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HABILITATION THESIS

Theoretical and Experimental Research on Structures and Historical Sites Using Advanced Surveying Engineering Methods

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Considerente Teoretice și Cercetări Experimentale Asupra Structurilor și Clădirilor Istorice Utilizând Metode Avansate a Științei Măsurătorilor Inginerești

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Domain: Geodetic Engineering

Specialization: Land Measurements and Cadastre

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THEORETICAL AND EXPERIMENTAL RESEARCH ON STRUCTURES AND HISTORICAL SITES USING ADVANCED SURVEYING ENGINEERING METHODS

A. ABSTRACT

Present thesis summarises the research activity of the candidate after defending the PhD Thesis at The Politehnica University of Timisoara and confirmed by The Ministry of Education and Research, on the basis of Order no. 5764, dated 28.11.2006.

The research activity and achievements presented here are developed in a few of main thematic directions.

The first one is – **Contribution to applying topographic methods for studying and monitoring terrain and constructions**, which continues and diversifies with new subjects, the topic of the PhD Thesis or others subjects related to this.

It should be noted that the activity of the candidate in the field of special surveying engineering and applying topographic methods for studying and monitoring terrain and constructions (20 years of research in this field), from the beginning, September 1996, until the defending of PhD Thesis, and for the post-thesis period, is in line with the fields of research of the department of Overland Communication Ways, Foundation and Cadastre and especially with the team from Terrestrial Measurements and Cadastre from Faculty of Civil Engineering, Politehnica University Timisoara, but also with private companies and departments from EU universities.
The new subjects of research in the post-thesis period can be synthetized in four distinguish themes, each of them related to the following aspects:

- **DEVELOPING METHODS AND MODELS TO EVALUATE AND DETERMINE THE REAL DEFORMATIONS OF TERRAIN ANS STRUCTURES;**
- **REVERSE ENGINEERING AND LASER SCAN TECHNOLOGY APPLIED TO CULTURAL HERITAGE DOMAIN, DEVELOPMENT OF 3D MODELS FOR CULTURAL HERITAGE SITES;**
- **USING OPEN SOURCE AND LOW-COST SOLUTIONS AND GIS PLATFORMS FOR DIFFERENT USERS TO ARCHITECTURAL AND CULTURAL APPLICATIONS;**
- **EDUCATIONAL PLATFORMS FOR E-LEARNING PROCESSES.**

One on my research area enhanced by me at Politehnica University Timisoara is related to developing new **methods and models to monitoring the dynamic deformations of structures** – this fact is proved by scientific papers published in ISI and BDI journals. This preoccupation emerged from the fact that the engineering structures, civil construction and historical buildings are subjected to dynamic deformations and also degradation over time.

Measurements are taken over minutes, hours, weeks, months or years to a number of targets with the goal of measuring uneven settlements, displacements or long-term permanent or specific deformations (Herban and Musat, 2012). Due to the fact that my main activity has been developed almost entirely together with my colleagues from the aforementioned department, I believe that developing and better understanding of the displacement and deformation phenomena of the engineering structures and also their monitoring is a natural direction followed by the candidate. Moreover, studying these phenomena, led to another research theme, namely

historic and old constructions, which meant that this domain has opened new opportunities for research and cooperation. This new directions are presented hereinafter:

Reverse engineering. 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 the last years, the interest of using accurate CH 3D data acquisition for historical, archaeological research and virtual reconstruction documentation is not just a scientific preoccupation but also a recommendation of public authorities (Herban *et. al*, 2014). Besides digital reconstruction, a study on monitoring and analysis of the structure of Cultural Heritage buildings becomes less difficult by testing the parameters that ensure the integrity and safety of the buildings using geodetic methods based on total station, close range photogrammetry or Laser Scan technology (Musat and Herban, 2012).

3D Laser Scan Technology allows user to produces a high-precision digital reference data that records condition, provides a virtual model for replication, and makes possible easy mass distribution of digital data. The cost and complexity of 3D laser scanning technologies have made 3D scanning impractical for many heritage institutions in the past, but this is changing, as an increasing number of commercial systems are being customized and marketed for heritage applications and also Photogrammetry begun to be used as complementary method to 3D laser scan technologies in domains such as architecture and civil engineering (Musat and Herban, 2012). The study of these technologies as well as comparisons between the resulted 3D models represents one of my goals of the research studies conducted in the last couple of years.

3D Models for Cultural Heritage sites was -and still - representing a continuous preoccupation and as assistant professor and researcher at Politehnica University Timisoara, Department of Land Measurements and Cadastre, I was involved in the process of creating and modeling different objects, e.g. Buildings, Structures, Monuments, Digital Terrain Model (DTM).

In this context, one specific target of my research is the development of methods for "re-creating" and promoting 3D Cultural Heritage objects. The results have been published in two papers at ISI journals and ISI conferences.

My findings challenged the conventional assumption that Cultural Heritage, 3D modeling and also **GIS platforms or, even better, webGIS** are the next natural step forward for both conservation and preservation of Cultural Heritage objects, and also for understanding and promoting them. These facts are sustained both by developing and participating in EU programs realized in international consortiums with universities from Greece, Hungary, Slovakia, Austria and Romania in order to obtain results for modeling 3D objects using Low-Cost digital photogrammetry. GIS Platforms are not only the key for sustainable management, but also an excellent solution to manipulate and use spatial information. Usually, the term GIS is related to land information, but also the GIS platforms are used to monitor different movements of the earth, as has been highlighted in some scientific papers (published in the ISI Journal of Environmental Protection and Ecology).

Another applicative dimension which included **Open Source solutions** was developed in cooperation with University of Life Science from Norway, Department of Natural Resource and Management. Together with researchers from Norway and some of my students from Politehnica University Timisoara, we established new models for integrating LIDAR data in Open Source GIS platforms by an inter-institutional agreement whose departmental director I was.

Nowadays, in the context of using **Open Source or Low-Cost solutions** and to respond to the needs of applicative research in Cultural Heritage domain, one can mention the program EPOCHE in Greece where I presented and sustained the interest in accurate and rapid Low-Cost solutions for Cultural Heritage data acquisition and processing of 3D archaeological documentation.

As a consequence of the collaborative work between academics, researchers and students, scientific information characterizing the process of **realization of 3D models** using Low-Cost or professional software emerged, the results being published on the internet, which makes reconstruction Cultural Heritage (CH) objects even more attractive. As an outcome of the collaboration between the participating teachers, researches and students, was the applicative research and virtual reconstructions of CH published on the website of the program. Also, together with the unlimited possibilities offered by the World Wide Web, creating physical virtual replicas of Cultural Heritage objects is more and more attracting and interesting.

Educational platforms for e-learning processes are the instrument where all the information and the scientific work is transfered to the students. Current trends in the university network require implementation of the policy for restructuring the higher education system, by focusing on the student's educational activities. The new methods involve experimentation learning based on scenarios, alternative solutions and direct interaction between the student, the subject of learning and the learning environment. In this context, when the institutional support is provided, improvement and diversification of educational offers for geodetic engineering and their correlation with the labour market are defined on two main directions. As regards the bachelor cycle, 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. For the master cycle, emphasis is put on the use of the Virtual Campus of the Politehnica University Timisoara, system based on Moodle, an open-source platform which is an online educational environment of academic support for all faculties belonging to Politehnica University Timisoara (Vilceanu and Herban 2015).

B. SCIENTIFIC, PROFESSIONAL AND ACADEMIC ACHIEVEMENTS

1. INTRODUCTION

The main research field in which I was involved consists mainly in theoretical studies and practical support regarding Survey Engineering, GIS and Cadastral problems with impact on the large domain of construction.

Continuing the subject of my PhD thesis entitled “CONTRIBUTION TO APPLYING TOPOGRAPHIC METHODS FOR STUDYING AND MONITORING TERRAIN AND CONSTRUCTIONS” further studies were made on similar themes or complementary studies. Most of my research activity was made within the frame of different projects, such as:

Grants / Projects 2000-present (extract)

- Geodetic Study to establishment and implementation of topographic and cadastral works for building lots and land registration for ANL –Timisoara – MLPAT – **Director UPT**;
- Geodetic study regarding realizing the topo-cadastral documents for unifying, cadastral dismemberment, dividing and tabulation of terrains for building constructions L15/2003 and Gross Market –Timisoara – MLPAT – **Director UPT**;
- Topographic and cadastral studies for realizing the documentation of extraction from AC according to the Urbanistic Zonal Plan –Timisoara – MLPAT – **Director UPT**;
- Excellence in Photogrammetry for Open Cultural Heritage Education –EPOCHE 2013-, proiect nr. 2012-1-GR1-ERA10-10609, 32.342 EUR – **Responsible UPT**;
- Using Airborne Laser Scanning For Assisting Commercial Inventories In Young ForestsInter-Institutional Agreement Romania-Norvegia: Scholarships and Inter-Institutional Cooperation in Higher Education; Financed by the EEA and Norwegian Financial Mechanism, 2013 – **Departamental Coordinator UPT**;

- Research and studies regarding the movements of foundations of CET South and CET Center- SC EXPERT SRL 2012 – **Director UPT**;
- Research and studies regarding the identification of immoveable SC HOLCIM SA, Calea Mosnitei, Timisoara 2010 - SC HOLCIM România SA– **Director UPT**;
- Application of the terrestrial laser scanning for environmental processes and changes - ATLAS, project no.10/0242-E/4005/2011, 31.802 EUR – **Team Member**;
- Real Estate Mapping in Romanian Counties, contract no. 674/2007, 6.000EUR – **Team Member**;
- Studies and topographic precise measurements for tracking the movement at passages located on Caransebes ByPass - Constructora Copisa Barcelona – **Director UPT**;
- Conduct studies and research for the execution of topographic measurements and engineering for modeling three-dimensional representation and input pressure vessels – 6400 Euro SC PRESAFFE SRL 2014-2015 – **Director UPT**;
- Designing Database for using Geospatial Information for Registration and Monitoring cemeteries in Timisoara, Romania, contract no. 182/2008, 14.000EUR – **Team Member**;
- Studies and experimental research concerning the improvement of technological performances of Francis FVM DE 57.5-128.5 turbines, hydro-electrical plant Bradisor, Romania, Topographic evaluation, contract no. 174/2010, 57.571EUR – **Team Member**;
- National Project for Infrastructure Modernisation-Interdisciplinary Laboratories, Surveying and Cadastre department, contract no. 2575/2007, 100.181EUR – **Team Member**;
- Online network for university collaboration to develop the capacity of providing superior competences in Geodesy, contract POSDRU/86/1.2/S/63140, 2010-2012– **Team Member**;
- INSTRUCT – Laboratory development for large scale tests, **PN II** Modul I, Capacităţi, 90 CP/ I/ 14.09.2007 (2007-2008-2009) – **Team member**
- POSDRU87/1.3/S/60891: Academic School for trainers in the domain of Engineering Technical Specializations – DidaTec – **Long term expert** (2010/2013)
- POSCCE-A2-O2.2.1-2013-1: The integrated platform of research-development for building extreme actions behaviour (Platformă integrată de cercetare – dezvoltare pentru comportarea construcţiilor la acţiuni extreme - ACTEX), 2013-2015, Total Revenue 21.000.000,00 Lei – **Responsible for Geomatics Laboratory**;
- SMART IT POSDRU87/1.3/S/60891 POSDRU/189/2.1/G/156555, 2015 – **Responsible for Civil Engineering Faculty, Geodesy Specialization.**

Proposed Grants 2014 – under evaluation:

- Grant PN II Partnership Romanian Bilateral Cooperation - China UEFISCDI - Monitoring Technologies Development for urban green areas using Remote Sensing. Comparative Study, Timişoara – România , Beijing – China, 2014 – **Principal Investigator;**

Proposed Grants 2010-2015:

- Grant Young Research Teams - PN-II-RU-TE-2014-4 - 3Dmodels and Open Source webGIS platforms for Cultural Heritage monitoring (MyHeritage), 2014, **Principal Investigator;**
- Grant Application Erasmus+ KA2 SP.3 Low-cost Cultural Heritage Digital Documentation (Smartphone 3D Scanning), 2014 -**UPT Responsible;**
- EEA Financial Mechanism 2009-2014 Multi-criteria optimal decision support systems in fragmented forested landscapes: EEA 2013 – **UPT Responsible;**

- International project - Modernization and Harmonization of Curricula in Cadastral measurements and Geodesy according to EU policies - Tempus Life Long Learning Programme – 2012 – **UPT Responsible.**

The results of my scientific research are materialized mainly in specialty scientific articles and books. Therefore, I have always focused on this aspect, considering that not only the quantitative aspect of the work is important, but also the quality and the value of the material published. It can be seen in the list of the scientific papers attached that I collaborated with colleagues from other Romanian universities at writing articles in my specialty.

One of my priorities in the recent years was the publication of scientific articles in conferences and journals of different scientific events, indexed in Web of Knowledge (ISI), or magazines and volumes of different scientific events also indexed in other relevant international database (BDI).

At present time, my research activity tends to be inter or multidisciplinary, involving specialists in civil engineering, environment, architects, web developers, experts in information technology, researches in the field of geosciences etc. This multidisciplinary cooperation, the contact with specialists from different research fields within the research teams I was a member of, have represented for me an important qualitative improvement. The collaboration has contributed to my training and my development from the professional and scientific point of view.

Another important component of my personal research activity consisted in the research documentation work on the subject of the international scientific activity in the geomatic engineering field. Lately, I have become more involved in taking part at different scientific committees of various manifestations or international publications, as well as in the activity of scientific referent of these publications.

During 2010-2016 I was a member of various management and implementation teams for projects financed by structural funds, national scientific competitions organized by UEFISCDI, SEE. In this context I played an active part in submitting projects with the team from Geodesy Specialization an also with coleagues from Civil Engineering Faculty, in the activities of elaboration and logistics and in getting the projects ready to take part at the competitions, respectively.

As far as the collaboration with other institutions with the same profile from abroad is concerned, I initiated bilateral agreement and partnerships for educational and research projects, Collaboration program – West University of Hungary OBUDA University, Faculty of Geoinformatics Szekesfehervar; Inter-Institutional Agreement UPT – Norwegian University of Life Sciences (UMB) Aas Norway; Bilateral protocol UPT – Military Economics Academy of Wuhan, China; Erasmus Intensive Programmes as coordinator on behalf of my university etc.).

The recognition of my activity is also marked by being a member of various professional organisations, such as: Uniunea Geodezilor din România (The Union of Romanian Geodesists), Ordinul Geodezilor din România, (The Order of Romanian Geodesists), Asociația Generală a Inginerilor din România (The General Association of Romanian Engineers), Ministerul Dezvoltării și Administrației Publice (Ministry of Development and Public Administration), EUROLIS, Balkan Environmental Association (BENA), FIG (Federation International des Geometres), Asociaţia evaluatorilor funciari din Romania AEF (Land Register Evaluators Association).

As a leader or as a research team member, involved in national and international projects, I can mention the following contributions related to the mentioned domains:

- Creating 3D models for different engineering porpose. In this large domain I would like to mention few distinguish direction: 3D models for Cultural Heritage study and reconstruction, 3D model of metallic structures or determine the quality of Pressure Vessels using precise surveying techniques.

- Studying different types of terrain instability or creating Digital Terrain Models for assesing touristic potential;
- Integrating spatial information in webGIS sollutions;
- Develop and using e-learning platforms in Geodetic Education.

The didactic dimension of my work also involves assisting several interdisciplinary PhD theses concerning the domain of Civil Engineering with geodetic component, presented by eng. Adrian ALIONESCU, Beatrice VILCEANU, Georgiana RUSU, Cristian GRADINARU, Ioan VLAD, from Politehnica University Timisoara.

The fact that important names of our domain in Romania and international experts accepted to take part to these evaluation comities as scientific referents and the fact that they truly appreciated the performed work in all cases, underlines the importance and the quality of the research and they serve as a significant acknowledgement (confirmation) of both, the thesis itself and of the researchers. In this context, I activate as an editor and reviewer for The International Conference of Numerical Analysis and Applied Mathematics ICNAAM starting with the year 2013. I have to mention that this conference is ISI Thomson Reuters indexed.

As author or coauthor, I published more than 35 research papers between 2009 and 2016 in the field of Survey Engineering, Geodesy, Cadastre, GIS indexed in international database (ISI Journals, ISI Proceeding; other International Database).

The most important papers were published in international/national recognized journals or conference Proceedings, such as: Journal of Surveying Engineering, Journal of Environmental Protection and Ecology - JEPE, Journal of Geodesy and Cadastre - RevCAD, Research Journal of Agricultural Sciences - RJAS, SGEM Proceedings, WSEAS Proceedings, ICNAAM Proceedings.

In terms of applicability of the previous research conducted, it is important to mention that the completion of the studies performed, enabled extensive measurements and performance evaluation of the actual stage of the geodetic frame in the region of Timişoara city, extended to national work and also partnerships with EU universities for international work and research. The research was materialized by its dissemination at several professional Conferences and Journals.

It has to be mentioned that for six years I was member in the management team of the Surveying and Cadastre Laboratory which is part of the CCTFC Department, within Faculty of Civil Engineering at Politehnica University Timisoara and also for the Intergraph Research Registered Laboratory (RRL). During this period the first laboratory was accredited by the National Authority in Cadastre and Land Registration (ANCPI).

In the last years, two other laboratories were also established, connected to the Surveying one. I was a key person in the constant development of these laboratories, encouraging their expansion through important research contracts both with the industrial and the academic environment with distinguish professor for European Universities. The results of my implication in development and management activity were quantifiable by constant improvement of laboratory facilities (equipment, data acquisition systems, IT infrastructure, software support etc.), i.e.: acquisition of equipment in amount of over 150.000EUR. In view of all of the above mentioned, it is considered that all the requirements for a proper research activity have been met by the existing infrastructure, with minor adjustments in the future.

In recent years I was the responsable person for Geomatic Laboratory in POS CCE program implemented by Civil Engineering Faculty.

Particularly goals of the program was to development the existing RD infrastructure and creation of new RD infrastructures through:

- the achievement of a multidisciplinary axis of research, that satisfies various RD requirements with direct impact on the economic environment, or coming from the economic environment;
- the improvement of the knowledge within priority themes of the civil engineering sector;
- the training of the human resource, in particular of doctoral students, post-doctoral students and young teaching staff;
- the increase of the participation to the RD circuit, within large cooperation and projects, nationwide and worldwide;
- knowledge transfer activities, including support and promotion of innovative solutions in industry.

Concluding, the scientific activity in the mentioned period increased constantly reaching the following level:

- ISI journals – 7;
- ISI proceedings – 15;
- BDI journals – 12;
- BDI proceedings – 11;
- Papers from International conferences – 27;
- Other Scientific events - 7
- Citations: ISI Hindex= 3, Scopus Hindex =3, GoogleScholar Hindex =4;
- Books – 4 as author/ co-author; E-books – 9 as author/ co-author;
- Research Grants: 3 international grants / projects 1 as director and 1 as member and 1 as coordinator; 10 national grants 2 as director and 8 as member; 6 grants over 10.000 EUR; 35 grants less than 10.000 EUR.

It has to be mentioned that during 2000 – 2015, I elaborated a **total number of 79 papers** and **54 projects/research grants as coordinator or member in research teams.**

1.1. ARTICLES CONSTITUTING THE HABILITATION THESIS

This is a survey of the results constituting my habilitation thesis. It is based on the following articles:

1. **Herban I. Sorin**, Muşat C.C., *Measuring and Determining the Dynamic Deformation of Constructions using Modern Technologies and Techniques*, JOURNAL OF ENVIROMENTAL PROTECTION, ISSN 1311-5065, pag 1200-1208, 2012, Accession Number: WOS:000310557300043, **(ISI Journal);**

2. **Herban I. Sorin**, Vilceanu, C.B., Alionescu A., Grecea C., *Studying the Movement of Buildings and Developing Models to Determine Real Settlements* JOURNAL OF ENVIROMENTAL PROTECTION, ISSN 1311-5065, pag 789-796, 2014 Accession Number: WOS: 000339362500044, **(ISI Journal);**

3. **Herban I. Sorin**, Vilceanu, C.B., Grecea C., Bacuca N., Bala A., *Application of Laser Scan Technology to Landslide Monitoring, Volumetric Calculus and DEM*, INTERNATIONAL MULTIDISCIPLINARY SCIENTIFIC GEOCONFERENCE-SGEM, GEOCONFERENCE ON INFORMATICS, GEOINFORMATICS AND REMOTE

SENSING - CONFERENCE PROCEEDINGS, VOL II, pag. 49-56,Albena, Bulgaria 2013, Accession Number: WOS:000349067300007 **(ISI Proceeding);**

4. **Herban I. Sorin**, Vilceanu, C.B., *Terrestrial Laser Scanning Used for 3D Modeling, 12TH INTERNATIONAL MULTIDISCIPLINARY SCIENTIFIC GEOCONFERENCE, SGEM 2012, VOL. II* , pag 795-804, Albena, Bulgaria, Number: WOS:000348532 700101 **(ISI Proceeding);**

5. Vilceanu CB., **Herban Sorin**, Alionescu A., *Processing Of Environmental Data Using Digital Terrain Models For The Western Part Of Romania*, 15th International Multidisciplinary Scientific GeoConference SGEM 2015, www.sgem.org, SGEM2015 Conference Proceedings, ISBN 978-619-7105-35-3 / ISSN 1314-2704, June 18-24, 2015, Book2 Vol. 2, 1043-1050 pp. **(ISI Proceeding);**

6. Dinu F., Dubina D., Neagu C.,.. **Herban I. Sorin,** *Experimental And Numerical Evaluation Of A Rbs Coupling Beam For Moment Steel Frames In Seismic Areas,* STEEL CONSTRUCTION, Copyright © 2013 Ernst & Sohn Verlag für Architektur und technische Wissenschaften GmbH & Co. KG, Berlin, pag 27-38, DOI: 10.1002/stco.201300005 **(BDI Journal)**;

7. Gridan R., Alionescu A., **Herban I Sorin**, *The Concept of Sustainable Development Applied to Retechnology A Hydroelectric Power Plant*, Research Journal of Agricultural Science, 43 (x), 2011, Vol 43(3) 1 - 529 (2011), **(BDI Journal);**

8. **Herban I. Sorin**, Alionescu A., *3-Dimensional Modeling for Assessment of the Touristic Potential*, 12TH INTERNATIONAL MULTIDISCIPLINARY SCIENTIFIC GEOCONFERENCE, SGEM 2012, VOL. II, pag 525-532, Albena, Bulgaria, Number: WOS:000348532700117 **(ISI Proceeding);**

9. **Herban I. Sorin**, Rusu G., Grecea O., Birla G.A., *Using the Laser Scanning for Research and Conservation of Cultural Heritage Sites. Case Study: Ulmetum Citadel* JOURNAL OF ENVIROMENTAL PROTECTION, ISSN 1311-5065, pag 1172-1180, 2014 Accession Number: WOS: 000339362500043, **(ISI Journal);**

10. Vilceanu C.B., **Herban I. Sorin**, Grecea C., 3 *E-Learning In Engineering – Impact Upon The Student's Mentality And Development*, THE 11TH INTERNATIONAL SCIENTIFIC CONFERENCE ELEARNING AND SOFTWARE FOR EDUCATION BUCHAREST, April 25-26, 2015 10.12753/2066-026X-15-000, **(BDI).**

1.2. ACHIEVEMENTS AND GOALS

The scientific research activity can be synthesized and developed on the areas listed below:

A. Main PhD activity

The fact that for my PhD thesis I had as scientific coordinator not one, but two professors of an exceptional quality (one with expertise in the field of terrestrial measurements in the person of professor Mircea Neamţu and the second one, with expertise in the field of mechanics and geotechnics), helped me understand the complex phenomenon of terrain's deformations and displacements. Implicitly, this phenomenon affects the foundation soil and the constructions built there, the two disciplines aforementioned that are interconnected are needed for a complex and eloquent study. Therefore, I understood even from the beginning of the doctoral studies that:

- it is essential to properly know the properties and characteristics of the soils on which buildings are located the are known for an effective monitoring program;
- displacement phenomena are complex and in this case taking into consideration of all factors (or most-some possible unknown) is essential in correct determination of the displacements;
- methods and models used for determining the displacements of construction must be tested and validated even during the course of our studies;
- taking into account prior knowledge leads to correct values closer to reality;
- the advantage of topo-geodetic methods as well as their usefulness in the study of constructions' deformations are proven once again in doctoral research.

B. Post-Doctoral Activity

Postdoctoral activity was materialized in several studies that have derived from the domain of the PhD thesis. In this context, I wish to recall the developed directions through research contracts conducted by groups in which I was involved:

- creating 3D models using low cost photogrammetry;
- studying, together with the colleagues from Geodesy and Cadastre collective, different engineering structures: art works located on the Caransebeş Bypass, determining the displacements and understanding of the terrain instability phenomenon's dynamics;
- studying and determination Cernavoda's bridge and bridges from Caransebes belt, etc. displacements;
- creating 3D models of metallic structures;
- development of an experimental program for planning, field measurements and processing; analysis of the experimental results;
- description of the behaviour of the local network under different models of processing; proposal of a proper transformation algorithm; comparative studies.

C. Future post Habilitation activities

- adapting and creating new models to understand and manage deformation phenomena;
- application of the terrestrial laser scanning for Cultural Heritage and industrial purposes;
- creating 3D models of heritage objects using image processing;
- using webGIS platforms to integrate 3D models and spatial analysis.

2. METHODS AND MODELS TO MONITORING THE CONSTRUCTIONS, TERAIN AND ENGINEERING STRUCTURES

2.1. INTRODUCTION

The certainty of normal operation without danger of construction is a necessity; it is a fact and a challenge for both designers of engineering structures and for specialists who are monitoring the structures and constructions behaviours.

Assessing the movements of an engineering structure, which serves as a support of the human life of today's modern world, are exhibiting safe behaviours. So, a lot of deformation monitoring studies for determining and analysing different kind of engineering structures such as high-rise buildings, dams, bridges, viaducts, industrial complexes etc., are implemented. During these studies, the used measurement techniques and systems, which could be geodetic or non-geodetic, are determined considering the type of the structure of whose deformations will be monitored, its environmental conditions and expected accuracy from the measurements. As related to the used monitoring techniques, the deformation measurement equipments are varied. Also, according to professions which use the deformation monitoring techniques, these techniques and instrumentation have traditionally been categorized into two groups: *geodetic surveys*, which include conventional (terrestrial, such as precise levelling measurements, angle and distance measurements etc.), photogrammetric (terrestrial, aerial and digital photogrammetry), satellite (such as Global Positioning System-GPS, InSAR), and some *special techniques*: geotechnical/structural measurements, using lasers, tiltmeters, strainmeters, extensometers, joint-meters, plumb lines, micrometers etc.

Moreover, a case study that describes implementing the deformation analysis of a large viaduct using different technologies from Total Stations to GPS and Precise Levelling and Laser Scan technique will be discussed here and presented by the author using different case studies.

The development of measuring techniques has permitted and created the possibility to observe and emphasize the behaviour of the studied buildings. There are lots of classification criteria, methods of research and observation of buildings and structures.

Taking this into consideration, criteria depending upon type of deformations, type of equipments and location of the equipment during the observations have been developed.

By the place where equipment is located during the observations process, there are two possibilities to determine the movements and deformations:

- physical methods: with the equipment located inside the building; in this case the equipment moves at the same time with the building, so relative movements and deformations can be evaluated.
- geometric methods: in this case, the equipment is placed outside the building or of its influential area, the measurements will be linked to a network of fixed points situated outside of the deformation area of the factors that can affect the building and the foundation ground that it is situated on.

Through this process, absolute values of the horizontal or vertical movements will be established. The topographic-geodetic methods belong to this category of movements and deformations determinations.

Monitoring the dynamic behaviour of large structures has been always a topic of great relevance, due to the impact that these structures have on the landscape where they have been built.

Many instruments and surveying methods have been used in order to support the control of these structures. However, the main aim in most of the developed plans has been to ensure the possibility of measuring displacements in a singular number of points. The difficulty in the measurement of these displacements is to find a spatial measurement technique that respond to a numerous properties, such as: precision, reliability, low cost and easiness to use.

Some of these advantages can be seen in several methods, but it is really hard to find a method compromising all of them. In the next paragraphs some of the approaches developed in this context are reported (starting with the classical techniques and finishing with the new technologies).

2.2. DIFFERENT STYLES AND MULTICRITTERIA APPROACH TO DETERMINING BUILDING DEFORMATIONS

Over the years, specialists in measurements have developed techniques and technologies to estimate correct, accurate and precise structures movements. These techniques are presented as follows:

- Classical topographic methods based on angles, distances and height variation measurements are very popular in the quantitative surveying field. The equipment used consists of accurate and appropriate theodolites or total stations. When the point that has to be determined is inaccessible, indirect methods are used, for example: single or multiple intersections.

Furthermore, contact sensors can complete these measurements, such as: an inclinometer, a pendulum, dial gauges or extensometers. However, this contact nature prevents them from use at the final stages of destructive load testing, and they can only acquire measurements in one dimension (Herban 2009).

- The Global Positioning System (GPS) has been used in structural monitoring of large structures with considerable range of displacements, as well as combined with other sensors. In spite of this, GPS has two significant limitations, as well. Firstly, as signals are received from satellites, coordinates cannot be measured indoors or through above obstacles. The second limitation is that the current precision levels of GPS are limited to +/- 1cm horizontally, and +/- 2cm vertically (Herban 2009).
- Digital close-range photogrammetry has been an alternative, and is highly accurate. It also offers a quick, remote, three-dimensional data acquisition with images that provide a permanent visual recording of the test, but the compulsory use of targets might be disadvantageous in some circumstances; especially when the access to the object is risky or when it is inaccessible to operators. Due to the lack of scale definition in the photogrammetric process, measurements must be taken by using additional instrumentation (Herban et al. 2014 a).
- Terrestrial Laser Scanning has become a new alternative to the monitoring of structures incorporating novelty approaches and computer methods. Although the approaches noted above present an accurate modelling strategy and have demonstrated their viability for structural monitoring, none of them has been tested yet over complex structures such as large and high structures. The reported analysis focuses on two main problems: the first one is the accuracy and the stability of georeferencing, which is fundamental to make comparisons between different multi-temporal scans; the second one is the computation of deformation based on the acquired point-clouds. Particularly, a comparison is performed using different surfaces types, such as: resample point cloud, mesh and polynomial surface (Herban 2009).

Determination movements and irregularities of an object in the primary analysis requirements strains in relation to time and space. Current development of constructions imposed the need to monitor changes and possible displacements. In this sense becomes critical to analysis behaviour of objects such as bridges, dams, towers, buildings with a high pitch, not only in terms of phenomenology, but also as a result of processing and the inclusion of cases in these models of analysis (Herban 2009).

Representation of deformations as a function of time schematic can be seen in figure 2.1:

Phenomenon During	Phenomenon type	Characteristics	Evaluation methods
0.01 s	OSCILLATIONS	Oscillation from own machines	Continuous measurement
1 s		Oscillation from own construction	Continuous measurement and specific geodethic methods
10 s	SHORT TIME MOTIONS	Strains under the demands dynamic short	
24 h		Strains under the demands dynamic long	Geodethic methods, fotogrametric methods, satellite methods
10 yars	LONG TIME MOTIONS	Tectonic movements Movements of the earth's crust	Geodethic methods, fotogrametric methods, satellite methods
100 years			

Figure 2.1. Schematically representations of deformations and the methods used to determinate movements (Herban, 2009)

As it can be seen in the figure above, each main measurement technique has its own advantages and drawbacks. Geodetic techniques, through a network of points interconnected by angle and/or distance measurements, usually supply a sufficient redundancy of observations for the statistical evaluation of their quality and for a detection of errors. They give global information on the behaviour of the deformable structure while the non-geodetic techniques give localized and locally disturbed information without any check unless compared with some other independent measurements (S. Erol *at al,* 2003). On the other hand, the instruments, which are used in non-geodetic measurements, are easier to adapt for automatic and continuous monitoring than conventional instruments of geodetic measurements. Geodetic techniques have traditionally been used mainly for determining the absolute displacements of selected points on the surface of the object with respect to some reference points that are assumed to be stable. Non-geodetic techniques have mainly been used for relative deformation measurements within the deformable object and its surroundings.

2.3. CASE STUDIES

2.3.1. Determining deformations of constructions, structure and terein using applied geodesy's principles

Deformation parameters are estimated based on a time series of monitoring campaigns. For each monitoring campaign the measurements contribution is in determining the relative positions of the network points and defining the datum of the network. When part of the datum definition contained in the measurements is not constant in time, the estimated deformation parameters could be erroneous. For a single monitoring campaign datum parameters contained in the distance measurements may be used for estimating the coordinates of the network points.

However, in 4D geodetic networks a part of the datum definition determined by the geodetic measurements may not remain consistent. For example, the estimated deformation parameters related to scale could be wrong in distance based networks. In this study the measurements from each campaign are stripped from their datum content by extended free network adjustment constraints. The datumless measurements are used to define the datum by preliminary coordinates and linear constraints, which remain constant for all monitoring campaigns, as well as to define the position of the network points. Later on, the variations in the network geometry can be modelled by means of a physical model (Gilad Even-Tzur 2010).

According to Chen (1983) and Chrzanowski et al (1983), the above deformation parameters in three-dimensional space can be obtained if the displacement field $d(x,y,z,t-t_0)$ is known.

The displacement field can be approximated by fitting a selected deformation model to displacements determined at discrete points:

$$d\left(x,y,z;t-t_0\right)=B(x,y,z;t-t_0)e \qquad 2.1$$

where d is the vector of displacement components of point (x_i, y_i , z_i) at time t with respect to t_o;
B is a matrix of base functional values
e is the vector of unknown deformation parameters.
The mathematical model Eq.(2.1) can be explicitly written as

$$d=\begin{pmatrix} u(x,y,z;t-t_0) \\ v(x,y,z;t-t_0) \\ w(x,y,z;t-t_0) \end{pmatrix}=\begin{pmatrix} B_u(x,y,z;t-t_0)e_u \\ B_v(x,y,z;t-t_0)e_v \\ B_w(x,y,z;t-t_0)e_w \end{pmatrix} \qquad 2.2$$

where *u, v*, and *w* represent displacement components in the *x, y*, and *z* directions respectively, and they are functions of both position and time.
From Eq.(2.2), the non-translational deformation tensor can be calculated by

$$E=\begin{pmatrix} \frac{\partial u}{\partial x} & \frac{\partial u}{\partial y} & \frac{\partial u}{\partial z} \\ \frac{\partial v}{\partial x} & \frac{\partial v}{\partial y} & \frac{\partial v}{\partial z} \\ \frac{\partial w}{\partial x} & \frac{\partial w}{\partial y} & \frac{\partial w}{\partial z} \end{pmatrix} \qquad 2.3$$

and the normal strains, shear strains and the differential rotations around *x, y, z* axes are respectively

$$e_x=\frac{\partial u}{\partial x}, e_y=\frac{\partial u}{\partial y}, e_z=\frac{\partial u}{\partial z} \qquad 2.4$$

$$e_{xy}=(\frac{\partial u}{\partial y}+\frac{\partial v}{\partial x})/2, e_{xz}=(\frac{\partial u}{\partial z}+\frac{\partial w}{\partial x})/2, e_{yz}=(\frac{\partial v}{\partial z}+\frac{\partial w}{\partial y})/2 \qquad 2.5$$

$$w_x=(\frac{\partial v}{\partial z}-\frac{\partial w}{\partial y})/2, w_y=(\frac{\partial u}{\partial z}-\frac{\partial w}{\partial x})/2, w_z=(\frac{\partial u}{\partial y}-\frac{\partial v}{\partial x})/2 \qquad 2.6$$

In addition, certain functions of these strain parameters, e.g., maximum strain (*e*), dilatation (*d*), pure shear (r_1), simple shear (r_2), and total shear (*r*) may also be of interest and they are defined as (Frank, 1966).

$$e = \sqrt{e_x^2 + e_y^2 + e_z^2} \tag{2.7}$$

$$\Delta = e_x + e_y + e_z \tag{2.8}$$

$$r_1 = e_x - e_y \tag{2.9}$$

$$r_2 = 2e_{xy} \tag{2.10}$$

$$r = \sqrt{r_1^2 + r_2^2} \tag{2.11}$$

As for the selection of a deformation model, it depends on any a priori information that is available and, especially, from whatever trend or change is exhibited by the measurements or by the location of the stations. When using the *"UNB Generalized Approach"* in geometrical deformation analysis, the whole area covered by the deformation surveys is treated as a non-continuous deformable body consisting of separate continuous deformable blocks. Thus the blocks may undergo relative rigid body displacements and rotation, and each block may change its shape and dimensions. In the case of single point movement, the given point is treated as a separate block being displaced as a rigid body in relation to the undeformed block composed of the remaining points in the network. Examples of typical deformation models in two-dimensional space are given below (Chrzanowski et al., 1983; Chrzanowski et al., 1986):

1. Single point displacement or a rigid body displacement of a group of points, say, block B can be represented as (Fig. 2.1. a) with respect to block A. The deformation model is expressed as:

$$u_A = 0,\ v_A = 0;\ u_b = a_0 \text{ and } v_B = b_0, \tag{2.12}$$

where the subscripts represent all the points in the indicated blocks.

2. Homogeneous strain in the whole body and differential rotation (Fig. 2.2. b), the deformation model is:

$$u = \varepsilon_x x + \varepsilon_{xy} y - \omega y \tag{2.13}$$

$$v = \varepsilon_{xy} x + \varepsilon_{xy} y + \omega x \tag{2.14}$$

where the physical meaning of the coefficients is defined in Eq.(2.4) to (2.6) with ω_z in Eq.(2.6) being replaced by ω.

