The New Albanian Network and GPS measurement Campaigns

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I. The development of Albanian co-ordinate systems is very closely connected with historical events of the country. From this point of view, we can divide the development in four periods:

I.1. The Triangulation Network was established by Military Geographic Institute of Vienna (MGIW) during 1860-1873, in the framework of the construction of the geodetic basis for mapping of Balkan at 1 : 75 000 scale. We have not any detailed information about, but we know that in the 1918 the geodetic co-ordinates of the points of triangulation were calculated on Bessel ellipsoid, Gauss-Krüger cylindrical projection, with origin the intersection of the Equator by the meridian of Ferro.

I.2. Later, in the 1927-1934 period, Military Geographic Institute of Italy (IGM) carried out a new triangulation in four orders, which served for maps at 1 : 50 000 scale. The geodetic co-ordinates of the points of triangulation were calculated on Bessel ellipsoid, Bonn projection with central meridian Lo=20', as origin was determined the astronomical point of Lapraka, Tirana.

At the same time, IGM carried out the Leveling Net (about 150-170 km). The origin for Heights System was chosen the MSI, of Adriatic Sea, determined with a temporary tide gauge very short recording time (one month).

I.3. In the 1955, the specialists of Military Topographic Group of Albania carried out the reconstruction and the densification of the IGM Net in order to grant the request for mapping at 1 : 25 000 scale. At the same time, the first-order network was transformed from the IGM. System (1934) into the 1942 co-ordinate system, which based on Krassovsky ellipsoid, Gauss-Krüger projection with central meridian Lo=21'.

I.4. The New Albanian Net, which constituted from Triangulation and Leveling was designed, rebuilt, measured and calculated from Military Topographic Institute of Albania (MTI) during 1970-1985.

The triangulation was designed to fulfill the requirements of mapping till at 1 : 10 000 scale (on account of accuracy) and for perspective maps at 1 : 5 000 scale (on account of density), Fig. 1. Standard error in the reciprocal position of two adjacent points of the first-order network was planed to be ± 0.123 m.

The triangulation composted from three orders. The first order consists in full triangular net with a regular geometric shape. The first order net is based on 7 initial bases (accuracy 3.5 *10-5) at the ends of which were determined the respective Laplace Azimuths. At the middle of the network, Kamza, Tirana was determined the main Astronomical Point.

Actually at this point, selected as initial point, the parameters (φ, λ) were not usable, because the gravity measurements were not performed, thus we determined the initial point from the 1955 existing triangulation using the results of the new measurements carried out by M.T.I., so the network is *not oriented precisely.*

Actually, it would be necessary:

- to determined the initial point according to the conditions of orientation of the recent WGS 84.
- to perform the gravity measurements and to put the respective corrections for the deflection of the plumb line.
- to perform the geoid.

Leveling Networks, were designed, measured and calculated at the same time as the triangulation, during 1970-1985, from M.T.I.

The Datum of the elevation system was chosen the MSL of Adriatic Sea, determined from recordings of tide gauge for 1958-1977, which was establish since before second world war from Military Geographic Institute of Florence, Italy. From this tide gauge was establish the Fundamental Bench Mark (FBM) of the First Order Leveling (FOL). Connection between tide gauge and FBM was made through a Initial Leveling Net (ILN). The FOLN was made from four loops, 10 level lines, that followed mainly national roads, Fig.2. Realized accuracy for measurements of the first order were:

Systematic error = ±0.02 mm/km,

Accidental error = ±0.17 mm/km

On this FOLN was leaned second and third orders. Total lengths of Leveling Network for three orders is about 4500km, average length between bench marks vary from 2 to 5 km. The accuracy parameters were planed to be:

Zero Order ± 2mm*SQRT L

First Order ± 4mm*SQRT L

Second Order ± 10mm* SQRT L

Third Order ± 20mm*SQRT L

In absence of gravity measurements we hadn't real gravity values at bench marks of leveling lines, so leveling observations were corrected only for normal gravity. In consequence we haven't a correct Orthometric Height System but *an approximate one.*

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II. A Global Positioning System (GPS) geodetic control network survey was performed in Albania during October 1994 in collaboration with United States Defense Mapping Agency Aerospace Center (DMAAC).

The purpose of the survey was to establish World Geodetic System 1984 (WGS 84) positions on 35 existing stations within the Albanian geodetic control network. The selection of the stations to be included in the survey was made by M.T.I. personnel. We determined 5 survey stations from astro-geodetic network, 18 stations from horizontal control network and 12 stations from vertical control network (sketch 1).

