GEODESIC TECHNICAL ASSISTANCE FOR HAZARD AND FLOOD RISK MAPS IN HYDROGRAPHIC SPACE PRUT – BARLAD

Constantin COSARCA, Associate Professor, PhD, Technical University of Civil Engineering Bucharest, Faculty of Geodesy, e-mail: constantin_cosarca@yahoo.com;
Paul Daniel DUMITRU, Lecturer, PhD, Technical University of Civil Engineering Bucharest, Faculty of Geodesy, e-mail: paul.dumitru@gmail.com;
Adrian SAVU, Lecturer, PhD, Technical University of Civil Engineering Bucharest, Faculty of Geodesy, e-mail: adisavu2002@yahoo.com;
Aurel NEGRILA, Assistant Professor, PhD, Technical University of Civil Engineering Bucharest, Faculty of Geodesy, e-mail: negrilaa@yahoo.co.uk;
Alexandru CALIN, Lecturer, PhD, Technical University for Civil Engineering Bucharest, Faculty of Geodesy, e-mail: alexcalin1975@yahoo.com;
Aurel SARACIN, Associate Professor, PhD, Technical University of Civil Engineering Bucharest, Faculty of Geodesy, e-mail: saracinaurel@yahoo.com;
Caius DIDULESCU, Associate Professor, PhD, Technical University of Civil Engineering Bucharest, Faculty of Geodesy, e-mail: caiusdidulescu@yahoo.com.

Abstract: *To ensure the reference system necessary for detailed topographic measurements, bathymetric measurements, the photogrammetric flights and flights operated with LiDAR technology, in accordance with the requirements of the specifications, is necessary to perform an appropriate Bridging and Survey Geodetic Network, as the level of accuracy and easy access to points. Achieving the Bridging and Survey Geodetic Network (RGIR) is a mandatory step in order to ensure the technical conditions to make all measurements and subsequent technical operations necessary to achieve the ultimate goal of hazard and flood risk maps. Realization of the Bridging and Survey Geodetic Network (RGIR) aims to meet the administrative, economic and legal requirements and represents the basis of the topographic measurements performed for various purposes.*

1. Hazard and Flood Risk Maps. Overview

The disasters caused by natural risks still have a growing impact on people around the world. Recent studies show that more than half the world's population lives in areas with significant exposure to natural disasters that are affected by climate change due to the frequency and intensity of weather conditions. All regions of the planet risks being influenced of hazards induced by climate change. Along with increasing global warming, it is possible that both the number and intensity of the adverse natural phenomena to be increased in many parts of the world. It is also possible that many arid regions to become drier and start to expand desertification.

In advanced countries in terms of technology were assured the minimum acceptable conditions of risk on the basis of supervision strategies that produce phenomena that affect the survival conditions of the population and the environment. An important role returns to cartographic representation, ie making maps based on analytical calculation of risk indicators and especially the integration of a large amount of information included in the geographical information systems. The practical importance of these cartographic products is recognized by all the users, whether they are directly involved, such as geographers, hydrologists, climatologists, geologists, etc., well as policy makers, who are the beneficiaries of more precise knowledge systems of the vulnerability of land, land location, spatial demarcation of areas with different levels of exposure to natural disasters and can act effectively to reduce the damaging effects of the phenomenal nature. The maps receive thereby analytical and practical valences, increasing their social utility side in addition to the scientific and practical significance, often called mathematical models of land. The models are used to study real and abstract physical phenomena, both for creating more precise images of reality, but especially for creating a virtual prototype that describes the structure and behavior of natural phenomena under different conditions. Digital terrain model is widely used in the world. Among the natural phenomena with a strong impact on the Romanian territory in recent years stands out floods, which caused major damage significantly affected the Romanian economy. Identification, location and delimitation of natural hazard risk areas, in which flooding is a major element, has the finality the development of digital maps of flood risk that will be used to establish the scientific rigorous measures of prevention and protection.

Essentially a flood risk map contains a map that represents planimetric base map or basic layer, overprinted with data elevation related to base flood (Base Flood Elevation - BFE) and the boundaries of the special flood hazard area (Special Flood Hazard Area - SFHA) calculated from the hydrological modeling of the data elevation for the entire water catchment area and hydraulic modeling of the data elevation of the valleys and floodplains, but not including the actual routes of the level curves.

For the new flood risk maps, called DFIRM (Digital Flood Insurance Rate Maps), are used the digital orthophoto images as base map, overlapping with georeferenced digital data elevation of flooding. Figure 1 shows schematically the concept behind the new product, also known as digital map flood risk (DFIRM - Digital Flood Insurance Rate Map).