3. Another deformable body with one discontinuity is represented in (Fig. 2.2. c), between blocks A and B, and with different linear deformations in each block plus a rigid body displacement of B with respect to A. Then the mathematical deformation model is written:

$$u_A = \varepsilon_{xA} x + \varepsilon_{xyA} y - \omega_A y \tag{2.15}$$

$$v_A = \varepsilon_{xyA} x + \varepsilon_{yA} y + \omega_A x \tag{2.16}$$

and

$$u_b = a_0 + \varepsilon_{xB}(x - x_0) + \varepsilon_{xyB}(y - y_0) - \omega_B(y - y_0) \quad 2.17$$
$$v_b = b_0 + \varepsilon_{xyB}(x - x_0) + \varepsilon_{yB}(y - y_0) + \omega_B(x - x_0) \quad 2.18$$

where x_0, y_0 are the coordinates of any point in block B.

The components Δ_{ui} and Δ_{vi} of a total relative dislocation at any point *i* located on the discontinuity line between blocks *A* and *B* can be calculated as:

$$\Delta u_i = u_B(x_i, y_i) - u_A(x_i, y_i) \quad 2.19$$
$$\Delta v_i = v_B(x_i, y_i) - v_A(x_i, y_i) \quad 2.20$$

These principles can be applied both to linear displacements or planar displacement and total deformation after adjustment will be calculated from Eq 2.12 and 2.20.

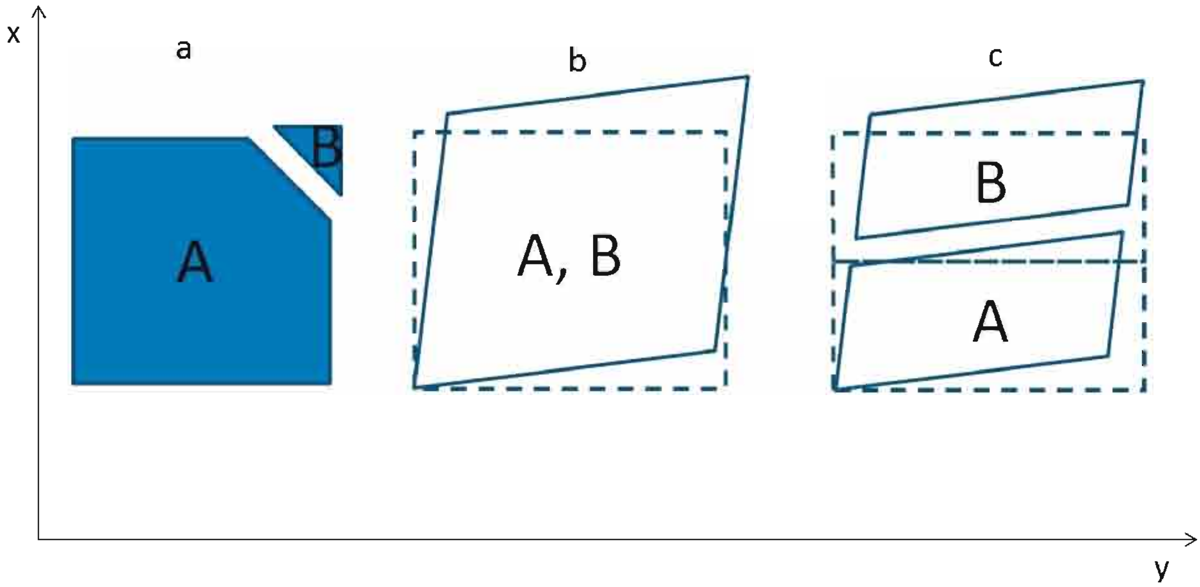


Figure 2.2. Typical deformation models (after Chrzanowski et al., 1986)

The development of measuring techniques has permitted and created the possibility to observe and emphasize the behaviour of the studied buildings. There are lots of classification criteria, methods of research and observation of buildings and structures.

Taking this into consideration, criteria depending upon type of deformations, type of equipments and location of the equipment during the observations have been developed.

Through this process absolute values of the horizontal or vertical movement will be established. The topographic-geodesic methods belong to this category of determinations of movements and deformations.

2.3.1.1. Experimental description a deformations analysis of a transport coal machine

This study is based on the experimental research, their results and interpretation which the author has developed in his PhD. thesis and that have been published in several scientific papers.

To determine the movement of some buildings or land surfaces, topographic-geodetic networks, especially created for this purpose and always updated using the most precise equipment, are used. The procedures that must be followed when creating the topographic-geodetic network belong to geodetic methods which are the oldest, most precise and accurate methods even today, being much better than those non geodetic or photogrammetric or even GPS satellite method.

During the determination of a deformation, we will always find a cause that through a transmitting function will lead to the effect (figure 2.3.). The transmitting function is expressed through mathematical relations and is part of the statistics category, we cannot be sure of what is going on just with a certain probability we can find a relationship. The effect is always the deformation, defined as a spatial modification (Herban Musat, 2007).

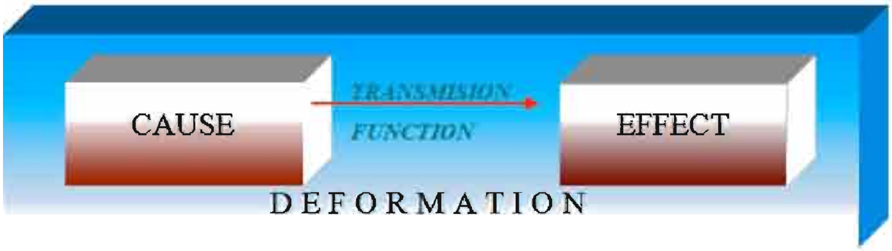


Figure 2.3. The cause-effect relationship

Taking into account the domain of use and the physical cause that generates the deformation phenomenon, we can establish the following determining cases of deformation and movement of constructions and land: tectonic conditioned movements, sliding phenomenon, diverse meteorological phenomenon, endogen causes, and proper causes of each object as well as the action of man. Use of dynamic models in studying and tracking deformations schematic can be seen in figure 2.4.

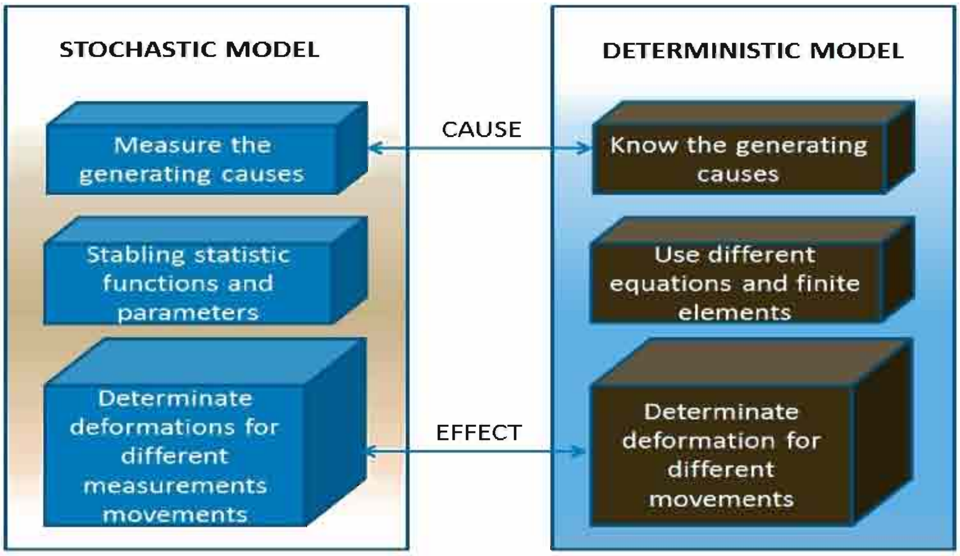


Figure 2.4. Dynamic model

The vehicle that runs on the route is a **"Vehicle for taking and staking coal"** with a frequency of 1200tons/h, type T 3214, having an arm 35m long and weighting 460tons.

The foundation of the running way is made of prefabricated cement with steel, having another layer of cement 32cm thick to fix the rail to the foundation having the rails embedded 70-80cm with small variations. The foundation is 50cm wide on the top part, and the bottom part 125cm, being at the same level with the ground and in some parts underneath this level, being covered along by coal powder (Herban at al. 2012).

This environmental strategy, in order to be properly implemented and to achieve good results for the environment, was based on a decision involving interdisciplinary and collaborative approach to environmental issues.

Therefore, across the railroad we executed 5 (five) geotechnical drills: F1, F2, F3, F4, F5 and 10 (ten) easy and dynamic penetrations: PDL, PDL2,..., PDL10 in order to determine the location stratigraphy. By means of topographic surveys, both dynamic and static monitoring of the structure has been possible. Moreover, different techniques for determining the settlements and horizontal displacements have been used and by comparison of the results it was appreciated the most accurate method.

The monitoring system of the structure was conceived to be one of long-term, therefore the rough data collected from the monitoring system will be too huge in volume to store. Thus, a special measure should be adopted to store the rough data. In addition, some data coming from the data processing and data analyses system should be managed efficiently too. A database is the optimum tool for managing huge spatial data, but in this case the characteristic of the database that contains the monitoring data is to be dynamic. The data in the dynamic database should be updated automatically at regular intervals, i.e. the existing data in the database could be backed-up and be replaced regularly by new data (Moving Objects Databases: Issues and Solutions (O Wolfsony *et al.*, 2002).

Table 2.1. Minimal and maximal values of the horizontally and vertically deviance of the railroad

Measurement cycles	Line	Horizontally deviance (mm)		Vertically deviance (mm)		Gauge deviance (mm)
		Int.	Ext.	Min.	Max.	
I	A	-45	+30	-14	-169	-36
	B	-36	+28	-14	-196	+15
II	A	-54	+43	-14	-177	-40
	B	-41	+33	-14	-213	+19
III	A	-58	+46	-14	-182	-40
	B	-46	+37	-14	-215	+22

The representation of the levelling on PDL was effected in figure 2.5.

For the plane determination from the 2D coordinates of the targeted points, a predetermined network of points is essential on the occasion of conventional instruments, for the completion of the intersection method. The third dimension can be defined through levelling. In addition to that, the existence of special geodetic targets is also of high importance.

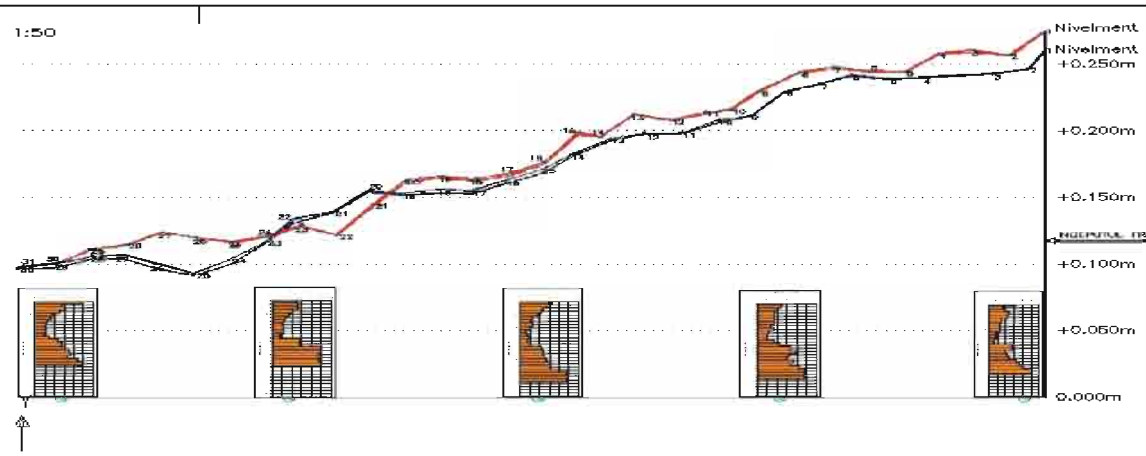


Figure 2.5. Settlements representation with PDL

However, due to the hard accessible configuration of the terrain, and sometimes its hazardous nature, the measurement campaigns have been difficult and the attachment of any kind of target to the surfaces to be monitored has been impossible. On the contrary, reflectorless instruments do not require the existence of geodetic targets, since they can directly acquire distance measurements and hence, provide 3D coordinates.

On the base of the determinations realized, some statistics have been made and are illustrated in figure 2.6, as well as the determination of the instant levelling shown in figure 2.7.

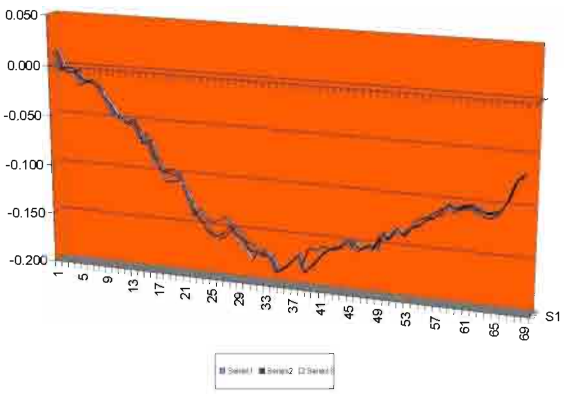


Figure 2.6. Statistical representation of settlements of A track

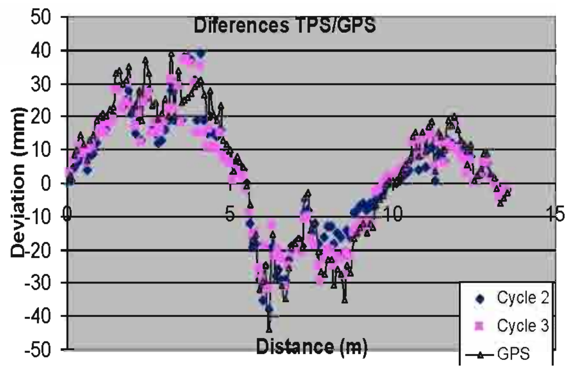


Figure 2.7. The displacement measured by GPS and Total Station Leica 1205

In figure 2.8 statistical representation of deformation in vertical plane can be seen. Also the dynamic movement of the structure was measured and represented in figures 2.6 and 2.7. The value of this deviation is very small being of millimetres.

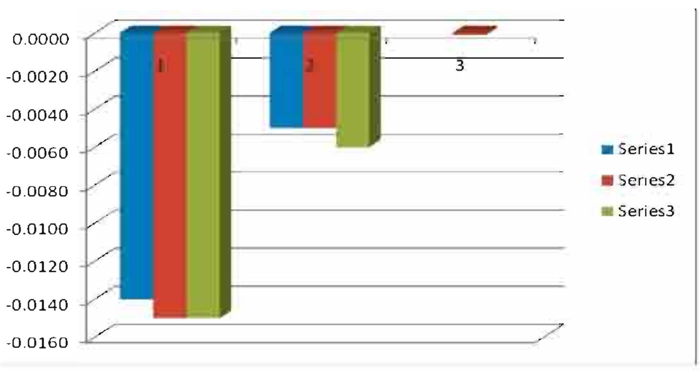


Figure 2.8. Representation of instant settlements in the right of SS PDU

CONCLUSION

The topographical methods used to determining vertical and horizontal movements are the most accurate methods for evaluating real deformations and provide security of the structure during its exploitation.

The tests executed have shown the necessity of a modern approach based on different quality reports according to the precision factors evaluated and characteristically elements of the error ellipsis for the monitoring network points.

From the results presented it can be seen that measuring the slow dynamic deformation is possible.

Non-uniform settlements contribute or induce the creation of harmful supplementary strains and efforts in the structure's elements thus facilitating the appearance of cracks in the reinforced concrete buildings or deformations in case of metal constructions. These facts impose strict and rigorous monitoring of civil industrial construction or works of art.

Direct surveying by means of topographic-geodetic methods of both vertical and horizontal constructions' displacements contribute to deepening the knowledge and representation method of the evolution of building structures, confirming or invalidating some of the assumptions defined in the design stage.

The problem of determining and measuring the construction's settlements, horizontal linear displacements, inclination of various objects requires further studies and interdisciplinary research. In this case, besides the knowledge in the field of terrestrial measurements information in the Geotechnics and foundations, constructions' and terrain mechanics domains are necessary, creating links between the science of land measurements and civil engineering.

Determination of instantaneous relative settlements under the action of external strengths and taking into consideration prior knowledge which provides information related to: the settlement's magnitude, the environment in which the movement occurs, the nature of the foundation soil and time or time frame that best captures the movement or displacements of an object or deformities have been studied and developed in the doctoral thesis.

Starting with this domain of my research, in my post-doctoral studies I was involved in some research contracts and grants where I deepened what I have studied in the doctoral period which were embodied in the following case studies:

2.3.1.2. Using modern geodetic technologies for road structure monitoring in Romania

This study is based on the scientific paper entitled "Road structure monitoring with modern geodetic technologies", written by the autor in collaboration with Carmen Grecea and Beatrice Vîlceanu, that is under review to be published in Journal of Surveying Engineering, ISI indexed.

Recently, investments have been made in the development and improvement of the Romanian road network in order to ensure enhanced comfort, safety and efficiency in transport conditions, observing sustainable development policies. The most important objective for Romanian road authorities has been to improve the safety of the road system so as to achieve a secure and efficient movement of people and goods within the public network, while effectively managing risks associated to road transport operations. Infrastructure related risks include personnel injuries and material damages which can result from physical and natural hazards, accidents and engineering failures. In this context, the present paper brings forward the applicability of state-of-the-art geodetic technologies in adjacent domains such as civil engineering and road infrastructure works, also highlighting the fact that the best solution can only be found following a thorough interdisciplinary collaboration between specialists. Thus, the study focuses on complex monitoring methods and the models used for a road structure in Romania. The main objective of the paper is to describe the methodologies (geodetic and laser scanning) used for assessing the deformations of a real road structure. By using these technologies, the authors found real deformations as well as their underlying cause, thus managing to adopt the optimal technical solution for rehabilitating the road structure. Finally, the discussed study case has provided us with highly accurate results, given that the methods and technology used have allowed millimetre-precise measurements of the displacements, linear and angular deformations suffered by the construction. The consequences of the climatic changes are making their effects present in Romania and have led to the elaboration of certain strategies (A. Răutu *et al.*, 2011), (Bennis M. and P. De Buhan, 2003), (A. Berenyi *et al.*, 2010, a) for the administration of potential risks and for the reduction of their impact, i.e.: The National Strategy for Communication and Public Information in Case of Emergency Situations, The National Strategy for the Administration of Risk in Case of Flooding, The National Strategy for the National Strategy for Climate Changes, The National Strategy for the Administration of Road Traffic Safety, The National Strategy for the administration of Emergency Situations on Public Roads, and certain guides for the evaluation of risks in the road areas.

The monitoring of road structures, of the area adjacent to the road or of motorway embankment implies, on one hand, determining the geotechnical parameters of the terrain and on the other hand, the monitoring of horizontal displacements, examination during the execution of the strength parameters of the embankment material, observations on the protection against erosion, checking of the permeability of the embankment material and of the foundation field, and the depth at which freeze occurs on the top of the embankment (A. Berenyi *et al.*, 2010, b), (A. Bobu, 2011). Thus, this application requires treating a growing volume of digital data that appear important in a raw form or indexed by one or more parameters (F. Pater, 2011). The new and performing technologies and methods used by geodesists are of great aid in better understanding of phenomenon, by precise measurements and modeling solutions (Z. Zhu and I. Brilakis, 2009) can be adopted for achieving sustainable development in road infrastructure sector.

A. TECHNICAL SOLUTION FOR THE CONSTRUCTION OF THE VIADUCT – REINFORCED EARTH TECHNOLOGY

In Romania, in the last years, a great accent is placed on complex infrastructure works that are in the framework of modern and sustainable European transport infrastructure. Thus, when designing overland communication ways works, the chosen technical solutions are realized with innovative technologies that imply monitoring their behaviour in time to demonstrate the reliability of the initial designing hypotheses. This fact can be achieved by means of topo-geodetic methods.

An eloquent example of innovative technology is represented by reinforced earth which is, in fact, a consolidation technology, i.e.: making a composite material by the association of compact layers with linear reinforcement insertions. The reinforcements can be made of metal (metallic galvanic strips with high adherence) or can be synthetic (made of polyester, coated in polyethylene). The system of precast concrete walls fixed by reinforcements in earthwork ensures a very good behaviour at earthquakes (Terre Armee Romania 2011).

The main components of reinforced earth are presented in detail in Fig. 2.9:

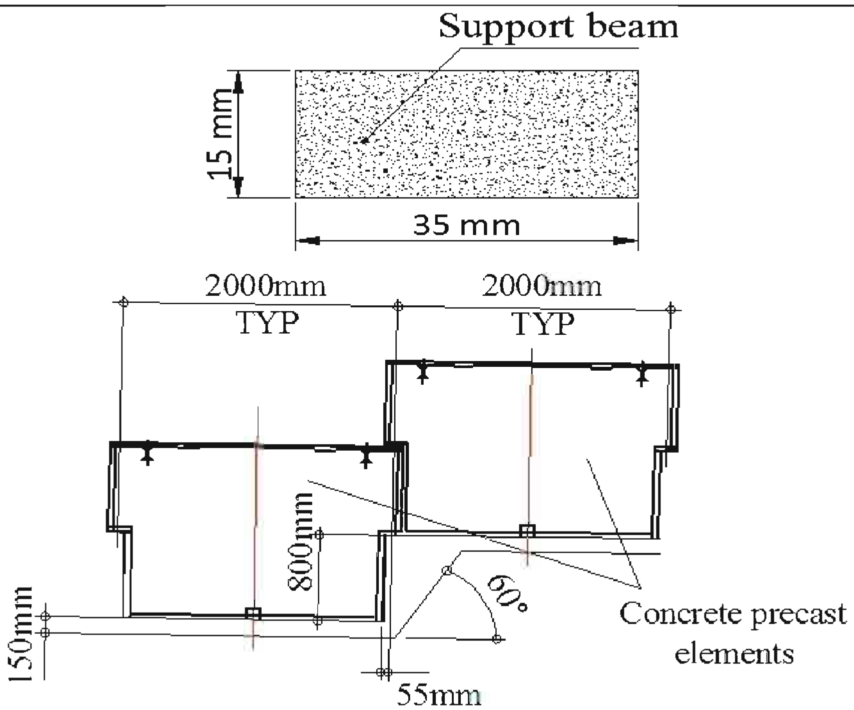


Figure 2.9. The component parts of the reiforced earth technology

In making an above-described wall type there are three main types of reinforced concrete boards C32/40, with a current thickness of 0.14m, which can vary function to the project:

- standard boards, T shape, height 1.60m and length 2.00m;
- rectangular boards, at the wall basis, height 0.80m and length 2.00m;
- cross-shaped boards, at the upper part of the wall, maximum height 2.40m and length 2.00m.

The support between the panels is made of two EPDM (Ethylene Propylene Diene Monomer) rubber plots, of 150x80x22. Their role is to distribute the pressure made by the weight of the upper boards and to absorb the differential settlement.

The reinforcement (Fig. 2.10) is made of 10 high resistance polyester beams with a low density polyether coat treated with black pigment (see Table 2.2.). They have a width of 85–90mm, thickness varies between 4–6mm. Tests effected demonstrated that there was no evidence of any migration of ions through the polyethylene barrier which protects like a shield the polyester fibre.

Table 2.2. Ordinary types of synthetic reinforcement

Minimum Resistance to breaking (kN)	Net width (mm)	Net thickness (mm)	Length of the roller (m)	Net weight of a roller (kg)	Colour of the package
30	85	2.2	100	15.7	blue
50	90	3.5	100	23.8	yellow
75	90	4.0	100	31.0	beige
100	90	6.0	100	38.5	red

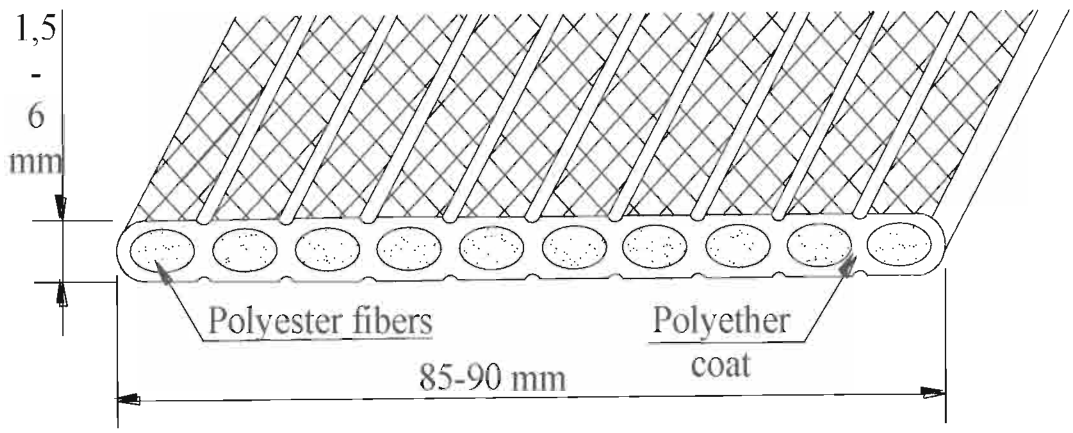


Figure 2.10. Synthetic reinforcement

Protection of the working joints is ensured by a geotextile strip, with a minimum width of 40cm, centred on the joint, and fixed on the back of the boards.

Elements for joints (working joints):

- two support boards, made of elastomer, with the size of 150x70x22mm, placed horizontally under the concrete board. Their role is to fix the position of the upper board function to the bottom one (or adjusting beam) and to distribute the pressure corresponding to their weight;
- the horizontal joint between the boards is covered with a polyethylene thread;
- for embankments with a high percentage of fine gravel, as well as for the works where there is the danger of potential infiltrations, it is used a 400mm geotextile strip which is placed exactly in the position of the horizontal and vertical joints.

The walls, according to the design norms and to the experimental determinations, have a life span of at least 100 years and are made in such a way that for their whole working period they do not need maintenance.

The applicability of this technology for the terrestrial communication roads is the following (Fig. 2.11).

In the field of roads and motorways the most used applications are support walls and support for bridges which represent the infrastructure of both urban and suburban roads, as well as rural roads in mountainous areas. The main applications include: walls to support the roads, abutments, covering walls around abutments, walls for access ramps, earthworks.

Likewise, support walls are used in many countries along railways, underground train railways or light underground train railways, since they absorb the vibrations induced by the passing of the trains very well.

Figure 2.11. Works made with reinforced earth technology

In the field of industrial constructions specific solutions have been developed for the support and for the sealing of coal mine walls or other mineral mines, for support walls of big warehouses or factories, reservoirs for liquefied gas or other hazard substances, stations for small-sized scrap and crushing. Considering its advantages, the reinforced earth is also used for the construction of protection systems, i.e.: civil, military or industrial. Among them, one can mention: many structures have withstood impacts, explosions, infiltrations with liquid gases and fire explosions. The arches associated with this technology have proved to be an efficient, rapid and economical solution for the construction of military shelters and bunkers, as well as for the transport tunnels.

In the field of maritime infrastructure, the applications along the rivers, lakes, or coast areas, as well as for the walls for piers or for the rehabilitation of the existent dams, are ordinary for the reinforced earth technology. The underwater dam walls have been made by such modified methods. These methods have been successfully used in several countries, for marine ports and fishing dams.

An original earth reinforcing procedure consists of the insertion of synthetic reinforcement connected with precast concrete panels, thus making the external surface. The originality of the system consists in the use of synthetic composite reinforcements which offers, in all the situations, very good mechanical characteristics, durability and easiness in operation. More than this, by their nature, the reinforcements are not exposed to corrosion, irrespective of the chemical nature of the earth.

B. CASE STUDY – MONITORING A STRATEGIC VIADUCT ON THE CARANSEBEŞ BYPASS

The viaduct under study was made with a reinforced earth support structure, using the technology presented above. Because of the fact that Romanian technical normatives in force impose the implementation of certain monitoring programs both for massive constructions, such as: dams, special constructions, as well as for modern infrastructure, the need for topo-geodetic monitoring emerged as soon as the construction of the viaduct was over and the heavy traffic was permitted.

The necessity of the study is also given by the fact that the viaduct under study “Valea Mică” is located on the E70 European route transport, part of the Pan-European Transport Corridor IV (road and railway) (Fig. 4) and connects the west of the country (Hungarian border) with the southern part, being situated relatively close to the “Porţile de Fier” strategic dam and hydroelectric power plant and the Serbian border.

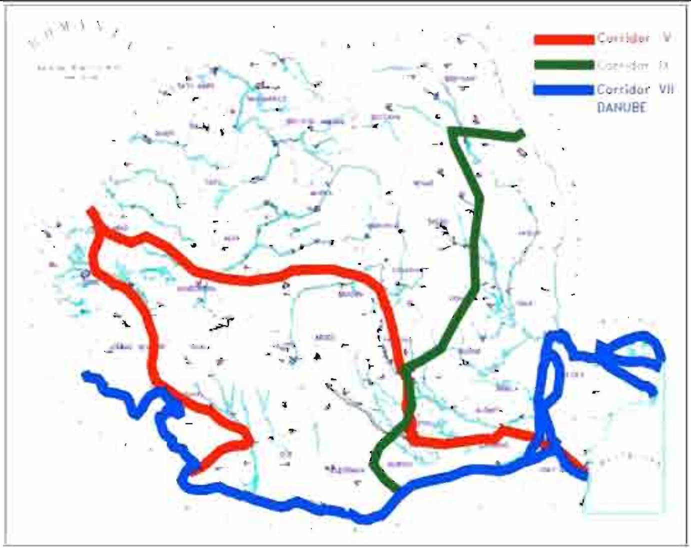


Figure 2.12. Pan-European transport corridors in Romania according to EU strategies

The monitoring process aimed at observing the behaviour in time for the viaduct "Valea Mică", in terms of determining both horizontal and vertical displacements that may occur, as this kind of structure is relatively new in Romania.

The viaduct located on the bypass of the town Caransebeş was conceived to be a flexible and sustainable structure. The monitoring methodology was conceived by the authors and followed two directions, namely a traditional survey which involved weekly topo-geodetic measurements for a period of 9 months (October 2012 – June 2013), as well as a modern approach, using terrestrial laser scanning (December 2012) that helped us getting a spatial image of the earthworks or of the reinforced earth wall support (Vîlceanu 2013). The second method of surveying was also chosen because it has already demonstrated its capabilities (Gordon and Litchi 2007) and because of the major disadvantage of total station, which is lack of detail in the surface model created in contrast to laser scanner which also allows road mapping without the need of road closure (Berenyi; Lovas and Barsi 2010a).

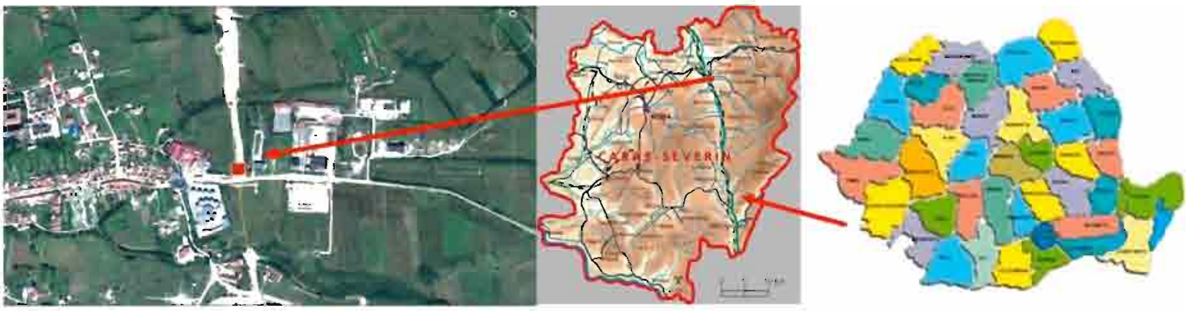


Figure 2.13. Delimitation of the study area

The placing of the monitoring benchmarks on the parament was made as shown in Fig. 2.14 (15 benchmarks on each side).

The placing of the monitoring benchmarks on the road axis was made as shown in Fig. 2.15. We have posted 12 tracking benchmarks between km 7+310 and 7+420.

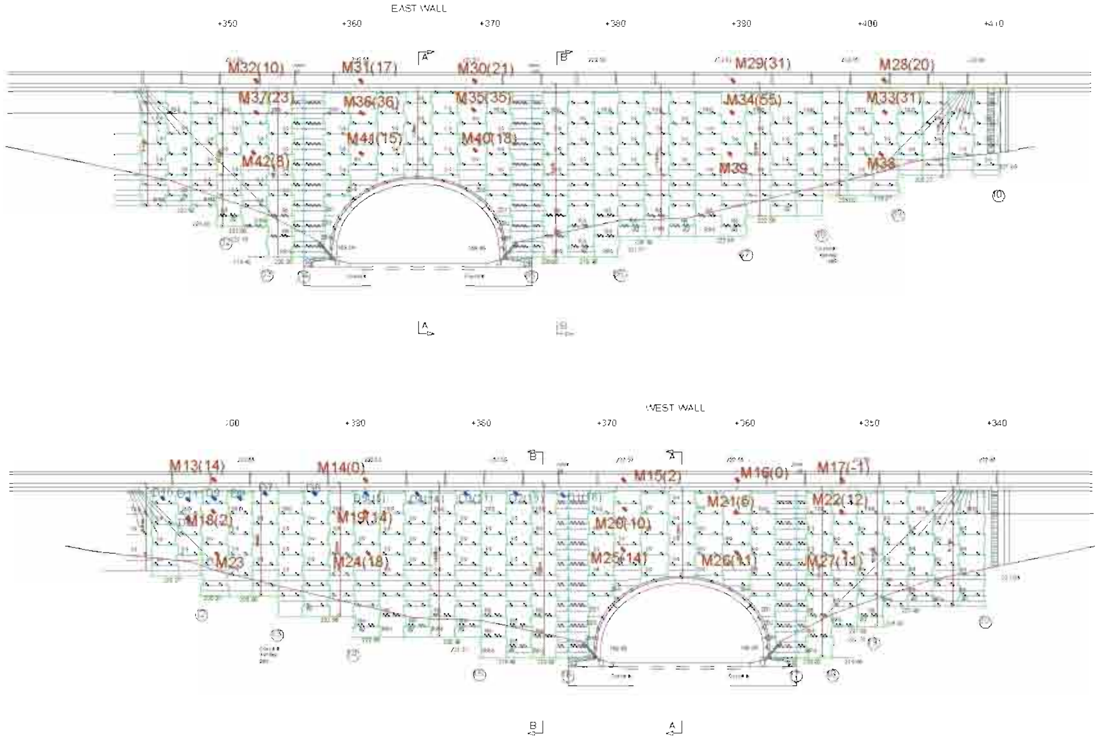


Figure 2.14. Positioning of benchmarks for monitoring the paraments of the viaduct under study

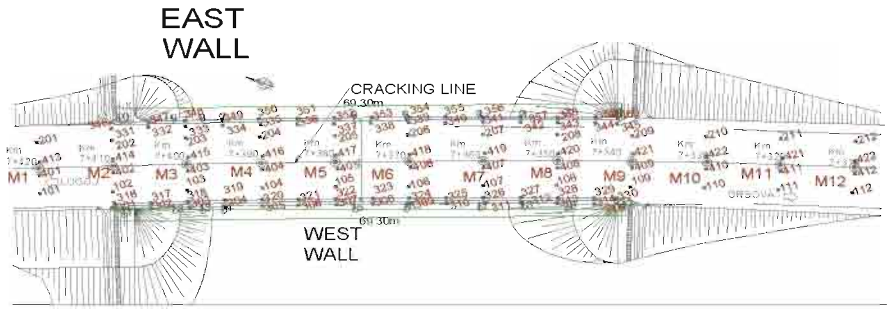


Figure 2.15. Positioning of benchmarks for monitoring the road axis of the viaduct under study

Unfortunately, during exploitation, a series of degradations occurred, among which the most important are the side displacements of the precast panels of the parament (Fig. 2.16), cracking of the panels of parament, significant rotation towards inside of the parapet beams and the longitudinal cracking in the central area of the road structure (Fig. 2.17)

Figure 2.16. Side displacements and cracking of the precast boards of the parament

Figure 2.17. The cracking line occurred in the road structure

Given the situation, the study became more important and the need to identify the causes of the degradation emerged. As a consequence, investigation measurements were needed to complete the seven stages that form an integral part of the monitoring process as suggested by Fig. 2.18.

