DRAFTING THE TOPOGRAPHIC AND BATHYMETRIC STUDY FOR DESIGNING THE INVESTMENTS OBJECT LACUSTRIAN TOWN ON SIUTGHIOL LAKE, MAMAIA

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***Abstract**: In order to encourage investments in the Romanian seaside resorts, tourist development projects must be elaborated. These projects are used for the creation, development and modernization of the tourism infrastructure, for the use of the natural resources and the increase in the quality of tourist services.*
This topographic and bathymetric study was executed at the request of the Constanta City Hall and is aimed at offering bathymetric information for the design of the investment project: Lacustrian town on Lake Siutghiol, Mamaia.

***Keywords**: regional tourism development project, bathymetry, topographic and bathymetric study.*

1. Introduction

Constanta City is located in Constanta County, in the southeastern extremity of Romania, on the Black Sea shore. Mamaia resort is located at the city’s north boundary. Mamaia is characterized by its beach spread on 8 km, having a width of almost 100 m, as well as by the fact that the hotels are very close to the beach.

Located in the western part of Mamaia resort, Siutghiol Lake has an area of 1,900 ha, a length of 7.5 km and a width of 2.5 km (Figure 1).

Figure 1. Siutghiol Lake, Constanta (Google Earth, 2009)

The resort's tourism potential is very high because, from a geographical point of view, Mamaia offers what no other resort does: lake and sea in one place.

In order to develop the area's tourism sector and in particular for increasing the tourism attractiveness of Mamaia resort (Figure 2), a series of projects have been proposed among which

- Developing and modernizing the water sports entertainment facilities:
  - Mamaia pedestrian footbridge and marina;
  - Pescarie marina;
  - Tomis marina;
  - Tomis Riviera – modern access road to Mamaia resort and the historical center of Constanta City;
- Rehabilitating the hydrotechnical system for protecting the beaches and fighting the erosion process
  - arranging seven artificial entertainment islands (three in Constanta area, along the Black Sea shore, and four in the Mamaia resort area);
- Increasing the tourism activity of Siutghiol and Tabacariei Lakes:
  - cleaning and dragging Tabacariei Lake;
  - arranging a navigable connection between Siutghiol Lake and Tabacarie Lake;
  - arranging a "sea lock" between Siutghiol Lake and Black Sea;
  - arranging a "Lacustrian Town" on Siutghiol Lake;
  - water ski-lift on Siutghiol Lake;
  - arranging new water sports entertainment units on Siutghiol and Tabacariei Lake;
- Rehabilitating the peninsula area.

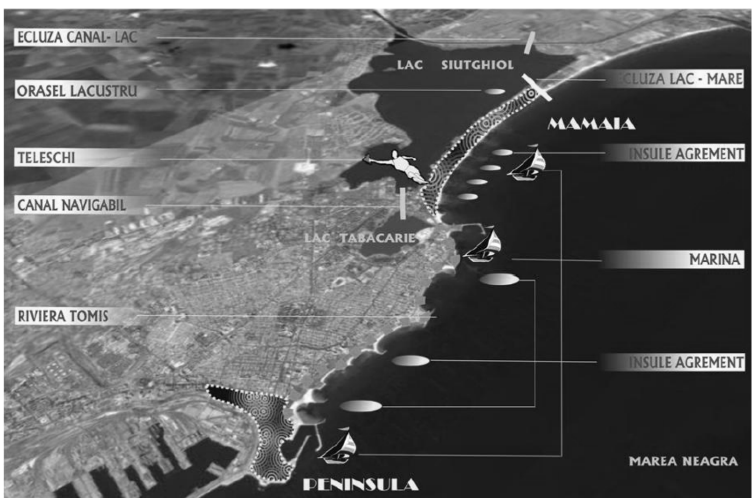


Figure. 2 Urban regeneration projects that support the tourism development

2. Geodesic references

Considering the devices used for performing the measurements, two projection systems were used that would supply maximum identification precision according to the location specific. For the two systems, transcalculation parameters were determined, thus for the study results to be represented in any of the projection systems:

- Stereographic 1970 on a single secant plan;
- Universal Transversal Mercator, area 35, ellipsoid WGS84.

2.1 Support grid sketch

Five points placed on the bank of Siutghiol Lake have been chosen. They have been materialized in concrete bollards and metallic bolts embedded in concrete. These points are part of different support grids (Ovidiu separation grid, Constanta City grid, grid for lining out ducts for removing wastewaters to the sea). The criteria for choosing these points are

- adequate materialization;
- perimeter placement of locations, mainly near banks.

