Upon receipt of the probabilistic form of writing complex risk the problem arises in the definition of the local probabilities of each of the negative events that can lead to emergency situations in main pipeline transport. To determine the probability of initial events is real by various ways.

Obviously that the company of main pipeline transport contains both as production and non-production processes. As a result its activity can be attributed to semi-structured domains where qualitative, fuzzy factors tend to dominate. This circumstance gives the basis for the application of method of expert estimations.

The main drawback of this method is that the information received by experts is subjective. To increase the objectivity of the evaluation can be made by comparing opinions of different experts. However, even with proper organization of the group the expert survey has several disadvantages. First of all, this form requires large expenditures of resources including financial costs and time costs. In addition, it requires special training of organizers and experts themselves. Also there is the risk of manifestation of various psychological effects. At the same time this method can be applied only in the case in which there are no historical statistics and dangerous factors are of different etiological nature.

Thus, the advantage of the proposed method for the determination of complex risk is that both technical and organizational dangerous factors can be taken into account. In this research an open question remains to determine the initial probability of negative events using the expert evaluation method with the involvement of experts in the field of the main pipeline transport.

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PLANE COORDINATE TRANSFORMATION ON THE BASIS OF THE STATISTICAL CHARACTERISTICS OF MULTIVARIATE VALUES

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As an alternative to the traditional method of the plane coordinate transformation there are two solutions of the transformation task, based on the fact that the transformation is a special case of multivariate regression. The identity of the obtained transformation coefficients and estimate of accuracy were shown. The expediency of the application of these methods in geodetic practice is justified.

The task of coordinate transformation on the plane as a special case of linear transformations can be stated as follows. There are coordinates *(x, y)* for *n* points in the old coordinate system K_c and there are coordinates *(X, Y)* for the same points in the new system $K_н$. It is necessary to find the optimal transition function *f* from the old to the new coordinate system

$$(X,Y) = f(x,y), \quad \text{or} \quad K_H = f(K_C).$$

Most of coordinate transformations for geodetic tasks can be reduced to ordinary linear transformation, which in the most general case involves shifts and scale changes in two axes, rotation of the axes of one coordinate system with respect to the other. Then, a linear function with the transformation matrix *A* and the vector of shift *b* is used as a conversion function

$$K_H = A \cdot K_C + b \tag{1}$$

This kind of transformation is called affine. In formula (1) $A = \begin{bmatrix} a & b \\ d & e \end{bmatrix}$, $b = \begin{bmatrix} c \\ f \end{bmatrix}$, *a, b, c, d, e* and *f* – coefficients of linear affine transformation on the plane.

The system (1) can be unfolded for *i*-th point as [1]

$$\begin{bmatrix} X_i \\ Y_i \end{bmatrix} = \begin{bmatrix} a \cdot x_i + b \cdot y_i + c \\ d \cdot x_i + e \cdot y_i + f \end{bmatrix} \tag{2}$$

where X_i, Y_i, x_i, y_i - coordinates in old and new system, respectively.

It is obvious that three common points are sufficient for unique determination of transformation parameters. In geodetic practice the redundant number of points is taken for control and estimate of accuracy which leads to overdetermined system (2). This system is traditionally solved by the least squares method (LSM) with obtaining required conversion elements.

There are many methods of realization of the transformation task. Most often so-called "stretching method" is used to solve the assigned task. However, the task of transformation can be treated as a two-dimensional regression with a two-dimensional response. Solution of the two-dimensional regression with two-dimensional response may be realized by a different method. In this paper the solution is proposed to make by means of the generalized least squares method (or pseudo-independent regression method) and on the basis of the theorem about the characteristics of a multivariable conditional distribution law.

«Stretching method» is traditional. Here all the unknowns are stretched into a vector and then a decision is made by the ordinary least squares method. The decision on the basis of this approach was described in many sources (see, e.g. [2]).

In the 60s A. Zellner [3] proposed the procedure of optimal solution of multivariate regression with multivariate response on the basis of the LSM. The generalization of Zellner's approach is the generalized least squares method.

It is easy to notice that the task of coordinate transformation on the plane can be reduced to two-dimensional regression with two-dimensional response - as a special case of the multivariable model with multivariable response [4], [5]. Modification of system (2) by means of adding of the translation vector in the transformation matrix is the expedient for the solution of the assigned task:

$$\begin{bmatrix} X_1 & Y_2 \\ \dots & \dots \\ X_n & Y_n \end{bmatrix} = \begin{bmatrix} x_1 & y_2 & 1 \\ \dots & \dots & \dots \\ x_n & y_n & 1 \end{bmatrix} \cdot \begin{bmatrix} a & b \\ d & e \\ c & f \end{bmatrix}$$