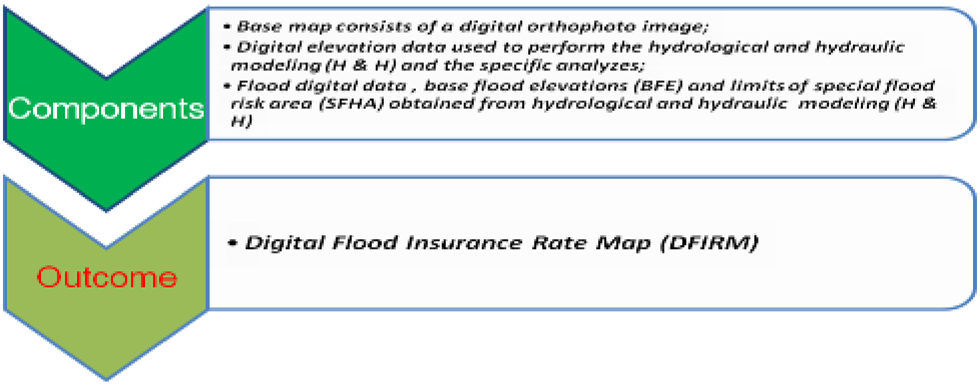

Figure 1. The components of digital maps for flood protection (Digital Flood Insurance Rate Map)

This concept emphasizes that a digital map flood risk or protection result of combining photogrammetric following products:

- a digital orthophoto image that serves as a base map or layer based on the GIS context;
- elevation digital data used for the hydrologic and hydraulic modeling (H & H) and also of the analyzes performed in this modeling process;
- the digital data of floods (BFE and SFHA - Base Flood Elevation and Special Flood Hazard Area) that are obtained from hydrologic and hydraulic modeling (H & H);

With the introduction of the technology of Digital Elevation Model (DEM), hydrological modeling is performed on different classes of digital elevation models that can be obtained much more quickly, efficiently and with the required precision. Determination of the volume and velocity of water flowing on the surface is deduced very efficient, fast and accurate from the digital data extracted from DEM.

Hydraulic modeling is performed on digital models structured as TIN (Triangulated Irregular Network) structure that facilitates the inclusion of land slope break lines in the model structure, increasing its decisive morphological fidelity. This element defines the cross-sectional geometry of the channels and water drainage ditches.

2. Bridging and Survey Geodetic Network. Overview

Achieving The Bridging and Survey Geodetic Network (RGIR) is a mandatory step in order to ensure the technical conditions to make all measurements and subsequent technical operations necessary to achieve the ultimate goal of this work.

Realization of The Bridging and Survey Geodetic Network (RGIR) aims to meet the administrative, economic and legal requirements and represents the basis of the topographic measurements performed for various purposes:

- realization of the model of a quasi-geoid used to correct all altitudes values (heights) determined with modern positioning technologies;
- realization of the overhead photos flights, resulting orthophotomap;
- realization of the preparation of control, in order to produce orthophotomap;
- making measurements with LiDAR technology resulting digital terrain model (MDT) and its derivatives;
- Terrestrial Laser Scanning of the Hydrotechnical Objectives in Hydrographic Space Prut – Barlad;
- realization of transverse and longitudinal profiles of the river water bodies in hydrographic space Prut - Barlad, both by topographic and bathymetric measurements;
- making topographic measurements (topographic surveys) in order to draw up plans of special character;
- realization of the informatics system, specific for the domain and its maintenance;

3. The Bridging and Survey Geodetic Network project. The general concept

Given the purpose of this network and respecting rules and regulations in force (no.534/2001 Order of the Minister of Public Administration, no.634/2006 Order of the General Manager of National Agency for Cadastre and Land Registration, Order 108/2010 of the General Manager of National Agency for Cadastre and Land Registration, Decision no.1/2008 of the Director of the Geodesy and Cartography Direction ANCPI) the Bridging and Survey Geodetic Networks were designed in a preliminary form.

At the preliminary design was used information taken from the National Agency of Cadastre and Land Registration and from the Water Basin Administration (ABA) Prut - Barlad, consisting of coordinates points inventories of Spatial National Geodetic Network of Class A (GNSS permanent stations), Class B (ground points), class C (ground points belonging to national geodetic triangulation network) and information about Romanian Geodetic Leveling Network for the interest area and information about “CSA landmarks” (CSA – the Superior Council for Water Resources) from the works for water courses cadastral axis determination, located in the ABA database. The design of bridging and survey networks aimed to provide the corresponding density in the network, thus providing the possibility of using the entire network for development in the next step of polygonal traverses necessary to the detailed topographic survey, in order to obtain the above-mentioned products.

