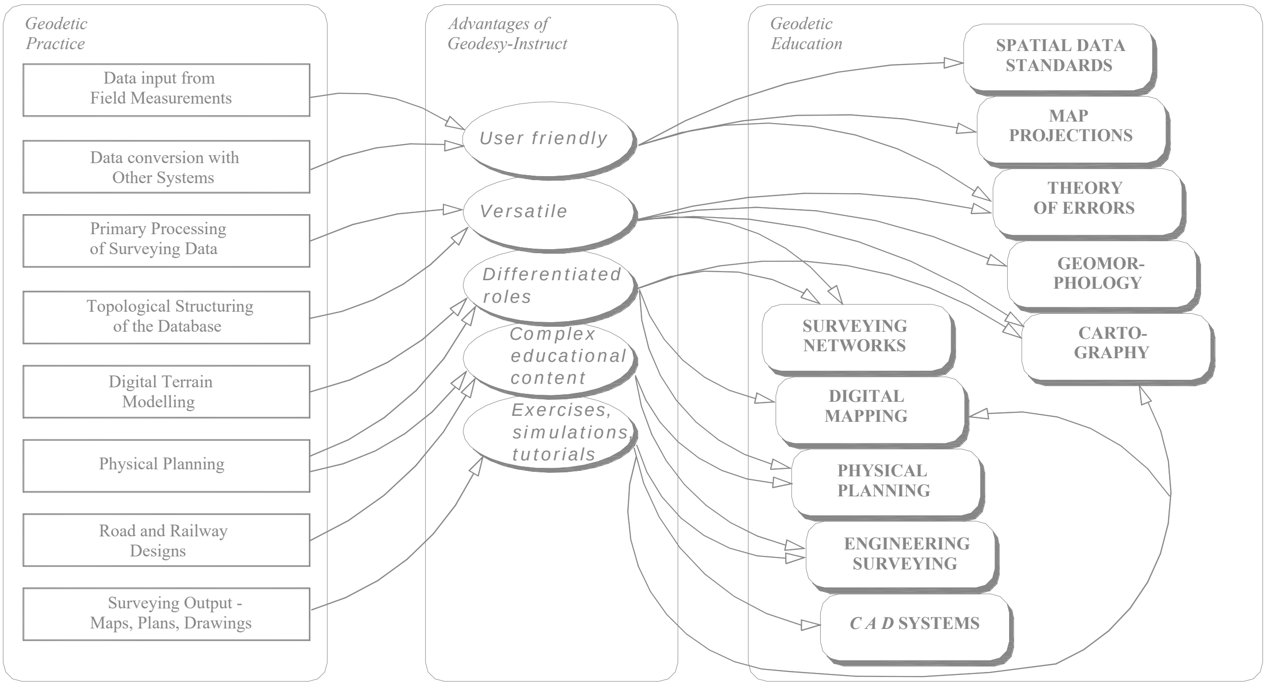


Figure 90. Characteristics of Geodesy-Instruct

II. Knowledge transfer by e-Learning vs. traditional methods

Developing students' personalities by the higher education system has been treated with much more attention in the last 10 years. This is because higher education tends to express a range of characteristics specific for adult education. While enrolled in the system, students are passing through a stage that accomplishes their cognitive and affective development and at the same time, allows them to assume social responsibilities which support them to become active, creative and autonomous persons. In this context, it is clear that teaching-learning activity in higher education should be oriented towards and adult education that ratifies at the same time organizational principles and requirements. On the other hand, implementing new learning environments aiming to developing abilities and skills for students through the use of information and communication technologies (ICT) has facilitated the transition from hard-copy to digital materials. This represents one of the most significant changes in the last decades, both in terms of classroom practice and in terms of policymaking, since both new teaching skills and approaches are called for in order to use the new media in a sensitive and relevant way.

Starting from the idea that most of the undertaken research is focused on highlighting the benefits that virtual systems bring but no one has the courage to analyse/or to shed light on the long-term impact of this environment that sometimes robotizes us and transforms us into a finished product sold and bought, necessary or unnecessary, the authors provided a framework for a comparative study regarding the overall results of students (development, skills acquired, theory assimilated, progress) using e-Learning technologies (platform mentioned above) versus the traditional method. Similar studies have been developed regarding other subjects (Capita & Capita, 2016), (Ioan-Marginean, 2016). The students belong to the 2nd and the 4th year of study, Bachelor cycle, as the study also focused on differences between students situated at the beginning of their studies and students that are close to graduation.

Cognitive aspects and the way students are taught highly influence the success of learning. Therefore, e-Learning used in a geodetic learning system have to be designed and applied according to principles derived from the human cognition process. Modern computer technologies with ICT offer excellent conditions for creating attractive and user specific learning environments. However, the use of e-Learning for training does not automatically cause an improvement in education. Better education will be attained only if computer based learning combine the power of e-Learning with cognitive and didactic aspects. This comparative study will point out that the domains aimed at knowledge and use of technical equipment – such as that of Geodesy – cannot be managed 100% by virtual platforms.

The educational approach

The comparative study took place over the first semester period of the 2016-2017 study year and involved 20 students (10 from the second year and 10 from the 4th year of study from the Bachelor cycle) and three teachers from “Land Measurements and Cadastre” study programme at Politehnica University Timisoara.

Study results

In many ways the student perspective mirrors that of teachers with the exception that several of the students went away feeling that they knew a little about a lot. Many of them were concerned that if they were probed in depth about a particular topic they would not be able to provide a detailed explanation of how the surveying technology (digital levels and total stations) worked. For example, all the students from the 2^{nd} year of study were concerned that they could not explain how or why, total stations, worked. They did however acknowledged that, if they were asked again about total stations they would now the purpose for which it could be used. Several of the students commented on the fact that it had made them think about problem solving from a wider perspective.

The study results that were taken into account are:

- Acquired knowledge: concepts, definitions, formulas, processes, laws, principia, theories;
- Intellectuality: ratiocination, arguing and interpretation, divergent thinking, independent thinking, creativity;
- Ability to use acquired knowledge: competences, skills, mastering work techniques using topographical tools and apparatus;
- Personality traits: attitudes, behaviours, conduit, opinions.

Table 3. Study results for the 2nd year

	E-Learning	Traditional
Acquired knowledge	30%	70%
Intellectuality	32%	68%
Ability to use acquired knowledge	8%	92%
Personality traits	44%	66%

Table 4. Study results for the 4th year

	E-Learning	Traditional
Acquired knowledge	55%	45%
Intellectuality	81%	19%
Ability to use acquired knowledge	15%	75%
Personality traits	47%	53%

The teaching materials have to be conceived to be student oriented suitable for guided self-study. The active learning modules should incorporate the theoretical material within learning activities.

Facing all the challenges that the current and, most likely, future technology prepares for individuals, the domination of the virtual learning environments can also represent a trap for the evolution of the human species by depersonalization, lack of face to face dialogue, destroying team spirit that can only be developed through the true knowledge of the dialogue partner, the excessive development of personal self without human interaction etc.

The domains aimed at knowledge and use of technical equipment – such as that of Geodesy – cannot be managed 100% by virtual platforms, so the solutions is represented by a mixed educational environment. In the field of engineering, the classical approach of courses is imperiously required for debating, in-depth understanding of certain methods, experiments and elucidation of matters relating to efficiency of the chosen solutions.

