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Topographic Maps Remodelling When Changing Height System

Dr. George Valev*
Dr. Penka Kastreva**
Dr. Adib Al-Kamouh***

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□ ABSTRACT □

The change of the coordinate and height system in one country as well as the transformation to another height level and system requires compulsory transformation of the local contents and of the represent of the relief. The height transformations are not so insufficient clarified in GIS and CAD products that's why this question is very important and gets really actual nowadays. There are many publications on the way of transforming the elevations of the benchmarks of the existing height systems and the calculation of the corrections of the elevations in the Baltic system in relation to the European Height System with an initial point the gauge in Amsterdam. Unfortunately a methodology for the practical transformation of the contour lines has not been developed yet.

In this paper some basic issues and procedures on the practical application, related to the solution of this problem, have been discussed - how to correct the image of the relief, as part of the content of a digital map, while passing from one projection to another, respectively from one coordinate system into another. The problem is inevitably related to the transformation of heights, which is obligatory when changing the Sea level and the Height System.

We can use this research and its results in similar studies and researches in SYRIA.

Key words: Coordinate system, heights, transformation.

*Professor DSc. Eng. ***KONSTANTIN PRESLAVSKY UNIVERSITY***, Shumen, Bulgaria.**
****Professor Dr. Eng. SOUTHWEST UNIVERSITY NEOFIT RILSKI , BLAGOEVGRAD, BULGARIA.**
*****Professor, Department of Topographic Engineering, Faculty of Civil Engineering, Tishreen University, Lattakia, Syria.**

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إعادة نمذجة (صياغة) الخرائط الطبوغرافية عندما يتغيّر نظام الارتفاعات

الدكتور جورجي فالف*
الدكتورة بِنكا كاستريفا**
الدكتور أديب القاموع***

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□ ملخّص □

إنّ تغيير نظام الإحداثيات ونظام الارتفاعات في بلد ما يتطلّب التحويل إلى نظام ارتفاعي. ويتمّ التشكيل الإلزامي للتفاصيل المحليّة، وإعادة تمثيل تضاريس المنطقة في الجملة الجديدة.

إنّ التحويلات الارتفاعيّة ليست كافية وغير موضحة في الدراسات والأبحاث المتعلقة بأنظمة المعلومات الجغرافية *GIS* ، وأنظمة الرسم *CAD* . لهذا يعدُّ هذا السؤال مهماً جداً ويأخذ في الواقع حيّزاً من الدراسات في هذه الأيام. وتوجد مقالات عديدة تبحث في طرق تحويل الارتفاعات إلى مراجع التسوية، حسب أنظمة الارتفاعات المعتمدة، مع حساب تصحيحات المناسيب وفق نظام بحر البلطيق *Baltic System* والعلاقة مع نظام الارتفاع الأوروبي *European Height System* انطلاقاً من النقطة الأوليّة المعتبرة في القياس في مدينة أمستردام. ولسوء الطالع؛ فإنّ منهجية التحويل العملي لخطوط التسوية *Contour lines* لم تُناقش بعد.

تقدّم الورقة البحثيّة بعض النتائج الأساسية والإجراءات في التطبيقات العملية والمتعلّقة بحل هذه المشكلة. فقد نوقشت كيفيّة تصحيح تمثيل التضاريس، كجزء من محتوى الخريطة الرقمية، وذلك عند الانتقال من نظام إسقاط إلى نظام إسقاط آخر، وبالتالي الانتقال من نظام إحداثي إلى نظام إحداثي آخر. إنّ المشكلة متعلّقة حتماً بنظام تحويل الارتفاعات، وهي ضرورية عندما يتغيّر مستوى البحر والنظام الارتفاعي المعتمد.

وتُمكننا الاستفادة من هذا البحث ونتائجه في دراسات وأبحاث مماثلة في سورية.

الكلمات المفتاحيّة: نظام إحداثيات، الارتفاعات، التحويل .

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*أستاذ– جامعة كونستنتين بريسلافسكي – مدينة شومن – بلغاريا.
**أستاذة– الجامعة الجنوبية الغربية نِأُوفت رِليسكي – مدينة بلاغويف غراد– بلغاريا.
***أستاذ – قسم الهندسة الطبوغرافية– كلية الهندسة المدنية–جامعة تشرين–اللاذقية– سورية.