To this purpose, groups of two points with visibility between them were provided (materialized at distances of about 200-300 m), located outside the influence of future construction, which could be the starting base and - respectively - closing of subsequent measurements made with GNSS technology or polygonal traverses. This network design is a guarantee of accuracy detail topographic survey. At the preliminary design were identified potential positions for a total of approximately 294 points (147 pairs of points, denoted by sign P001..... P147) that will are part of the Hydrographic Space bridging network Prut – Barlad (Figure 2). Given the purpose and usefulness of the designed bridging network points, were observed following criteria:

- points to be as close to Geodetic Leveling Network points of Romania to achieve and transmission - the geometric precision leveling - altitude in the national reference system;
- points to be located at the junction of two or more streams river located in the Hydrographic Space Prut - Barlad;
- sites are easily accessible for measurement and possible preserving the points in time;
- will use for every possible designed position a total of two benchmark (benchmark pairs) to provide infrastructure for achieving both measurements with GNSS modern technology and traditional technology;
- to be located near lakes and major hydro construction;
- to be evenly distributed over the entire area of interest;

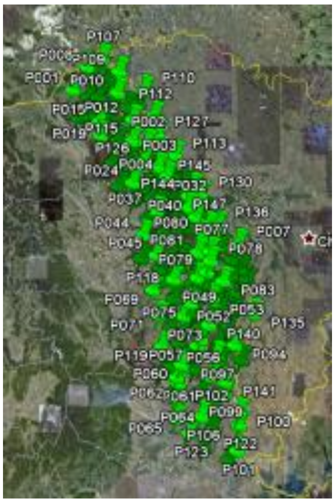

Figure 2. The Project of RGIR (The projected locations of the RGI points)

4. Materialization of the Bridging and Survey Geodetic Network points

The points RGIR of the Hydrographic Space Prut – Barlad were materialized by concrete benchmarks, compliance with Technical Regulations in force (**Benchmark**: **STAS SR 3446**, h = 0.70 m, B = 0.20 m, b = 0.15 m, benchmark medium format, size 1, Appendix 1 / A9, A10, **Mark: STAS 4294**) – Figure 3, and benchmarks FENO type – Figure 4. It is worth mentioning that this materialization is accepted by Technical Norms in force.

Were included in RGIR every of existing points (CSA, ANCPI, OJCGC, IGFC benchmarks, the network tracking dams benchmarks, etc..) which design conditions are appropriate (materialization, position, opportunities for conservation, providing conditions to GNSS observations) – Figure 5.

5. The design of the GNSS observations made in Geodetic Network

When designing GPS (GNSS) observations it should be given importance to other elements than those of the classic design of geodetic networks. The design must take into account a number of factors such as:

Figure 3. New concrete benchmarks (medium format)

Figure 4. FENO type benchmarks

Figure 5. Existing benchmarks

- the satellite configuration in measurements carrying out;
- the number of satellites that can be followed simultaneously in a point;
- the base length;
- the number and type of receivers at their disposal;
- the economic aspects;

Network configuration made using satellite methods is not too important or not as important as networks traditional made. Networks are generally made with a specific purpose. Therefore the intended network can be achieved in several ways, using different technologies: triangulation (measurements are made only horizontal angular directions), trilateration (performed only measurements of distances), global positioning systems, polygonometry. Currently the most common methods of obtaining a network point coordinates are: polygonometry and measurements with satellite navigation systems.

Advantages of the GPS (GNSS) are undisputed in the other classical methods for determining the position of points in a coordinate system, but because Romania is still a country in transition, the spread of these technologies is still low compared to other developed countries. As in Romania, currently national projection system is "Stereographic 1970", coordinates determined by GPS (GNSS) technology will be transformed from the WGS 84 (ETRS89) system in the national system. It is necessary for this to calculate the transformation parameters, which requires two sets of coordinates. In this kind of network it should be selected points measured GPS (GNSS) to cover in a uniform manner designed network. Their density, depending on the destination network can be a point at 2-5 km, grouped with two points-of-sight. GPS (GNSS) points must meet the following conditions:

- There are no obstacles that obstruct the horizon above the elevation of 15^0 because they can reduce the number of observable satellites;
- There are no reflective surfaces near the antenna, as this may lead to the effect of *multipath*;
- There is no high power wiring or near stations relay transmitters, which can disrupt satellite signals;
- Be easily accessible, preferably by car;
- To be protected from destruction.