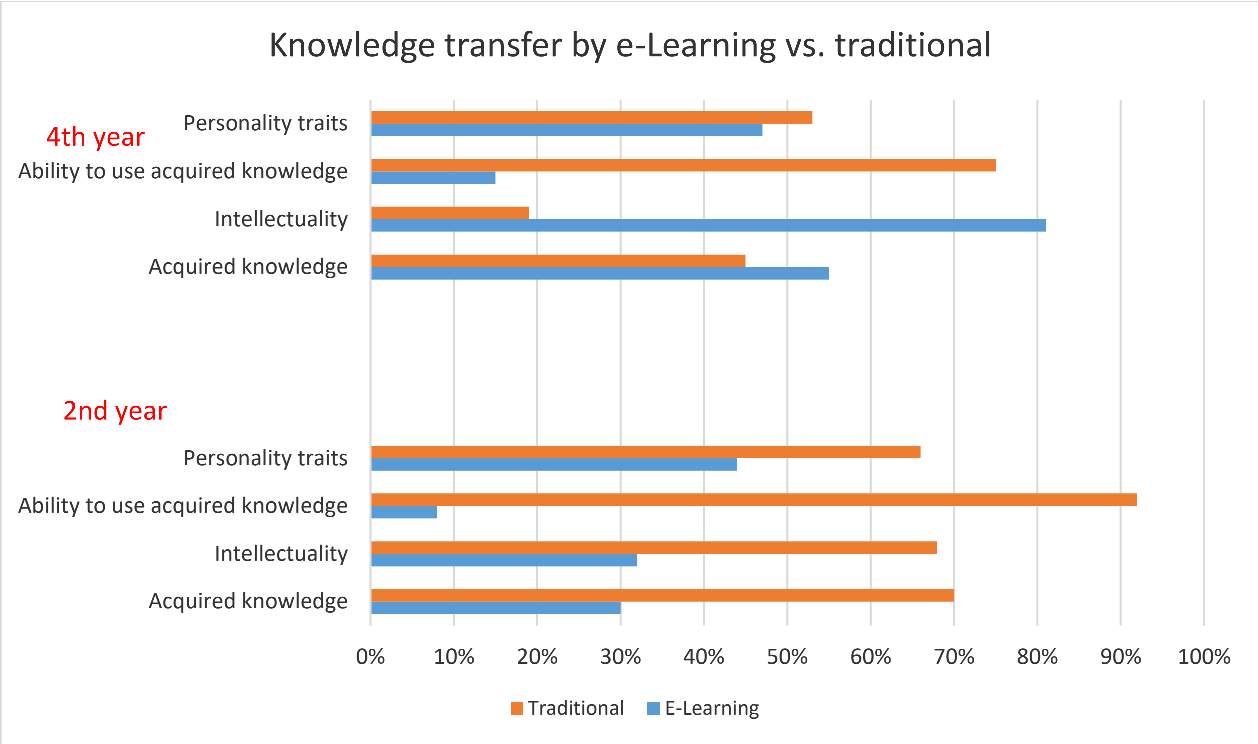


Figure 91. Comparative study regarding e-Learning vs. traditional methods

III. Conclusions

The study aimed to determine the challenges and threats that the exclusive use of E-Learning activities in the field of geodesy can represent.

Integrating geodetic education with multimedia technologies with a view of acquiring digital literacies provides opportunities for stimulating student learning and providing students with a broader experience. This is particularly true when using a traditional approach for course delivery. The present value of using e-Learning to facilitate the education process is, as a mechanism of delivery, not as flexible as the "face to face" contact provided by the classical classroom environment. Teaching geodetic skills by using only e-Learning has several major limitation: acquiring practical skills of using technical equipment for surveying and the depth with which any topic can be addressed.

2.2.4.2. Cultural Heritage modeling potential highlighted by e-Learning resources

The topicality is given by the novelty of the 3D models realized by students, both individually and by teamwork, for a touristic promotion of Timisoara municipality in the context of competing and winning the title for "European capital of culture" initiative. Moreover, the authors propose implementing a spatial data geoportal at Local Administration level using EU non-refundable funds that could be a smart solution for managing secure and valuable property based on Internet of Things meant to reinforce Europe's cultural diversity by making our heritage and our cultural creations available to a wider number of citizens. One of the strategies developed by the European Commission refers to Digital Single Market and includes tasks such as investing on network and technologies by funding research that enables new technologies like 5G and IoT. The aim is to benefit European citizens with fast and accessible Internet for the future and make cities more sustainable in view of Europe's 2020 targets. With a view to reaching this target, Romania is constantly trying to develop smart solutions in the interest areas that also permit funds attracting. In particular, Timișoara Municipality has set its goal to become one of Europe’s smart cities and communities, thus developing (among others) a cultural strategy for 2014 – 2024.

I. Cultural heritage (CH) AND Internet of Things (IoT) for smart cities

Actual challenges the cities are faced with refer to growing population (Fig. 92), traffic congestion, space, resource management, climate changes, tighter city budgets, aging infrastructure and population that lead to the need for smarter cities. (Vasiu, 2015)

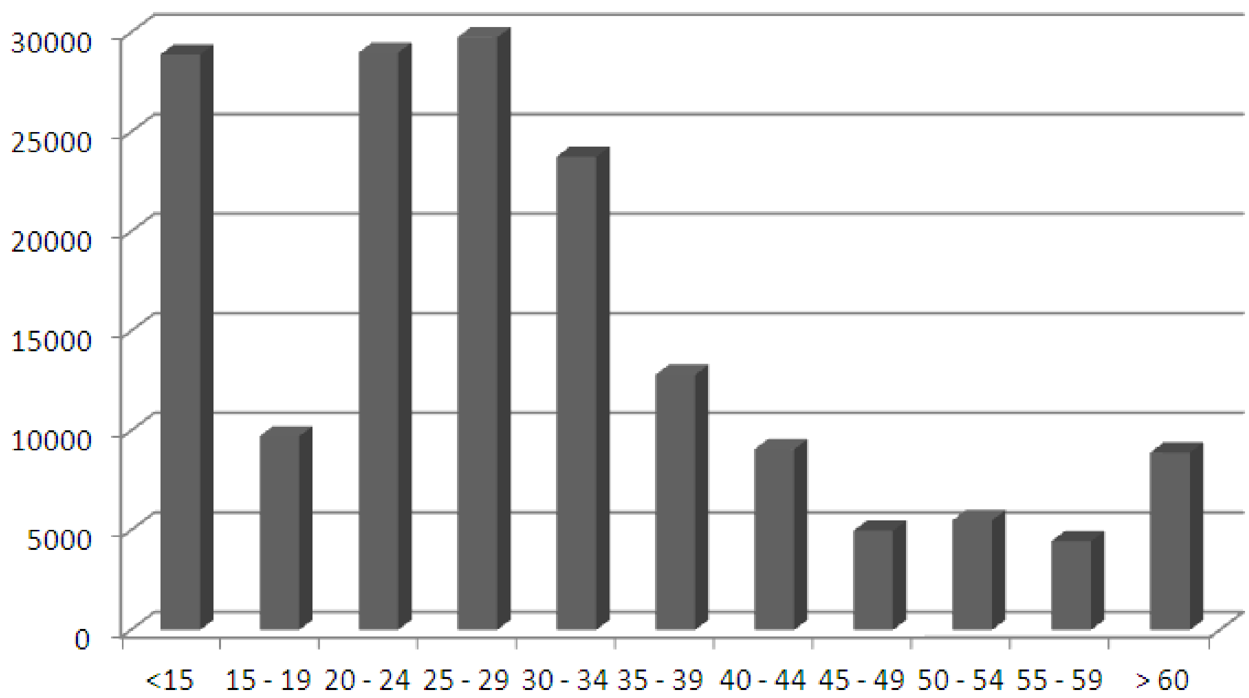


Figure 92. Migration of Romania’s population to urban areas based on age groups in 2015

The European Commission stipulates into the Digital Agenda for Europe (Digital Agenda for Europe, 2018) the following definition: “A smart city (Fig. 93) is a place where the traditional networks and services are made more efficient with the use of digital and telecommunication technologies, for the benefit of its inhabitants and businesses.”

Figure 93. EU Smart Cities and Communities Initiative (source: https://eu-smartcities.eu)

Sustainable urban planning is the one that seeks to minimize the negative environmental impact of buildings by efficiency and moderation in the use of materials, energy, and development space. It uses a conscious approach to energy and ecological conservation in the design of the built environment with a view of stimulating investments, attracting tourists and increasing the inhabitants' living standards. (Grecea, Herban, & Vilceanu, WebGIS Solution for Urban Planning Strategies, 2016)

A smart city based on the policies of sustainable development takes into consideration the following:

- balance between urban modernization, controlled urban growth through development of rural areas and conserving spaces dedicated to agricultural activities;
- social and urban functions' diversity, both in the rural and urban environment;
- balanced and economical use of natural, urban, conurbation and rural areas, controlling the movement and car traffic necessity, conserving air, water, soil, underground resources, green spaces, natural or urban landscapes' quality, reducing noise pollution, protecting valuable urban developments and national heritage buildings, preventing foreseeable natural and technological hazards and general pollution. (Radoslav, et al., 2010)

Smart cities functioning based on the idea of sustainability take into account the following development directions:

- environmental sustainability and efficiency;
- sustainable homes and buildings;
- efficient use of resources;
- efficient and sustainable transportation systems;
- better urban planning.