A total of eight days of observation with Ashtech GPS receiver were need for completion of the survey. Three 5-hour observing session were for the absolute positioning and Two 3-hour observing sessions for relative positioning each day.

A total of 375 vectors were computed using *Ashtech XII GPS Post-processing System (GPPS) version 5*.0. Each daily session was adjusted with *Ashtech Fillnet version* 3.1. The standard error of unit weight was 0.094 m, the highest standard error of all relative stations was 0.016 m.

The Ashtech 30-sec data was converted to Receiver Independent Exchange (RINEX) version 2.0 using *ASHTECH ASHTORIN* program. WGS84 absolute positions were processed using DMA software, *GPS Absolute Sequential Positioning* program (GASP), version 5.5. WGS84 relative positions were obtained using *Ashtech GPPS* version 5.0.

All observation sessions for each station were used in the GPS *Absolute Sequential Positioning* (GASP) processing. The accuracy in each component is ±1m for each station for absolute positioning and 1ppm to the fixed station ALB BUNKER for relative positioning.

Having the co-ordinates in ITRF and our local system we have determined the transformation parameters between two systems through 3D-Helmert transformation which after {5} are:

a. The estimation error of Horizontal Datum (Tab.1, Fig.3) is not higher than 0.20 m in 67% of cases in each of its horizontal components, ± 0.40 m in 95% of cases and 0.60 m in 0.3% of cases.

b. The estimation error of Vertical Datum (Tab.2, Fig.4) is much higher. It is not higher than 0.70 m in 67% of cases, ±1.4 m in 95 % of cases and ±2.1 m in 0.3% of cases.

III. The objective of GPS measurements campaign of February 98 in collaboration with University of Wisconsin, Florida, USA was:

Connect the Albanian Geodetic Network to the International Terrestrial Reference System (ITRF) and define the inter-relationship between the local and international reference frameworks.

It was proposed to occupy stations included in US National Imagery and Mapping Agency (NIMA) GPS network of 1994, thus it would be possible to re-adjust the NIMA network data. The fiducial network included the IGS stations GRAZ, MATERA, SOFIA and PENC and stations KAMZA, KORCA, SHKODRA (sketch 2).

Station occupations varied 14 hours with Trimble Navigation Limited (TNL) 4000SSI geodetic receiver for connections to the IGS stations. The GPS baselines were processed using Trimble Navigation's GPSurvey^{TM} software, version 2.30. The IGS combined orbits referred to epoch 1998.1. The final coordinates are referenced to ITRF 96, Epoch 1998.0, also the final WGS 84 geodetic coordinates (φ,λ,h).

Standard deviations for the computed coordinates of fiducial stations vary 1-2cm, the computed accuracy of the NIMA points 10cm or better.

IV. For the connection of Albania, to the ETRS 89 network, GPS observations were carried out within the EUREF 98 campaign at 9 new EUREF stations, 5 survey stations from geodetic network and 4 new survey stations from geo-dynamic network. Additionally, 3 stations at the Rinas airport in Albania were observed for air traffic control purposes (sketch 3).

The GPS measurements of the EUREF 98 GPS measurements campaign were performed between September 09, 1998 in 5 session length of 24 hours for each day from 08:00 UT. GPS observations were carried out by the staffs of MTI.

The processing and analysis of the EUREF98 GPS Campaigns was performed by the BKG in Frankfurt/Main, using the Bernese GPS software version 4.0. For the processing of these data the CODE orbits for GPS Week 974, referred to the ITRF96, were used (BEUTLER 1998). The co-ordinates of the ITRF stations included in the processing were determined based on the ITRF96 at the epoch 1998.7 using coordinates and velocity values published in the IERS Technical Note in the ITRF96, Epoch 1997.0.

The final co-ordinates for the new EUREF stations were performed by fixing the co-ordinates of four ITRF stations (Wettzell1202) and are given in the International Terrestrial Reference Frame ITRF96, epoch 1998.7 and then transformed to the ETRS89.

The standard deviations ± 2mm in the north and east components, ± 6.5 mm in the height.

We wish and hope that collaboration with us will extend in the future.

Literature:

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{3} *The Land Market Development Project,* University of Wisconsin-Madison, USA: Establishment of Geodetic Infrastructure and Integrated Property Surveying and Mapping, April 1998.

{4} ALTINER Y., SCHLÜTER W., SEEGER H.: *BKG Frankfurt/Main: The results of the EUREF98 GPS Campaign in Albania*, Symposium of EUREF99, Prague 1999.