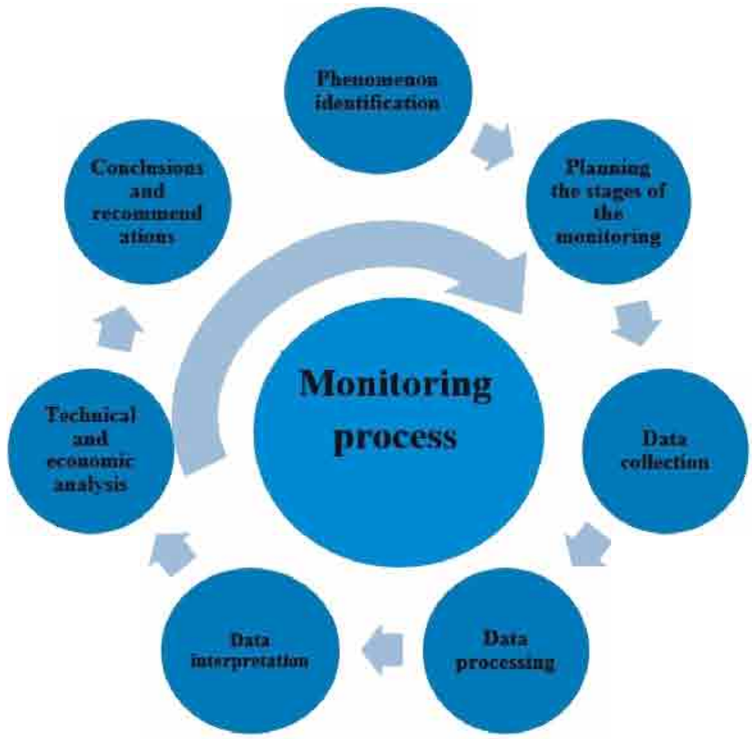


Figure 2.18. The stages of the monitoring process

Due to the fact that the first stage had been already accomplished, then the existent technical documents, such as designing layouts, reinforced earth's characteristics, geotechnical studies conducted etc. have been studied once again. To go forward, with the designer's consent, and with the aid of experts in geotechnical engineering further geotechnical investigations have been proposed. As can be seen in Fig. 9, they consisted in two geotechnical drillings/boreholes, F1 and F2; two dynamic hard penetrations, corresponding to PDG1 and PDG2, and an open geotechnical survey S1. F1 and F2 have been located in the area of the working joints, in the direction of the upstream parameter along the entire height of the embankment. PDG1 and PDG2 were placed at the same location and at the same depth. S1 made after stopping the traffic, was placed in the area of the maximum side displacements (approximately the central area, towards the uphill parameter).

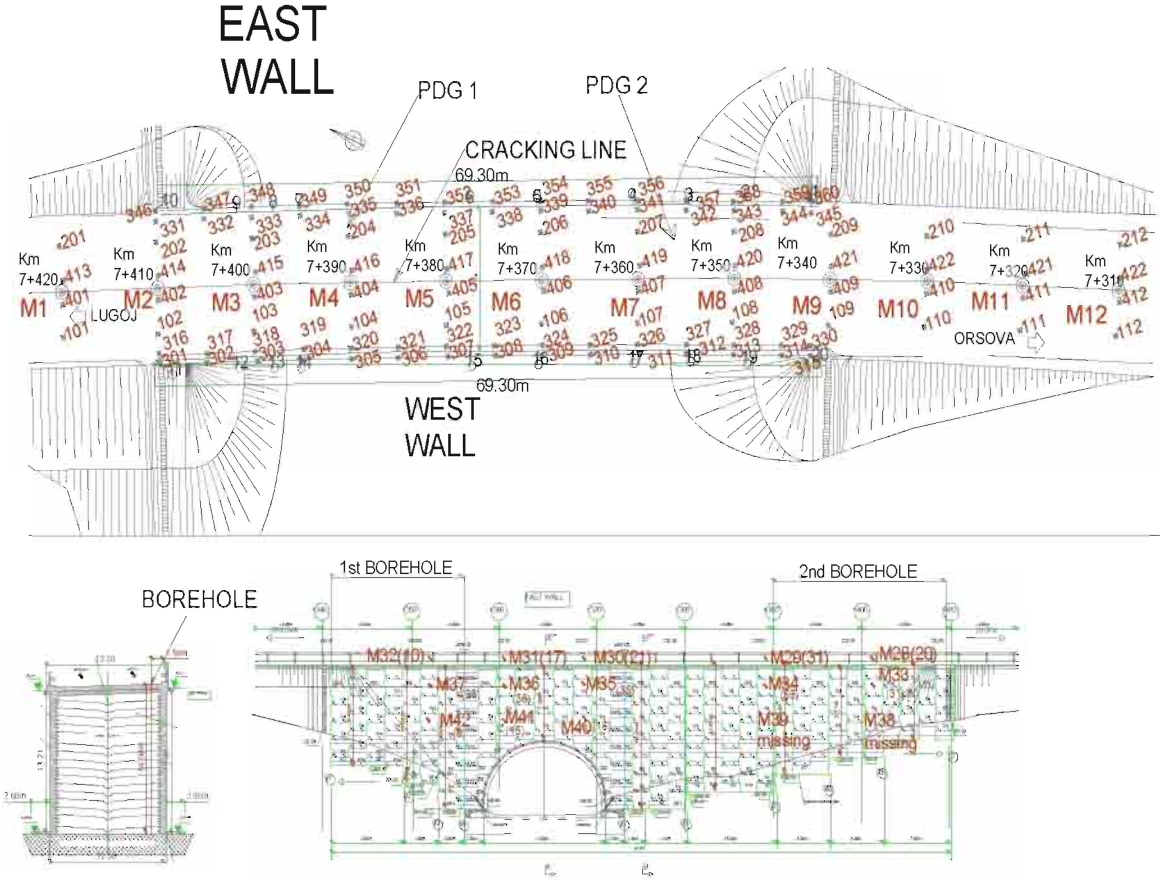


Figure 2.19. Location of the supplementary geotechnical investigations

Likewise, the focus was on a thorough topographic surveillance to analyse in time the displacements and the settlement, consisting in placing on the studied area of additional benchmarks, namely D1 – D13 (Fig. 2.20).

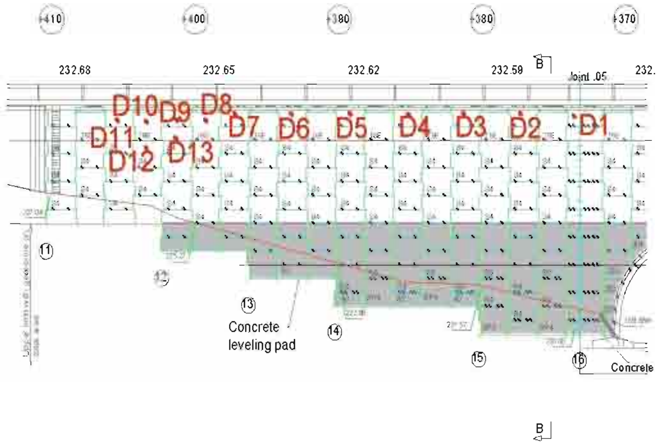


Figure 2.20. Positioning of additional benchmarks under the support beam

Following the measurements made in several cycles and the processing of the observations with specialized software, in the data interpretation stage, it was observed that the displacements inside the reinforced earth structure have increased constantly reaching the maximum admissible value of 70mm, recorded by the benchmark M34. More than this, at the area of benchmark M30 it can be noticed a breaking of the earth massif (Fig. 11, 12) which leads to a pronounced instability of the road structure.

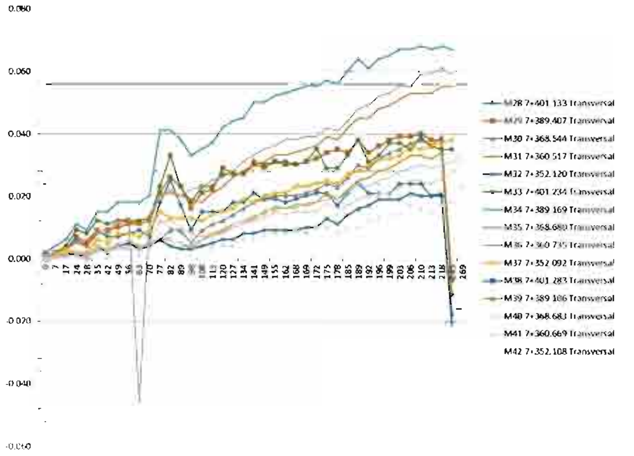


Figure 2.21. Evolution of the displacements at the viaduct “Valea Mică” – upstream parament

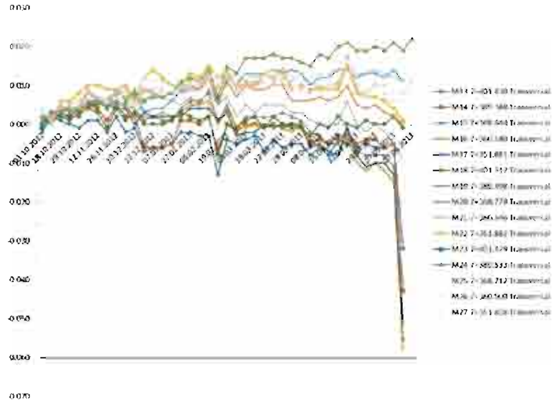


Figure 2.22. Evolution of the displacements at the viaduct “Valea Mică” – downstream parament

Regarding the representative period of time when the observation using total stations were realized, because of speed and ampleness of deformation, measurements were realized weekly for 9 months so a huge amount of data had to be managed in a short period of time

Although we had the data obtained by topographic measurements, for a better understanding of the reinforced earth structure and its behaviour we decided to further reinvestigate the problem. To do this we settled upon another modern technology i.e.: the terrestrial laser scanning which is being increasingly used for highway construction applications among transportation agencies in the United States and Canada (W. Johnson and A. Johnson, 2012). It was considered that the big advantage of using this technology is: it allows the creation of the real digital model (Styliadis and Sechidis 2011) which gives the opportunity to represent all design and fabrication information in a single integrated source (Sacks; Eastman and Lee 2004)

The accuracy of the determinations using laser scanner depends on the operator settings, has to be carefully considered (Berenyi; Lovas and Barsi. 2010b) and can reach up to 20mm, which for this study case was very good. A traditional laser scanning survey has been followed: planning, scanning and registration and QA/QC (Quality Assurance / Quality Control) (Herban and Vîlceanu 2011). The monitoring approach involved comparing the displacements with the one obtained by traditional surveys as many studies in civil engineering applications have had been previously developed and the results have proven the remarkable potential of terrestrial laser scanning (Mill et.al. 2011).

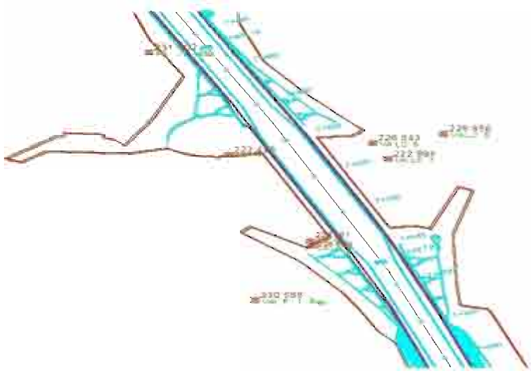


Figure 2.23. Support network made by the viaduct builder

Therefore, starting from the local support network (Fig. 2.23) made by the constructor in the execution phase of the viaduct we planned a measurement campaign using the terrestrial laser technology.

C10 ScanStation was used for scanning. The resolution of the point cloud was set to be 5cm by the operator, this indicating the level of detail of the point cloud. Georeferencing the 3D model was realized with the aid of professional targets used during on field scanning session (target to target registration of the point clouds). For a supplementary control, the positions of the professional targets have been determined previously by using the traverse method. This facilitated georeferencing the point clouds. The point clouds obtained from the 3 station points are illustrated in (Fig.2.24). The pre-processing phase consists in eliminating the erroneous data (Didulescu et.al. 2011).

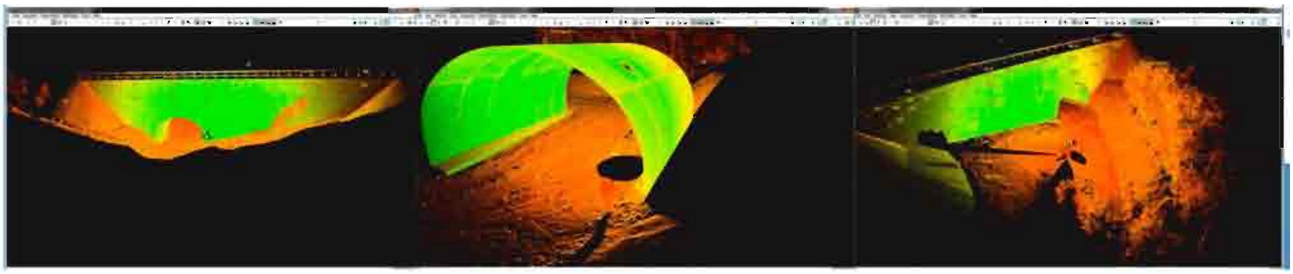


Figure 2.24. The 3 Point Clouds obtained in the scanning process

Present stage of the works consists in processing the first set of measurements made with the terrestrial laser scanner and in comparing the resulted 3D model with the initially designed one (Fig. 2.25, 2.26). In the process of determining the behaviour and stabilization of the viaduct the next step is a second campaign of measurement.

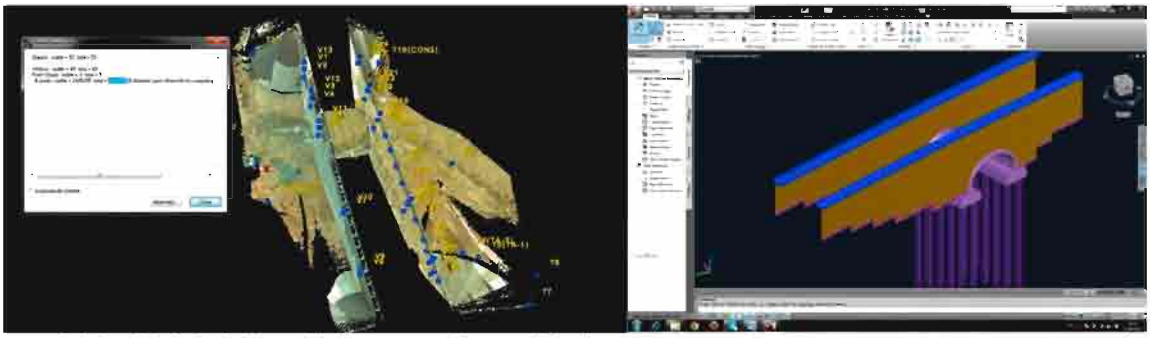


Figure 2.25. 3D Model made by scanning – 17-A and 3D model designed of the viaduct – 17-B

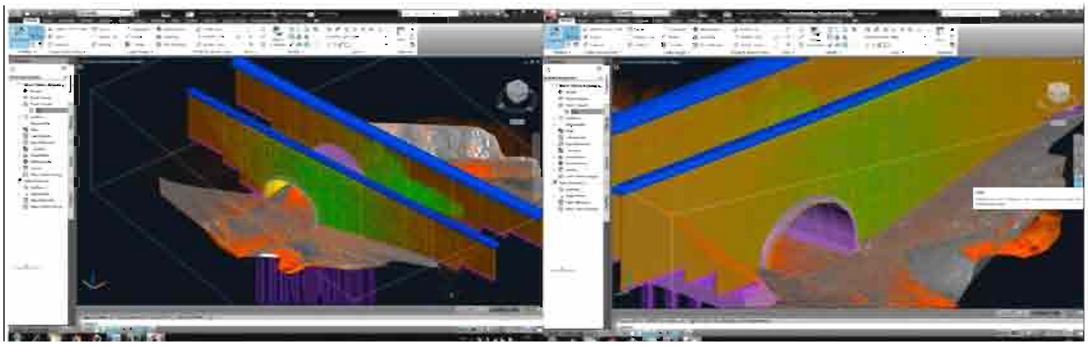


Figure 2.26. Overlapping 3D model obtained through scanning with the one initially designed

As degradations made their effect sensed with direct consequences on the comfort and safety of the transportation, the process of adopting the optimal technical solution resulted from the investigations realized upon the road structure was pushed forward. Thus, the results obtained by June 2013 had to be analysed and interpreted in order to establish the causes that led to the degradations mentioned above. Then, together with the technical crew involved (geotechnical experts) remedially solutions have been defined and presented to the viaduct builder. In agreement with the National Road Authority, and taking into account the technical solutions resulted and the economic factor, the optimal solution was represented by totally demounting of the "Valea Mică" viaduct. This meant that a second measurements campaign using laser scanning was not possible.

Following a thorough analysis of the investigations made on the road structure, the conclusion was that, the side displacements are consequences of using a material of poor quality (mediocre) on a reinforced earth structure.

The drillings showed that, in the construction stage, a totally different earth filling from what has been requested by the project (required a granular material with fine particles less than 15% and the friction angle greater than 36° as well as a certain grading diagram – and found a non-homogeneous material, powder-clayey preponderant with fine particles more than 60% and the friction angle of 19-25°) had been used.

Having in mind the benefits of the laser scanner and for the assuredness that the displacements have only affected the superior level of the viaduct, this technology was used.

Overlapping the digital models (the one initially designed with the one obtained by laser scanning) has highlighted the following aspects:

- the data obtained by terrestrial laser scanning corresponds to the traditional topo-geodetic surveys performed by observing directions and the spread of the displacements;
- the accuracy of topo-geodetic surveys is superior to scanning, reaching 0.1mm, but in this case because of the large displacements – 70mm – laser scanning proved its utility through the representativeness of the digital model created
- in this particular study case, the terrestrial laser scanning is an useful alternative to traditional geodetic surveys due to the fact that the digital model that results is accessible, easy to understand and very suggestive because of the force of the visual impact. Possible breakings of the earth massif and losses in bearing capacity are easy to be noticed on an accurate digital model.

C. CONCLUSIONS

The reinforced earth viaduct over "Valea Mică", km 7+374 (DN6) Caransebeş has a deformed structure, where different types of settlement occur due to the fact that the central part of the viaduct is supported by a reinforced concrete arch (with pillar foundation); the rest of the viaduct is supported by the natural clay soil (consistent plastic clay).

Concerning the geodetic measurements realized on the structure, they have demonstrated their utility in establishing both the causes of the side displacements and the direction of the movements. Also, by their interpretation, the designing hypotheses have proven to be right, but incondite placement of filling let to the fact that the linear displacements exceed, in some parts of the reinforced earth viaduct, the critical values.

Technically, the final solution of totally demounting the viaduct and rebuilding it as from the original design and specifications (that were not followed at the first construction stage), it was considered to be optimum because of the obvious constant degradation the structure had suffered and because of the continual growing side displacements highlighted by the topographic works realized between October 2012 and June 2013. The demounting represents a limitation of the present study because the planned second scanning campaign and subsequent comparison of the displacements could no longer be performed. Nevertheless, the single digital model obtained was of great help for the understanding of the phenomenon.

Finally, it has to be pointed out that terrestrial laser scanning technology should be used more often in monitoring the behaviour of such objectives that are part of the infrastructure road network. Because they are extremely sensitive, they also have a high risk of losing the resistance stability. The laser scanner provides a complex representation of an object in space (3D representation) by making certain measurements, both on the vertical and on the horizontal plans, at pre-established intervals.

By repeating the measurements, at a set interval the behaviour in time of the deformations and of the settlements of the contraction under study can be observed. Given the advantages of the terrestrial laser scanner technique, the data obtained is difficult or even impossible to measure with traditional topographic tools. The probability to have non-scanned areas because of shading is minimum, since one can scan from different angles and then overlap the results of the scanning. The whole visible structure of certain objects is measured and not only some predefined points, thus providing the possibility of precise investigations.

2.3.1.3. Geodetic studies with significant contribution to landslide monitoring in south-western Romania – area with high risk potential

This study is based on the scientific paper entitled "Geodetic studies with significant contribution to landslide monitoring in South-Western Romania – area with high risk potential", written by the autor in collaboration with Carmen Grecea and Beatrice Vîlceanu, which is accepted for publication in Technical Gazzete, ISI indexed.

In this chapter I would like to present some geodetic studies that are in close connection with landslide modeling and must be used for continuously monitoring the areas affected by geomorphological hazards. Although sometimes the geodesist's contribution to certain projects for landslide monitoring meant to develop early-warning-systems or risk maps is not adequately appreciated as stated in FIG Working Group (2006) and he is only seen as supplier of measured geometric data, the geodesist has a significant contribution through his abilities regarding the modelling of dynamic systems, like strategic constructions (dams, tall buildings etc.) or landslides and data interpretation.

The study of how an objective affected by landslides behaves in time implies geodetic measurements performed at pre-set time intervals using state of the art technologies, which allow processing and review of data thus obtained in a three-dimensional system. Moreover, the goal is to set the stage for the shaping and optimization of monitoring networks by choosing the optimal research methods to be used.

A. INTRODUCTION

The specialists (D. Li *et al.*, 2009) drew attention to the fact that 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 (IPPC, 2007).

Recent studies (M. Giardino *et al.*, 2012) that have been conducted show that a very important role in hazard monitoring is played by geodetic technologies, namely GPS (G. Liu *et al.*, 2005), remote sensing (P. Canuti *et al.*, 2004), (P. Farina *et al.*, 2004), InSAR (Y. Yin *et al.*, 2010), LiDAR (F. Ardizzone *et al.*, 2007), TLS (P.E. Miller *et al.*, 2008), (L. Sui *et al.*, 2009), GIS (F.P. Da Silva and D. Bălteanu, 2009), (F. Mancini *et al.*, 2010) due to their known advantages (F. Guglielmino *et al.*, 2012) in obtaining pertinent results related to 3D models of landslide affected areas and risk assessment.

Taking an overall view of the risk potential to landslides on the territory of Romania (Fig. 2.27), the necessity of studying these phenomena at regional level emerges, taking into account natural and anthropogenic factors in the area, to ensure the comfort of life, property that can be affected, planning space and land use, infrastructure upgrade, long-term resource management and adopt preventive measures for improving reactions to extreme natural phenomena.

The south-western region of Romania deals with instability phenomena, requiring timely detection of slide prone areas, in order to establish prevention methods and update the existing risk maps, issue also debated in (D. Bălteanu *et al.*, 2010), (I. Stoian *et al.*, 2011).

Landslides are not characteristic to the Mehedinţi County, but in recent years there have been many such phenomena due to heavy rainfall, massive deforestation and lack of banks and slopes along overall communication ways.

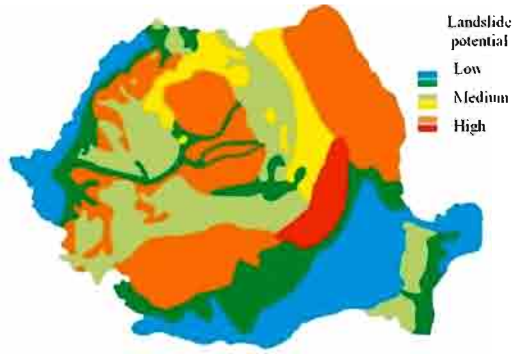


Figure 2.27. Romania – country with landslide potential (S. Manea and E. Olinic, 2009)

The case study detailed in this paper aims to describe the methodology of monitoring the phenomenon of instability that has affected the access road to Aeolian plants of 3MW located on the Dranic peak in the Mehedinţi County by an overview of the geodetic measurements conducted. Current works include the processing of two sessions of geodetic measurements realized in order to determine the behaviour of the slope in time. The need for landslide monitoring is imposed by national legislation and policies of sustainable development.

What the present paper brings as innovation is that it proposes a work methodology that comprises complementary methods and technologies from the field of geotechnical and geodetic engineering that can be used for the evaluation and monitoring of landsliding risk generating processes. At the same time, the capabilities of programs specialized in 3D data processing (C. Didulescu *et al.*, 2011) will be demonstrated, namely to generate real results when it comes to volumetric calculations.

As a follow-up study to previous primarily field-based geotechnical studies by the authors (C.B. Vîlceanu *et al.*, 2013) and according to the Romanian normative NP 074/2007 (NP 074, 2007) entitled "Normative on the principles, exigencies and methods for the geotechnical research of the foundation ground", we have established the level of the geotechnical risk for the road infrastructure by combining some information on landslide phenomena and geologic conditions, as shown in Table 2.3.

One point is added to the total score obtained by the 4 factors and it corresponds to the calculus of the seismic area of the location. We obtain a total score of 15 points, which ranks the work in the "major" risk geotechnical category and from the geotechnical category point of view in category 3.

Table 2.3. Level of the geotechnical risk for the road infrastructure

Factors of influence	**Characteristics of the location**	**Points**
Soil conditions	Sliding soils, and soils with heaves and big contractions	6
Underground water	With normal dewatering	2
Classification of the construction according to the category of importance	Normal	3
Neighbouring	Moderate risk	3
TOTAL SCORE		**14**

B. DESCRIPTION OF THE INSTABILITY PHENOMENON

In February 2011, at km 1+642 of the road situated in a road curve, a landslide was produced, having a width of 40m and a length of 70m, downstream of the slope as illustrated in figure 2.28.

Figure 2.28. Geographical location of the studied area and the first landsliding in 2011

We have to consider the fact that Aeolian plants 3MW were placed on the Dranic Peak (Dranic Slope), i.e. this implied the transport of the materials needed in order to make the foundations, the transport of the proper equipment, therefore the infrastructure as well as the superstructure of the technological road have been affected since they were not designed for heavy traffic.

The main factor that led to the instability of the roadway was the breakdown of the natural slope, from downstream up to the torrential valley placed at the foot of the slope, as a consequence of the excessive humidity of the area. Additional factors that led to the phenomenon were the following: the vibrations induced by the heavy traffic and the pressure exerted on the foundation soil.

C. MATERIALS AND METHODS

Geodetic methods as well as modern technology such as GPS (L. Manetti *et al.*, 2002) and TLS have been used for materializing a comparative study of digital terrain models of the area affected by the described landslide obtained both with the TCRA 1205+ total station and with the C10 Scanstation terrestrial laser scanner.

Local geodetic support network

In May 2012, after the field analysis and study of the existing materials, we created a support geodetic network which consisted in 7 points. The 4 geodetic height datums (GPS1, GPS4, GPS2, RGPS2) were materialized in the field under the form of reference marks type FENO (Fig. 2.28.) which were placed on safe grounds. The distance ranges from 200-300m from the phenomenon observed in order to eliminate any possibility of being influenced.

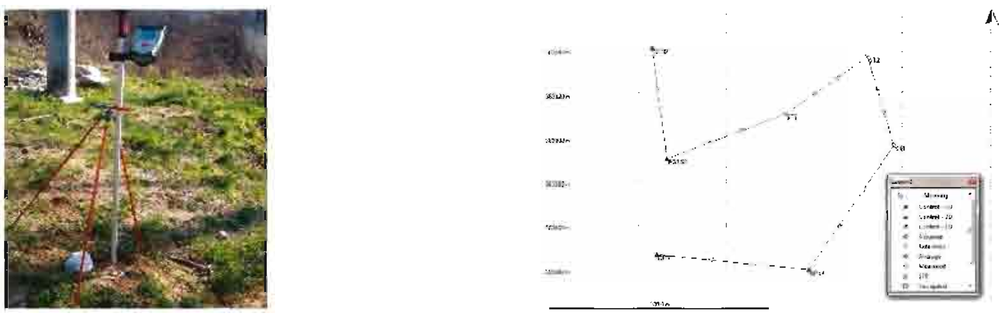


Figure 2.29. Marking of the FENO reference mark and the sketch of the geodetic support network

The point coordinates in the local geodetic support network were determined using GNSS technology, with the aid of the RTK Romanian Position Determination System service, by connecting to the Drobeta Turnu-Severin permanent reference station inside the national GNSS permanent network stations (RN-SGP). The projected accuracy of the network points is according to the RTK service of the GNSS network of reference stations, namely smaller than 5cm. As regards the accuracy of the transformation parameters, it is given by the Romanian official projection system, 1970 Stereographic system.

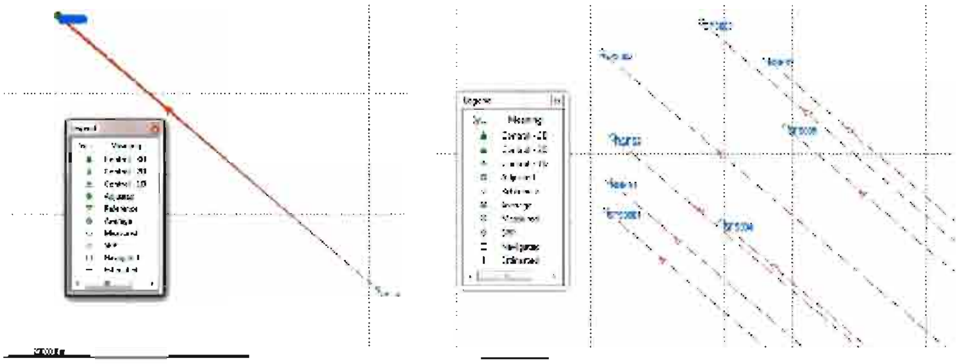


Figure 2.30. Sketch of the RTK network materialized

To assess the accuracy of the calculations, the error ellipses are highlighted for each traverse point and it is observed that the values of their semi-axes correspond to a class of very high precision – millimetre values, the maximum being 2.3mm (Fig. 2.31.) for the major semi-axis of the ellipse of ST1 traverse point.

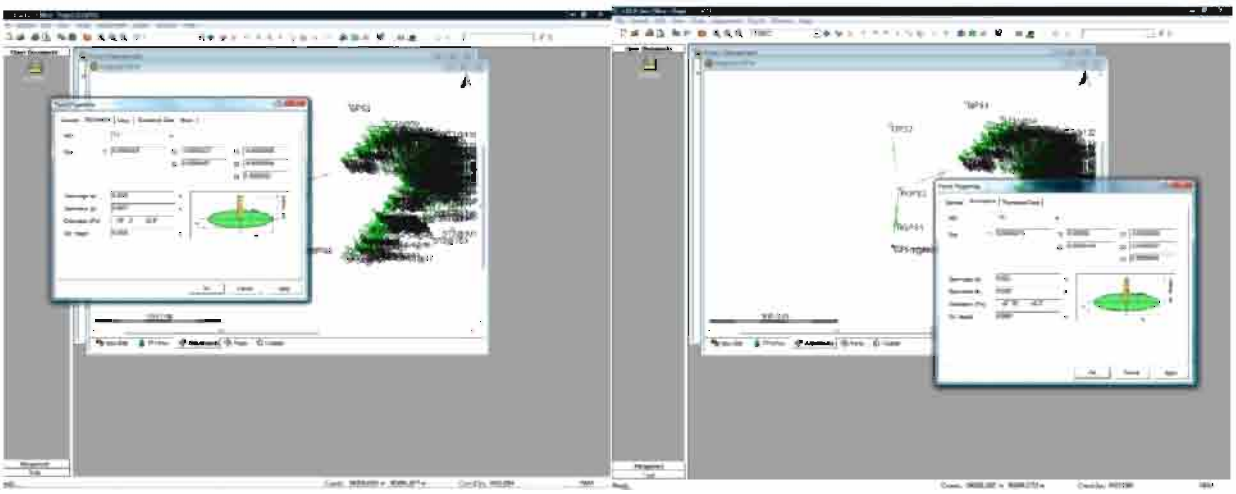


Figure 2.31. Traverse report, Error ellipses

The point coordinates are shown in table 2.4.

Table 1.4. The reference mark coordinates in the local geodetic support network – 2012

Station	Easting	Northing	Height
GPS4	296517.5931m	363839.7123m	131.1902m
ST1	296555.6426m	363896.1986m	138.8403m
ST2	296543.8275m	363936.6568m	145.4058m
ST3	296506.3540m	363910.4718m	150.1728m
RGPS2	296452.9216m	363890.1311m	156.3458m

In 2013, the point coordinates in the local geodetic support network were determined again (Tab. 2.5) in order to establish both the compaction and the displacements of these reference marks (Tab. 2.6) illustrated in figure 2.32.

Table 2.5. The reference mark coordinates in the local geodetic support network – 2013

Station	Easting	Northing	Height
GPS4	296517.5918m	363839.7145m	131.1866m
ST1	296555.6444m	363896.1986m	138.8301m
ST2	296543.8280m	363936.6588m	145.4014m
ST3	296506.3520m	363910.4729m	150.1645m
RGPS2	296452.9220m	363890.1338m	156.3374m

Table 2.6. The horizontal and vertical displacements between 2012 and 2013

Point	Δy(m)	Δx(m)	Δh(m)
GPS4	-0.0013	0.0022	-0.0036
ST1	0.0018	0.0000	-0.0102
ST2	0.0005	0.0020	-0.0044
ST3	-0.0020	0.0011	-0.0083
RGPS2	0.0004	0.0027	-0.0084

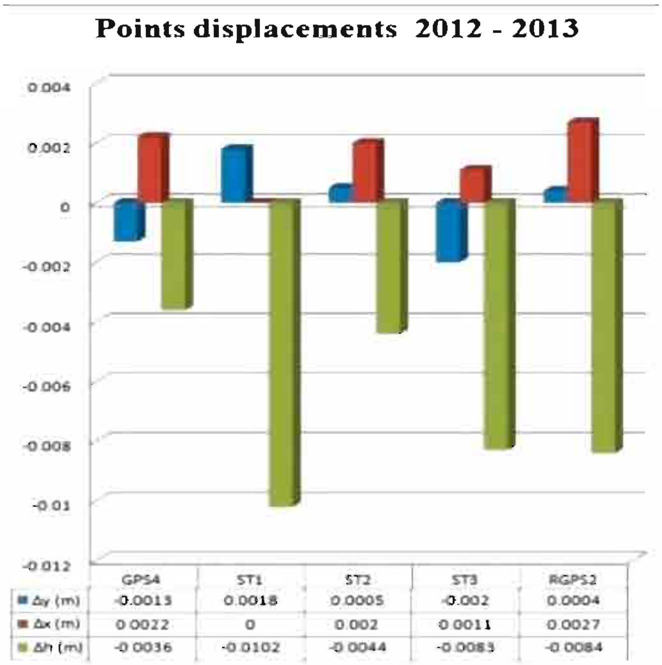


Figure 2.32. Graphic representation of the reference marks displacements

Post processing of the measurements

In order to obtain the digital terrain model, the measurements must have a tridimensional character. The survey was realized using Leica TCRA 1205+ total station and the points on the body of the landslide have been collected in a manner that describe contour lines.

After performing and processing the measurements, files containing the planimetric coordinates of the points and their heights resulted. Then, these files have been imported into special software, Golden Surfer 9 and Civil 3D 2013, in order to create the DTM (digital terrain models) which may be useful 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.

Civil 3D processing

Post processing of the data started with the plotting of points on the orthophotoplan and then contour lines and 3D surfaces were created for both measurements campaigns as seen in figures 2.33, 2.34, and 2.35.

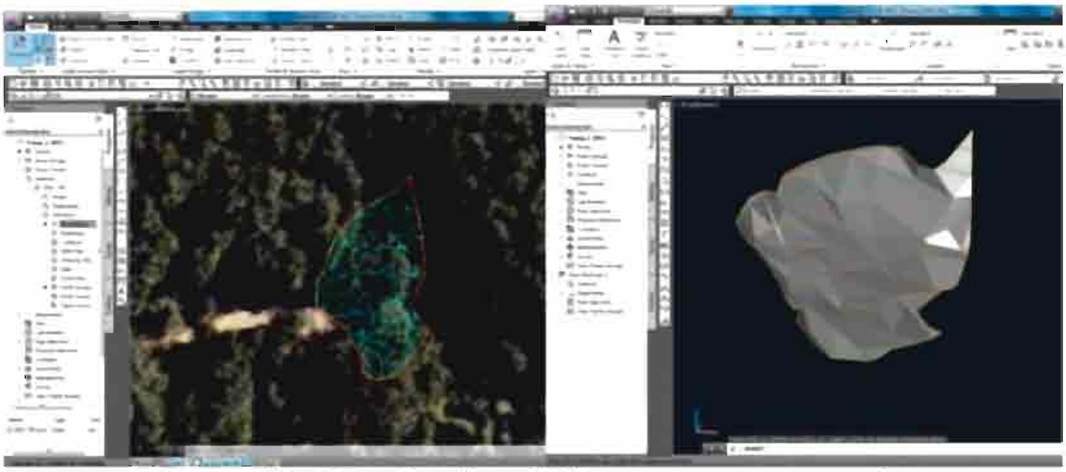


Figure 2.33. 3D surface from 2012 measurements campaign

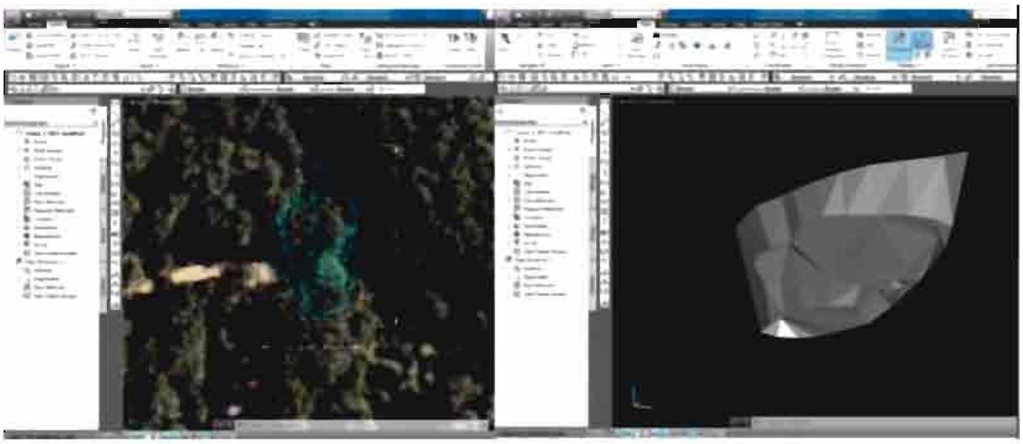


Figure 2.34. 3D Surface 2013 measurements campaign

For a comparative study, firstly we calculated the volume using TopoLT software, thus resulting the three-dimensional model of the terrain based on surveyed points with known X, Y, Z coordinates or spatial lines and polylines. The interpolation method for this version of the program is only the triangulation method with linear interpolation (Triangulation with Linear Interpolation).