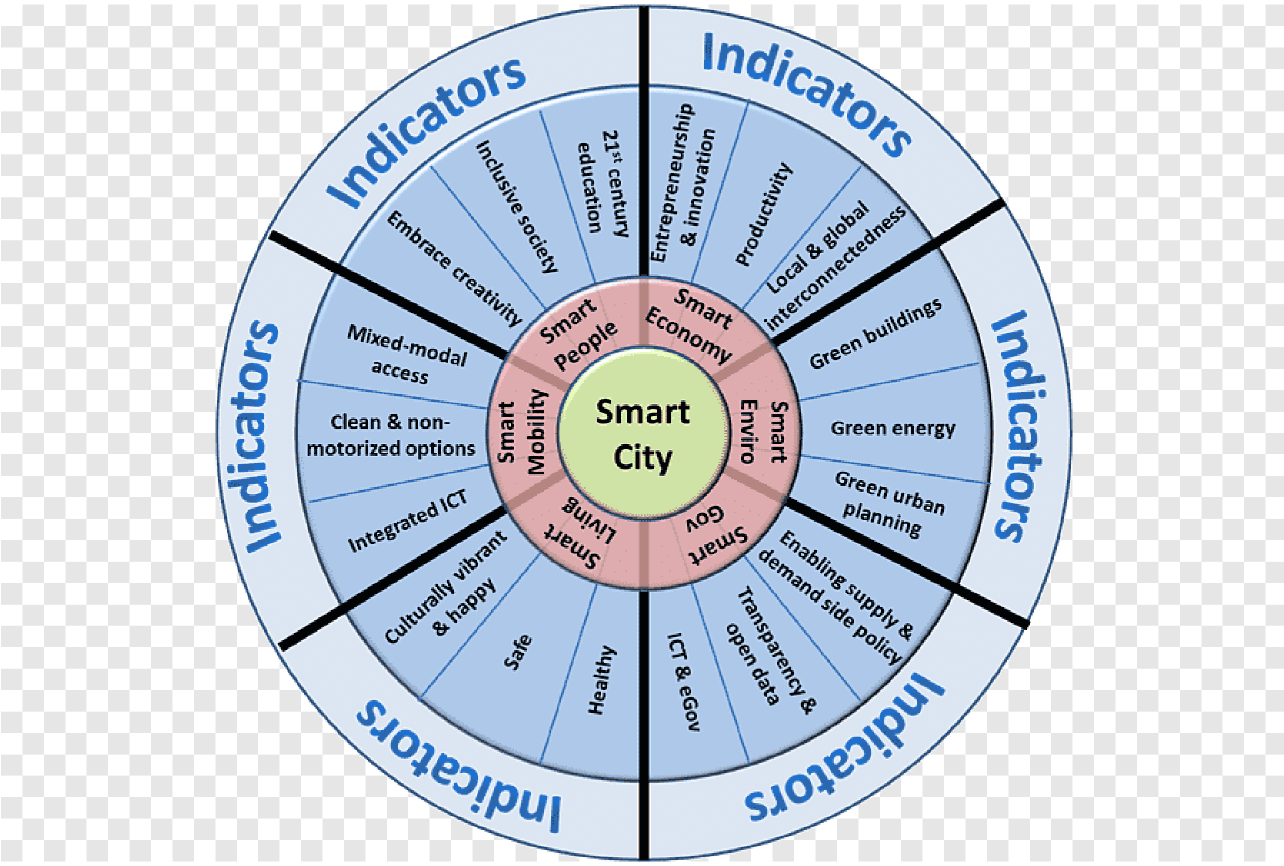


Figure 94. The Smart Cities Wheel developed by Cohen

The Smart City concept (Fig. 94) is therefore based on a six pillars model (Cohen, 2018), with the corresponding indicators:

1. Smart Economy: innovative spirit, entrepreneurship, economic image & trademarks, productivity, flexibility of labour market, international embeddedness, ability to transform.
2. Smart Mobility: local accessibility, (inter-)national accessibility, availability of infrastructure, sustainable, innovative and safe transport systems.
3. Smart Environment: attractivity of natural condition, less pollution, environmental protection, sustainable resource management.

4. Smart Governance: participation in decision-making, public and social services, transparent governance, political strategies & perspectives.
5. Smart People: level of qualification, affinity to lifelong learning, social and ethnic plurality, flexibility, creativity, cosmopolitanism/open mindedness, participation in public life.
6. Smart Living: cultural facilities, health conditions, individual safety, housing quality, education facilities, touristic attractivity, social cohesion.

European commission policies for smart cities

Timişoara (www.primariatm.ro, 2018) has the widest architectural heritage area in the country, of important value to both Romania and Europe. The preservation of this Cultural Heritage (Fig. 95) is a duty of the authorities, the owners and the citizens with a well-developed civic spirit. (Herban, Vilceanu:, & Alionescu, 2014)

Figure 95. Map of Timişoara highlighting areas with historical buildings

Nowadays, referring to Cultural Heritage objects, one of the first aspects implies not only the object itself, but also creating 3D models using different technologies starting with simple measurements upon the object, using facilities of total stations, close range photogrammetry and also laser scan technologies. (Vîlceanu, Herban, & Grecea, Creating 3D Models of Heritage Objects Using Photogrammetric Image Processing, 2013) Therefore, data collection is varied from simple to very complex and depends on the type, time, manner and technology used for measuring the object.

Smart city Timişoara

Sustainable urban mobility plan covering the growth pole in Timişoara (Fig. 96) consisting of the city and 15 adjacent villages and concerns joint strategic objectives such as: accessibility, safety and security, the environment, economic efficiency and the quality of the urban environment.

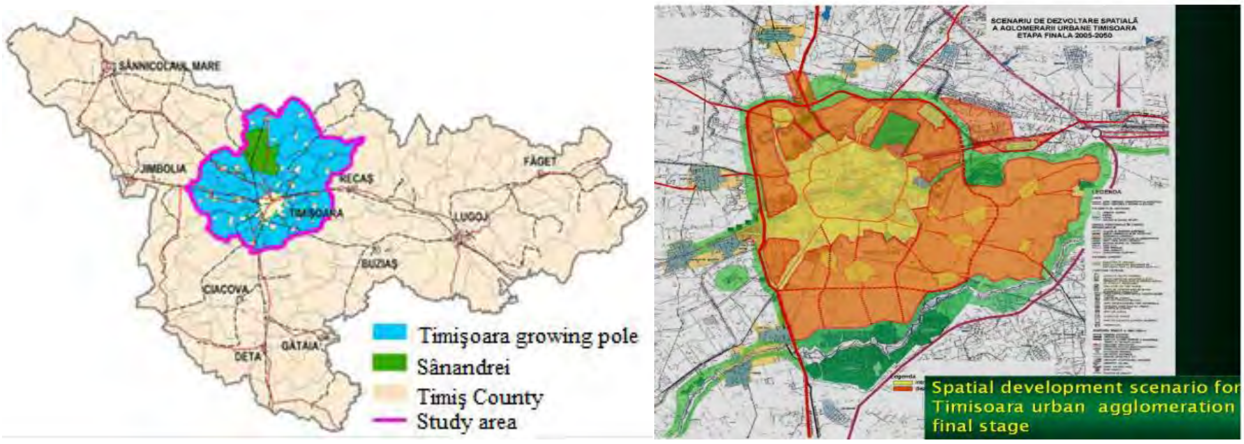


Figure 96. Timişoara growing pole (left) and Spatial development scenario for Timişoara urban agglomeration (2005-2050) (right)

Timisoara is already active as regards the European Innovation Partnership on Smart Cities and Communities initiative, by the partnership formed by Politehnica University of Timisoara, Timisoara City Hall and the Smart City Association submitted the Commitment 7711, related to the use of Open Data Sets for creating smart applications to the benefit of citizens. The result consisted in an increased number of data sets made available by Timisoara City Hall on the governmental portal which located it on the first place in Romania.

