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Geodetic and oceanographic precision measurements for connecting tide gauges at surveying network and integration of National Geodetic Network in European EUREF and EUVN Reference Systems

Marius Dorin ANTON[1], Radu CRIȘAN[2], Vasile NACU[3] , Ioan STOIAN[4]

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Abstract

Over time, our country used several reference systems relative to levels Adriatic "zero Triest" Black Sea "zero Sulina" Black Sea "zero Constance" Baltic Sea "Kronstadt zero "Black Sea" zero Constanta 1975 "and the Black Sea" zero Constanta 1975 (1990 edition)".

Between 1974-1989, Institute of Geodesy, Photogrammetry, Cartography and Land Management (IGFCOT) executed geometric leveling network works of Romania`s high precision (ord.I) processed in normal altitudes system relative to the reference system "zero Constanta "established by the Department of Military Topography (DTM) in 1975 and named" Black Sea 1975.

In Constanta city there is a tide gauges polygon, designed and executed in 1974, which was measured by high-precision geometric leveling annually in the period 1974 - 1990.

Also in 1997, on the occasion of realization of connection, using GPS technology of Romania`s national high precision leveling network to the European leveling network EUVN, near the Tide Gauge Commercial Port Plate(PMPC) Constanta, to the north about 0.70 m, was planted a brand type A EUVN(MGM) model, which was determined using GPS technology in 1997.

The works were resumed in 2004 and repeated in 2012-2014, according to the "Cooperation Agreement" registered between ANCPI and INCDM concerning to the achievement of precision leveling measurements and oceanographic measurements at the tide gauges and reflectors from Constanta, Mangalia, Sulina ports for biding tide gauges at leveling network and integration of national geodetic networks in European reference systems.

To achieve the project requirements, both classical technology was used to determine differences between the normal level of tide gauges and reference landmark of GPS permanent stations, as well as GPS technology to determine ellipsoidal difference level and relative positioning of respective points.

This article presents,beside a brief history of the issue, the results obtained in the period 2012-2014 and perspectives for further work.

Keywords

tide gauges , surveying networks, leveling

1. Brief history

The need of tracking the multiannual level of Black Sea at the Romanian shore, had as effect, over time , the installation in 1895, near Genoese Lighthouse, a meter medimari- meter that worked until 1903, installation in 1933 of an analogical tide gauge OTT type from trading port Constanta berth, currently operating , installation in 1974 of analogical tide gauges from Tomis Harbor and Constanta Harbor and after 1990 a digital tide gauge in Constanta Harbor, beside the Constanta Harbor Museum, also known as the Queen`s Nest.

The analogical tide gauges, put into operation in 1974 in Tomis Harbor and Mangalia Harbor were included in a local network of high geometric precision leveling, made outside the zone of influence of the sea for the purpose of prosecution in time of the stability of tide gauges and the linkage between the two zero tide gauges from Constanta with the one from Mangalia. The annual periodicity of leveling measurements achieved in the two networks of tide gauges from Constanta and Mangalia Harbors, provided data and information necessary to establish the behavior in time of tide gauges landmark tracking and position "zero" from the reflectors of the three existing analogical tide gauges in the two harbors.

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The installation after 1990 of a new tide gauge, equipped with digital equipment, with automatic recording and real-time transmitting, of sea level,and the installation in 2004 of the Permanent GPS Station from Constanta Harbor on the Harbor Museum building creates new opportunities in the most efficient use of tide gauges network in connection with the use of GPS technology. Over time, our country used several reference systems relative to levels Adriatic "zero Triest" Black Sea "zero Sulina" Black Sea "zero Constance" Baltic "zero Kronstadt" Black Sea "zero Constanta 1975" and the Black Sea "zero Constanta 1975 (1990 edition)". Between 1974 - 1989, Institute of Geodesy, Photogrammetry, Cartography and Land Management (IGFCOT) executed geometric leveling network works of Romania`s high precision (ord.I) processed in normal altitudes system relative to the reference system "zero Constanta "established by the Department of Military Topography (DTM) in 1975 and named" Black Sea 1975 (edition 1990). The new network has as origin the value of elevation landmark soil type I DTM located in Constanta Military Chapel courtyard and has a value of 36.49970m. The need of tracking the multiannual level of Black Sea at the Romanian shore, had as effect, over time , the installation in 1895, near Genoese Lighthouse, a meter medimari- meter that worked until 1903, installation in 1933 of an analogical tide gauge OTT type from trading port Constanta berth, currently operating, installation in 1974 of analogical tide gauges from Tomis Harbor and Constanta Harbor and after 1990 a digital tide gauge in Constanta Harbor, beside the Constanta Harbor Museum, also known as the Queen`s Nest. The analogical tide gauges, put into operation in 1974 in Tomis Harbor and Mangalia Harbor were included in a local network of high geometric precision leveling, made outside the zone of influence of the sea for the purpose of prosecution in time of the stability of tide gauges "reperilor martori" and the linkage between the two zero tide gauges from Constanta with the one from Mangalia. The annual periodicity of leveling measurements achieved in the two networks of tide gauges from Constanta and Mangalia Harbors, provided data and information necessary to establish the behavior in time of tide gauges landmark tracking and position "zero" from the reflectors of the three existing analogical tide gauges in the two harbors. The installation after 1990 of a new tide gauge, equipped with digital equipment, with automatic recording and real-time transmitting, of sea level,and the installation in 2004 of the Permanent GPS Station from Constanta Harbor on the Harbor Museum building creates new opportunities in the most efficient use of tide gauges network in connection with the use of GPS technology. **The research issue of annual average level of the Romanian Black Sea shore**, starts in 1895 by placing a medimarimeter in Constanta near Genoese Lighthouse which had records until World War I when it was destroyed. The activity is resumed in 1932 when in Constance, near the Maritime Station, Army Geographical Institute installed an analogical tide gauge which operates today. In 1973-1974 in Constanta in Tomis Harbor and Mangalia Harbor were placed another two analogical tide gauges of which currently only the one from Tomis Harbor works.

In the period 1981-1984 in cooperation with the Institute of Geodesy and Cartography from Bulgaria, on this subject was achieved the theme " Research of variation of Black Sea medium level based on the high precision leveling and records from the tide gauges from Romania and Bulgaria"**.**

Compared to financial resources which it was disposed , it was achieved the "Tide Gauges Polygon", which through a network of high precision geometric leveling polygons, assured the biding of tide gauges from Romanian seaside with the tide gauges from Bulgarian seaside, respectively from Varna and Burgas. After 1990 were placed on the Romanian seaside three new digital tide gauges at Constanta,Sulina and Mangalia. With the resources of which it was disposed was achieved

in 2004 the binding of the digital tide gauge from Constanta at Tide Gauges Polygon, and also at the Permanent GPS Station in Constanta. These three digital tide gauges are included in the European network ESEAS (European Sea Level Service),

but the tide gauges from Sulina and Mangalia still can not be used at the normal potential because they are not integrated in the network of tide gauges high precision leveling from the Romanian seaside, with repercussions on the research of multiannual level of Black Sea and the research of Romanianan coastline cord evolution.

Fig. 1 Tide Gauges Polygon

Under this project, the tide gauges from Sulina and Mangalia become research points of the average of the Black Sea and in collaboration with IRCDM-Constance , with AFDJ and Central Danube Delta Biosphere will be able to develop new research papers relating to the volume of water and sediment brought by Sulina arm, evolution of the coastal belt in the area of the three arms of the Danube Delta, the impact of the mainstream from the Black Sea over the new lands of the Delta, the Danube contribution to increasing the strength of this current and its impact on the entire Romanian seaside.
The same studies will extend also in the shedding areas of Danube-Black Sea Canal. High precision leveling network of the " Tide gauges polygon" crosses the two fault lines which borderat north and south the Black Sea microplate leading to subduction in Carpathians of Curvature (Vrancea), which has the main contribution in the production of earthquakes in Vrancea . Through repeated measurements of this network required for research of multiannual average level of the Black Sea,will be able to highlight the areas of motion of these microplate, possibly velocities, and also its direction of movement.The heights of the points that make up the leveling networks of any order that originate a foothold, basic called fundamental point or zero point.
The elevation of this point is determined toward the seas and oceans average level, determined from observing this level for a period of approx. 30-50 years. The problem of locating the vertical position toward the geoid, of a landmark located on the seashore shall be reduced to determine the position of the average level of the sea. For this it must be recorded the local snapshot of sea level variation toward zero position of a measuring instrument of flows(tide gauges).As an average of local snapshoot sea level is determined by local sea level. Whereas the average sea level varies from a place to another, it was necessary the biding of all altimetric fundamental points at European level and has been adopted, in 1958, as a starting point,zero (Kronstadt) from Baltic Sea. In order to determine the average sea level were used the measurements executed at Constanta maregraph between 1933-1975 based on the results of calculations, using arithmetic average as the most probable value of the Black Sea level. Over the time, had been used as fundamental points: zero Sulina 1857 in Transylvania, zero Adriatic Sea (1923), zero Black Sea with the fundamental point being a bronze plate with a height of 2.48 m toward zero reflector tide gauge Constanta, zero Baltic Sea (1951-1975) and nowadays the altitudes system is called "Black Sea 1975 zero system" with fundamental point located in Constanta military chapel.

2. THE FIRST TIDE GAUGE

The establishment of Black Sea zero level in 1975 and the calculation of the fundamental landmarks elevation were imposed by the need to establish its own reference areas of our country, as close to reality, based on data recorded by tide gauge Constanta.
Making repeated measurements of high
precision leveling for tracking the land stability in the tide gauges and fundamental landmark area it was necessary that the placement of the fundamental landmark to be put in an area with a larger stability over time.

Fig. 2 Tide Gauges port of Constanta

3. The project objectives

-Integration of national geodetic networks in the European Reference EUREF and EUVN and the need to achieve the binding of tide gauges to the leveling network for accurate determination of quota "0" normal altitude.
-Rehabilitation of geodetic reference system for time monitoring based on measurements of the coastal belt;
- Following the morphological evolution of the coastal belt and cadastral works;

4. Need and project justification

Besides the objectives set out in the protocol, the project could accomplish with the same measurements and another purpose, that one regarding the resumption of a research topic carried out by IGFCOT (current CNC) from 1983 to 1985, which aimed at tracking the evolution of morphological whole coastal belt and its associated coastal works. The conclusions of this theme were valued by Research and Design Institute for Water Management (ICPGA) at that time for forecast and systematic tracking of coastal belt.
The theme is topical for both the National Research Institute - Marine Development "Grigore Antipa" Constanta and for ANCPI.
Comparing some recent satellite records (2005) with the coastline plans from various stages was found a major beach erosion along the entire coastal belt and remarkable changes regarding the coasts morphology.
These tendencies have been reported since the first stage of coastal belt research-1983 - when repeated precision

leveling measurements were performed between Constanta and Vama Veche.

Also, the same research topics between 1984-1985 were made the first aerial photography and photogrammetric imaging of the entire coastal belt that can be used as a starting point for future studies and researches.

Since 1985, the phenomenon has not been measured and interpreted as a whole but in parts, depending on the specific needs and financial possibilities.

Database: The initial project of fundamental point quotation "Tariverde" was realized by the staff of Geodesy of IGFCOT from 1980.

Equipment and tolerances: To fulfill the objectives were imposed to use two electronic levels LEICA providing an accuracy of at least ± 2 mm per km. double leveling.

The tolerance allowed for leveling measurements must satisfy the project`s objectives: ± 2.5 mm√L, where L is the distance in km of leveling line.

5. Quotation of the fundamental point Tariverde

It has been choosed to bring the geometric elevation from the analogical tide gauge Constanta Harbor respecting the following route: --Tariverde fundamental point - Istria - Săcele - Corbu - Năvodari - Mamaia - Constanta – Constanta Harbor analogical tide gauge.

In the campaign of measurements realized in 2013 were ended measurements on the route: DTM MB Church Corbu de Jos - Constanta - Constanta Harbor analogical tide gauge on 28.44 km distance.

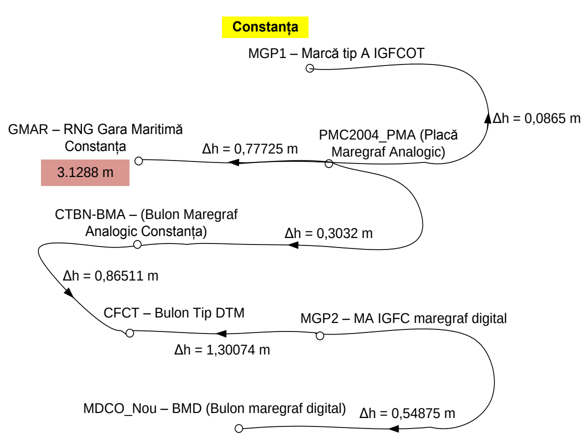

Fig. 3 Geometric leveling route realized in 2013

In the campaign of measurements realized in 2014 were ended measurements on the route: MB DTM Corbu Lower Church – Milestone TM 18 - km.13 OCPI Milestone - Milestone ONCGC km. 12 - 11.5 km OCPI Milestone – Milestone ONCGC km 10 – Milestone OCPI km. 9 - MA Navodari Bridge.

In the campaign of measurements realized in 2014 were ended measurements on the route: MB DTM Corbu Lower Church – Milestone TM 18 - km.13 OCPI Milestone - Milestone ONCGC km. 12 - 11.5 km OCPI Milestone – Milestone ONCGC km 10 – Milestone OCPI km. 9 - MA Navodari Bridge.

RESULTS: The results of high geometric precision leveling measurements are shown. It was considered as fundamental leveling point "Tariverde" as being constant with the value determined at the time IGFCOT 1980 : +122.74956 m.

Fig. 4 Geometric leveling route realized in 2013

For comparison between different measurement periods we have four (4) common landmarks realized by IGFCOT measurements performed in 1980 and CNC in 2012, namely: fundamental Landmark Tariverde - MA IgFc Inters. DJ 226 A (km.22 + 650) - RNG SPOC Căminul Cultural Săcele Km. 16 + 350 - MB IGFCOT No.18 own. Vişan Alex. Km.4 + 500.

For Tariverde fundamental landmark at measurements made in 2012 was considered the quota deducted from measurement campaigns from 1980 made by IGFCOT, namely: +122.74956 m. In the following lines we make several references to the possible dynamics of the Earth's crust between 1980-2012, for which, for the four common points quoted in the two periods made the difference.

Δhmm = [hm CNC(2012) – hm IGFCOT (1980)].

a. Δhmm MA IGFCOT Inter DJ 226A (km.22+650) = - 4.39 mm
b. Δhmm RNG SPOC Camin Cultural Sacele km. 16+350 = +42.24 mm
c. Δhmm MB IGFC nr. 18 Propr. Visan Alex. Km. 4+500 = - 5.49 mm

Toward the landmark "considered" as fixed in time, unassigned them into any movement on the vertical part in landmark`s case a) is noticed a terrestrial crust subduction of 4.39 mm along the leveling route of 11,382 km, which means an average of 0.20 mm / year. In these tiny values case we conclude that these difference is due to the different precicisions of the equipment used in the two measurements campaigns and inherent measuring errors (human, atmospheric, etc.) accumulated during the approx. 12 km of leveling.

Opposed to those conclusions reached in the landmark case a), for landmark b) the effect of the value of +42.24 mm / 21,644 km of leveling from the landmark "fixed" we assume that it was due to a lifting ("uplift" word enshrined in geology) terrestrial crust of 1.32 mm / year.

On the other hand, assuming we compare the values between landmarks a) and b) considering this time as a landmark "fixed ", part a), would result a lifting of Earth's crust near landmark b) of 46.63 mm / 10,262 km leveling, equivalent to 4.54 mm / 1km leveling as the idea when we consider lifting Earth's crust as linear.

In the landmark case c) we notice a tendency of a subsidence around 5.49 mm / 28,439 km. geometric leveling.

6. Quoting fundamental point Sulina

The projected and realized leveling line has the next configuration: Old Lighthouse (Museum), RNG Milestone - Pyramid Sulina - Sulina Chapel RNG - NewMilestone CNGCFT - Old Milestone (Suldal) –Tide gauge Sulina Milestone (MSUL) - MB Tide gauge Sulina (MSUL-RNB CSA).

In the measurements campaign done in 2012 were ended measurements on route: MB Tide gauge Sulina (MSUL-RNB CSA) - Old Milestone (Suldal) - Sulina tide gauge Milestone (MSUL) on a route length of 0.92 km.

Results: Whereas in 2012 has only managed to make high precision geodetic levelling measurements on a route of only 0.92 km can not be drawn eloquent conclusions.

7. Conclusions

After the measurements made both for binding the tide gauges to the levelling network and integration of national geodetic networks into European reference systems EUREF and EUVN we consider: is mandatory to continue the high accuracy geometric levelling measurements (tolerance = 1.25 mm)

This even more because in the Subcommittee on Europe (EUREF) International Association of Geodesy for (IAG) which took place in 1994 was imposed the activity to develop and determine a unique altimetric reference system for Europe. In accordance with Resolution no.3 of EUREF Symposium held in Warsaw and in accordance with the decision of Resolution no. 4 over he results UELN-95/13, offset by the name UELN in the network configuration UELN95 / 98 presented at EUREF Symposium held in Bad Neuenahr / Ahrweiler in 1998 and endorsed by the participants, among others, has been taken the following decision, regarding directly the geodetic activity from Romania:”Also, we consider that the high accuracy levelling measurements must be done in parallel with classic high accuracy equipment level 002 NI and with purchased equipment during 2012 for the same section way back since there was a decrease in accuracy at measurements performed with this equipment.

Sea level factors considered one features a state of the marine environment, coastal geomorphology influence decisively and hence default position shoreline and beach surface.

From the analysis of sea level changes over the past 50 years (Fig. 5, Fig. 6) can distinguish four different relative periods:

- 1962 - 1967 period level rise;
- 1968 - 1985, the period of declining levels;
- 1986 - 2007 period heavenly level;
- 2009 - 2012, the period decreases the level, although in 2010 recorded maximum period 38, 7 cm.

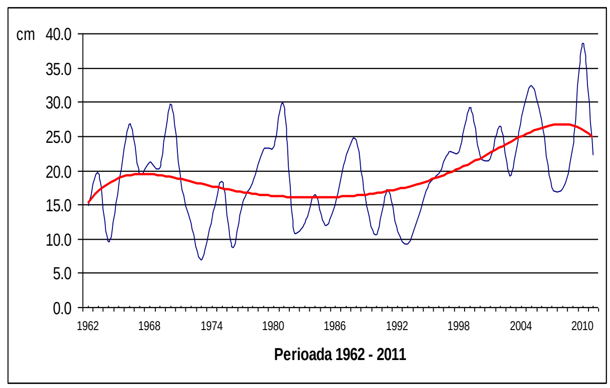

Fig. 5 Sea level changes recorded in Tide Gauges Constanta in January 1962 - December 2011 (annual average)

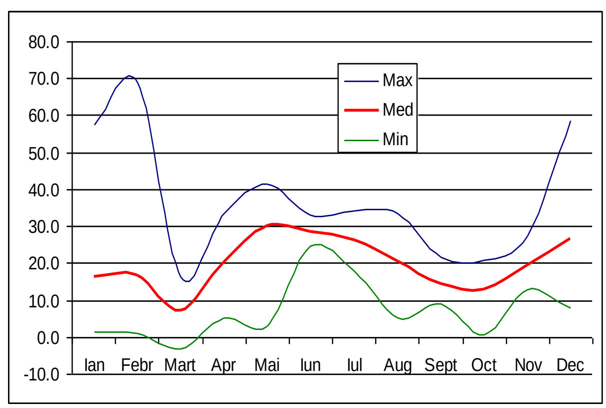

Fig. 6 Sea level changes recorded in Tide Gauges Constanta in year 2012

Characteristic of this period, 1962 - 2012, is given by alternating cycles of increase / decreases the need but particularly stressed that span the entire media lags 2, 6 cm above the average annual multiannual

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A comparative study between gravimetric method and geometric method about determination of a precise quasigeoid for the area of Romania

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Abstract
With the official launch of Romanian Position Determination System - ROMPOS, whose basic infrastructure consists of a network of 74 active geodetic reference station, the main problem of surveyors in Romania is to calculate a precise quasigeoid model.
The topic was addressed in several large studies, particularly doctoral thesis, noting that the absence of gravity measurements, gravimetric method was treated for only a limited area, namely the Bucharest zone.
Therefore, this article presents a comparative study between the geometric and gravimetric determination methods for a quasigeoid model, test area being limited to Bucharest.

Keywords:
GNSS, precise levelling, quasigeoid, gravimetry, physical geodesy.

1. Introduction

Achieving high precision geoid model is possible only through a unified and consistent policy at national level in this regard, by cooperation between specialized institutions in the country, such as profile universities, National Agency for Cadaster and Land Registry - ANCPI through its subordinate units, Romanian Geological Institute, Military Topographic Directorate and so on. Also, both interdisciplinary nature and high degree of complexity of such a project involves allocating substantial budgets to achieve the expected objectives.

For the reasons stated above, the issue of determining a national geoid model or quasigeoid has long been neglected. However, over the years, some of surveying specialists in our country have made considerable efforts to determine some geoid models viable corresponding to national territory. These investigations were made in some isolated projects, in most cases being the subject of some doctoral dissertations. We list below some of the most important studies in the field, made in recent decades in Romania:

- Mihăilescu, M. – Doctoral thesis – ”Quasigeoid for Romania, determined through astronomic and geodetic methods” – 1974;
- Ioane, D. – Study of Geological Institute of Romania in partnership with Canadian specialists – ”Geoid for Romania based on global geopotential model OSU91”;
- Serediuc, C. – Doctoral thesis – ”Geoid for a test area which covers approximately 20% of Romanian territory, determined using the finite element method” – 1996;
- Marinescu, M., Tomoioagă, T. – Theme of scientific research developed in the Research Agency for Military Equipment and Technologies, beneficiary being the Military Topographic Directorate – ”Geoid for Romania based on global geopotential model EGM96 and military gravimetric network” – 1998;
- Rus, T. – Doctoral thesis – Studies and research on topo-geodetic precision positioning using satellite methods - Modern methods of determining the geoid” 2000;
- Spiroiu, I. – Doctoral thesis – ” Contributions to the development of methods for determining a high resolution geoid undulations for theree dimensional geodetic networks” – 2005;
- Tomoioagă, T. – Doctoral thesis – ”Contributions to determine geoid undulations using global geopotential models and local gravimetric” – 2007;
- Tomoioagă, T. – ”Considerations about precision of determination of gravimetric geoid” – 2008;
- Dumitru, P. D. – Doctoral thesis – ”Contributions for quasigeoid determination in Romania” – 2011;

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- Sorta, V. – Doctoral thesis - ”Contributions for a precise geoid / quasigeoid model for the area of Romania” – 2013.