If there are obstacles to making observations (forests or areas with tall buildings) should be established eccentric stations. Observation time depends on:

- Length basis;
- Number of satellites observed;
- Satellite geometry (GDOP);
- Ionosphere;

The Table 1 shows an approximate guide base and altitude observation times for average current levels of ionosphere activity when using dual frequency sensor.

Table 1. Guide about the GPS bases

Observation methods	**No. of receive satellite GDOP ≤ 8**	**Base length**	**Approximate time of observation**	
			Day	**Night**
Rapid Static	4 or more 4 or more 5 or more	Until 5 km 5 – 10 km 10 – 15 km	5 – 10 minute 10 – 20 minute over 20 minute	5 minute 5 – 10 minute 5 – 20 minute
Static	4 or more 4 or more	15 – 30 km over 30 km	1 – 2 hours 2 – 3 hours	1 hour 2 hours

The values of GDOP (Geometric Dilution of Precision) show you the geometry of the satellite constellation. A low value indicates a geometry GDOP's good. A high value of GDOP's shows you a constellation of satellites insufficient (inappropriate).

If the geometry is insufficient, the post processing solutions will be weak. In the fast static measurement method the GDOP values must be less than or equal to eight. A five GDOP value or less is ideal. The best way to minimize the effect of GDOP is to receive many satellites as possible.

The geometry constantly changes to the continuous position satellites changes (GPS satellites moving in orbit and users move across the earth). Therefore, at times, it is possible that the satellite geometry to be unfavorable. Hence disruption of satellite signals.

6. GNSS measurements

GNSS measurements in RGIR were made - on average - with 10 to 15 receivers TOPCON HIPER Pro, Topcon GR3, GR5 TOPCON, Radian - SOKIA and Javad type, dual frequency, from December 2011 to Mars 2012.

According to the observation plan prepared and distributed to every team, the receivers were connected to the antenna and the power supply (by default) so that the recordings are performed simultaneously in the station points.

All the GNSS measurements performed in RGIR were carried out using the static method, known as the advantages in terms of its accuracy criteria (Figure 6).

Figure 6. Aspects from the measurements carried out with GNSS technology

7. Processing GNSS measurements made in RGIR

The processing of the measurements made by GNSS technology was performed using specialized software (software component of the TOPCON company), mainly aiming to obtain solutions of "fixed" type (fixing ambiguities) for each vector (base, distance between points, length) and their compensation as a constrained network using measurements and coordinates of the National Space Geodetic Network (A Class) - provided by Romanian ROMPOS service of determination of the position (GEO ROMPOS service). To the Bridging and Survey Geodetic Network processing determined by GNSS technology have followed the following steps:

1. verification of data at their disposal;
2. importing data into a new project;
3. their visualization;
4. establishment of GNSS data processing parameters (elevation, type solution, ionosphere and troposphere models used);
5. preliminary processing of GNSS data;
6. analysis results (Loop Closure, statistical tests);
7. processing the determined vector;
8. generate reports on determined vectors (relative coordinates and accuracy);
9. establishment of the network compensation parameters;
10. defining constraint points by entering their coordinates in ETRS89 system and declaring that fixed;
11. bridging and survey geodetic network compensation, as a constrained network;

12. analysis results after compensation;
13. generate reports on network compensation (compensated vectors and ellipsoidal coordinates B, L, h / XYZ in reference system ETRS89) – Table 2 and Figure 7 to 10;

Table 2. Geodetic coordinates of the RGI points (partial)

Name	Latitude	Longitude	Ell.Height (m)	Std Dev n (m)	Std Dev e (m)	Std Dev u (m)
A001	47°58'23.52918"N	26°22'49.16045"E	188.903	0.001	0.001	0.002
A002	47°58'14.92924"N	26°22'40.11080"E	189.215	0.001	0.001	0.002
A003	48°10'14.29920"N	26°44'35.05655"E	179.295	0.002	0.002	0.005
A004	48°10'20.33619"N	26°44'33.08106"E	183.189	0.002	0.002	0.005
A005	48°07'57.97910"N	26°31'42.88536"E	167.671	0.002	0.002	0.004
A006	48°08'04.75386"N	26°31'43.30584"E	170.288	0.002	0.002	0.004
A007	48°06'47.59807"N	26°39'29.75624"E	162.845	0.002	0.002	0.004
A008	48°06'37.93008"N	26°39'26.41979"E	163.181	0.002	0.002	0.005
A009	48°06'08.76803"N	26°51'53.15027"E	162.151	0.002	0.002	0.005
A010	48°06'15.87814"N	26°51'54.78672"E	157.707	0.002	0.002	0.005
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The transformation of Bridging and Survey Network points coordinate from reference system ETRS89 in National Planimetric Reference System S-42 (*Ellipsoid Krasovski 1940*), Stereographic Projection Plan 1970 and altimetric „*0 fundamental point Black Sea 1975*" reference system.