Introduction:

The remodeling of two dimensional data from digital map to other map projection and different coordinate system requests transformation and simplifying of the data. We make corrected image, which fit best to the used common control points. The space models, which can construct on the basic of the maps, are a combination from two images: the first one is situational or projection, the second one is connected by the relief. Since of the map is plane image, it is evident the plane or two dimensional transformations have substantial importance.[1, 2]

The height transformations from one system to another is little or almost not covered at all. But it will be needed more and more often especialy, with the transition to united height system.

As it is well known in Europe some intensive process of transition to EUREF and EUVN is going on. A new height system is defining, which is realizing by the benchmarks of National leveling, which will be connected to European unified vertical network (EUVN)

A lot has been written about the introduction, usage and application of the European Reference Frame (EUREF) and the European Vertical Reference System (EVRS). A major part of the issues related to the establishment of a common European geodetic system have found theoretical and practical solution in the works of many authors.

Undoubtedly the new European coordinate and height systems have a great significance for the cartographic work. Their introduction will lead to the remake of the existing digital plans and topographic maps, as well as of the situational content and the modeling of the relief.

The introduction of EVRS in the European countries, in addition to the numerous positive aspects, will create some problems. The height transformations are an important issue that is especially topical nowadays. There are many publications on the way of transforming the elevations of the benchmarks of the existing height systems and the calculation of the corrections of the elevations in the Baltic system in relation to the European Height System with an initial point the gauge in Amsterdam. Unfortunately a methodology for the practical transformation of the contour lines has not been developed yet.[3]

In this paper some basic issues and procedures on the practical application, related to the solution of this problem, have been discussed - how to correct the image of the relief, as part of the content of a digital map, while passing from one projection to another, respectively from one coordinate system into another. The problem is inevitably related to the transformation of heights, which is obligatory when changing the Sea Level and the Height System.

How to correct the contour lines which represents the relief when the height system had been changed? By applying the different transformations of a system of points with known heights we can define the heights of all points from the model in the new height system. The difference between the two Sea levels should be a constant value. But from the fact that the sections are shifted with one and the same value it does not ensue that the shift of the drawn contour lines should be equal, i.e. that they should be parallel to each other. It is necessary to move the contour lines to an appointed distance while one and the same points from both maps but with different heights are covered. With the modern computer equipment this procedure shouldn’t be a problem for the surveyors.

In Bulgaria a lot has been done about the introduction of EVRS. An important document is the accepted and approved by the Ministry of Regional Development and

Public Works “Instruction for the application of the Council of Ministers with the aim of introducing The Bulgarian Geodetic System 2005 (BGS2005). In the instruction concrete directions and standards have been developed on all issues related to the reference system, the coordinate system, the height system, the map projection, the scale and the system for graduation and nomenclature of the maps, the system for digital geographic information.[4]

Introducing Of The European Vertical Reference System Euvn In Bulgaria:

During the last few decades in Europe and the world there have been global changes in the field of geodesy, coordinate systems and networks. By means of satellite technologies today we can perform precise definition of coordinates in the 3D space. Undoubtedly one of the most effective and promising technologies is the GPS (GNSS) with which the base of a new geodetic DATUM was established. The common European geodetic basis in the 3D space is defined by the geodetic coordinate system ETRF-89 by means of the built EUREF-network in Europe and the Common European Levelling Network.

The national height systems for the countries in Western and Northern Europe and in Eastern and Central Europe are with different kinds of heights and a different starting point. The zero level for UELN is the mareographe (tide-gauge) in Amsterdam, and for UPLN – Kronstadt. The difference between the two levels h(Amsterdam) – h(Kronstadt) is calculated for every East European country, included in EUVN. The new height system is based in data from normal heights, related to the mareographe in Amsterdam.

Till 2006 the national height network of 26 European countries has become part of the UELN network, including Bulgaria. After Bulgaria joined it in 1995 the results of the inclusion of the State Levelling Network (SLN) in the European Height System EUVN have been published.

The state of the UELN network with the inclusion of SLN of Bulgaria after leveling is characterized with the following parameters: [5]

- Total average error from the networks of the participating countries is 1,28 mm/km.
- The difference between the levels in Amsterdam and Kronstadt for Bulgaria is +18 cm.

Experimental Investigation:

The introduction of a unified European geodetic system reflects on the cartographic and geodetic products. This will result in remaking the existing digital plans and topographic maps, not only of the situational content but also of the relief representing.

At this stage the geodetic staff has accumulated rich experience in the transformation from one coordinate system into another of the situational content of the plans and maps by means of famous Bulgarian and foreign software products. Up till now, however, there’s no practice, nor a methodology for the practical transformation of the contour lines when passing to another height system. In this paper some basic issues and procedures on the practical application, related to this problem, are discussed.

