













$$\sigma_p = \left[ \frac{1}{3} (\sigma_{X_i}^2 + \sigma_{Y_i}^2 + \sigma_{Z_i}^2) \right]^{1/2};$$

3) Confidence absolute ellipses or ellipsoids, which were used for a consideration of the real 2D or 3D in the point accuracy. We need to know the ellipsis constructional elements, i.e., semi-major axis  $a$ , semi-minor axis  $b$ , bearing  $\varphi_a$  of the semi-major axis and ellipsoid flattening  $f$ , ( $f = 1 - b/a$ ).

The network quality is mainly characterized by accuracy and reliability. Position accuracy of points can be expressed in addition to numerical and also graphical indicators of the network accuracy, which are the confidence curves and confidence ellipse (confidence ellipsoids in 3D case). Ellipsoids determine a random space, in which the actual location of points will be lie with a probability  $1 - \alpha$ , where  $\alpha$  is the chosen level of significance, according to which the ellipsoids are of different size. In geodetic practice, the standard confidence ellipsoids are used for 3D space. Their design parameters can be derived either from of the cofactor matrix  $Q_L$  of the adjusted coordinates, which shall be these design parameters on the main diagonal, or from the coordinate covariance matrix of the coordinate estimations  $\Sigma_{\hat{c}}$  of the determined points, which shall be them on the main diagonal.

All calculated data according to the presented specific theory about the deformation vector estimation in a case of any accepted changes in the geodetic network of the monitoring station are presented in **Tables 1-5**. In general, **Tables 1-5** focused on the accuracy and quality assessment of the geodetic network (**Table 1**: global indices; **Table 2**: mean errors; **Table 3**: absolute confidence ellipse elements; **Table 4**: local indices; **Table 5**: values of deformation vectors<sup>2</sup>).

**Table 1.** Global indices (spring 1976 / autumn 2014)

Rank	Track	Determinant	Average mean error	Norm
$rk(\Sigma_{\hat{c}})$ [mm <sup>2</sup> ]	$tr(\Sigma_{\hat{c}})$ [mm <sup>2</sup> ]	$det(\Sigma_{\hat{c}}) 10^{25}$	$\sigma_{\hat{c}_{pr}}$ [mm]	$Nor(d_{\hat{c}})$ [mm]
14/14	7041.901 / 040.879	2.869 / 2.871	22.428 / 23.051	124.218 / 25.043

<sup>2</sup> The values of the deformation vectors from the last geodetic measurement (autumn 2014) are compared to the deformation vectors from measurements in 2007 (spring 2017). In 2007, the theory of a specific deformation vector solution presented in the article was verified for the first time in the Košice-Bankov mine subsidence.

**Table 2.** Mean errors (spring 1976/autumn 2014)

Point	$m_x$ [mm]	$m_y$ [mm]	$m_z$ [mm]
2	15.7 / 17.8	32.9 / 44.6	12.5 / 70.9
3	14.8 / 31.2	27.2 / 59.0	30.5 / 69.8
30	21.1 / 27.7	26.5 / 21.9	45.5 / 31.2
38	16.6 / 21.6	16.3 / 10.3	20.1 / 19.1
104	18.2 / 40.4	34.1 / 68.7	55.4 / 79.9
105	28.2 / 34.9	17.1 / 24.2	9.9 / 20.4
227	20.0 / 19.2	8.5 / 8.5	10.9 / 12.5

**Table 3.** Absolute confidence ellipse elements (spring 1976 / autumn 2014;  $\alpha = 0.05$ )

Point	$a_i$ [mm]	$b_i$ [mm]	$\varphi_{a_i}$ [gon]	$f$
2	49.9 / 53.5	5.9 / 8.2	172.303 / 172.684	1.8818 / 1.1008
3	40.8 / 30.4	12.3 / 3.5	172.704 / 179.148	0.6985 / 0.8794
30	43.0 / 42.4	18.2 / 20.1	160.340 / 160.054	0.5767 / 0.7821
38	23.5 / 29.8	21.8 / 23.4	40.966 / 41.122	0.0723 / 0.2523
104	47.5 / 79.7	24.0 / 10.1	211.146 / 217.101	0.4947 / 0.8991
105	42.8 / 45.0	15.3 / 19.3	370.337 / 371.011	0.6425 / 0.5851
227	28.8 / 25.4	8.1 / 9.8	19.634 / 12.226	0.7188 / 0.6673

**Table 4.** Local indices (spring 1976 / autumn 2014)

Point	Mean 3D error $\sigma_p$ [mm]	Mean coordinate error $\sigma_{xyz}$ [mm]
2	36.4 / 39.7	25.7 / 19.2
3	30.9 / 28.7	21.8 / 24.7
30	33.9 / 32.4	23.9 / 23.5
38	23.3 / 27.2	16.5 / 12.9
104	38.6 / 17.2	27.3 / 55.4
105	32.9 / 26.2	23.3 / 21.5
227	21.7 / 23.7	15.3 / 19.1

**Table 5.** Deformation vector values (spring 2007<sup>3</sup> / autumn 2014)

$d_{\hat{c}}$ [mm]	Point						
	2	3	30	38	104	105	227
2.4 / 3.1	-2.9 / -2.8	-8.0 / -9.8	6.7 6.9	-4.0 / -5.7	0.6 / 1.4	9.7 / 10.5	

**Tables 1-5** comprehend the adjusted mean errors of the individual coordinates, global and local 3D indices and their absolute confidence ellipsoid elements determining 3D accuracy of some chosen replaced points. The numbers in front of the back slash belong to year 1976 when geodetic measurements were started. The numbers after the back slash belong to the autumn of 2014<sup>4</sup> when all geodetic measurements were finished. In 2007, the points No.: 2, 3, 30, 38, 104, 105 and 227

<sup>3</sup> 2007 — the year of verification of the theory of the presented specific solution of the deformation vector in the Košice-Bankov mine subsidence.

<sup>4</sup> Deformation survey on the monitoring station of Košice-Bankov without the reclamation work intervention was finished in the autumn of 2014.











