Protection of the Environment and Modelling Surface Movements in GIS in the East Slovak Region

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Key words: 3D deformations, GPS, geo-tectonic movements, landslides, GIS, protection of the environment.

SUMMARY

3D deformation investigation of the points of the monitoring station stabled in the Košice-city and the Košice Fold territory in East Slovakia is the main task of the presented paper. The obtained results are transformed into GIS in a frame of the environmental protection.

The terrestrial and GPS measurements are realised on points of the geodetic network (*GN*) localized in the Košice Fold (Slovakia) (*Fig.1*). The aim of these measurements is determining recent geo-tectonic movements, landslides and subsidence of the earth surfaces caused by underground mine activity in the urban agglomeration of Košice-city. The main tectonic fault in the Košice Fold, according to which two expressive geological faults of the Earth ground blocks should move, is assumed in the north-south direction along the river Hornád. The secondary tectonic faults of smaller extent are in the direction perpendicular to the Hornád fault, i.e. in the east-west direction. The landslides are expected in the territory of Košická Nová Ves closed to Košice-city. The mining subsidence is occurred in the Košice-Bankov forest park, which is situated in the magnesite underground mine Košice-Bankov.

Database part of GIS for the mine subsidence Košice-Bankov application runs on MySQL database, because it is free distributed for non-commercial projects. PHP supports native connections to many databases, for example MySQL, MSSQL, Oracle, Sybase, AdabasD, PostgreSql, mSQL, Solid, Informix. PHP supports also older database systems: DBM, dBase, FilePro ...PHP can communicate with databases with ODBC interface and this feature represents PHP to work with desktop applications supporting ODBC interface. PHP cans attend to another Internet services, because includes dynamics libraries of some Internet protocols (i.e. HTTP, FTP, POP3, SMTP, LDAP, SNMP, NNTP, etc.).

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1. INTRODUCTION

The terrestrial and GPS measurements are realized on points of the geodetic network (*GN*) localized in the Košice Fold (Slovakia) (*Fig.1*). The aim of these measurements is determining recent geo-tectonic movements, landslides and subsidence of the earth surfaces caused by underground mine activity in the urban agglomeration of Košice-city. The terrestrial and GPS measurements are periodically realized twice a year (spring and autumn). Altogether, 20 points of *GN* are measured by means of using the trigonometric and GPS kinematics method. The determined *GN* points are solved by double GPS vector technology always regarding two reference points, i.e. three GPS receivers are used for measurements.