The difference of +18 cm between the two height systems logically raises some questions:

1. How the drawing of the new horizontal lines will be drawn and how the already existing ones will be erased?

2. How will this difference in the elevations affect the change of the representation of the contour lines?

3. To which scale order of the plans and the maps the difference between the two height systems will change the relief and a shift of the contour lines will be necessary?

Regarding the first question there is hardly any doubt that the answer will be: by means of a digital model of the relief. Of course this means that the respective map has to be digitalized and it's obligatory that the situation and the contour lines are in two different levels. Further on the basis of the digital model of the relief in the old height system all elevations increase with the value of 18 cm. On the basis of the changed elevations a new interpolation of the contour lines is carried out and the new height model is laid on the model of the situation. It is necessary to change the individual isolated captions of heights of separate objects.[6]

In connection with the solution of the other two problems several experiments have been done. There have been used images of contour lines in different sections of the relief in the following scales: 1:500, 1:1000, 1:2000, 1:5000, 1:10 000, 1:25 000, 1:50 000 and 1: 100 000. Suitable objects for investigation have been chosen, which include both flat and steep terrains.

On the basis of the analyses of the results ideas for solving the problem have been suggested and also a technology for their practical realization. Bearing in mind that the cartographic activities are connected mainly with digital models of the area, the aim of the investigation was to find what is the value of the shift of the contour lines for the different scales and a technology for remaking the image of the relief with the means of the computer and information technologies.

On the first place experiments for the remaking of the relief have been made by using a system of points, chosen along the contour lines. Their density was considered according to the requirements for an average number of detailed points with different categories of the terrain and scales of the picture. The points are chosen to be uniformly situated on the area and for representing characteristic relief forms additional points are used. For the chosen points on the horizontal lines the elevations are changed with +18 cm and new contour lines are interpolated. As it has logically been expected, when comparing the two models it has been found that the new contour lines do not follow the same configuration of the old contour lines and they are not parallel to each other.

For M 1:500 the experiment was repeated with detailed points from a geodetic survey, from which the initial contour lines were interpolated. The problem with the lack of parallels between the two images appeared in this case as well and we consider it is due to several reasons. First, the contour lines in the original are interpolated manually and the modeling of the relief depends on the personal perception of the forms by the cartographer, while at the present research an automated ay is applied by using specialized software and the subjective moment is excluded. Secondly, in order not to repeat the same contour lines from the original the point chosen by the above mentioned rules are not enough. Because of the lack of parallelism of the contour lines with the same names from the original and the copy the shift of the contour line is not with a constant value in its different parts.[7]

The second group of experiments is done with all points from the digital model from the relief. In this way the newly formed contour lines fully "repeat" the configuration of the original.

Theoretically we can calculate the relation between two neighboring contour lines with a change in the height of the section with +18 cm and with a different inclination of the terrain. (see Table 1)

Table 1. Basic section of the relief with a different inclination of the terrain and ecartement between the neighboring contour lines with a height of the section h=0,18 m.

Inclination of the terrain	Ecartement D (h=0.18)	Basic section H in scales:							
		500	1000	2000	5000	10000	25000	50000	100000
Flat to 3°	3.43	1	1	1	1	1	10	10	20
Flat and hilly to 6°	1.71	1	1	1	1	2	10	10	20
Mountaneous to 12°	0.84	1	1	2	2	5	10	10	20
Alpine above12°	Above 0,84	1	1	2	5	10	10	20	40

Within the map sheet regions with a different inclination of the terrain were chosen for every scale. New contour lines are interpolated with a height changed with +18 cm for every point from the digital model. In the compared digital model every pair a homonymous contour lines (original and newly formed) are compared and the distances among them on the whole territory are accounted. The received average deviations of the homonymous contour lines fully confirm the theoretical deviation (see Table 1), calculated for a different inclination of the terrain. (See Table 2).