2. Determination of the quasigeoid model for the Bucharest area by gravimetric method

Quasigeoid model for Bucharest area is integrated in TransDatRO software and takes the form of a grid of height anomalies, with density of 15”x15”, grid limits being defined by rectangle of coordinates:

(λminim : 25.95671898°; φminim : 44.32533744°),
(λmaxim : 26.24838588°; φmaxim : 44.60033766°).

Data sources that were the basis for achieving quasigeoid model were:

- values of absolute gravity for 129 points, uniformly distributed on Bucharest and Ilfov County. 2 points were reference points in which were transmitted absolute gravity values by linking to the 1st order National Network from Surlari Observatory and Dealul Piscului Observatory;
- GNSS measurements in the 129 gravimetric points;
- normal heights in gravimetric points determined through 1st order geometric levelling;
- Bouguer anomalies for Romania, given by International Gravimetric Bureau (BGI);
- high resolution digital terrain model for Romania, in DTED-Level 2 format;
- digital terrain model for Europe from SRTM 4 mission;
- Global Geopotential Model EGM2008.

Gravimetric measurements were performed by specialists belonging to SC PROSPECȚIUNI S.A. and National Center for Cartography (CNC) using a Lacoste-Romberg G model gravimeter, gravimetric points are arranged as in Fig. 1. GNSS measurements were performed at the same points that were determined relative values of gravity, being carried out by teams of specialists from the CNC. These measurements were carried out with Trimble, model 4000 SSI receivers, observations realized for one hour sessions and with a registration rate for 10 seconds.

Precise geometric levelling measurements were performed in 2010, 2011 and 2012by specialists from CNC. For this purpose were used three tipes of levels: Carl Zeiss Jena Ni002 and Ni007 and Leica Sprinter 250M.

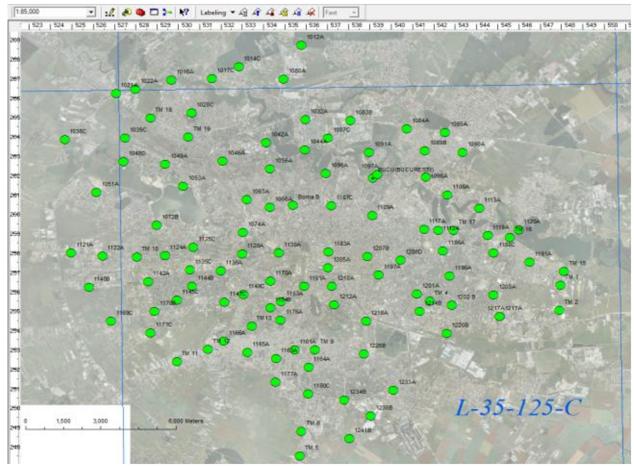

Fig. 1: The arrangement of gravimeric points (Source: CNC)

Below it can be seen the levelling network scheme:

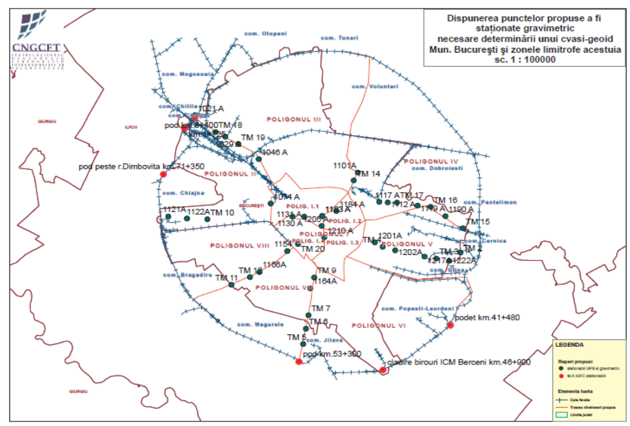

Fig. 2: The scheme of levelling network (Source: CNC)

Gravimetric data processing stages are divided into three areas of processing:
- precise gravity domain (in gravimetric points);
- gravity domain in the grid nodes, grid based on improved Bouguer anomalies for Romania, published by BGI;
- domain of height anomalies which results from applying the remove – restore algorithm.

The main stages of data processing to generate quasigeoid model were:

a. Preparation of digital terrain models to calculate terrain corrections and indirect effect.

Were used two digital terrain models:
- a more detailed model with a higher resolution in DTED Level 2 format that is used for close point computing;
- a less detailed model with lower resolution in DTED format from STRM4 (Shuttle Radar Topography Mission 4), which is used for the remote area of computed point.

b. Correction of improved Bouguer anomalies, published by BGI

Were performed the following steps:
- Coordinate transformation from Krasowski 1940 ellipsoid to GRS80 ellipsoid;
- Computing of normal gravity using Silva – Casinis formula;
- Computing of normal gravity using parameters and derived constants of GRS80 ellipsoid given by Moritz (1980) and the close formula of Somigliana;
- Computing of the new improved Bouguer anomalies in the grid nodes.

c. Calculation of Faye anomalies, terrain corrections and improved Bouguer anomalies in gravimetric points

For calculating terrain effect on the gravity anomalies, was used the homogenous rectangular prisms method combined by spherical harmonic formulas (Mc Millan). This depends on terrain geometry, grid density and distance from computed point. Maximum radius is 100km.

Terrain correction was computed using the two digital terrain models, taking into account the following general relation (Physical Geodesy, Nico Sneeuw, Stuttgart, 2006):

$$TC = G\int_x\int_y\int_{z=H_P}^{H}\frac{z-H_P}{r^3}\rho(x,y,z)\,dx\,dy\,dz \qquad (1)$$

where r is the distance to computed point P.
The implementation of this integral to a certain resolution digital terrain model can be like in the following figure:

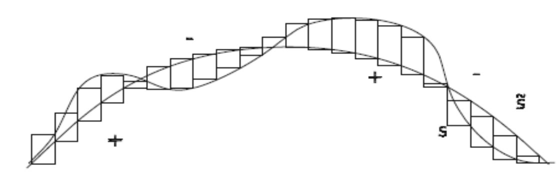

Fig. 3: The implementation of prisms method on finite elements of terrain

The evaluation of terrain correction for each finite element from the digital terrain model assume customizing of the relation no. (1) for a constant density rectangular prism, like in the bellows figure:

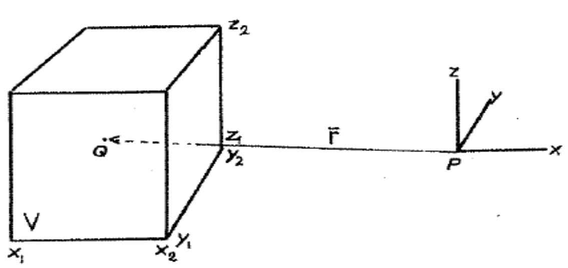

Fig. 4: Cartesian coordinate system {x,y,z} used for the evaluation of terrain correction of a rectangular prism

The computing formula used for terrain correction of a rectangular prism over the P point is the following (MacMillan 1958):

$$2TC = G\rho\left|\left|\left|2xy\log(z+r) + 2xz\log(y+r) + 2zy\log(x+r) - x^2 arctg\frac{yz}{xr} - y^2 arctg\frac{xz}{yr} - z^2 arctg\frac{xy}{zr}\right|_{x_1}^{x_2}\right|_{y_1}^{y_2}\right|_{z_1}^{z_2} \qquad (2)$$

Applying computed terrain corrections were determined the improved Bouguer anomalies in the gravimetric points.

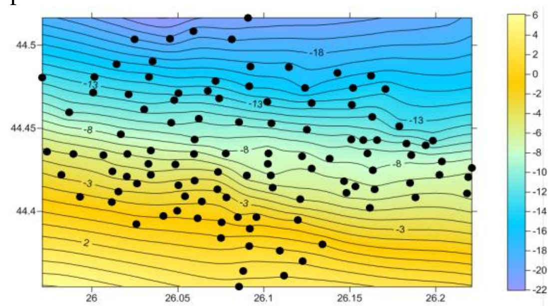

Fig. 5: AImproved Bouguer anomalies in the gravimetric points

d. Generation of improved Bouguer anomalies grid using the collocation / minimum curvature method

For this purpose was used a tension factor T=0.25 recommended by Smith and Wessel (1990).

e. Determination of long wavelength components in grid nodes using global geopotential model coefficients EGM2008

These elements were computed using the grids and software given by team which realized the EGM2008 model.

f. Calculation of residual gravity anomalies in the grid nodes

These were computed using relation:

$$\Delta g = \Delta gF - \Delta gEGM2008 \qquad (3)$$

g. Calculation of medium wavelength component of the geoid undulation in the grid nodes (NΔg)

Calculation of medium wavelength component of the geoid undulation in the grid nodes was realized using the Stokes formula.

h. Calculation of the indirect effect in the grid nodes (Nind)

This step was realized for close area and for remote area situated at a maximum distance of 50 km.

i. Calculation of the final values of geoid undulation in the grid nodes

The final values of the geoid undulations were obtained by correction of the mean wave-length component of the indirect effect and the addition of the long wavelength component, using the formula:

$$N = NEGM2008 + N\Delta g + Nind \qquad (4)$$

j.Calculation of the height anomalies in the grid nodes

For calculation of the height anomalies was used the relation developed in 1993 by Heiskanen and Moritz in ”Physical Geodesy”:

$$N - \zeta = \frac{\bar{g} - \bar{\gamma}}{\bar{\gamma}} H = H^{*} - H \tag{5}$$

According to the considerations made by the same authors, all previously cited in the paper, on page 327, it can be writed that:

$$\frac{\bar{g} - \bar{\gamma}}{\bar{\gamma}} = \frac{\Delta g_B}{981 gal} = 10^{-3} \Delta g_B \tag{6}$$

where Δg_B represents the Bouguer anomaly, in gal, and H represents the normal height, in meters.

The height anomalies are represented as follows (Fig. 6):

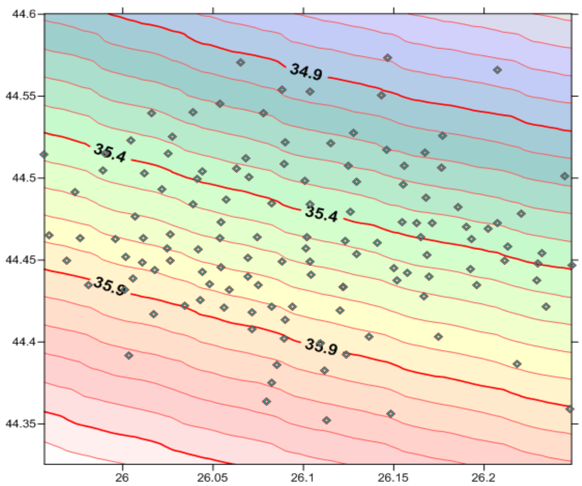

Fig. 6: Representation by isolines of height anomalies, corresponding to Bucharest area (Sorta, V – Doctoral thesis)

Based on height anomalies wre computed the following statistical parameters:

Table 1: Statistics of the height anomalies in the grid nodes

Statistics	Height anomalies [m]
Min.=	34.570
Max.=	36.672
Average=	35.618
Std. dev.=	0.503

3. Determination of the geometric quasigeoid for Bucharest area

The quasigeoid model for Bucharest area was determined through geometric method based on static GNSS determinations and levelling measurements realized in 121 gravimetric points. GNSS determinations were realized in one hour sessions, with 10 seconds registration rate.

For generating the geometric quasigeoid were used the relation:

ζ≈helipsoidal-Hnormal (7)

where ζ represents the height anomaly.

Based on height anomalies in measured points were computed the following statistics:

Table 2: Statistics of height anomalies in measured points

Statistics	Height anomalies [m]
Minim=	34.899
Maxim=	36.282
Media=	35.660
Ab. Standard=	0.281

4. Comparison between the geometric method and the gravimetric method for modeling the quasigeoid for Bucharest

Until now only one study was conducted in our country, in the Bucharest area, which can be carried out a comparison test between the geometric and the gravimetric method: Sorta, V. - Doctoral thesis - *”Contributions for a precise geoid/quasigeoid model for the area of Romania” – 2013.*

Considering the grid corresponding to the gravimetric quasigeoid, the height anomalies in the gravimetric points were interpolated.

On the other side, in the same points, were calculated the geometrical height anomalies, obtained as differences between ellipsoidal and normal heights.

After that, were determined the differences between gravimetric and geometric anomalies, given in the next table:

Table 3: Examples of values for height anomalies in common points computed using gravimetric method and comparison with the geometrical values

No.	absolute g [mgal]	γ [mgal]	$\zeta_{gravimetric}$ [m]	$\zeta_{geometric}$ [m]	Δζ [m]
1	980528,505	980577,028	35,174	35,157	0,017
2	980536,269	980569,776	35,775	35,777	-0,002
3	980537,132	980568,359	35,896	35,851	0,045
4	980539,302	980568,105	35,684	35,673	0,011
5	980542,180	980563,769	36,012	35,997	0,015
6	980529,111	980578,602	34,993	34,899	0,094

Taking into account these differences, were obtained the next statistics:

Table 4: Statistics of differences between geometric and gravimetric height anomalies

Statistics	Anomalies differences [m]
Min.=	-0.118
Max.=	0.127
Media=	0.002
Ab. Standard=	0.039

Considering the relation no. (7) and supposing that helipsoidal and Hnormal are independent variables, we can conclude the following relations for computing the geometrical height anomaly:

$$\sigma^2_{\zeta GPS/NIV} = \sigma_h^2 + \sigma_H^2 \qquad (8)$$

And for the height anomalies differences

$$\sigma^2_{\Delta\zeta} = \sigma^2_{\zeta Gravimetric} + \sigma^2_{\zeta GPS/NIV} \qquad (9)$$

This implies that the precision of gravimetric heght anomaly will be

$$\sigma^2_{\zeta Gravimetric} = \sigma^2_{\Delta\zeta} - \sigma_h^2 - \sigma_H^2 \qquad (10).$$

Considering the previous formulas we can conclude that the precision of the gravimetric quasigeoid model is about ±2,5 - 3,3 cm and the precision of the geometric quasigeoid model in GNSS determined points and precise levelling is about ±3,4-4,2 cm.

5. Conclusions

In most developed countries tend to achieve precise geoid models or quasigeoid, which served as a reference surface for a series of measurements and phenomenon, providing the main support for multiple engineering disciplines related to the Geosciences (navigation, seismology, tectonics study, the internal structure of the Earth, mapping, surveying, engineering surveying, etc.).
On the other hand, in Romania, measurements using GNSS technologies have experienced exponential growth in recent years. In this context, the National Agency for Cadastre and Land, through the Department of Geodesy and Mapping has developed a national system for determining the position, ROMPOS (Romanian position determination system), based on the latest generation of GNSS technology, being in agreement with European standards. Through this system, users can determine their 2D position in real time with high precision (of the order of centimeters). However, it still faces difficulties in determining altitudes (through GNSS measurements are obtained ellipsoidal heights which are not referred to a physical surface) and there is not a geoid model or quasigeoid viable for the national territory. Regarding the criteria of efficiency, ie the economic and precision, it is known that, in the conduct of gravimetric measurements, expenses, both material and human resources and time are reduced significantly compared with those allocated for a GNSS - leveling campaign. For example, to achieve measurements in Bucharest (relating to the present case study), while for gravimetric determinations was necessary a single operator (specializing in gravimetry) with one tool, GNSS - leveling measurements implied use of several devices together with mixed teams of specialists. In addition, the rough areas (hill and mountain), by lowering the leveling lines and the need to use trigonometric leveling measurements, observations accuracy drops significantly, being often cumbersome and also access to points where it wants to make measurements is difficult. Also, when performing GNSS observations may occur number of drawbacks, the main disadvantage consisting of lower accuracy for determining ellipsoidal heights.
Given the above, we can also conclude that establishing and maintaining precision leveling networks presents a great importance throughout Romania, which implies a coherent strategy in this regard of the relevant institutions, in particular National Agency for Cadaster and Land Registry. This network will have utility for gravimetric quasigeoid determination at national level and to perform other specialized works, such as works of photogrammetry, cartography, digital terrain models determinations, surveying and other technical works that require a precise determination of the altitudes. In this context, it is worth noting that currently there are no other methods to replace leveling where the values of altitudes are desired with millimeter precision. However, with the completion of gravimetric quasigeoid nationally, some functions will be taken over by leveling GNSS technology.

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Discretization of structures by finite element method for the displacements and deformation analysis

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Abstract

This paper presents a theoretical approach to meshing objects and how to extract information on movements and deformation analysis, providing a data processing about the studied object by finite element method. The flow of data in such a processing is based on the systems theory, with input data, a module for processing them on the basis of transformation functions and data output are subject to a check in advance. In this context, special importance is the process of achieving a mathematical model to approximate the processing to be better physical phenomena acting on analyzed the object and imposing designed limits on movements and deformations.

Keywords

numerical modeling, finite element, meshing, nodal displacements, degrees of freedom, efforts, natural coordinate system.

1. Introduction

A classification of methods for numerical modeling of structures can be done mathematical point of view, on three main areas:

- finite difference method,
- finite element method and
- border elements method.

The finite element method attempts to approximate a solution to a problem by admitting that the domain is divided into subdomains or finite elements with simple geometric shapes and function unknown state variable is defined around each element. [11]

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In this method, the equations describing the problem with an infinite number of degrees of freedom, are transformed into a system of equations with finite number of degrees of freedom.

However, this method allows the integration of the equations by numerical calculation and systems of differential equations on a domain, taking into account the boundary conditions or contour of a known configurations which describing different problem and physical phenomena.

2. Concepts in the formulation of the finite element method

Following application of the finite elements method, partial differential equations which shape physical systems with an infinite number of degrees of freedom are reduced to systems of algebraic equations, i.e. one discrete system with a finite number of degrees of freedom.

There are three ways to formulate the finite elements method:

a) direct formulation;
b) variational formulation;
c) residual formulation.

Direct formulation is based on matrix calculation of structures with displacement method.

Variation formulation is based on the minimization of the potential energy of the solid, deformable, based on a criterion of stationary potential energy. By minimizing the potential energy of solid deformable under a principle residence is obtained elastic nodal equilibrium equations system. By solving the system of equations is obtained displacements, strains and stresses of deformable solids.

Residual formulation may be used if they do not have a functional form, which is a more general formulation than the formulation variation. To formulate residual finite element method can be used: the method of least squares Galerkin method, method of co-location, etc.

The basic idea of this method is that if the studied structure is divided into several parts called *finite elements* for each of these can be applied calculation theories corresponding the scheme adopted (theory of beam, plate or block).
Dividing the structure into smaller parts, called *meshing* operation that will result in obtaining simple forms for finite elements composing the structure studied. [3] The computational model used in finite element analysis model is approximately obtained by finite element assembly components, taking into account the geometry of the structure. Connecting finite elements is performed only at certain points called nodal points or *nodes*. Nodes are points of intersection of the rectilinear or curved contour lines of the finite elements. Finite elements can be 1D, 2D or 3D depending on the geometry of the structure that shapes. [1]
The character of generality of the method gives the advantage to adapt, with simple modifications, the most complex and varied problems, such as linear and nonlinear problems, static and dynamic stresses, structures bar, flat or curved plates, contact problems, problems of fracture mechanics, of tiredness, etc.
The spatial configuration at a time of a system is described by its *degrees of freedom*. They are also known as *generalized coordinates* or in a more mathematized as *state variables*. A system where the number of degrees of freedom is infinite, the system is continuous, and if the number of degrees of freedom is finite, the system is discrete. [2]
Since MEF is a method of discretization, that the number of degrees of freedom of a finite element model is binding finite. Degrees of freedom are collected in a vector called *the state vector* **d** or *nodal displacement vector*.
Each degree of freedom corresponds to a generalized force. These forces are collected in a vector **F** called *the nodal forces vector*. The link between the two vectors, degrees of freedom and nodal forces is the linear nature and is known as *the rigidity matrix* (**K**):

$$K*d = F \tag{1}$$

The generic name, *the rigidity matrix*, is found both in modeling the behavior problems of mechanical and non-mechanical. Physical significance of the vectors **d** and **F** in the various applications of the problems of the field is given in the table below

Application domain	The vector *d* represents	The vector *F* represents
Continuum mechanics and structures	Displacements	Mechanical forces
Thermal transfer	Temperatures	Heat flux
Acoustics	Potential displacement	Particle velocity
Liquid flow	Pressures	Particle velocity
Electrostatics	Electrical potential	Electric charges
Magnetostatic	Magnetic potential	Magnetic intensity

The main steps in finite element analysis are:
1) idealization
2) discretization
3) obtaining the solution each having a source of errors.
This process can be schematized as follows:

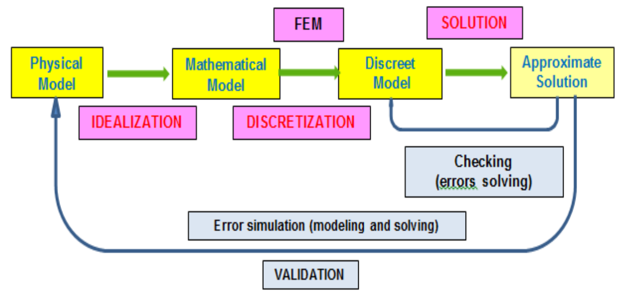

Fig. 1

Mathematical modeling or *idealization*, is an abstracting process by which an engineer transform a physical system into a mathematical model of the analyzed system. The idealization of complex engineering systems can be described in relation to a smaller number of parameters. Thus was filtered a number of significant details of the behavior of the system.
For a flat plate structures loaded her normal median plane at which idealization is allowed at least four known mathematical models:
1) The very thin sheet model which switches state of membrane with the bending
2) The thin plate model
3) The thick plate model
4) The very thick plate model - 3D elasticity theory
The responsible person for *idealization* must have sufficient knowledge of the advantages and disadvantages of each model and the applicability domain thereof. [14]

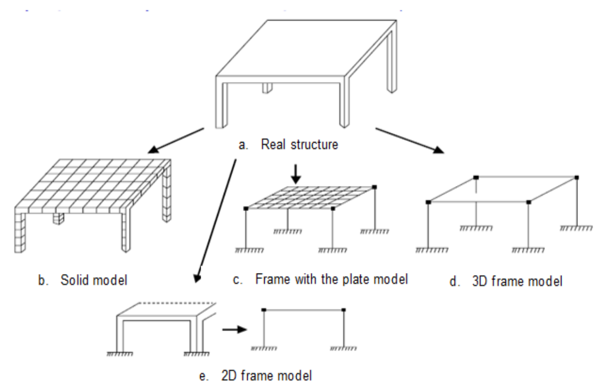

Fig. 2 Choice alternatives of the real structure model

For numerical simulation can be applied practically, must have the number of degrees of freedom are reduced to a *finite number*. The reduction of degrees of freedom is called *discretization (meshing)* and model is a discrete model. [11]

The response of each finite element is expressed on a finite number of degrees of freedom that are unknown values of function (displacement function) in a number of nodal points.
The answer of the mathematical model will result as an approximation of the discrete model response obtained by assembling answers of all elements of the model.

a. Types of elements

Finite element is characterized by the following attributes:
a) Dimension - 1D, 2D, 3D.
b) The nodes - each element has a finite number of nodal points. They serve to define the geometry and location of degrees of freedom. In general the simple elements (linear), the nodal points are positioned at the corners or ends of the elements. Higher order elements are nodes besides the ends and corners or on the sides or faces placed nodes or elements within them.
c) The geometry of the element - is defined by way of placement of nodes. They can have straight shapes (beams) or curved (parabolic elements, cubic, etc.).