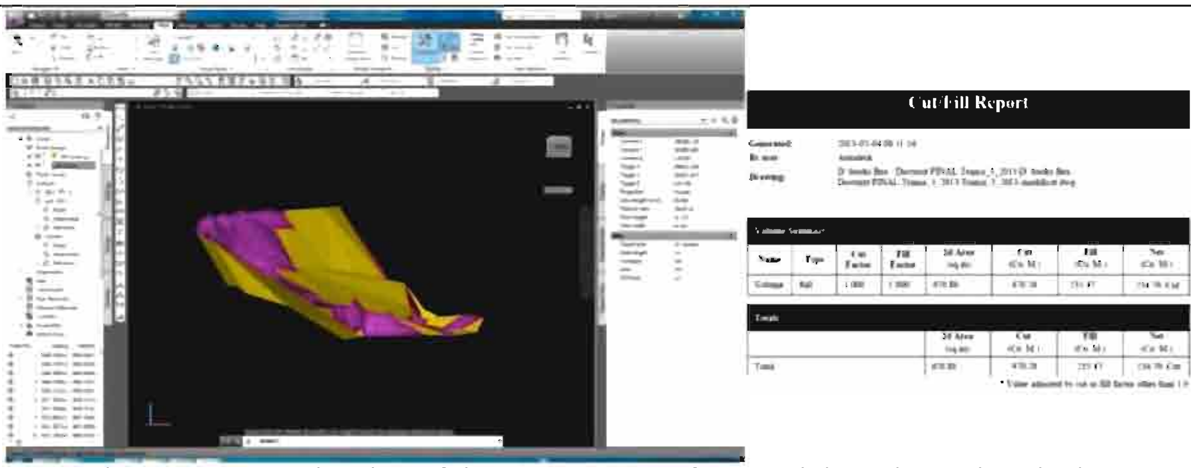


Figure 2.35. Overlapping of the 2012-2013 surfaces and the volumetric calculus

The final stage consisted in calculating the volume of the landslide to be able to compare it to the data obtained with the second program. Thus, we could identify which is best to be applied in the case of landslides and which provides the best results.

Golden Surfer 9 processing

The principle of processing the measured data is the same as the one previously described. The only difference is the fact that this programme implies the creation of some initial grids with the help of the coordinate files X, Y, Z from the measurement campaigns of 2012 and 2013.

The contour lines for the studied area, schematic views of the created 3D object form and structure (Wireframes), shaded reliefs and the 3D models (Fig. 2.36) have at the basis the grids that have to have the same limits for each measurement campaign.

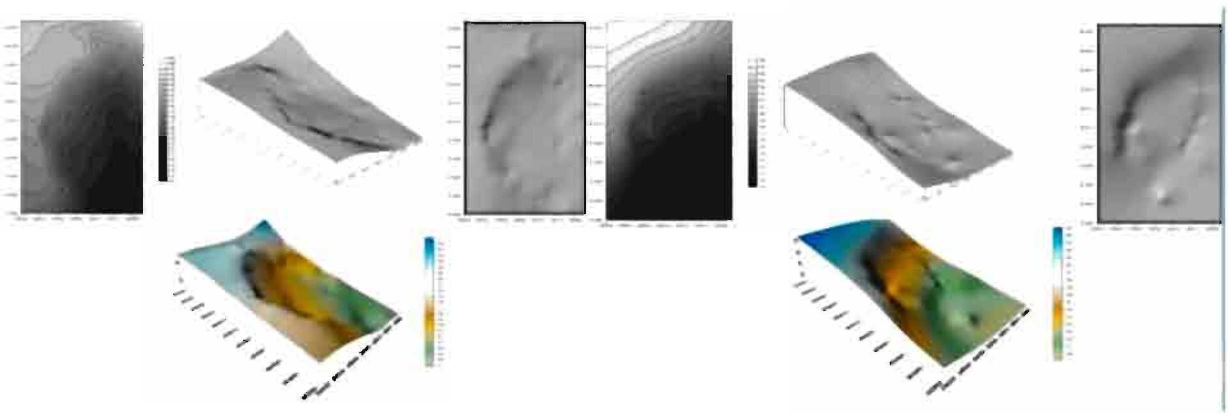


Figure 2.36 Digital terrain models of the area affected by landslides, from km 1+642 (on the technological road) between Orşova and the Topleţ Plateau, Dranic peak, 2012 (on the left side) and 2013 (on the right side)

To be able to calculate the volume difference between the 2 measurement campaigns (2012 – 2013) we have to establish the interest perimeter. Out of the perimeter of interest we extract the coordinates X, Y of the points which define the contour and we create a new coordinate file. We used programme Dxf2xyz 2.0. to be able to extract the point coordinates out of the file type .dwg which define the perimeter (Fig. 2.37.).

The coordinates thus obtained are introduced in the Surfer 9 specialized software, creating a new work sheet.

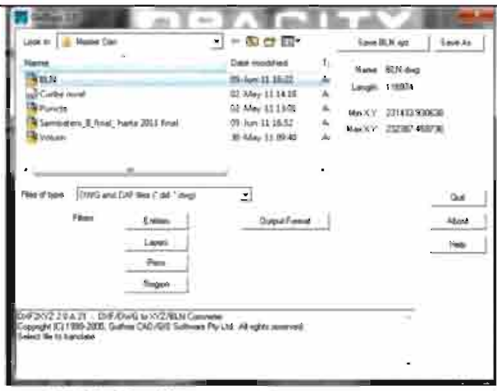


Figure 2.37. Dxf2xyz 2.0 programme interface

Above the first column we write the number of points that delimit the perimeter and which coordinates have been introduced.

Above the second column we write figure 0, which signifies the interest zone. Figure 0 coincides with the interior of the perimeter and figure 1 with its exterior. Likewise, in order to suggest to the program a correct closing of our perimeter, the coordinates of the point 1 will have to be reintroduced at the end of the columns of the coordinates created. Then we have to save the modifications of the perimeter file, introduce a suggestive name, and choose the corresponding extension, i.e. .bln. Thus it can be made 3D models of the interest area in the program (Fig. 2.38 and 2.39).

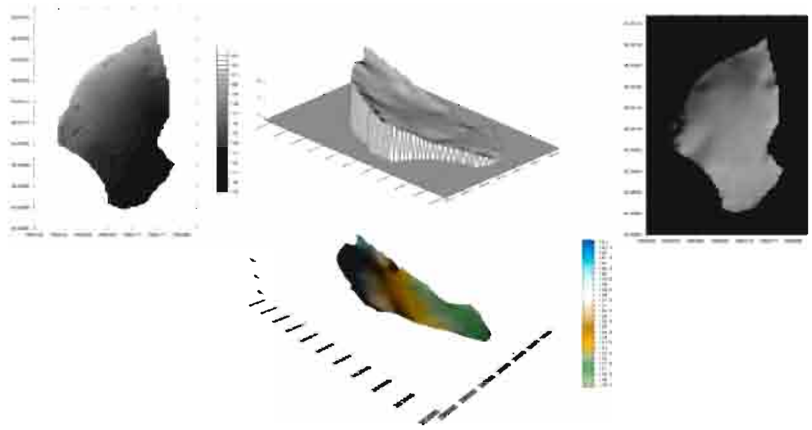


Figure 2.38. The 3D model of the interest zone – 2012 measurements campaign

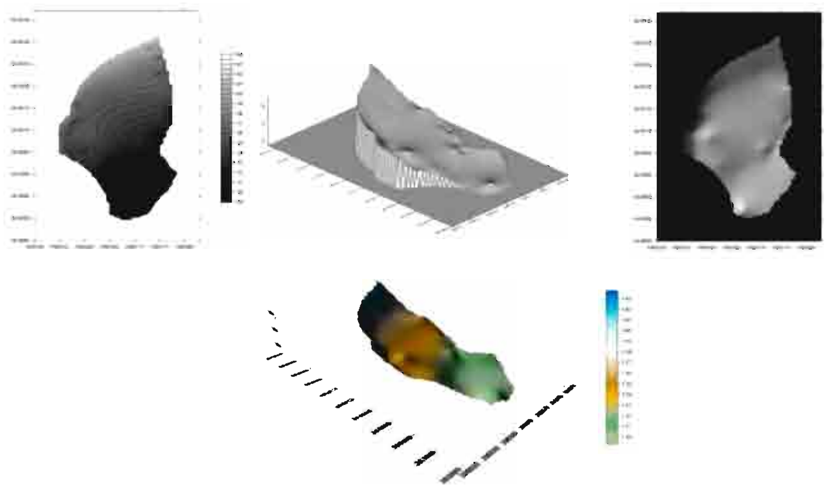


Figure 2.39. The 3D model of the interest zone – 2013 measurements campaign

Before starting the proper volumetric calculus shown in table 2.7 we overlap the grids created initially with the file of the perimeter obtained. Program Surfer 9 will then generate a report with the data on the volume of the existing earth in the interest area.

Terrestrial Laser Scanning processing

The scanning field campaigns have been performed at the same time with the topographic measurements effected with the total station that we have previously described.

The digital models of the scanned terrain (Fig. 2.40) were obtained following the use of a data filtering algorithm. This enables the point clouds to be separated from those points that are not relevant for creating the desired surface; operation that is possible by means of setting a rectangular network at equal distance specified by the user. Around the intersection points of the grid, the cylinders will be developed (automatically, by means of a program function), inside which the points with the lowest height will be searched. All points with the lowest height found inside the cylinders will be added to a Surface in Civil 3D, which actually represents the digital model of the terrain.

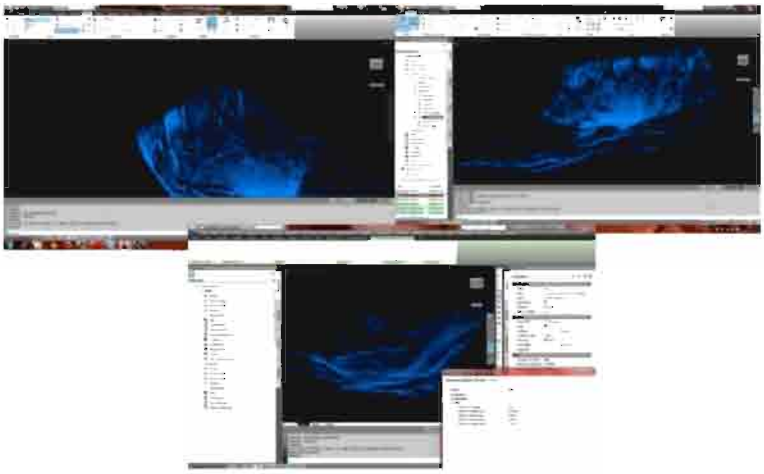


Figure 2.40 TIN surfaces after TLS data colection

Figure 2.41 illustrates both the overlapping of the two 3D surfaces created in order to determine the terrain's displacements and the producing of longitudinal profiles through the overlapped 3D surfaces needed for the highlighting of the landslide volume difference between the 2 measurement campaigns (2012 – 2013).

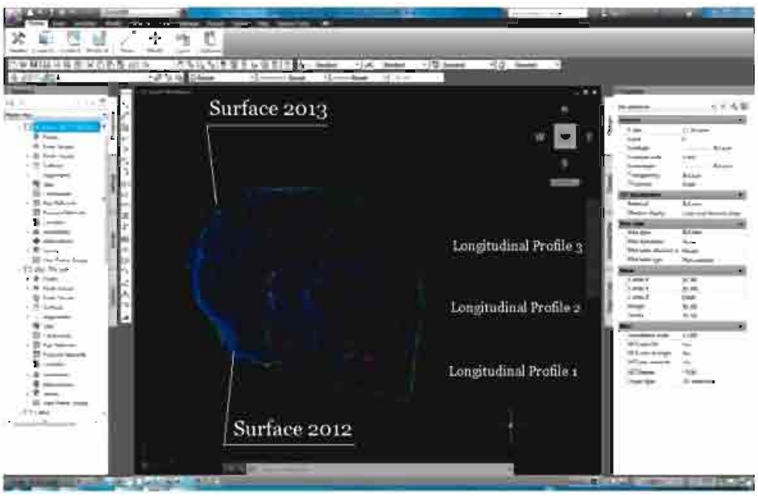


Figure 2.41. Overlapped 2012-2013 surfaces and directions for creating profiles

The next stage consisted in creating a new surface (Fig. 2.42), namely "Volume surface" which shows the settlings and is useful in the quantitative assessment of the landslide volume. After that, the interpretation of the obtained results becomes effortless, for example a visual analysis reveals the fact that the nature and extent of the displacements were highlighted so one may easily perform a visual inspection in order to identify the landslides (S. Herban and C.B. Vilceanu, 2012).

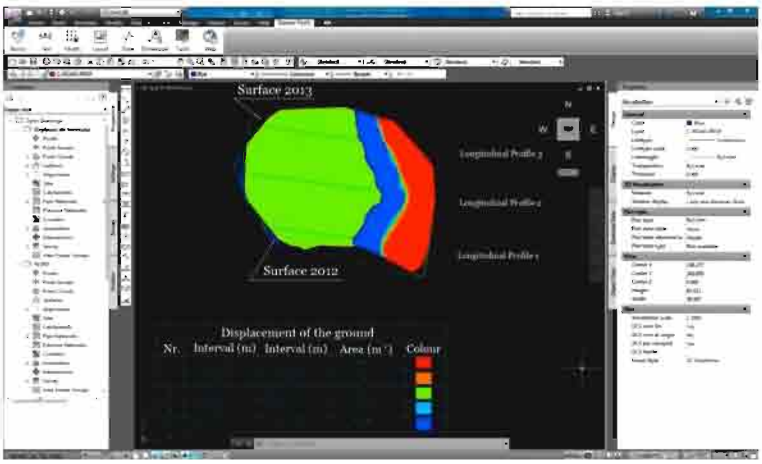


Figure 2.42. Terrain displacements – Instability analisys

As it arises from figure 2.42, the most important displacements appear in the areas symbolised with red and orange colours. The red colour signifies the largest displacements contained in the interval [-500mm, -200mm] which are located at the upper part of the landslide and have affected the access road. The lower part of the slope was the less affected, the displacements being situated in the interval [-50mm, -2mm] (Tab. 2.7)

Table 2.7. Volumetric calculus between the 3D models 2012-2013

Criterion	Total station TCRA 1205+		Scanstation C10
	Civil 3D 2013	**Surfer 9**	**Civil 3D 2013**
Volume of the landslide	470,26m^3	482,041m^3	477,530m^3
Volume of the filling	235,47m^3	227,005m^3	228,270m^3
Difference between the landslide volume – filling volume	234,79m^3	255,035m^3	249,260m^3

D. RESULTS

The landslide studied is of low depth, having a sliding plan situated at a distance of -5m, and the displacement speed can be characterized as slow. As far as the sense of displacement is concerned it is of progressive type.

To study the landslides and to highlight their characteristics (E. Călăraşu et al., 2009), a comparative study of the study results of modeling has been made with the help of the Program Surfer 9 and Civil 3D 2013. Thus, for the study made on the access technological road, Dranic Peak – Orşova, it can be noticed that the Program Surfer has several advantages in comparison with Civil 3D:

- from the visual point of view the models made with the Program Surfer provide more information on the studied phenomenon to the specialist. On the 3D model obtained as a result of the measurements made in the year 2013 it can be seen the ditches made by the meteoric water. Thus it can be easily concluded that the yielding by sliding of the land massif was caused by excessive humidity and by the fact that the meteoric water ponds at the foot of the slope and infiltrates itself in the land massive, transforming the dusty clay layers and the sandy clay layers into soft sliding soils;

- it does not require complex 3D modeling knowledge, since it has a friendly interface and suggestive commands;
- it allows the visualization of colour scale bars for a better understanding of the 3D model created, unless the drape option is used;
- it has a lower price.

As far as the geodetic measurements are concerned we made a SWOT analysis of the obtained results.

As less favourable aspects we can mention some limitations. The initial idea was to make a digital model of the land affected by instability by digitalizing the level curves on the existing maps to be able to make a comparison between the 3 methods of obtaining these models. We found out that this type of processing is possible only if we have access to topographic plans at high scales, which also contain the level curves. More than this, the study area should be well represented, especially if it is of small dimensions, or, if the modeled zone is vast. Anyway, at this kind of study the precision of this type of processing would have been the lowest and the high costs could also have been a problem.

Even if the terrestrial laser scanning is not used on a wide scale for monitoring the surface of the earth crust within sciences that have it as a main point of interest, a significant number of scientists have proven the value of this technology for monitoring landslides and other hazards. The downside is that, after the analysis of the two three-dimensional models created, the 3D model resulted from the geodetic measurements was of inferior quality, although state-of-the-art technology was used.

As favourable aspects, we can mention:

- the use of modern geodetic technologies (both equipment and state of the art programs) offer significant benefits, such as: ability to measure the points situated in hard to access areas, minimizing the time needed to do the field measurements, complex and high precision results, pointing out the real evolution in time of a construction element or of the whole structure as an assembly, etc. However, the most important benefit is the obtaining of the 3D models of the terrain;
- the values of the compaction of the points in the local geodetic support network Orşova – Dranic Peak are low, i.e.: millimetres, the maximum compaction being recorded at the reference mark ST 1 situated near the landslide;
- the planimetric displacements determined for the points in the local geodetic support network are of millimetres, being situated in the admitted tolerance for this type of studies

E. CONCLUSION

In order to quantify the impact of landslides on the environment, one must identify the behaviour and then assess the consequences that they might have on the environment. One can say that this quantification is an analysis to determine how sensitive the sustainable development is when landslides occur.

The aim of quantification is to take measures to avoid slope sliding, which is can be achieved by regular monitoring and by finding consolidation solutions.

It can be concluded that the breakdown by soil slip was caused by excessive humidity and by the fact that there is a coincidence between the geological slope of the earth layers and the slope of the natural slope of the hill.

The studies led to the conclusion that the stabilization of the access road towards the Aeolian aggregates can be made only by a complex road layer work that has to have the followings:

- ditches to drain the water at the intersection of the 2 natural slopes which meet at the curve at km 1+642; they would have the role to discharge the meteoric water and the water resulting from the snow thawing in the torrential valley at the foot of the hill;
- recompacting works for the land massif from the foot of the natural slope, with the area comprised between the line of the gabion positioning and the torrential valley at the foot of the slope. To make these works we think that large spalls should be used to be able to fill in the land in the area and the geogrid layers to reinforce the massif in the area, up to a minimum thickness of 2.00m.

From the point of view of landslide monitoring, we think that this paper highlights the importance of specialized geodetic research and situates it on a higher level in the hierarchy of environmental management and decision making process.

The processing and comparative interpretation of the terrain's digital models obtained by means of measuring campaigns performed at pre-set intervals offer precious information regarding the reason why landslides occur, the geomorphologic dynamics etc., with real value in the investigation and prognosis of such phenomena for relatively narrow areas. Grounded on these analyses, the following measures can be adopted by the local authorities in order to prevent a high landslide hazard: allot funds for landslide risk prevention, draw up monitoring programs with the purpose of developing early warning landslide systems, draw up emergency plans in case of landslide disaster, and set up programs to insure people and goods in the event of landslides. Last but not least to restrict or even prohibit the construction of buildings in the affected area and the changing of the land category.

2.3.2. Survey engineering techniques applied to study of engineering structures analisys

2.3.2.1. Survey engineering techniques applied to experimental and numerical evaluation of a RBS coupling beam for moment steel frames in seismic areas

This study is based on the scientific paper written by the autor in collaboration with Florea Dinu, Dan Dubină, and Florea Dinu, which was published in "Steel Constructions – Design and Research" journal, issue 1/2013.

In recent years there has been considerable interest in the construction of super high-rise buildings. From the prior art, various procedures and devices for surveys during and after the phase of erection of a high-rise building are known. High-rise buildings are subject to strong external tilt effects caused, for instance, by wind pressures, unilateral thermal effects by exposure to sunlight, and unilateral loads. Such effects are a particular challenge in the phase of construction of a high-rise building, inasmuch as the high-rise building under construction is also subject to tilt effects, and will at least temporarily lose its – as a rule exactly vertical – alignment. Yet construction should progress in such a way that the building is aligned as planned, and particularly so in the vertical, when returning into an un-tilted basic state (AISC 341-05 2005).

The precision of the entire surveying procedure depends on the reference points serving as fixed points for the total station; therefore, points are selected for which absolute constancy of the position is guaranteed. Primarily points close to ground are suitable that are not subject to influences producing shifts. However, increasing construction heights, possibly aggravated by densely built-up surroundings, give rise to difficulties in the use of ground-level fixed points, inasmuch as the distance between the total station installed on the uppermost construction level of the high-rise building and the reference points becomes excessive for exact referencing of the total station while the relative distances between the fixed points become too small, particularly so in heavily developed zones. Beyond a certain threshold height, it becomes altogether impossible to use ground-level reference points.


Figure 2.43 Process of data colection

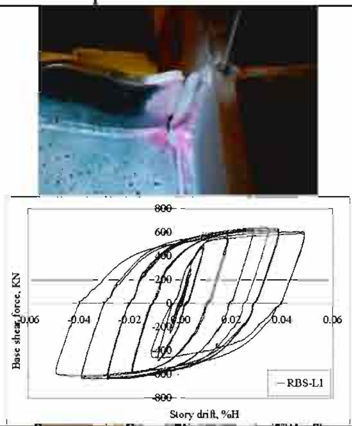
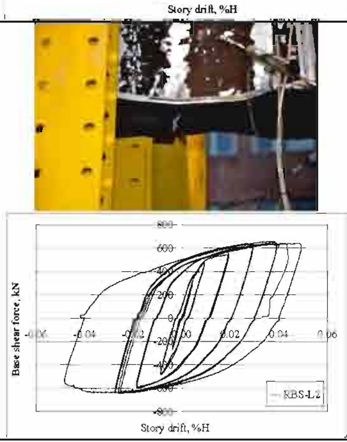
For such beams, the shear stresses may become a controlling factor in the design, as the moment's capacity is influenced by the presence of the shear. This is an important matter when such a beam is part of the seismic lateral force resisting system that is designed according to the dissipative concept. In this case, the contribution from the shear force affects the dissipation capacity and plastic mechanism. The study presents the test-based evaluation of moment frames with short beams and reduced beam section connections, with the purpose to check availability of application the plastic hinge model. Full scale specimens, extracted from an 18 story building, have been tested. Test results and their interpretation are summarised hereafter.
The finite element models were calibrated using experimental tests performed on four full-scale specimens at the Laboratory of Steel Structure, Politehnica University Timisoara, Romania. The particularity of the project consists of very short bay widths coupled with the use of reduced beam section connections for the moment frame connections. In addition, the project incorporates flush-end plate bolted connections for beam splices and therefore the study addresses concerns regarding the potential for brittle failure of the bolts.


Figure 2.44. Layout plan and the building's elevation

The extract from Table 2.8 summarizes the experimental results, with observations regarding the behaviour and failure mode of each specimen.
Specimens with longer beams, RBS-L1 and RBS-L2, remained elastic until a drift of 30mm, or 0.6% of the story height. Two failure modes were recorded. First mode involved the fracture of

the top beam flange to column flange welding, that after propagated in the beam web. The second failure mode involved the fracture of the bottom flange, due to the large tensile forces at ultimate loading stage. Both failures occurred at interstory drifts larger than 5% of the story height. The plastic behaviour was dominated by the buckling of the flange in compression and out of plane buckling of the web.

Table 2.8. Results of experimental tests

Specimen	Failure mode	Details: failure mode and force-displacement curve	Observations
RBS-L1	-cracks initiated in top flange to column welding, fracture propagated in web		-failure at interstory drift of 5%; -no slip at splice connection; -large dissipation capacity, reduce cyclic degradation.
RBS-L2	-failure due to fracture of the flange in the reduced area, then propagation in the web		-failure at interstory drift of 5%; -no slip at splice connection; -large dissipation capacity, reduce cyclic degradation.

The figures in the table show the evolution of web out of plane plastic deformations in the zone adjacent to the column. Under the increasing lateral force, the plastic mechanism in the web involves both bending moment and shear force. The contribution from the shear force to the overall deformation is more important for the short specimens, RBS-S, and it can be observed following the inclination of the shear buckling waves of the web (Fig. **Error! Reference source not found.**2.45).

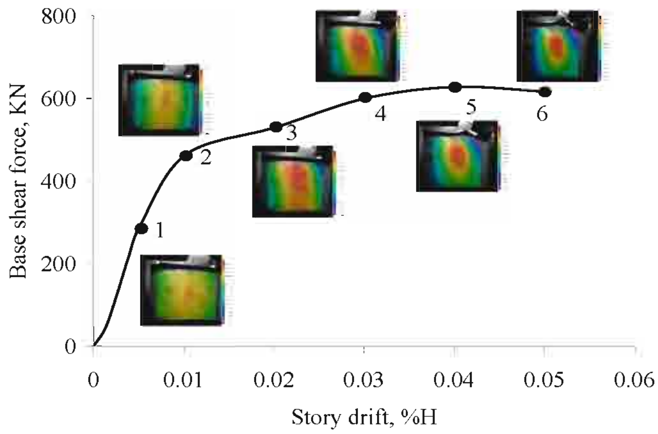
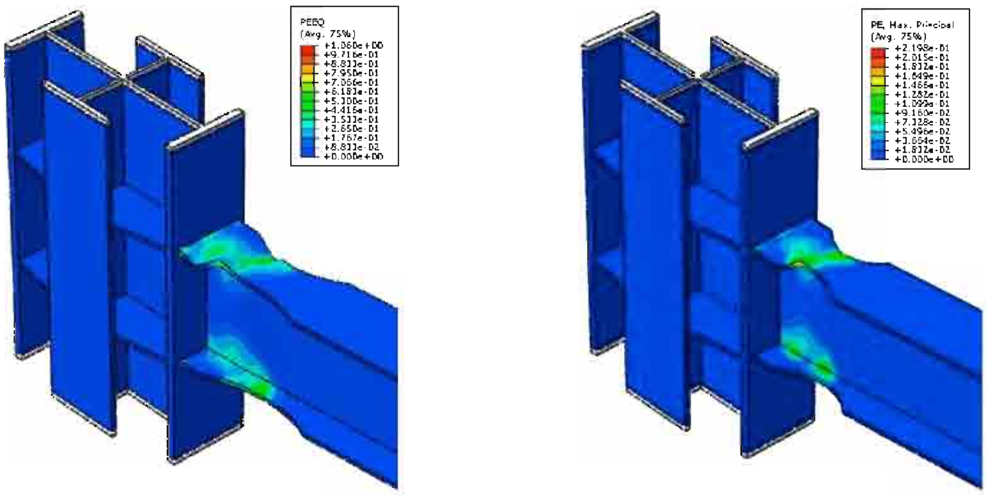


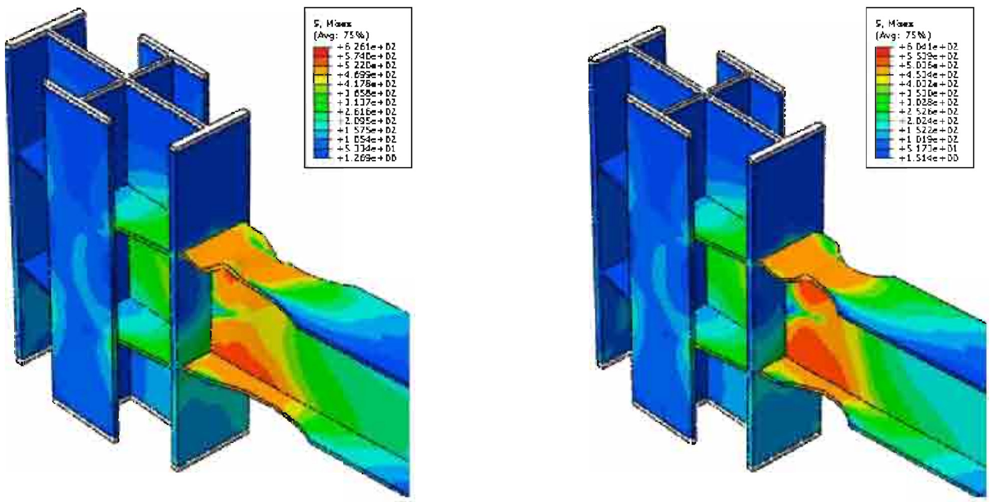
Figure 2.45. Plan layout and elevation of the building

As it can be seen in 2.46.b, the plastic deformation are developed only in the reduced beam section, in comparison with the initial configuration (RBS-L3) shown in Figure 2.462.46.a. The von Misses stress distribution for the two cases is presented in figure 2.47.



a) b)

Figure 2.46. Equivalent plastic strain: (a) RBS-L3; (b) RBS-L3_MOD.



a) b)

Figure 2.47. Von-Misses equivalent stress: (a) RBS-L3; (b) RBS-L3_MOD.

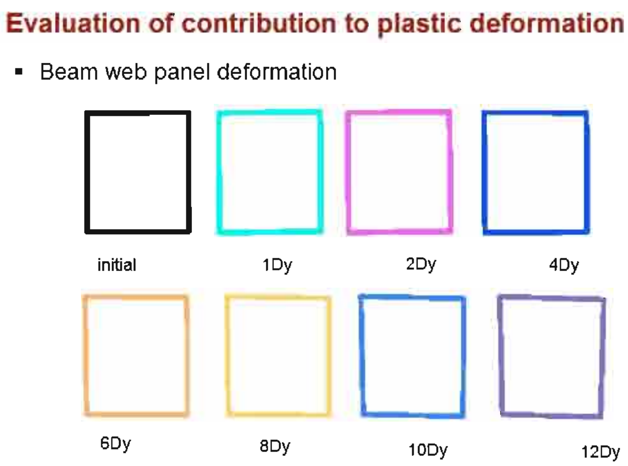


Figure 2.48. Planimetric evaluation of deformation

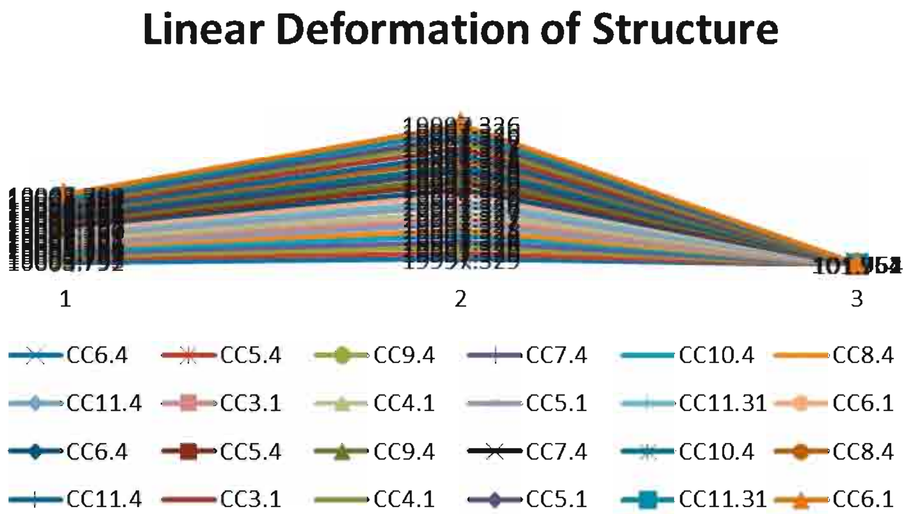


Figure 2.49. Evaluation of deformation –grafic reprezentation

Table 2.9. Extract from spatial coordinates

Point	X[m]	y[m]	z[m]
B1	10001.4527	20002.4778	101.6987
BB.1	10001.4576	20002.4729	101.6984
B2	10001.4749	20002.2086	101.7069
BB.2	10001.4790	20002.2037	101.7067
C2.4	10003.8036	19997.3439	101.7516
C1.4	10003.8046	19997.3423	101.7521
C2.1	10003.8029	19997.3416	101.9637
C1.1	10003.8044	19997.3408	101.9638
CC4.4	10003.7926	19997.3296	101.7518
CC3.4	10003.7936	19997.3295	101.7517
CC6.4	10003.7916	19997.3291	101.7519
CC5.4	10003.7927	19997.3289	101.7518
CC9.4	10003.7885	19997.3287	101.7516
CC7.4	10003.7916	19997.3282	101.7519
CC10.4	10003.7873	19997.3280	101.7516
CC8.4	10003.7907	19997.3279	101.7519
CC11.4	10003.7858	19997.3271	101.7516
CC3.1	10003.7923	19997.3269	101.9636
CC4.1	10003.7911	19997.3268	101.9635
CC5.1	10003.7908	19997.3262	101.9636
CC11.31	10003.7842	19997.3257	101.7509
CC6.1	10003.7904	19997.3257	101.9639
CC11.57	10003.7840	19997.3255	101.7510
CC10.1	10003.7847	19997.3250	101.9633
CC7.1	10003.7899	19997.3250	101.9636
CC9.1	10003.7867	19997.3250	101.9634

Capturing errors in dynamic mode survey facilitates the understanding of the deformation phenomenon of the metallic structure subjected to testing. To achieve precision determinations in a short time we have chosen that the distance between the observed structure and the total station's position does not exceed 10m. For distances measuring – less precise component of Total Stations we have used multiple distances towards the same point measuring mode. The average value has been calculated as a result of the 5 measured distances.

Precise topographic measurements on the 3 dimensions (XYZ) describe the movement of characteristic points of the metallic structure, thus confirming the deformation or yielding of the element taken into account at the design stage and determined using numerical models.

The measured dynamic displacements measured using topo-geodetic methods and equipment confirmed what failure mode and force-displacement curve shown and brought additional information in those points or areas where it was not possible to install captors for carrying out measurements.

2.3.2.2. Data Collection, Procces and Creating the 3D Model Applied to Retechnology a Hydroelectric Power Plant

This study is based on the scientific paper entitled "The concept of sustainable development applied to retechnology a hydroelectric power plant", written by the autor in collaboration with Carmen Grecea and Roberta Gridan, which was published in Research Journal of Agricultural Science, BDI indexed, in 2011.

Engineering companies and contractors are facing challenges never experienced before. They are being charged with - and being held liable for - the health of the structures they create and maintain. To surmount these challenges, engineers need to be able to measure structural movements to millimeter level accuracy. Accurate and timely information on the status of a structure is highly valuable to engineers. It enables them to compare the real-world behavior of a structure against the design and theoretical models. When empowered by such data, engineers can effectively and cost efficiently measure and maintain the health of vital infrastructure.

The main purpose of our measurements represents the evaluation of the real conditions from the Bradisor hydro power plant. The data from the technical drawings were verified on the field, for evaluating the real situation. As a result, measurement of the hydraulic path, upstream of the hydraulic turbine (the penstock area near the butterfly valve and the spiral case). The obtained results were compared with the data from the technical drawings for the discrepancy determination.

A. MATERIALS AND METHODS

The point spatial coordinates measurements process using electro-optic measurement and the Electronic Distance Measurement (EDM) model were used for the field measurement. The spatial measurement process makes possible a direct determination of tridimensional point coordinates. The object points Cartesian three dimensional coordinates are determined with measuring instruments, using the orthogonal method, generate - by constructive conditions – a rectangular coordinate system.

The method is utilized for surveying of topographical or geodetical details which take place predominantly one side and the other of a reference alignment (A-B), which can be a side of a traverse and the terrain is about horizontal ($p<5^g$). The method also can be used for surveying engineering characteristic points of the buildings façades, the ones characteristic of technical facilities in localities and also for surveying the plot limits, the lake contour or the river banks and for surveying in the close domain (industrial buildings, special constructions and quality control of finished products) or - in general – the characteristic points coordinate determination of different shape and size details.

The principle of the methods consists of measuring from point A the reference leg, on the alignment A-B, from the abscissa AP1=d1=a to the perpendicular foot high with the help of a topographical square, from the alignment to the detail point P ($\beta=100^g$). On the new direction the ordinate P1P = d2 = b is measured until P point of the topographical detail, which must be surveyed until A-B alignment.

In the present day all the known companies building topographical instruments offer so called Measurement Systems in Industry, with whose help can be determined points in a tridimensional system, throughout multiple direct intersection in the close domain.

In the Industry Measurement Technique there are two types of systems, which work after this principle:

- Industry Measurement Systems which utilizes the theodolite, that can measure bearings toward the object points;
- Photogrammetry Measurement Systems, the bearings are deduced from the image coordinates (Cosarca, 2009).

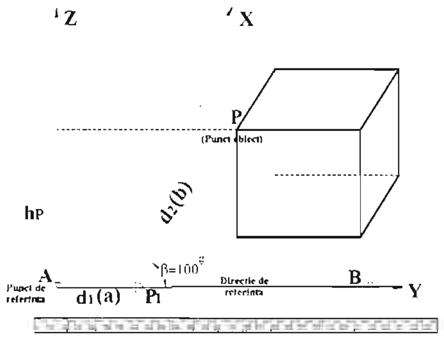


Figure 2.50. The rectangular coordinates measurement principle (Cosarca, 2009)

Both systems work without direct contact with the measured object. Due to the facilities and to the mobility that these systems offer, they allow measuring objects of different shapes and sizes. Another geodesic method for determining the spatial coordinates is offered by the instruments which work according to the surveying principle by polar coordinates method. For using this method only one station point is sufficient to achieve the tridimensional coordinates (3D). The object point coordinates are calculated from measured elements: horizontal angles, vertical angles (zenithal angles) and tilting range (Cosarca C. 2003).

Measured elements:

- horizontal angle ω_A (relative to the reference point direction)
- tilting range S_{AP}
- vertical angle β_A

The local coordinates system definition:

- the system origin is in the theodolite pointing center from point A (0, 0, 0);
- Oy axis direction to the point of reference.

