Solution on the three transformation method gave the following results (Table).

Transformation coefficients and estimate of accuracy are calculated by three methods

Method	The solution by stretching method	The decision on the regression model with two-dimensional response on the basis of the generalized least-squares method	The decision on the regression model with two-dimensional response on the basis of the theorem about the characteristics of a multivariable conditional distribution law
Results of the solution	$\hat{x} = \begin{bmatrix} 1.039159 \\ -0.816950 \\ 0.599934 \\ 1.258032 \\ 100.113 \\ 200.026 \end{bmatrix}$	$\hat{k} = \begin{bmatrix} 1.039159 & 0.599934 \\ -0.816950 & 1.258032 \\ 100.113 & 200.026 \end{bmatrix}$	$\hat{X} = \begin{bmatrix} 1.039159 & -0.816950 \\ 0.599934 & 1.258032 \end{bmatrix}$ $\hat{D} = \begin{bmatrix} 100.113 \\ 200.026 \end{bmatrix}$
Estimate of accuracy	$\hat{\sigma}_o = 0.07824$ $\hat{\sigma}_a = \hat{\sigma}_d = 0.000000938$ $\hat{\sigma}_b = \hat{\sigma}_e = 0.000000661$ $\hat{\sigma}_c = \hat{\sigma}_f = 0.00161753$	$\hat{\sigma}_o = 0.07824$ $\hat{\sigma}_a = \hat{\sigma}_d = 0.000000938$ $\hat{\sigma}_b = \hat{\sigma}_e = 0.000000661$ $\hat{\sigma}_c = \hat{\sigma}_f = 0.00161753$	$\hat{\sigma}_o = 0.07824$ –

Thus, the results of the calculation have shown that all three methods have presented similar conversion coefficients and the same estimate of accuracy. However, the second and third methods of transformation have a simpler realization of the algorithm. They were derived from the interpretation of the problem of transformation as a two-dimensional regression with two-dimensional response. Also the sense of the produced actions is visible at every step in the second and third approaches in contrast to the first transformation method. It allows better built calculations and analysis. Also it is important that the reducibility of a plane affine transformation to the two-dimensional regression with two-dimensional response makes it possible to use all the possibilities that are inherent of regression analysis, for example, determination, robustness, orthogonal regression, race-extension analysis. In its turn it makes it possible to obtain more qualitative and more adequate results of processing.

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UDC 528.5

INVESTIGATION OF FEATURES SIGHT AND MEASUREMENT LINES USING GEODETIC REFLECTORS

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The article presents an analysis of the errors of sight and measuring lines. These errors occur when non-strict orientation geodetic reflector rangefinder. The dependence of the magnitude of the error on the conditions of orientation and design of the reflector.

Surveying reflectors are important devices in the production of surveying. However, many surveyors still pay attention to the characteristics of the tacheometer, forgetting about the impact on the accuracy of the reflector. To perform high-precision measurements it is necessary to consider various factors of influence of geodetic reflectors on measurement of corners and distances.

The main factors that have the greatest impact on the results of geodetic measurements are precision centering of the reflector in the assembly (alignment of the reflector) and the strict orientation of the reflective surface on the rangefinder [1]. This article presents a study of the effect that occur when no strict orientation membrane and prismatic reflectors on the rangefinder.The study was performed at different times for the two lines of different lengths. The temperature and pressure were taken into account when measuring (table 1).

Table 1 – Characteristics of the measurement series

Series	Measurement distance, m	Temperature, C°		Pressure, Millimeter of mercury
		beginning of a series	end of series	
1	50	9	6	749
2	100	15	13	747

The measurement was carried out on the lines in the membrane, and prismatic reflectors. Tacheometer Trimble M3 2013 DR5 " was used for the measurements. Accuracy of measurement lines Trimble M3 Total Station 2013 DR5 2 mm + 2 ppm using a prism and 3 mm + 2 ppm in reflectorless mode. [2]

As the target points used prismatic reflector Leica Geosystems series GPH1 with precision centering of 2 mm [3], as well as the reflective film ORAFOL 100 × 100 mm (fig. 1) [4].