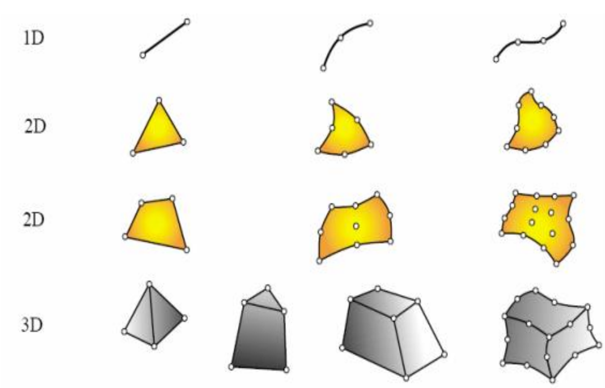

Fig. 3

d) Degrees of freedom - state parameters specific item. They are defined as field values or derivatives of displacements (u, v, w, Rx, Ry, Rz - components of displacements and rotations). With their help you can connect the elements which have common nodes.
e) Nodal forces - they are in one to one correspondence with the degrees of freedom (displacement corresponds to a force and rotation corresponds to a momentum).
f) Characteristics of the material - material behavior under load is characterized by constitutive laws. The simple and linear elastic behavior is corresponding to Hooke's law. In this case the behavior of the material is characterized by elastic modulus E, Poisson's ratio and coefficient of linear thermal expansion. [14]

2.2 Shape functions

In order finite element analysis is to find as accurately variables nodal points. The elements of the field variables from the nodal points define the form function or interpolation function. [7]

Considering the displacement such as variable field, this relationship can be expressed as:

$$u = \sum_{i=1}^{n} N_i u_i \tag{2}$$

$$v = \sum_{i=1}^{n} N_i v_i \tag{3}$$

where: u - horizontal displacement, v - vertical displacement, u_i - horizontal displacement in node i, v_i - vertical displacement in node i, N_i – expression of the shape function in node i.
The functions that expressed the shape are always as expressed in a natural coordinate system. A natural coordinate system is a coordinate system that allows you to specify a point on the element that is the origin and coordinates of other points do not exceed unity. For a rectangular element with four nodes can illustrate the natural coordinate system in the figure below.

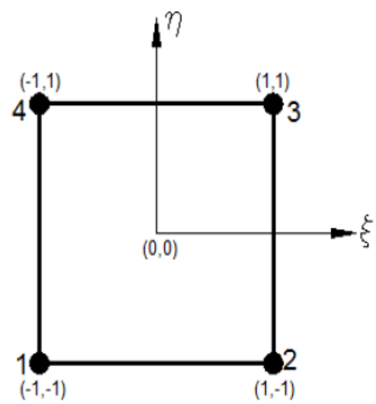

Fig. 4 Natural coordinates in four node rectangular element

$$u = \sum_{i=1}^{n} N_i u_i = N_1 u_1 + N_2 u_2 + N_3 u_3 + N_4 u_4 \tag{4}$$

$$v = \sum_{i=1}^{n} N_i v_i = N_1 v_1 + N_2 v_2 + N_3 v_3 + N_4 v_4 \tag{5}$$

where,

$$N_1 = \frac{(1-\xi)(1-\eta)}{4}, \qquad N_2 = \frac{(1+\xi)(1-\eta)}{4} \tag{6}$$

$$N_3 = \frac{(1+\xi)(1+\eta)}{4}, \qquad N_4 = \frac{(1-\xi)(1+\eta)}{4} \tag{7}$$

Therefore, displacement can be written as matrix, thereby:

$$\begin{pmatrix} u \\ v \end{pmatrix} = \begin{pmatrix} N_1 & 0 & N_2 & 0 & N_3 & 0 & N_4 & 0 \\ 0 & N_1 & 0 & N_2 & 0 & N_3 & 0 & N_4 \end{pmatrix} \begin{pmatrix} u_1 \\ v_1 \\ \cdot \\ \cdot \\ u_4 \\ v_4 \end{pmatrix} \quad (8)$$

2.3 The efforts matrix of displacements

The relationship between efforts at any time in analyzed element and nodal displacement can be designed using the efforts matrix of displacements. [7]

$$(\varepsilon) = \begin{pmatrix} \varepsilon_{xx} \\ \varepsilon_{yy} \\ \varepsilon_{xy} \\ \varepsilon_{zz} \end{pmatrix} = [B](u) \quad (9)$$

where, (ε) - efforts at any point of the element, (u) - vector of nodal displacements values for that element, $[B]$ - efforts matrix of displacements.

Efforts matrix of displacements is dependent on partial derivatives of shape functions or interpolation functions, dependent, in their turn, on the Cartesian coordinates x and y. But the shape functions are not directly dependent on x and y, but the natural coordinates ξ and η, can be used for differentiation rules in chain. [15]

For example, consider a quadrilateral element with four nodes, we can write:

$$B = \begin{pmatrix} \frac{\partial N_1}{\partial x} & 0 & \frac{\partial N_2}{\partial x} & 0 & \frac{\partial N_3}{\partial x} & 0 & \frac{\partial N_4}{\partial x} & 0 \\ 0 & \frac{\partial N_1}{\partial y} & 0 & \frac{\partial N_2}{\partial y} & 0 & \frac{\partial N_3}{\partial y} & 0 & \frac{\partial N_4}{\partial y} \\ \frac{\partial N_1}{\partial y} & \frac{\partial N_1}{\partial x} & \frac{\partial N_2}{\partial y} & \frac{\partial N_2}{\partial x} & \frac{\partial N_3}{\partial y} & \frac{\partial N_3}{\partial x} & \frac{\partial N_4}{\partial y} & \frac{\partial N_4}{\partial x} \end{pmatrix} \quad (10)$$

but,

$$\frac{\partial N}{\partial x} = \frac{\partial N}{\partial \xi} \cdot \frac{\partial \xi}{\partial x} + \frac{\partial N}{\partial \eta} \cdot \frac{\partial \eta}{\partial x} \quad (11)$$

and

$$\frac{\partial N}{\partial y} = \frac{\partial N}{\partial \xi} \cdot \frac{\partial \xi}{\partial y} + \frac{\partial N}{\partial \eta} \cdot \frac{\partial \eta}{\partial y} \quad (12)$$

and for any node can write:

$$\begin{bmatrix} \frac{\partial N_i}{\partial x} \\ \frac{\partial N_i}{\partial y} \end{bmatrix} = \begin{pmatrix} \frac{\partial \xi}{\partial x} & \frac{\partial \eta}{\partial x} \\ \frac{\partial \xi}{\partial y} & \frac{\partial \eta}{\partial y} \end{pmatrix} \begin{bmatrix} \frac{\partial N_i}{\partial \xi} \\ \frac{\partial N_i}{\partial \eta} \end{bmatrix} \quad (13)$$

If we introduce the Jacobean matrix linking the local coordinates of the global coordinates, i.e.:

$$[J] = \begin{pmatrix} \frac{\partial x}{\partial \xi} & \frac{\partial y}{\partial \xi} \\ \frac{\partial x}{\partial \eta} & \frac{\partial y}{\partial \eta} \end{pmatrix} = \begin{pmatrix} \frac{\partial N_1}{\partial \xi} & \frac{\partial N_2}{\partial \xi} & \frac{\partial N_3}{\partial \xi} & \frac{\partial N_4}{\partial \xi} \\ \frac{\partial N_1}{\partial \eta} & \frac{\partial N_2}{\partial \eta} & \frac{\partial N_3}{\partial \eta} & \frac{\partial N_4}{\partial \eta} \end{pmatrix} \begin{pmatrix} x_1 & y_1 \\ x_2 & y_2 \\ x_3 & y_3 \\ x_4 & y_4 \end{pmatrix} \quad (14)$$

we can write:

$$\begin{bmatrix} \frac{\partial N_i}{\partial x} \\ \frac{\partial N_i}{\partial y} \end{bmatrix} = J^{-1} \begin{bmatrix} \frac{\partial N_i}{\partial \xi} \\ \frac{\partial N_i}{\partial \eta} \end{bmatrix} \quad (15)$$

Therefore, the efforts matrix of displacements can be calculated for any type of elements, using these expressions.

2.4 The stiffness matrix

Displacements in an element are a result of externally applied load or self-weight. Relationship between these parameters can be formed using what is called stiffness. Taking into account a small part of elastic material subjected to applied external nodal force, {dF}, resulting displacements {du}, efforts {dε} and stresses {dσ} at the nodes.

Since the minimum potential energy principle, which states that "due to activities in outer load is equal to the internal strain energy", the following equations can be written:

$$W_e = \frac{1}{2} du dF \quad (16)$$

or in matrix form,

$$W_e = \frac{1}{2}\{du\}^T\{dF\} \quad (17)$$

And internal activity, W_i, is equal to integrated over the volume of the element:

$$W_i = \frac{1}{2}\int_{vol} d\varepsilon d\sigma dV \quad (18)$$

or in matrix form,

$$W_i = \frac{1}{2}\int_{vol} \{d\varepsilon\}^T\{d\sigma\} dV \quad (19)$$

Assimilating external and internal activities and simplifying, we can write:

$$\{dF\} = \int_{vol} [B]^T[C][B]dV\{du\} \quad (20)$$

The stiffness matrix of the element $[K_e]$, relating nodal forces $\{dF\}$ to nodal displacements $\{du\}$, is therefore:

$$[K_e] = \int_{vol} [B]^T[C][B]dV \quad (21)$$

This results in the generalized equation of displacement based finite element equation:

$$\{F\} = [K]\{u\} \quad (22)$$

The nodal displacements are evaluated using the relationship:

$$\{u\} = [K^{-1}]\{F\} \tag{23}$$

The stiffness matrix for the whole system which is called the global stiffness matrix (size = total number of unknowns x) can be assembled first with all elements zero and then placing the stiffness matrices of each element in the "place" corresponding to the degrees of freedom of each point in the global system. The integral can be evaluated using the Gauss numerical integration method.

Forces acting on an element can be externally applied loads or due to the self-weight. In any case these loads can be applied at the nodes as a point load, hence they must be distributed to the corresponding nodes using the shape functions using the expressions below.

$$\{F\} = \int_{vol} [N]^T \{X_b\} dV + \int [N]^T \{T\} dl \tag{24}$$

while, $\{X_b\} = \begin{Bmatrix} 0 \\ -\gamma \end{Bmatrix}$

where: γ = self-weight of material, N = shape function, {T} = external load applied uniformly.

For quadrilateral elements the integration order is between two and seven, for example if n = 2 there are 2x2 = 4 integration points and if n = 3 there are 3x3 = 9 integration points which are symmetric to the origin of the natural system of the coordinate axes ξ and η, with the same magnitude.

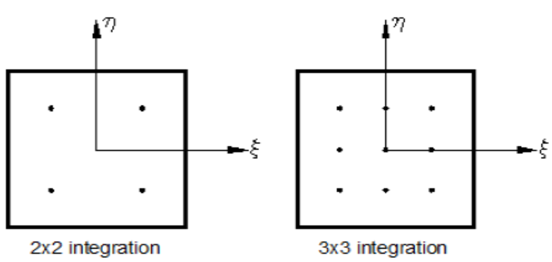

Fig. 5 Integration order in rectangular element

3. Interpretation of results

A very important step in the finite element analysis is the interpretation of the results, as during problem solving or after results, some questions arise. [11]

Answering these questions finalizes analysis of the problem or request that certain steps be repeated. Typically, in order to answer questions, are required to go through two steps:

1. *Validation of the model*. The user the method must verify the results of corresponding to satisfy calculation model.
2. *Interpretation of results*. Through interpretation of the results after validation, it show how works the structure studied. On the other hand may be required maximum values to be compared with the admissible. It is also important that the results are presented in a form that allows a better understanding, without prior knowledge of the model.

In this case the results for mechanical structures can be grouped in the following forms:

- representation of the displacements;
- representation of the deformed and undeformed object contour;
- representation of the forces and the moments;
- representation of the stresses and strains on the contour;
- representation of the principal stress directions;
- calculation of the deformation energy;
- listing of the stresses and deformations in ascending or descending order, etc.

It is important that parts of the structure to be shown in graphical form and the directions of coordinate system axes to be clearly shown and explained. If numerical values are included, the location of nodes, elements or sections to which they refer must be presented graphically and the conventions of signs to be clearly explained.

Some examples of representations can be seen below.

Fig. 6 Bradisor dam

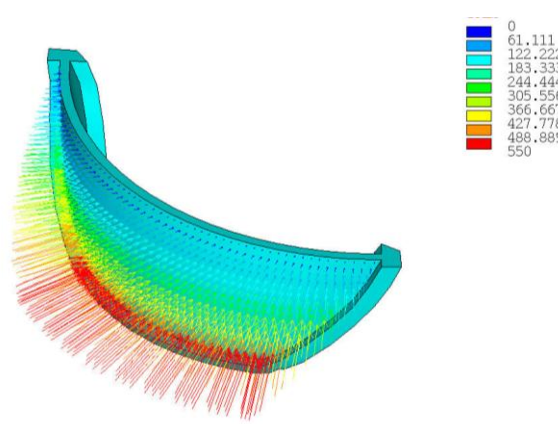

Fig. 7 Arrangement of hydrostatic pressure on the upstream face

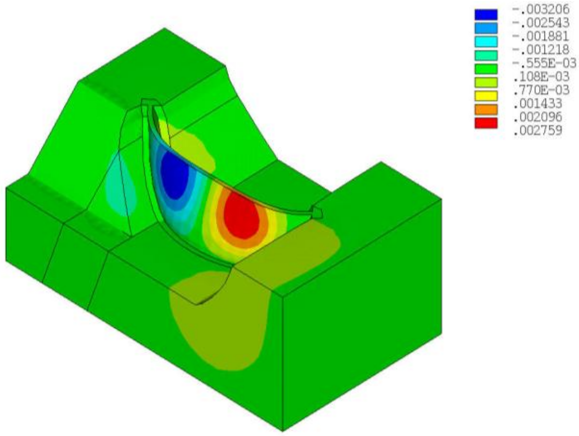

Fig. 8 Self-weight + hydrostatic pressure - displacement left bank - right bank (ux) (m)

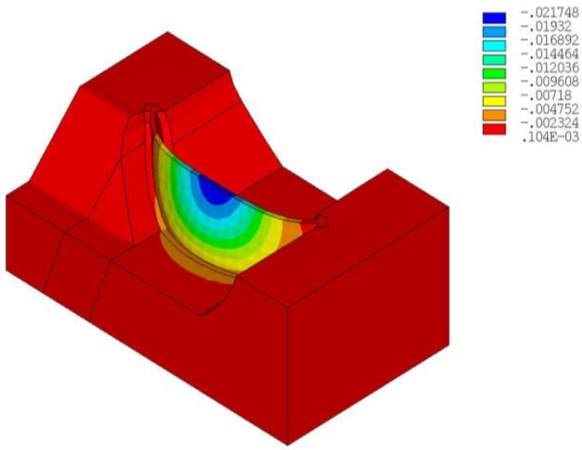

Fig. 9 Self-weight + hydrostatic pressure - displacement upstream - downstream (uy) (m)

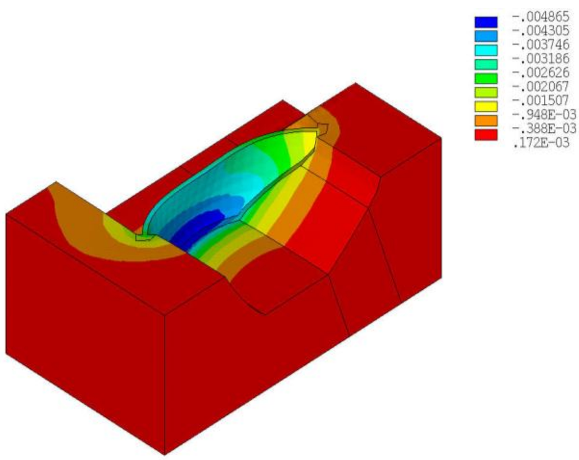

Fig. 10 Self-weight + hydrostatic pressure - vertical displacement (uz) (m)

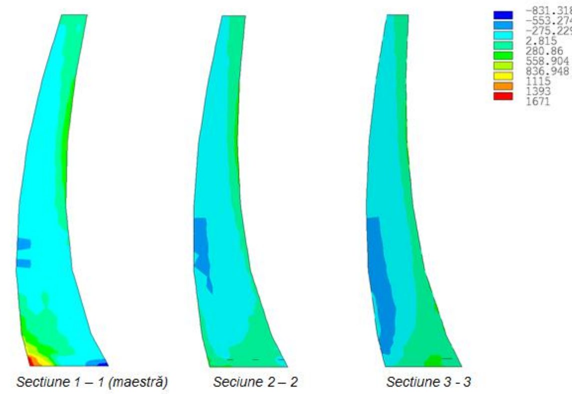

Fig. 11 Self-weight + hydrostatic pressure - main efforts σ1 (KN/m^2)

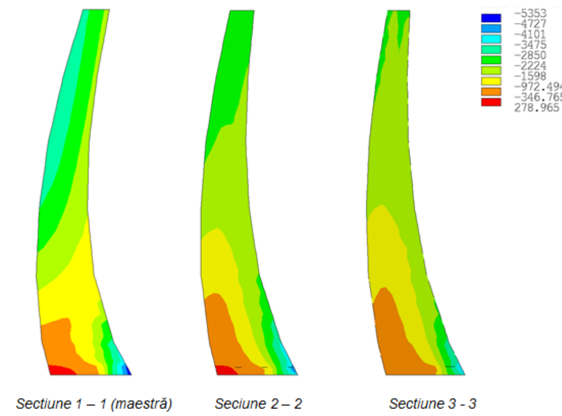

Fig. 12 Self-weight + hydrostatic pressure - main efforts σ3 (KN/m^2)

Fig. 13 Ovoid tank

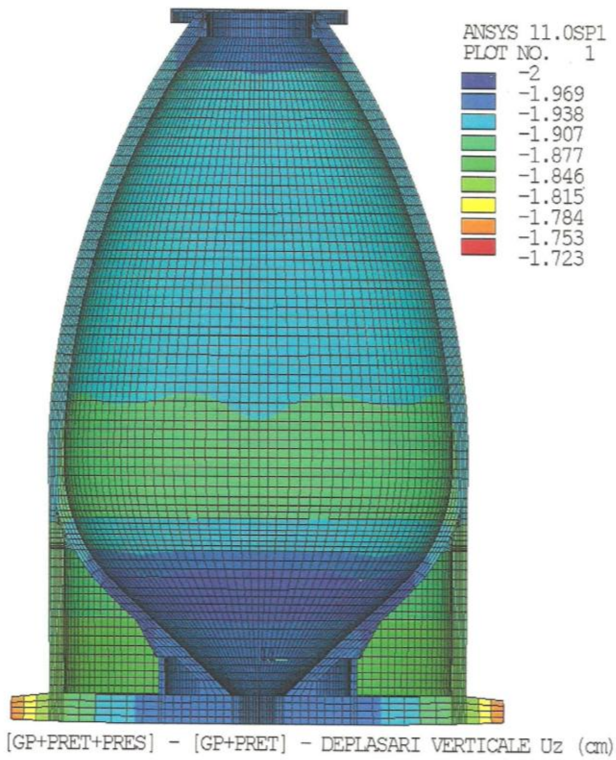

Fig. 14 Self-weight + internal pressure - vertical displacement (uz) (cm)

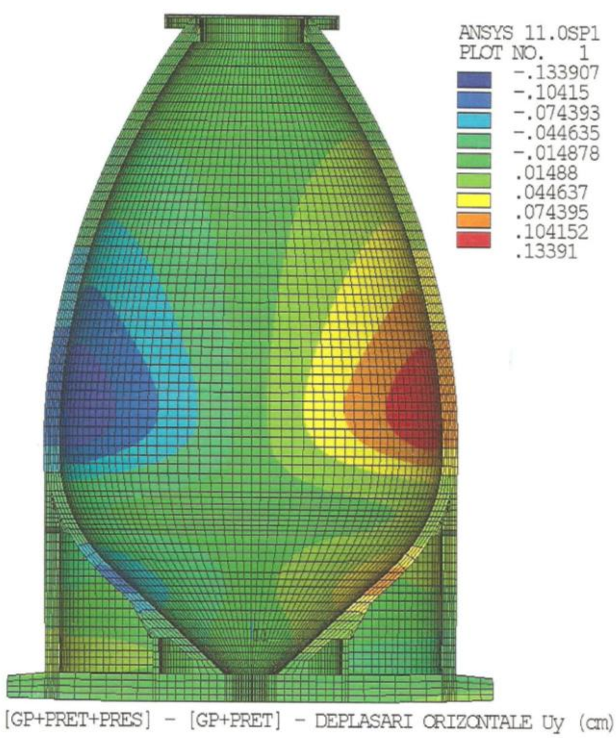

Fig. 15 Self-weight + internal pressure - horizontal displacement (uy) (cm)

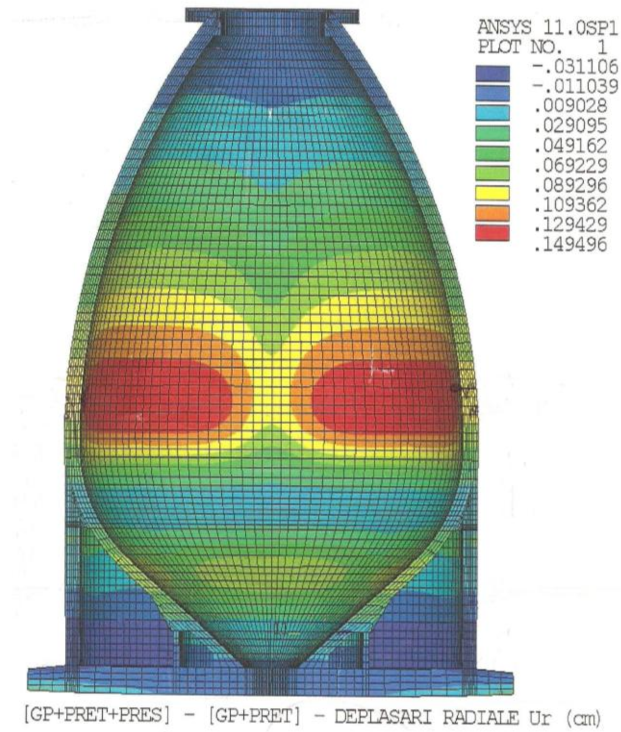

Fig. 16 Self-weight + internal pressure - radial displacement (ur) (cm)

3 Conclusions

Analysis of complex structures requires the establishment of calculation models to represent more accurately the behavior of the building. A valid general principle is that accuracy assessment of the dynamic characteristics of the model with finite elements, not exceed the modeling accuracy of the real structure.