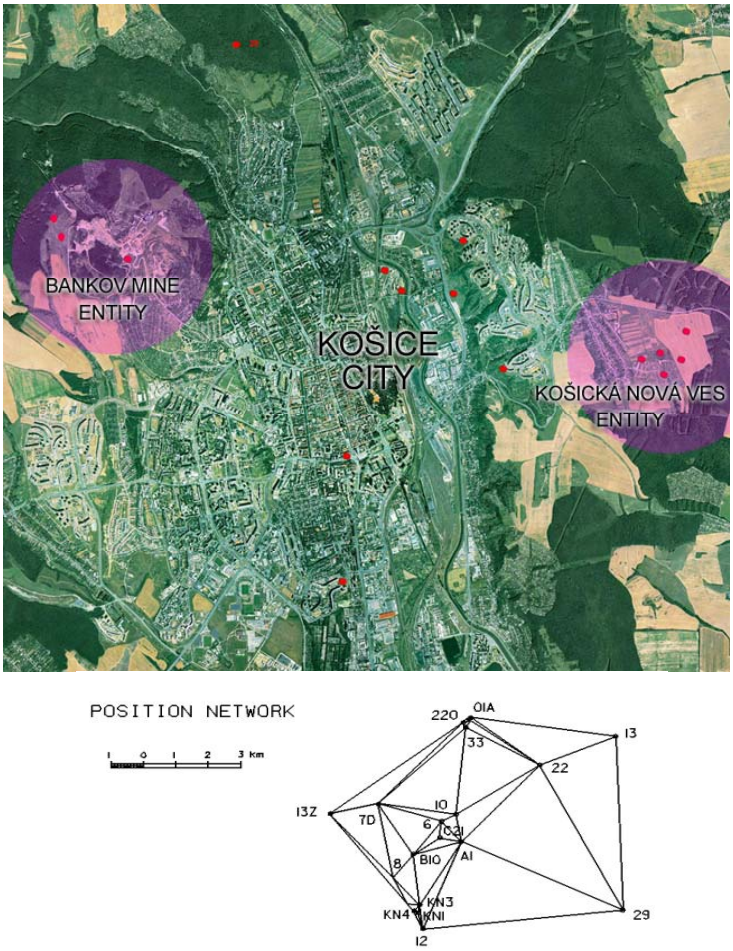

Fig 1: Position of the Košice Fold GN

The main tectonic fault in the Košice Fold, according to which two expressive geological faults of the Earth ground blocks should move, is assumed in the north-south direction along the river Hornád. The secondary tectonic faults of smaller extent are in the direction perpendicular to the Hornád fault, i.e. in the east-west direction. These secondary tectonic faults are mutually parallel. The landslides are expected in the territory of Košická Nová Ves closed to Košice-city. The mining subsidence is occurred in the Košice-Bankov forest park, which is situated in the magnesite underground mine Košice-Bankov (*Fig.1*) [2].

The GPS receivers ASHTECH: ProMARK X-CM and the total stations TOPCON: GTS 6A were used for satellite and terrestrial measurements. The non-linear rotary matrix method was applied to the adjustment. After transformation, the coordinates were consecutively adjusted by an adjustment with constraints [1].

2. DEFORMATION ANALYSE

The Košice Fold *GN* can be adjusted by two ways. If we consider datum parameters as absolutely accurate and we do not include them into an adjustment process, the adjustment with constraints is considered in this case. In fact the datum parameters are also determined with a concrete accuracy that has an influence on an accuracy of adjustment parameters except for measurement accuracy. In this case a network can be adjusted by a free adjustment with consideration of datum parameters. Regarding the applied confinement adjustment in the Košice Fold *GN* a theoretic procedure of this adjustment is presented, which is the most convenient for our national geodetic [2].

The least mean square method is chosen as an estimate principle, and the inverse solution is chosen as a mathematical principle (Gauss-Markov model), which is a standard procedure in an adjustment of the Košice Fold *GN*. After adjustment the position and form of *GN* are changed but the datum point positions are not changed (datum points are considered as absolutely accurate).

The analyze of deformations is realized in the following basic phases:

- Measurement of the *GN* points in the first - base period and determination co-ordinate estimates.
- Measurement of the *GN* points in the further period and determination co-ordinate estimates.
- Determination of the position differences and their testing.

The test decision procedure for appreciate the stability of points is demonstrated in *Fig.2*. At first, the global test for reference points is made. If the test is positive, unstable points are transposed to the object points. The test of object points is similar. The stable and unstable points are determined by an individual test.
As the base period was chosen the first period, which was measured in autumn 1997. For a consideration acquired co-ordinates is established a deformation vector. The differences are tested for a consideration of the defined null hypothesis. At first was tested the whole *GN* by the global test, which showed the ones of points changed their position. By the individual test we are detected which ones.

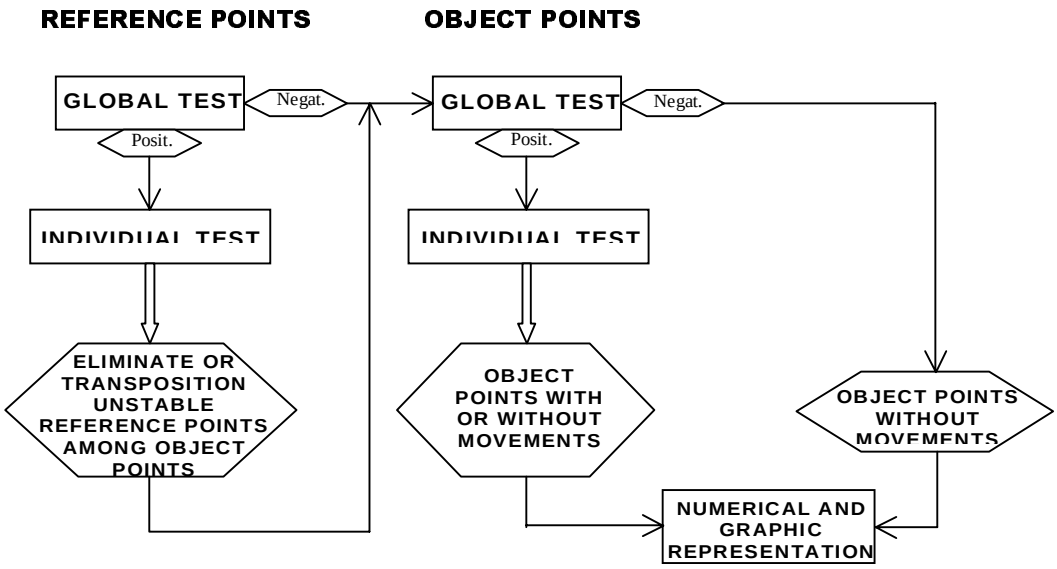

Fig. 2: Test decision procedure.