Fig. 1. Construction of target points

The technique of research consisted in performance of measurements of lines and directions at a turn of reflectors with the set step in 10 ° in horizontal (prismatic and membrane reflectors), vertical (prismatic) and the horizontal-vertical planes (prismatic). In all series measurement of distances on a prismatic reflector was carried out in the standard mode of a range finder of STD, measurement on a film reflector - in the reflectorless mode DR. The results were averaged over the three measured values. The study was performed in the conventional coordinate system. In the conventional system, the X-axis coincides with the line of sight to the reflector at the location of the reflective surface perpendicular (angle of rotation of the reflector is equal to 0).

The results of measurements of distances and directions are listed below. The data were obtained by averaging the values of three measurements. Tables 2, 3, 4 presented experimental data for the distances of 50 and 100 meters. The turn of a prism is executed in the horizontal plane.

According to the results of the experiment with a prism pattern are the following:

1. The maximum reversal prism Leica GPH1 from the normal to the line of sight of 50 ° in the horizontal plane at a distance of 50 meters and decreases with increasing length of the measured line;

2. The operating range of turning the prism increase the measured distance is not observed.

3. Turn the prism has a tendency:

– A significant angle of rotation in a horizontal plane for a distance of 50 and 100 meters making significant errors in the measurement of the horizontal direction and in the transverse component ΔY.

– Turn in a vertical plane is significantly distorts the zenith distance and altitude component ΔZ.

Table 2 – A prism turn in the horizontal plane (S≈50, 100 m)

A prism turn in the horizontal plane										
The angle of rotation	STD (prism, S≈50 m)					STD (prism, S≈100 m)				
	Δα	Δz	ΔX, m	ΔY, m	ΔZ, m	Δα	Δz	ΔX, m	ΔY, m	ΔZ, m
50°	-14"	0"	0	-0,004	0,001	-	-	-	-	-
40°	-11"	-2"	0	-0,003	0,001	-10"	-1"	-0,001	-0,006	0
30°	-6"	-1"	-0,001	-0,001	0,001	-8"	2"	-0,003	-0,004	0
20°	-7"	-1"	-0,001	-0,002	0,001	-7"	-1"	-0,002	-0,004	0,001
10°	-5"	-2"	0,001	-0,001	0,001	-4"	2"	-0,002	-0,002	-0,001
0°	**0''**	**90°05'02''**	**50,203**	**0,000**	**0,073**	**0''**	**90°04'47''**	**100,118**	**0,000**	**0,139**
-10°	1"	-1"	0,002	0,001	-0,001	2"	1"	-0,002	0,001	0
-20°	2"	1"	0,001	0	-0,001	5"	-1"	-0,002	0,002	-0,001
-30°	3"	-1"	0,001	0	-0,001	7"	1"	0,001	0,004	0
-40°	4"	0"	0	0,001	-0,001	10"	2"	0	0,007	0
-50°	8"	0"	0,001	0,002	-0,001	-	-	-	-	-

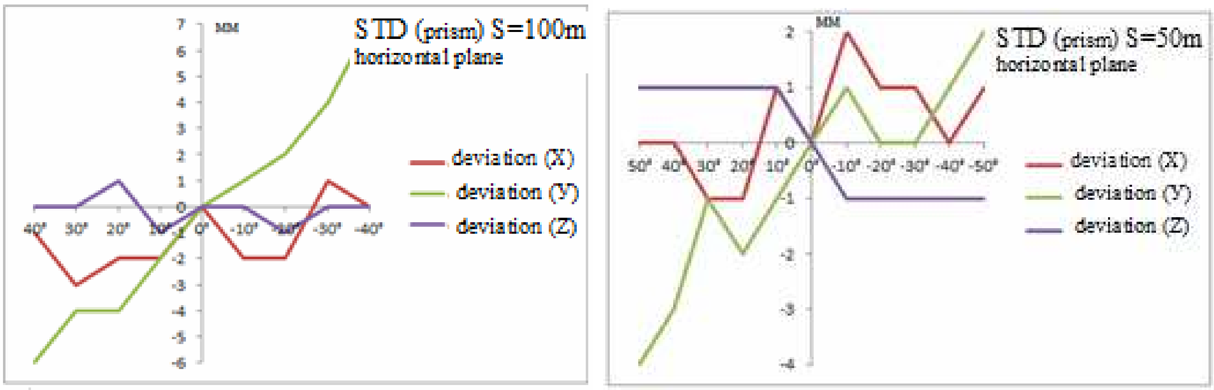

Fig. 2. The error of measurement directions and lines
according to the angle of rotation of the prism in a horizontal plane