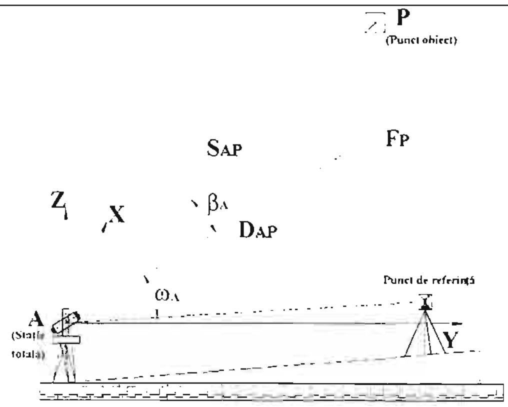


Figure 2.51. The measuring principle for determining coordinates through polar method

B. RESULTS AND DISCUSSIONS

The method used for determining the spatial coordinates is the polar method. In contrast with the space intersection where are necessary two station points, using this method only one station point is necessary for determining the tridimensional coordinates (3D). The object point coordinates are calculated from measured elements: horizontal angles, zenithal angles and tilting range.

The local coordinates system definition: the system origin is in the total station pointing center, the station point with coordinates (0, 0, 0); Oy axis direction to the point of reference.

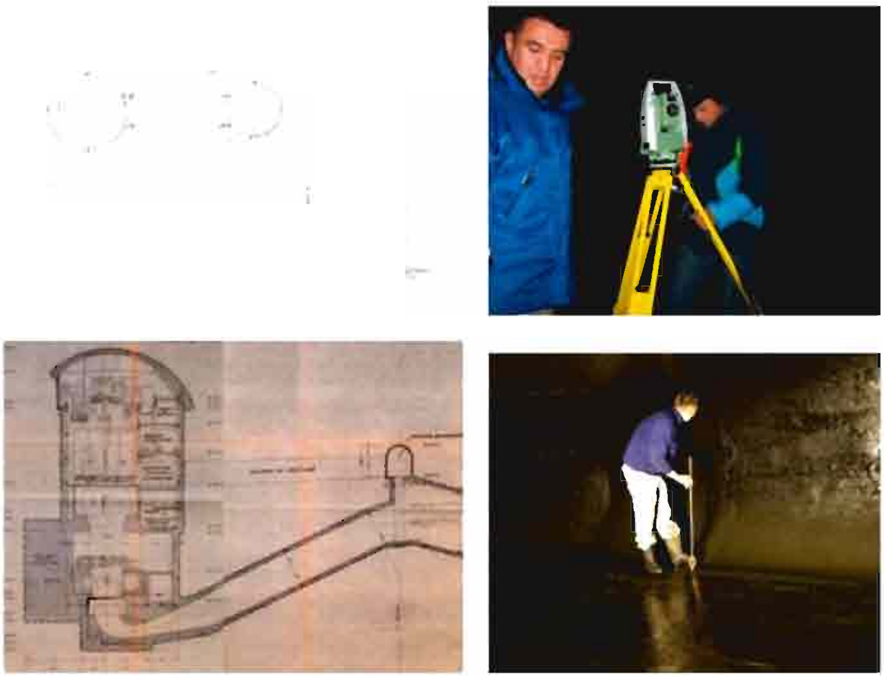


Figure 2.52. Procces of data colectiong inside of powerplant

This methods principle consists in measuring, from the total station point of coordinates (0,0,0) the horizontal angle's side support and the horizontal distance, to the detail point, which rectangular plane coordinates will be determined based on the known coordinates and on the elements measured on the field.

The programs used for data downloading, processing and setting off were:

- LEICA Geo Office Combined and TopoSys

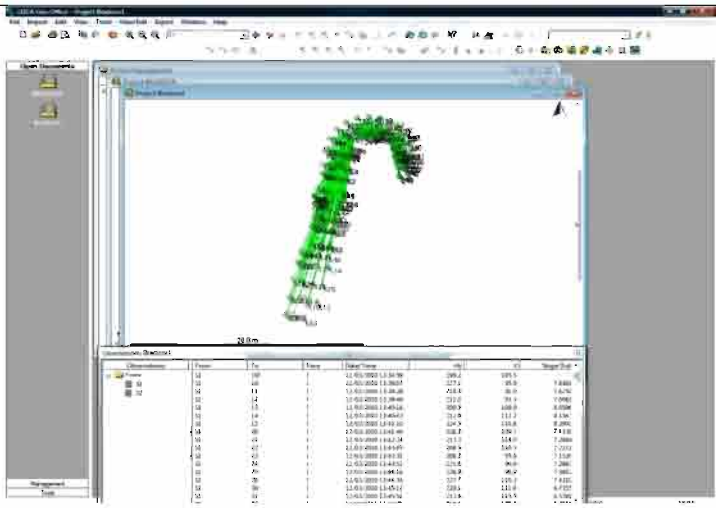


Figure 2.53. Processing data and creating spatial coordinates

The processed data has been uploaded to AutoCad Civil 3D where I started creating cross-sections then generating the surfaces and volumes of the objects. This process is shown in figures 2.54 and 2.55.

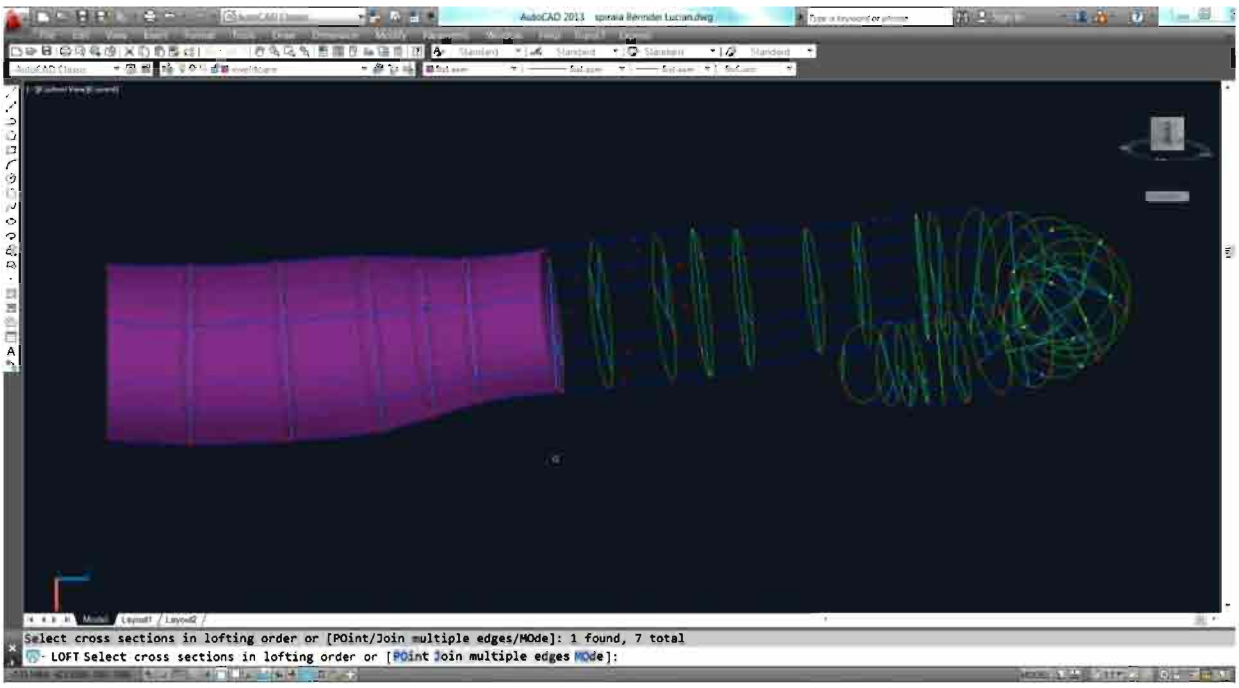


Figure 2.54. Creating transversal sections and model the structure

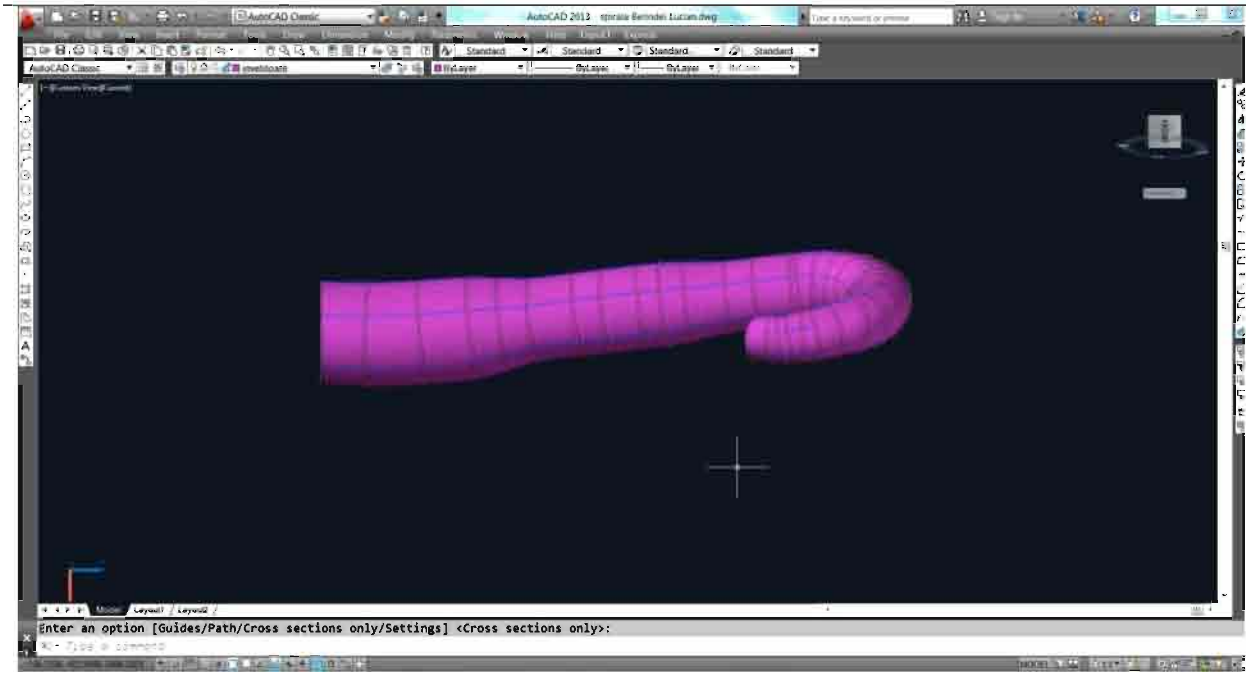


Figure 2.55. Completing model of structure

The hydraulic layout upstream the turbine runner includes: the enforced penstock (the area near the butterfly valve), the spiral case and the distributor (the stator and the guide apparatus). A reconstructed view of this layout is represented in the figure 2.56.

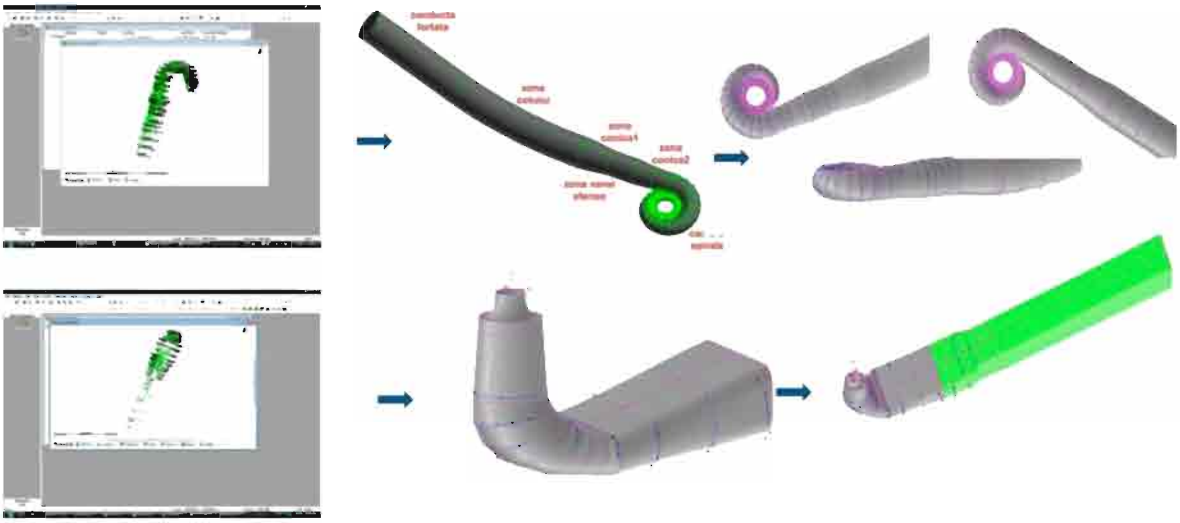


Figure 2.56. The reconstructed hydraulic layout with 3D geometry

Figure 2.57. Photo of the spiral case, the stator columns

C. CONCLUSIONS

Monitoring this kind of constructions is made both physical methods and topographic methods. The advantage of physical methods is that through the used gear they are providing information about the monitored construction behavior at small time intervals (hours, days, weeks). This information has a relative character because the measurements are made on certain construction elements reported to other construction elements. The topographic methods have an absolute character because the measurements are executed towards the construction independent reference system.

Based on the documents provided by the beneficiary (represented by the magenta color) and the new measurements (represented by the blue color) we made an accurate comparison analysis between the reconstructed 3D model and the measured one. Following the assessment, we concluded that minor differences were found between geometry reconstructed based on the documents made available by the beneficiary and the data measured in situ. The geometric deviations found are within the accuracy of used measuring equipments and available in situ measurement conditions.

2.3.2.3. Survey engineering techniques applied to preassure vessels used on oil platforms

This study is based on a contract managed by the author and the scientific paper which describes the methodology and the results obtained is under review.

A. MATERIALS AND METHODS

Nowadays, as state-of-the-art technology in the geodetic domain is evolving at a high rate, the speed of the surveying process becomes a qualitative issue. Thus, for the producing companies, the challenge is to go beyond the users' requirments. In this context, Leica Geosystems has once again proven its superiority by adding a Plus to their well-known Leica TPS1200. This led to the creationg of a new total station – Leica TPS1200+. This total station presents superior qualities when it comes to scalability, accuracy, productivity and ultimately, productivity. The data from the pressure vessels has been collected using the aforementioned equipment.

Figure 2.58. Procces of data colectiong inside of powerplant using Leica 1200 Series

Figure 2.59. Comparing functionalities of Leica and Trimble for data collecting

The TPS1205 series builds on the proven concepts and strengths of the TPS1100, but also improves these concepts and strengths to reach an even higher level of measurement performance. This measurement performance directly translates into the productivity of a surveyor by allowing more points to be measured in the same time. So what are factors, which contribute to the higher performance and productivity? The main contributors are high reliability, the highest accuracy and measurement speed, longest range, highest measurement confidence and minimized non-productive time. TPS1205 provides all of the above through improvements to all measurement technologies:

- an enhanced angle measuring system;
- and compensator, a new EDM, a new ATR;
- and a new automation concept – this newsletter focuses on these new technologies.

At that time, the Total station that we use to do the measurement provide the Smallest Measurement Spot Size The measurement spot of the PinPoint EDM is significantly smaller than others total stations because it is using pulsed laser technology. This allows measuring to small objects or building corners - quickly and directly with only one measurement (According System 1200 Newsletter – No.2).

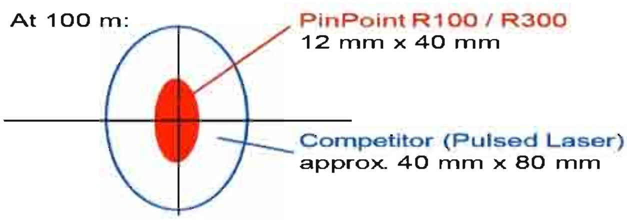


Figure 2.60. Comparing functionalities of Leica and Trimble for data collecting

Looking at the red line in the graph below, which shows measurements to a building corner.

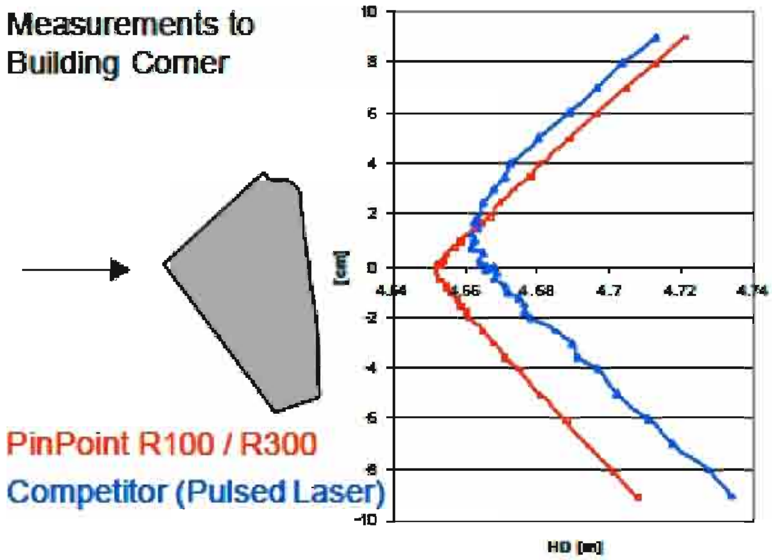


Figure 2.61. Comparing Pinpoint with other solutions

Therefore the combination of the new PinPoint EDM, greatly improved ATR and outstanding automated performance within the TPS1200 all contribute to one unique system to deliver the highest performance and productivity to surveyors.

After studying the specialty literature I have come to the conclusion that for creating the 3D model and for representing the holes of the structure, the most opportune manner is to align the measurements realized using the total station according to a principle characteristic to laser scanning, namely target to target.

Another developed application in the field of terrestrial measurements is realizing models of pressure vessels used on oil-tanker. Realizing 3D models of entrances and communication zones between them must be performed using topographic techniques and then represented with high accuracy.

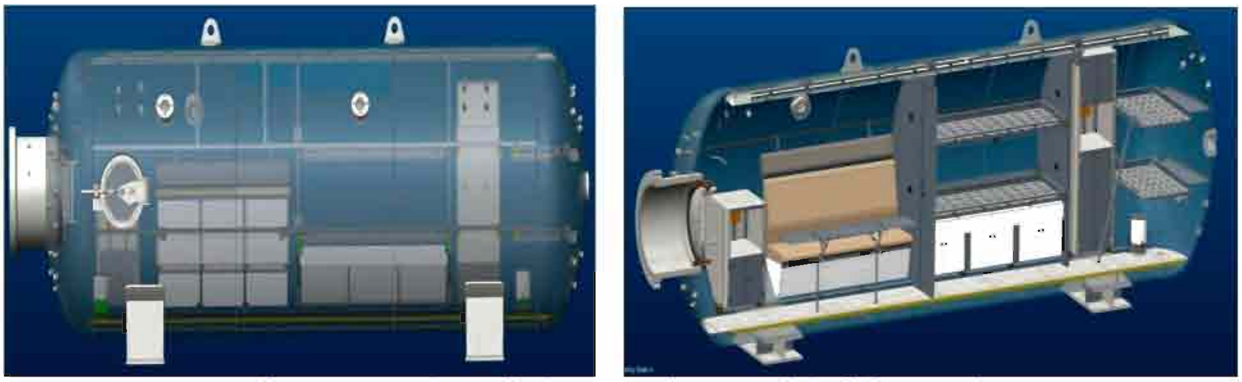


Figure 2.62. Theoretic / Projected 3D Model of the vassels

There are a large number of examples of areas where reflectorless, or tape measurements are used at a distinct advantage. Underground mining uses reflectorless technology frequently, but generally the accuracy required is not high. In mining (and other earthworks) situations, a value with 0.05m accuracy would be sufficient. Mechanical surveys where new prefabricated steel structures need to bolt to existing steel structures can require accuracies to within millimetres only. There would be circumstances where even closer tolerances are needed, but these situations require specialist equipment and personnel and so won't be studied here.

They are generally large and high, and usually cylindrical. If there is no access to the top, measurements must be taken looking up and so there is doubt as to what the returned measurement has reflected off. This angle can be improved though, by moving further away from the bin to measured, if circumstances allow for this (Coaker, 2009).

For example, when large diameter pipelines are surveyed, the accuracy needed is within a couple of millimetres. If bolt on flanges are needed to fit together correctly the first time, such as with expansions to major gas supply lines. In cases like this, the pipeline will be shut down for a minimal time only, and the expansion pieces need to bolt in without further welding or cutting. If using reflector less measurements, there needs to be no doubt that the measurements are correct, even with a lot of clutter to measure around, and the fact that measurements will sometimes need to be taken to a curved surface and not at a perpendicular angle (Coaker, 2009).

Traditional survey methods generally require access to any points that need to be measured. One exception would be to record a vertical and horizontal angle to a single point from at least two different positions. The coordinates could then be calculated. While this is possible, it would also be time consuming, especially if there were a large number of “hard-to-see points”.

Regarding precision, the words accurate and precise are generally interchangeable. In surveying however, accuracy and precision refer to separate results. Accuracy refers to the result’s closeness to the true or accepted value. Precision refers to the spread of results for a number of measurements.

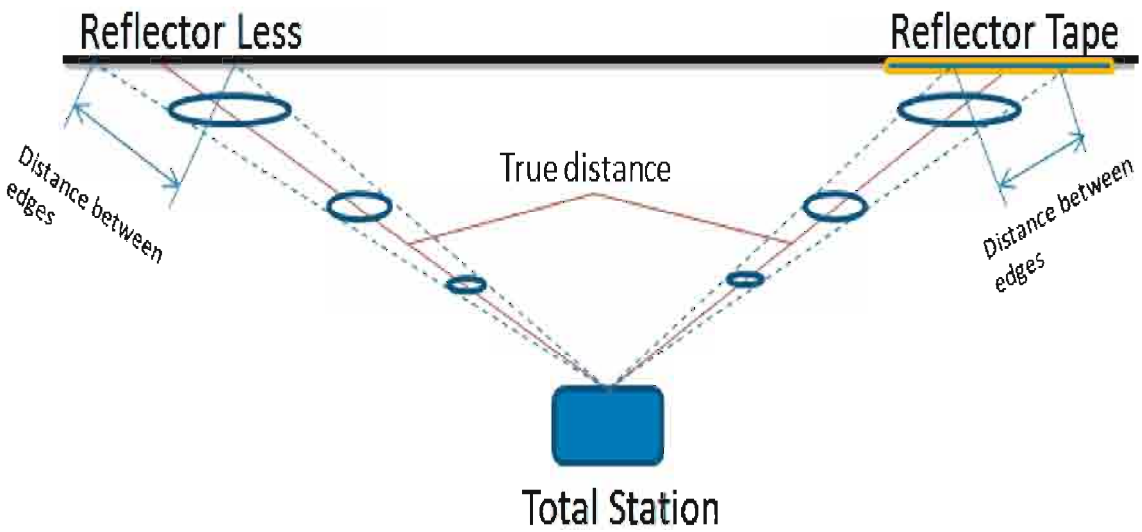


Figure 2.63. Aquracy Reflectorless Reflector Tape

According to Leica (Leica Geosystems), the laser beam divergence varies greatly between instrument manufacturers, with the laser ‘spot’ varying in size from 9x28mm to 100x110mm at a distance of 50m from the instrument. Obviously, with such a variation, different instruments could be used in some applications while others would become unreliable (Coaker, 2009).

Taking into consideration those practical inconveniences of divergence, and to reduce it, the distance in our case was between 5-10m from station to reference point and the distance to pressure vessels was 2-5m for accurate data collection and representation.

Thereby a representation of our study can be seen in figure 2.64. a and b

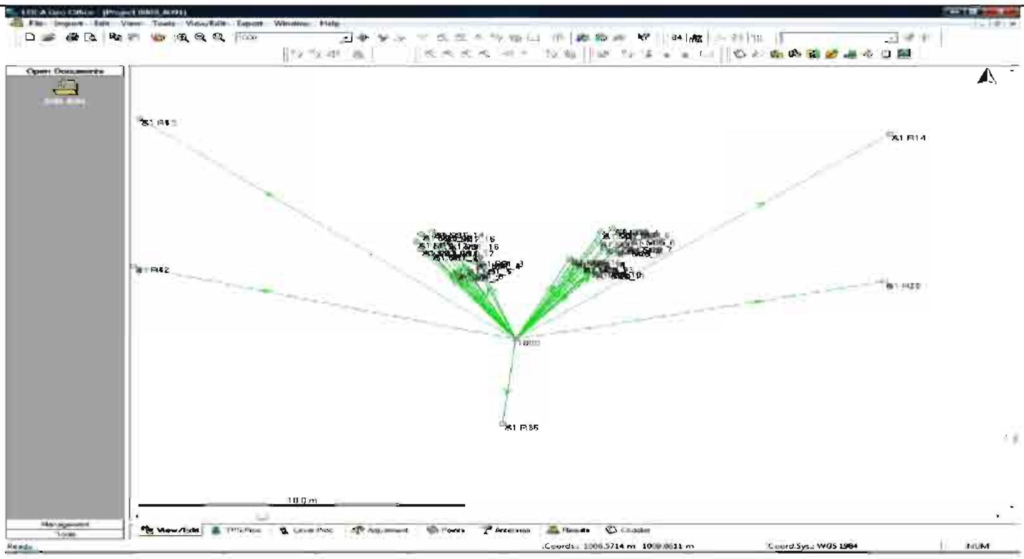


Figure 2.64. a Data processing / exporting spatial points LeicaGeoOffice

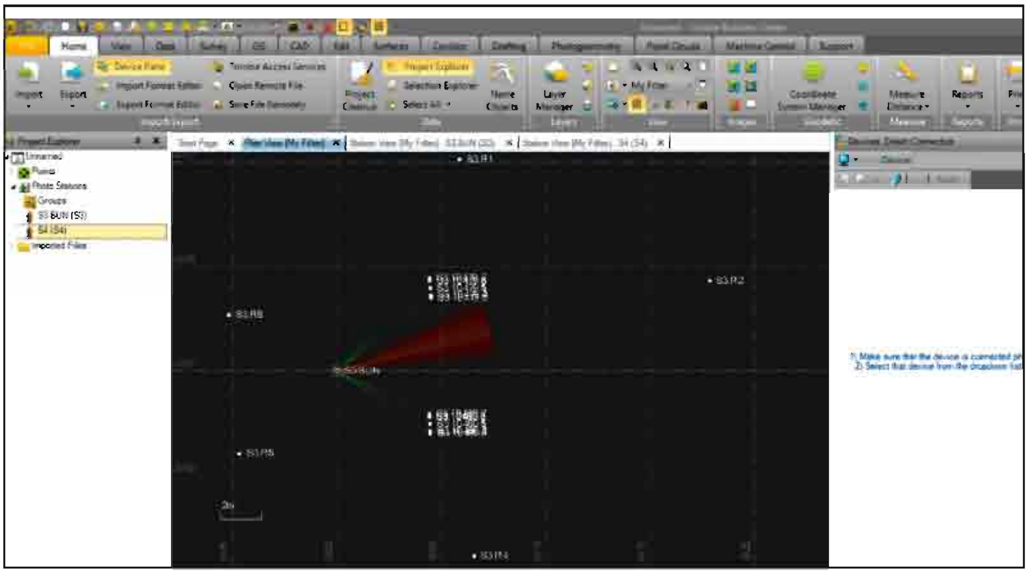


Figure 2.65. b Data processing / exporting spatial points TrimbleBusinessCenter

After the data processing it was created the 3D model of vessels and their entrances and contact points shown in figure 2.65.

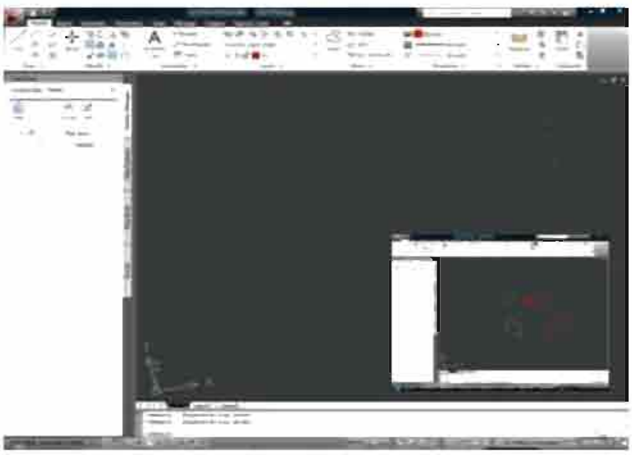


Figure 2.66. Control points on 3D model. Spatial representation

B. CONCLUSIONS

Realizing models, respectively precise determination of spatial coordinates of entrances in pressure vessels may only be executed using the precise topo-geodetic methods. Creating 3D model of all elements of the contact is part of the quality control system of pressure vessels and ensures the continuity of these vessels inside the projected parameters.

Meshing points is a process which requires special attention, process carried out by the beneficiary but coordinated by the surveying engineering.

The measurements were performed using very high precision (angular precision reading of 1" or 0.5", linear measurements 2 +-2 ppm and 1 ppm + 1.5 ensuring spatial coordinates determination with sub-millimetres values.

Positioning of observation points must respect the principle of perpendicularity both on object points and on support points.

In order to bring the measurements into the same reference system, I have applied the property or method characteristic to laser scanning, namely realizing the model using target to target registration.

2.3.3 Three Dimensional Modeling for Assessment of the Touristic Potential

This study is based on the scientific paper written by the autor in collaboration with Adrian Alionescu, which was published in the Proceedings of International Multidciplinary Scientific Geoconference, ISI indexed, in 2012.

An effective infrastructure for civil engineering purposes requires more and more detailed background information. To create a model using the traditional approach, such as 3D topographical contour models, involved a long process of cutting layers of material. These were stacked on top of each other to form the model. Creating a model in a modern way involves computer modeling, rendering, scenarios, panting, illustrating etc. Developing and building a ski resort implies a huge responsibility, also a strategy and a scenario that should take into consideration the economic and social impact, tourists' services and all the possible negative consequences resulted from the transformation of the fragile alpine environment. Using any of the GIS standard formats, both 2D and 3D data can be visualized as a 3D perspective. Thus, for engineering purposes the necessity of using measured data in order to create Digital Elevation Models (DEM) and integrate them with high resolution images is a requirement in our days. Cartographers might prepare digital elevation models in a number of ways, but they frequently use remote sensing or direct survey data. The methods of generating DEMs often involve interpolating digital contour maps that may have been produced by direct survey of the land surface; especially for mountain areas. Note that the contour line data or any other sampled elevation datasets (by GPS or ground survey) are not DEMs, but may be considered digital terrain models. The presented study describes the technology and methods used to obtain complex data regarding a ski resort that will be useful for local authorities and developers.

A. INTRODUCTION

Setting up a touristic area is a work of a very high extent intended to realize an entire ski resort capable to satisfy the most demanding desires of a large number of users, having been realized as a result of complex studies. The choice of the resort is made by considering many conditions, among the most various, such as the region, that it is going to serve, different economic criteria or the positioning at an appropiate altitude.

Reliable global warming tendencies reported more conspicuously over the past decade, the requirement of the ski resort to be located at high altitudes, around 1800-2000 m to take advantage of the extended maintenance of snow. (A Rolando et al.), (http://www.poiana-marului.ro/)

Following more specialized studies developed by firms, not only in the country but also abroad, has been concluded that the Poiana Mărului Area with the mountainous plateau of the Țarcu mountains has a high long-term tourism potential, because it is the area that corresponds best with the current tendencies of the placement of ski areas (http://www.poiana-marului.ro/).

B. THE DATA AQUISITION PHASE

The data acquisition – is a process, which has been realized in more stages. The first stage of actual measurements has been done when in order to obtain the approvals necessary to start work, the measuring of the start and end coordinates of the future ski trails and the cable transport facilities was necessary. To achieve this step, a thorough study of the existing plans, both cadastral and those resulted from wing photography done in the years of 2005-2006, has been required. At the same time we made use of the forest district of Oțelu Roșu for the forest management plans to be studied.

After the completion of the documentation process, the measurements have been done on the field within this stage. Data acquisition has been done through GPS measurements, using the "stop and go" method.

Figure 2.67. The circulation between the measured points has been made with a snowboard

The second stage has meant the actual topographic survey, a stage during which the entire area under discussion has been measured, in order to realize the sky resort.

Considering that both studied routes cross both the area of alpine meadows and forested areas, it has been decided to conduct both GPS measurements and total station measurements. Data acquisition with the GPS has been done using the RTK method, it has been used especially in the areas of alpine meadows, where the satellite signal could be received under optimal conditions.

Figure 2.68. Reading a point situated at the edge of a plateau

In forested areas, where the GPS did not work, measurements were carried out with the total station, executing planimetric and level radiations and courses. It has been proceeded at the determination of fixed points with the GPS in particular areas, where it has been functioning, which have been used subsequently as points of support for the courses made with the total station. In many areas the help of a team of forest caretakers, who facilitated the access to less accessible areas through deforestating some trees, has been required.

C. DATA PROCESSING

The result of detailed topographic survey has been a set of coordinates obtained in the STEREO 70 projection system, having the Black Sea 1975 as a reference system. This data has been processed using the Surfer 8 software in order to realize the 3D model. Considering the difficult conditions of data aquisition and the limitation to a finite number of measured points, the use of the interpolation methods has been required.

The software allows the selection of the method of interpolation and therefore the person who processes the data must necessarily have enough experience and have enough sufficient knowledge of the measured area. There is not a clearly best method but only the optimal choice under certain circumstances. One should at first review the characteristic and theorem of each method as well as the property and spatial analysis of the data before he or she can successfully select a spatial interpolation method, which is relatively the best in a certain situation. (http://www.jaketa.hu/software/surfer/surfer_detalii.html), (Chin-Shung Yang et al.)

Realizing the digital model of the field is based on generating the level curves. Generating DEMs often involves interpolating digital contour maps that may have been produced by direct survey of the surface of the land; this method is still used in mountainous areas. The accuracy of such DEMs depends on different factors: the effect of sampling density used to derive contours, the vertical interval between contours (spacing), the grid cell size of the DEM (resolution), the complexity of the field, and the spatial filtering of the accuracy of the DEM and the slope derivative. (H. Zahit Selvi, I. Oztug Bildirici), (F. M. Ziadat).

The terrestrial measurement equipment has nowadays an increasing accuracy. GPS has changed all that, and it is now reasonable to measure baselines and 3D coordinates at centimeter accuracy.

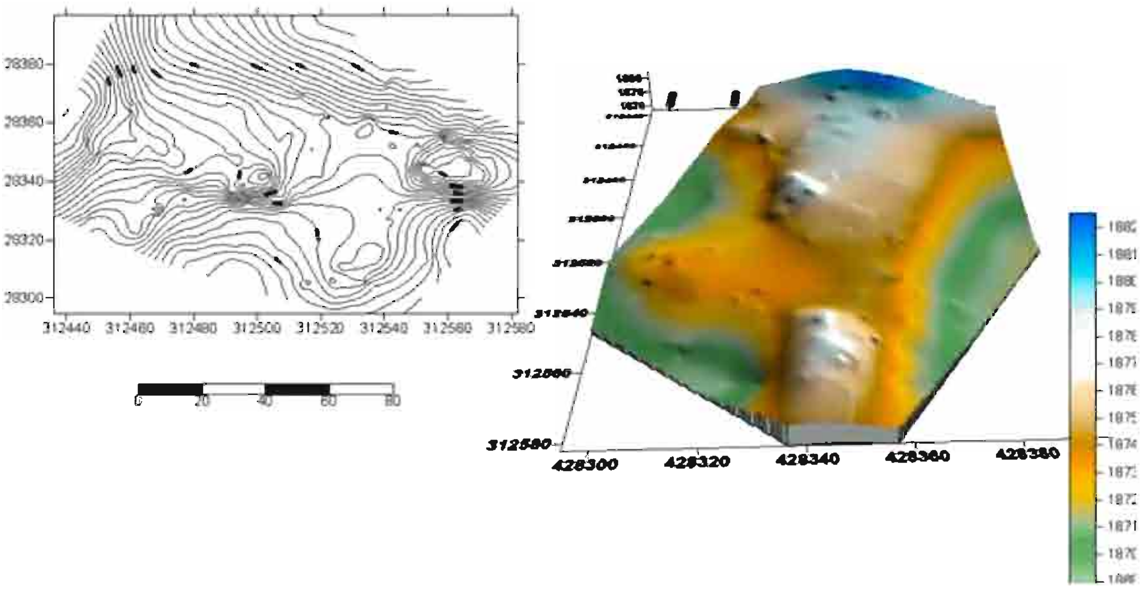


Figure 2.69. The level curves map and the 3D model for the placement of future constructions

Fitting curves and surfaces to a set of data points is a fundamental geometric problem with application in a wide variety of practical situations. (Xueming Xu).