There are many special programs for finite element analysis, giving the user a number of settings to resolve the problem, most of the operations necessary of the processing steps being the automated, starting from creating geometry of the model and ending with evaluation of results. [9]

We may say fact that in the analysis of displacements and deformations of building structures, it is important to realize a mathematical model corresponding with an adequate discretization, considering as many internal and external influences upon the structure analyzed. [10]

For checking and validation the mathematical model of the structure studied exists in this moment many techniques and methods for geodesic measurements, but and in this regard we have to make a choice consistent with the accuracy imposed for determining the characteristic points position of the structure. Thus, it can use:

- Terrestrial photogrammetry technique with high performance digital cameras calibrated;

- Techniques and methods of measuring with high performance total stations, possibly motorized, for which can set a grid of points that follows to be observed; [8]
- Techniques that use sensor systems of different types, with which can be measured displacements and deformations of structures in the characteristic points; [13]
- Terrestrial laser scanning techniques, static or dynamic, having able to set the takeover grid of points in accordance with the shape and dimensions of the finite element which composes the structure mash studied; [4], [5], [6]
- Terrestrial interferometry techniques (T-InSAR, GB-InSAR, D-InSAR) that can achieve the sub-millimeter accuracy of determination. [12], [13]

Combinations of these measurement techniques leads to obtaining some data sets complete and complex, that can confirm the viability of the mathematical model of a structure in a low number of iterations, leading to reduce the time and cost for conception of the structure model and its implementation for simulating an multiple analysis of displacements and strains, in different hypotheses.

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Application of the law 165/2013 by the inventory committee on Calarasi village, county of Dolj

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Abstract
On 16.05.2013 was issued Law no. 165 on measures to complete the process of restitution in kind or equivalent buildings abusively taken during the communist regime in Romania. The main purpose of this law is to inventory each locality across farmland available for restitution to former owners, owners who until now have not been put in possession mainly because local committees of Land argued that no more land available for putting them in possession and issuance of property titles. In this regard in the date of June 19, 2013 have been published and implementing rules provide for the establishment of committees of inventory farmland, responsibilities for each member of the committee, the role of the specialist surveyor under these implementing rules specialists in surveying and identifying the land and transposing plots in digital format on orthophotomap, inventoried land boundaries in the form of closed polylines in national projection system in dxf. Format. Wil be presented as a case study village Calarasi, County of Dolj.

Keywords
property laws, cadastre, land inventory.

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1. Introduction

On 16.05.2013 was issued Law no. 165 on measures to complete the process of restitution in kind or equivalent buildings abusively taken during the communist regime in Romania. The main purpose of this law is to inventory each locality across farmland available for restitution to former owners, owners who until now have not been put in possession mainly because local committees of Land argued that no more land available for putting them in possession and issuance of property titles.So we tried to identify for each locality so that availability of land claims backlog but validated by the County Commission can be resolved. In this regard the date of June 19, 2013 have been published and implementing rules provide for the establishment of committees of inventory farmland, responsibilities for each member of the committee, the role of the specialist surveyor under these implementing rules specialists in surveying and identifying the land and transposing plots in digital format on orthophotomap, inventoried land boundaries in the form of closed polylines in national projection system in dxf. format. This stage required by law to complete the annexes drawing 01-09 required by law.

2. Stages:

In the following shall be taken as a case study village Calarasi, County of Dolj.
1) Acquisition of existing graphical data OCPI for Calarasi village.
During this stage were taken from OCPI village cadastral plan scale 1:10 000 (Fig.1), orthophotomap village (Fig.2) dxf file with cadastral documentation previously received, TAU limit (Fig.3). It was taught in DXF format plan that includes vectorization sectors and their name and vectorization sector 0.

Fig.1. Cadastral map

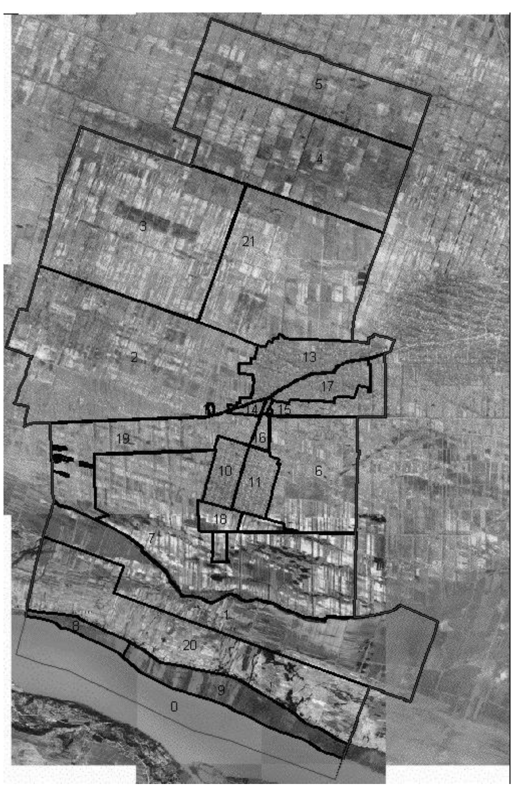
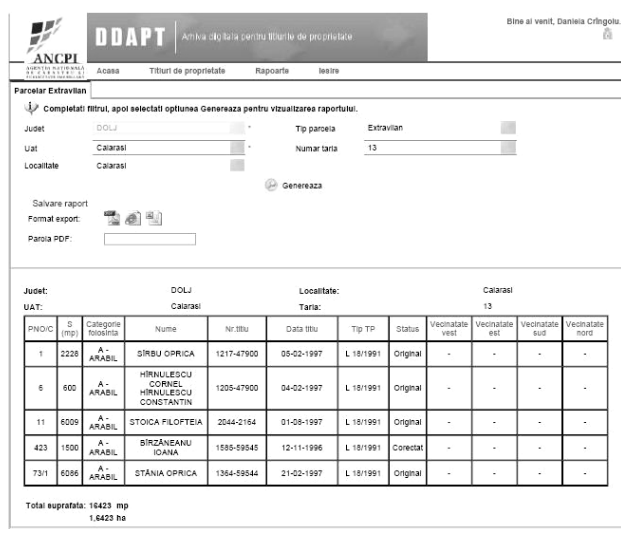


Fig.2.Ortophotomap with cadastral sectors

Fig.3. Cadastral documentation previously received.

2) Together with the agricultural officer and secretary of the commune to do an inventory of property titles on each tarla, and restitution claims validated by the County Commission. Inventory was done using the program DDAPT ANCPI (Fig.4).



Judet: DOLJ Localitate: Calarasi

UAT: Calarasi Tarla: 13

PNO/C	S (mp)	Categorie folosinta	Nume	Nr.titlu	Data titlu	Tip TP	Status	Vecinatate vest	Vecinatate est	Vecinatate sud	Vecinatate nord
1	2226	A - ARABIL	SÎRBU OPRICA	1217-47900	05-02-1997	L 18/1991	Original	-	-	-	-
6	600	A - ARABIL	HÎRNULESCU CORNEL HÎRNULESCU CONSTANTIN	1205-47900	04-02-1997	L 18/1991	Original	-	-	-	-
11	6009	A - ARABIL	STOICA FILOFTEIA	2044-2164	01-08-1997	L 18/1991	Original	-	-	-	-
423	1500	A - ARABIL	BÎRZĂNEANU IOANA	1585-59545	12-11-1996	L 18/1991	Corectat	-	-	-	-
73/1	6086	A - ARABIL	STĂNIA OPRICA	1364-59544	21-02-1997	L 18/1991	Original	-	-	-	-

Total suprafata: 16423 mp
1,6423 ha

Fig.4. Application DDAPT of ANCPI.

3)There have been inventoried with Hall representatives the land surfaces that are in the public and private communities, and areas of wilderness.
4)Were taken from other holders of land documents for the ownership and management of this land. Although the law states that they must provide the local commissions inventory DXF files. contour surfaces held, almost without exception they could not do this. For this reason it was necessary to be vectorized and these surfaces such as those held by the ADS, research stations, military units, etc (Fig.5.).

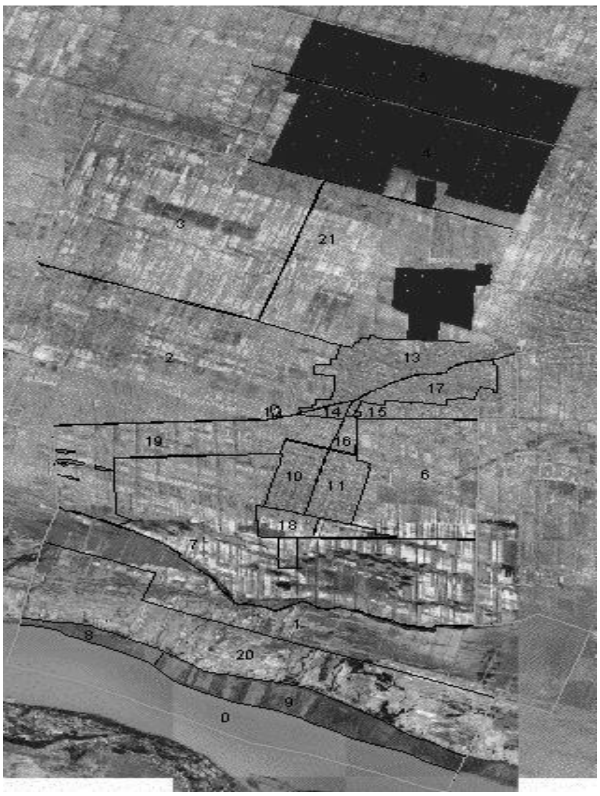


Fig.5. Land surfaces owned by Research Institutes.

5) Were retrieved from Romsilva plans with silviculture and were plotted on the plans.
6) Preparing Annexes 01-09.
Annexes 1 to 6 were prepared by the secretary of the mayoralty after receiving all information from specialist surveyor. In this way the plans were vectorized and were determined contours and surfaces of the tarla that make the sectors OCPI delivered in DXF format.
In a sector we find land belonging to private owners and state institutions.
To determine the reserve level of the surface area of the sector were low vectorised areas occupied property titles and areas occupied by state institutions (ADS, research stations, military units, forest land) wilderness area under Prefect Order ,surfaces public and private domain of the municipalities and land of the state (operating roads, canals).

Fig.6. Surfaces held Romsilva

It was found that in some sectors the surface put in possession of the land exceeds the surface of the sector .
Due to lack of toponymic points in metering applications unresolved restitution claims could not be done at the sector level, they count at the ATU.
Thus obtained was plotted with the mention "uncertain positioning surface." Annexes 01 to 06 were pooled in Annex 07 representing agricultural and forestry land situation which can be reconstituted ownership and Annexes 02, 04, 06 are centralized in Anexa08 representing centralized situation of land with or without investment in public and private property of the state and the administration of public authorities and institutions, institutes and research stations - Annexes 02,04,06.
In Annex graphics were represented: limit ATU Anexa01, Anexa02, Anexa03, Anexa04, Anexa05, Anexa06, sector 0, cadastral sectors (Fig.8).

Table 1. Anexa7

JUDEŢUL DOLJ								Anexa nr. 7
UNITATEA ADMINISTRATIV – TERITORIALA CALARASI								la norme
SITUATIA								
terenurilor agricole şi forestiere care pot face obiectul reconstituirii dreptului de proprietate								
Nr. crt.	Nr. sector cadastral	Suprafaţă rezerva retrocedabilă	Total suprafaţă Anexa 2	Total suprafaţă Anexa 3 - ha -	Total suprafaţă Anexa 4 - ha -	Total suprafaţă Anexa 5 - ha -	Total suprafaţă Anexa 6 - ha -	Total suprafaţă Col (2+3+4+5+6+7) - ha -
0	1	2	3	4	5	6	7	8
1	1	0,3480	0,0000	0,0000	0,0000	19,8000	0,0000	20,1480
2	2	28,0562	0,0000	12,0000	0,0000	0,0000	0,0000	40,0562
3	3	48,2442	0,0000	87,7300	0,0000	0,0000	0,0000	135,9742
4	4	39,2600	0,0000	157,3986	545,7632	0,0000	0,0000	742,4218
5	5	0,0000	0,0000	74,0006	410,4965	0,0000	0,0000	484,4971
6	6	13,9656	0,0000	11,4900	0,0000	0,0000	0,0000	25,4556
7	7	22,6361	0,0000	25,1138	0,0000	44,4000	0,0000	92,1499
8	8	0,0000	0,0000	48,9799	0,0000	0,0000	0,0000	48,9799
9	9	0,0000	0,0000	214,7431	0,0000	0,0000	0,0000	214,7431
10	10	0,0000	0,0000	0,4600	0,0000	0,0000	0,0000	0,4600
11	11	0,0000	0,0000	0,3100	0,0000	0,0000	0,0000	0,3100
12	12	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
13	13	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
14	14	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
15	15	0,9169	0,0000	1,8000	0,0000	0,0000	0,0000	2,7169
16	16	0,0000	0,0000	0,5200	0,0000	0,0000	0,0000	0,5200
17	17	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
18	18	1,4832	0,0000	3,3317	0,0000	0,0000	0,0000	4,8149
19	19	11,3530	0,0000	8,7600	0,0000	0,0000	0,0000	20,1130
20	20	2,3894	0,0000	0,0000	0,0000	153,8000	0,0000	156,1894
21	21	15,5113	0,0000	364,7496	134,7607	0,0000	0,0000	515,0216
Total UAT:		184,1639	0,0000	1011,3873	1091,0204	218,0000	0,0000	2504,5716

Table 2. Anexa8

JUDEŢUL DOLJ							Anexa nr. 8
UNITATEA ADMINISTRATIV – TERITORIALA CALARASI							la norme
SITUAŢIA CENTRALIZATOARE							
a terenurilor agricole cu sau fără investiţii, aflate în proprietatea publică şi privată a statului şi în administrarea unor autorităţi şi instituţii publice, institute şi staţiuni de cercetare - anexele 2,4,6							
Nr. crt.	Nr. sector cadastral	Denumirea administratorului terenului	Regimul juridic		Suprafaţa/suprafaţa aferentă investiţiei - ha -	Categoria de folosinţă/tipul de investiţie	Observaţii
			domeniul public	domeniul privat			
0	1	2	3	4	5	6	7
1	4	SCDCPN DABULENI	X		542,7315 / 41,4800	arabil, livada, vie / 12028,60 ron	
2	4	SCDCPN DABULENI		X	3,0317 / 3,0317	curti constructii / 12612,00 ron	
Total sector:					545,7632 / 44,5117	arabil, curti constructii, livada, vie / 24640,60 ron	
3	5	SCDCPN DABULENI	X		408,6444 / 12,0600	Livada / 5518,35 ron	
4	5	SCDCPN DABULENI		X	1,8521 / 1,8521	curti constructii / 10955,00 ron	
Total sector:					410,4965 / 13,9121	curti constructii, livada / 16473,35 ron	
5	21	SCDCPN DABULENI	X		134,7607 / 14,1955	arabil, balti, livada / 623676,00 ron	
Total sector:					134,7607 / 14,1955	arabil, balti, livada / 623676,00 ron	

3. Conclusions

In steps be taken above were encountered many problems that led to the extension and

even beyond the deadlines stipulated by the law, among them:

- The dxf. file with territorial administrative limit the file received from OCPI contained three different limits, which could lead to confusion (what has happened) .

- Sectors cadastral not respect natural limits existing in field .

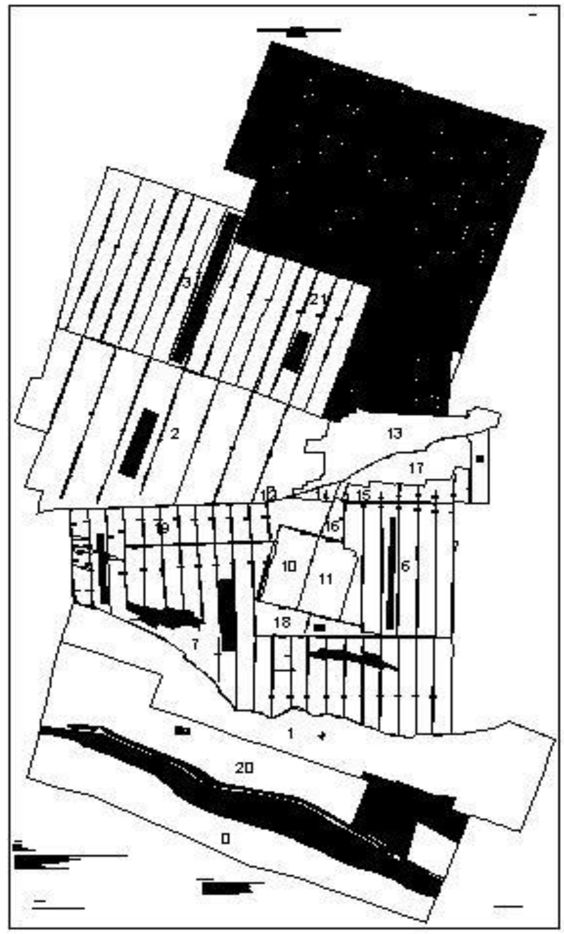


Fig.8.Anexa 09

- With few exceptions, the owners / managers of other land territory ATU were not able to provide the Commission inventory dxf file. land contours provided by law. For this reason, specialist surveyor he had to vectorize these surfaces, surfaces that were different from those recorded in the documents of ownership / management. Representatives of these institutions have been reluctant in signing annexes under the ground that they are not give to give up areas of land.

- The same problem was encountered in terms of forest lands from their managers are welcoming plans for forest planning that after vectorisation and overlap with the real situation on the ground and because of their age there were differences of surfaces.

- Existing data in application DDAPT National Agency for Cadastre are incomplete, shows errors due to wrong writing both property titles and their registration in this database.

It was also found that the launch of this application no local Land Fund Commission did not check it and not addressed ANCPI for correcting existing errors. Since inventory Commission had no powers to correct errors in the sense mentioned above, these data were recorded as they were found in inventory.

- Lack of parceling plans and the short time provided by law to finish this stages resulted reserve in Annex graphics without definite location. This means that to complete commissioning possession proven reserves will require plans drawing lots.
- Because the determination was made graphic surfaces and the fact that there has not been provided a margin of error (percentage) were inventoried in a very small sector reserves accumulated from multiple land parcel which can not be identified an never put in possession.
- After completing the graphic annexes have found problems in integrating drawn polylines in DXF format in GIS environment due to different principles by which programs are working with two types of file and handles the graphics entity.

Given the above we can conclude that this phase of the law 165/2013 lead to the identification of areas of land that could be put in possession to solve a part of the requirements made by the entitled. At the level of about 20 villages in Dolj county from which we had data we can say that the reserves discovered land can not settle into possession claims validated.

Also consider that in the inventory crept inevitable errors and estimate the accuracy with which these surfaces were determined is around 5%. After completing the inventory phase will be put in possession of land areas identified as reserves available, so being able to put in possession just after make lots plans .

As a final conclusion we can say that the best solution to problems of land fund in Romania is the general cadastre works across each locality.

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Precise point positioning – Current state

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Abstract
The development of the permanent reference station networks all over the world has led to an increase number of real-time positioning technique users. Improved methods were developed to process the raw GNSS data, calculate the differential correction and transmit the standardized messages to the final users. A new approach, aiming for the individual GNSS error component was instated in terms of Space System Representation (SSR) concept. The expansion of the communication enabled projects such as EUREF-IP or IGS-REAL-TIME SERVICE to provide the necessary data stream over the internet. Precise point positioning (PPP) is the technique that benefits at full of this improved model.

Keywords
GNSS, Space System Representation, Precise Point Positioning.

1. Introduction

Geodesy is one of the first domains that were highly influenced by the development of satellite based navigation systems. Even though they were designed mainly for military purpose, the applicability of the Global Navigation Satellite Systems for the civil and commercial sector was significant.
The broadcasted messages were used by the civilian users from the very beginning, despite the intentional degradation of the navigation signal known as Selective Availability (SA).

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The effects of SA feature were overcame by knowing that every GPS receiver from a given area is influenced almost equally, hence having a fix station (base station) with an accurately known position, the SA error value can be measured and transmitted to local GPS receiver from the nearby area in order to correct their position as well.
This approach is known as Differential GPS or DGPS and its availability worldwide has led to ineffectiveness of SA.
DGPS is also effective in mitigating several other GNSS errors, there for it continues to be used even though SA was turned off in May 2000.
A more precise technique used to correct for the important sources of GNSS errors is the Real Time Kinematics (RTK). In this case phase measurement are used instead of pseudo-random noise codes correlation. The major drawback of this method as properly aligning the navigation signals, whereas every cycle of the carrier is similar to every other. This is referred as the Integer ambiguity problem.
The differential methods can be deployed at a local scale, even by a single user, case in which the cost is higher, or in a network of reference stations that has national or even continental coverage.
The next logical step is to use the correction and products provided by a global network of reference stations and enable users to access a globally unique solution for positioning.
This stage is carried out through positioning methods like Precise Point Positioning.

2. The Concept

The different GNSS error components do have different characteristics. Satellite orbit, ionosphere and troposphere are spatially correlated and it is therefore possible to determine the effects in differential GNSS processing. However, the effects decorrelate with distance and introduce a distance dependent error into processing results. The clock errors are estimated or eliminated in the modeling approach of the GNSS data processing. Antenna phase variations and multipath are station dependent errors and must either be corrected or be adequately accounted for (Wübbena et al., 2005).

In general the GNSS errors can be determined based on one reference station, but the distance depending error makes the correction accurate only for the location of the reference station. Combining multiple reference stations in a network configuration with a method of interpolation, the correction can be calculated for the position of a user (rover) that is situated in the coverage area of the network.

In the figure bellow is represented the principle of error interpolation in a network of reference stations.