Table 3 – A prism turn in the vertical plane (S≈50, 100 m)

A prism turn in the vertical plane										
The angle of rotation	STD (prism, S≈50 m)					STD (prism, S≈100 m)				
	Δα	Δz	ΔX, m	ΔY, m	ΔZ, m	Δα	Δz	ΔX, m	ΔY, m	ΔZ, m
40°	-1"	-8"	-0,001	0	0,004	0"	-4"	0,001	0.001	0,002
30°	0"	-7"	0	0	0,003	-1"	-1"	0.001	0	0.001
20°	0"	-4"	-0,001	0	0,002	0"	-1"	-0,001	0	0,001
10°	0"	-1"	-0,002	0	0	-1"	-2"	0	0	0.001
0°	**0''**	**90°05'02''**	**50,203**	**0,000**	**0,073**	**0''**	**90°04'47''**	**100,118**	**0,000**	**0,139**
-10°	-2"	5"	0	-0,001	-0,002	0"	3"	0.001	0	-0,001
-20°	1"	7"	0	0	-0,003	0"	2"	-0.001	0	-0,001
-30°	1"	9"	0	0	-0,004	0"	5"	0	0	-0,002
-40°	1"	10"	0	0	-0,007	0"	6"	0	-0.001	-0,003

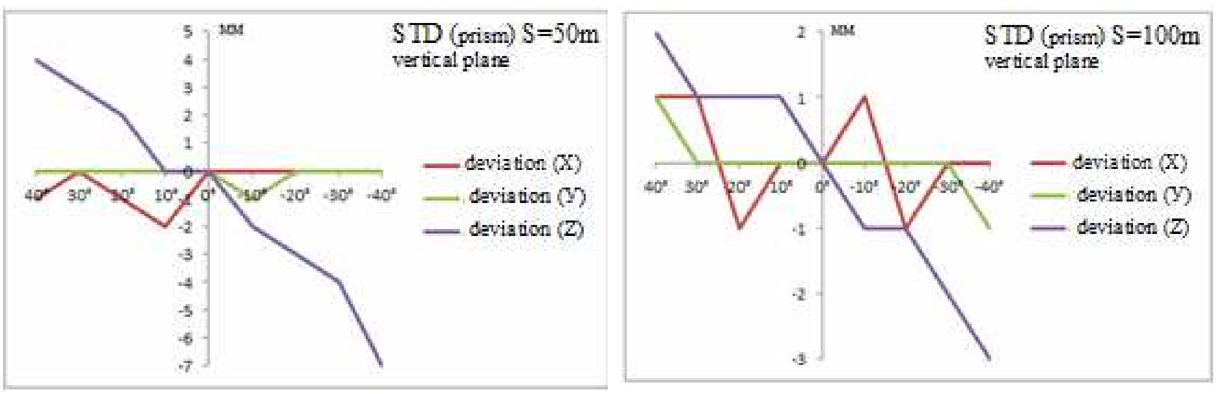

Fig. 3. The error of measurement directions and lines
according to the angle of rotation of the prism in a vertical plane

Table 4 – Turn the prism in horizontal and vertical planes (S≈50 and 100 m)