The points chosen are the following (Figure 3):

- PALAZU_N – bollard located on the highest cliff point – Palazu Commune;
- ONCGC_93 – bollard located between CDMN and the lake's north bank;
- IGCFC NEPTUN – bolt on the foot bridge from Neptun Coffee shop;
- IGCFC TIC_TAC – bolt on the foot bridge from Tic – Tac Coffee shop;
- BORNA_DEAL – bollard near the fishmonger, located on the highest point

For determining the coordinates, static and RTK regime GPS measurements were performed, as well DGPS measurements in Omnisar HP regime.

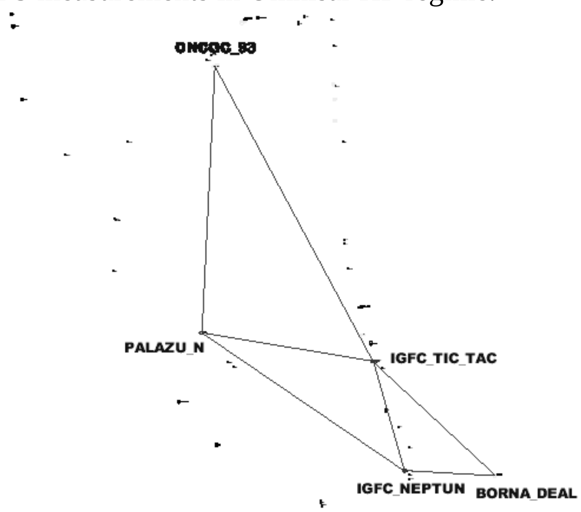


Figure 3. Support grid sketch

2.2 Projection systems

2.2.1. STEREO 70 projection system

This system is the national standard and it is necessary for acquiring the endorsements and authorizations necessary for the investment. The hydrographical measurements, given the type of equipments used, have been made in a projection system specific to the positioning system with GPS satellites. The data measures with GPS techniques have been transcalculated in the national stereographic projection system 1970 (table 1).

Inventory of coordinates in stereographic 1970 Table 1

Point name	North	East
BORNA_DEAL	308679.09	791301.67
IGFC_NEPTUN	308745.78	789927.95
IGFC_TIC_TAC	310407.72	789444.38
PALAZU_N	310851.85	786843.69
ONCGC_93	314868.76	787042.16

2.2.2. UNIVERSAL TRANSVERSAL MERCATOR projection system, area 35 ellipsoid WGS84

For performing the hydrographical measurements, a GPS L1/L2 Wide Area Differential GPS receiver was used, with a plan accuracy of 10 cm 95% CEP in Omnistar HP differential correction regime.

For determining the transcalculation parameters between the local system and the UTM projection system, GPS static determinations have been made with the Omnistar 5 receiver, in 5 predetermined points of the support grid (table 2):

Inventory of coordinates in UTM system area 35 Table 2

Point name	North	East
BORNA_DEAL	4897492.49	631360.67
IGFC_NEPTUN	4897593.33	629990.06
IGFC_TIC_TAC	4899265.94	629548.69
PALAZU_N	4899774.58	626961.84
ONCGC_93	4903782.99	627260.24

2.3 Reference system for quotas

The national standard imposes the use of the Black Sea 1975 reference system. However, on the Danube, the historical reference system is Black Sea Sulina, and the points of the state geodesic grid are determined in Baltic Sea system.

Romanian Waters National Company has installed two hydrographical leveling rods: at Neptun wharf and in the North area of the lake. Because finding the relation between “zero” leveling rod and one of the reference systems above was unsuccessful, two metallic bolts embedded in concrete have been used to achieving connection to the reference system at the following quotas:

- IGCFC_NEPTUN point located on the foot bridge of Neptun wharf;
- IGCFC_TIC_TAC point located on the foot bridge of Tic Tac wharf, quota 2.559.

The quotas are supplied in Black Sea 1975 system.

2.4 Staff, devices and software

The authorized staff has made the topographic measurements by using the following equipments:

- GPS RTK GNSS TRIMBLE R8 L1/L2/L5 system (Figure 4, a);
- DGPS Omnistar HP8300 (chipset Novatel L1/L2/Lband) system, Omnistar HP correction subscription (Figure 4, b).

Processing the data gathered with the total station and the GPS systems has been made with the use of several software developed by S.C. Insert S.R.L. and the Trimble Total Control software.

(a)

(b)

Figure 4. Devices used for gathering field data

2.5. Topographical plan

For filling in the layouts, the results in the measurements performed in 2004 in this area have been used.