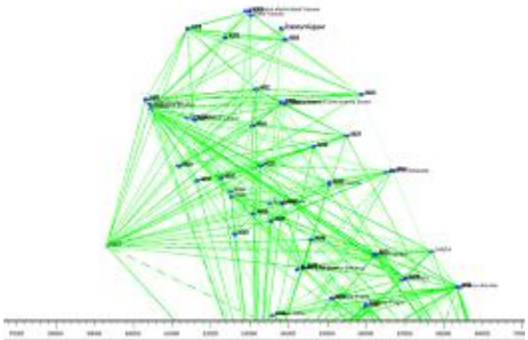

Figure 7. The GNSS network sketch, Botosani county.

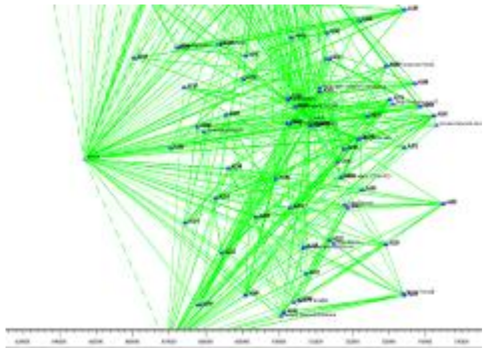

Figure 8. The GNSS network sketch, Iasi county.

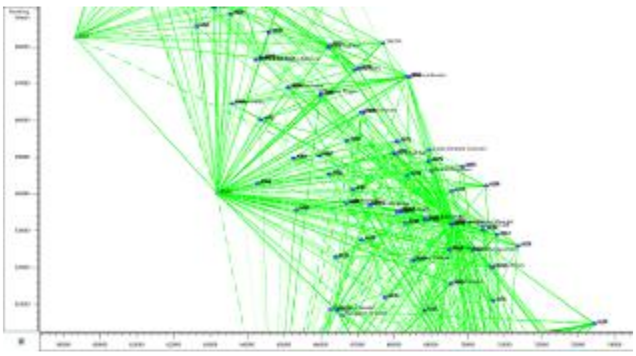

Figure 9. The GNSS network sketch, Vaslui county.

Figure 10. The GNSS network sketch, Galati county.

8. Framing in the national Geodetic System. Projection system. Reference system.

Based on the results obtained from processing of Bridging and Survey Network determined by GNSS technology - namely ellipsoidal coordinates in ETRS89 reference system – a transformation has made into national planimetric reference system.

To make the transition of the coordinates determined in ETRS89 system to the coordinates in the national system was used **TransDatRO** transformation program, based on a set of points with coordinates determined in both systems (national and European) – Table 3. The determination of the normal altitudes (zero fundamental point Black Sea 1975) was based on modeling a (quasi) geoid on the river space Prut - Bârlad, model results from combining the measurements with GNSS technology with precision geometric leveling measurements, having as base points (leveling control points / marks) from leveling national network.

Table 3. Coordinates of RGI points in the national geodetic system (partial)

Name	**North (m)**	**East (m)**	**H_MN75 (m)**	**OBS.** (Heights from quasi-geoid model)
A001	720267.787	603183.354	155.305	H_CVG
A002	719998.877	603000.343	155.615	H_CVG
A003	742759.204	629776.865	145.711	H_CVG
A004	742944.748	629731.897	149.605	H_CVG
A005	738215.075	613905.877	134.093	H_CVG
A006	738424.491	613910.485	136.707	H_CVG
A007	736237.941	623604.646	129.227	H_CVG
A008	735937.880	623541.960	129.567	H_CVG
A009	735384.879	639008.523	128.620	H_CVG
A010	735605.275	639037.140	124.177	H_CVG
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9. Geodetic assistance for LiDAR scanning activity

9.1 Ensuring permanent GNSS stations - to the ground

Design of flight operations for air laser scanning has resulted in a Flight Project. Hydrographic space was divided into 14 separate areas (Figure 11). In each of these areas have made flying missions with longitudinal bands (the NS direction, for example) and - for each block - with one or two transverse bands, performed as substantial control of the final results (Figure 12). The air laser scanning measurements (using LiDAR technology) need a substantially "support" consisting of measurements (satellite records) made by receivers located on the ground. The campaign of GNSS measurements (to the ground) is necessary for accurate calculation of the trajectory plane.