Turn the prism in horizontal and vertical planes										
The angle of rotation	STD (prism, S≈50 m)					STD (prism, S≈100 m)				
	Δα	Δz	ΔX, m	ΔУ, m	ΔZ, m	Δα	Δz	ΔX, m	ΔУ, m	ΔZ, m
30°/30°	-14"	-10"	0	-0,003	0.002	-5"	-8"	0	-0,002	0.004
20°/20°	-4"	-3"	-0,001	-0,001	0,001	-4"	-6"	-0,001	-0,002	0,002
10°/10°	-5"	-1"	-0,002	-0,001	0	-2"	-2"	-0,001	-0,001	0,001
0°/0°	**0''**	**90°05'02''**	**50,203**	**0,000**	**0,073**	**0''**	**90°04'47''**	**100,118**	**0,000**	**0,132**
-10°/-10°	1"	3"	0	0	-0,001	0"	1"	-0,001	0	0
-20°/-20°	2"	2"	0	0,001	-0,001	2"	3"	-0,001	0,001	-0,001
-30°/-30°	6"	5"	0,001	0,002	-0,002	6"	8"	-0,001	0,003	-0,003

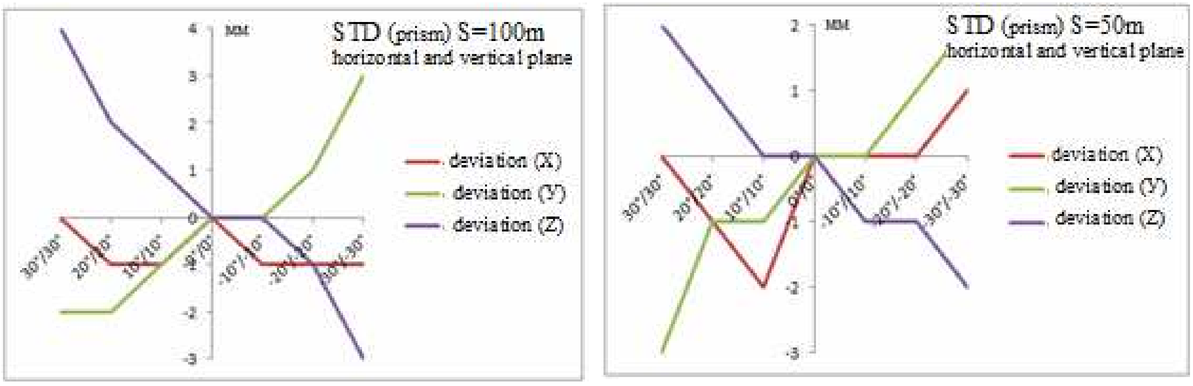

Fig. 4. The error of measurement directions and lines
according to the angle of rotation of the prism in a horizontal and vertical plane

Table 2 – A membrane reflector turn in the horizontal plane (S≈50, 100 m)

A membrane reflectors turn in the horizontal plane										
The angle of rotation	DR (membrane reflector, S≈50 м)					DR (membrane reflector, S≈100 м)				
	Δα	Δz	ΔX, m	ΔУ, m	ΔZ, m	Δα	Δz	ΔX, m	ΔУ, m	ΔZ, m
60°	10"	1"	0,003	0,000	0	11"	1"	0,002	0,000	0
50°	9"	0"	0,002	0,001	-0,001	10"	1"	0,002	0,001	-0,001
40°	6"	0"	0,002	0,000	0	7"	0"	0,002	0,000	0
30°	4"	1"	0,002	0,001	-0,001	6"	1"	0,001	-0,001	0
20°	3"	1"	0,002	0,001	0	2"	--1"	0	0	0
10°	1"	0"	0,001	0	0	2"	0"	0,001	0	0
0°	**0''**	**89°48'27''**	**50,364**	**0,000**	**0,169**	**0''**	**89°54'32''**	**75,012**	**0,000**	**0,260**
-10°	-2"	1"	0,001	0,000	0	-1"	0"	0,001	0	0
-20°	-3"	1"	0	0,001	0,001	-3"	-1"	0	-0,001	0
-30°	-5"	0"	0,001	0,000	0	-5"	0"	0,001	0,000	0
-40°	-6'	1"	0,002	-0,001	0,001	-7'	1"	0,001	0,000	0,001
-50°	-8"	-1"	0,002	0,000	0,001	-8"	-1"	0,002	-0,001	0,001
-60°	-11"	0"	0,003	0,000	0	-9"	0"	0,001	0,000	0

