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Composition of Engineering and Geodesic Works During the Forensic Land Survey

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Abstract

Current research considers the stages of engineering and geodesic work in the implementation of forensic land survey. Technological schemes of execution of field and desktop engineering and geodesic works are given.

Keywords: land survey, engineering and geodesic works, conclusion, instrumental method.

INTRODUCTION

According to Article 11.1 of the Land Code of the Russian Federation, a land plot is a part of the land surface, the borders of which are determined in accordance with federal laws. The location of borders of the ground area is characterized by flat rectangular coordinates of its characteristic points calculated in local (state) system of coordinates [14].

Depending on the object of the expert examination and the questions raised to the expert, the content of the expert study within the judicial land surveying (JLS) may vary [3, 7, 13, 22]. In the general case, the study includes study of case materials submitted by the court for expert examination, and field survey of land plots by carrying out engineering and geodesic work to determine the area, size, configuration of the land plot (or land plots), as well as the location of the borders of land plots with subsequent analysis of the received data and their comparison with the data of the State Real Estate Cadastre (SREC), legal and technical documentation.

Nowadays, the normative documentation does not regulate the *list of engineering and geodesic works*, which are the most important part of JLS. There are numbers of normative acts which are possible to apply to regulation of accuracy and an order of performance of engineering-geodetic works within the limits of carrying out JLS [5, 6, 7, 8, 10, 15].

RESEARCH SUBJECT.

The list of works during the land survey can be divided into three stages (Figure 1):

- Obtaining initial data in the form of a land survey and court ruling;
- Execution of engineering and geodesic works;
- Execution of the received results.

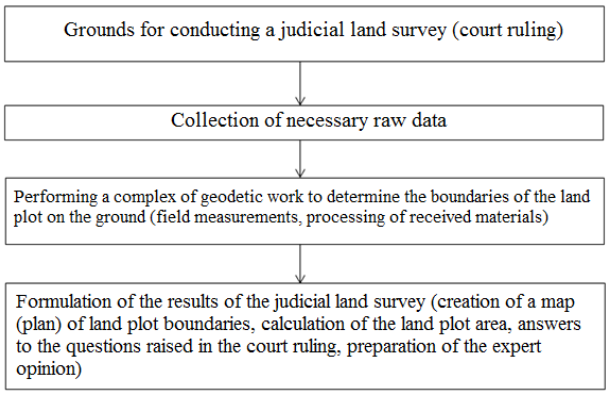

Figure 1 - Technological scheme of forensic land management expertise

The execution of the complex of engineering and geodesic works can also be divided into three stages [11, 12]:

1) Preparatory;

2) Field;

3) Cameral.

EXPERIMENTAL PART/EXPERIMENTAL SET UP

The composition of engineering and geodesic works is formed depending on the object of land surveying, accuracy and the selected method for determining the coordinates of land plot boundaries.

The following methods are used to determine the coordinates of characteristic points of land plots: cartometric, photogrammetric, satellite geodetic measurements (definitions), geodetic (triangulation, polygonometry, method of straight, reverse or combined notches, etc.).

At present, the cartometric method is practically not used due to the low accuracy of point coordinates determination and the irrelevance of information on cartographic material [15, 20, 21].

The photogrammetric method is expedient to apply when the object of expertise is land plots of a large area, such as agricultural land or forest areas [15, 19].

Nowadays, the usage of instrumental method, which includes the method of satellite geodetic definitions and classical geodetic methods, prevails in the course of engineering and geodesic works in the course of judicial land management expertise [15].