Table 2. Comparison of the mean differences of the homonymous contour lines and limit distance for representation

Scales	Inclination of the terrain On the research area Ecartement for height section 0.18 m	Deviation between the same contour lines by measurements from the digital model	Minimal distance between two neighbour contour lines (0.2M)
500	Inclination - 4.3% (2˚.5) Theoretical deviation 0.18/0.043=4.18m	Min 2.84. Max 5.46m Mean 4.15m.	When the difference is (0.2M)>10cm some new contour lines are modelling
1000	Inclination 15.7% (8˚9) Theoretical deviation 0.18/0.157=1.15m	Min 0.24m. Max 2.50m Mean 1.38m	When the difference is (0.2M)>20cm. some new contour lines are modelling
2000	Mountain 12% (6˚.9) Theoretical deviation 0.18/0.12=1.50m Plane 6.1% (3˚.5) Theoretical deviation 0.18/0.06=3m	Min 0.58m. Max 2.28m Mean 1.30m Min 2.67m Max 12.93m Mean 6.40 m	When the difference is (0.2M)>40cm. some new contour lines are modelling
5000	Plane 4.08 (2˚.33) Theoretical deviation 0.18/0.04=4.5m Height mountain 18.1% (10˚.29) Theoretical deviation 0.18/0.18=1m	Slope terain 15% -(8˚.5) Min 0.24m Max 2.50m Mean 1.38m. Plane terrain Inclination 1.1% -(0˚.65) Mean 8.6m	When the difference is >(0.2M)>1m some new contour lines are modelling
10 000	2.5% (1˚.48) Theoretical deviation 0.18/0.025=7.2м	Min 5.95m. Max 8.14m Mean 6.97m	When the difference is >(0.2M)>2m Some new contour lines are modelling

25 000	Plane 2.48% (1˚.42) Theoretical deviation 0.18/0.0248=7.2m	Min 5.95m. Max 8.14m Mean 6.97m.	When the difference is >(0.2M)>5m new contour lines are modelling
50 000	Height mountain 28% (15˚.9) Theoretical deviation 0.18/0.28=0.64m	Min 0.24m Max 2.50m Mean 0.90.	When the difference is (0.2M)=10m<mean difference 0=90 new contour lines are not modelling
100 000	Plane 3.3% - 1˚.94 Steep 18.5% (10˚.5)	Min 0.24m Max 2.20m Mean 0.46m.	(0.2M)=20m< mean difference. 0.46 new contour lines are not modelling

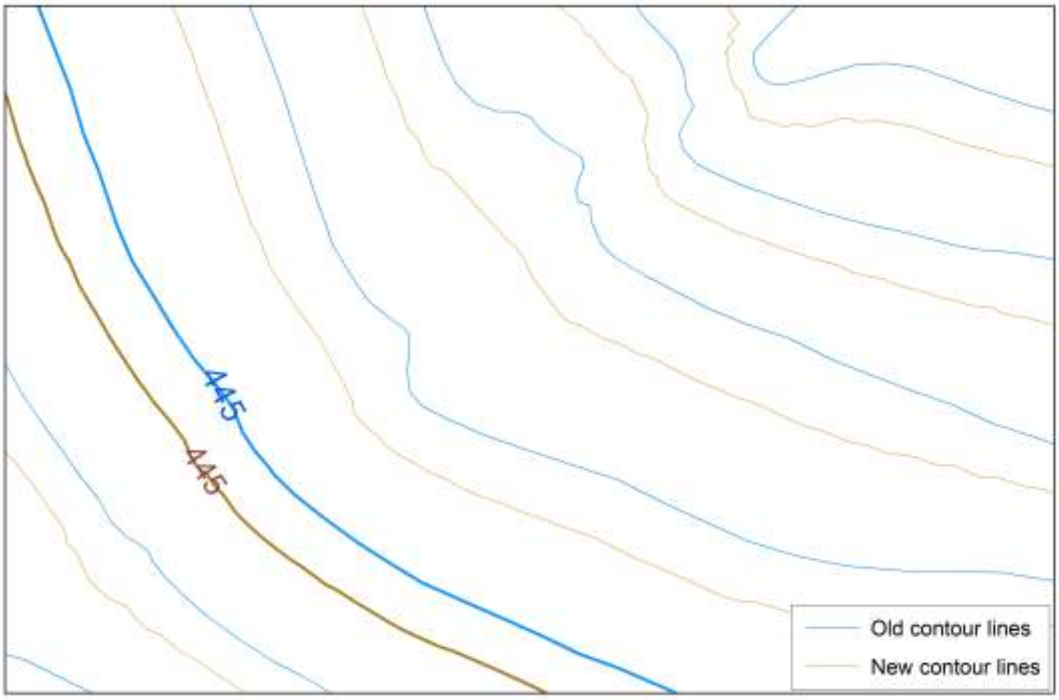

Figure 1.Part of a combined digital model in M 1:500

The human eye has a limited ability to discern details. There is a minimal perceptible distance, which can be used to distinguish the graphic elements and below this limit they will fuse. The distance that is necessary to input neighboring signs to ensure their individual representation with a naked eye under normal conditions of visibility is 0,2 mm for parallel lines or closely touching territories. In the geodetic and cartographic literature this term, related to the smallest possible distance, which can be represented on the map, is known as utmost graphic accuracy.

