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HUNGARIAN GPS NETWORK TRANSFORMATION INTO DIFFERENT DATUMS AND PROJECTION SYSTEMS

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Abstract

The results of the GPS network adjustment are the adjusted co-ordinate components of vectors, the co-ordinates of network stations and accuracy data. We have more options to convert the co-ordinates into national datum depending on whether the co-ordinates of the national initial station are obtained from absolute point positioning (local datum) or the initial station is included in the EUREF network having known co-ordinates. In the latter case a quasi transformation can be performed with the known transformation parameters. To reduce discrepancies we apply 2D Helmert, affine and 5th order polynomial transformations.

Keywords: GPS data processing, transformation.

1. Introduction

The application of GPS technology becomes more important nowadays. Every user can choose from several manufacturers products including geodetic accuracy GPS receivers and navigational receivers as well according to their demand and financial situation. Most of the users apply such software systems for data processing which belong to receivers. Consequently the obtained results are very rarely suitable for immediate practical aims. In most cases further computations needed for the obtained data can be applied to a user defined co-ordinate system. In the following we present kinds of computation methods and procedures which allow to convert GPS observable results processed by manufacturer's software into the Hungarian unified national projection system (EOV), Gauss-Krüger and UTM projection systems. The applied methods satisfy the accuracy requirements both for the geodetic and the geomatic fields. Using the national GPS network point with known EUREF co-ordinates, the adjusted co-ordinates will be in EUREF system as well. It is very important to distinguish these two cases (EUREF and local datum) because one can obtain even 100 meter differences in co-ordinates for the same point applying the above mentioned two methods (HOFMANN–WELLENHOF et al., 1994).

2. Transformation between GPS and National Geodetic Datums

It could be seen that the derived co-ordinates refer either to local or to EUREF geodetic datum (ÁDÁM–BORZA, 1995). Because none of them correspond with the currently applied geodetic datum in Hungary, consequently, a transformation has to be performed. Depending on source systems there are different options for transformations. One can compute the transformation parameters in advance for later use if the geodetic control network points have EUREF and unified national projection system (EOV) co-ordinates as well. In contrast to the earlier case using local datum we have to measure common points with GPS for determining local transformation parameters. In the following we present three transformation methods. The first one can always be applied if at least three common points are available. The others have been established to perform transformation between EUREF and HD72 geodetic datums.

2.1. The Seven Parameter 3D Transformation

The seven parameter spatial similarity transformation can be performed between two 3D systems belonging to two different geodetic datums. The transformation parameters are the 3 rotation angles, the 3 translation parameters and the scale factor. For determination of seven parameters at least three common points are necessary 3D co-ordinates of which are known in both systems. On the basis of three points we can set up nine equations for determining transformation parameters. As the number of equations (9) is greater than the number of unknown parameters (7) we can use least-square adjustment technique for determination of the parameters. This method can be applied between any arbitrary systems where the 3D co-ordinates of common points are known. If the plain co-ordinates of the common points are available, we can compute the ellipsoidal latitudes and longitudes. The ellipsoidal height can be obtained by adding orthometric height to the geoid undulation in a given point. Using such ellipsoidal latitudes, longitudes and heights, it is possible to compute the 3D co-ordinates. The step by step solution is described in (PAPP et al. 1997, 1999; VARGA 1986).

3. Two Conversion Alternatives Using EUREF System

We used the Hungarian national GPS frame network consisting of 43 points with given EUREF and HD72 ellipsoidal co-ordinates and EOV plane co-ordinates as well. The reference surface of EUREF geodetic datum is the GRS80 ellipsoid practically with the identical parameters as WGS84 ellipsoid. The existing reference system called Hungarian-Datum 1972 (HD72) was developed by applying the ellipsoid of the IUGG Geodetic Reference System-1967. In Hungary a double projection is used, which means that first we project from IUGG67 ellipsoid to the local Gaussian sphere, then from the sphere to the oblique conformal cylindrical projection system (EOV) (VARGA, 1986).