For this there are two methods:

• Using existing GNSS permanent stations;

• Using GNSS determined points or so-called "permanent stations to the ground". They consist in points (evidenced to the ground) whose coordinates were previously determined. In these points are located GNSS receivers that work simultaneously with the GPS receiver on plane board.

The Hydrographic Space Prut-Barlad and the surrounding (West area) is "covered" by a total of 11 GNSS permanent stations belonging to ANCPI, respectively to a private company (the permanent station Botosani). On the assumption that the "coverage" of a permanent station is about 25 km, have resulted in a number of "no coverage" areas across the entire Hydrographic Space. In these "no coverage" areas were placed, during flight missions, GNSS receivers that have constituted in "permanent stations to the ground." These points were selected from the Bridging and Survey Geodetic Network, points materialized over the entire Hydrographic Space and determined in an earlier stage.

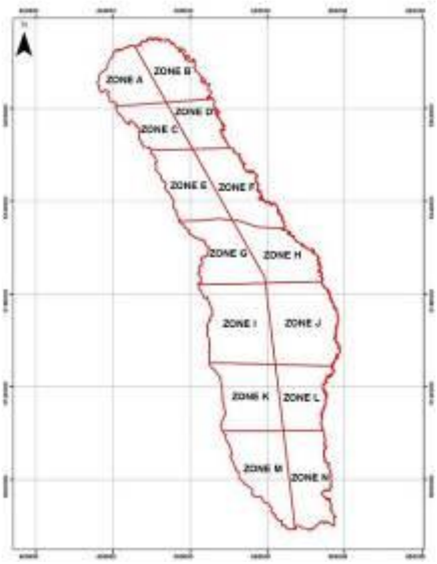

Figure 11. The Flight Project

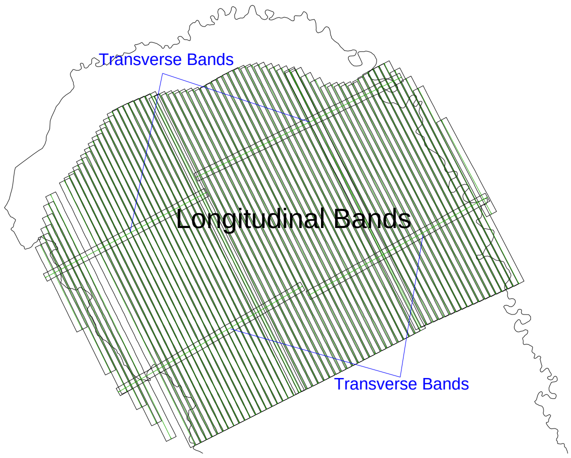

Figure 12. Longitudinal and Transversal Flight Bands

To solve this category of works the GNSS technology was used, ensuring common stationary periods with flight missions performed, by installing on the designated points - according to the conditions mentioned above - of GNSS receivers, which have constituted so in "permanent stations to the ground "during the flight missions. Measurements were performed with two GR5 receivers – Topcon, from the Faculty of Geodesy Bucharest, between 21.03.2012 - 10.07.2012. Stationary period was between 8 and 12 hours daily. As a measurement method, the static method was used (Figure 13).

The measurement systems were set to take satellite records with 1Hz (1 sec.) frequency, as initial inquiry and recorded data were stored - after each session of measurements - the magnetic medium. The recorded data were later translated into RINEX file type (universal format) and sent to the team that processes data from air laser scanning.

Figure 13. GR5 receivers – Topcon

9.2 The determination (surveying) of the control surfaces

As already stated, according to Flight Project the Hydrographic Space was divided into 14 separate areas. In each of these areas have made flying missions with longitudinal bands (the NS direction, for example) and - for each block - with one or two transverse bands, performed as substantial control of the final results.

To obtain accurate final data were used as a support for planimetric and altimetric check a series of measurements made on distinguishes surfaces, chosen at the ends and mid-transversal flight strips. Particularly, these measurements to "control surfaces" were constitute in topographic surveys of some distinct details characteristics of these surfaces, with a corresponding density of points, which were useful in confidence determining of LiDAR product. These points were used to determine the surface model with increased local accuracy of the final results, respectively at georeferencing point cloud obtained by using LiDAR technology. For these surfaces were chosen on the court such details (every detail large enough area that is supposed to result from laser scanning and it will be located in an approximately horizontal area) easily identified in LiDAR point cloud.