Other studies conducted by specialists of Politehnica University Timişoara revealed that the owners of individual houses from Timişoara are interested for their property's value not to drop in investments such as learning, sports and relaxation facilities, quietness, public transport, edilitary and road infrastructure. At the same time, the entrepreneurs from Timişoara, that operate in the investments domain, aim to work within a long-term strategy, to have as big a profit as possible and favourable execution conditions in order for the bureaucracy to be reduced.

The scenario for the spatial development of the urban agglomeration of Timişoara, initiated in 2004 and approved by the Local Council Timişoara in 2005 started from the relation between the city of Timişoara with the larger whole – Europe, DKMT Euroregion, the Western Region of Development, the Metropolitan Area of Timişoara, and resulted in nine different strategies: the electronic city by applying the GIS, the city of infrastructure, the residential city, the commercial city, the city of services and industry, the green city, the social city, the multicultural city and the universitary city, with specific objectives, development directions and measures.

The strategy of the electronic city by applying the GIS includes the objective of continuous updating of the cadastral and topographic surveys in Stereo 70 on a magnetic support, of the edilitary and road infrastructure, of the Building Permits (BP), of the dismemberments and property transactions, of the overlapping of the laws referring to constitution and reconstitution of the properties, as well as the objective of obtain satellite images and ortophotoplans every year.

The City Hall of Timişoara is the first institution in Romania starting the GIS (Badea & Badea, The advantages of creating compound GIS functions for automated workflow, 2013) for urban planning purposes (Munteanu, Mihaiescu, & Dimen, 2012), at present, being the most advanced city in this domain.

The implementation of the GIS started in 1996 and covered a total area of 129,2km^2; 34 Cadastral Sectors; 900 blocks and 27000 property sheets. Positioning of each entity is made on the reference given by the cadastral digital plan, 1:500. Updating this plan is based on a photogrammetric plan by using existing records, parcelling projects, urbanism certificates, documentations from archives, documents on land retrocession, and modifications on the street scanning as a consequence of systematization etc. aiming to extend this system throughout the metropolitan area. An eloquent example of updating of the database for the Urban GIS (Fig. 97) implied acquisition of all information regarding the cemeteries, project carried out between 2007 and 2009 by Politehnica University Timişoara. (Grecea, Ienciu, Dimen, Bălă, & Oprea, 2012)

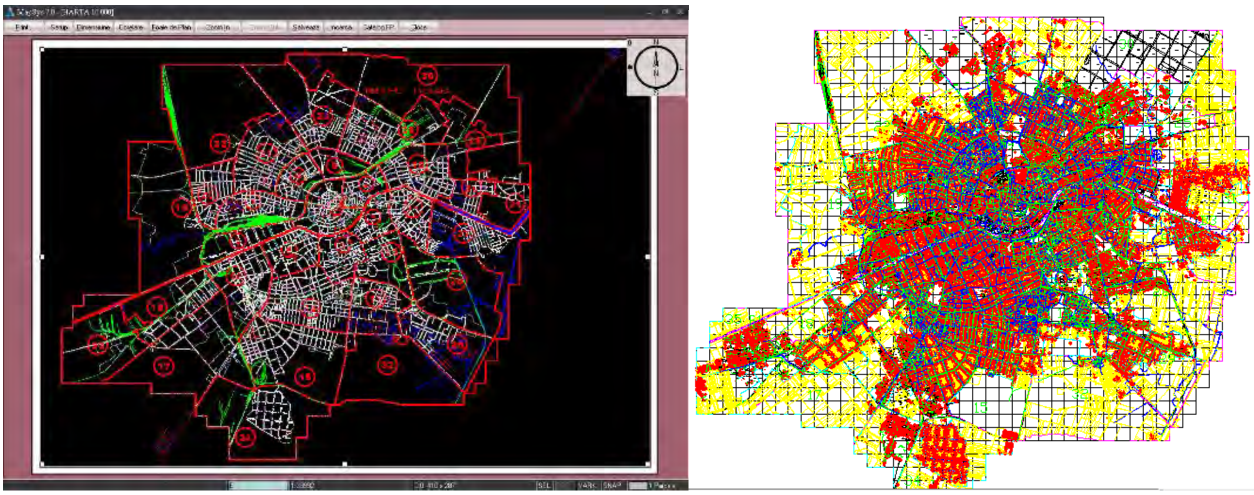


Figure 97. a) Map of cadastral sectors; b) Overview of urban GIS

Timişoara Municipality has set its goal to become one of Europe's smart cities and communities, thus developing (among others) a cultural strategy for 2014 – 2024. The strategy includes, besides the context of strategy's elaboration, methodology and analysis of the external environment, general objectives, measures and action plan, procedures and indicators for assessing the implementation of the necessary tools, mapping of cultural resources.

Mapping has been centred on three types of resources: cultural spaces (current and potential), cultural workers (organizations and public institutions of culture) and cultural events (events and large-scale projects, relevant for the city). Joint documentation efforts have meant sending 12 requests for information to the authorities and public institutions, specific documentation, more than 40 interviews with resource persons from the city, interviews and sending questionnaires to the religious institutions in the city and Neighbourhood Advisory Councils.

Thus, data from the sociological research carried out within the project Cultural Poles in 2013, also general data regarding social economy of the county, cultural statistics, including cultural vitality, and information provided by cultural operators on special meetings has been corroborated. Mapping of cultural resources (Fig. 98) provides a general image on both cultural life profile and cultural operators from Timisoara, compared to the region and the rest of the country and highlights most performant cultural domains (in terms of cultural vitality) and those which need support to develop. It includes visual arts; show arts; libraries, publishing houses and written culture; audience development and cultural expressions diversity; cultural education; audience development; amateur arts, multicultural diversity; cultural and creative industries; broadcasting and cinematography; training and support for business ideas incubation in the field the Cultural and Creative Industries (CCI); encouragement of the CCI market through competitive public acquisitions and creative interventions for aesthetic city; workspaces for business incubators, creative hubs; museums; music; architecture – cultural heritage – built environment; contemporaneous architecture; arts and culture spaces; natural heritage.

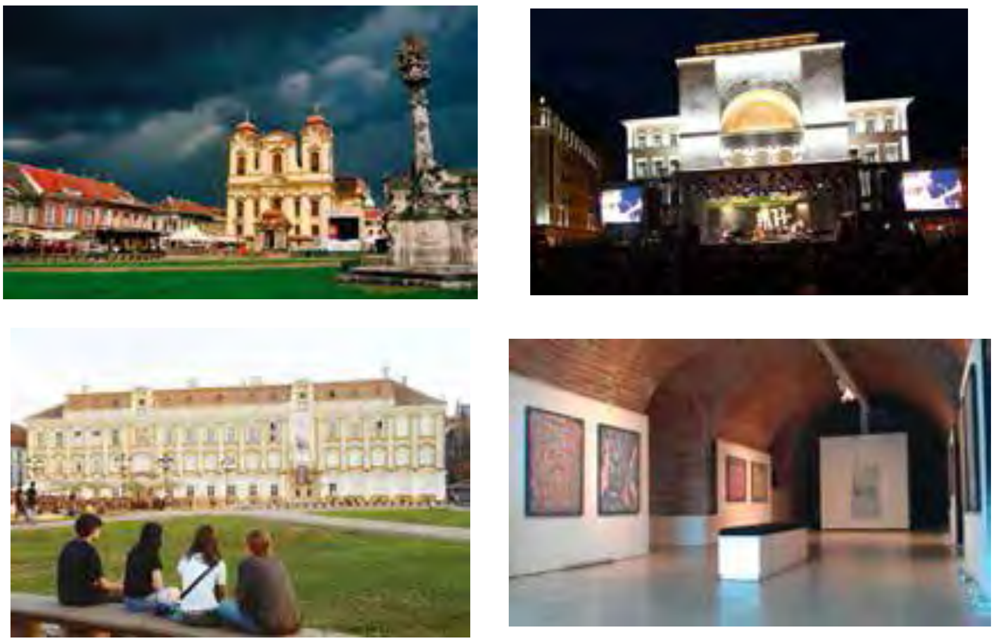


Figure 98. Mapping of Timisoara’s cultural resources

"The award title of European capital of culture will continue to rely on a cultural program created specifically for European capital of culture, which should have a strong European dimension. The program should also be part of a long-term strategy with sustainable impact on economic, cultural and social development".