{5} QEMAL SKUKA, NEKI KUKA: *The conversion from Albanian Coordinate System to WGS84 and vice versa*, Revista Gjeodezike 4/1997

Table 1. Variance analysis of regression model

Fig.3. The estimation of the transformation operator of geocentric co-ordinates

Table 1. Variance analysis of height regression model

Fig.4. The estimation of the transformation operator of so called orthometric heights

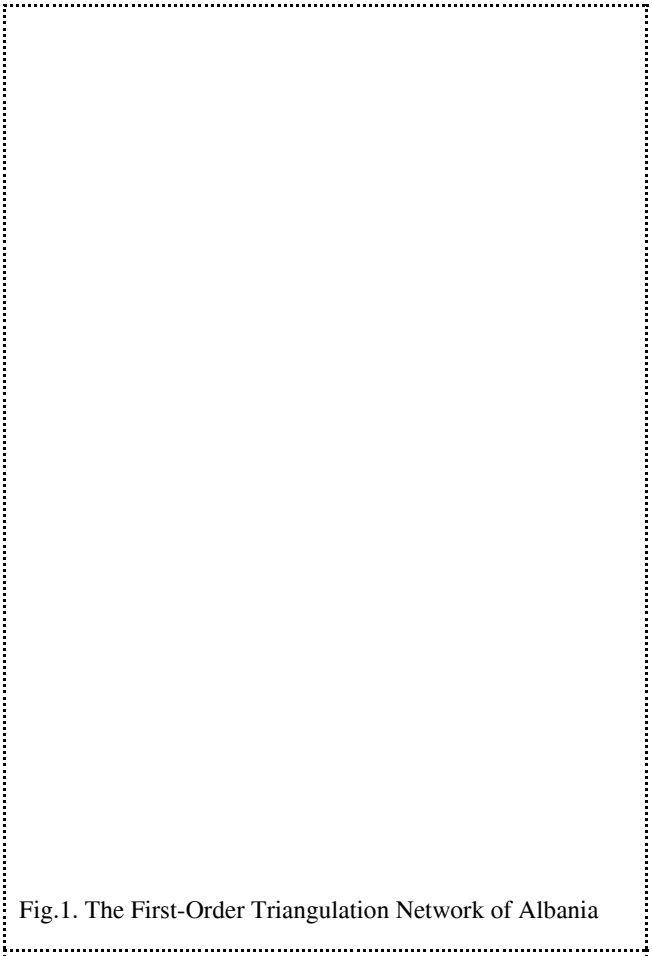


Fig.1. The First-Order Triangulation Network of Albania

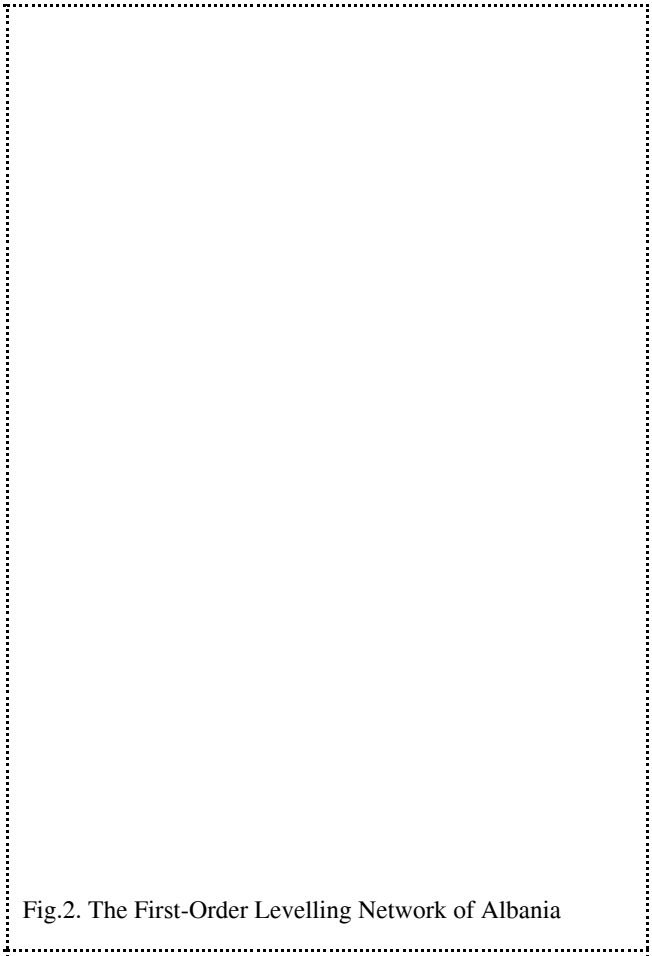
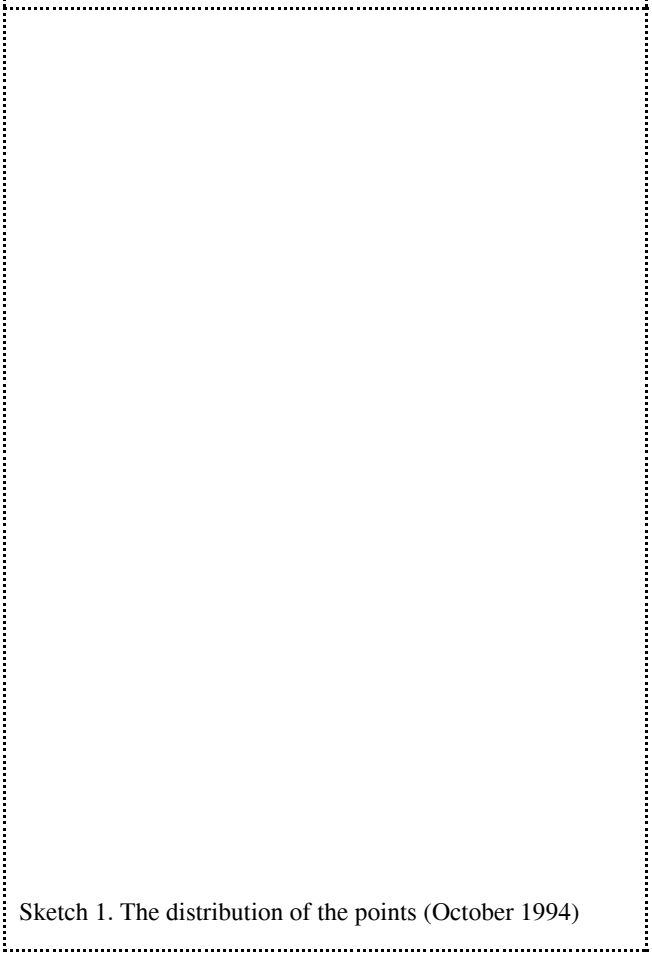
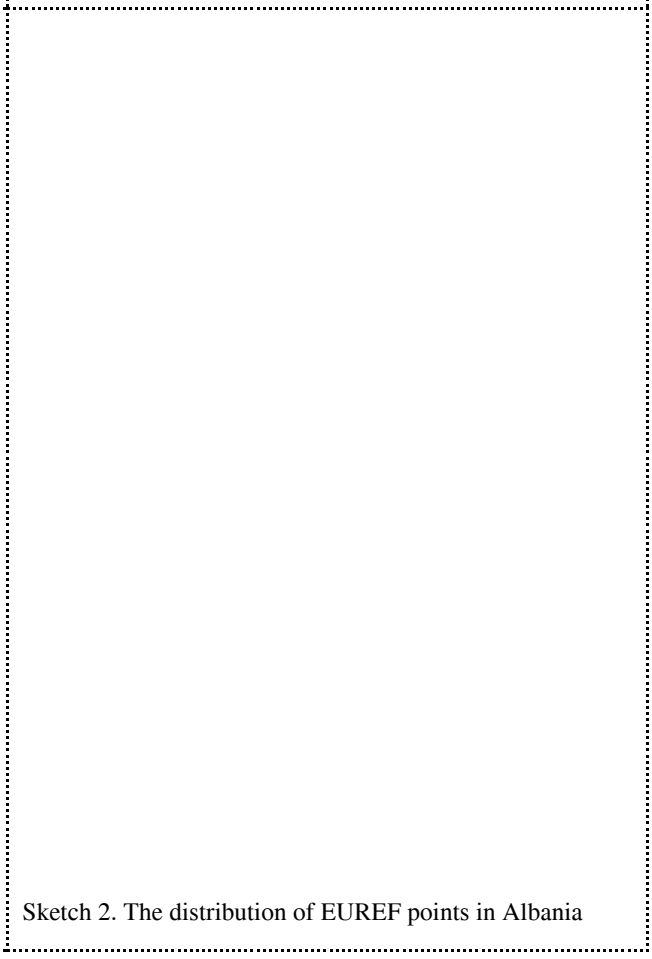


Fig.2. The First-Order Levelling Network of Albania



Sketch 1. The distribution of the points (October 1994)



Sketch 2. The distribution of EUREF points in Albania