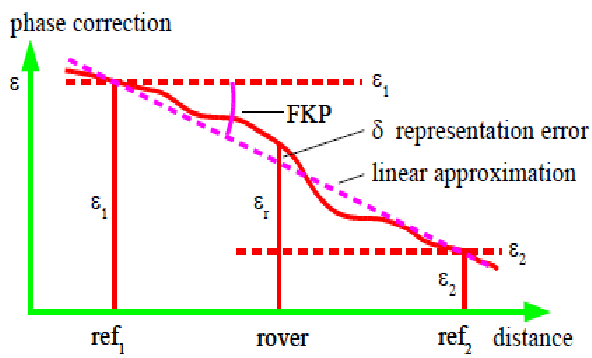

Fig. 1 RTK networking and OSR principle, representation error (FKP, VRS, PRS) for linear approximation.

For the traditional differential methods distance dependent state parameters are derived and combined with reference station observations that are transmitted to GNSS users in the field using the RTCM standards.

This approach is referred as Observation Space Representation (OSR) and is the concept currently used to provide correction to a user in GNSS based positioning.

OSR describes the cumulative influence of the errors that are affecting the navigation signal. This influence is close related to the reference station, and the satellite system signal characteristics.

OSR is the currently used method to provide correction as well in RTK network applications. Several particular methods were implemented based in this concept along the time:

- observation data + network correction: RS (Reference Station) + FKP
- network-corrected (individualized) observation data: PRS (Pseudo Reference Station) or VRS (Virtual Reference Station)
- observation data of multiple reference stations: MAC (Master-Auxiliary-Concept)

In contrast to OSR is the State Space Representation that is used for the representation of the complete GNSS state. Meaning that the state space modeling (SSSM) follows the idea to model the actual error sources instead of handling the effects of the errors as OSR currently does.

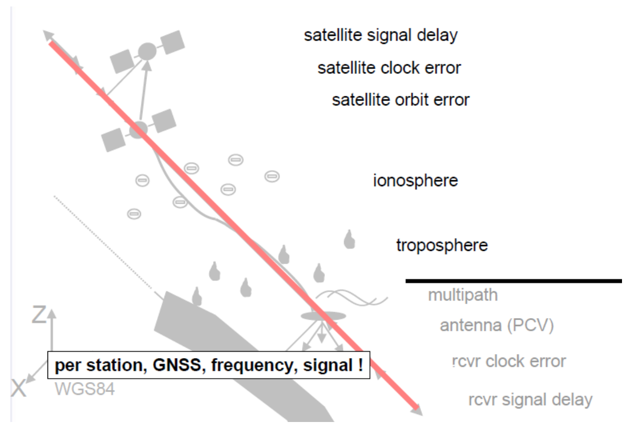

Fig. 2 Observation System Representation Schmitz, M (2010) - State Space Technology – Principle, RTCM Standardization and Examples on “GNSS-reference networks”, June 2010, Hannover, page 6

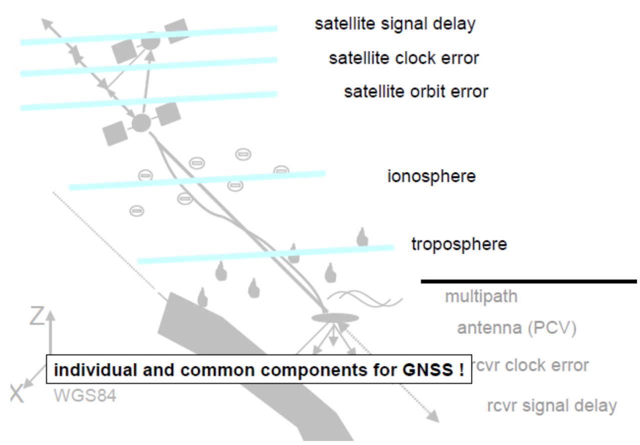

Fig. 3 State Space Representation- Schmitz, M (2010) - State Space Technology – Principle, RTCM Standardization and Examples on “GNSS-reference networks”, June 2010, Hannover, page. 7.

The state space representation is a description of the actual state of the environment in which the positioning is accomplished. The state of the system is transmitted to the rover as correction parameters for individual errors. At the rover side the observation are corrected based on this parameters. Using observation from a global network of reference stations to compute the parameters gives the SSR concept a global acceptance in terms of positioning. As in the case of differential methods based on OSR, single and dual frequency application could be implemented with SSR as well.

Table 1 Comparison of different state representation techniques (++ very good, + good, - fair to bad) Wübbena,G; Schmitz,M; Bagge,A (2005) – ION GNSS-05 - PPP-RTK: Precise Point Positioning Using State-Space Representation in RTK Networks – september 2005, California, page 5.

	Representation Technique	Broadcast	Covered Area	Bandwidth	Representation Error	Kinematic Applications	International Standards
SSR	SSR	++	unlimited	++	++	++	+ / -
OSR	RS+FKP	+	100 km	+	+	++	+ (SAPOS)
	PRS+FKP	+	100 km	+	+	++	-
	PRS	-	100 km	+	+	++	-
	VRS	-	local	+	-	-	-
	MAC	+	MA stations	-	+ / -	++	++

3. The Method

At the very base of the Space State Representation is the Precise Point Positioning method.
Relevant works concerning Precise Point Positioning has been carried out along the years by:

- Zumberge et al. (1997)
- Witchayangkoon (2000)
- Kouba and Héroux (2001)
- Gao and Shen (2001),
- Bisnath et al.(2002)
- Deo et al. (2003)
- Columbo et al.(2004)
- Chen et al.(2009)
- Geng et al(2010)
- Soycan and Ata (2011)
- Martin et al. (2012)

Precise point positioning can be seen as an improved single point positioning technique that uses precise orbit and clock information instead of the broadcast data. To get this enhanced data the user must have access to the Internet. More than this only one receiver is used for positioning and no reference stations are involved in the processing. Thanks to this precise point positioning (PPP) has gained more and more popularity in the GNSS scientific community.
The performance of PPP for positioning determination has been demonstrated in various studies of the above mentioned researchers, mainly using post-mission precise orbit and clock from IGS or other organisations. PPP was originally developed for static applications, but with the improved near real-time or real-time clocks and satellites orbits, real time precision positioning was also proved to be possible.
Unlike relative positioning, common mode errors do not cancel in PPP, since is a zero-difference approach. Station movements that result from geophysical phenomena such as tectonic plate motion, Earth tides and ocean loading enter the PPP solution in full, as do observation errors resulting from the troposphere and ionosphere. Relevant satellite specific errors are satellite clocks, satellite antenna phase center offset, group delay differential, relativity and satellite antenna phase wind-up error. Receiver specific errors are receiver antenna phase center offset and receiver antenna phase wind-up (Witchayangkoon, 2000)
Dual frequency receivers are used to compensate for the ionosphere effect by modeling an ionosphere free combination of:
code pseudoranges

$$P_{IF} = \frac{f_1^2 * P_1 - f_2^2 * P_2}{f_1^2 - f_2^2} =$$
$$= \rho + cdt + d_{trop} + dm_{IF} + \varepsilon(P_{IF})$$

and carrier phases.

$$P_{IF} = \frac{f_1^2 * P_1 - f_2^2 * P_2}{f_1^2 - f_2^2} =$$
$$= \rho + cdt + d_{trop} + dm_{IF} + \varepsilon(P_{IF})$$

where,
P_{IF} is the measured pseudorange on $L_I(m)$,
Φ_{IF} is the measured carrier phase on $L_I(m)$,
ρ is the geometric range,
c is the speed of light
dt is the receiver clock error,
d_{trop} is the tropospheric delay,
f_I is the frequency of L_I,
N_1 is the integer ambiguity on L_I,
δm_{IF} is the multipath efect,
ε is the measurement noise

The clock and satellite orbit errors were removed from the equations since the use of precise ephemerides makes these parameters known quantities. Yet we must bear in mind that precise clock files are only available with rapid and final ephemeris and therefore you can expect worse accuracy with ultra-rapid ephemeris.

The unknown parameters in a PPP vector processing are the three coordinates, the tropospheric delay, receiver clock error and ambiguity term (Gao and Chen, 2004)

In the case of single frequency receivers the ionosphere effect is counteracted by applying a model for its influence.

Although accurate ionosphere models are not general available, single frequency receivers can be used for positioning in non-critical applications.

As for the tools used to accommodate PPP, several software products implementing a PPP processing strategy have been developed by government agencies, universities, industries and individuals, even some online PPP services are also available at the PPP Software Centre that is a website that was created under the auspices of the Geomatics for Informed Decisions (GEOIDE) Network of Centres of Excellence Project 31 in Canada. The website has been functioning since May 2009. The main purpose of this website is to allow access to four different PPP applications via RINEX observation files sent by e-mail. These four different services are as follows:

- The CSRS-PPP, operated by the Geodetic Survey Division of Natural Resources, Canada, uses the in-house NRCan-PPP software, employing a least-squares batch process (Héroux et al., 1993).

http://www.nrcan.gc.ca/earth-sciences/geomatics/geodetic-reference-systems/tools-applications/10925#ppp

- The APPS, operated by the Jet Propulsion Laboratory, United States, uses version 6.3 of the GIPSY-OASIS software (Zumberge et al., 1997).

http://apps.gdgps.net/

- The GAPS, v5.5 operated by the University of New Brunswick, Canada, uses software that was originally written in MatLab but has been re-designed and re-written in C++ (Leandro et al., 2008).

http://gaps.gge.unb.ca/

- The MagicGNSS, v2.5 operated by GMV Aerospace and Defense, Spain, is based on software developed for GALILEO orbit determination and time synchronization. A batch least-squares algorithm is used to minimize measurement residuals, and to determine orbits, satellite and station clock offsets, phase ambiguities, tropospheric zenith delays and station coordinates (Píriz et al., 2008).

http://magicgnss.gmv.com/ppp/

	NRCan	GAPS	APPS	magicGNSS
Static Processing	All epochs / Forward only	5-min epochs / Forward only	5-min epochs / Smoothed	All epochs / Batch solution
Kinematic Processing	All epochs / Smoothed	All epochs / Forward only	5-min epochs / Smoothed	All epochs / Batch solution

Fig. 4 Software Characteristics and solution type offered by The PPP Software Centre

In Martín et al. (2011), a comparison of these four software tools can be found for a static PPP configuration. Also numerous tests had estimated the accuracy of PPP in kinematic applications. The software packages had evolved so that the processing can be done in post mission or in real-time, and the programs can be run in either static or kinematic mode.

Precise point positioning based on RTK networks (PPP-RTK) overcomes the limitations of ambiguity resolution, convergence time and accuracy offering centimeter-accuracy in a few seconds (Wübbena et al., 2005).

4. The Infrastructure

For more than 20 years, International GNSS Service (IGS) is the main provider for GNSS the data product. Based on a network of over 350 reference stations from more than 200 organizations IGS is the largest free-access provider of GNSS product.

Real-time Service (RTS) deliver the users GPS orbit and clock corrections that are crucial for PPP. RTS is intended to reach its full capability by the end of this year and offer data products for GLONASS observations as well. This stage is already implemented since final orbit correction for GLONASS satellites are already available with 3m accuracy and a latency of 12 – 18 days. The main characteristics of the offered products that present interest for PPP are:

- The IGS Final products have the highest quality and internal consistency of all IGS products. They are made available on a weekly basis, by each Friday, with a delay up to 13 (for the last day of the week) to 20 (for the first day of the week) days. The IGS Final products are the basis for the IGS reference frame and are intended for those applications demanding high consistency and quality.
- IGS Rapid products (IGR) The IGS Rapid products have a quality nearly comparable to that of the Final products. They are made available on a daily basis with a delay of about 17 hours after the end of the previous observation day; i.e., the IGS Rapid products are released daily at about 17:00 UTC. For most applications the user of IGS products will not notice any significant differences between results obtained using the IGS Final and the IGS Rapid products.

Nowadays over 70 satellites are already on the sky, and with the completion of the present GNSS emerging systems their number will rise up to 120 in couple of years. The development of new constellations of satellites had led to the need of expanding and updating the IGS network. From this aspect the Multi GNSS Experiment (MGEX) was born. Numbering 90 stations at the present time, MGEX will collect and analyze observation from GPS, GLONASS, and at least from one new emerging system: Gallileo or BeiDou. MGEX network is deployed around the globe in parallel with the legacy IGS network that tracks GPS and GLONASS satellites.

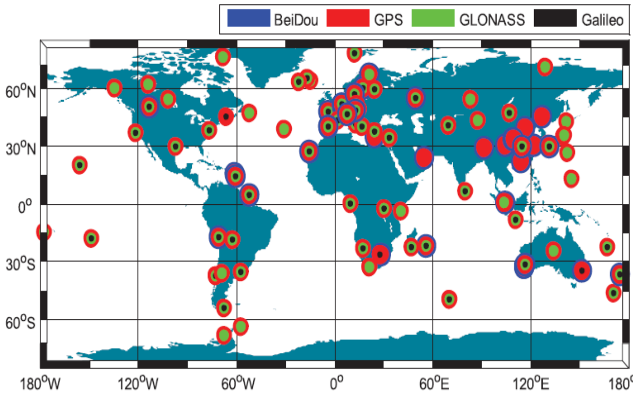

Fig. 5 The distribution of multi-GNSS stations from MGEX
Li et al. 2015

1. The Accuracy

In a Master's of Science Thesis in Geodesy from KTH Institute of Sweden, testing of PPP static method was undertaken using observation files from three different sources: three SWEPOS-stations at two different days, four IGS-stations and four self-measured points situated in different types of environment. Five different sets of ephemerides (final, rapid, ultra-rapid measured, ultra-rapid predicted 12h and 24h (predicted 8h and 13h for self-measured)) were used to process the observation files (24h, 6h, 2h and 1h) under the Bernese and Auto-Gipsy software.
As expected best results were achieved with final and rapid solutions for ephemerides, under 10 cm of accuracy after one hour of observation.

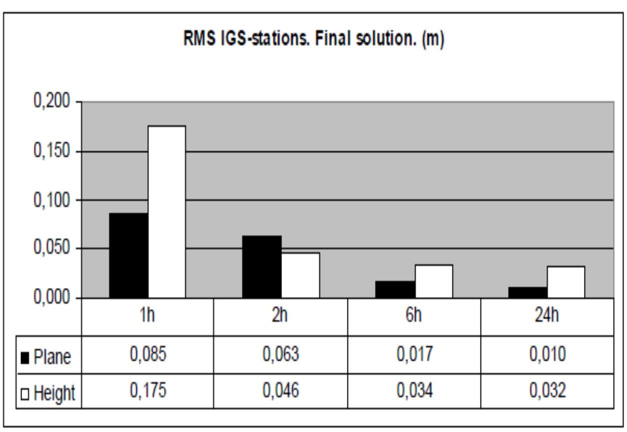

Fig. 6 RMS (m) for IGS stations (Bernese software)
Trehn, E. (2006) - „GPS Precise Point Positioning
An Investigation in Reachable Accuracy"

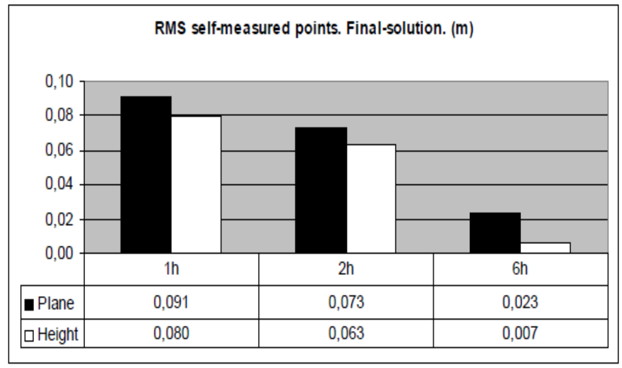

Fig. 7 RMS (m) for self-measured points (Bernese software)
Trehn, E. (2006) - „GPS Precise Point Positioning
An Investigation in Reachable Accuracy"

In Gao and Shen (2004), tests of kinematic PPP for a vehicle and a helicopter were conducted. The results indicate that positioning information with an accuracy level of 10 cm could be obtained.
In Héroux et al. (2004), the precise GPS positions of two aircraft GPS antennas were computed using kinematic PPP processing. For the distance between the two antennas (3.804 m), the Root Mean Square (RMS) was below 5 cm and the range was below 25 cm.
In Leandro and Santos (2006), GAPS software was used to determine the trajectory of a boat via kinematic PPP. The results include RMS values of 6.5, 5.5 and 13.9 cm for the North, East and up components, respectively.
In Hu et al. (2008), the IGS station SHAO was evaluated in kinematic mode on days 295, 296 and 297 of the year 2007. The maximum mean differences were 0.6, 3.2 and 4.3 cm for the North, East and up components, respectively.
In Tsakiri (2008), seven continuous days (24 h, 30 s observation files) of data for 2 IGS stations were processed using kinematic PPP with the CSRS-PPP software. Centimetric standard deviations in both the horizontal and vertical components were obtained. A kinematic vehicle test was also performed that yielded results of 5 to 6 cm for the horizontal component and 13 to 14 cm for the vertical component.
In Kjorsvik et al. (2009), the researchers analyzed 14 days of continuous observations of a ferry route between Lauvvik and Oanes (Norway) at a 1 Hz observation rate. The comparison of the PPP results with the reference trajectory computed via differential positioning yielded mean error rates of 6.7 and 10.0 cm for the horizontal and vertical components, respectively.
In Martin et al. (2012) a comprehensive test of kinematic PPP was taken. GPS observations from 8 permanent IGS stations (BRST, CONZ, KOUR, MDVJ, MTKA, NANO, REUN and TOW2) were used. The data sets used cover the first four hours of days 33, 211 and 347 of the year 2010, with data recorded at 30 s intervals. The coordinate bias (accuracy) was obtained by comparing the solution

for every epoch obtained using the kinematic PPP method with the static PPP solution for the day under consideration.

Table 2 Mean kinematic PPP bias (m) for the IGS permanent sites
.

Software	N		E		Up	
	σ	range	σ	range	σ	range
APPS	0.014	0.133	0.013	0.120	0.043	0.515
GAPS	0.244	1.789	0.225	1.448	1.107	6.655
NRCan	0.052	0.506	0.036	0.301	0.095	0.735
MagicGNSS	0.020	0.173	0.019	0.180	0.062	0.558

In order to simulate real conditions and introduce multipath biases the trajectory of two airplanes were recorded using GAPS, NRCan and MagicGNSS software, and also the trajectory of a car, and a moving pedestrian.

Table 3 Mean kinematic PPP bias (m) for one airplane

Software	N		E		Up	
	σ	range	σ	range	σ	range
GAPS	0.337	2.368	0.477	2.827	0.989	8.389
NRCan	0.015	0.087	0.013	0.069	0.029	0.147
MagicGNSS	0.008	0.065	0.011	0.068	0.021	0.137

Table 4 Mean kinematic PPP bias (m) for the car trajectory

Software	N		E		Up	
	σ	range	σ	range	σ	range
GAPS	0.267	2.182	0.191	1.678	1.002	3.895
NRCan	0.085	1.514	0.095	1.416	0.174	1.299
MagicGNSS	0.082	1.480	0.089	1.366	0.331	2.603

Table 5 Mean kinematic PPP bias (m) for the moving pedestrian

Software	N		E		Up	
	σ	range	σ	range	σ	range
GAPS	0.250	1.195	0.180	0.932	0.365	2.325
NRCan	0.106	0.685	0.079	0.548	0.255	1.705
MagicGNSS	0.105	0.57	0.044	0.487	0.156	1.431

Upon the development of the MGEX project a series of testing involving observations from GPS, GLONASS, Gallileo and BeiDou were undertaken. The results obtained for single-, dual and four-system modes at station CUT0 from Australia were compared.
The left sub-figures show the single-system PPP results of GPS-only, BeiDou-only, GLONASS-only and Galileo-only, respectively. For the GPS-only solution, the positioning accuracy can be better than 1 dm after a convergence time of about 30 minutes. About 2 hours of convergence is required to ensure an accuracy of better than 5 cm in all three components. The mm accuracy can be achieved after the long convergence time of several hours. The convergence of GLONASS-only PPP is longer compared to GPS-only PPP, about 3 hours to achieve an accuracy of a few centimeters. Meanwhile, the GLONASS positioning accuracy after sufficient convergence time is also slightly worse compared to the GPS solution. The BeiDou-only PPP presents good performance in the horizontal components, few cm accuracy can be achieved within one hour. However, the vertical component is much more unstable than GPS and GLONASS. A Galileo-only PPP solution cannot be derived at this station as not enough satellites can be observed.

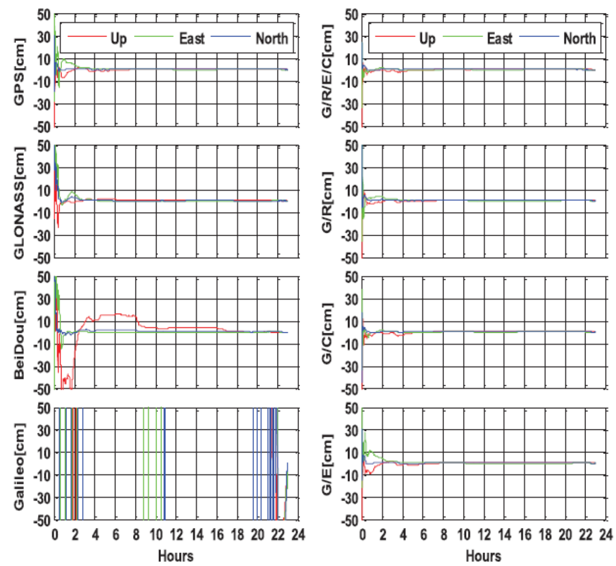

Fig 8 Static PPP solutions of single-system (G, R, E, and C), dual-system (G/R, G/C, and G/E) and four-system (G/R/E/C) modes at station CUT0 (Australia, 32.006S, 115.896E,), on September 3, 2013 (GPS Time). The north, east and up components are shown by the blue, green and red lines, respectively. (Li et al. 2015)

The combined GPS/BeiDou, GPS/GLONASS, GPS/Galileo, GPS/BeiDou/GLONASS/Galileo PPP solutions are shown in the right sub-figures. Obviously, the multi-GNSS combination significantly improves the PPP performance, compared to the left sub-figures of the single-system solutions. It can be clearly seen that the combined GPS/BeiDou and GPS/GLONASS solutions significantly shorten the convergence time and improve the position series compared to single- system PPP. The Galileo satellites also contribute to the combined GPS/Galileo PPP solution to some extent, although they are not sufficient for autonomous positioning. The combined GPS/BeiDou/GLONASS/Galileo PPP present the fastest convergence, the most stable position series and highest accuracy for all three components. It only takes several minutes to achieve an accuracy of better than 10 cm, less than 30 minutes to be better than 5 cm, and a few hours to reach mm level accuracy. (Li, et al, 2015)

5. Conclusion

In the context of the modern advent of GNSS technology new improved positioning methods that take full advantage of the created conditions had been developed. Precise Point Positioning is one of these methods. Increased popularity of PPP among researchers and users reveals with every study the real potential and efficiency of this precise positioning method. PPP offers a global stable, high accuracy solution and eliminates the need of high density reference station.