The topographical plan is drafted in digital form (AutoCAD 2002) and comprises the following layers:

- TOPO_LINII: contour lines of the planimetric elements;
- TOPO_CONSTRUCTII: contour of the constructions;
- TOPO_HIDRANT- hydrants;
- TOPO_LAMPADAR – lamp posts;
- TOPO_MAL – contour of the bank;
- TOPO_POMI – trees area;
- TOPO_STUF – contour of reed;
- TOPO_TXT – explanations.

The layouts are drafted in the projection system STEREOGRAPHIC 1970 and comprise only the planimetric elements corresponding to year 2004.

After setting out the location solution, the topographical plan may be updated in order to be used for acquiring the endorsements and authorizations.

3. Hydrographical works

3.1 Overview

Hydrography is the science of measuring, describing and mapping the surface waters and shores. Hydrography is, in fact, the science of “sea geography”. It includes the procurement of field data, pro-processing (processing them in order to simplify and eliminate errors) and post-processing data (modeling and mapping the lands located under water). Hydrography may be considered similar to topography, except for the fact that in this case, topography cannot see the point whose quota it determines and it cannot identify its position by the classic methods.

The classic techniques assumed the determination of water depth with the help of a manual graded probe (lead thread principle) and the determination of a point in which the depth is measured by the help of the sextant or of the theodolite.

Modern hydrography uses ultrasound for determining the depth and the global positioning system by satellites for identifying the position of the points where depth determination is made.

For the hydrographical studies in Siutgiol Lake, only the modern hydrography principles have been applied, thus insuring that the requirements in international hydrographic standards (norms of IHO - International Hydrographic Organization) on precision and plan positioning, for determining depths and the cover degree with measurements of areas investigated corresponding to lakes, are met.

By the methodology used was insured a plan positioning precision of 10 cm, a depths determination precision of 10 cm and two cover degrees with measurements:

- paths perpendicular to the bank with an equidistance of 5 -10 m;
- paths parallel with the bank with an equidistance of 5-10 m.

3.2 Devices and software

3.2.1. Boat

For traveling the paths, an outboard motorboat was used endowed with a device for mounting the ultrasound transducer in metacentre (Figure 5).

Figure 5. Boat

3.2.2. Plan positioning systems

For determining the position of a moving target (ultrasound transducer mounted on the motorboat), GPS (Global Positioning System) receivers were used, Wide Area DGPS type (differential correction of great distance position), Novatel OEM 4 LbPlus L1/L2 make, HP 8300 type (Figure 6). In order to insure the position determination precision (that in the simple GPS receivers is 5-15 m), differential correction services supplied by the L-Band Omnistar satellites network have been used. The receiver used is part of Real Time Cinematic DGPS class – supplies in real time the position of a moving target, , with decimetric precision, according to the RTCM corrections applied to a moving GPS receiver.

Figure 6. Novatel OEM 4 LbPlus L1/L2, tipul HP 8300

3.2.3. Depths measurement systems

Determining the depth upon relying on ultrasounds assumes mounting in water (at a predetermined draught) a transducer that sends ultrasounds. The hydrographical probe gathers data on the propagation time of sound in water from the transducer to the bottom of the lake and back, according to celerity (speed of sound in water) and supplies the distance from the transducer to the underwater obstacle. The water depth as against the level at the measurement time is the sum between the transducer draught and the distance supplied by the probe.

The following have been used:

- ultrasound transducer for measuring depths, propagation cone 7 degrees, frequency 200Mhz;
- ODOM HYDROGRAPHICS, HYDROTRACK type hydrographical probe (Figure 7).

Figure. 7 ODOM HYDROGRAPHICS, HYDROTRACK type hydrographical probe

3.2.4. Calculus technique and software

The following were used:

- portable calculator having multiple interfaces and powered by car batteries;
- computer assisted navigation software and software for real time acquisition of position and depth of a moving target on water;
- software for processing hydrographical data;
- software for digital terrain modeling;
- computer assisted drawing software (AutoCad).

3.2.5. Coordinates system. Transcalculation

Usually, a GPS receiver supplies geographical coordinates as against the WGS84 ellipsoid. In order to insure the synchronization between the GPS signals and the ultrasound signals, as well as for storing the hydrographical data for a subsequent processing, during navigation the data concerning the position are stored in Latitude and Longitude WGS84 ellipsoid form, computer time. And the real time display of a moving target on the computer monitor (GPS terrestrial located on the ultrasound transducer vertical) is made by using a projection system specific to navigation, this being Universal Transversal Mercator projection, 6 degree axle, area 35.

After the preliminary processing of hydrographical data, the UTM 35 Cartesian coordinates have been transcalculated in the coordinates of STEREO 70 system.