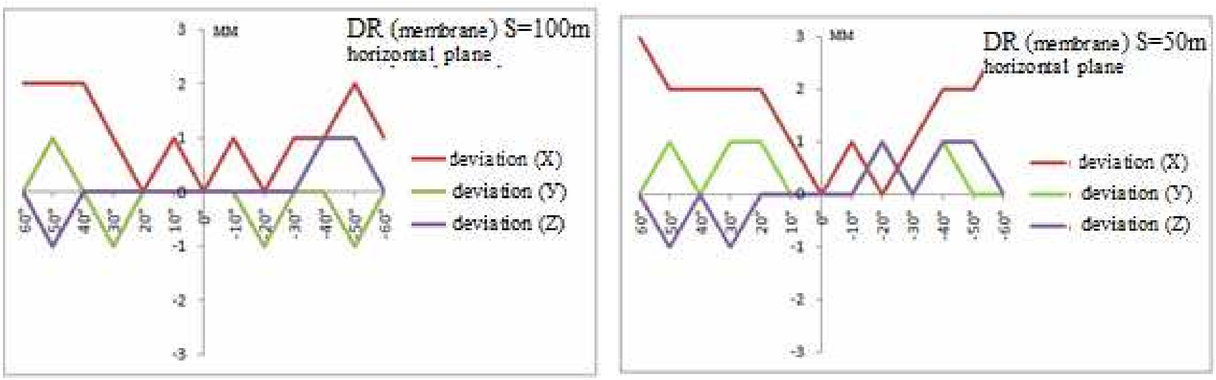

Fig. 6. The error of measurement directions and lines
according to the angle of rotation of the membrane reflector in a vertical plane

Turn in both planes has a general tendency of errors for the transverse component and horizontal directions, and for vertical component and zenith distances.

The results of the experiment with membrane reflector contains the following laws:

1. The maximum reversal membrane reflector from the normal to the line of sight is 60 °. Growth of the angle of rotation of the membrane reflector is accompanied by a linear tendency to increase the measured distance.

2. The maximum reversal membrane reflector from the normal to the line of sight does not introduce errors in the results of measurement of a horizontal direction and a transverse component of ΔU.

On the basis of the experiments the following conclusions:

1.The maximum range of the angles of rotation prism is 40 ° ... 50 °, which is slightly smaller than the membrane reflector 60 °. This difference is due to the design of the prism body. The maximum rotation angle of the prism depends on the measured distance.

2. the measurements on film reflector, an increase of the measured distance with the increase of the angle of rotation of the reflector.

3. Work reversal prism in the horizontal and vertical planes is 20°. After turning 20° in the measurement results include significant errors. Acceptable reversal film reflector, in which the measured distance changes slightly, 40 ° -50 °.

4. Turn the prism in the horizontal plane showed a tendency to increase measurement errors horizontal directions. Turn the prism in the vertical plane showed a tendency to increase measurement error zenith distances. Turn the membrane reflector in the horizontal plane does not introduce errors in the measurement of the horizontal direction.

5. Based on these results it can be argued that the use of the prism when performing high-precision engineering and surveying, as well as the use of film for fixing reflectors geodetic networks for works of high precision is possible only when the strict orientation of the reflecting surface in the rangefinder.

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APPLICATION OF GIS-TECHNOLOGIES FOR INFORMATION SUPPORT OF DECISION-MAKING MANAGEMENT AT THE LOCAL LEVEL

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The article presents an example of creation and possibility to use geographic information system for the management of urban areas. The structure and data organization in a municipal GIS are presented. The possibility of a comprehensive approach to municipal management with application of remote sensing (RS) that allows providing government institutions, profit organizations and urban population with current information is reflected.

To meet the challenges of the UN programme "Goals of sustainable development" from 2015, that has underlined the importance of geospatial information, as well as in connection with the concept of informatization of the Republic of Belarus, work package for information and analytical support of all areas of national economy activities are planned to be carried out in the country.

To improve the management functions at the global and regional levels, it is necessary to start with changes in local territorial units. Geographic information systems are systems of collection, storage, analysis and graphical visualization of spatial data. [1] Municipal service management is one of the largest application field of