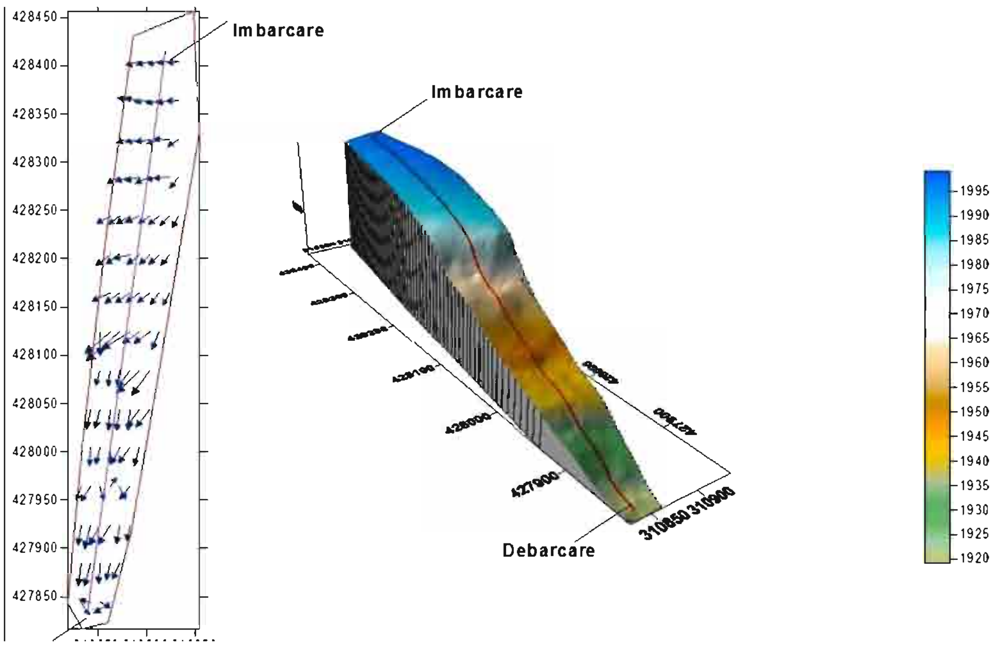


Figure 2.70. The vectorial map and the 3D model for the sky lift route

With the Surfer Software vectorial maps can be instantly created, which represent the direction and the size of data in the selected points of the maps. The vectorial maps can be realized on the basis of a grid or two grids. Two components (the direction and the size) of the vectorial map is done automatically from a single grid by calculating the gradient of the represented surface. In every junction of the grid, the direction of the arrow indicates the direction of the steepest descent. The size of the arrow varies depending on the inclination of the slope. Double grid vector maps use two separate grid files to determine the direction and the size of the vectors. (H. Zahit Selvi, I. Oztug Bildirici).

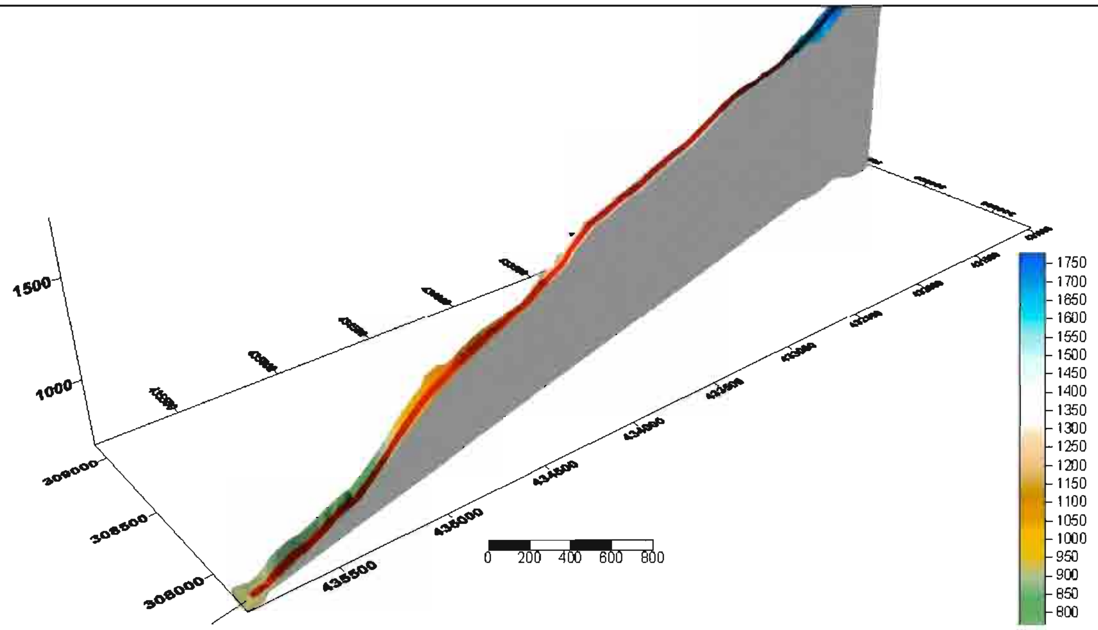


Figure 2.71. The route of the gondola lift, which will link the town and the plateau of the moutains

D. CONCLUSIONS

Obtaining the 3D model is very important, because it allows complete analysis related to some decisions, which will be taken in the design stage of each element. Therefore, by using the 3D model there can be made a complete analysis with regard to the configuration of the field and its slope. Taking into account these elements, there can be done accurate calculations regarding the sizing of the cable transport facilities.

At the same time, by analysing the land configuration, the decisions are taken related to the infrastructure works, which will be realized in order to improve the quality of the ski runs. Considering the fact that the intervention on the environment should be as low as possible, the digital model of the field permits making the best decisions to fulfil the objective.

E. ACKNOWLEDGMENT

The author wish to thank the company S.C. Belevion Geotopo S.R.L. Deva, member of the group "BELEVION" Bucharest, especially to Mr. eng. Adrian LUNCAN, technical director, for the given support and for the permission of using in this paper images and results, which belong to the company.

2.3.4. 3D models and Open Source webGIS platforms for Cultural Heritage monitoring

Cultural Heritage documentation includes an interdisciplinary approach with the aim of an overall understanding of the object itself and collection of all the information which characterize it.

Cultural Heritage documentation is more than a generic term used to define the intelligent collection of all kind of information needed to know an object in order to document it before restoration, conservation and management or just to share knowledge and to transfer it to the future (Patias and Santana, 2009). Cultural Heritage documentation represents a complex and various process, also having both spatial and textual data and one of the most efficient methods for integrating this huge amount of data into the same platform lately being Geographic Information System (GIS). Because the Cultural Heritage documentation, besides the spatial information itself, also involves diverse areas of specialists the most suitable manner of managing all this various data, starting with collecting, interpretating and sharing it and the results of its interpretations, is on GIS platforms (preferably web-GIS and Open Source Platforms) (Rinaudo *et. al*, 2007).

On the other hand, the web mapping or webGIS concepts have significantly changed with the release, by Google in 2005, of Google Maps digital mapping. Google's approach, quite different from any existing platform at that time, was an instant success. The idea was quickly taken over by competitors (Yahoo, Microsoft, AOL) and by the FOSS4G community (http://eart.unibuc.ro/).

Concluding, the numerical formats used today to record all the information (from historical to metric and/or physical data) require also the use of GIS technology to record and manage it.

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).

In this context various society fields demand realistic 3D city models for diverse purposes. For historical buildings even ancient fortresses, analysing in a 3D virtual reality world is much more efficient than imaging the 2D information on maps. Navigation systems and virtual tourism also take benefit from realistic 3D city models. Manual recreation of 3D city models is undoubtedly a rather slow and expensive procedure, because of the enormous number of buildings and complexity of building shapes; this is why automated procedures substantiated on scientific protocols are necessary in an ICT world (Shiode, 2001).

Timişoara has one of the widest architectural heritage area in the country, of important value to both Romania and Europe. The preservation of this Cultural Heritage is a duty of both the authorities and the owners (www.primaria tm.ro).

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 (Vilceanu *et. al* 2013 b). Therefore, data collection is varied from simple to very complex and depends on the type, time, manner and technology used for measuring the object.

Currently, in Romania there is a simple GIS platform that inventories monuments all over the country, giving only a brief description of their presentation and grouping them by LMI code 2010, geographic area, address or a legend classifying on LMI, assemblies, monuments, sites, inventory, and provides graphical and textual information in real time about various monuments, historical sites (http://egispat.inp.org.ro/).

Studying international scientific literature, I noticed that there are concerns and scientific work and papers of topicality showing embodiments of 3D models for spatial objects. Thus, there are scientific papers proposing the use of GIS for analysis and documentation of Cultural Heritage management but there is a lack of information regarding webGIS platforms referring to Cultural Heritage and 3D objects. This is due to:

- most GIS or webGIS platforms are customized for analysing and managing land related data or public administration fees being provided by ESRI, INTERGRAPH, AutoDesk etc, as well as Open Source solutions: GRASS GIS, Map Window GIS, QGIS etc.
- integrating spatial objects such as Cultural Heritage ones into webGIS platforms is quite difficult because of the fact that creating the 3D models of this kind of objects can be laborious and time consuming, besides creating the objects there is a need for the digital reconstruction of the original containing the missing parts and inserting the 3D model into a geo-database represents a demanding process (http://www.osgeo.org/).

Objectives studies in Cultural Heritage areas

The present project has 2 major objectives which arise from its concept, namely:

- **creating 3D models for Cultural Heritage objects;**
- **integrating 3D models into a webGIS platform**.

Several Cultural Heritage objects will be presented, studied and analyzed (starting with simple sculptures, historical buildings, ruins etc.) together with the techniques and technologies for data collection and digital object realization, as well as a comparative study between the results obtained by using different techniques and technologies for data acquisition. Thus, are proposed Close Range Photogrammetry and processing of the images using Open Source and Low-Cost specialized software and laser scan technology for data collection and realizing the 3D models, followed by an analysis of the results from the point of view of the accuracy obtained.

Another direct benefit of the first objective is related to 3D modeling of the historical buildings or constructions for realizing the 3D Cultural Heritage or City model, for virtual tourism purposes and highlighting the zones with structural deformations especially for the buildings located in seismic areas.

Even though there are significant differences between the costs required by data acquisition on field, in the sense that Terrestrial Laser Scanning implies high financial resources, it must be taken into account the fact that the scanning results are of higher quality regarding accuracy and level of detail. 3D scanning offers other interesting applications, for example an accurate deformation analysis if an external motorized thermic camera controlled through the scanner's interface is used.

The second major objective of the project is associated with integrating the results of the 3D modeling into webGIS platforms designed and customized for Cultural Heritage domain. Realizing this objective is necessary both for scientific and social purposes because, on one side, it represents a preoccupation of the specialists at international level (Arca, 2012) as it is an increasing need in our days and, one the other side, it consists of a recommendation given by the European Commission for **making our heritage and our cultural creations available to a wider number of citizens**. The study of the different solutions available on the market at the moment, those which demand for financing and those which are Open Source, there is an imperative process for offering the most suitable solution in this domain. Integrating digital images and simple textual data is already achievable, but integrating 3D models of diverse objectives and customizing the webGIS platform corresponds to a challenge and a continuous preoccupation for specialists in different domains. The research proposed in the project represents a suitable solution or solutions to developing a dynamic data model that would resource the development of the ability of the webGIS technology to provide to wide range of users with faster response time and updated temporal and attribute information, as specific facilities of a location-based service.

From scientific point of view some missing information regarding two important aspects I would like to complete relying on following case studies conducted by the author:

2.3.4.1. Using the Laser Scanning For Research and Conservation of Cultural Heritage Sites

This study is based on the scientific paper written by the autor in collaboration with R. Georgiana, O. Grecea and G. Barla, which was published in Journal of Environmental Protection and Ecology, ISI indexed, in 2014.

One of my case studies realized in collaboration with SC BlackLight SRL was a study to recreate an old fortress located in Dobrogea.

Archaeological site "Fortress Ulmetum" was included in the list of historical monuments in 2004 - Constanţa, at no. 374, LMI code: CT-I-have-A-02726. Ulmetum Latin name in Romanian means "forest of elm".

A. INTRODUCTION

Ulmetum camp ruins, situated on the lake Razelm were brought to light by Vasile Parvan, from his first campaign of excavation in 1911, and contain inscriptions and statues from the Roman era decadence. Archaeologists have determined that in Constanta, at the end of the fourth century, the city has hosted hundreds of federates Ulmetum Goths, who had received the right to settle in this area. During excavations in the center of fortification was discovered tomb of a nobleman Germanic, which contradicts the assumption that the cemeteries were located just outside the towns.

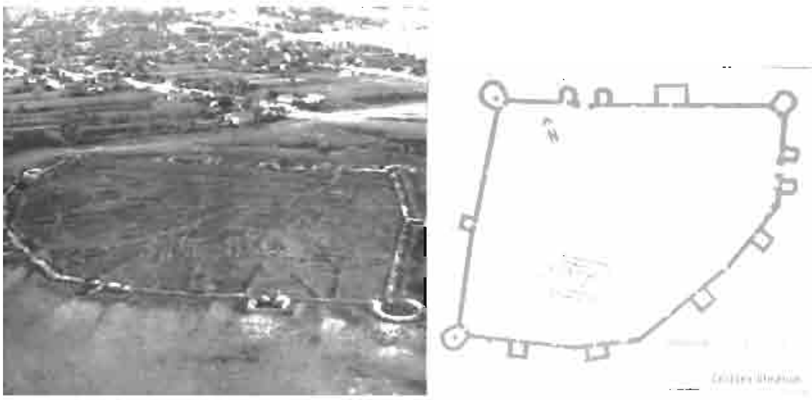


Figure 2.72. Image with the fortress' ruins and old plan with the ruins

3D scan data is useful in archeaeology, paleontology and cultural heritage applications for dimensional analysis and study, providing a digital archival record, increased access to objects in remote locations, and to produce replicas useful for public exhibits. There is no way to record a complex object than with a high resolution 3D scan. The fringe projection method used in white light scanning allows non-contact digitization of art and sculpture and historical artifacts. Direct comparisons can be made of dimension and shape. Scanning allows revisitation of any object over time, including redrawing of cross sections, 3D volume calculations, and other analysis that would otherwise prove to be very difficult if not impossible (Herban S and Musat C 2012b).

B. DATA ACQUISITION AND PROCESSING

Traditionally, archeological information is published in a monograph or book. But this kind of documentation can not be distributed economically and does not adequately depict the complex visual and technical data needed for study.

Vectorization is the process of making explicit, information in the raster image, by defining objects within the image using lines, arcs, closed polygons, etc. Vectorization of contours from a scanned topographical map is a complex procedure, requiring identification of features, rigorous image classification strategies and manipulation of spatial data structures like direction of line, boundaries and nodes, polygon vertices chain, etc. the automatic extraction of contour lines from a scanned topographical map and its subsequent vectorization is one of the major research problems in computer cartography and GIS (figure 2.72).

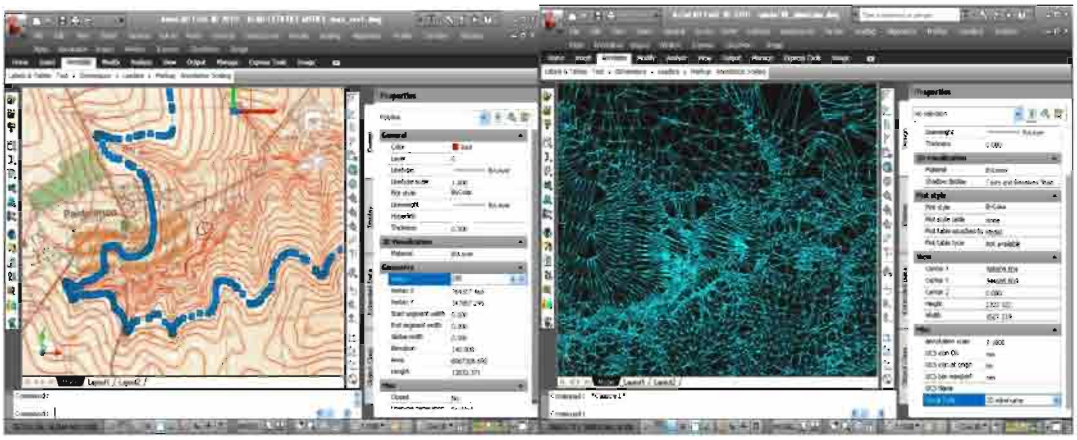


Figure 2.73. The modeling workflow: contour vectorization and creating the digital terrain model

The purpose of a 3D scanner is usually to create a "point cloud" of geometric samples on the surface of the subject. These points can then be used to extrapolate the shape of the subject (a process called reconstruction). If color information is collected at each point, then the colors on the surface of the subject can also be determined. The "picture" produced by a 3D scanner describes the distance to a surface at each point in the picture. 3D laser scanner combines non-cooperation laser range finder and angle measure system (Kivistö S. and Pihlström S, 2010).

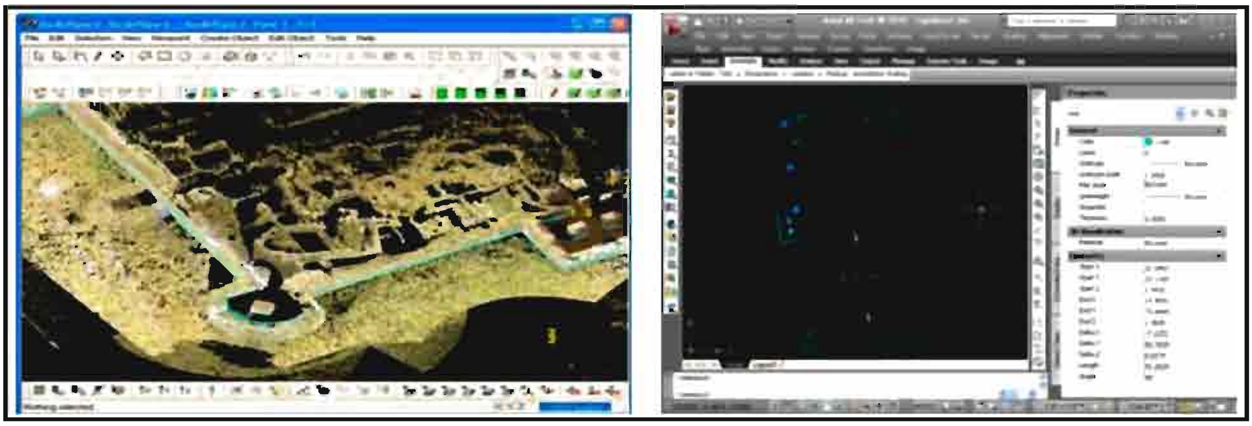


Figure 2.74. Technical modeling of visible parts of the ruins

Assembling digital terrain model and the city architecture, texture mapping, adding background and lights, creating animation was relalizat 3DStudioMax program developed by Autodesk. Model and texture characters, props and environments more efficiently in 3DS Max, with expanded Graphite and Viewport Canvas toolsets that deliver intuitive new brush-based interfaces for 3D painting, texture editing, and object placement. Meanwhile, a new in-context direct manipulation UI helps make polygon modeling faster and helps you maintain focus on the creative task at hand, while customized user interface (UI) layouts keep your choice of frequently used actions and macro scripts readily accessible. And, for projects where collaboration is critical, a significantly enhanced workflow with Containers enables multiple users to work in parallel, helping to meet tight deadlines.

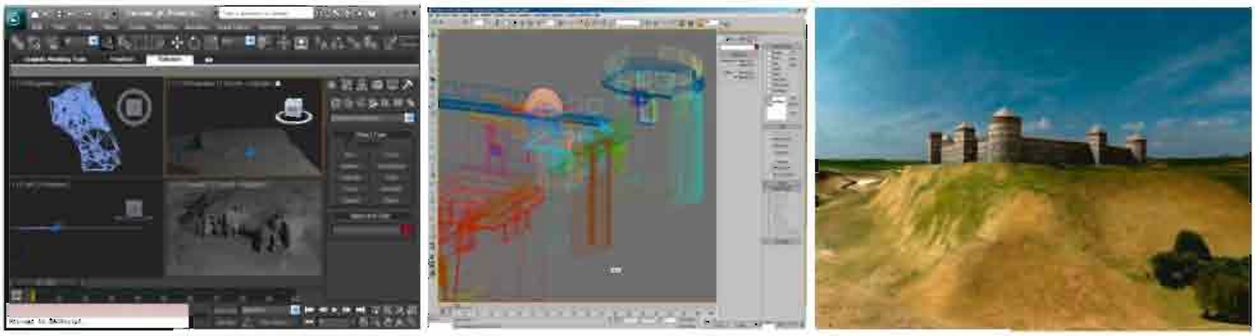


Figure 2.75. Assembling digital terrain model and creating architecture of the 3D Model process

C. CONCLUSIONS

3D laser scanning technology can acquire 3D point cloud quickly with high accuracy. This meets the needs of historical architecture surveying and protection. 3D laser scanning technology can replace traditional measuring methods completely in historical architecture surveying. 3D point cloud can be gained by laser scanner, then construct the 3D model. In addition, detail structure can be got by close-range photogrammetry method, which produces the orthoimage and linear drawing.

Surveying of Historical architecture based on 3D laser scanning technology can not only reduce field work, improve efficiency but also provide different kinds of products such as 3D model, CAD construction drawing and so on. 3D laser scanner is growing towards high speed, high accuracy, large range and multi-information etc at present. All these will impulse laser scanning application to historical architecture surveying and protection.

By digitizing these significant monuments, which are not well recorded, and are at ongoing risk of damage from environmental and human causes, the Cultural Heritage Sites recovery project made a big contribution to permanently preserve many of ruins. The 3D data of the heritage sites give the scientists the opportunity to study and document the engravings or small structures in the sites, and also compare sites of different locations. The 3D acquisition of heritage sites becomes more important because weather influences slowly disintegrate stones, and broken pieces disappear in the luggage of tourists.

D. ACKNOWLEDGMENT

The author wish to thank the company S.C. BlackLight S.R.L., , especially to Mr. eng. G BARLA, the director of the company, for the given support and for the permission of using in this paper images and results.

2.3.4.2. Creating 3D Models of Heritage Objects Using Photogrammetric Image Processing

This study is based on the scientific paper written by the autor in collaboration with C. B. Vîlceanu, which was published in AIP Conference Proceedings, ISI indexed, in 2013.

In this study is presented and created a 3D model for historical artefacts using low cost programs and technologies. It also brings forward the stages that must be followed when using specialized photogrammetric software in order to obtain the 3D model of an artefact, efficacious in assessment and monitoring of cultural heritage, thus contributing to historic conservation. The method presented can be easily combined with laserscan technologies. All over the world and also in Romania, three-dimensional documentation methods have begun to be used in archaeology, but these methods are generally expensive. Three-dimensional documentation for archaeological studies needs not so much the use of a highly technical or expensive technology as a realistic and feasible methodology for documenting artefacts (A. Styliadis and L. Sechidis 2011)

A. INTRODUCTION

3D refers to objects that been created in 3 position (X, Y and Z). Nowadays, there are a lot 3D objects that you can see in cultural heritage, civil engineering, digital terrain model, product designs etc. Even though they are commonly seen these days, their creation is not a simple fact. One needs 3D programs or specialized applications or websites that offer ready-made 3D models but not to specific scale. The starting point of the modeling approach is a mathematical principle of decomposition of a mixed process into parts that reflect its complementary aspects, random and non-random. This principle of decomposition is first appeared in the works of H. Wold in the '40s on the behaviour of time series (F. Pater 2012).

In the '60s Helson and Lowdenslager gave a multidimensional extension of the above principle, highlighting a fundamental characteristic of multi-D case in comparison with 1-D case, namely a supplementary decaying part called *evanescent*. In 2D, for example, this third part shows a composite look to this predictable-random process, in accordance with the horizontal/vertical 2-D directions (W Arveson, 1998).

3D graphics can be created with a number of powerful "Mathematic" functions and various programs. These programs will allow specialists to create 3D graphs for mathematical, scientific, engineering or business purposes. While creating these models and graphs, one can use such options of the listed software as rotation, zoom or perspective drawing. The resulting models can be saved or exported to different file formats used by other specialists from different domains of activity, especially archaeologists or architects.

Architectural Photogrammetry for the reconstruction and preservation of the cultural heritage statues, artefacts and ancient objects unfortunately remains a relatively unknown field for the majority of archaeologist, architects, restores and historians. Also this technology can be useful in medical or criminalist field. Having photographs as originating documents, architectural photogrammetry permits that every detail of a building should be precisely documented. Accurate examination of each detail may be undertaken latter with no hurry, and this is not always possible when the measurements are manually done. Thus, there is no risk of losing details that are kept preserved to the future.

Architectural photogrammetry is also an excellent method of:

- following-up restoration of buildings, allowing costs estimations more realistic than speculative;
- reduction of direct cost of the works, as well as some administration costs (Gomes C.J.M. and Prado W.S, 2012).

B. METHOD

Digital architectural photogrammetry evolves rapidly (due to new cameras, new software, new algorithms for data extraction and processing, etc.). Methods of data acquisition and processing in terrestrial photogrammetry are very different from aerial photogrammetry and the software packages in this last case are mainly dedicated to cartography and often not usable for modeling objects as buildings (Grussenmeyer P., And Al Khalil O, 2008).

For simple photogrammetric documentation of architecture, simple rules which are to be observed for photography with non-metric cameras have been written, tested and published by (Waldhaeusl & Ogleby, 1994).

These so-called “3x3 rules” are structured in:

- 3 geometrical rules:
    - preparation of control information,
    - multiple photographic all-around coverage,

- taking stereopartners for stereo-restitution.

- 3 photographic rules:
  - the inner geometry of the camera has to be kept constant,
  - select homogenous illumination,
  - select most stable and largest format camera available.
- 3 organizational rules:
  - make proper sketches,
  - write proper protocols,
  - don't forget the final check.

Photogrammetric multi-image systems are designed to handle with two or more overlapping photographs taken from different angles of an object. Presently, the software usually processes image data from digital and analogue imaging sources (réseau, semi-metric or non-metric cameras).

The acquisition of linear objects can be directly evaluated due to superimposition in the current photogrammetric image. These systems are designed for multi-image bundle triangulation. The main contribution of digital images in architectural photogrammetry is the handle of textures. The raster files are transformed into object surfaces and digital image data is projected onto a three-dimensional object model. Some systems are combined with a module of digital orthorectification.

The Canadian PhotoModeler Software Package developed by Eos Systems is well known as a low cost 3D-measurement tool for architectural and archaeological applications [http://www.photomodeler.com]. PhotoModeler (figure 12) is Windows based software that allows measurements and transforms photographs into 3D models. The basic steps in a project performed with PhotoModeler are:

- shoot two or more overlapping photographs from different angles of an object;
- scan the images into digital form and load them into PhotoModeler;
- using the point and line tools, mark on the photographs the features you want in the final 3D model;
- reference the points by indicating which points on different photographs represent the same location on the object;
- process referenced data (and possibly the camera) to produce 3D model;
- view the resulting 3D model in the 3D viewer;
- extract co-ordinates, distances and areas measurements within PhotoModeler;
- export the 3D model to rendering, animation or CAD program.

C. EXPERIMENTS

Photogrammetry is a 3D coordinate measuring technique that uses photographs. The fundamental principle used by photogrammetry is again triangulation (Remondino, El-Hakim, 2006). By taking photographs from at least two different locations, so-called "lines of sight" can be developed from each camera to specific points on the object. These lines of sight are then mathematically intersected to produce the 3D coordinates of the points of interest. As the involved mathematics is not the purpose of this paper, we present the method by describing a complete progress of an experiment from the early stage, i.e. from taking the pictures until the final point cloud processing.

The process begins with the camera calibration. The camera optics is not perfect. By imaging a reference background (coded circles on a white plane board), the optics defects may be calculated and the future pictures corrected (one speaks about "idealized" pictures). Once calibration is done, one can take a pair of pictures of the object to digitize. It is of course important to work with the same objective which means that the zooming capabilities of the camera should be avoided since the calibration corresponds to only one fixed position of the zoom (Yildiz F, 2011).

Calibrating the camera is a process of taking photos side in normally, 90 degrees rotation mode and from top of a calibration plate and inserting them into the program which starts a calibration project, as it can be seen in the following images (figure 2.75). 9 photos are usually needed (Alby E et al.)

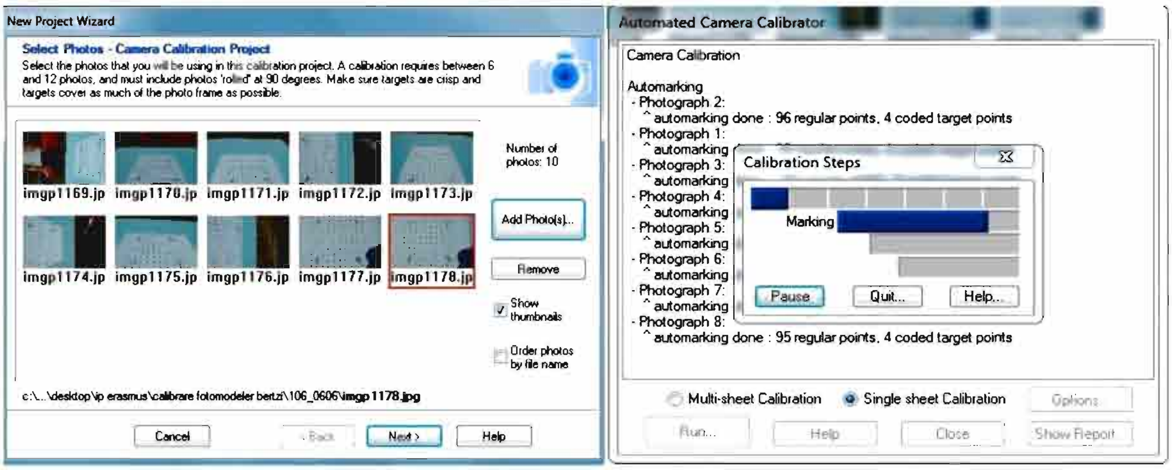


Figure 2.76. Calibrating the camera

Rectification process in the PhotoModeler program starts with selection of the first two photos for the orientation. For the orientation of photos for this case was used a minimum of 6 points in two photos and the PhotoModeler did the orientation, showing the report of orientation, and the residual errors (figure 2.76).

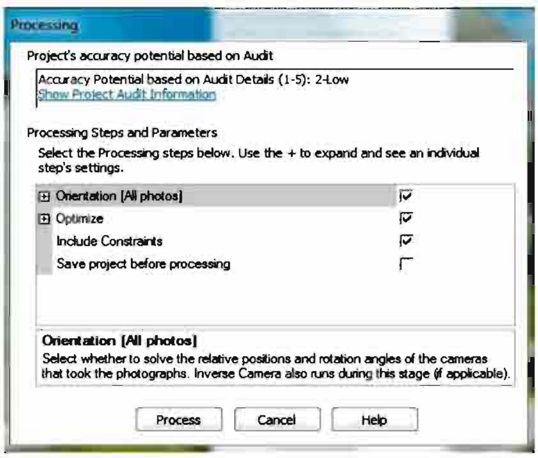


Figure 2.77. The report of orientation, and the residuals

For creating the 3D model we have to connect points by mark lines mode and make surfaces by path mode. Then we open a 3D viewer and there we choose 3D viewer options. Also we can change surface types in display style to fast texture (Havemann S, 2005).

A very promising way to visualize 3D-data is to create so-called "worlds", not only for computer games but also for "more serious" applications. VRML is a new standardized format (ISO 1997) describing three-dimensional models and scenes including static and dynamic multi-media elements. Most Internet browsers support VRML file format. 3D object models can be viewed and inspected interactively by the user or animated in real-time even on a PC. Thus, VRML is well suited to create e.g. interactive environments, virtual museums, visualizations and simulation based on real world data.

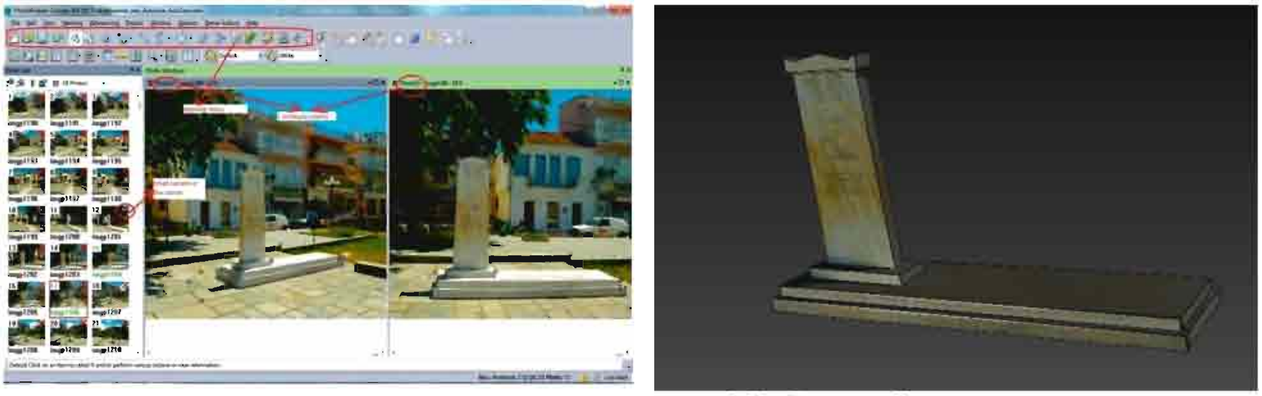


Figure 2.78. Creating 3D model of an artefact

D. CONCLUSIONS

The main purpose of this paper is the improvement of all methods for surveying of cultural monuments and sites, especially by synergy effects gained by the combination of methods under special consideration of photogrammetry (Kasser M and Egels Y., 2002). 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 virtual visits of objects in order to evaluate them, being the most important advantages.

E. ACKNOWLEDGMENTS

"This work was possible through the instrumentality of the Erasmus IP Program: EPOCHE (Excellence in Photogrammetry for Open Cultural Landscape & Heritage Education) Thassos Island, Northern Greece June 2-16 2013, Leader University TEI of Kavala, and Department of Landscape Architecture". Politehnica Univeristy Timisoara was a partner in this program by CCTFC Department.

2.3.4.3. Comparative study of TLS and digital photogrammetry

This study is based on the scientific paper written by the autor in collaboration with Adrian Alionescu, Carmen Grecea and Beatrice Vîlceanu, which was presented at the International Conference, Integrated geo-spatial information technology and its application to resource and environmental management towards GEOSS held in Hungary, 2015.

A. INTRODUCTION

Photogrammetry is the practice of determining the geometric properties of objects from photographic images. Photogrammetry is as old as modern photography and can be dated to the mid-nineteenth century.

In general, digital photogrammetry is the art of using computers to obtain the measurements of objects in a photograph. It typically involves analyzing one or more existing photographs or videos with photogrammetric software to determine spatial relationships. Although commonly used to create topographical maps, it may also be useful in a variety of industries such as architecture, manufacturing, police investigation, and even plastic surgery.

There are several important variables involved in digital photogrammetry. First, it may be useful for a photogrammetrist to know information about the camera, such as what type of camera took the photograph, the focal length of the lens, or the distance of the camera to the object of interest. A special type of camera, called a metric camera, is often used to take these photographs because it is calibrated to take precision photographs with little lens distortion.

A second variable to consider in digital photogrammetry is the desired dimensions of the measurements. Some projects require only two dimensional (2D) measurements, such as the height of a building or the width of a river. These measurements can be made from a single photograph. If, however, the measurements need to be three dimensional (3D), the process will then typically involve creating a 3D model from two or more photographs.

This process of creating a 3D model is usually called digital stereophotogrammetry. Stereophotogrammetrists usually analyze two or more photographs of the same object, taken from different angles. They typically use the space where the photographs overlap or common points of reference shared by the photographs to create a digital 3D model. The images may then be mapped, pixels by pixel within the model to create measurable space in three dimensions.

A third variable is the type of photographs used. Photogrammetrists usually use either still digital photographs or video. Film photographs and video tape typically must be scanned into a computer in order to be used in digital photogrammetry.

The two main categories of photographs are aerial and close-range. Aerial digital photogrammetry, often used in topographical mapping, begins with digital photographs or video taken from a camera mounted on the bottom of an airplane. The plane often flies over the area in a meandering flight path so it can take overlapping photographs or video of the entire area to get complete coverage.

Close-range, or terrestrial, digital photogrammetry often uses photographs taken from close proximity by hand held cameras or those mounted to a tripod. Close-range photographs can be used to create 3D models, but they are not usually used in topographical mapping. This type of photogrammetry is useful for the 3D modeling of many objects or areas such as buildings, automobile accident scenes, or movie sets.

On the other hand, cultural heritage objects are an expanding application area. In this context, the present paper brings forward a comparative study of TLS (Terrestrial Laser Scanner) and digital photogrammetry for 3D modeling of the Martyr's cross monument located in Arad, Romania. The authors take into account the accuracy of the 3D models obtained, the overall costs involved for each technology and method and the 4th dimension – time. The paper proves its applicability as photogrammetric technologies are nowadays used at a large scale for obtaining the 3D model of cultural heritage objects, efficacious in their assessment and monitoring, thus contributing to historic conservation. Its importance also lies in highlighting the advantages and disadvantages of each method used – very important issue for both the industrial and scientific segment when facing decisions such as in which technology to invest more research and funds. For cultural heritage purposes, the 3D models of the Martyr's cross monument realized in this comparative study meet the accuracy criteria and sustain the idea that not in every modeling process there is much need of using highly technical or expensive technology as a realistic and feasible methodology for documenting cultural heritage objects with the aid of GIS.

The accuracy and the precision of the model are directly influenced by the quality of the measurements realized on field and by the quality of the software. The software is in the process of continuous development, which brings many improvements.

The main advantage of photogrammetric modeling is that one obtains information regarding inaccessible structures or elements of structures, which is of great importance for architectural and cultural heritage objects located in difficult places.

In contrast with traditional drawings of architectural and cultural heritage objects, which only contain their dimensions, the 3D model also includes detailed information regarding the materials used. This fact is very important when parts of the structure are destroyed, assigning their dimensions when the model is created.

The main advantage of photogrammetric modeling is the cost of the procedure. Field work is considerably reduced compared to classic surveying method which imply measuring all dimensions on the field. The necessary time for modeling is roughly equivalent to that required of drawing the object directly. Also, due to the development of the digital cameras, cultural heritage specialists have begun to consider 3D not just an "expensive" option, but a very affordable one for the production of maps, sections, cross-sections, and volumetric analyses with a high level of accuracy.