For setting out the transcalculation parameters, a 5-point number in the measurements network was chosen.

3.2.6. Determining the lake water level

For the hydrographical measurements, the ultrasound probe supplies the depth from the water surface to the terrain located beneath the water (or from the depth where the transducer is mounted, considering the draught).

In the hydrographical works, the materialization manner is usually the hydrographical leveling rod, mounted with a given offset as against the reference level.

For the navigation plans, on the plan will be written the depth (positive value) as against a reference level.

For the topographical and hydrographical plans, on the plan will be inscribed the terrain quota as against a quotas reference system.

Terrain quota = leveling rod offset as against the reference system + water surface quota read at the leveling rod – measured depth

For Siutghiol Lake, hydrographical leveling rods have not been used for determining the water level. The water quota was measured by direct reading with the total station of the level difference between a known quota point and the water surface.

On the measurements date, the water quota was +1.66 m in the chosen quotas reference system.

Examples:

- point with 3 m measured depth at a water level of + 1.00 m
  measured point quota = 1.00 – 3.00= - 2.00 m;
- point read on the plan, quota – 4.00 for a water level of + 1.50 m
  depth = 1.50 - (- 4.00) = 5.50 m.

3.2.7. Performing the hydrographical measurements

Before each measurements set, the propagation speed of sound in water was determined (correlating the depth read with the ultrasound probe with the depth measured with the graded probe). Measurements were made only in the days with favorable weather conditions (no precipitations, no strong wind). The water surface quota was read with the total station before the measurements.

The measurement method assumes traveling the pre-set out paths (navigation map) by the boat having adequate endowments.

During the navigation, the following are acquired in real time:

- successive positions of GPS terrestrial, with a given frequency (the 1 Hz frequency was used - 1 position /second);
- successive values of depth between two known coordinate positions (in average, 10 values per second at a motorboat speed of 2 - 3 m / s).

The data are displayed in real time on the computer monitor and are stored in raw data files (gross field data).

The measurement paths (Figure 8) have been planned thus

- near the bank with a density of 5m;
- in the remaining area of the rectangular grid with meshes of 10 - 20 m.

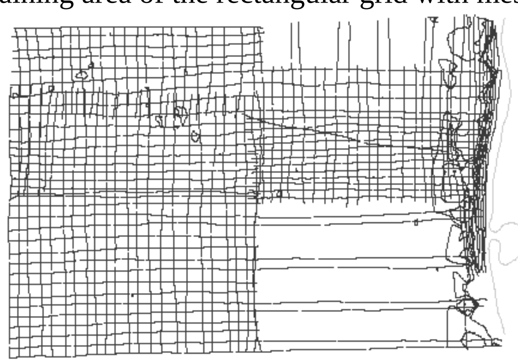


Figure 8 Paths of hydrographical measurements achieved

4. Processing data and digital modeling

RAWDATA – primary hydrographical data have been processed as it follows:

- eliminating the false signals due to air bubbles (spikes);
- diminishing the insignificant points (only the breaking points of the spread profile are kept);
- eliminating the redundant points (identical depths located at near points in the plan);
- data suppression (keeping only the significant data) in order to be represented graphically at different scales.

The points radiating to the terrain have been integrated in a “break lines” grid.

It was possible to inscribe the measured and filtered data in the plan as three-dimensional points (X, Y, Z data cloud) using the Autocad software.

According to the points cloud, a triangles grid was sketched by default (using a software developed by S.C. Insert S.R.L.) using the Delauney method, thus obtaining the digital model of the terrain DTM (Digital Terrain Model).

DTM is a structure of coherent knots and sides, separated by an exterior boundary and possible interior islands that allow interpolation in order to section it with vertical plans (cross and longitudinal profiles) and with horizontal plans (level curves, isobaths).