Seen by some of the authors as a method limited only by the present state of the communication systems, PPP is obviously offering great advantages in terms of obviously precision and cost.

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Combining the techniques of taking details relating to underground utility networks in the field

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Abstract
This paper aims to present the main techniques of taking details relating to underground utility networks in the field, non-invasive techniques that complete each other. This paper is based on a job that could only be completed using all methods in the field.
The client had a requirement to accurately map the existing underground utility network within a site boundary in Carlow. The survey was largely due to developers and contractors not carrying out accurate as built surveys on underground service utilities during the construction period. The field team was contacted by the client and asked to provide a non-intrusive and accurate solution to their requirement. Therefore in obtaining a solution, the operators combined a number of survey methods together to achieve the required result. These methods included a ground penetrating radar survey incorporating a multi frequency array radar system, radio detection surveys and finally manhole surveys.

Keywords
GPR, multi frequency array radar system, radio detection.

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1. Purpose of Investigation

The objective of the survey was to locate the position and depth of all existing underground utilities using a combination of non-intrusive survey techniques. As the main investigative techniques used are largely non-destructive, the findings given in this report are based on indirect measurements and the interpretation of acoustic, electrical and electromagnetic signals. The findings represent the best professional opinions of the surveyors, based on the field team experience and the results of non-intrusive pipe location carried out elsewhere on similar materials and projects.

2. Health, Safety & Environmental

Prior to commencing work all personnel working on the project on site had passed the FAS Safe Pass Scheme (training and employment authority) and the FETAC (further education and training awards council) approved detection and location of underground services scheme. No work was undertaken in the survey zones by any personnel who have not attended these schemes.
All works were carried out in a safe manner, using only certified equipment, and the work site maintained so that it functions safely and efficiently.
All persons, except when in offices or similar accommodation wore appropriate Personal Protection Equipment:

- Safety boots
- High visibility jackets, leggings and waistcoats
- Hand Protection
- Eye Protection

Where appropriate:

- Ear Protection

3. Survey

There were no restrictions on access to the site. All access was cleared with the client and landowners prior to mobilising to site.

Fig. 1 Equipaments used on this project

The successful detection and mapping of buried utilities involves the combination of several techniques, the results of which are synthesised down to a single interpreted plot. The techniques and methodologies used will primarily depend upon the required outcome for the survey, the site conditions and the type of pipes or cables being targeted.

- Survey crew open manholes and record and photograph all details
- Radio detection survey and Sonde survey is carried out within the survey area.
- The Ground Penetrating Radar survey is carried out across the survey area.
- Survey data is post processed and analysed then crossed referenced against site service records information in office.
- All survey information is reference onto a topographical survey drawing.

4. Ground Penetrating Radar (GPR)

A number of different GPR grids were set out over the site. Data field files were collected with a multi frequency array antenna system to give maximum depth penetration whilst maintaining a high resolution at both shallow and deep depths. Full calibration was carried out at the start scan with constant quality monitoring during acquisition and frequent recalibration checks were carried out where necessary.

Depth readings from GPR rely on multiplying the measured two-way travel time by the velocity of the radio signals passing through the materials under investigation. As the surface and subsurface of the site changes, frequent recalibration of the subsurface velocities results in an accurate calculation of depths and thicknesses of located features relative to the surface.

Where possible, the whole site was covered by a tight GPR grid, using our Multi Frequency Array systems, in order to detect any sub surface utilities not located by other methods and to ascertain depths of all targets.

5. Radio Detection Survey

The radio frequency location equipment that we use on every site is the RD4000 cable locator. This has 4 modes or methods of operation that are outlined below. These methods have been developed to fit particular circumstances of locating known and unknown utilities on site. The radio frequency locator is used at the same time as our GPR system to determine the line and depth of metallic pipes and cable services i.e. Gas, Electricity, Water, Telecoms, CATV and Sewers with the aid of Sonde equipment. The way in which we use this equipment is to start from a known point on a service and trace it using one or more of the four methods.

Method 1 - Direct Connection

This is where we input a signal into a known feature i.e. a lamppost or service valve.

Method 2 - Clamp Connection

This is where we input a signal into a known pipe or cable, at access points i.e. inspection covers and manholes.

Method 3 - Induction

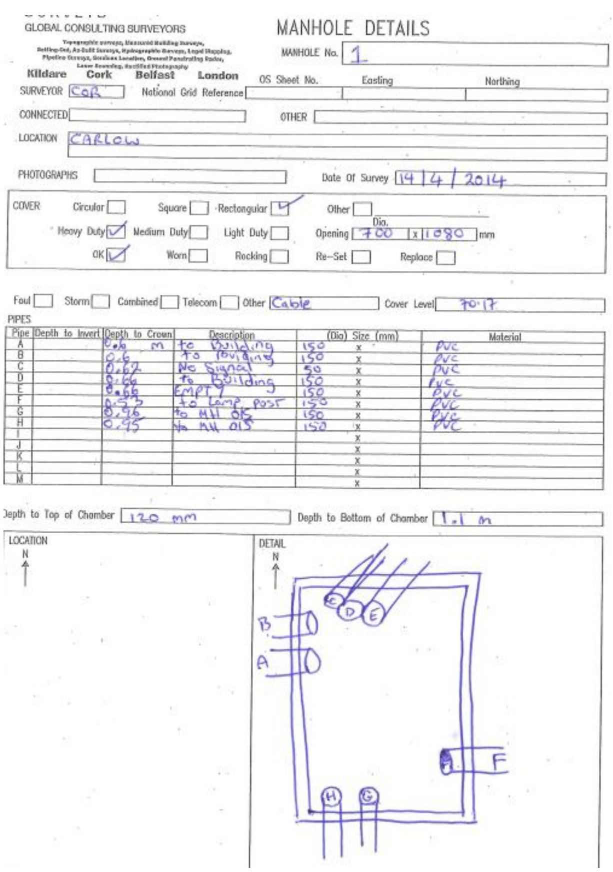
This method is used to trace a known service where there are no access points to use. The transmitter puts a signal (frequency MHz) into the ground which travels in both directions down the service. The surveyor will then pick up the transmitted signal with the receiver. As with all signals, they will only travel for a certain distance before they fade, it is very much dependent on the condition of the pipe or cable and how the material that it is made from, conducts the signal. When the signal fades, the surveyor will move the transmitter to the last detected point, then continue to trace the service through the survey area. As he goes along the service, he will take

depth readings and mark them on the ground.
Method 4 – Induction and Find Sweeps
Once the investigation has been completed and the Team Leader has confirmed with his team that all known services and any additional unknown service have been detected and pick up by our land surveyor, there is one last procedure that is carried out, this is called our final sweeps.

6.Chamber/Manhole Inspection Survey

Each manhole/ inspection cover within the survey area was opened and the contents documented. These measurements are recorded on a digital manhole description sheet. The manholes were individually numbered. All depths recorded inside the chamber were by disto, measuring tape or leveling staff,. Details included:

- Cover Levels
- Invert levels
- Service Type
- Service Material
- Pipe sizes
- Chamber dimensions
- Direction of flow
- Photographs


GLOBAL CONSULTING SURVEYORS
Kildare Cork Belfast London
MANHOLE DETAILS
MANHOLE No. 1
SURVEYOR COB
National Grid Reference OS Sheet No. Easting Northing
CONNECTED
OTHER
LOCATION CARLOW
PHOTOGRAPHS
Date Of Survey 14 / 4 / 2014
COVER Circular Square Rectangular ✓ Other
Heavy Duty ✓ Medium Duty Light Duty Opening Dia. 700 x 1080 mm
OK ✓ Worn Rocking Re-Set Replace
Foul Storm Combined Telecom Other Cable Cover Level 70.17
PIPES

Pipe	Depth to Invert	Depth to Crown	Description	(Dia) Size (mm)	Material
A		0.6 m	to Building	150 x	PVC
B		0.6	to Building	150 x	PVC
C		0.62	No Signal	50 x	PVC
D		0.66	to Building	150 x	PVC
E		0.66	EMPTY	150 x	PVC
F		0.53	to Lamp post	150 x	PVC
G		0.96	to MH 015	150 x	PVC
H		0.95	to MH 015	150 x	PVC
I				x	
J				x	
K				x	
L				x	
M				x	

Depth to Top of Chamber 120 mm Depth to Bottom of Chamber 1.1 m
LOCATION N
DETAIL N

Fig. 2: Manhole Inspection Sheet

7. General GPR Limitations

GPR surveying is limited by the following guidelines		Minimizing GPR Limitations
Depth and size of Utility	In good ground conditions and within the depth range of two metres the ability to detect a utility will reduce in diameter by 1mm for each 10mm of depth. i.e. a 200mm pipe can be detected at 2m and a 50mm pipe at 0.5m but a 25mm plastic water service pipe to a house cannot be detected at 1.2m with radar	The field team incorporated Radio Detection surveys in areas where GPR was found to be ineffective.
Shadowing	This can happen where shallow buried utilities hide or mask deeper buried utilities below.	The staff used mutli frequency radar systems to reduce the effect of shadowing.
Soil Condition	GPR surveying operates best within high resistivity material. Clay overburden can impair GPR surveying. The depth penetration and quality of the data depends on the ground conditions on site. Poor data maybe a result of areas with high conductivity	The team calibrate our GPR Systems for varying soil types on each project.
Plan Accuracies	Plan accuracies of the order of + or – 150mm maybe achieved but this figure will depend on the depth of the service below ground level.	The field crew incorporated Radio Detection surveys in areas where GPR was found to be ineffective.

Utility Location	Although all reasonable steps have been taken to locate all features, there is no guarantee that all will be shown on the drawing as some above ground features may have obstructed the survey.	The utility surveyors are all qualified and certified to locate underground services.
Existing Utility Records	Existing record information showing underground services is often incomplete and unknown accuracy; therefore it should be regarded only as an indication.	It is always our intention to use the Utility provider's details, if supplied prior to survey commencement, as a guide for locationpurposes. However, should we not be able to locate those guided services we shall not be held responsible for the accuracy, or otherwise, of the location of that service, as issued by the utility provider therefore and shown "Taken From Records" on the drawing and we are not liable for any loss that may arise due to the lack of accuracy in the guided information.
Loss of Signal	It is not always possible to trace the entire length of each underground service.	The processors indicated on the drawing if a service trace is lost.
Utility Congestion	Where similar services run on close proximity, separation maybe impossible.	The team incorporated Radio Detection surveys in areas where GPR was found to be ineffective.
Pipe Material	Successful tracing of nonmetallic pipes maybe limited due to material construction of the pipe.	The field crew incorporate Radio Detection/ Manhole& PWG surveys in areas where GPR was found to be ineffective.

Tab. 1 General GPR Limitations and solutions

8.Accuracies

Estimated Detection Rate		
Depth Range	Utilities buried within this range	Estimated Confidence
0 to 800mm below surface	65%	Approx 90%- 98% of Utilities Detected.
800mm to 1500mm below surface	20%	Approx 80%- 95% of Utilities Detected.
1500mm to 2200mm below surface	12%	Approx 70%- 92% of Utilities Detected.
2200mm+	3%	Unknown
The American Society of Civil Engineers in their 'Standard Guidance for the collection and depiction of existing subsurface utility data' has a useful rule of thumb for GPR which in, metric values, can be summarised as: 'In good ground conditions and within the depth range of two metres the ability to detect a utility will reduce in diameter by 1mm for each 10mm of depth. i.e. a 200mm pipe can be detected at 2m and a 50mm pipe at 0.5m but a 25mm plastic water service pipe to a house cannot be detected at 1.2m with radar'.		

Tab. 2 Accuracies

9. Findings

Detected Utilities	
Gas	No evidence of Gas plant was detected within survey area. The site service records show the gas pipe connecting the buildings within survey area. No signal was detected of those pipes and GPR results were inconclusive due to the presence of concrete slab found on GPR scan and due to the signal being absorbed by the pipe material rather than reflected back to the radar antenna. The gas main lines drafted and marked as taken from records.

Cables-Electric	ESB cables were located and mapped within survey area. It was not possible to verify the depths on every ESB line. Where it was not possible to verify the ESB lines as per records service drawing, those lines were drafted and marked as taken from records.
Telecoms	Telecom cables were located and mapped. Where it was not possible to verify the Telecom lines as per records service drawing, those lines were drafted and marked as taken from records.
Lighting	Lighting cables were located and mapped. Where it was not possible to verify the public lighting lines as per records service drawing, those lines were drafted and marked as taken from records.
Water main	Water main pipes are untraceable with radio detection methods. There was no signal detected of the sluice valve nearby some manholes or other valves/hydrants located nearby survey boundary possible due to non-metallic nature of the pipes. There were a number of inspection chambers with disconnected water pipes. No signal was detected of that disconnected pipes. Due to the signal being absorbed by the pipe material rather than reflected back to the radar antenna the GPR results were inconclusive. The water main lines were drafted and marked as taken from records.
CCTV/ CATV	No evidence of BT (Esat) or UPC (NTL) lines were detected within survey area.
Fibre Optic	SMART telecom lines were untraceable with radio detection methods possible due to the fibre optic nature of those cables. SMART telecom was drafted and marked as taken from records.
Drainage	Storm water, foul and combined sewer pipes were located and mapped.
GPR Anomalies	As well as all the confirmed utility services, there are a number of unidentified features shown as Unidentified GPR Anomalies within survey area. These features may be the result of services which are running through the sites but couldn't be detected with radio detection methods i.e. due to the non-metallic nature of the pipes, abandoned services, natural geological features or land drains amongst other things. The particular concrete slabs were marked as hatched areas.

Tab. 3 Findings

10. Conclusion

The data collected from the utility survey has ranged from reasonable to a high quality from the various methods used across the site.
Although 100% detection of all utilities was not achieved using ground penetrating radar, the correlation using the combined methods of the radio detection survey and the GPR survey yielded a very accurate set of results as opposed to carrying out each method independently or carrying out a desktop study only. However, due to the limitations based on site conditions, a 100% guarantee cannot be offered.
Every effort has been made to ensure that all results are accurate and reliable. Ground Penetrating Radar is a well-established technique to determine subsurface utilities, voids and anomalies.
It is recommended to carry out a slit trenching works to investigate route, depth and diameter of water main and gas main pipes which were untraceable with radio detection methods.

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Current issues in the field of immovable properties' registration and their prospects for settlement

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Abstract
Considering the discussions taking place, in the current period, at national level, in this article are approached specific aspects of different issues relating to the preparation of cadastral documentations and registration of properties in the land book register and possible solutions in order to improve the legal framework.

Keywords
cadastre, real estate publicity, sporadic property registration, systematic property registration, cadastre and land registration law no. 7/1996, ANCPI's Director General order no. 700/2014.

1. Introduction

- Law no. 7/1996 has put the legal bases of a real system of unified cadastre and land registry for the Romania, designed to replace the old real estate publicity systems that were applicable until the date of implementation of this law.
- The challenge aimed by the unique law was to create normative legal prerequisites of an integrated cadastre and land book system through a gradual and progressive expansion of the new real estate publicity system, based on the cadastral plan of immovables and land books established for each of these properties.
- In support of these issues, it is noted that in the original version, Article 61 of the Law provided that, until completion of implementation of the general cadastre for each administrative unit, registrations having non-definitive character shall be carried in land books, in and upon the completion of the general cadastre, land books become definitive.
- These considerations have been taken into account right from the design of Law on cadastre and real estate publicity and were the motive for which, over time, were developed subsequent enactments, amendments and additions were made to the special law, so that to achieve a regulatory framework for the creation of an appropriate integrated cadastre and land registry system and adapt working methods regarding cadastral measurements, to the practical realities in order to simplify property registration methods, in terms of sporadic registration, but especially in terms of systematic registration of immovables.
- The major importance of cadastre and land book is recognized by the New Civil Code, which pays particular attention to real estate registration, dedicating to this area, of national importance, a title - Title VII, entitled 'Land Registry' in Book III (On ownership).
- In considering these issues, the Civil Code uses for the first time the term cadastral number, thus recognizing the importance of building's unique identifier and confirms the benefits of systematic registration of real estate rights by regulating constitutive effect of entries in the land book applicable following completion of cadastre at the level of an administrative-territorial unit.
- Mission of creating an appropriate regulatory framework by simplifying, optimizing and ensuring the effectiveness, uniqueness, accessibility and unity regarding the operation of cadastre and land registry system, for ensuring the civil circuit of buildings belongs to the National Agency for Cadastre and Land Registration as single state authority in the field of cartography, cadastre and real estate publicity.
- National Agency for Cadastre and Land Registration (ANCPI) manages in Romania the integrated cadastre

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and land registry system, a uniform and mandatory system of technical, economic and legal evidence of national importance of all immovable throughout the country, having a defining role in the identification and registration of real property that creates the potential to achieve a real basis for evaluation, taxation and guaranteeing of property rights.

- Creating a coherent legislation and a necessary infrastructure for the implementation of best working methods involves political, economic and administrative decisions, to create a conceptual framework and structured actions and coherent solutions regulating situations applicable which cause problems in the practice of local offices, both in terms of cadastre component and real estate component is the main concern of ANCPI.

- No less important is the preoccupation of ANCPI to improve mapping service provided to a wide range of users, by the National Mapping Centre, which provides products and services in the fields of geodesy, topography and cartography.

- Related to these issues, ANCPI drafted Rules of approval topographical plans, reception cadastral works and registration of rights in the land book records, approved by Order of the Director General of ANCPI no. 700/2014, hereinafter called Regulation, normative act that establishes work procedures on registration immovable properties in the integrated cadastre and land registry system, endorsement and acceptance of topographical plans and cadastral works.

- The regulating act, drawn up pursuant to Law no. 7/1996, currently subject to amendment and completion, is a regulatory and problems solving instrument of situations that been reported in the current activity of cadastre and land registry, constituting a guideline for specialized, staff in the regional offices, for collaborators as well notaries, legal or natural licenced suveyors, on the procedures and rules required to be complied with in the cadastre and land registry.

- Also related to ANCPI's rolle, as regulatory state institution, sole public authority in the fields of cartography, cadaster and real estate publicity, as well as the power conferred by art. 9 of Law no. 24/2000 to give note to normative acts which affect this area, to the authorities concerned in their implementation, depending on the purpose of the legislation, the National Agency will perform all the necessary steps for the modification of the regulatory framework incident to the field, namely the legislation on the construction, planning, civil law, commercial and mortgage-related legislation, etc., in order to eliminate conflicting rules and simplify the procedures for registration of buildings in the integrated cadaster and land register.

2. Current Issues identified in cadastral and land book activity and how to solve them

- In light of the above, showing the permanent concern of ANCPI to design and implement best practices in their activity, there have been identified, in order to solve to solve them out, problems that generate blocking situations to accelerating systematic registration of properties as well as their sporadic registration.

- Amending the Law no. 7/1996, the subsequent normative acts issued for its implementation and the regulatory framework in the field incident or the law relating to building, planning, civil law, commercial and mortgage-related legislation, etc., linked to taking necessary measures for human and material resource allocation to ensure implementation of the measures proposed below, constitutes means to address these problems and improve the cadastral and land registry work.

- The lines below will expose these issues and punctual necessary measures to be implemented in order to solve respective practical aspects identified as possible causes of some negative effects if optimal ways of solving shall not applied that involves clarification, harmonization, revisions and adjustments at strategic, institutional and legal level.

I. ISSUES RELATED TO CADASTRE COMPONENT:

1. Lack of cadastral documentation issuing procedures for registration of de ownership real rights on dismemberments established over a determined portion of the property registered in the land book, registration governed by art. 88 of the Regulation, in which case it is necessary, in order to ensure full enforceability of the right, to reflected in the wording of the cadastral documentation and of the attached graphical annex to the land book, which contains the description of the building, of the part of the building affected by dismemberment;

- WAY OF SOLVING:

- Develop a procedure for issuing the cadastral documentation dedicated to registration of ownership rights ' dismemberments established over a determined portion of the property registered in the land book, ensuring, by amending the e-Terra IT application, the taking over of the wording of cadastral documentation annexed to lad book, of the graphic description of part of the building affected by dismemberment, meaning that it will produce a PAD, accepted through the technical acceptance workflow without cadastral number assignment;

2. The need to settle additional criteria to be respected during preparation of cadastral documentation that concern construction registration in order to ensure

consistency between the reality on the ground and their legal situation, following to the lack from the building permits and the minutes of reception of sufficient evidence to give cadastre inspector the possibility to check compliance with the building permit, verification incumbent as reported to art. 37 Para. (5) of Law no. 50/1991, according to which "Constructions erected without building permits or in breach of its provisions, and for which have not been made the reception on completion of works, according to the law, shall be considered as finalized and cannot be tabulated in the land book."