For retrieving data through 3D laser scanning technology, issue debated by author in the specialty literature, togheter with the team we used Trimble TX5 laser scanner. It features a quick-acting laser, capable of measuring up to 976.000 points in one second, up to a distance of 120 metres and an integrated camera, able to make panoramic photos up to 70 megapixels. Adding these pictures over the point cloud resulted from the scanning process, photorealistic 3D images will obtained. The scanner has a two-axis compensator, an electronic compass and an altimeter, these enabling the registration (linking station) of the scans. Due to its very small size (240mm x 200mm x 100mm) and its very low weight (5kg), compared with the other scanners, it is very easy to set and used. Commands are carried out by means of a touch screen or via cell phones, tablets and computers Wi-Fi. The control software is very easy to use, being created in a logical and intuitive manner. Surveyed data is stored on a SD memory card, which can be later transferred to a computer easily. After downloading, data may be processed in Trimble RealWorks software, which provides various commands for advanced 3D modeling and processing of the point clouds.

B. PROCESS, APPLIED METHODS

TLS 3D modeling of the Martyr's cross monument

Similar to any traditional topographic word, the 3D scanning process starts with the study of the terrain and of the object to be measured. To have an operative and accurate campaign of measurements, we came to the conclusion that 3 stations in which the scanner to be set would be enough. After determining the approximate location of the stations, the spherical targets were placed in order to facilitate the registration process. The scanning session lasted 40 minutes and the processing of the data was realized using Trimble RealWorks software.

Once the scanned data is imported, the point cloud is created and the operator has the possibility of customizing it by choosing the number of points, their density etc. In this phase, the scans are not connected, so by using the panoramic photos realized during the scanning process, the targets will be selected in order to register the scanning. The software offers has 2 options: either it selects automatically the circular targets from a user defined area or the operator manually (Fig. 2.78) chooses the targets.

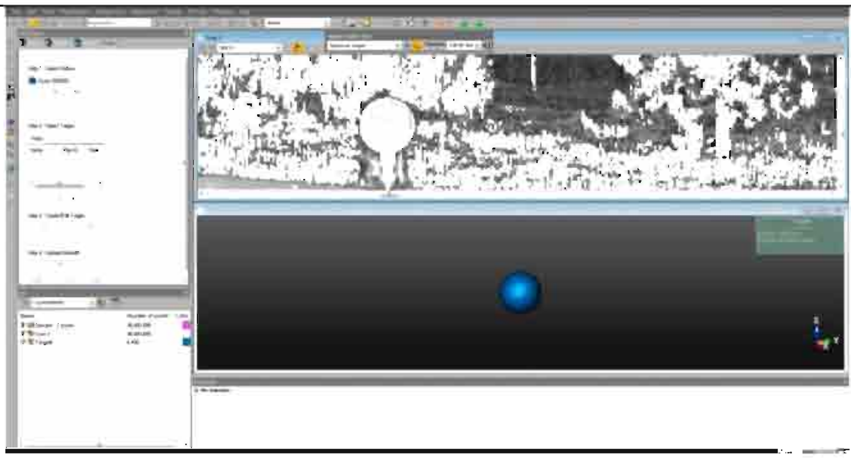


Figure 2.79. Manually inserting the targets

Once the selection of the circular targets is finished, by using the “Adjust” command, the link between the scanning stations (Fig. 2.79) is created and the registration details are transmitted: the residual error for each station and target.

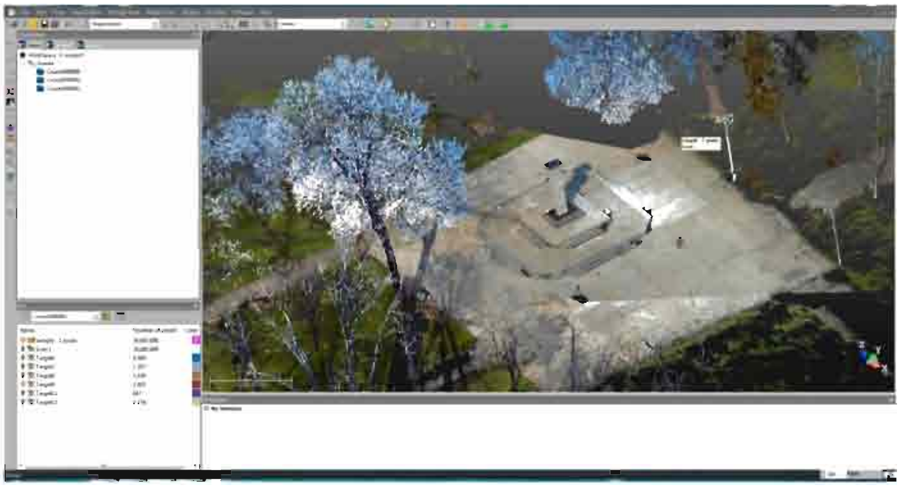


Figure 2.80. The point cloud after registration

For better visualization purposes of certain details of the point cloud and to reduce the noise, different tools for the selection of certain portions of the point cloud are available, also called areas of interest. Because in this case we are interested only in the Cross of the Martyrs, we remove all the other points that are surplus. The command which enables this procedure is “Segmentation Tool”. Once selected the area of interest, we can move on to the actual modeling of the point cloud. The cloud will be modeled with mesh surfaces. This command can be selected from the “OfficeSurvey” module and then “Mesh Creation” command. We create the mesh for the socle and the cross (Fig. 2.81).

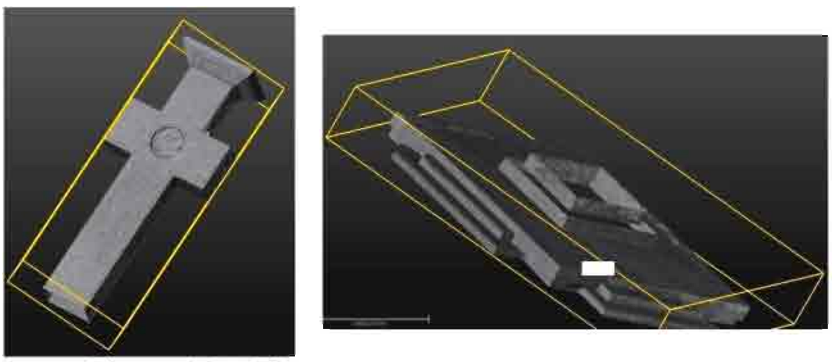


Figure 2.81. The meshes for the cross and its socle

Digital photogrammetry 3D modeling of the Martyr's cross monument

The shooting session of the Martyr's cross was achieved using a compact (DSLR) Nikon D60 camera. About 50 pictures of the monument were taken, but, for the creation of this model only 17 images have been used. The photos were taken from about 10 metres from the monument, at a distance of approximately 2 meters between each position of the observer (operator).

The photogrammetric processing (Fig. 2.82) of the digital images was done by means of Agisoft PhotoScan software.

An advantage is represented by the fact that preparing for a digital photogrammetric application such as the one described above does not require previous training, involving for the field work, only the use of a digital camera, a total station or a measuring tape.

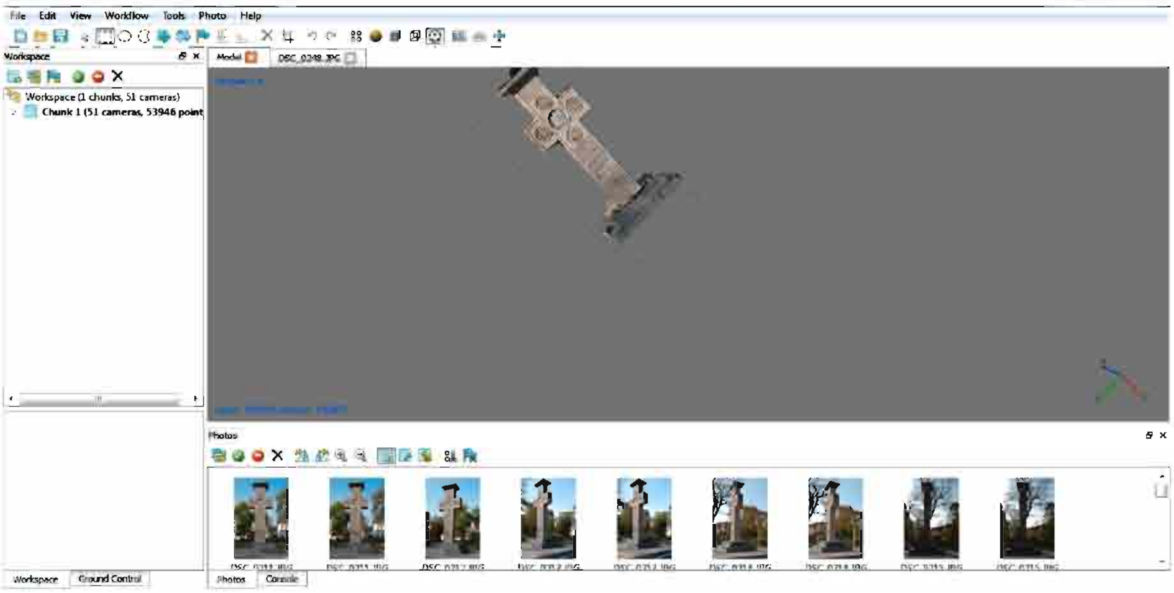


Figure 2.82. The mesh model with texture on it

As regards the specialized software, it is fully automated to create the point cloud, build the geometry and the texture of the object. User only cuts out the unnecessary points, which are not important for the modeling around the object. It is recommended to use PhotoScan for the objects with complicated geometry. The speed of the calculation depends on hardware capabilities of the computer (Herban S et al. 2014 c).

3D modeling technique based on images demonstrates the useful character of digital photogrammetry for accurate 3D modeling and visualization of the actual objects which respect regular geometric shapes (monuments, buildings etc.). The accuracy with which the 3D models are obtained (less than one pixel) corresponds to applications in the field of assessment and conserving cultural heritage, thus photogrammetry can become the best alternative to traditional measuring techniques.

Analysis of the 3D models obtained and proposing a general workflow

The importance of the comparative study is reflected by the practical usefulness of the specialized software, through which 2D and 3D models can be realized, using relatively easy to use equipment. Furthermore, a comparison between different techniques and technologies always brings value from the economic point of view.

The models recorded with the above-mentioned technologies were ready for 3D visualization a few hours after data Capture (Forte M, 2014).

The GIS solution is usually understood as a desktop solution. Many books and manuals on GIS technology talk about a GIS application and its subsequent publication on Internet (Xie M.W., et al. 2012)

Nowadays, it is possible to conceive a new type of GIS project based on a client-server approach using a relational spatial database where all data (e.g. geometric, alpha-numerical) can be collected together and directly managed by the client application on the WEB.

Thus, the authors propose a general workflow (Fig. 2.83) for documenting cultural heritage applications aiming to later create a Spatial Information System published on the WEB.

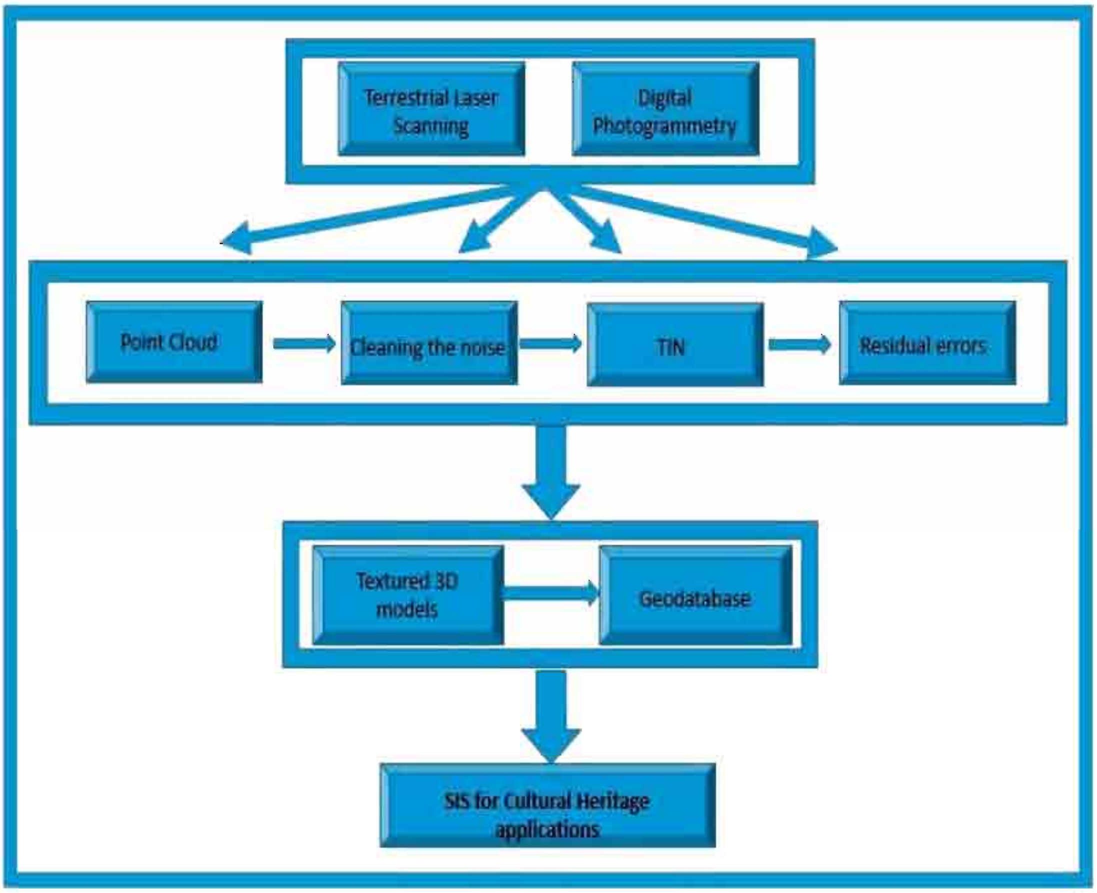


Figure 2.83. Workflow from laser scanning and digital photogrammetry to 3D modelling and visualization to WebSIS

C. CONCLUSIONS

By the comparative study of the two methods used for creating a 3D model, we can conclude that there are both resemblances as well as differences between the two technologies presented. Depending on the complexity of the work, the need for accuracy and the necessary funds allotted, one can choose the most suitable method which meets the criteria mentioned above.
By comparing the time needed to realize the 3D model, laser scanning is relatively time-consuming compared to the digital photogrammetric method which, instead allows for immediate results. As regards the accuracy, the scanning is once again more accurate, by creating a 3D model very close to reality; instead, regardless of software and photos taken, by photogrammetric methods, the model is close to reality, but not very accurate. Laser scanning requires longer post-processing, but produces higher quality data.

From the financial point of view, incontestably the photogrammetric methods are much cheaper than 3D laser scanning, even though the present work has been carried out using one of the cheapest scanners on the market. Nevertheless, laser scanning campaign’s cost, along with software for data processing, is somewhere around the amount of 50.000 euros. Instead, the photos can be taken with any digital camera, 3 megapixels, including with the camera of your phone. The cost of this method is substantially lower.

Regarding the workflow proposed for 3D modelling and visualization to WebSIS, the conclusion is that 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. As we stated in the introduction of the present paper, Web-GIS solutions have several advantages among which the access to spatial data characteristic to cultural heritage documentation for different specialists and different purposes. The entire workflow involves the following steps: on-site data-capturing using different technologies, post-processing, stereo visualization, 3D spatial georeferencing and GIS implementation.

2.3.4.4. Architectural and Touristic Potential of Timisoara, Romania Highlighted by WebGIS Solutions

This study is based on the scientific paper, written by the autor in collaboration with O. Grecea and A. Alionescu, which was published in the 15th International Multidisciplinary Scientific GeoConference SGEM 2015, ISI indexed.

Proposing and implementing the methodology for creating and adapting the spatial webGIS platforms or Open Source webGIS for integrating 3D Cultural Heritage objects. Another main aspect arising from the present project and its development is the establishment and adjustment of spatial GIS-type platforms or Open Source webGIS for adding 3D Cultural Heritage objects. The integration of information, both textual and spatial, in a single platform facilitates access for many users without the need for specialized software, decision making process for better conservation of Cultural Heritage objects as well as what regards possible interventions to prevent degradation or conservation with a view to rebuilding them (Herban and Grecea, 2011).

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.

Implementing and realizing this project will result in adding information to the scientific literature both at national and international level. So, various specialists in areas such as land measurements, geography, architecture, archaeology, history etc. will benefit from the results and findings of this project which gives a strong note of interdisciplinary to the project.

In terms of quality/cost indicator, the study and creation of digital models, the techniques and technologies used for their realization bring added value to related fields such as medicine (human 3D model and facial reconstruction as a result of accidents, automobile industry, forensics etc.).

The study of the deformations of a Cultural Heritage object using Laser Scan technology and thermal cameras can be applied to the field of civil engineering for assessment of cracks and material degradations affecting various structural elements of bridges, tall buildings etc. *(*Herban and Musat, 2012).

Current research in this domain differentiates between creating 3D models for Cultural Heritage objects or buildings and creating GIS solutions for them. There are methods and models for digital realization of both objects and buildings belonging to Cultural Heritage and there also are GIS solutions for Cultural Heritage purposes but most of them do not work with 3D models integrated into GIS platforms (Oreni *et. al*, 2012). Moreover, the possibility of integrating 3D models (the model itself and a spatial analysis of its deformations) into customized Open Source or Low-Cost GIS platforms and the analysis of webGIS platforms and their functionalities for 3D Cultural Heritage has not been studied and realized, thus there is a lack of knowledge.

P. Patias and M. Santana (2009) have shown that the base line used in Cultural Heritage documentation implies a training approach that should identify and define the parameters relevant in particular heritage assessment. The chart in figure 2.84 describe the components of a baseline record and information retrieval in the 3D Model.

This baseline, additionally, could be used as starting point for designing and implementing plan monitoring strategy, allowing detecting changes affecting the statement of significance of the heritage place. A baseline is defined by both a site report and a dossier of measured representations that could include a site plan, emplacement plan, plans of features, sections, elevations, three-dimensional models etc. The following checklist can be used as guideline to adequate requirements of information required for defining the baseline and training purposes (figure 2.84).

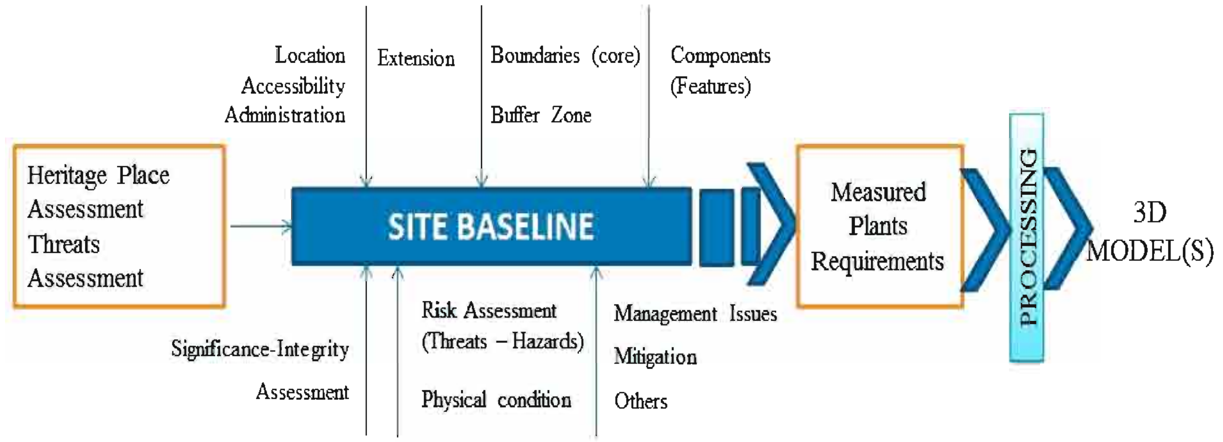


Figure 2.84. Defining a base line and 3D model Processing

Speaking about experimental design and data collection is based also on the close range photogrammetry, proposed by (Z. Li and J. Chen, 2011). In their paper, the authors specify that the creation of 3D models of heritage and archaeological objects and sites in their current state requires a powerful methodology able to capture and digitally model the fine geometric and appearance details of such sites. Digital recording, documentation and preservation are demanded as our heritages (natural, cultural or mixed) suffer from on-going attritions and wars, natural disasters, climate changes and lack of preservation. In particular, the built environment and natural heritage have received a lot of attention and benefits from the recent advances of range sensors and imaging devices (Li Z., *et al.*, 2008 and Li D *et al.*, 2009).

Indeed, remote sensing technologies and methodologies for Cultural Heritage 3D documentation and modeling (Cowley, 2011) allow the generation of very realistic 3D results (in terms of geometric and radiometric accuracy) that can be used for many purposes, such as historical documentation , digital preservation and conservation (Remondino, 2000), cross-comparisons, monitoring of shape and colours, simulation of aging and deterioration, virtual reality/computer graphics applications (Bruno, 2010), 3D repositories and catalogues (Manferdini and Remondino, 2010), web-based geographic systems, computer-aided restoration, multimedia museum exhibitions, visualization and so on. For modeling the surface, a Triangulated Irregular Network (TIN) can be calculated based on the laser scan datasets using the 3D-Analyst extension. The model created by using this technique can then be converted into a raster digital elevation model (DEM) in order to be used for generalizing and smoothing the very detailed DEM for different ruins, ancient buildings and artifacts.

The Timis County has a total area of 8.687 square kilometres and is situated in the western part of Romania, on the border of three countries: Romania, Hungary and Serbia. Timisoara is the capital city of the Timis county and during the ages was under German, Hungarian, Serbian or Turkish occupation. This fact has left a strong landmark upon the architectural, cultural and economic development, which lasted until the present days and can be found in the architectural styles' diversity and in the multitude of nationalities living here. Due to the fact that Timisoara is located in the Banat plain, natural resources are poor, so the richness of the region consists in the architectural and touristic potential. In this context, historical buildings play an important role in the cultural heritage scenario: their main value is due overall to age, artistic and structural features and to surrounding environment. Sustainable architecture 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.

On the other hand, the styles of people's consumption and entertainment have dramatically changed with the improvement of living standards. Travelling has become one of the main activities of leisure due to its multiple advantages. In recent years, many new forms of tourism such as long-distance travelling and outbound tourism have greatly accelerated the development of this industry. Nowadays, integrating this amount of information into webGIS platforms is not just a desire, it is a necessity. Based on the tourists' requirements for information, the structure and functions of tourism services can be optimally defined using webGIS. While Desktop and Server GIS will continue to play a key role in the future, a new pattern of web-centred GIS is emerging. This involves GIS-ready services that supply data, maps, imagery and models, and community sharing of information through search and discovery portals.

In this context, the main idea of sustainability or ecological design is to ensure that our actions and decisions today do not inhibit the opportunities of future generations.

A. INTRODUCTION

At a greater scale, Timişoara is situated in the south-eastern part of the Pannonian basin, in a very favorable position from a commercial point of view: it is less than 700 km away from 13 European capitals. The city also has a very good accessibility - by road, train and air.

Timişoara is located at the intersection of the 45°47' north latitude parallel and the 21°17" east longitude meridian, in the northern hemisphere, at almost equal distances from the North Pole and the Ecuator, and at the same time in the eastern hemisphere, at 550 km from Romania's capital city, Bucharest, and 300 km from Belgrade and Budapest. Geomorphologically speaking, Timisoara is part of the Banato-Crişana plain, with a total surface of 12.926,83 ha and rising.

The Timisoara growing pole has always been manifested as a workforce attractor for other regions of the country, especially for northern Moldavia, north western Transylvania and Oltenia. At this time, the Timis county consists of: 35000 hungarians, 15000 bulgarians, a few thousand italians (which form a stable community in Timisoara), 500-600 jews, almost 1000 arabians (sirians, palestinians, iraki, lebanese, egiptians, moroccans and tunisians), hundreds of chinese, over 6000 ukranians, over 11000 serbians, a few thousand slovakians and a few hundred turks and russians.

"Timişoara has always been an emblem of multiculturalism!..of promoting communication between different nationalitiesand cultures! The world is so beautiful in so many colours! (opinion over Timişoara on a news webpage by Alchimistul verbal - 11 may 2012, 13:24).

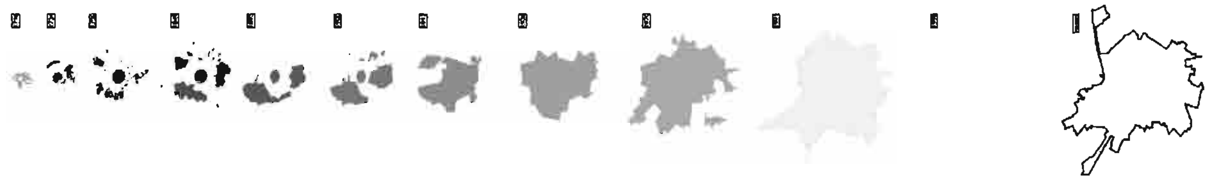


Figure 2.85. Timisoara's growth graphic - from 1716 to present (source: PUG 2012)

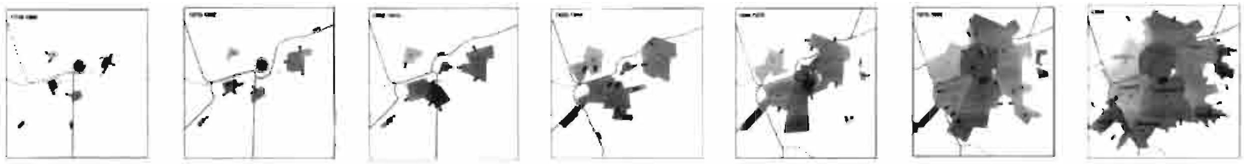


Figure 2.86. Neighborhood evolution in Timisoara - from 1718 to 1998 (source: banaterra.eu)

Historical monuments have both a documentary and scientifical value and they are part of the autobiographical value of the people. " (V. Drăguț).

Historical monuments are scientifically defined as "built goods over the territory of Romania, which are significant for the history of culture, national and universal civilisation (*Law nr. 422/2001 of Historical Monuments*). Therefore, the cultural built patrimony is a keeper of the memory and identity of the Banat space, defining at the same time the architectural specificity of the area. As a part of society's memory, historical monuments survive depending on historical, social and economical conditions, but also depending on people's behaviour towards them. The geographical position of our county, as a gate between the East and the West, has brought throughout the years roman, byzantine, romanic, gothic or renaissance influences, which characterize the archaeological and architectural sites of the area.

This inherited patrimony has a great value, being acknowledged both nationally and internationally through the personalities of some architects that have worked in Budapest, Vienna and other European cities (L. Szekely, L. Baumhorn etc). These buildings are part of special selections and a part of the Historical Monuments' List. Even if the original functions of these buildings are no longer actual or have changed throughout the years, they need a complex refurbishment intervention, which would successfully introduce them in the touristic visiting circuit (Grecea O, 2013)

A characteristic that defines the unicity of the Banat patrimony could be the interesting phenomenon of stylistical interferences, between post byzantine and baroque styles. This phenomenon is very present in the architecture of a lot of orthodox churches that were built during the XVIIIth century in Banat and are is yet emphasized enough (through intervention policies regarding the monuments' restoration and preservation (Jucu I.S., 2012).

Figure 2.87. Captures with some Churches: 1. Roman-Catholic church (Cetate neighbourhood) 2. Roman-Catholic church (Fabric neighbourhood) 3. Roman-Catholic church (Elisabetin neighbourhood)

This present analysis refers to the build scene in Banat, starting with the second decade of the XVIIIth century, after this area has been added to the Habsburg Empire. These monuments have been representative for this period and they still exist today, which places a great focus on their actual form and preservation possibilities. The political stability and economical prosperity that came with these times generated a whole series of architectural investments: fortified cities, administrative buildings, Roman Catholic churches and housing for the newly colonized population (Wanner R., 2010).

The rehabilitation of the old fortified cities was a priority for the new administration, for example the ones in Timisoara, Lugoj or Caransebes. In Timisoara, the Vauban fortifications consisted of nine strongholds, named Carol, Francisc, Therezia, Iosef, Hamilton, Castelul, Mercy, Elisabeth and Eugeniu. The Therezia Bastion is the only one left of the old city; it offers today a good example of an “alive” historical monument.

The Class A Monument (according to the National List of Monuments) was rehabilitated in 2010 by a team of local architects, which gave the built space and its surroundings the power to express themselves properly. Due to the development of the central area of Timisoara in the past years, which brought new functions like bank headquarters, the Faculty of Fine Arts and Design, the Medicine Faculty, in the vicinity, this space needed to be reinvented for a developing society which learns to take charge of its urban life.

Figure 2.88. Aerial simulation for the Theresia Bastion (source: http://www.kromston.ro)

The main guidelines of the project were: implementing cultural and socializing functions, defining a new urban space by redesigning the Honour Court and connecting this space with the existing square framework of city and reassembling the image of the monument through a careful restoration process. So, the main concept theme catered on reintegrating and defining a new urban pole by applying creativity on the public space – an area in which too little has been invested in the past twenty years in Romania.

Figure 2.85 Images of the finished project: varieties of public spaces (source: http://www.archdaily.com, © Stefan Tuchila)

Throughout the above mentioned historical perimeter, there is a great number of important monuments - barracks, dwellings, churches etc. that are waiting for a chance of expression.

From an architectural point of view, Timisoara has a total of approximately 14500 historical buildings. Timisoara's case is the most complex in the western region, with buildings like roman catholic churches from the Cetate, Iosefin, Fabric and Elisabetin neighbourhoods, the sinagogues in Cetate and Fabric, education buildings (Piarist highschool, the superior school for girls, Pedagogical highschool, C.D. Loga highschool etc.), bank buildings, Lloyd building, Commerce Chamber. To these, we could also add the protected area of extensive residential areas that were built between the end of the XVIIIth century and the first half of the XXth century in the historical neighbourhoods of Cetate, Iosefin, Fabric, Elisabetin.

Figure 2.89. Captures with important objectives: 1. Art Museum (The Baroque Palace), 2. Piarist complex (Cetate neighbourhood, arh. A. Baumgarten, L. Szekely), 3. Commerce Chamber building (Cetate neighbourhood), arh. L. Szekely

B. CONSIDERATIONS REGARDING 3D MODELING FOR CULTURAL HERITAGE DOCUMENTATION

In this context, cultural heritage documentation includes an interdisciplinary approach having as purpose an overall understanding of the object itself and an integration of the information which characterize it. This integration is nowadays realized in GIS mediums which are suitable for handling vast amount of geospatial data and offering detailed investigations on the object of interest. Because a cultural heritage documentation involves diverse areas of specialists and also huge data, besides the spatial information itself, the most suitable manner of managing all this various data, starting with collecting, interpreting and sharing it and the results of its interpretations, is on GIS platforms (Buhmann E, 2010). Also, a special attention should be paid to ensuring both standardization and interoperability of the data.

A much greater amount of information is obtained using the 3D model than 2D drawings (Herban S and Vilceanu B. 2012). Once completed the 3D model, we can generate any orthogonal projection or centred on the object (Rinaudo F et al.2007). The model can be exported to several other modeling or animation software, allowing further editing of the model (editing, adding elements of lights, creating dynamic visualizations etc.).

The accuracy and the precision of the model are directly influenced by the quality of the measurements realized on field and by the quality of the software. The software is in the process of continuous development, which brings many improvements.

The main advantage of photogrammetric modeling is that one obtains information regarding inaccessible structures or elements of structures, which is of great importance for architectural and cultural heritage objects located in difficult places.

In contrast with traditional drawings of architectural and cultural heritage objects, which only contain their dimensions, the 3D model also includes detailed information regarding the materials used. This fact is very important when parts of the structure are destroyed, assigning their dimensions when the model is created.

The main advantage of photogrammetric modeling is the cost of the procedure. Field work is considerably reduced compared to classic surveying method which implies measuring all dimensions on the field. The necessary time for modeling is roughly equivalent to that required of drawing the object directly. Also, due to the development of the digital cameras, cultural heritage specialists have begun to consider 3D not just an “expensive” option, but a very affordable one for the production of maps, sections, cross-sections, and volumetric analyses with a high level of accuracy.

C. ANALYSIS OF THE 3D MODELS OBTAINED. PROPOSAL FOR A GENERAL WORKFLOW

The importance of the comparative study is reflected by the practical usefulness of the specialized software, through which 2D and 3D models can be realized, using relatively easy to use equipment. Furthermore, a comparison between different techniques and technologies always brings value from the economic point of view.

The models recorded with the above-mentioned technologies were ready for 3D visualization a cple hours after capture the data. Some advantages and disadvantages of 3D modeling using the terrestrial laser scanning and digital photogrammetry are highlighted in the following figure (Fig. 2.90).

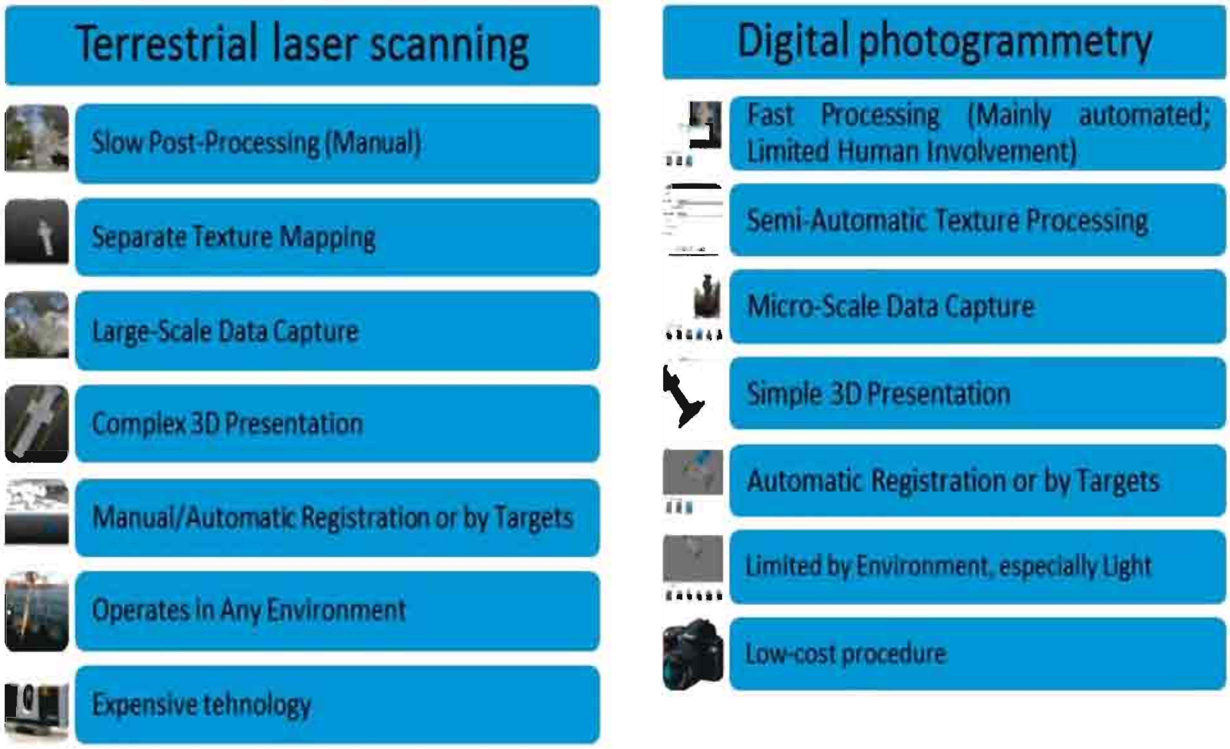


Figure 2.90. Advantages and disadvantages of the methods used for 3D modeling

The GIS solution is usually understood as a desktop solution. Many books and manuals on GIS technology talk about a GIS application and its subsequent publication on web.

Nowadays, it is possible to conceive a new type of GIS project based on a client-server approach using a relational spatial database where all data like: geometric, alpha-numeric can be collected and directly managed by the client application on the WEB.

Thus, the authors propose a general workflow (Fig. 2.91) for documenting cultural heritage applications aiming to later create a Geographic Information System published on the WEB.