By recognizing the role of culture for development and quality of life, contemporary cultural policies call attention to the need to inherently integrate the cultural sector in other areas of public life. Concern for the cultural life of the city of Timişoara implies a strong relationship between culture and urbanism, architecture, environment, education and contributes to local and regional development.

The city is prepared to invest in its heritage and to foster cultural phenomena. The potential offered by the Euroregion of historical Banat represents the foundation for the projects and initiatives meant to support the development of a common identity based on a natural collaboration between people and organizations. Moreover, culture represents an investment for the local economy, which, through the development of tourism based on cultural heritage and on major events, aims to draw visitors and transform the city and the region in a cultural pole with wide international opening.

Competing and winning the title for "European capital of culture" initiative implied involving the entire community in embarking socio-economic and infrastructure projects supported by an information platform which ensures efficient data management for the municipality. This platform facilitated a good visibility of the candidate city in the context of enhancing the contribution of culture to its long-term development in accordance with its priorities and strategies.

II. e-Learning – basis for spatial data geoportal

As an educational field with its specific features, training in surveying demands a lot of automation and facilities for solving geodetic tasks. Now, in the age of total stations, GPS receivers, GIS technologies, laser scanners, UAVs, everything is, in fact, computerized. Computer software changed the geodetic activities and therefore, the required skills for geodetic engineers. Even from the beginning of their training, the students have to deal with different kind of computational tasks and knowledge about the principles of solving geodetic problems.

E-Learning for the purposes of geodetic education is needed because it offer advantages such as: save time; allow self-study; present information graphically and make the educational process more interesting. The institutional support for realizing the above described project is provided consisting in an e-Learning online network. Geodesy Instruct was implemented for university collaboration to develop the capacity of providing superior competences in Geodesy, mainly for harmonization and standardization of a training program at multi-regional level.

E-Learning support for realizing the 3D models

Implementing a spatial data geoportal at Local Administration (Timişoara City Hall) level using EU non-refundable funds could be a smart solution for managing secure and valuable property based on IoT meant to reinforce Europe's cultural diversity by making our heritage and our cultural creations available to a wider number of citizens.

The authors propose a workflow diagram (Fig. 99) with the actual working process for creating the 3D cultural heritage model, step by step, to be used in the geoportal. (Alionescu, Herban, Grecea, & Vîlceanu, 2015)

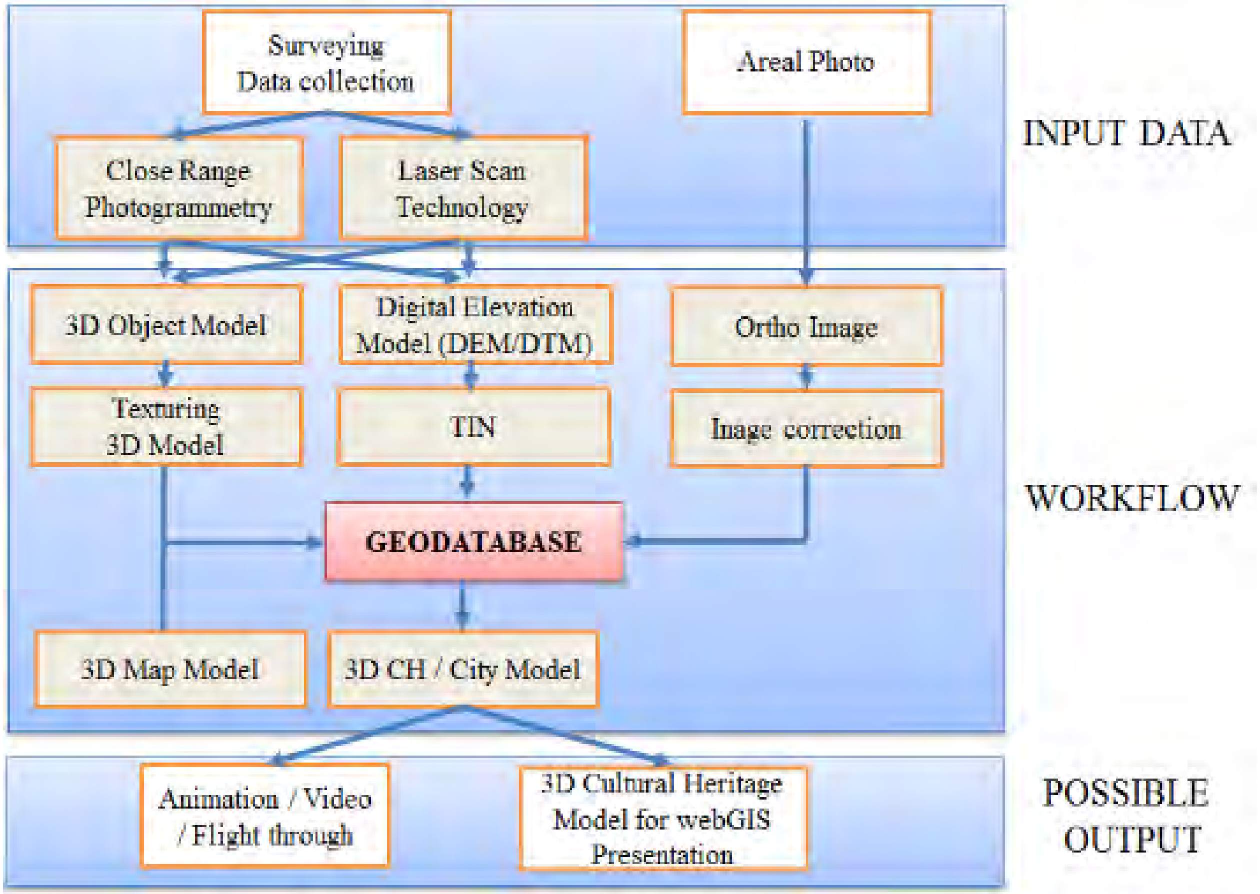


Figure 99. Workflow diagram – logical scheme

As regards the creation of the 3D models of cultural heritage objects, there are several technologies available for data collection: close-range photogrammetry, laser scanning, UAVs (Unmanned Aerial Vehicles).

For processing and creating 3D models, the alternatives are: model in specialized software (e.g. Cyclone, Solid Scan, GeoVerse, JRC 3D Reconstructor), model directly in 3D CAD (Civil 3D), model only surface (for pure restauration purposes – created from photographs – Corel Draw).

For the present objective the data was collected using the Zoller + Fröhlich scanner from Politehnica University Timisoara.