- WAYS OF SOLVING:

- Completion of the provisions of the Regulation regarding compulsory attachment to the cadastral documentations whose subject is registration of construction, of the plans attached to the building permit, procedure which is applicable until the amendment of Law no. 7/1996 as proposed in paragraph 26 bis of Pl-x -131 / /2014, through which it is provisioned the modification of art.36, Para (1) of the Law, according to the following provisions "Ownership right of the building is registered in the land book under a attestation certificate provided by the local authority which is issuing the building permit confirming that the construction was erected according to building permit and minutes from completion of reception exist" . If this provision is approved, responsibility for certifying compliance with the provisions of the building permit to complete the construction will return to local authority issuing the permits, and the specialists from the regional offices will be relieved of such verification;

3. The lack of detailed rules governing the technical method of preparation of the fitting to the Tarla plans, regarding the determination of the limits of tarla respectively by measurement or by digitization;

- WAYS OF SOLVING:

- Completion of the provisions of the Regulation, by introducing digitization of cadastral measurements as an alternative method, used for determining the Tarla limits;

4. Omission of regulation for adjoining and detachment of individual units respectively apartments, despite the fact that special legislation provides so, and the issuance of permits for any kind of construction works, redevelopment, restructuring, etc.;

- WAYS OF SOLVING:

- Completion of the provisions of the Regulation, by expressly regulating and detailing procedure for the issuing of documentation on condominium and individual units or apartments, including the clarification of ways to draw up sketches and of reports and documents required to be submitted as justification for this operation, based on special legislation, namely art. 3 Para. (1) of Law no. 50/1991 which states the necessity of issuing permits for reconstruction, consolidation, modification, extension, rehabilitation, repair or change of destination, and the provisions of art. 648-659 of the Civil Code on co-ownership of the common parts of buildings with several floors or flats;

5. Failure to regulate the procedure for removal of the words: "immovable registered in a cadastral plan without proper shape and location" - notation which is designed to warn third parties on uncertain technical situation of the building, so that the absence of a provision establishing mandatory deletion of such note can generate negative consequences such as inability to access real estate loans and breach of the principle of legality of land book entries through reflection of an inaccurate situation on the technical state of the building;

- WAY OF SOLVING :

- Completion of the provisions of the Regulation, by the procedure for deletion of the words: " property registered in the cadastral plan without proper shape and location ", deletion that will be performed automatically on the basis of the note issued by the Cadastre Service of the OCPI stating that buildings no longer overlap in the electronic cadastral plan or the property was correctly located by repositioning, following the restoration of cadastral documentation by agreement or parties or by final judgment in this regard;

6. The failure to regulate the content of the required cadastral documentation for the reception of cartographic documents necessary for public use, although there are many requests in this regard;

- WAY OF SOLVING :

- Completion of Art. 275 of the Regulation with dispositions on the content of documentation for the reception cartographic documents intended for public use;

7. Need for detailing the contents of cadastral documentation issued in the application of art. 1051 par. (3) f) Code of Civil Procedure, which provide compulsoriness for the attachment at the request of usucapio submitted in court, by the plaintiff, of "the technical cadastre documentation of the real estate carried out (...) by a natural or legal person authorized by law"; and of which basis shall be ruled a sentence that ascertains the acquisition of property right;

- WAY OF SOLVING :

- Completing provisions of art. 76 para. (2) Of the Regulation with mentions that refer to the method of issuing, necessary supporting documents to be attached, the service code used to file the application and requirements to be met for acceptance of cadastral documentation drawn up in pursuance of art. 1051 par. (3) f) Code of Civil Procedure relating to adverse possession (usucapio), based on the need to ensure an uniform practice and to the fact that the approval procedure of judicial technical expertise, to which the present provision of the Regulation reffer, does not detail these aspects;

8. The need to regulate a simplified way of making parceling plans, needed to unlock particular situations identified both as sporadic registration and systematic

registration of properties, given the issuance of numerous land titles based on analog plans and the status of land inventory is carried out based on Law no. 165/2013 on completion of which will proceed to issue property titles to entitled persons on the basis of parceling plans;

- WAY OF SOLVING :
- Regulating a simplified procedure for making parcelling plans which provide for the possibility of drawing up documentation aimed for the reception of parceling plans based on analogue parceling plans in the archives of municipalities, converted into digital format and integrating data taken from surveys made by authorized persons for the purpose of issuing property titles on their basis;

9. The need for detailed rules of procedure applicable to buildings acquired in extravillan under the laws on property restitution, which passed in the intravillan (see art. 87 of the Regulation) following the approval of the PUZ, PUG, in relation to particular situations in which certain plots of an immovable or the entire immovable situated in a tarla have undergone transition to intravillan and where on such lands constructions have been erected;

- WAY OF SOLVING :
- Completion of Regulation by detailed rules to take into account situations where it is necessary or warranted the drawing up of plans for location in the tarla for buildings that have passed from extravillan to intravillan by punctual description of applicable procedure in terms of buildings fenced in whole or in part, placing the whole immovable or only some components in the intravillan, issuance of a building permit on a land that was located in extravillan, etc;

10. The need to clarify the concept and procedure for amending the buildings' limits, involving in most cases also a change in the immovable's area, by reference to the legal effects of such operations, which may involve impairment of essential attributes of ownership rights, such as the decrease of the area of land in favor of the neighboring building owner, which may be interpreted as a disguised sale;

- WAY OF SOLVING :
- The clear definition of the concept of amending the limits and of the applicable procedure in order to avoid possible confusion regarding the revision and repositioning of buildings for cases where such operations generate area changes, reported the provisions of art. 914 in Civil Code, which governs the amendment of the description of the building, according to which: "The property owner registered in the land book can demand in any moment changing notes contained by the land book regarding the description, destination, or building surface, according to the law.", and the establishment of percentages applicable to surface modifications that are generated by this operation;

11. The lack of a procedure to reposition the buildings from extravillan for situations where there is no parcelling plan;

- WAY OF SOLVING :
- Develop a procedure to reposition the buildings from extravillan, in the absence of parcelling plan in the respective tarla, which relate to the existence / non-existence in the database, of the geometry of the surrounding buildings, in which case the repositioning will follow common rules, being also necessary to detail the procedure for registration and repositioning of buildings from non-cooperativized zones, by regulation of alternative solutions for situations of unavailability or refusal of signing the neighborhood minutes by one of the owners of neighboring buildings, provided that the existing limit to be defined by fences or other natural landmarks easily identifiable.

12. Absence of regulations that address how to handle requests for registration of buildings located on lands that are affected by overlapping, land that had previously been registered in cadastral records based on cadastral documentation prepared in a local reference system, the overlap being ascertained during any type of cadastral documentation preparation in STEREO 1970 system. In this case, clarification of the legal situation of the property, belongs to courts of law, failing agreement of owners of affected neighboring buildings, but this should not affect the registration of ownership rights over construction for the scope of opposability against third parties, especially since the civil Code and Law no. 7/1996 defines the immovable as land with or without buildings;

- WAY OF SOLVING :
- In order to reflect the actual technical state of buildings affected by the overlapping, if registration request of buildings located on them, based on the definition of the immovable and on condition that these building should not be located on the part of the immovable that was affected by overlapping, cadastral documentation is receptioned by mentioning on the PAD the fact that the building is affected by overlapping, mention what will be done also in the land book;

13. The need for special regulations to eliminate the possibility of ruling a legal sentence regarding an immovable, which may not be based on a legal technical expertise approved by the competent territorial office, motivated by the fact that although the Regulation has provided in such cases the possibility to register the immovable in the land book , by appropriately mentioning the overlaps in order to eliminate the risk of formulating criminal complaints against staff involved in processing the application, such a solution does not clarify the legal situation of the immovable, but opens gate for a number of litigations that may relate bordering , corrections of land book entries, etc.;

- WAY OF SOLVING :
- In order to eliminate the risk of issuing court decisions on the immovables, which produce tabular effects containing errors in the immovable's description , and registered in the land book, Code of Civil Procedure

would require an amendment enforcing that expertise reports on real estate prepared xc1in judicial proceedings, to be approved by the competent territorial office. A similar solution should be emphasized in all court proceedings in which judicial decisions have an impact on land registry records. Also reported to the lengthy procedures to amend the Code of Civil Procedure, it is necessary to amend the provisions of art. 57 Para. (1-3) of GEO. 80/2013 regarding judicial stamp duties, in the sense of enforcing technical expertise necessary to draw up legal in all cases concerning property and tabular effect and in situations where buildings are registered in the land books court to consider cadastral documentation received by the territorial office with regard to the technical issues related to immovable;

14. The mandatory allocation of cadastral numbers to distinct portion of the property located in intravillan, respectively to the portion in extravillan of the same building, as there have been reported complaints about the cost of drawing up cadastral documentation for dismemberments, updating cadastral documentation and detachment ones, and in some cases there have been registered mortgage lenders refusing to accept the dismemberment of the building. Agreement of mortgage lenders is mandatory under the provisions of art. 879 Para. (3) of the Civil Code, stating: "The annexation or detachment of encumbered property cannot be done without the consent of the holders of those tasks";

- WAY OF SOLVING :

- In order to eliminate problems caused by costly procedure for updating the cadastral information of the buildings included in the integrated cadastre and land book system, followed by the dismemberment of the building if the buildings have been registered in the land book, crossed the demarcation line between the extravillan and intravillan reported also to the provisions of art. 47 Para. (2) of Law no. 350/2001, under which: "After approval by the local council decision of the PUG and PUZ, municipalities are obliged to submit the decision accompanied by documentation for PUG and PUZ approval to the Cadastre and Land Registration Office in view to update by default the destination of registered immovable in the integrated cadastre and land system " in conjunction with art. 481 Para. (2) of the same law, according to which: "The establishment of intravillan limits through general and zonal urbanistic plans will be made in relation to the development needs of communities within a certain administrative-territorial unit", provisions showing that intravillan limit is dynamic and urban planning special law stipulates the need to update the destination of immovables and not their dismemberment in view of the allocation of separate cadastral numbers, it is appreciated as useful to the repeal of paragraph (4) of Article 2 of Law no. 7/1996;

15. The need to clarify situations which require preparation of cadastral documentation on interrupted stream in pursuance of Article 131 Para (2) of the Regulation, in order to eliminate the possibilities of interpreting situations in which possession noting requires proper documentation, according to art. 40 Para. (7) of Law no. 7/1996 and the interpretation that these provisions are applicable or not to land books in the area of application of Decree Law no. 115/1938;

- WAY OF SOLVING :

- In order to eliminate the possibility of interpreting the situations in which one can draw on interrupted stream cadastral documentation for drawing up acts and certificates of inheritance or sharing documents based on possession exercised in the name of the owner or author of the succession, it is necessary to amend section 3 of the Cooperation Protocol no. 1404/2010, published in the Official Gazette no. 475 / 09.07.2010, concluded between ANCPI and UNNPR, meaning to expressly provide impossibility to make such legal acts in the area of application of Decree Law no. 115/1938, where has operated constitutive effect rights so that one cannot appreciate the inexistence of the title, as well as to update references to the text of the Law no. 7/1996

16. The need to clarify cases where it is necessary the issuance and annexation of urbanism certificate to the cadastral documentation to be subject of registration os condominiums, of individual units, etc, related to the regulatory framework;

- WAY OF SOLVING :

- Introducing clarifying rules to every type of cadastral documentation, or operation, stating expressly that the urbanism certificate ought to be attach a component part of the reception and registration documentation and that the person responsible in charge for verification of urbanism certificate relative to art. 29 Para. (2) of Law no. 350/2001, according to which: "Urbanism certificate should be issued for cadastral documentation on consolidation or dismemberment of at least three land parcels, where those operations concern apportioning or aggregations of plots required for the achievement of construction and infrastructure and the establishment of an easement of passage on an immovable. In the situation of property sale or purchase, planning certificate contains information on the legal consequences of the transaction, while requesting of urbanism certificate is optional when apportioning operations or amalgamations of parcels are subject to giving up joint property, unless the request is made for the purposes of the construction and / or infrastructure works. " ; Also, based on these provisions it is necessary to amend the text of the Law no. 350/2001, to expressly provide that entity has an obligation to check the issuing of urbanism certificate in these situations, respectively the notary public, executor, liquidator or specialized staff in the regional offices;

17. Lack of procedures to enable authorized natural and legal persons access to the information managed by the e-Terra information system, in view of download and uses them in the technical cadastral documentation.

- WAY OF SOLVING :
- In order to enable authorized natural and legal persons to access to the information managed by the e-Terra information system, to download and use them in the technical cadastral documentation, it has been developed a procedure which includes also an annex with terms and conditions, to be approved by Order of the Director General of ANCPI in application of Art. 3 Para. (6) of Law no. 7/1996, according to which: “Providing online cadastre and land book services can be made available to other interested natural and legal persons in accordance with procedures established by normative order of the Director General of the National Agency.”;

II. CURRENT ISSUES IN THE FIELD OF REAL ESTATE PUBLICITY:

1. The need for regulation at the level of detail of the procedure for registration of public or private buildings of state and territorial administrative units for situations where statements describing the building of the centralized inventory of goods in question, attested by the Government under the law or the Property Act such as expropriation decree does not correspond with reality on the ground, reported to the fact that the that enrollment in the land book of the immovable is seen as a prerequisite for the update of the Annex to the Government Decision no. 1705/2006 respectively of the inventory position where the property is found, are issues that have generated many difficulties in the proper administration and management of the state public domain;
- WAY OF SOLVING :
- To allow registration of ownership of immovable property belonging to the public domain of the state where their description in the centralized inventory does not correspond with the real situation on the ground, can be achieved based on the documents referred to in art. 40 Para. (5) of the Law, which can be filled in, to make up with inadequacies on the individualization of immovables, with a certificate issued by the legal representative of the State or public legal person who has the right to manage, use or lease on the building, certifying the identity between the property identified by the cadastral documentation with the one in the legal supporting document.

2. The elimination of the interpretation of the shape of the supporting documents, land registry operations and charges levied for the relocation of mortgage right as a result of its surrendering by any of the forms permitted by law such as novation, subrogation and assignment of debt guaranteed by mortgages ;
- WAY OF SOLVING:
- Reported to tabular effects of entries resulting from the preparation of legal documents which interferes subrogation, assignment of receivables secured by mortgages, novation by change of creditor, i.e. the requirement to mention the quality of mortgage lender person / entity who subrogee mortgage lender enrolled in part III of the land register, the three institutions should be treated similarly, both in terms of form of the supporting documents and in terms of the operation that is performed on the basis of such acts. In terms of seniority of entries, will be able to make appropriate entries in relation to the legal effects conferred by the Civil Code, that debtor to settle the obligation to the original creditor and the birth of another obligations to the new lender or conversion obligations in a new one. Therefore, amending the provisions of art. 36 Para. (19) - (25) of Law no. 7/1996, because the procedure for registration regarding these legal institutions be treated as one. As regards the form of legal acts that will be the basis for entry in the land register or request legal basis enabling authentic form, are mentioned provisions of art. 888 of the Civil Code which provide that: "Registration in the land book shall be based on the authentic notarial document, the final court decision, the certificate of inheritance or under another act issued by administrative authorities, in cases where the law provides as so.";

3. The need for regulation at the level of detail of the form of documents and modality of cadastral documentation issuing for first registration, respectively the cadastral documentation for dismemberments issued following the executor’s request in the process of foreclosure;
- WAY OF SOLVING :
- Regulation in the Collaboration Protocol between ANCPI and UNEJ, currently under issuing of a provision stating that:” In the situation provided by art. 845 Para. (3) Sentence II of the Code of Civil Procedure, the executor may request, on the basis of cadastral documentation, reception and land book registration of dismemberment in which case it is not necessary to establish authentic act of dismemberment. A document issued by the executor stating that the sale will be conducted separately for a specified part of the building shall represent the justificative act in order to register the dismemberment in the land book.” Also, to address issues arising from inability of the executor to obtain in all cases of property acts subject to prosecution under the debtor's property estate it was necessary to regulate the express exception to the rule of art. 28 Para. (1) Law no. 7/1996, as a supporting document of the registration application to be submitted in original or certified copy. In this regard, by Pl-x no. 131/2014 was proposed by UNEJ, to place par. (21) Art. 28 of the Law, as follows: "In the case of foreclosures, in the absence of original documents or certified copies, reception and registration application filed under Art. 828 Para. (2) Code of Civil Procedure may be accompanied by a copy of property deed certified by the issuing authority ". Also, pursuant to the Civil Procedure Code, which gives the executor possibility of requesting the establishment of the land book in the name of the debtor, in case of foreclosure the collaboration protocol between ANCPI and UNEJ still

under completion, is detailing component parts of cadastral documentation drawn up in this regard, as well as the necessary format of documents to be considered by the land book registrar, during the settlement of the claim;

4. Lack of correlation of dispositions of Regulation with the current provisions of the Code of Civil Procedure regarding registering rights of property acquired through adjudication, as a result of enforcement by the executor and explicit regulation of legal deeds necessary to erase the noting of levy of execution of the immovable and prohibitions of alienation and encumbrance of immovable, until full payment of the price and of appropriate interest as a result of adjudication of the building with the installment payment;

- WAY OF SOLVING :
- In order to eliminate inconsistencies between the Regulations and Code of Civil Procedure regarding entry that will be based on the adjudication document and the mentioning of document under which basis may be requested to erase interdictions and marking initiation of forced criminal pursuit, it is necessary to amend and complete the provisions of the Regulation, the way of mentioning that based on the adjudication deed will proceed to the intabulation of property rights and notation carried in ex-officio or upon request of an executor, following a forced pursuit start the will be made based document issued by the executor in that purpose;

5. Lack of regulations on how to intabulate property rights of immovablea acquired by former law partners, following the voluntary liquidation followed by the erasing of the company, in cases where the certificate issued by the Register of Commerce in accordance with art. 235 Para. (4) Law no. 31/1990 does not identify buildings with land registry data (art. 171 par. (1) of the Regulation);

- WAY OF SOLVING :
- Amendment of art. 235 Para. (4) Law no. 31/1990 Amendment of art. 235 Para. (4) of Law no. 31/1990 in the sense to complete text allowing the entry in the land book based on ascertaining certificate of the ownership of the distributed assets, noting that it is mandatory to identify the property by the confirmation of cadastral number and number of land book;

6. Need for delimitating cases of provisional registration of mortgage right from intabulation cases reported to Law no. 7/1996, the Civil Code and Law No. 190/1999 on mortgage ;

- WAY OF SOLVING :
- Defining cases of provisional registration of mortgage rights related to provisions of Law no. 7/1996, art. 898 pt. 1 Civil Code, according to which: “In addition to other cases provided by law, provisional registration in the land book will be required: (...) if the acquired real right (...) regards or burdens on a future construction” and provisions of art. 31 Para.(2) on Law on real estate mortgage no. 190/1999, according to which: „ Mortgage established under this law on a future good is registered in the land book if previously was noted the building permit " , can only be performed by amending and supplementing the provisions of Art. 176 paragraph (1) and (2) of the Regulation in the sense of precluding the need to drawing cadastral documentation in this case, noting that the building permit notation will be made provided the attachment to the application for registration of a document confirming accessing a loan for real estate investments, otherwise it would proceed to provisional registration of mortgage right, pursuant to the provisions of the Civil Code;

7. Lack of correlation of the provisions of Regulation to the ones of the Code of Criminal Procedure regarding the necessary documents for noting, respectively erasure of noting of the commencement of criminal action for an entry in the land book made by an offense under criminal law;

- WAY OF SOLVING :
- In order to correlate the special regulations on the matter with the provisions of art. 17 of the Criminal Procedure Code regarding the necessary documents needed for noting, respectively erasing noting of the commencement of criminal action for an entry in the land book by an offense under the criminal law should be amended and completed provisions of Art. 197 of the Regulation;

8. The need to regulate, at the level of detail of the aspects regarding the pricing of particular situations resulting from the conversion of land books to be assimilated to the first registration of the immovable in the integrated cadastral and land registry system, pursuant to art. 39 Para. (3) of Law no. 7/1996;

- WAY OF SOLVING :
- In terms of how to solve the different interpretations given in practice to the provisions of art. 79 Para. 1 of the Regulations is necessary to reconsider the proposal to introduce paragraphs (11) and (12) in relation to the provisions of art. II of Law no. 133/2012, according to which: "Until 31 December 2020, reception of cadastral documentation and opening of land books will be done according to provisions of Law no. 7/1996 republished, as amended and supplemented, with exemption from charges, ex officio or upon request of: ... b) of holders of real rights registered in the land books opened under Decree-Law no. 115/1938; ... " considering useful the proposal coming from OCPI Brasov, according to which are assimilated to the first registration in the integrated cadastre and land book system the cadastral number assignment and the opening of a new land book for the immovable registered into land books issued in accordance with Decree Law no. 115/1938, with the exception of condominiums which are subject of an updating regardless of the type and number of cadastral and land registry operations carried out in this regard .

9. Making more simple the procedures for systematic registration of real property in view to accelerate the registration process, the development of rules providing for exemptions from the regulatory situation concerning the sporadic registration of ownership;

- WAY OF SOLVING :
- Simplification of the systematic registration of immovable was envisaged by the draft amendment to Law no. 7/1996, included in the list of draft laws under debate in the Chamber of Deputies (PL-x no. 131/2014), which provides a series of regulations aimed at reducing costs borne by owners of buildings and to accelerate the procedure of systematic registration of property, consisting of regulations concerning:
- an exemption from direct and indirect taxes owed to the state / local budget in the process of systematic registration in order to speed up the systematic registration process and compliance with the free of charge nature of these works. Note that by GEO no. 6/2015 was abolished mandatory verification of payment of the tax on income from transfer of property, registrars being thus relieved of the responsibility of such checks. The reasoning behind this regulation was that the property registration is not required to be subject to checks for payment of such tax, which certifies the arguments made by ANCPI in the proposed deletion of this provision from the Fiscal Tax Code, which had the effect of making it impossible, unjustifiably, for the acquirer of an immovable, to enjoy his right, although the quality of taxpayer belonged to the one from whose patrimony the property rights were transferred.
- an introduction under national cadastre and land registry Program of co-financing for systematic registration carried on cadastral sectors, initiated by the administrative authorities as well as for systematic registration works started within the Project CESAR;
- streamlining the update of administrative-territorial units through a similar procedure to the one for setting limits. Correction / updating limits will only be carried by on the basis of ground measurements, which will ensure the principle of systematic registration, reflecting the reality on the ground and allow the urgent initiation of systematic registration.
- Also, by the new draft law on cadastre and real estate publicity, objective of the project "The property - the foundation for national and European policies", conducted with the participation of World Bank consultants, it is intended to promote simplified procedures for systematic registration of property.
- The new draft law on cadastre and real estate publicity has been designed in order to ensure transparency, to simplify systematic registration of property, the basic principle of this record being the massive registration of properties according to the reality on the ground, by focusing on public display.
- In this respect, the draft law includes a number of regulations referring to:
- a public information campaign, which makes public, inter alia, systematic works procedure, their benefits and the rights and obligations of property owners (holders of interests in land and property owners) during this work ;
- registration of land and construction according to the reality identified in the field in favor of their holders;
- registration of possession in fact using a simplified procedure that does not involve authentication procedures;
- procedure of debating the non-debated successions, when conducting systematic registration of immovables;
- a provisional registration of property rights in favor of holders who were issued certificates of ownership and minutes of reinstating of possession, in accordance with land laws;
- a quality control of information will be conducted by outsourcing reception works or by reception prior to the publication of technical documents by the specialists of functional compartments for systematic registration of immovables, established at the level of field offices and at headquarters level;
- a prior announcement on the public display of technical documents locally and centrally, that are published, for public information purposes, on how public display of technical documents of the cadastre is made, in a newspaper of wide circulation, in a local newspaper, at the headquarters of the local council, the local government's website and on the website of ANCPI;
- an extension of the duration of public display for technical documents from 30 days at present to 60 or even 90 days;
- enhancing of public display methods in order to ensure public information by posting at the headquarters of the local council or in another specially place appointed for that purpose by the mayor and on the website of the local public administration and centrally on the website which will be created by ANCPI for this purpose;
- eliminating the land book conclusion from the systematic registration process.