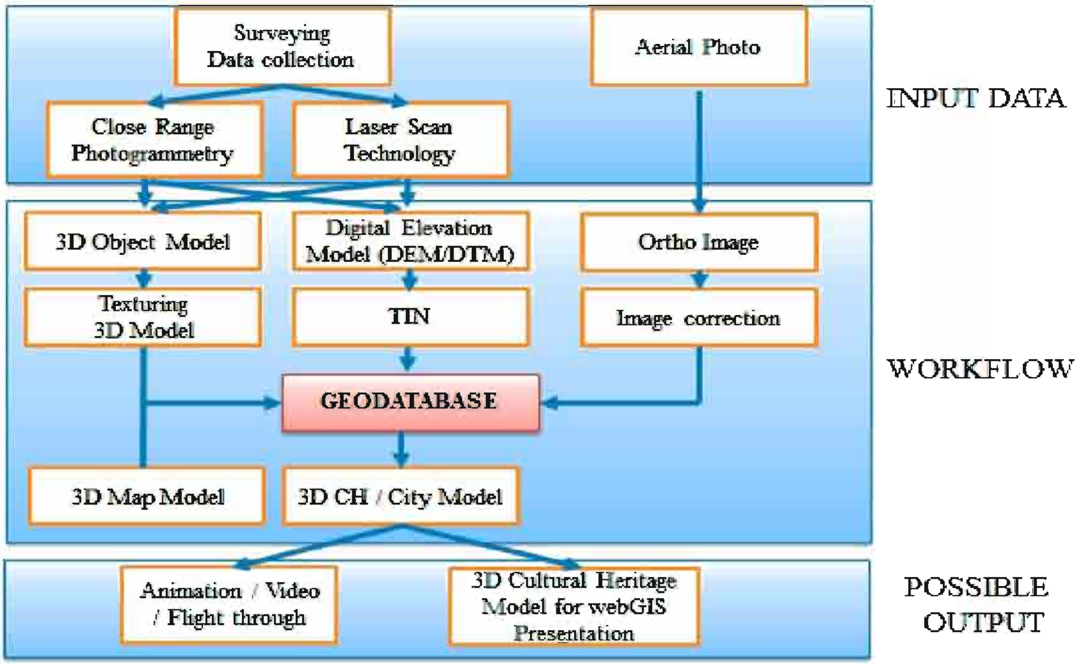


Figure 2.91. Workflow from laser scanning and digital photogrammetry to 3D modelling and visualization to WebGIS

Figure 2.92. Proposed workflow for a web architectural and touristic webGIS

D. CONCLUSIONS

Historical buildings play an important role in cultural heritage scenario: their main value is due overall to age, artistic and structural features. By conceiving the 3D model of such buildings, they can be better preserved in time for restauration purposes and they can offer virtual tourism tours if they are made available by means of webGIS.

Regarding the workflow proposed for 3D modelling and visualization to WebSIS, the conclusion is that 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. As we stated in the introduction of the present paper, Web-GIS solutions have several advantages among which the access to spatial data characteristic to cultural heritage documentation for different specialists and different purposes. The entire workflow involves the following steps: on-site data-capturing using different technologies, post-processing, stereo visualization, 3D spatial georeferencing and GIS implementation.

A proposal of integrating webGIS cultural heritage model can be seen in the video attached at the habilitation thesis.

2.3.5. E-Learning and Engineering Studies

2.3.5.1. E-Learning in Engineering – Impact upon the Student's Mentality and Development

This study is based on the scientific paper written by the autor in collaboration with Carmen Grecea and Beatrice Vîlceanu, which was published in the 11th eLearning and Software for Education, Rethinking education by leveraging the eLearning pillar of the Digital Agenda for Europe, Vol. 1, ISI indexed.

The purpose of this study is to support and promote the techniques and technologies based on e-learning system. Current trends in the university network require implementation of the policy for restructuring the higher education system, by focusing on the student's educational activities. The new methods involve experimentation learning based on scenarios, alternative solutions and direct interaction between the student, the subject of learning and the learning environment. In this context, when the institutional support is provided, improvement and diversification of educational offers for geodetic engineering and their correlation with the labour market are defined on two main directions. As regards the bachelor cycle, 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. For the master cycle, emphasis is put on the use of the Virtual Campus of the Politehnica University Timisoara, system based on Moodle, an open-source platform which is an online educational environment of academic support for all faculties belonging to Politehnica University Timisoara. In the present paper, the authors aim to put forward issues such as: where the academic system is heading to (Quo Vadis Academia?) at the beginning of the 3rd millennium in a Europe that is supposed to be Globally Competitive; what are the requirements of the higher education system and of research seen as key positions in the EU strategy; what does quality in higher education mean, as well as presenting their own experiences regarding the implementation of e-Learning technologies in geodetic engineering, its impact on the development and mentality of students and proposals for enhancing the system by offering Open Educational Resources.

A. GENERAL CONTEXT

The opportunities provided by the use of Open Educational Resources (OER) spread beyond classroom collaboration. In the past years, Romanian universities have had several OER initiatives for higher education system in the technical sciences and engineering field (R. Vasiu and D. Andone, 2014).

As regards the Romanian geodetic higher education, like any other education system in the world, it cannot evolve as a closed system, inflexible to increasing demands of beneficiaries, to today's challenges, but also to specific developments of the European area, in the field of education.

As a result, the notified bodies considered necessary the implementation of improvement processes based on models, mechanisms, concepts, and stable rules, validated and accepted, taking into account, at the same time, real and specific conditions characteristic to Romanian education, having as general goal upgrading the curriculum, including the Geodesy domain.

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.

In the context of implementing into the University network the policy for restructuring the system of higher education, by focusing on the student's educational activities, it is proposed to improve and diversify educational offerings for Geodesy domain and correlate them with the labour market.

Taking into account the advantages of e-Learning such as: online support, constant and continuous-academic and communication, communication tools and ongoing support//teaching activity, improving academic activity, involvement and student motivation; e-Learning platforms for geodetic engineering must be designed so as to ensure the harmonization and standardization of a training program at a wide multi-regional level. This strategy depends on the existence of several similar programs in Romania to promote learning platforms for providing a common foundation of information. A training program is designed to allow, firstly, the adaptation of curricula's content to the requirements of a globalised market and ensure a much wider opening of the skills that students will acquire at the end of their studies.

B. WHERE THE ACADEMIC SYSTEM IS HEADING TO? WHAT DOES QUALITY IN HIGHER EDUCATION MEAN?

Aiming to improve the use of ICT in higher education together with producing a positive impact on students' motivation, development and mentality, at the beginning of the 3rd millennium in a Europe that is supposed to be Globally Competitive, the question that arises is where the academic system is heading to (Quo Vadis Academia?). This question naturally suggests another one, namely: what does quality in higher education mean?

The 3 directions that quality in higher education should follow are:

- presentation of pertinent information; value, compelling and relevant judgments;
- the formulation of recommendations for students, the labour market and academia;
- the promotion of a new culture of academic quality in higher education.

In this context, the challenge consists in determining the requirements (Fig. 2.93) of the higher education system and of research seen as key positions in the EU strategy.

1. The internal Reform of the system

- Curriculum reform (focus on student and learning, skills training, mobility of students/ eurostudent, teachers/euroteachers and programs);
- Financing reform (diversified sources: education fees, grants, loans etc., substantially increasing the allocations from the State budget);
- Management reform (increasing of university autonomy, professionalization of university management and academic administration, quality assurance).

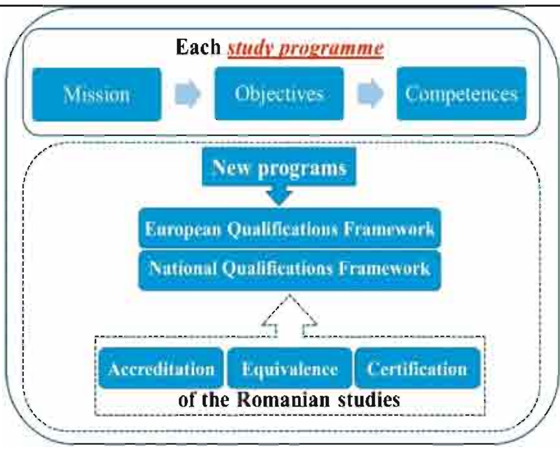


Figure 2.93. Specific manner of thinking the discipline, the study programme and the bachelor specialty

2. Reform of the universities' strategic partnerships

- Innovative capacity (increase the performance in research);
- Creation of partnerships (university-university, university-economic units etc.);
- Involvement of universities in regional development programmes.

Harmonization with international quality standards presumes detailed analysis of the specific needs and circumstances, so that directing the existing resources will have as finality increasing the quality. This can be ensured by achieving the highest standards of professional competence. "Professional competence" is hard to define, though is a concept with which all experts, including geodesy specialists must be familiar. For newly-qualified geodetic engineers "professional competence" combines the skills of knowledge, cognitive skills and business skills with a central core of expertise and/or personal behaviour (T. Kennie et.al, 2000).

The most important aspect to be taken into account when developing curricula is that technology changes the specialist profession. The two basic aspects of the profession – the ability to position objects in the physical and legal world and the ability to represent these objects on a map – are influenced to a considerable extent by developments in electronics, information technology and ICT. Surveying becomes a fully automated process, and in the representation of the results, the production of maps is replaced with the ability to create graphs and charts from digital data models. The surveying specialist (geodesist) will need to understand society's needs for all types of properties, legal basis and legal procedures for defining and modifying the bodies of property, the technical arrangements for the creation of buildings, as well as economic and ecological consequences of the existence of the parcels of land.

Quality assurance model must be designed in accordance with the general framework established by the European Association for International Education (EAIE). (http://www.eaie.org/home/in-the-field/mission.html) The purpose of this model is to provide a framework that attempts to simulate key characteristics which could have a significant impact on the development of quality program for Geodetic Engineering domain.

The diagram (Fig. 2.94) presents the factors that define quality, according to the mentioned model. It aims to combine the goals and objectives of an educational program with the analytical curriculum, students' evaluation form and expected knowledge, aptitudes and attitudes acquired by students at the end of the study cycle (Bachelor or Master) (P. Dragomit et al., 2012).

Increasing the quality of the educational offer in technical geodetic education can be done through better correlation of the study programme with the constantly changing requirements of the labour market and facilitating access to higher education by implementing software solutions in the teaching and learning activities.

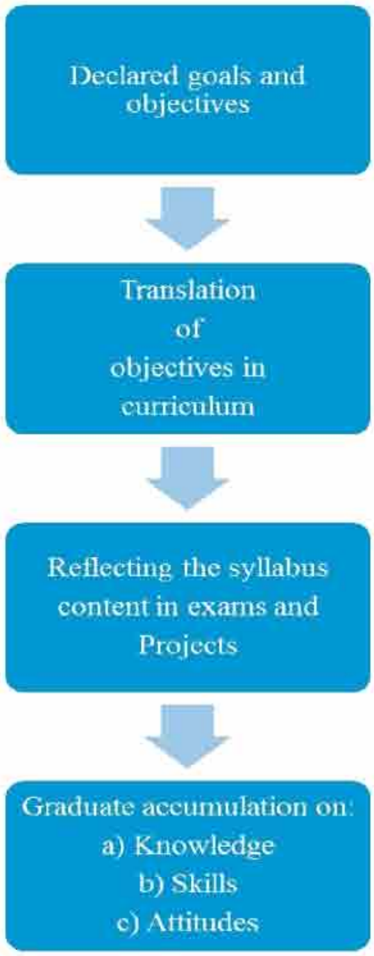


Figure 2.94. Model for quality assurance

C. SPECIFIC EXPERIENCES FOR GEODETIC ENGINEERING (GEODESY-INSTRUCT AND VIRTUAL CAMPUS)

1. E-Learning and OER requirements for students

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 and OER for the purposes of geodetic education are needed because they offer advantages such as: save time; allow self-study; present information graphically and make the educational process more interesting.

Time saving

Nowadays, when time is very valuable, this feature is very important and should be appreciated. Because of the new techniques developed in geodetic science, new topics and subjects are more and more involved. Moreover, this process is moving faster than revision and cancellation of already obsolete topics and subjects. Consequently, the curricula is overcrowded while the hours of lectures and exercises is supposed to remain the same. Thus, the time for some of the topics has to be reduced which causes difficulties for both, lecturers and students. By saving time, e-

Learning and OER in geodetic education can help creating more intensive lectures and exercises on any given topic without worsening the quality of received knowledge.

Self-study

In contemporary world education, the factor of self-study is becoming more important. The students in geodetic engineering can receive no more than 50-60% of the material during the lectures, which emphases the significance of self-study.

The process can be assisted by a tool in order to make it more efficient. E-Learning and OER can include both theory and exercises, which can help students to acquire the subjects as their own during self-study periods.

Graphical Presentation of Information

As a general rule, technically oriented people have a more visually based memory. Consequently, graphical presentation for students in geodetic engineering is very important for good understanding and development of skills.

Because graphical representation on the blackboard becomes quite difficult for geodetic purposes, E-Learning and OER can supply students with graphical tools which are to be used during lectures and exercises.

However, E-Learning and OER cannot replace completely the teacher and the learning itself cannot be automated (S. Enemark, 2004). But, in most cases, software can be a helpful device, because graphical presentation can replace a long sequence of explanations which, sometimes can be ineffective or boring.

Making Education Process more interesting

The use of software in education process makes it more interesting, attractive and exciting. When the teaching process itself starts to attract students, the lectures will become more intensive and useful.

The technical nature of surveying education makes it necessary to present the material attractively. Exciting presentation only helps focus the students' attraction and develop their professional interests. The tool for that purpose can be successfully implemented software, which through graphical presentation can make education in land surveying an interesting and attractive process.

When the knowledge is received from information, which is supplied in an interesting way, one remembers it longer. The development of such an approach for surveying education is needed. Software has the potential to achieve this objective due to its capabilities to attract student's attention and to provide them with skills using graphical presentations. In this way, the qualification of tomorrow's specialists can be improved and the durability for their skills can be extended.

2. Experiences for Bachelor students: Geodesy-Instruct

The specialization "Land Measurements and Cadastre" from Politehnica University Timişoara wanted, 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. Thus, 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 (figure 2.95) 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.

Figure 2.95. The Geodesy-Instruct platform's interface (www.geodesy-instruct.ro)

On the AEL online network online courses specific to geodetic engineering have been uploaded: Cadastre, Geometric representations of topographic surfaces, Surveying, Monitoring land and constructions' deformations, Basis of geodetic measurements, Infographics for land measurements, Topographical drawing, Fundamentals of engineering measurements, Design and optimization of geodetic networks, Land Information Systems, Basis of physical geodesy, Measurements' adjustment and statistics, Special surveys.

The platform 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, being organized on the following sections: personal pages, teaching, learning, working spaces, administration and forum.

Teaching (Fig. 2.96) provides possibilities for course management; absences and marks; homework; reports for courses; available courses; registration and approval of participants.

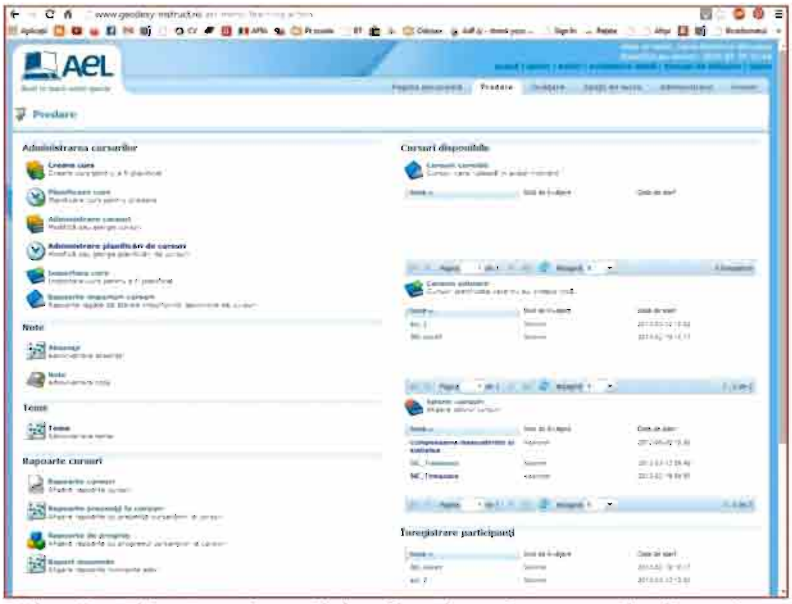


Figure 2.96. The Teaching section of the Geodesy-Instruct platform (www.cv.upt.ro)

Learning section includes courses in progress; absences and marks; homework; reports for courses; school portfolios; available courses (current, future and their history).

The platform represents a smart additional tool to work, characterized by efficiency and capacity to adapt (G. Badea et al., 2012), (A.C. Badea et al., 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. 2.97) 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.

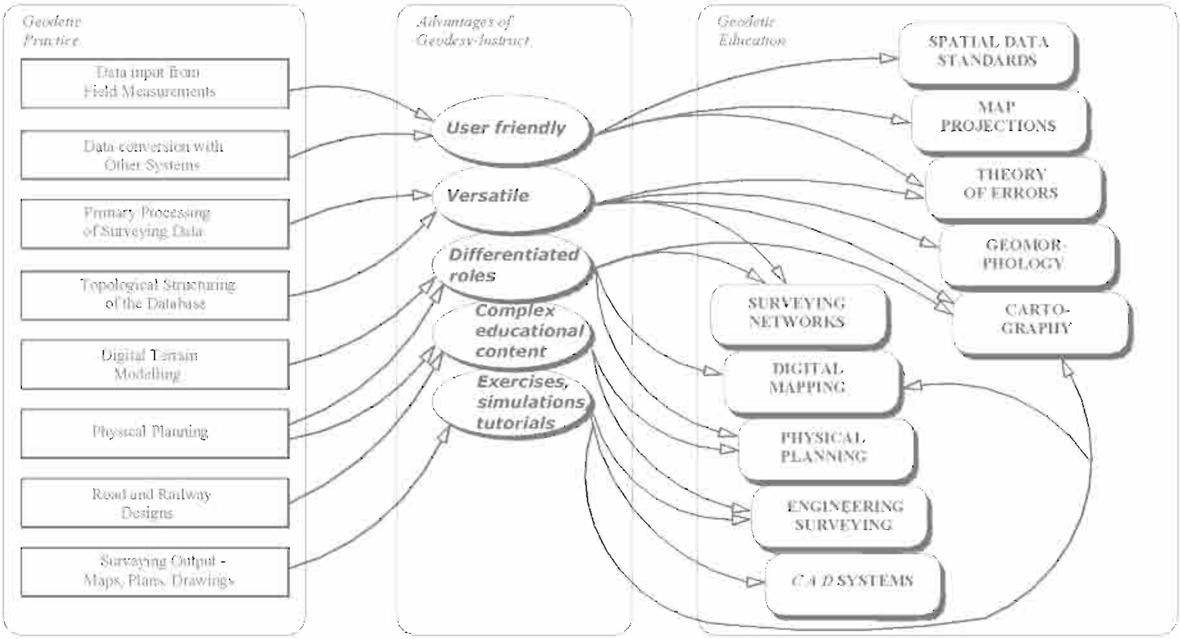


Figure 2.97. Characteristics of Geodesy-Instruct

3. Experiences for Master students: Virtual Campus

The ID/IFR and e-Learning (CeL) centre of the Politehnica University Timişoara has developed the Virtual Campus, an educational online environment of academic support for all faculties belonging to the university and for distance learning. This platform aims at online learning modules and mobile learning for students at academic training specializations through distance learning, as well as academic and administrative support for students enrolled at Master and doctoral programs (blended learning).

Virtual Campus platform comes in support of current students, constituting an interface for communication between the administration, teachers and students and a base for direct interaction between professors and students.

Figure 2.98. Interface of the Virtual Campus of Politehnica University Timişoara

Given the fact that the profile of students enrolled in the Master cycle, specialization “Cadastre and the Evaluation of Immovables” is: age between 23-28 years, 68% are working full-time, dedicating 8-10 hours per week to study (generally in the evenings and Saturdays), have unlimited access to the Internet, using web 2.0 tools, maintain close collaboration with colleagues and opt for courses connected with the labour market; Virtual Campus represents the interface for communication between the administration, teachers and students. Inside the Virtual Campus, the interaction between teachers and students is facilitated through the learning management system (LMS), the support for educational materials (LCMS) and the use of open source platform based on Moodle.

The main features of the Virtual Campus are: creating personalized accounts for administration, teachers and students (keeping the existing email accounts); custom layouts for each specialization and the introduction of course material and/or seminar/lab/project into the space attached to the course. In this way, the master students can study the materials made available to them, they prepare the homework and projects assigned without the need to move physically to the University.

D. CONCLUSIONS

The following recommendations on specific issues should be considered when applying the model of quality assurance: the continuous improvement of the curriculum and educational programmes, in line with the evolution of technology in the field of Geodesy and continually referring to similar institutions in the country and in the European Union; doctoral training of teaching staff; development of research areas highly topical as the computerisation of land registration, land information systems, GIS, satellite technologies. Also, as the use of software in surveying education seems to become more and more important, the actual trends in this direction are to implement professionally developed software packages in order to improve the quality of training in land surveying.

Geodesy-Instruct is a virtual platform used by professors and students for the exchange of information and knowledge in geodesy and cadastre domain using e-Learning system.

Positive aspects

Access to digital (online) learning and research resources contribute to attracting and motivating young valuable people, to adapt them to current and future requirements of the labour market, to improve their participation to the Master cycle and thereby improve the initial training of future researchers to important areas of the national economy, thus contributing to the formation of highly specialized human resources professional and competitive on the national and international labour market.

Advantages of projects (Geodesy-Instruct and Virtual Campus) implementation are: a considerable reduction of material resources involved, independence for the number of trainees against the physical space available, reducing the expenditure on teaching materials and expenses with maintenance facilities inland.

The projects detailed in this paper contribute to increasing the rate of people who have a stable and durable job due to the deployment of on-line training activities. Moreover, both Geodesy-Instruct and Virtual Campus, beside the fact they represent active and interactive methods of training, offer easy access to geodetic knowledge, which is customized according to the past experience and facilitate a continuous monitoring of the students’ progress.

The most important positive aspect highlighted in this paper is that, by combining the traditional methods of learning with e-Learning methods, the 2 platforms designed to help the educational process represent modern training initiatives and prerequisites for OER in the higher education system.

Less positive aspects

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.

The domains aimed at knowledge and use of technical equipment – such as that of Geodesy – cannot be managed 100% by virtual platforms, so alternative solutions have to be found.

2.3.5.2. A Framework for Personalized Geomatic Engineering E-Learning Experiences

Adaptive, intelligence or personalized e-learning is recognized as the most interesting research area in distance learning on-line Web-based Education. In particular, for the WBE Geomatics education, so far, there are not well-defined and commonly accepted rules on how the learning material should be designed (metadata-based content development), organized in reusable Learning Objects, selected and sequenced to make "instructional on-line sense" in a Web-based Geospatial ICT course. Hence, the goal of this paper is to propose a framework for personalized e-Learning based on selected user profiles and a domain ontology in order to shorten the gap to between the established traditional e-learning management systems (like Moodle) and the modern adaptive & intelligent WBE tutoring for the benefit of the Geomatic Engineering education.

Hence, the goal of this paper is to propose a framework for personalized e-Learning based on selected user profiles and a domain semantic Web mining ontology in order: (a) to respond effectively to the needs and competencies of the learners; and (b) to shorten the gap to between the established traditional e-learning management systems and the modern adaptive & intelligent WBE tutoring for the benefit of the Geomatic Engineering education (http://topo.epfl.ch/research-elearning.)

In particular, the proposed WBE Geomatic Engineering framework introduces a new metadata schema for reusable LO with GICT functionality, i.e. an enhancement by the integration of adaptive features to LO that allow for the delivery and management of personalized learning experiences. Then incorporates a number of reusable LO, related to topics which are common in the three main Geomatics disciplines (GIS & Digital Cadastre; Photogrammetry & Remote Sensing; and Surveying & Geodesy), e.g. digital design LO (Fig. 2.99), with learners' profiles and techniques for personalized content selection. Finally, the proposed framework could be used for adaptive course sequencing and personalized WBE GICT course delivery, management and online support.

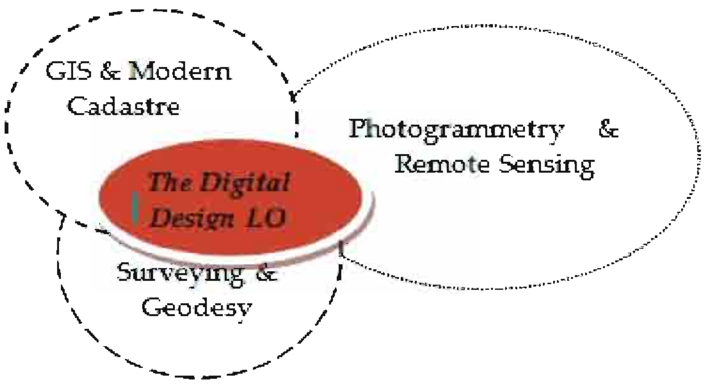


Figure 2.99. Positioning of the "Digital Design" LO between the three main Geomatic Engineering disciplines

Actually, the proposed methodology benefits from a LO's simple and flexible metadata-based design and an XML implementation (as a semantic Web ontology) with embedded GICT functionality, according to the cognitive style of learning needs and preferences in geomatics education. The proposed learning rules are generic (i.e. domain-, view-, and user-independent), hosting accordingly lecturing functionality for other relative courses (e.g. WBE for digital Architecture courses).

In the proposed framework the markup language XML could be combined with a MySQL database. This allows for the integration of the framework into the Moodle Learning Management System (LMS) already used in surveying and geomatics courses. The main functions of the proposed framework are: the generation of Internet accessed exercises; the metadata presentation; the related ontologies for GICT personalized LO (reusable data) implementation; a collection of answers in HTML form; and finally the automated corrections & hints for the individual users.

Concluding, the presented work, which is just a framework and not an e-learning ready-to-use system, is an attempt to address the content development and the LO selection and sequencing problem in intelligent personalized learning systems with Geospatial ICT functionality. For the content development a simple metadata schema was introduced and incorporated in LO structure as a challenging ontology for design pedagogy; so reusability is supported and the GICT LO are designed in a simple de-contextualized manner. The proposed methodology provides the framework for designing intelligent e-learning systems in geomatic engineering, in digital architecture, etc. and tries to integrate the semantic Web mining vision by using ontologies with WUM (Web Usage Mining) techniques for a better adaptation of learner's needs and requirements. A limitation of the framework relates to that: The created ontology depicts the way that the e-Learning domain should be taught to the learners and based on the view of the designer. Hence, if the semantic Web ontology is not implemented correctly, then the initial set of recommendations will be far away from the actual user's learning attitude and in this case the proposed framework will not be able to add new recommendations into the initial fault set.

In future extensions, learning characteristics like content difficulty or semantic functionality, which affects both selection and sequencing of reusable LO must be defined. Also, future research would related to LO intelligent selection and decomposition from existing WBE courses in similar disciplines, allowing reuse of these disaggregated LO in different disciplines (while preserving e-learning functionality and the educational characteristics they were initially designed for).

C. PROPOSAL FOR THE FUTURE ACADEMIC, SCIENTIFIC AND PROFESSIONAL CAREER DEVELOPMENT

All the scientific, professional and academic future development plans of the candidate revel in principal with the following main thematic directions:

- *Developing methods and models to evaluate and determine the real deformations of terrain ans structures.*
- *Reverse Engineering and Laser Scan Technology applied to Cultural Heritage domain, Development of 3D Models for Cultural Heritage sites;*
- *Using Open Source and Low-Cost solutions and GIS Platforms for different users to architectural and cultural applications;*
- *Educational platforms for e-learning processes.*

My personal development plan for a university career is sortly synthetized of my scientific research activity, my professional and as well didactic activity in the time interval 1996-2016. In this period I had the honor and opportunity to work at Politehnica University of Timisoara sourrounded by coleagues with an excellent moral and professional conduct.

C1. THE SCIENTIFIC RESEARCH ACTIVITY

The results of my scientific research are materialized mainly in speciality scientific articles and books. Therefore, I have always focused on this aspect, considering that not only the quantitative aspect of the work is important, but also the quality and the value of the material published. It can be seen in the list of the scientific papers attached that I collaborated with colleagues from other Romanian and EU universities to contribute at enriching the literature in domain of applied geodesy realated to Civil engineering domain.

A main priority in the last years was to make known stiintific concernes of me and my colleagues from MTC Specialization throught the publication of scientific articles in magazines and journals of different scientific events, indexed in Web of Knowledge (ISI), or magazines and volumes of different scientific events also indexed in other relevant BDI.

At the present time, my research activity as I shown in the present thesis tends to be multidisciplinary, involving specialists in civil engineering, architects, archeologists, experts in information technology, researchers in the field of geo science, etc. This is an inter or multidisciplinary cooperation, and represent for me an important gool both for me and for specialization and the teem were I am involved. The collaboration has contributed to my training and my development from the professional and scientific point of view. Another important component of my personal research activity consisted in the research documentation work on the subject of the international scientific activity in the geodetic engineering field on aplyed mathematics in engineering. Lately I have become more involved in taking part at different scientific committees of various manifestations or international publications, as well as in the activity of scientific referent of these publications.

During 2010-2016 I was a member of various management and implementation teams for projects financed by structural funds, national scientific competitions organized by UEFISCDI, SEE; In this context I played an active part in submitting projects with the teem from Geodesy Specialization an also with coleagues from Civil Engineering Faculty, in the activities of elaboration and logistics and in getting the projects ready to take part at the competitions, respectively.

As far as the collaboration with other institutions with the same profile from abroad, I initiated bilateral agreement and partnerships for educational and research projects, Collaboration program - West University of Hungary OBUDA University, Faculty of Geoinformatics Szekesfehervar; Inter-Institutional Agreement UPT–Norwegian University of Life Sciences (UMB) Aas Norway; Bilateral protocol UPT-Military Economics Academy of Wuhan, China; ERASMUS Intensive Programmes as coordinator on behalf of my university etc.).

The recognition of my activity is also marked by being a member of various professional organisations, such as: Uniunea Geodezilor din România (the Union of Romanian Geodesists), Ordinul Geodezilor din România, (The Order of Romanian Geodesists) Asociația Generală a Inginerilor din România (The General Association of Romanian Engineers), Ministerul Dezvoltării și Administrației Publice (Ministry of Development and Public Administration), EUROLIS, Balkan Environmental Association (BENA), FIG (Federation International des Geometres), Asociatia evaluatorilor funciari din Romania AEF (Land Register Evaluators Association);

The results of my implication in developenent and management activity were quantifiable by constant development of laboratory facilities (equipment, data acquisition systems, IT infrastructure, software support, etc.), i.e.: acquisition of equipment in amount of over 150.000 EUR. In view of all of the above mentioned, it is considered that all the requirements for a proper research activity have been met by the existing infrastructure, with minor adjustments in the future.

In recent years I was responsable person for Geomatic Laboratory in POS CCE program implemented by Civil Engineering Faculty.

Particularly goals of the project is to development of the existing RD infrastructure and creation of new RD infrastructures through:

- the achievement of a multidisciplinary axis of research, that satisfies various RD requirements with direct impact on the economic environment, or coming from the economic environment;
- the improvement of the knowledge within priority themes of the civil engineering sector;
- the training of the human resource, in particular of doctoral students, post-doctoral students and young teaching staff;
- the increase of the participation to the RD circuit, within large cooperation and projects, nationwide and worldwide;
- knowledge transfer activities, including support and promotion of innovative solutions in industry.

The scientific activity in the mentioned period increased constantly attending the following level:

- ISI journals – 7;
- ISI proceedings – 15;
- BDI journals – 12;
- BDI proceedings – 11;
- Papers from International conferences – 27;
- Other Scientific events - 7
- Citations: ISI Hindex= 3, Scopus Hindex =3, GoogleScholar Hindex =4;
- Books – 4 as author/ co-author; E-books – 9 as author/ co-author;

- Research Grants: 3 international grants / projects 1 as director and 1 as member and 1 as coordinator; 10 national grants 2 as director and 8 as member; 6 grants over 10.000 EUR; 35 grants less than 10.000 EUR.

Director of grant and projects (**extract**):

- Geodetic Study to establishment and implementation of topographic and cadastral works for building lots and land registration for ANL –Timisoara – MLPAT - **Director UPT**;
- Geodetic study regarding realizing the topo-cadastral documents for unifying, cadastral dismemberment, dividing and tabulation of terrains for building constructions L15/2003 and Gross Market –Timisoara – MLPAT - **Director UPT**;
- Topographic and cadastral studies for realizing the documentation of extraction from AC according to the Urbanistic Zonal Plan –Timisoara – MLPAT- **Director UPT**;
- Excellence in Photogrammetry for Open Cultural Heritage Education –EPOCHE 2013-, proiect nr. 2012-1-GR1-ERA10-10609, 32.342 EUR – **Responsible UPT**;
- Using Airborne Laser Scanning For Assisting Commercial Inventories In Young ForestsInter-Institutional Agreement Romania-Norvegia: Scholarships and Inter-Institutional Cooperation in Higher Education; Financed by the EEA and Norwegian Financial Mechanism, 2013 – **Departamental Coordinator UPT**;
- Studies and topographic precise measurements for tracking the movement at passages located on Caransebes ByPass, 2014 - Constructora Copisa Barcelona - **Director UPT**;
- Conduct studies and research for the execution of topographic measurements and engineering for modeling three-dimensional representation and input pressure vessels – 6400 Euro SC PRESAFFE SRL 2014-2015 **Director UPT**;
- POSCCE-A2-O2.2.1-2013-1: The integrated platform of research-development for building extreme actions behaviour (Platformă integrată de cercetare – dezvoltare pentru comportarea construcţiilor la acţiuni extreme - ACTEX), 2013-2015, Total Revenue 21.000.000,00 Lei - **Responsible for Geomatics Laboratory**;
- SMART IT POSDRU87/1.3/S/60891 POSDRU/189/2.1/G/156555, 2015 - **Responsible for Civil Engineering Faculty, Geodesy Specialization.**

It has to be mentioned that during 2000 – 2015, I elaborated a **total number of 79 papers** and **54 projects/research grants as coordinator or member in research teams.**

C2. THE ACADEMIC ACTIVITY AND PROFESIONAL STAGES

In 1991, I became a student at Faculty of Civil Engineering from Politehnica University of Timisoara, and I graduated specialization of Cadastre as promotion chief in 1996, from 1996 to 1997 I followed courses of Master Program Transport Infrastructure.

After graduation, in 1996, I won the competition for the position of junior assistant at Civil Engineering Faculty from Politehnica University of Timişoara. From this position I conducted the laboratory works for the disciplines Topography, Survey Engineering, Topographic Special Works, guidance and mentoring students for their projects, conducting diploma projects and leading the practice of students from Cadastre Specialization.

In 1997 I was admitted for the doctoral studies at the Faculty of Civil Engineering within the Politehnica University of Timisoara with the following research theme: Contribution to Applying Topographic Methods for Studying and Monitoring Terrain and Constructions. The thesis was finalized in 2006, and I was awarded the scientific title of Doctor of Technical Science, branch Science and Technology, for the doctorate field: Civil Engineering.

In 2007, I took part at the competition for the position of Lecturer and I obtained this position at Chair of Geotechnical Engineering and Terrestrial Communication Roads at the Faculty of Constructions. The main didactic activities consisted in giving lectures, and being in charge with seminar and laboratory activities for the following subjects: Surveying Engineering, Automating Cadastral Works, Topographyc Special Works and Topography; coordinating diploma projects; responsible for the student annual training period. Since 2009 up to present, I have been a member of the Commission for Diploma Examination for this specialization.

In 2014 I took part at the competition for position on Associate professor and I obtained this position at Chair of Geotechnical Engineering and Terrestrial Communication Roads at the Faculty of Constructions. In all these years I supervised al least 8-10 bachelor students for their diploma projects, 6-8 master stundent for their dissertation thesis and also I was and I am part of doctoral commissions for PhD students at Politehnica Univeristy.

The teaching activity, irrespective of the degree held, was backed up the scientific research, and by my participation at various events and scientific manifestations, national and international. 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.

C3. DEVELOPMENT OF THE UNIVERSITY CAREER

In what concerns the future research and development plans of the candidate, related to the fields of research presented above, the following research topics will continue or will be developed:

- National/Local Program for infrastructure modernization
- Experimental research for improving Geomatic technologies performances
- Application of the Terrestrial Laser Scanning for engineering porposes
- Geodetic applications for Open Cultural Heritage
- Developing methods and models to evaluate and determine the real deformations of terrain ans structures

The development plan for the scientific development consists of two phases, short and medium term development plan and also long term research plan.

In order to improve and develop the research activity, on a short and medium term I plan to do the following tasks:

- I intend to involve myself more intensely in promoting the findings of the scientific research I have been involved in, either as author or coauthor, in articles to be published in publications with impact factors;
- constant publication of articles in scientific journals indexed ISI and/ or BDI;
- have a sustained activity by taking part at scientific competitions, national and international by: closer collaboration with research institutions and other profile faculties in Romania on subjects specific to our interes field. So far, I have had collaborations with colleagues from our country for the elaboration of scientific articles, in various authors groups from several faculties with the same profile (București, Alba Iulia, Iași, Cluj-Napoca, Petroșani); develot a multidisciplinary research team, with various specialists (construction, architects, archeologists, hydrology, geology, geography, etc), from

numerous institutions, able to respond more efficiently to the call for scientific competition; identify and promote several common research themes with other institutes and faculties, stating from the similar or complementary activities developed; identify and promote certain research themes in partnership with private institutions which have scientific research as activity object; identify and continuous initiate partnerships at institutional level, to take part at competitions financed by Gouvernamental Institution or International Autorities; involve students in the research activity.

From the professional point of view, I will continue my activity of proposing projects, in the field of geomatic engineering; monitoring behaviour of constructions and terain.

Finally, it have to be underlined that the active role of the candidate will continuously increase by participation with new research topics to international conferences and papers published in specialized journals.

Synthesis of my personal development strategies:

A. Short and medium term objectives (between 3 and 5 years) I'm planing to:

- be the director of at least one national contract and a team member at an international one;
- continue writing didactic materials – at least one specialty book to be published and also online support materials;
- continue my activity of writing at least 4 articles for journals ISI indexed with high impact in my research fild, to communicate my research findings at various scientific events, national and international conferences; minimum two articles per year;
- continue to take part in various international scientific committees, by reviewing specialist articles;
- continue to organize various internal and international scientific events;
- be the co-author, with my specialty colleagues, of one specialty book, in English, published at a foreign publishing house.

B. Long term objective (over 5 years)

- get involved in as many research projects as possible;
- be the author or co-author of 3 specialty treaties, out of which one in English;
- be the director of at least 2 projects;
- continue to a managing position.

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