3.1. Co-ordinate Transformation Using Differences of Latitude and Longitude

First we computed geodetic latitudes and longitudes of the points at the GRS80 ellipsoid, using the 3D Cartesian co-ordinates of the Hungarian national GPS frame network consisting of 43 points. Then we computed the geodetic latitudes and longitudes of the same points at the IUGG67 ellipsoid from EOV 2D plain co-ordinates. The next step was the computation of the $\Delta\Phi_i$, $\Delta\Lambda_i$ co-ordinate differences at all points and the $\Delta\Phi$, $\Delta\Lambda$ arithmetical means determination. After this we changed the GRS80 ellipsoidal co-ordinates of every newly observed point with $\mathrm{d}\Phi$ and $\mathrm{d}\Lambda$ values and these approaching IUGG67 (Φ), (Λ) co-ordinates were used for computation of the approximate EOV co-ordinates. The obtained approximate EOV $(Y$, $X)$ co-ordinates are near to the real EOV Y, X co-ordinates which can be directly used for geomatic purposes. In order to meet geodetic accuracy requirements and in geodetic applications we apply a 2D Helmert transformation, 2D affine transformation or fifth-order polynomial transformation to reduce transformation errors. Isolines had been constructed using remaining discrepancies (*Fig.1–3*).

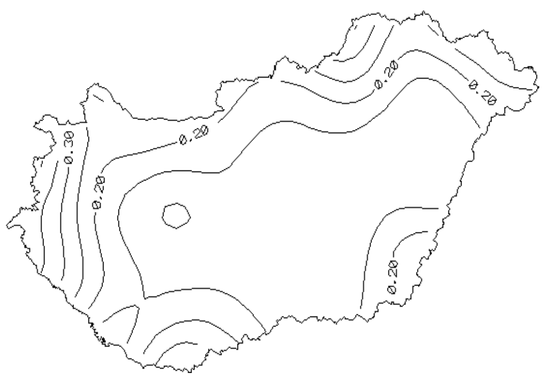

Fig. 1. Residuals after 2D Helmert transformation [m]

3.2. IUGG67 Ellipsoid Centre Fitting

We put the IUGG67 ellipsoid into the Earth's centre of mass corresponding to the WGS84 system. The approximate IUGG67 ellipsoidal co-ordinates computed from Cartesian GPS co-ordinates differ from the original IUGG67 ellipsoidal co-ordinates as a consequence of different parameters of IUGG67 and GRS80 ellip-

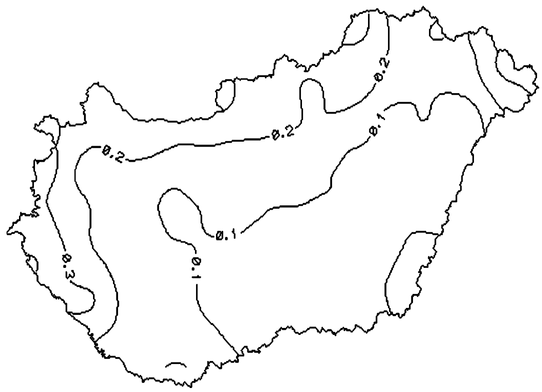

Fig. 2. Residuals after 2D affine transformation [m]

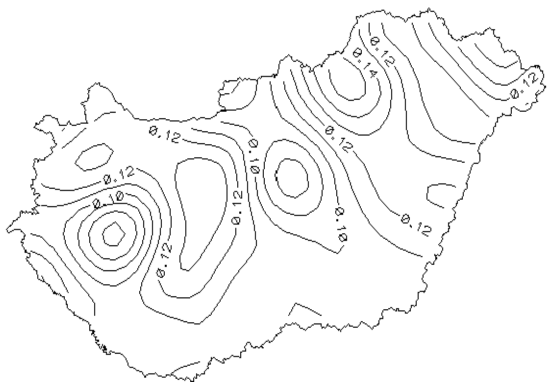

Fig. 3. Residuals after fifth order polynomial transformation [m]

soids. The magnitudes of differences are: $d\Phi = +0.9430''$ and $d\Lambda = +4.0495''$ (PAPP et al., 1997; 1999). Changing the approximate IUGG67 ellipsoidal co-ordinates by these differences the obtained (Φ) and (Λ) values are close to the real IUGG67 ellipsoidal co-ordinates. The computation of the approximate EOV co-ordinates can be done according to the previous solution. For presenting remaining discrepancies isolines were constructed (*Fig.* 4–6).