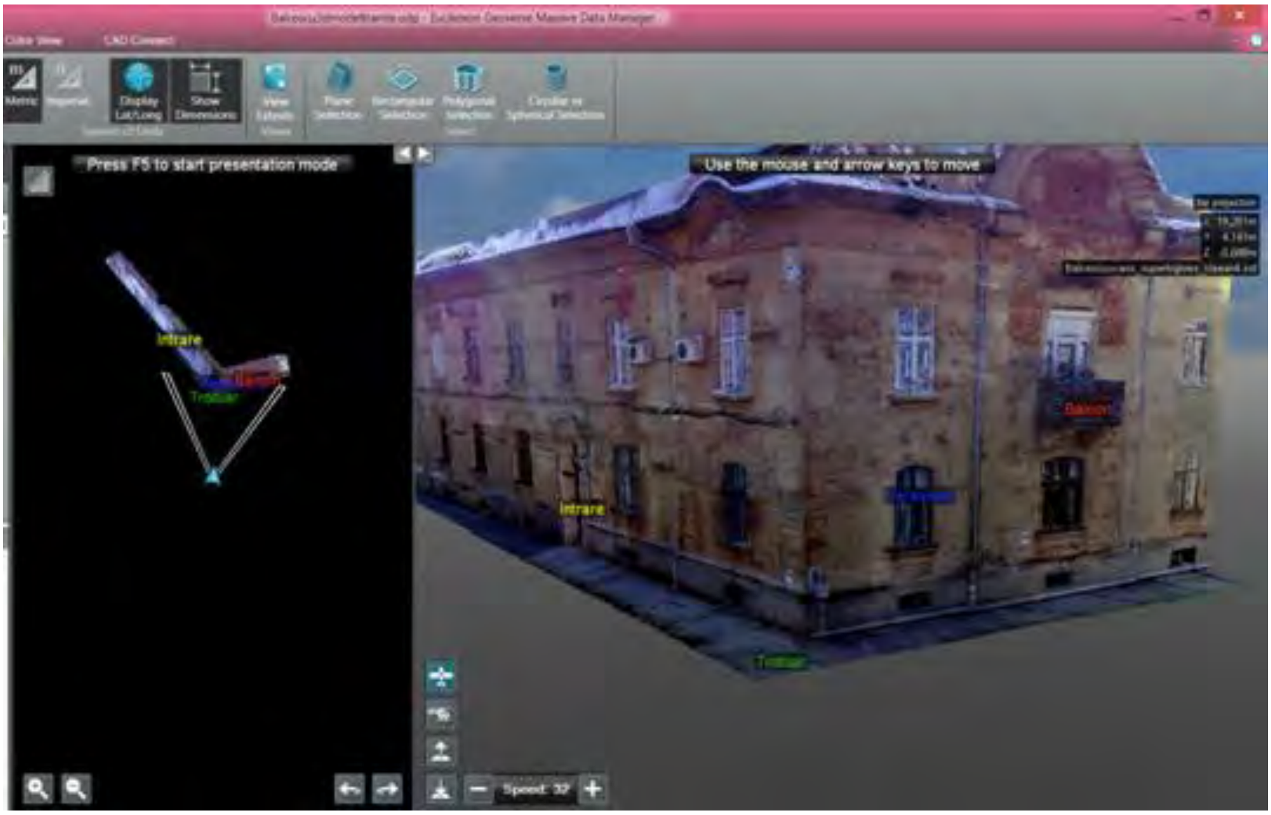


Figure 100. Point cloud obtained by scanning a historical building from Timisoara

After acquiring the digital data regarding the cultural heritage objects they can be processed individually or in group by 4th year bachelor students or by master students and then uploaded on the Geodesy-Instruct e-Learning platform. The last step of the project implies transferring the digital database with the 3D models to the proposed geoportal.

Figure 101.a). Selecting a cultural heritage object from the geoportal

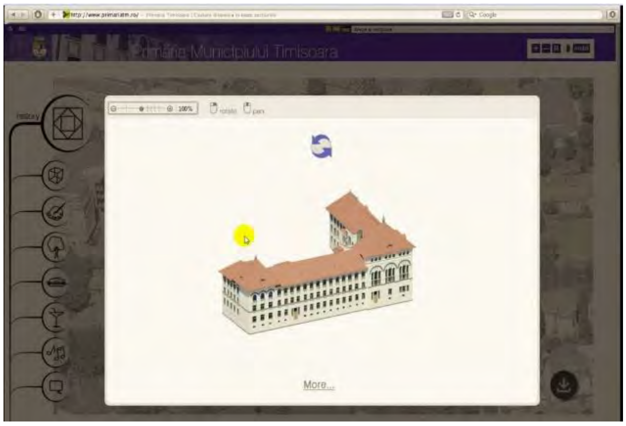


Figure 102.b) 3D model of the cultural heritage object

From the applicative point of view such a webGIS solution brings added value for all the institutions that manage and operate with Cultural Heritage objects. The fact that information is available at a glance as a webGIS resource for different users in an attractive and intuitive manner, it provides a powerful tool for cultural heritage conservation as an efficient strategy of urban planning.

III. Conclusions

Implementing the proposed spatial data geoportal at Local Administration level (Timişoara City Hall) would streamline the data workflow and provide easy access to it in order to increase the visibility of cultural and historical heritage of the municipality. The dedicated geoportal for the management of heritage objects represents a smart solution which completes the existing urban GIS primarily aiming to contribute to fostering the urban planning and the sustainability of the "European capital of culture" project. This geoportal should include the 3D models of the cultural heritage objects for better preservation over time or restauration purposes and offer virtual tourism tours if they are made available by means of webGIS.

The technical basis for this project should be represented by geodetic measurements, laser scanning, IoT and architectural support ensured by an unceasing teamwork of different specialists. The overall purpose of this project consists in developing people's digital skills and competences by using an intelligent, adaptive and personalized e-Learning platform that comes in support of students and represent both an efficient alternative for the individual study and resources for team-work. By using the e-Learning resource implemented by Politehnica University Timisoara students can load the results of their projects and work, namely the 3D models realized, both individually and by teamwork, for a touristic promotion of Timisoara municipality in the context of competing and winning the title for "European capital of culture" initiative.

The actuality of the paper arises from using webGIS solution in the "Internet of Things" (IoT) context to merge physical and virtual worlds, creating smart environments that represent the next natural step towards the digitisation of our society and economy.

The authors insist on the idea of creating a geoportal for cultural heritage objects as the future brings changings in terms of replacing desktop solutions by WEB solutions in order to allow the dissemination of the results and to increase the possibility of international collaboration between specialists. WebGIS solutions have several advantages among which we mention the access to spatial data characteristic to cultural heritage documentation either for specialists or ordinary users and different purposes.

An efficient urban planning strategy implies creating WebGIS for cultural heritage as the next natural step forward for both conservation and preservation of these objects, and also for understanding and promoting them. Also, together with the unlimited possibilities offered by the World Wide Web, creating physical virtual replicas of Cultural Heritage objects has become more and more attracting and interesting.

3. EVOLUTION AND DEVELOPMENT OF PROFESSIONAL, SCIENTIFIC AND ACADEMIC CAREER PLAN

3.1. Profesional activity and teaching

My professional training started with the period 2000-2004 when I attended highschool at the „Traian" National College in Drobeta Turnu-Severin, profile „Intensive Bilingual English Mathematics Informatics" where I obtained Professional Certificates of „Computer Operating Skills" and „Advanced language skills in English". During highschool I took the exam and obtained the Certificate of Advanced English issued by the University of Cambridge, OL Examinations.

In 2004 I was admitted to „Politechnica" University of Timisoara, Faculty of Civil Engineering, „Geodesy" domain, „Cadastre" specialization, studies that I graduated in 2009 as **Valedictorian**. Between the years 2009-2011, I attended the courses of the „Cadastre and the Evaluation of Immovables" master program.

In 2010, I also became a Bachelor in economic studies, „Finance" profile, „Finance and Banking" specialization.

Also in 2010, I was admitted for the doctoral studies at the Faculty of Civil Engineering within the Politehnica University of Timisoara with the following research theme: "Monitoring, modeling and analysis of landslides and reinforced-earth constructions using modern geodetic technologies". The thesis was finalized in 2014 and I was awarded the scientific title of Doctor in the field of Civil Engineering.

During the doctoral stage, I also worked as associated member of staff, teaching different disciplines at Terrestrial Measurements and Cadastre study programme, Civil Engineering Faculty from Politehnica University Timişoara. After the doctor diploma was issued, in 2015, I won the competition for the position of Assistant Professor. From this position, I conducted the laboratory works for the disciplines Topography, Geographic Informatic Systems, Cartographic and Topographic Drawing, Analytical and Digital Photogrammetry, guiding and mentoring students for their projects, conducting diploma projects and leading the works for 1st and 2nd year students' practice from Terrestrial Measurements and Cadastre study programme.

In the year 2018, I participated at the competition for the position of Lecturer obtaining this position within the Department of Overland Communication Ways, Foundations and Cadastral Survey, Civil Engineering Faculty. The main didactic activities consist in giving lectures, also being in charge with seminar and laboratory activities for the following subjects: Technical Drawing and Infographics, Geographic Information Systems, Special Adjustment Software in Cadastre, Database Geospatial Analysis Techniques; coordinating diploma and dissertations projects; responsible for the student annual training period. Since 2019 up to present, I have been a member of the Commission for Dissertation Examination for this study programme.

At present, I am part of doctoral guidance commissions for PhD students at Politehnica Univeristy.