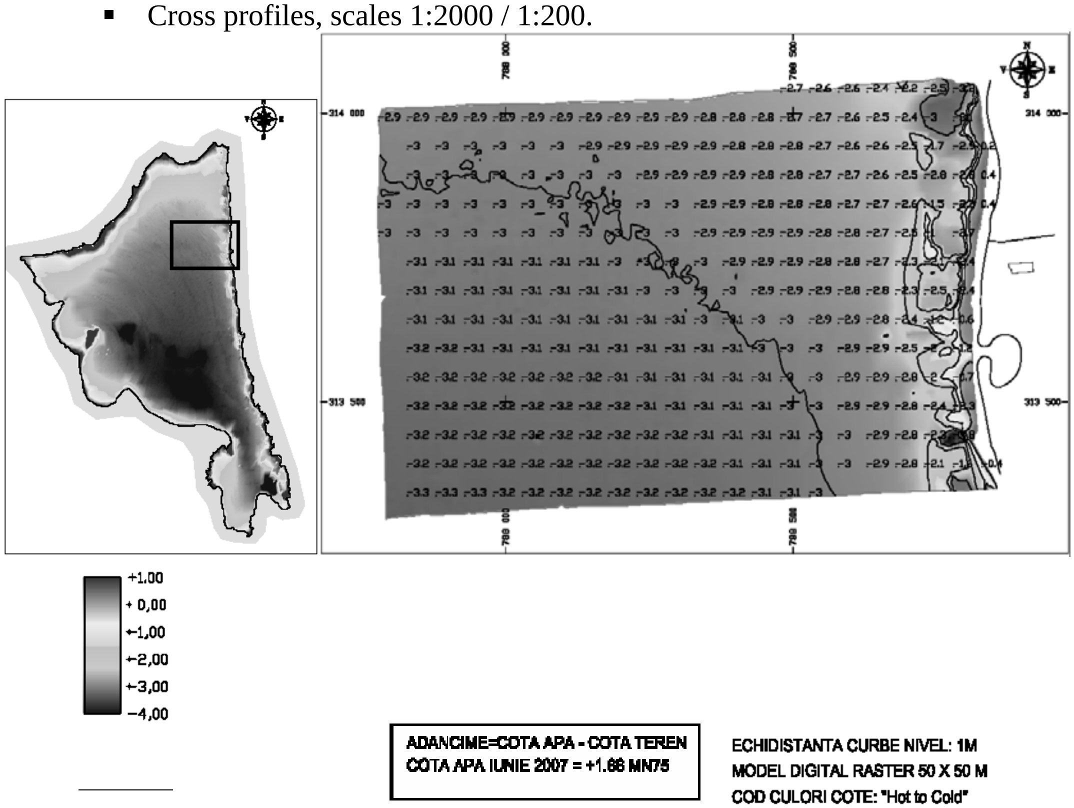
After generating the DTM, derived products were obtained as it follows:

- raster models of the terrain (rectangular grid of equidistant points obtained by interpolation);
- main and secondary level curves;
- representing the relief in colors (“hot to cold” method);
- cross profiles on E-W direction beginning with the bank line towards deep sea.

5. Mapping

The following plans were drafted:

- Area location plan (Figure 9 (a)) and general bathymetric plan, scale 1:5000 (Figure 9 (b));
- Layout, scale 1:2000 – Cover degree with measurements and Digital Terrain Model;
- General bathymetric plan, scale 1:2000;
- Detail bathymetric plan, scale 1:1000;
- Cross profiles, scales 1:2000 / 1:200.



(a) Area inscribing plan (b) General bathymetric plan (scale 1:5000)

Figure 9 Area location plan and general bathymetric plan, scale. 1:5000

6. Conclusions

The accomplishment of "Lacustrian town" project (Figure 10), worth of EUR 8 million, on Siutghiol Lake in Mamaia resort, is an advantage for the Romanian tourism in general and for the seaside tourism in particular.

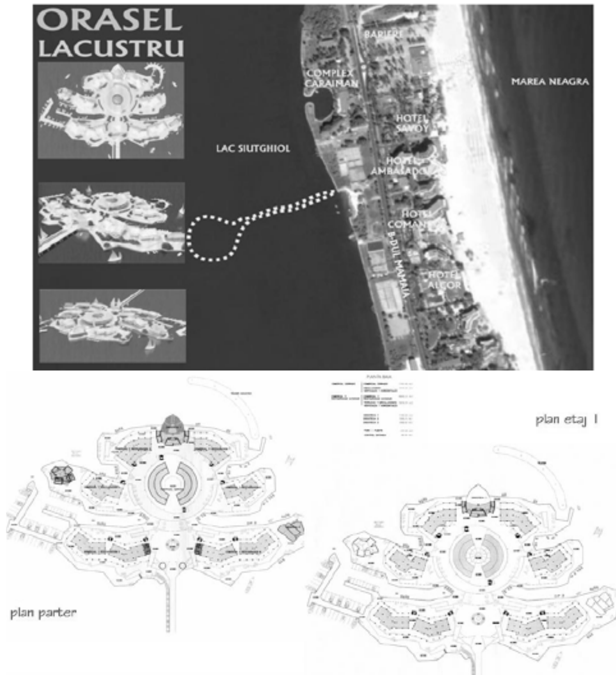


Figure 10 Lacustrian town

7. References

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