2.1 Graphic Representation and Analysis of Accuracy

The condition of observed points is transparently and completely displayed in individual periods by graphic representation in the following epochs:

- The isolines and vectors of movements (2D) in the period of two years since 1997 to 1999.
- The isolines and vectors of movements (2D) in the period of two years since 1999 to 2001.
- The isolines and vectors of movements (2D) in the period of the years since 1997 to 2001 (*Fig.3*). It is evident, the biggest movement occurred in the Košice-Bankov and Košická Nová Ves territory. It was verified by the deformation tests.

The numerical values (*WGS-84*) of the horizontal and vertical movements are shown in *Tab.1*. The points: KN2, KN3, 33, 112, 220, which changed their position according to the used test-statistics, are color marked.

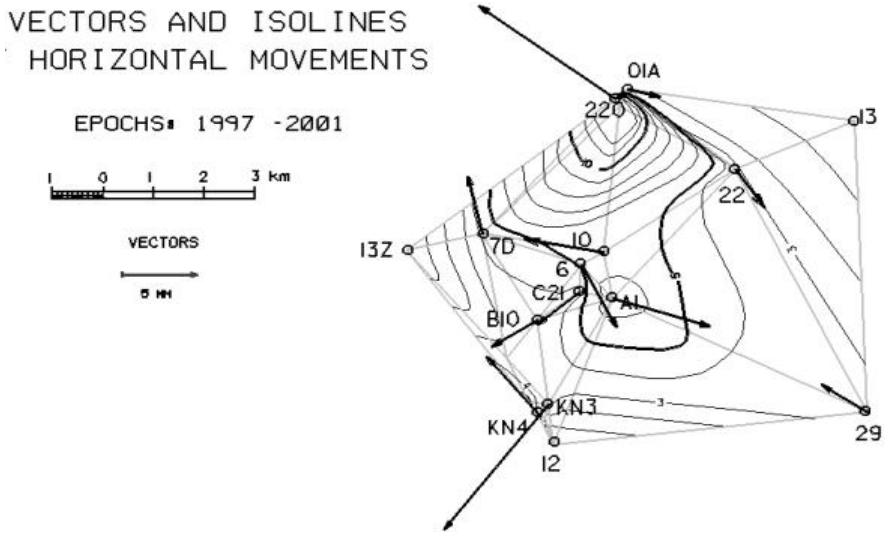

Fig. 3: Isolines and deformation vectors, 1997 – 2001 epoch.

Tab. 1: The deformation (2D & 1D) vector values and the vector bearings.

Object points	1997 - 1999			1999 - 2001			1997 - 2001		
	δ_p [m]	σ_{dp} [m]	δ_z [m]	δ_p [m]	σ_{dp} [m]	δ_z [m]	δ_p [m]	σ_{dp} [m]	δ_z [m]
KN2	0,006	80,6235	-0,0012	0,004	73,6583	-0,0013	0,010	77,6983	-0,003
KN3	0,006	34,2141	-0,0009	0,006	29,5069	0,0004	0,012	31,8001	-0,001
KN4	0,003	168,9086	-0,0016	0,003	159,5458	-0,0008	0,006	164,4653	-0,002
KN5	0,002	27,4548	-0,0004	0,001	29,1307	0,0000	0,004	28,1065	0,000
A1	0,003	315,0060	-0,0005	0,003	330,0773	-0,0003	0,006	322,7850	-0,001
B10	0,002	65,2953	-0,0006	0,002	71,7866	-0,0004	0,004	68,7907	-0,001
C21	0,001	81,4231	-0,0006	0,002	52,2829	0,0002	0,003	64,2709	0,000
6	0,003	351,6824	-0,0003	0,003	370,1831	-0,0003	0,006	361,2637	-0,001
29	0,001	144,8129	-0,0002	0,004	139,8180	0,0003	0,005	141,2165	0,000
22	0,001	337,3384	0,0003	0,002	351,4133	-0,0005	0,003	345,6190	0,000
10	0,003	142,4283	-0,0002	0,003	134,8389	-0,0004	0,006	138,5027	-0,001
7D	0,002	176,9814	-0,0007	0,002	180,8509	0,0002	0,004	179,0511	-0,001
33	0,008	134,2371	0,0011	0,007	130,4754	0,0010	0,015	132,5342	0,002
112	0,006	123,0186	-0,0061	0,005	130,4708	-0,0017	0,011	126,6067	-0,008
220	0,006	158,3338	0,0020	0,007	132,4913	0,0013	0,013	144,1060	0,003
01A	0,002	324,2060	-0,0007	0,002	312,0153	-0,0004	0,004	316,9566	-0,001
01B	0,001	102,3104	-0,0007	0,001	97,6472	-0,0005	0,002	100,3674	-0,001