Permanently, besides the teaching activity I had in mind conducting scientific research, and being up to date with the novel elements in the geodesy domain by participating at various events and scientific manifestations, at national and international level. As it can be concluded by my activity presented in the first chapter, I have also been a member in various teams for the elaboration/implementation/ execution of several projects/contracts/grants in the field of geodesy or in related fields.

3.2. Evolution of the university career

In the process of developing my university professional career, as short-term objective, I aim to obtain the habilitation certificate confirming my quality of coordinating doctoral theses. Obtaining the habilitation certificate will give me the opportunity to take my professional career a step further through the research activities that I will initiate and that, at some point, will serve as research topics in the elaboration of doctoral theses. To this end, I will carry out a continuous activity of documentation, having in mind the fact that the geodesy and terrestrial measurements domain is very dynamic and that data acquisition technologies are evolving internationally with a view of aligning to the alarming evolution of society, whether we are talking about the theoretical or practical part of terrestrial measurements.

The success of this activity materialized by the elaboration of this habilitation thesis will ensure my personal professional achievement, but at the same time it will impose a much greater responsibility towards future doctoral students, but also towards the academic and scientific community in the country and abroad. Thus, through the way I will carry out and manage my activity in the future, I aim to develop constantly, so as to become a much more experienced teacher, who will put passion in every action undertaken, who will improve permanently and connect to the daily reality being able to constantly share the novelties that appear in the habilitated field of activity.

I will also continue to participate in training courses in order to complete my professional career and to constantly interact with members of the academic community at national and international level.

Also, among the projects I want to initiate in the future, establishing closer collaborations with foreign universities in order to further develop research projects while expanding my own network of researchers can be found. Regarding the scientific research activity, it is a very important activity that

I will carry out constantly and that will represent the basis of my university career being an integral part of it.

I plan to carry out this activity through the following actions:

- annual participation in national and international conferences in the field of Geodesy, Digital Photogrammetry, GIS;
- continuing the activity of reviewer for national and international journals;
- updating the course materials developed so far, in trend with the evolution of the field of applicability;
- carrying out scientific research projects in order to access funds, especially for grants in the field of geodesy and land measurements and cadastre;
- participation in research teams for interdisciplinary projects;
- realization of research-development projects having as beneficiaries state authorities, legal or natural persons.

After obtaining the habilitation certificate, I propose to carry out research activities that are reflected in the fields of activity specific to my training, but not limiting, thus, by addressing interdisciplinary research topics in mixed groups of researchers for the fields involved I intend to undertake activities related to:

- involving students in scientific research contracts and attracting them to the research field;
- guiding students to attend conferences and scientific communication sessions;
- initiating and supporting research-development projects of grant type or research contracts with economic agents in the area.

Making the most of the research results will be realized by publishing scientific papers, so the research activity will materialize in a series of studies and articles that I intend to publish in the pages of prestigious journals, indexed in the Clarivate Analytics (former ISI Thomson Reuters) web of science database and in other recognized databases such as Scopus. These scientific papers will include both the results of research undertaken in the proposed research projects and the results of research from scientific research specific to the skills I have and the area of scientific interest that concerns me. In the medium and long term, publishing articles in Clarivate Analytics indexed journals (formerly Thomson Reuters) makes it easier for me to increase my scientific visibility and dissemination of research results, and on the other hand, supports the conditions for access to higher levels of university education, respectively, places the university I am employed in to higher hierarchical position in different rankings. Moreover, the advantages of participating in international conferences, in addition to publishing articles of high scientific value, facilitate my development by expanding the collaboration network with researchers from abroad to access grants on interdisciplinary topics such as Horizon Europe.

For the development of my academic career, obtaining the habilitation certificate would represent an official recognition of the activity I have undertaken so far, would contribute to access to higher levels of university education but would also be a form of gratitude to all which contributed to my training as a person, specialist, teacher and more.

I consider that the major benefit of the approach I have in mind is that it will be reflected in new research opportunities for the research centre I am part of, accessing grants on interdisciplinary topics, publication of articles of high scientific value, possible contracts with third parties such as local authorities (town halls, county councils, emergency situations inspectorates) and drawing up topics for bachelor's / master's / doctoral theses in order to establish bilateral teams to coordinate them on research topics in my area of interest.

My only job was at this university - Politehnica University Timisoara and I am aware that only with hard work, talent and dedication for the activity I carry out permanently, at some point, I will be able to be appreciated but also recognized at national and even international level, approaches that will bring me due respect within the scientific community of geodesists.

At the same time, the success of this step will be a milestone for the recognition of my work by the team of the academic community I belong to and will ease my task of becoming a mentor for future colleagues who will opt, at some point, for the beautiful world of university teachers.

Finally, I would like to mention that when, following a critical self-assessment, I will find that I have a well-established academic career, I will motivate and self-suggest to continue my activity at least at the same level and not fall into the trap of self-satisfaction and stagnation. At the same time, I will motivate myself by looking for and identifying new goals to achieve in the development of my career so that I would be permanently aware that I am in an academic community that has painted a positive image of me and that has high expectations of me. I will also aspire to respect my profession at all times and not to forget the responsibility I have assumed for it and the satisfactions I can experience with the recognition of the results of my activity.

4. REFERENCES

Alionescu, A., Bălă, A., Brebu, F., & Moscovici, A.-M. (2017). Creating 3D models of historical buildings using geospatial data. *AIP Conference Proceedings*, (p. 430002). doi:10.1063/1.4992598

Alionescu, A., Herban, S., Grecea, C., & Vîlceanu, C.-B. (2015). Comparative Study of TLS and Digital Photogrammetry for 3D Modeling of the Martyr's Cross Monument. *International Conference: Integrated geo-spatial information technology and its application to resource and environmental management towards GEOSS* (pp. 94-99). Sopron: Nyugat-magyarországi Egyetem Kiadó.

Arschcraft, H. (2008). Building Information Modelling: A Framework for Collaboration. *The Construction Lawyer*.

Badea, A., & Badea, G. (2013). The advantages of creating compound GIS functions for automated workflow. *SGEM Conference Proceedings*, (pp. 943-949). Albena. doi:WOS:000349067200121

Badea, A., Badea, G., & Clinci, T. (2012). E-Learning using educational software – a feasible alternative for training and learning. *Proceedings of the 12th International Multidisciplinary Scientific GeoConference SGEM*, *III*, pp. 1077-1084. Albena.

Badea, G., Badea, A., & Clinci, T. (2012). A platform suitable for implementing an e-Learning system – core conditions. *Proceedings of the 12th International Multidisciplinary Scientific GeoConference SGEM*, *3*, pp. 1035-1043. Albena.

Bălă, A., Brebu, F., & Moscovici, A. (2012). Using terrestrial laser scanning echnologies for high construction monitoring. *Proceedings of 12th International Multidisciplinary Scientifc GeoConference*, *2*, pp. 829-836. Albena.

Bălă, A., Grecea, C., Brebu, F., David, V., & Bota, C. (2012). Monitoring Mining Dumps in Relation with Environmental Protection. *Journal of Environmental Protection and Ecology, 1*(4), 2433-2438.

Bănescu, O.-A., Vîlceanu, C., & Hapenciuc, A.-D. (2018). Spatial data geoportal – a powerful interface for the local administration. *CoHeSION 2018 - International Conference on Heritage and Sustainable Innovation.* Timisoara, Romania,.

Bonazza, A. (2018). Study on Safeguarding Cultural Heritage from Natural and Man-Made Disasters. *International Conference Danube University Krems.*

Capita, C., & Capita, L. (2016). The transition from classic to digital textbooks - The case of history teaching. *Elearning Vision 2020!*, *1*, pp. 45-49. doi:10.12753/2066-026X-16-006

Cohen, B. (2018). *Boyd Cohen: The Smart City Wheel*. Retrieved August 2017, from Boyd Cohen: The Smart City Wheel: https://www.flickr.com/groups/sustainablebuilding/discuss/72157594260487070/

Didulescu, C. (2010). The 3D Urban Model, a New Tool in Support of Urban Planning. *RevCAD Journal of Gepdesy and Cadastre*, 65-70.