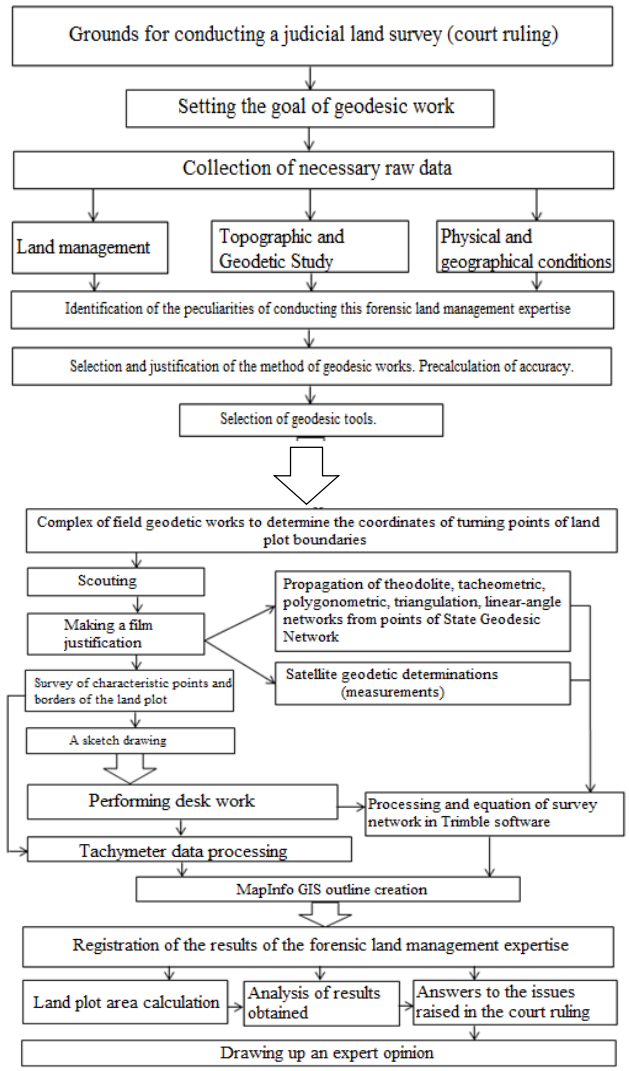

Figure 2 - Technological scheme of engineering and geodesic works at forensic land survey by instrumental method

In case of insufficient density of geodetic points, location of the land plot (object of expertise) at a large distance from them or in case of significant size of the land plot it is expedient to use satellite geodetic definitions for thickening the geodetic reference network [1, 4, 6]. It is also possible to take images of land plot boundaries using this method, if satellite receivers allow.

Traditional geodetic methods with the use of electronic total stations create an imaging justification from the points of the reference geodetic network and determine the coordinates of characteristic points of land plots, as well as buildings, structures, structures located on them.

Preparatory work for the judicial land survey includes a detailed study of the materials submitted by the court and the formation of the composition of work on the issues raised. The court submits documents such as the land survey case and the court ruling. In addition, the expert shall collect and (or) study the necessary information for engineering and geodesic work.

The preparatory phase includes collection and/or study:

- Data of the state land cadastre on the land plot(s);
- Documents certifying land rights (in their absence - title documents);
- Drawings of borders or cadastre maps (plans) with borders of the land plot;
- Topographic maps and plans;
- Catalogues (lists) of coordinates of points in the reference geodetic network;
- Addresses of persons whose rights may be affected by the survey.

After the expert has examined all the materials required to start the expert study, it is possible to set a date and time for the in-situ examination with mandatory notification of interested parties.

Recognostication of the location of an object of land survey during preparatory work includes identification of the state of points of reference geodetic basis. It is carried out to check the safety of geodetic base points, to select the method of work and to clarify the location of points of the surveying geodetic network [2, 5, 9].

At the stage of preparatory work the accuracy of the reference geodetic network construction and determination of coordinates of the land plot points is precalculated [2, 9, 18]. Requirements for the accuracy of engineering and geodetic work during the land survey depend on the measurement method and land category [8, 10, 15].

Creating a control survey. Survey of characteristic points of the land survey object is carried out from the points of the reference geodetic network or control survey points, whose position is known in the adopted coordinate system. Due to the fact that density of points of the reference geodetic network, which falls on the unit of the surveyed area, in the overwhelming cases is not enough, so on the ground is created an imaging justification.

A control survey is a point with known coordinates, fixed on the ground by special signs, concerning which the position of turning points of borders of objects of land surveying is determined [5].