In total we have carried out a number of 27 transversal flight bands, resulting in a total of 77 control surfaces. Considering that for each area were determined - on average - 50 points of detail, resulting a total of approximately 3,800 points for control surfaces. For measurements, the GNSS technology was used, available with four equipments Hyper Pro - Topcon from the endowment of the Faculty of Geodesy Bucharest. As a method of measuring, the kinematic measurement method was used. In applying this method were used as fixed points (base) the Bridging and Survey Geodetic Network points lying in close proximity of areas (surfaces) in question. For situations where was possible, we used the ROMPOS service solution. These statements imply the concurrent existence of satellites signal of GPS and / or GLONASS constellations and the link to the Internet via mobile phone networks services functional in Romania. In Figure 14 are examples of transversal flight bands respectively approximate positions of control surfaces.

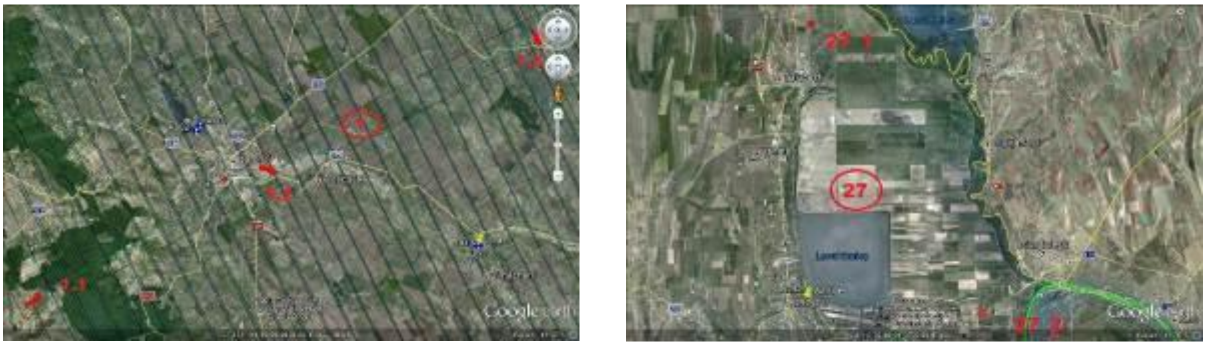

Figure 14. Examples of transversal flight bands

9.3 Terrestrial Laser Scanning of the Hydrotechnical Objectives

To complete the Digital Terrain Model derived from the flight performed with LiDAR technology was made - in addition - a series of measurements with terrestrial laser scanning technology for a total of 10 engineering objectives from Hydrographic Space.

Figure 15. Aspects from terrestrial laser scanning measurements

To the terrestrial laser scanning for engineering objectives from the Hydrographic Space Prut - Barlad we used two systems ScanStation 2 type, from Leica company, from the endowment of the Faculty of Geodesy Bucharest. The technical characteristics of this equipment are a guarantee of the quality measurement results (Figure 15).

9.3.1 Determining the position of constraint points (scan stations)

The orientation (registration) of the point clouds taken from different scanning stations in a single reference system (Stereographic 1970 projection system, respectively ETRS 89 and normal altitudes system with "0" fundamental point Black Sea 1975) requires the identification of similar points from adjacent stations. These points, materialized in the field and previously determined (as a position) were signaled with "targets of sight" Leica type (Figure 16).

Figure 16. Constraint points signaled with "targets of sight" Leica type

Determination of coordinates and elevations of constraint points ("tie points") was made before laser scanning operations using GNSS technology and with reference points from the Bridging Geodetic Network and the Quasi-Geoid model determined in an earlier stage. In this stage we used Topcon type GNSS equipment, from endowment of the Faculty of Geodesy Bucharest (Figure 17).

Figure 17. Determination of constraint points using GNSS technology

Since the design phase of terrestrial laser scanning measurements was taken into account as each engineering objective to be "framed" fair and as good as possible to highlight the technical features useful for getting a 3D model as expressive and to contribute to determining geometrical elements which leading to correct hydrologic and hydraulic modeling. The kinematic measurement method was used.

In the tables below (Table 4 and 5) are examples of Coordinates Inventory of constraint points (scan stations) determined with the GNSS technology.