The confidence ellipses, which cover non-random vectors parameter, were determined for each of the object points. The spectral analysis cofactor matrix of the co-ordinate estimate determines the structural parameters of the confidence ellipses.

2.2 GIS Applications

GIS of interested area is based on the next decision points:

- Basic and easy data presentation;
- Basic database administration;
- Wide information availability.

The best viable solution is to execute GIS project as a Free Open Source application available on Internet. The general facility feature is free code and data source viability through the HTTP and FTP protocol located on the project web pages. Inter among others features range simple control, data and information accessibility, centralized system configuration, modular stuff and any OS platform (depends on PHP, MySQL and ArcIMS port) [1].

Network based application MySQL is in a present time the most preferred database system on Internet. It is because, that MySQL company is a member of Open Source (based on GPL license), the price of this product is less than the prices of others commercial databases (i.e. Oracle, MS SQL Server, etc.), it has high-speed responses, uses fast data storing (in a binary file up to 1 TB - in 1 single file, supports unlimited quantity of s data files) etc. This database is relational database with relational structure and supports SQL language. At the present time MySQL 4.0 is released and supports transaction data processing, full text searching and procedure executing. PHP, which stands for "PHP: Hypertext Pre-processor" is a widely used Open Source general purpose scripting language that is especially suited for Web development and can be embedded into HTML. Its syntax draws upon C, Java, and Perl, and is easy to learn. The main goal of the language is to allow web developers to write dynamically generated web pages quickly, but you can do much more with PHP.

Database part of GIS for the mine subsidence Košice-Bankov application runs on MySQL database, because it is free distributed for non-commercial projects (*Fig.4*). PHP supports native connections to many databases, for example MySQL, MSSQL, Oracle, Sybase, AdabasD, PostgreSql, mSQL, Solid, Informix. PHP supports also older database systems: DBM, dBase, FilePro ...PHP can communicate with databases with ODBC interface and this feature represents PHP to work with desktop applications supporting ODBC interface. PHP cans attend to another Internet services, because includes dynamics libraries of some Internet protocols (i.e. HTTP, FTP, POP3, SMTP, LDAP, SNMP, NNTP, etc.).