The location and density of control survey are usually determined in accordance with the selected surveying method for terrain and situation. For 1:500 scale imaging the density of points is determined at reconnaissance [5].

The control survey points should be located so that all the necessary points of the examination subject can be easily taken from them. Figure 3 shows the creation of the survey justification in the form of a base line by satellite method from the points of which it is possible to take images of the land plot boundaries and buildings and structures located on it.

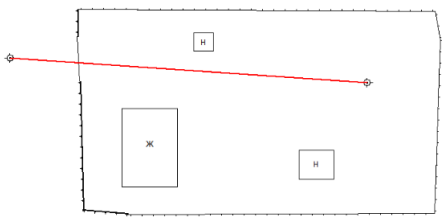

Figure 3 - Imaging network diagram of a small area of land, created by satellite method

On large areas of land, such as agricultural land or forest areas, the survey network can be created using the method of identification of individual points (serifs) (Figure 4).

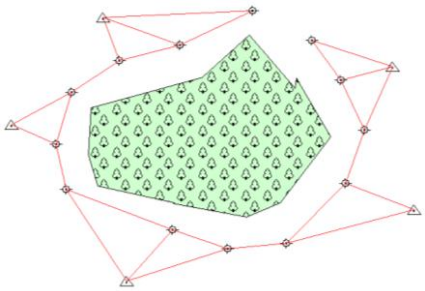

Figure 4 - Survey network diagram for a large area of land by serifs

While planning such survey justification it is necessary to ensure visibility between the points of the reference geodetic network and from the points of the reference geodetic network to the defined points of the survey justification, thus obtaining angular, linear or combined intersections. The geodetic construction should include at least 4 points of the reference geodetic network with known planned coordinates in order to ensure control, accuracy and reliability of obtaining the survey justification points coordinates.

The classical geodetic method with application of the electronic total station shall be used for creation of the survey substantiation from the points of the reference geodetic network by laying theodolite motions, polygonometric motions of 1 and 2 bits, or construction of linear-angle networks. The example of such survey network for performance of forensic examination of the ground area under extended linear object is resulted in figure 5.

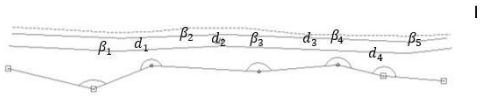

Figure 5 - Survey network diagram created by the theodolite stroke plotting

Maximum position errors of the points of the planned survey justification relative to the points of the reference geodetic network (the state geodetic network) should not exceed 0.2 mm in the open terrain and on the built-up area in the map or plan scale, and 0.3 mm - in the case of large-scale surveying on the terrain covered with wood and bush vegetation. So, for example, at survey in scale 1:500 the limiting errors of positions of points of a planned survey substantiation concerning points of a reference geodetic network should not exceed $m = 0{,}2\text{mm} \times M = 0{,}2\text{mm} \times 500 = 100\text{mm} = 0{,}10\text{m}$.

As a result of creating a survey justification, a diagram of the location of points is drawn up and their coordinates are calculated in the adopted coordinate system.

Survey of characteristic points and turning points of land boundaries. Survey of turning points of borders of the land survey object, as well as construction objects located on the territory of the land plot is carried out using the method called *horizontal survey*. Horizontal survey is also called theodolite, situational or contour survey and is performed at a scale of 1:500-1:5000. It is used in flat terrain, in complicated situations, when surveying built-up area. The purpose of horizontal surveying is to obtain an *outline of the terrain*.

Surveying a situation consists in measurements that determine the planned position of contours and individual objects of the terrain relative to the points of the survey network.

Also when carrying out surveying geodesic work, which is a stage of judicial land surveying, in addition to the characteristic points of land boundaries, the location of capital construction objects located on land plots is determined. Very often due to the data on the location of buildings, structures and structures on the land plot the expert can come to the right conclusion on the subject of the dispute.