Table 4_ETRS89 System / Ellipsoidal Elevations (partial)

Name	Latitude	Longitude	Ell.Height (m)	Std Dev n (m)	Std Dev e (m)	Std Dev u (m)
S2_Bar_Cucut	47°09'53,06680"N	27°24'35,03198"E	97.360	0.002	0.002	0.004
S3_Bar_Cucut	47°09'53,34040"N	27°24'35,06123"E	97.301	0.002	0.002	0.004
B1_Bar_Cucut	47°09'53,17288"N	27°24'33,96373"E	97.469	0.002	0.002	0.004
S1_Bar_Cucut	47°09'52,26283"N	27°24'34,30977"E	93.531	0.002	0.002	0.004
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Table 5_1970 Stereographic System / Normal Heights (quasi-geoid modeling) - partial

Name	Grid Northing (m)	Grid Easting (m)	H MN75(m)
S2_Bar_Cucut	632269.368	682788.579	64.823
S3_Bar_Cucut	632277.833	682788.937	64.764
B1_Bar_Cucut	632271.956	682765.989	64.932
S1_Bar_Cucut	632244.086	682774.133	60.994
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9.3.2. Measurements using terrestrial laser scanning technology

Terrestrial Laser Scanning operations were carried out in each station point belonging to each engineering objective. The scan result is represented by a considerable number of points, generic called „point cloud”.

The resulted points are characterized as position by the coordinates x, y, z, in a specific coordinate system of the measuring system with the origin at the point where the scan was performed. In each point was measured the device height and target of sight heights located in constraint points (tie points), whose coordinates were previously determined.

All scanning operations are "led" by **Cyclone** software component of the scanner system. Selected method from scanning was "**TRAVERSE**".

Figure 18. "Mircea" Bridge – photographic image

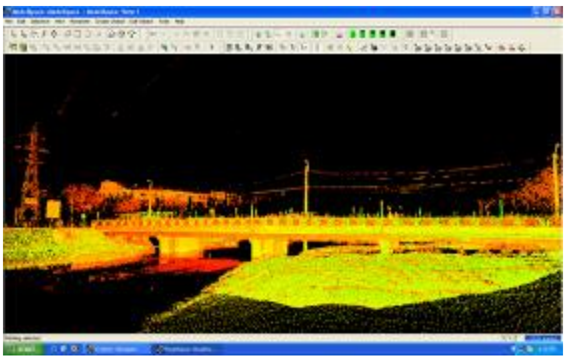

Figure 19. "Mircea" Bridge – cloud of points with unstructured information

- The immediate results (primary) of the scan:
  - 1:1 scale 3D geometric information (cloud of points with unstructured information);
  - Information on intensity (no information regarding the real color or texture);
  - Representation of the measured object according to the grid of points chosen (without characteristic points such as corners or end of detail)

In the images above (Figure 18 and 19) is an example of "point clouds" with the unstructured information for each scanned object, compared with their photographic image.

- "Mircea" Bridge - road bridge over the Bahlui River, 4 openings, upstream view;

The final products of the terrestrial laser scanning operations can be constituted in various forms:

- coordinates files: x, y and z (in the local coordinate system);
- coordinates files: X, Y, H (in a defined coordinate system);
- Point clouds in 3D projections;
- Topographical Plans, CAD building projects;
- 3D models;
- "Virtual inroads" by the 3D model (animation);

10. Conclusions

The Bridging and Survey Geodetic Network (planimetric and altimetric) designed and made to finalize the project "Hazard and flood risk maps in the Hydrographic Space Prut - Barlad" correspond to density points and precision requirements expressed by the beneficiary and is consistent with the rules regarding this type of works. Achieving this geodetic network, to the parameters of quality and high precision, ensure the quality of the future topographical works and achievement of the Digital Terrain Model, which will be the basis for hydrologic and hydraulic modeling.

The geodetic insurance activity carried for LiDAR technology flight is indispensable in the conditions imposed by the ultimate goal of the work: achieving the Digital Terrain Model. Application of modern technologies - the latest - to ensure the geodetic technical assistance for flight creates the premises to achieve a final product (Digital Model Terrain) with a proper quality.

Terrestrial laser scanning is necessary only to the objectives where is supposed the air laser scanning (with LiDAR system) will not provide (collect) sufficient points in order to achieve the full 3D model (for example the building objectives with slopes over 75 degrees). The conclusion is that the Terrestrial Laser Scanning is useful for objectives with complex geometry, where the use of other technologies is not effective or possible.

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