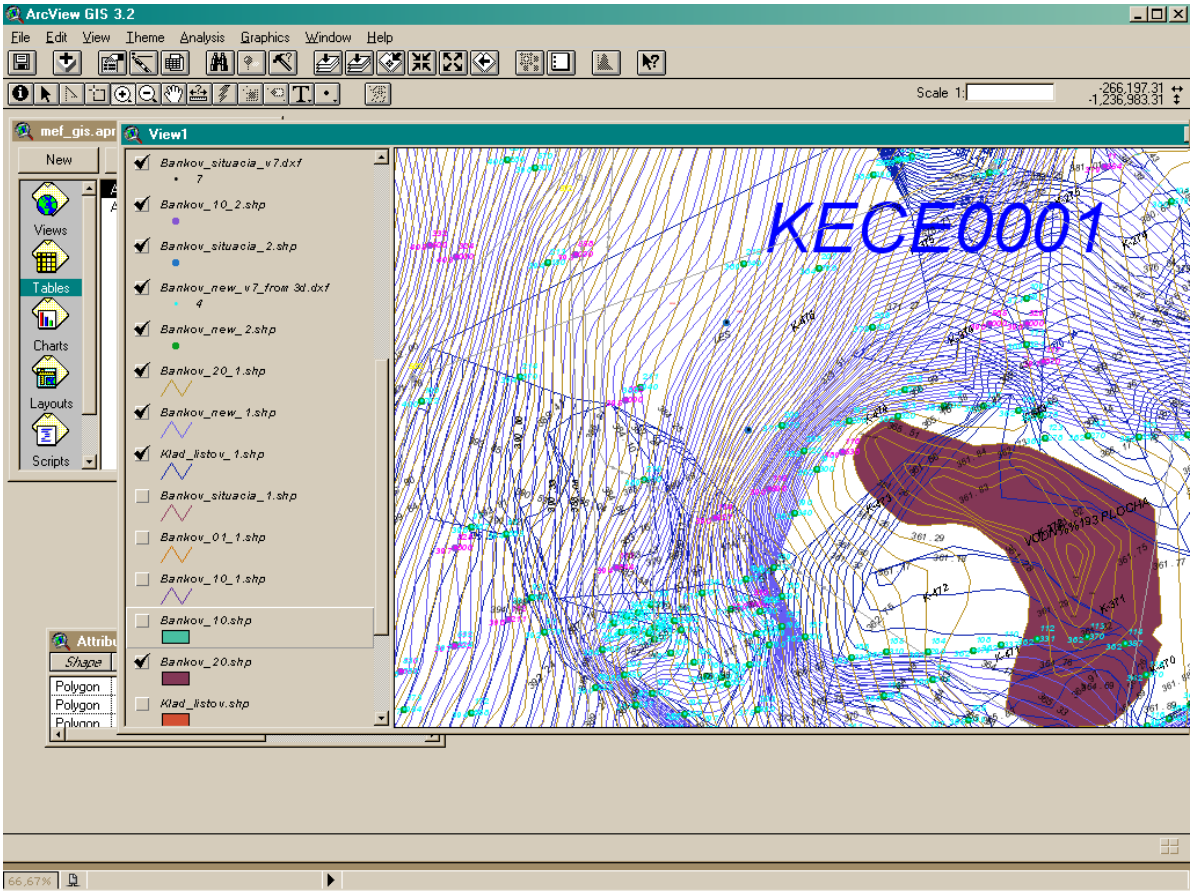

Fig. 4: The mine subsidence: Košice-Bankov (GIS-MySQL).

3. CONCLUSIONS

The results of measurements by GPS technology confirm a typical event of using this satellite measurement in *GN* with a spread application in geodesy. The applied kinematics method of GPS measurements shows on a high accuracy of satellite measurements, which is also acceptable for some other geodetic measurements, for example: a deformation surveying the earth surface and engineering structures [2]. The chosen confinement adjustment by means of using the Gauss-Markov model is demonstrated as the most suitable mathematical model in an adjustment of *GN* in the Košice Fold locality. The presupposed possible recent geo-tectonic movements in the direction of north south along the Hornád River are not confirmed.

The paper followed out from the research project No. 1/0368/03 and No. 1/8073/01 researched at the Department of Geodesy of the Technical University of Košice in Slovakia.

REFERENCES

[1] Frajt,M. & Mišovic,P., 2001: The vector applications and their utilization in GIS in the www-presentations. In: Proceedings: Mine Surveying and Engineering Surveying under the New Conditions, Herľany, Sep. 18.-19., 2001, 12-22.
[2] Frajt,M.: Modelling landslides and mine subsidence and their transfer into GIS. PhD. Thesis. TU Košice, 2002.
[3] Sedlák,V., 2000: GPS measurement of geo-tectonic recent movements in East Slovakia. In: SISOLS 2000 – Land Subsidence, Proceedings: 6th Int. Symp. On Land Subsidence, Vol.II., Ravenna, Italia, 24-29. Sep. 2000, 139-150.
[4] Sedlák,V., Hurčíková,V. a Molčíková,S., 2001: Possibilities of GPS Kinematic Measurements for Geological Survey in East Slovakia. In: Proceedings: IAG Workshop on Monitoring of Constructions and Local Geodynamic Process, Wuhan University, Wuhan, 22.-24. May, 2001, 262-268.

BIOGRAPHICAL NOTES

Prof. **Vladimír Sedlák**, MSc., PhD. is professor on mine surveying and geodesy. He is member of GA CLGE, ISM Presidium and ISM Commission 5. He published over 80 scientific papers in the Slovak and world journals and proceedings, 4 monographs and 5 books on geodesy, mine surveying, deformation survey and geophysics. **Soňa Molčíková**, MSc. and **Viera Hurčíková**, MSc. are assistant professors at the Institute of Geodesy and GIS of the Technical University of Košice. **Milan Frajt**, MSc., PhD. and **Pater Mišovic**, MSc. are research fellows at same institute. Sphere of their research activity is oriented to deformation measurements, GPS and GIS applications into the environment protection.

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