Depending on the nature of the terrain, the location of the contours relative to the survey justification, the available geodetic tools use different methods of surveying the situation. There are the following methods: *perpendiculars, polar coordinates, angle marks, linear marks, blade marks and others* [2, 9, 16].

The polar coordinate method is the most common, precise and convenient. Using this method, the position of each situation point is determined by the horizontal angle β measured from the corresponding side of the survey justification and the distance S measured from the corresponding point of the survey justification (Figure 6).

The polar coordinate method is used in open terrain with a large number of points on the contours, to take pictures of characteristic relief points, contours with fuzzy boundaries and considerably distant from the survey justification points. When shooting, it is necessary to have mutual visibility between the points of survey justification and the points being shot.

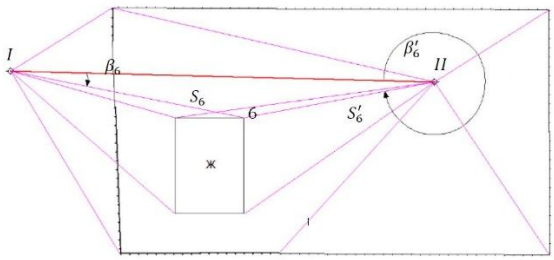

Figure 6 - Polar Coordinate Survey Scheme

Usually, polar coordinate imaging is performed using an electronic total station. Figure 6 shows the scheme of survey of characteristic points (land plot turning points and corner points of capital construction objects) by the method of polar coordinates with the control on point 6 as its coordinates are defined from two points *I* and *II* of the survey network.

The advantage of the polar coordinate method is independent determination of the location of each contour point, due to which there is no accumulation of measurement errors [17].

In cases when the surveying of land plot boundary points is carried out by the polar coordinate method from one point of the *I-II* baseline, the accuracy of coordinate determination will

be calculated by the formula:

$$M_t^2 = m_1^2 + m_c^2, \quad (1)$$

where m_1 is an error caused by the polar coordinate method;

m_c is an error of tool centering over the point of survey justification.

In the case when the survey is made from two points of the baseline I-II, the additional error of determining the coordinates of the point M_t will contain the error of the source data m_i, and the formula to calculate the accuracy will look like this:

$$M_t^2 = m_1^2 + m_c^2 + m_i^2. \quad (2)$$

Error of the initial data shows, with what accuracy relative to each other the coordinates of points of the survey network are determined. The following approach can be used to reduce this error. After satellite-based observations are made, a total station is installed above one of the survey points and a reflector is installed above the other and the length of the base line is measured with the help of a total station. During camera processing the coordinates of the survey network points are determined and the length of the base line is calculated from them. The calculated base line length is then compared with the measured total station length. If the values of the base line length measured in two ways coincided, the error of the initial data will be the value of the error of the total station length measurement. Since total stations measure line lengths with an error of about 2 mm per 1 km of line length, therefore, the accuracy of determining the relative position of the survey justification points in this approach will not exceed 2-3 mm.

Data processing. When performing desktop work, the received field materials are processed and their accuracy is assessed. Processing of geodetic materials and data is carried out with the use of specialized software (software) available from the expert organization (expert).

The technological scheme of desktop processing of field engineering and geodesic measurements using the instrumental method is shown in Figure 7.

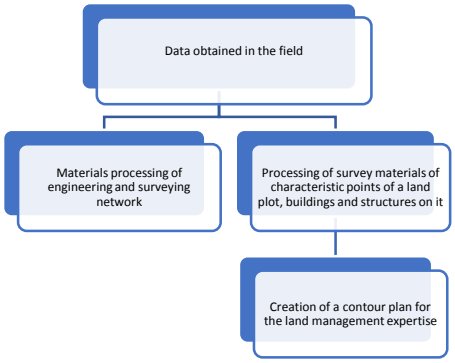

Figure 7 - Technological scheme of desktop processing

CONCLUSIONS.

The considered technological schemes of performance of engineering and geodesic works at carrying out of judicial land survey allow to organize correctly cameral and field works, and also to reach necessary accuracy of position of characteristic points of the ground areas.

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