Digital Agenda for Europe. (2018). Retrieved from http://ec.europa.eu/digital-agenda/digitalagenda-europe

Dinca, I., Linc, R., Tatar, C., Nistor, S., Stasac, M., & Bucur, L. (2017). Surveying the Rural Resiliance within the Oradea Hills Household Independent Cellar Landscape. *Proceedings of 17th National Techical-Scientific Conference on Modern Technologies for the 3rd Millennium*, (pp. 13-22). Oradea, Romania.

Dorninger, P., & Briese, C. (2005). Advanced geometric modelling of historical rooms. *XX Symposium of CIPA.* Turin, Italy.: ICOMOS&ISPRS Committee on Documentaion of Cultural Heritage.

England, H. (2017). *BIM for Heritage: Developing a Historic Building Information.* (S. Antonopoulou, & P. Bryan, Eds.) Historic England.

Goulden, T. (2009). *Prediction of error due to terrain slope in LiDAR Observations.* M.Sc.E. thesis, University of New Brunswick, Department of Geodesy and Geomatics Engineering Technical Report No. 265, Fredericton, New Brunswick.

Grădinaru, C., Herban, S., & Gabor, C. (2016). Development of Urban Green Space Monitoring technique with Remote Sensing and its application. *AIP Conference Proceedings*, (p. 350004). doi:10.1063/1.4952127, 2016

Grecea, C., & Gridan, R. (2011). Geospatial technology for 3D City and Urban modelling. *RevCAD Journal of Geodesy and Cadastre*, 69-75.

Grecea, C., Herban, S., & Vilceanu, C.-B. (2016). WebGIS Solution for Urban Planning Strategies. *Procedia Engineering, 161*, 1625-1630. doi:https://doi.org/10.1016/j.proeng.2016.08.637

Grecea, C., Ienciu, I., Dimen, L., Bălă, A., & Oprea, L. (2012). Cadastral Support for an Efficient Town Planning in Timisoara, Romania. *Journal of Environmental Protection and Ecology*, 1099-1107.

Herban, I., Vilceanu:, C.-B., & Alionescu, A. (2014). Application of close-range photogrammetry to cultural heritage. *RevCAD Journal of Geodesy and Cadastru, 16*, 104-112.

Herbei, M., Sala, F., & Boldea, M. (2015). Using mathematical algorithms for classification of Landsat 8 satellite images. *AIP Conference Proceedings*, (pp. 670004-1-670004-4).

Heritage, G., & Large, A. (2009). *Laser Scanning for the Environmental Sciences.* Wiley-Blackwell Publishing Ltd.

http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52005DC0229. (2018). Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52005DC0229: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52005DC0229

https://mapio.net/s/62770987/ . (2018). Retrieved from https://mapio.net/s/62770987/ : https://mapio.net/s/62770987/

Ioan-Marginean, A. (2016). E-Learning in fashion design at the National University of Arts Bucharest 2020. *Elearning Vision 2020!*, (pp. 111-114). doi:10.12753/2066-026X-16-016

Kensek, K., & Noble, D. (2014). *Building information modelling – BIM in current and future practice.* Wiley&Sons.

Moscovici, A., Păunescu, V., Sălăgean, T., & M. Călin, A. I. (2019). 3D Cadastre: A smart approach for road infrastructure. *AgroLife Scientific Journal,, 8*(1), 192-197.

Moscovici, A.-M., & Grecea, C. (n.d.). Geomatics, Support for an Efficient Urban Planning. *IOP Conference Series: Materials Science and Engineering*, *245 (5)*, p. 052041. doi:10.1088/1757-899X/245/5/052041

Moscovici, A.-M., Brebu, F., & Bălă, A. (2017). Geospatial Data Acquisitions Using 3D Laser Scanning Technology in the Context of Monitoring Mines. *Proceedings of the 16th National Technical-Scientific Conference on Modern Technologies for the 3rd Millennium*, (pp. 33-38). Oradea.

Munteanu, L., Mihaiescu, R., & Dimen, L. (2012). Using GIS for strategic environmental assessment case study: Cluj-Napoca metropolitan area. *SGEM Conference Proceedings* (pp. 1201-1212). Albena: STef 92 Technology Ltd. doi:WOS:000348532700153

Radoslav, R., Branea, A.-M., Bădescu, Ș., Găman, M., Morar, T., & Nicolau, I. (2010). *Organic Growth. Studies for Territorial Development, Urbanism and Urban Design.* (E. U. ILETE Program, Ed.) Timișoara, Romania: Proceedings of the activities of the project "Sustainability, land-use planning and urban planning".

Rusu, G., & Mușat, C. (2012). Modern concepts of 3D modeling in geodetic works. *RevCAD Journal of Geodesy and Cadastre*, 137-147.

Shashi, M., & Jain, K. (2007). Use of photogrammetry in 3D modeling and visualization of buildings. *ARPN Journal of Engineering and Applied Sciences, 2*(2), 37-40.

Styliadis, A., Honstantinidou, D., & Tyxola, K. (2008). eCAD system design - Applications in architecture. *International Journal of Compoters Communications & Control, 3*(2), 204-214.

Synge, E. (1930). Phil. Mag. *9*, p. 1014.

Tóth, Z., Balázsik, V., & Kiss, A. (2018). Modern data acquisition tools in archaeology. *17th edition International Technical-Scientific Conference Modern Technologies for the 3rd Millennium*, (pp. 117-123). Oradea, Romania.

Vasiu, R. (2015). *Development of Smart City Applications Based on Open Data.* Retrieved from https://www.researchgate.net/publication/289756600_Development_of_Smart_City_Applications_Based_on_Open_Data

Vîlceanu, C., Alionescu, A., Grecea, C., Herban, S., & Moscovici, A. (2019). Heritage studies in spatial planning; development and environmental policies. *Proceedings of Modern Technologies for the 3rd Millennium*, (pp. 79-84). doi:WOS:000617030100014

Vîlceanu, C.-B. (2014). *Monitoring, modeling and analysis of landslides and reinforced-earth constructions using modern geodetic technologies, Doctoral dissertation.* Timisoara, Romania: Politehnica Timisoara.

Vîlceanu, C.-B., Herban, I., & Grecea, C. (2013). Creating 3D Models of Heritage Objects Using Photogrammetric Image Processing. *AIP Conference Proceedings 1558*, (pp. 1599-1602). doi:10.1063/1.4825832

Vîlceanu, C.-B., Herban, S., & Grecea, C. (2015). E-Learning in engineering - Impact upon the student's mentality and development. *Rethinking education by leveraging the eLearning pillar of the digital agenda for Europe! II*, pp. 584-591. Book Series: eLearning and Software for Education. doi:10.12753/2066-026X-15-180

Vîlceanu, C.–B., Herban, S., & Muşat, C. (2011). The correlation between the surveying profession and sustainable development. *Research Journal of Agricultural Science, 43*(3), 522-529.

Wang, H., Pan, Y., & Luo, X. (2019). Integration of BIM and GIS in sustainable built environment: A review and bibliometric analysis. *Automation in Construction, 103*, 41-52.

www.advenser.ae/bim-services/. (2021). Retrieved from https://www.advenser.ae/bim-services/

www.coe.int/en/web/culture-and-heritage/strategy-21. (2019). Retrieved from www.coe.int/en/web/culture-and-heritage/strategy-21: https://www.coe.int/en/web/culture-and-heritage/strategy-21

www.geodesy-instruct.ro. (2018). Retrieved from www.geodesy-instruct.ro: www.geodesy-instruct.ro *www.jisc.ac.uk/guides/developing-students-digital-literacy* . (2018). Retrieved from www.jisc.ac.uk/guides/developing-students-digital-literacy : https://www.jisc.ac.uk/guides/developing-students-digital-literacy

www.primariatm.ro. (2018). Retrieved from www.primariatm.ro: www.primariatm.ro

www.thenbs.com/knowledge/bim-levels-explained. (2021).

www.trimble.com/imaging/Trimble-MX2.aspx. (n.d.). Retrieved from www.trimble.com/imaging/Trimble-MX2.aspx: http://www.trimble.com/imaging/Trimble-MX2.aspx

www.united-bim.com/bim-maturity-levels-explained-level-0-1-2-3/. (2021).