3. Conclusions

Generally the regulations implementing the main normative acts, as in this case the Regulation of approval topographical plans, reception cadastral works and registration of rights in the land book records, approved by Order of the Director General of ANCPI no. 700/2014, issued pursuant to Law No. 7 of cadastre and real estate publicity, shows the procedural rules of work that are in a constant change, as they have direct impact in practical work of both specialised staff in the cadastre and land registry offices, starting with clerks from the register, specialized cadastre inspectors, assistants registrars, registrars , and archive clerks as well as the main collaborators to the integrated cadastre and land book system respectively persons licensed by ANCPI / OCPI to execute works in the field of cadastre, geodesy, and surveying, public notaries, judicial executors, lawyers and even courts of law in some cases and on special procedures.

This paper proposes participation in public debate on the need to improve current regulations regarding cadastre and land registry, based on the requirements expressed by practitioners, who use these procedural rules in everyday life.

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Considerations on possibilities of quality control for geodetic instruments by metrological procedures applicable in the field

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Abstract
Quality control of geodetic instruments is one of the main objectives of geodetic metrology. Ideally, this control can be achieved in a metrology laboratory where most procedures can be applied in a unified manner. In the absence of such a metrology laboratory, quality control is a complex and difficult task, especially due to the lack of integration of the metrological measurement procedures. In this article, the authors present some considerations on possible solutions to such difficult problems.

Keywords
Geodetic metrology, electronic total stations, EDM (Electro-Optical Distance Measurements), quality control of instruments, geodetic calibration, geodetic testing, geodetic standards.

1. Introduction

According to DEX (The Explanatory Dictionary of the Romanian language) the metrology is: "Part of physics that deals with precise measurements, with the establishment of measurement units and measurements processes, etc. ; All the activities (legal and administrative) related to measurements, on standards, devices and measuring instruments and their oversight from economic standpoint" [1].
It is well known that geodesy includes a series of procedures which are based on physical and mathematical principles and methods. The geodetic instruments are complex electronic devices often being modular and to realize the quality control of these instruments returns to geodetic engineers who know the principles and how these tools work.

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In terms of metrology, the geodetic engineer has the following responsibilities:
a) The quality control of geodetic instruments
b) The optimal exploitation of geodetic instruments.
Both of these issues appear to be similar, but the differences between them are more substantial. Quality control of geodetic instruments (a) involves checking how the instruments respects tolerances provided by the manufacturers. Optimal exploitation of geodetic instruments (b) involves first finding the potential of the instruments (on each module) and then dealing with the procedures and methods that can achieve this potential. The optimal exploitation of geodetic instruments is often a neglected process wrongly considering that, once the instrument is controlled/checked and tolerances provided by manufacturers are respected, the metrology process ends here.
Unfortunately, things are not so simple. The two metrological directions are not independent but are correlated. The principles are the same in both metrological directions, some methods are the same and some different but similar. From this point of view it is difficult to draw a clear line between the two directions.
At first sight / approach, the quality control of the instruments seems to be a simpler task, more affordable than optimal exploitation, but this is not true. Both aspects of the calibration process have common fundamental principles and common application methods.
The quality control of geodetic instruments has two distinct phases:
1. The quality control process realized on the instrument purchase. It is an important stage and each engineer is responsible for checking how the instrument accuracy indicators are in tolerances - implicitly or explicitly provided by the manufacturer. The engineer must know the full meaning of specific terms, to know how to discern the technical data given in the technical manuals and to know the accuracy and precision

indicators interpretation of the instruments - listed by manufacturers. Once this information of the instrument is filtered, the engineer must be also familiar with its operating principles, its degree of complexity, how many module the instrument has and not least, to identify the metrological procedures and measurement methods that fit that instrument. In this respect, it is worth noting that some manufacturers make changes (from their point of view they are improvements) in the calibration processes, either in the software component or in the hardware component, and in some cases these changes are not at all documented [2].

2. Quality control performed periodically. This phase (executed repeatedly and periodically) is practically a metrological monitoring process. This phase is distinct from the monitoring conducted in the initial phase. In the initial phase are established specific values for the calibration constants, some of them taking the role of metrological references in the next stages. An example of this is the regular monitoring of the degree of wear of the quartz oscillator - that generate the carrier wave and then the fundamental frequency and implicitly the unit of distance in EDM devices (integrated -or not - in electronic total stations). In the first phase is established the scale constant (in fact establishing the degree of deviation of the fundamental frequency from the nominal value). In the next steps of monitoring, the scale constant is determined successively and periodically - the changes from the reference value reflecting directly deviations of the fundamental frequency from the initial frequency and hence from the nominal frequency..

In essence, the two phases of quality control (initial verification and regular monitoring) consist of the same metrological procedures and methods, following the same principles and also the same metrological arrangements.

2. Problematic

The two phases of quality control of instruments described in the previous section can be performed ideally in a geodetic metrology laboratory. A geodetic metrology laboratory is a laboratory specially built around the principles of classic metrology and geodetic metrology and can reproduce specific arrangements necessary for geodetic instruments calibration. Not every metrological laboratory is a geodetic laboratory - therefore it is not enough that it can provide horizontal or vertical references. A geodetic metrology lab is built so that it can resolve in an integrated way a complete series of metrological tests, suitable to as many geodetic instruments as possible.

The modern geodesy works with a diverse set of tools: theodolites classical and electronic theodolites, electronic total stations (modular instruments), specialized EDM instruments, distomats, classical and electronic levels, GNSS receivers, laser scanning systems, etc. If on these considerations is adding the fact that these tools are continuously improved we have a picture regarding the complexity of the quality control process for these tools.

The positive side is that a metrology geodetic lab well designed, well-implemented and well equipped, ensures, for most metrological tests (covering at least the basic modules), the following:

a) An integrated (and unitary) testing/calibration process. Most test and measurement procedures can be integrated in the same place, with minimal movement of the instrument that is checked.

b) Economy of resources involved. As a corollary to this unitary metrological approach - is that the measurement procedures can be achieved with a small number of operators (often a qualified person alone is enough), the costs being minimal.

c) Stable and controlled environment. A significant advantage of metrology laboratory is that it ensures stability in the environment of the testing process. Thus, a homogeneous medium (same atmospheric parameters at any point in the laboratory), a humidity control, lack of vibrations, no dust, etc. provide an optimal context when the measurement procedures are performed. This ensures also stability in the achieved results thus ensuring the metrology principle of reproducibility [3].

d) Accuracy. The most important aspect (linked to all others) is the criterion of precision and accuracy. A metrology laboratory provides simply superior accuracy in the diagnosis and calibration of geodetic instruments. Depending on its basic operating principle, a metrology laboratory allows similar or even superior accuracy of the interferometer. In a metrology laboratory is always respected a fundamental principle of metrology: the calibration reference must have at least an order of magnitude higher as precision and accuracy in relation to the size that is verified.

e) Minimum time. A complete calibration procedure is done in a minimal time, thus is obtained the maximum efficiency. Thus, by simulation the optical visa at infinity is instantly covered the entire measuring range of the instrument that is diagnosed. For example, the pointing errors (that participate both in measurements of distances but also in the angular measurements) are minimized in the metrology lab compared with those performed in the field [4]. Highlighting the energetic parallaxes of the beams emitted by an electronic total station with respect to the optical line of sight is made not only extremely accurate in a metrology laboratory but it is effectuated fir the entire measuring range of the instrument.

f) Unitary assembly. A metrology laboratory can (by its optical and mechanical arrangements) to solve problems that cannot be solved in the field (in some cases only partially). Some examples: testing and calibration of an instrument across its entire working range , checking the degree of perpendicularity between retro-reflective prism facets ("corner cube" prisms), monitoring of calibration constants for different work areas of the main axis of rotation of a theodolite / total electronic station (similar effect with the "precession" and "nutation" from astronomy) [5, 6] , the degree of flatness of a surface, the degree of parallelism and perpendicularity of the two or more surfaces, etc.

In contrast to the above mentioned, the field procedures suffer some obvious limitations:

a) Difficulties in ensuring a stable environment for testing / calibration. The presence of vibrations generated either by wind or natural phenomena (expansion / contraction caused by temperature variations) or artificial (passing trucks, subway, etc.) can affect the test / calibration to the point that is unusable. In addition, the residual errors in the detection of changes in air temperature degrades the accuracy of determining the calibration constants.
b) The compliance with the measurement principles can be slow and sometimes incomplete. For example, the calibration of an instrument is indicated to be in the entire work range of that instrument for the measured quantity. In the field procedures, this is extremely difficult and sometimes impossible, the operator is forced to resort to interpolations and extrapolations that generate additional errors in the calibration process.
c) Resources involved. Due to the lack of a unitary and integrated context for calibration, field procedures require the presence of additional operators. An optimal communication between them is necessary (walkie-talkie type systems). The metrological arrangements that respect the metrological principles are often implemented on the ground by several tripods with the associated adapters. They are heavy, difficult to handle and requires additional time in changing their location.
d) Failure to conduct complete measurement procedures or complete calibration procedures. The field procedures cannot check - for example - prism retro reflectors (degree of squareness of its facets) or cannot generate the verification reference planes for rotating levels. Certain procedures cannot be successfully implemented completely (only partially) in the field - such as checking of energetic parallax of the *EDM* line relative to the optical line of sight to some electronic total stations (the *EDM* beam passing through a horizontal slot, probably for constructive reasons). The angular deviation of *EDM* line from the line of sight can be determined in these cases only partially: through the horizontal component. For the electronic total stations that do not have this limitation, the field procedures determines the angular deviation of the *EDM* lines in both directions (horizontal and vertical), the calibration being completely from this point of view.

It is worth mentioning that there are situations (rare indeed) when field procedures allow calibrations that cannot be achieved without the help of a metrology laboratory (or it cannot be made at all).

In this regard, the scale constant for *EDM* devices cannot be determined easily in metrology laboratory. Discrimination of such a constant can be applied only on long alignments (over 500m or even 1Km). These are difficult to implement in metrology laboratories. There are solutions to this kind of problem, in that the *EDM* beam is deflected on various routes using mirrors that generate optical paths of several hundred meters. These solutions, however, are expensive and require additional space in the metrology lab.

Another disadvantage of a metrology laboratory (and an advantage of field procedures) is that it (metrology lab) is not always available. Field procedures, with all its disadvantages, are available to every operator. Even if the optimum exploitation of the geodetic instruments can be achieved only in favorable conditions, the quality control can be easily solved, being reachable for everyone who is well acquainted with the field procedures.

3. Field procedures – viable solutions in the absence of a metrology laboratory

Developing a complete standard for on-field verification of the geodetic instruments is a difficult task [7]. The difficulty lies in the complexity of surveying instruments and their quick evolution. It is estimated that the electronics domain progresses at a stunning rate: the performances double every 6 months. This progress in electronics is reflected visibly into geodetic instruments. Thus new facilities are implemented in electronic total stations, *GNSS* receivers and laser scanning systems.

Fortunately, many of these facilities are modular, allowing a modular metrology treatment for geodetic instruments. An electronic total station can be analyzed independently from a metrological perspective for each of its modules:

a) The angular module. This module is the electronic theodolite incorporated in the electronic total station. The module can be treated as a normal classic or electronic theodolite, for which all the metrological procedures are valid. Unfortunately, the electronic evolution of the geodetic instruments comes with several challenges. It is worth mentioning the fact that some electronic total stations [2] have implemented in their calibration software procedures a new way of computing the calibration constants – the incremental mode. This computing method comes with its advantages but the negative side is given by the lack of adequate documentation for this approach. In the technical book of this instrument this incremented computing method is not even mentioned [2].

b) The *EDM* module. The distance measuring device that is incorporated on each electronic total station can be treated as a separate module. Thus, a specialized *EDM* instrument (not measuring angles) or an electronic total station can be treated similarly in terms of metrology. It's worth mentioning that in the case of electronic total stations with reflectorless facilities, the *EDM* lines (infrared and reflectorless) are distinct and so these should be treated separately from a metrological point of view. Moreover, the whole *EDM* system includes the whole instrument-reflector assembly and so it must be entirely analyzed from a metrological perspective (including the reflection system, whether it is given by the optical prism or reflective surfaces).
c) The centering module. Whether the centering is performed optical or through laser, the metrological approach is the same.
d) The leveling module. It usually consists of two devices: a circular level which is mechanical or circular level coupled with an electronic compensator (playing the dual role of electronic levelling and mathematically processing the residual levelling errors of the instrument). The metrological approach is again the same: a homogenous one by comparison with a vertical reference (geometric or optical).
e) The laser guidance module
f) The automatic prism search module
g) The automatic prism tracking module
h) etc.

If the first 4 devices in the above list are found in most of the electronic total stations, the following modules are modern electronic facilities existing only in electronic stations from the top range of each instrument manufacturer. Each facility must be treated separately in terms of metrology. The main advantage, from a metrological point of view, derived from this modular approach is that metrology procedures (on field or laboratory) can be set up to treat each module individually. When a new module is emerged the related metrology procedures will be added to the existing set of procedures. By using this approach the entire process becomes one with successive improvements (updates approach).

Within the specialized team inside the Faculty of Geodesy from Bucharest and with the help of students (working on their bachelor's degree) a series of metrology on-field procedures have been developed which can solve most of the problems - that until now could be solved only inside a metrology laboratory:

a) Finding the resolution power of an *EDM* device that works with infrared and, respectively, visible light (*EDM* specialized tools, electronic total stations).
b) Computing the resolution power of a reflectorless *EDM* device (laser distance meter, *EDM* instruments, electronic total stations, laser scanning system).
c) Computation of the resolution power of the angular device (classic theodolite, electronic total station)
d) Computing the parallax of the energetic *IR* beam (or visible light beam) of the *EDM* devices inside the electronic total stations – in relation to the optical line of sight.
e) Computing the parallax of the energetic reflectorless beam of the *EDM* devices inside the electronic total stations – in relation to the optical line of sight.
f) Computing the parallax of the energetic beam determined by the laser guidance system inside the electronic total stations – in relation to the optical line of sight.
g) Estimating cyclical errors for *EDM* devices by assessing residual errors (obtained through specific procedures) of the additional constant.
h) Computing the scale errors of *EDM* devices using eccentric distance measurements.
i) Computing additional constants for various reflective surfaces depending on the chemical composition of the materials from which these surfaces are made.
j) Finding the precision and accuracy functions and work range for the *EDM* devices using *IR* and visible light
k) Finding the precision and accuracy functions and work range for the *EDM* devices using *IR* and visible light – depending on the distance measurement modes
l) Finding the precision and accuracy functions and work range – for *EDM* Reflectorless devices – depending on the reflectivity degree of the reflective surfaces (actually depending on the color of the reflected surface)
m) Finding the precision and accuracy functions and work range for *EDM* reflectorless devices depending on the distance measurements modes
n) Establishing the degree of correlation between angular and *EDM* devices for electronic total stations
o) Computing relatively the additional constants for different retro-reflector systems (even from different manufacturers)
p) etc.

All these new procedures are added to the existing metrology procedures included in the metrology standards (*EDM* device checking through optical-mechanical alignments, checking the angular device through the "series method", checking leveling instruments through geometric configurations etc.).

As it was already mentioned, the geodetic metrology procedures are in continuous development, in order to keep up with the developments implemented by geodetic instruments manufacturers. Depending on the available resources, the professor titular of geodetic metrology disciplines from the Faculty of Geodesy from Bucharest will aim to complete the set of on-field metrology procedures to offer their students the best training in dealing with such problems.

Unfortunately, field procedures, no matter how well thought and well implemented, cannot replace in certain situations laboratory procedures. To illustrate this idea, the procedural difference in determining the energetic parallax of the *EDM* beam, in relation with the optical line of sight will be presented further.

Inside the geodetic metrology laboratory, the angular deviation of the energetic *EDM* beam line from the optical line of sight can be obtained unitary, based on the detected linear components *x* and *y* (measured through the rectangular projection of the eccentricity vector) from the center of the energetic beam – in the coordinate system of the optical calibration system. This process is illustrated in Fig. 1.

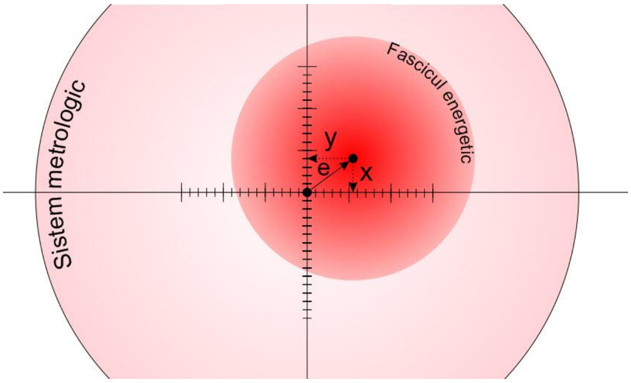

Fig. 1: Visual and analytical inspection of the energetic parallax of the EDM beam relative to the optical line of sight – the case of geodetic metrology laboratory.

Inside the field procedures, the angular deviation of the energetic *EDM* beam is obtained differently: computed through measurements of the angular eccentricity components (under which the linear segments *x* and *y* can be observed) towards the edge of the energetic beam, from which the total angular deviation can be deducted (Fig. 2).

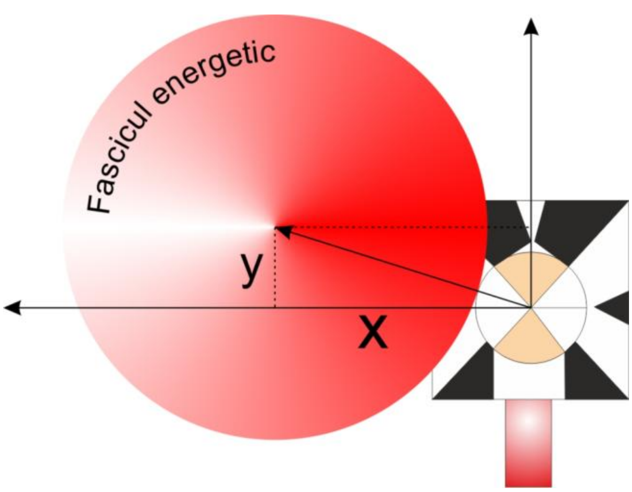

Fig. 2: Detecting the energetic parallax of a *EDM* beam with respect to the optical line of sight – the on-field procedure case

The on-field procedure allows obtaining the parallax value with accuracy – a similar statistically accuracy with the laboratory procedure. However, for some electronic total stations there are certain restrictions imposed by the manufacturers. These restrictions are probably imposed constructively, but from a metrological point of view these restrictions significantly affect the calibration process conducted on field.

Such a restriction refers to the fact that although the *EDM* signal is constructively emitted in a conical shape, it reaches the retro-reflective system (or the target for reflectorless) in a restricted form (truncated in its shape).

In Fig. 3, a projection of an *EDM* signal on a panel is shown (as it exists in a conical shape), the signal being constructively unrestricted by the instrument manufacturers.

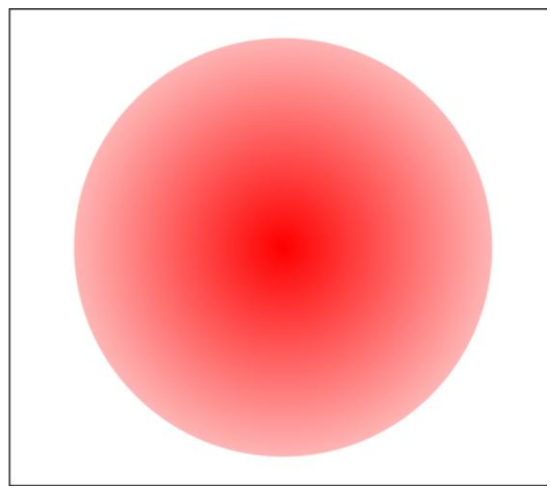

Fig. 3: The unrestricted projection of an EDM signal on a panel (the case for most of the EDM instruments and the electronic total stations)

Fig. 4 shows the projection of the *EDM* signal in a restricted form, as seen in some electronic total stations. The *EDM* signal most probably goes through a rectangular shaped slot before leaving the *EDM* instrument or the electronic total station.

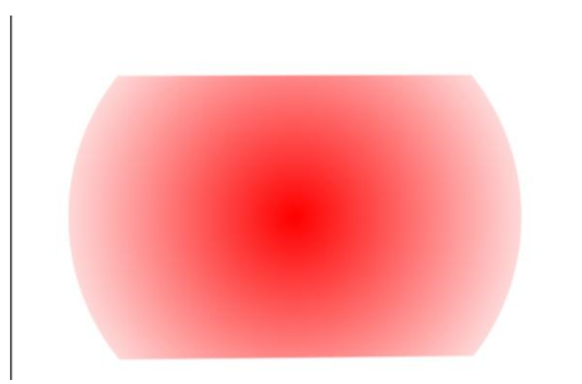

Fig. 4: The restricted projection on a panel of the EDM signal (case found on some of the electronic total stations)

It is not exactly known which of the most utilized electronic total station exhibits such a restriction as presented in Figure 4. In the near future, all the electronic total station owned by the Faculty of Geodesy from Bucharest will go through a metrology testing process and then more conclusions can be drawn. Also, it is unclear if these kind of restrictions is imposed only by one of the manufacturers or by more of them. The future will be able to answer this question also. What can be clearly observed is that the on-field metrological procedure for checking the energetic parallax of the *EDM* beam with respect to the optical line of sight is hindered to the point in which this can be achieved only partially. In these cases (hopefully more rarely), the on field metrology procedures reach their limits, the only appropriate solutions being provided by the geodetic metrology laboratory.

4. Conclusions

The geodetic metrology laboratory represents the optimal solution, solving most of the problems that come up in the calibration process. This laboratory provides (in relation to the on-field procedures) accuracy, a stable environment, reproducible results, savings in the human and financial resources involved and a minimal calibration time (provided by the unitary aspect of the calibration procedures). There are a few problems that cannot be solved in a metrology laboratory and also the issue of the implementation and administration costs of such a laboratory. Overall though, the metrology laboratory represents a necessity both at a national level as well as locally.

The on-field metrology procedures have the advantage of being easily implemented and with minimal costs but the resources involved and the execution time are significant. In addition, the metrological conditions are difficult to achieve, the precision and accuracy of the calibration process depends on external factors, and sometimes the on field procedures cannot solve certain stages of calibration.

Studying the advantages and disadvantages of the two methods of calibration (the laboratory procedures and the on-field procedures) it becomes clear that a smart combination of the two methods is the optimal solution. Hence the need to have both (supplied or available): a geodetic metrology laboratory and the necessity to be acquainted with the main on-field metrological procedures. In the quality control of the instruments (both in the purchase and the metrological monitoring phase), both solutions (laboratory and field procedures) are viable. If these solutions are used in tandem then the metrological calibration process becomes optimal.

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