When we compare the last column of Table2 with the measured average distances among the homonymous contour lines represented in the two height systems we can assess in which of the scale rows these deviations are outside the limits of the utmost accuracy and can be neglected. In spite of that when increasing the visual scale the contour lines are clearly distinguished from one another on the computer screen.

As it has been expected, the contour lines in the large scale plans and maps change their location significantly in the new height system, especially for a flat terrain. The deviations that have been found out can be represented in the scale of the map. This is established for the following scales: 1:500, 1:1000, 1:2000, 1:5000, 1:10 000 and 1:25 000. For the rest of the scales – 1:50 000 and 1:100 000 we consider that the measured distances between every two homonymous contour lines form the combined model of the relief won't cause a shift of the original contour lines since these differences are small enough to be reflected in the scale of the map.

All this is true when we speak of graphic images on paper or another surface. But the additional question rises whether the so called "graphic precision" of 0,2 mm is valid for the digital models. It is hardly possible to give a simple answer to this question. The issue has a scientific and practical aspect but also an economic one. The solution is probably a settlement of compromise.

Technology For Practical Application Of The New Height System:

The remaking of the relief of the map sheets from all scale rows requires a precise digitalization of the original contour lines. For a more precise reproduction of the configuration of the contour lines in the vectorization linear lines with a length of about 20 m in the scale of the map are formed, and in the curved areas with more points.[8]

Using all points obtained from the digital model of the relief has the advantage that the new contours are precise copies of the original and are parallel among each other. With the available software products we can comparatively easy to draw a list with the coordinates and elevations of each point from the digital model and to change their elevations with +18 cm with an ordinary text editor. When we use CAD software we can point as a disadvantage the comparatively huge files for one map sheet, from which TIN models are created and new contour lines are modeled.

To solve this problem is easier to use GIS software for modeling of a TIN model from digitized contours, choosing their new height, which are increased by 18 cm. It was introduced in the attribute table as a new property.

The suggested technology for modeling new contour lines uses the available possibilities of the software products. The results from the performed experiments, however, can bring forth new ides for automatic transformation of the representation of the relief from one to another height system similarly to the transformations of coordinate systems and map projections.