4. Processing Software Products

Adjusting, transformation and map projection conversation software products had been developed based on the previously described principles by TU Budapest Department of Geodesy and Surveying which use Trimble 4000SE and 4600LS single

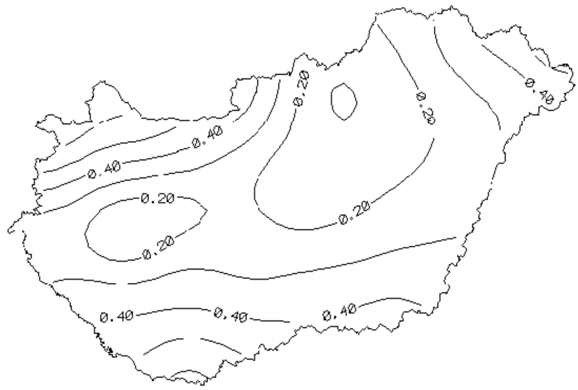

Fig. 4. Residuals after 2D Helmert transformation [m]

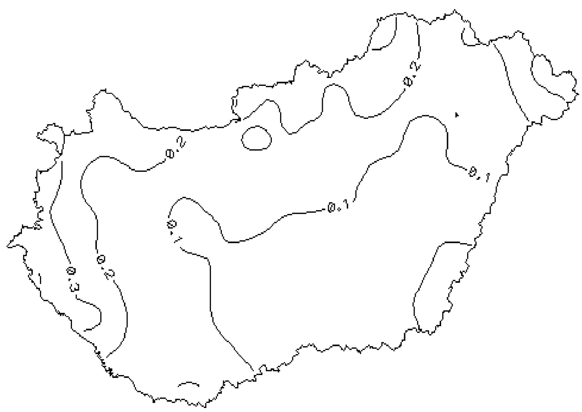

Fig. 5. Residuals after 2D affine transformation [m]

frequency GPS receivers and Trimble GPSurvey Geomatics Office software for post processing observables. As a result of processing the obtained file consists of the endpoint co-ordinates, the co-ordinate components of the observed vectors and the reliabilities. This file contains the input data of the home-made post processing software which can run under DOS and WINDOWS operation systems offering interactive computation. The network adjustment is the first step. Before the network adjustment the datum points have to be fixed. After this the computation can be done automatically. The next steps are transformations of adjusted network into desired datums and national projection systems. The common points can be stored in a file but can also be entered by keyboard.

A software system had been established on HEWLETT PACKARD 48SX scientific advanced calculator for quick and simple field computations. The available

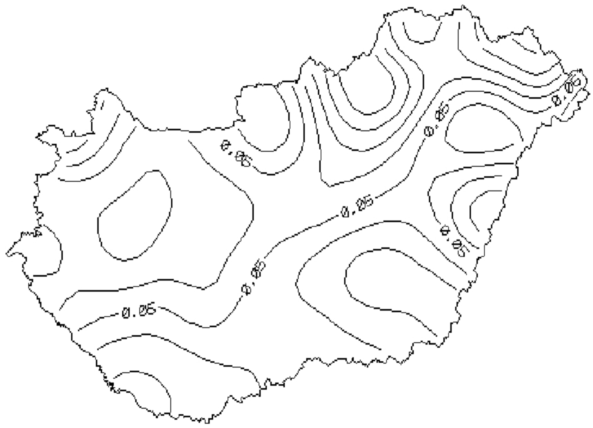

Fig. 6. Residuals after fifth order polynomial transformation [m]

software products include the Hungarian unified national projection system (EOV), 2D Helmert transformation, 2D affine transformation and fifth order polynomial transformation.

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