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

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Received: April 2015 / Accepted: September 2015 / Published: Iune 2016

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.

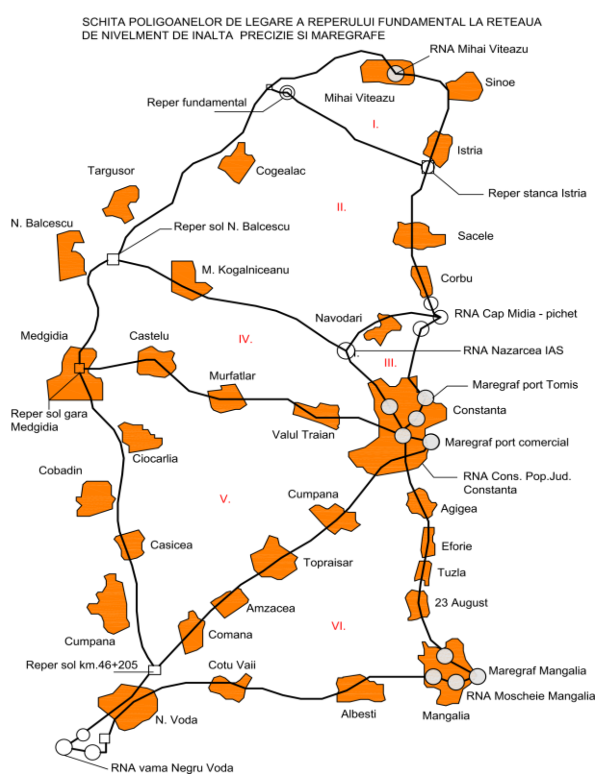

Fig. 1 Tide Gauges Polygon

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.

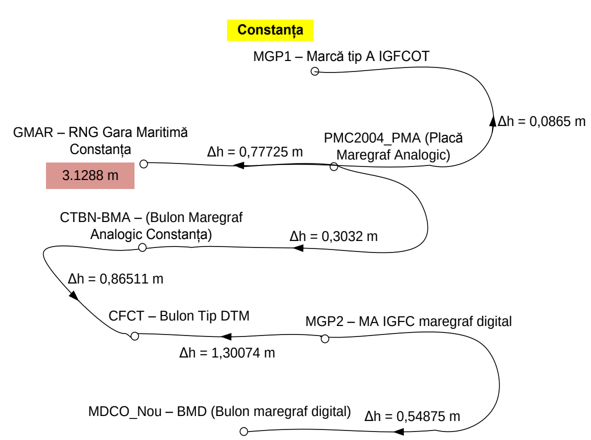

Fig. 3 Geometric leveling route realized in 2013

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.
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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.

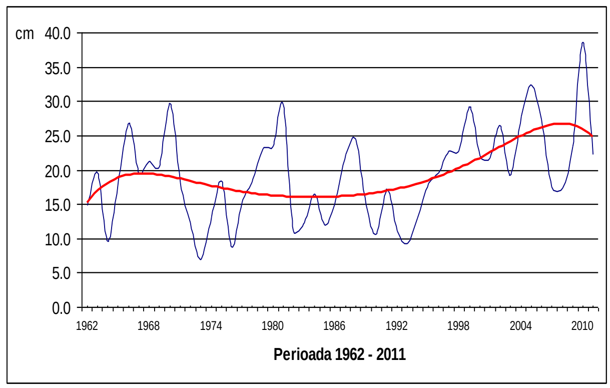

Fig. 5 Sea level changes recorded in Tide Gauges Constanta in January 1962 - December 2011 (annual average)

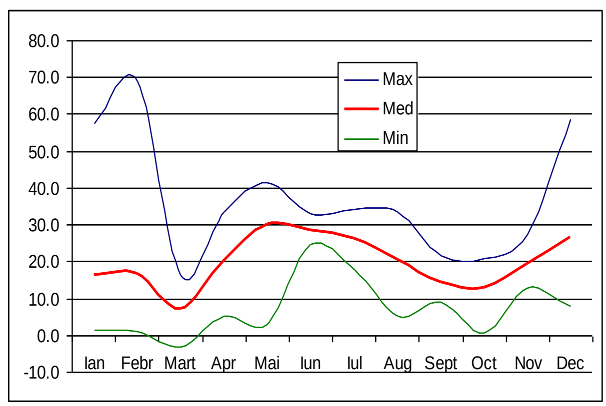

Fig. 6 Sea level changes recorded in Tide Gauges Constanta in year 2012

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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