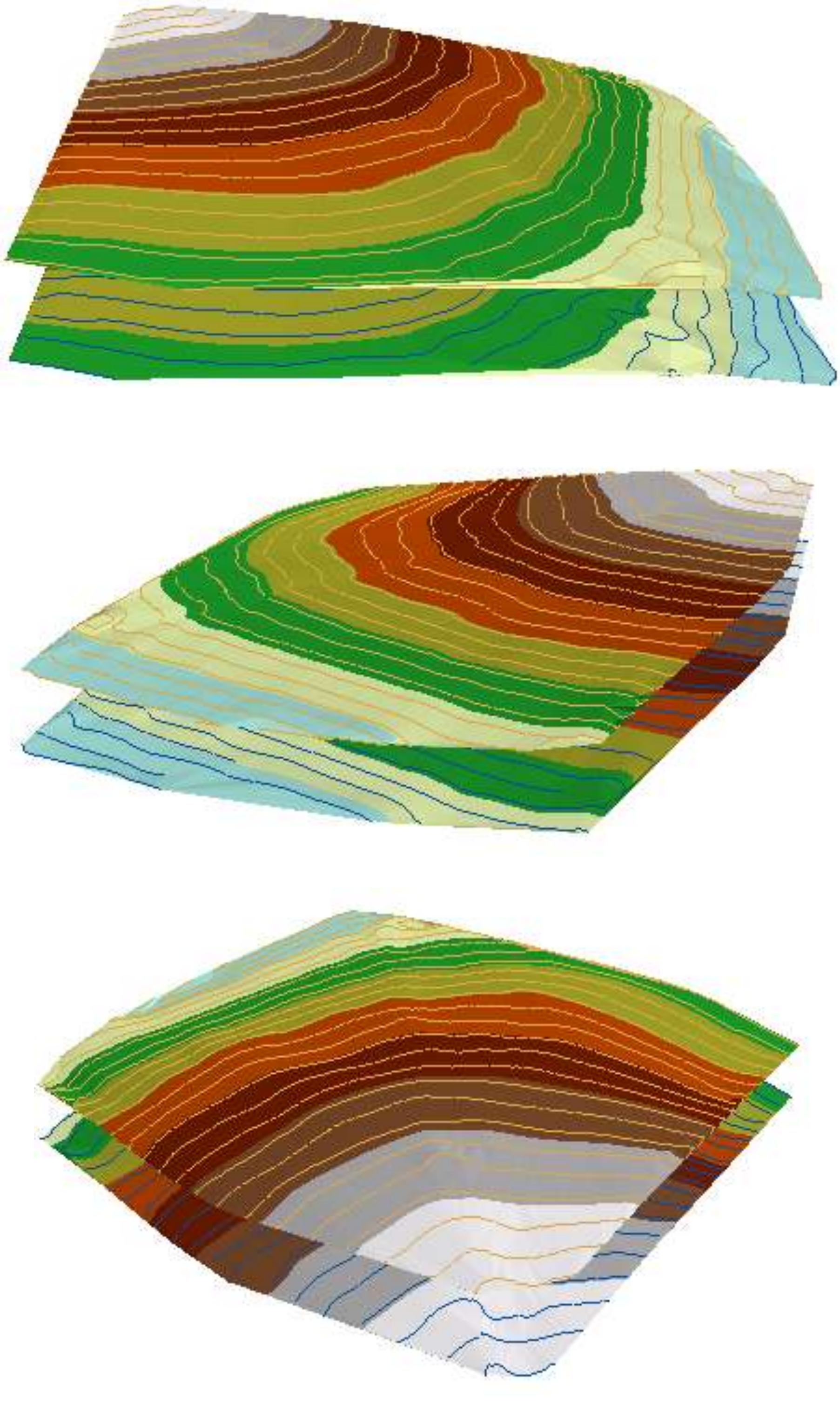

Figure 2 **Perspective view of the two surfaces – with the new contour lines and the old ones**

Conclusions:

The connection of points in a unified network from EUREF and EUVN for the first time in Europe is a step towards building an integrated coordinate-height system of the measurements in the field of geodesy. In their turn these networks are a basis for building of GIS in different fields of science and practice that require a constant spatial envelopment of the map content. This integrated approach gives the possibility of storing the map objects and their attributes in a common spatial model. A permanent spatial base in the 2D and 3D space can be built in a national, regional and global scale. From this point of view the advantages of the European Reference System are indisputable.

It is clear that the new plans and maps will be easily made in the integrated coordinate-height system of Europe by using the new geodetic networks EUREF and EUVN. The immense fund of geodetic and cartographic material, however, has to be used for many reasons – the immense investment of finances, time and labour resources, precise, quality and still topical map materials and other valuable qualities. All this requires remaking of the already created plans and maps in the new BGS 2005, which is fully compatible with the requirements of the new European reference system.

REFERENCES:

1-Belyashki T. (2004). Linking state leveling network in Bulgaria with the Unified European leveling network. Issue. 5-6, , 3 - 5. Geodesy, cartography and land management. 5-6, 2004 г.

2-Pashova L. (2009) Height systems used in Bulgaria and prospects for transition to European Vertical Reference System (EVRS), Part I, II, III. Geomedia.

3-B-G Reint. A simple way of introducing a global reference frame in surveying and mapping. The National Land Survey of Sweden. Vol 34, №264, pp 87-90.

4-H. Seeger, J. Ihde, A. Franke, J. Luthardt, U. Schirmer, H. Schoch, F. Stefani, F. Toppe. Advanced Geodetic Reference Systems in the New German States. EUREF – Symposium, June 04-07 1997, Sofia, Bulgaria.

5-Ihde J., W. Schluter. Proposal for a European Vertical GPS Reference Network (EUVERN). EUREF – Symposium, May 03-06 1995, Kirkkonummi, Finland.

6-Ihde J., W. Schluter, J. Adam, W. Gurtner, B. Harsson, G. Woeppelmann. European Vertical Reference Network 97 GPG Campaign (EUVN97). Report of the EUVN Working Group presented at the EUREF – Symposium, June 04-07 1997, Sofia, Bulgaria.

7-Lang H., M. Sacher, H. Schoch. Status and Results of the Adjustment and Enlargement of the United European Levelling Network 1995 (UELN-95). EUREF – Symposium, June 04-07 1997, Sofia, Bulgaria.

8-N. Rozic. Accuracy of the geometric leveling networks at the territory of Croatia. Symposium of the IAG Subcommission for Europe (EUREF) June 05-08 2002, Ponta Delgada, Portugal.