This system is easily solved on the basis of the algorithm of the generalized least squares method with the obtaining of the affine transformation coefficients

$$k = \begin{bmatrix} a & d \\ b & e \\ c & f \end{bmatrix}$$

A plan matrix for conversion *A*, vector of free terms *l*, normal matrix for the system of normal equations *N* and the vector of free members of the normal equations *b* are compiled for this

$$\begin{cases} A = \begin{bmatrix} x_1 & y_2 & 1 \\ \dots & \dots & \dots \\ x_n & y_n & 1 \end{bmatrix} \\ l = \begin{bmatrix} X_1 & Y_1 \\ \dots & \dots \\ X_n & Y_n \end{bmatrix} \\ N = A^T \cdot A \\ b = A^T \cdot l \end{cases} .$$

Solution of this system $\hat{k} = N^{-1} \cdot b$ gives the desired matrix of parameter estimate. It consists of transformation matrix $T = \begin{bmatrix} a & b \\ d & e \end{bmatrix}$ and vector of shift $s = \begin{bmatrix} c \\ f \end{bmatrix}$. It is necessary to take into account that the matrix *T* is obtained in the transposed form.

Estimate of accuracy is made on usual scheme of the LSM by using a matrix of residuals *V*

$$V = \hat{k} \cdot K_c - K_н .$$

The value of the objective function is $\Phi = v^T v$, where *v* is the matrix of residuals *V* stretched into a vector. The target function *Φ* can be obtained as

$$v^T v = Tr(V \cdot V^T),$$

where *Tr (*)* - the trace of the matrix.

The total error of the model in the form of standard deviation is

$$\hat{\sigma}_0 = \sqrt{\frac{v^T v}{2n-6}} \tag{3}$$

where n - amount of points, 6 - number of estimated coefficients for affine transformation.

Dealing with affine transformation the errors of the coefficients are equal line by line. To estimate of the accuracy the standard formula of the LSM for the covariance matrix $K_к$ may be used

$$K_k = \hat{\sigma}_0{}^2 \cdot Q .$$

The task of transformation can be solved on the basis of conditional mathematical expectation with two-dimensional response, using the theorem about the characteristics of a multivariable conditional distribution law (see. Eg, [6]). For solving the task the combining plane matrix K of the coordinates in the old $K_c = (x, y)$ and the new $K_н = (X, Y)$ systems is created on the columns for n points. Then the sample covariance matrix is calculate on the basis of the division into blocks

$$S = \frac{1}{n} C^T \cdot C = \frac{1}{n} \begin{bmatrix} C_c^T C_c & C_c^T C_н \\ C_н^T C & C_н^T C_н \end{bmatrix} = \begin{bmatrix} S_{cc} & S_{cн} \\ S_{нc} & S_{нн} \end{bmatrix},$$

where C_c and $C_н$ – cental middle old and new coordinate system, respectively.

On the basis of the matrix S, using of the theorem about multivariable conditional probability distributions, we have:

for the conditional mathematical expectation

$$MO(K_н / K_c) = \hat{K}_н = \overline{K}_н + S_{нc} \cdot S_{cc}^{-1} (K_c - \overline{K}_c) = \overline{K}_н + \hat{X} (K_c - \overline{K}_c)$$

or in the normal form

$$\hat{K}_н = \hat{X} \cdot K_c + (\overline{K}_н - \hat{X} \cdot \overline{K}_c) = \hat{X} \cdot K_c + \hat{D}$$

with the coefficient matrix $\hat{X}$, which is equal to the transformation matrix T and with the vector of free members of D, which is equal to the vector of shift s

$$\hat{X} = S_{нc} \cdot S_{cc}^{-1}$$
$$\hat{D} = \overline{K}_н - \hat{X} \cdot \overline{K}_c$$

where $\overline{K}_н, \overline{K}_c$ - vectors of the mean coordinate values of old and new systems.

To estimate the accuracy of the model when determining the transformation coefficients on the basis of multivariable characteristics the formula of conditional covariance matrix is used

$$\tilde{N}_{K_н|K_c} = S_{нн} - S_{нc} \cdot S_{cc}^{-1} \cdot S_{cн}$$

Trace of this matrix will exactly equal to the value of the objective function Φ. The standard deviation of the model is calculated by the formula (3).

For example, the conversion of five points located arbitrarily was considered (Fig. 1).

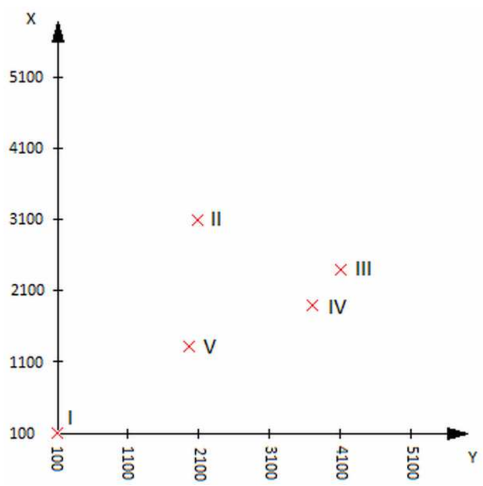

Fig. 1. Scheme of the location of points

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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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