Technological Aspects of Creating Infrastructure of Spatial Data of Land Plots

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Key words: spatial data, land management, cadastre, coordinate maintenance, indices of accuracy

SUMMARY

Technological aspects of creating infrastructure of spatial data of land plots are considered in the process of land management activities in the Russian Federation. Spatial data are the digital data about spatial objects including land plots, which contain information about their site, shape and features in the appropriate coordinate system. Infrastructure of spatial base data (ISBD) about land plots is the regional system of collection, processing and keeping information; which secures consumers free access to the resources of spatial data about a land plot which is an object of the state cadastre registry and has cadastre number in the condition of real time.

The study represents the infrastructure of spatial base data in the form of following systems (components): coordinate maintenance, monitoring of land plots boundaries, electronic bases of spatial data, indices of accuracy of the land plot boundary survey. Coordinate maintenance also consists of the following stages: establishment of geodetic system of coordinates and cartographical projections; construction of geodetic networks (GNW); definition of plane rectangular coordinates of monuments.

Geodetic networks are created in plane rectangular coordinates in Gauss projection which are calculated in local systems of coordinates which permit to secure the uniform state registry of real estate objects without additional transformations unequivocally and without additional transformations in a region (administrative area of the Russian Federation).

Production processes and technical tools for true determination of land plot boundary are based on the up-to-date satellite technologies, GLONASS and GPS. An example of this is the satellite system for land surveying (SSLS) which was developed in the Russian Federation in close collaboration with foreign experts. It is used for defining land plot boundary position and fundamental points of real estate objects on the territory of Moscow, Leningrad and other regions of the Russian Federation with the goal of establishing infrastructure of spatial data of land plots. For defining the position of real estate objects located in almost inaccessible regions it is recommended to use a frequency code GPS receivers (navigators).

By monitoring land plot boundaries there is a solution of revealing proper changes on location of monuments that were set on turning points of land plot boundary, as well as assessments of these changes. According to the accepted classification local monitoring on the basis of operative ran-

dom surveys is carried out with the purpose of the current data production. The change of a boundary location is estimated by means of corresponding criteria.

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1. INTRODUCTION.

In the study the following basic concepts adopted in the Russian Federation are used:

spatial object (SO) - any particular object which can be defined by the individual content and boundaries and is described in the form of a digital data set;

spatial data –(SD) – digital data about the spatial objects, including information about their site, the form and the properties presented in a coordinate system;

base spatial data (BSD) - digital data for open publication about the mostly used spatial objects which differ by stability of spatial position in time and can form a basis for positioning other spatial objects;

infrastructure of spatial base data of land plots (ISBDLP) – territorially distributed system of collection, processing and keeping information; which secures consumers free access to the resources of spatial data about a land plot which is an object of state cadastre registry and has cadastre number in the condition of real time.

metadata (MD) - data which allow to describe the content, volume, position in space, quality and other characteristics of spatial data and spatial objects;

geodetic network (GNW) - the geodetic network for special purpose created for coordinate maintenance of actions on land administration of Russia, including land management, cadastre of real estate objects, land cadastre, etc.;

monument (M) – an artificial landmark which fixes a position of turning point of a land plot boundary.

Spatial objects are land plots, as well as buildings, constructions and so forth, attached to them. They are defined by individual content and boundaries in the form of digital, namely, base spatial data sets, in the form of plane rectangular coordinates of monuments and also their normal heights. Spatial objects include also other real estate objects (industry, transport, etc.). Each of them can also be defined by this or that individual content and is described by base spatial data in the form of corresponding coordinates (geodetic, plane rectangular, spatial rectangular, etc.).

The description of land plots is carried out by use of *base spatial data (BSD)*. Afterwards BSD can be used for creating and developing infrastructure of spatial data of the Russian Federation (DISD) which will be created in 3 stages (2006 - 2015). Generally we shall present ISBD about land plots in the form of the following systems (components):

- coordinate maintenance;
- monitoring of land plots boundaries;
- electronic bases of spatial data;
- accuracy indices of land plot boundary survey.

The summary of each of the listed systems is resulted below.

2. COORDINATE MAINTENANCE

Coordinate maintenance of ISBD means the definition of monument coordinates according to accuracy index of land plots surveying (p.5) and also consists of the following stages:

- establishment of geodetic system of coordinates and cartographical projections;
- construction of GNW;
- definition of plane rectangular coordinates of monuments.

2.1 Establishment of geodetic system of coordinates and cartographical projection

By creating IBPD of land plots there is an application of plane rectangular coordinates in Gauss projection which are calculated in local systems of coordinates. At the same time there must be their unique link with the state system of coordinates. For each local system of coordinates the following parameters of a coordinate grid on a plane in Gauss projection are established:

- longitude of an axial meridian of the first zone;
- quantity of coordinate zones;
- coordinates of the arbitrary origin.

The local system of coordinates is created on the territory of each subject (cadastral district, administrative area) of the Russian Federation with one or several three or six degrel zones. Parameters of local systems of coordinates and keys of transition to the state system of coordinates are established by a corresponding federal body. Local systems of coordinates are used in corresponding subjects of the Russian Federation in the process of realization of the Federal program « Creation of the automated system of the state land cadastre and the state registration of the real estate objects (2002-2007)» and it's sub- program « » Creation of cadastre of real estate system (2006-2011) ». They are open for using by citizens and legal entities that allows to deliver them without data restrictions on any land plot, as well as base spatial data on other objects in any region of the country. Application of local system of coordinates on the territory of the subject of the Russian Federation (cadastral district) allows to conduct the Uniform state regisry of lands without additional transformations.

2.2 Construction of GNW

Geodetic networks are created in local system of coordinates. Stations of GNW form a special geodetic basis for creating ISBD land plots. Geodetic network is subdivided into two classes which are designated as GNW1 and GNW2 whose accuracy of construction is characterized by rms errors of mutual position of stations accordingly 0,05 and 0,10м. Usually GNW1 is created in cities for solving the problems on establishment (restoration) of boundaries of a city territory, and also boundaries of land plots which are ownership of citizens or legal entities. Control network

GNW2 is under construction within other settlements boundaries, on the lands of agricultural and other uses. It is intended for surveying land plots, state monitoring and lands inventory, etc.

Establishment of GNW is preceded by the following actions:

- planning, reconnaissance and technical designing;
- foundation of station centers on the lands which is the state or municipal property in view of their availability, and also according to the written approval of a proprietor, an owner or a user of land plots or another real estate object (a building, a construction, etc.);
- conducting geodetic measurements and satellite observations, their mathematical processing, etc.

The geodetic tools of measurements used for creating GNW, are controlled by metrological service of the corresponding organizations. Coordinates of GNW stations are defined mainly by supervision of navigating satellites of the Earth (NSE), global navigating satellite system GLONASS and (or) GPS. The technique and accuracy of geodetic measurements at creating GNW, the order of the field control and other technical reguirements are established by corresponding technical regulations. They contain the plot, the content and the structure of the field geodetic documentation. In detail technology of creating GNW is given in the monography (2).

2.3 Definition of plane rectangular coordinates of monuments

For definition of monument coordinates various methods are used: satellite, geodetic, cartometric, based on digitalizing maps and plans, photogrammetric. The choice of a corresponding method is substantiated by local conditions and production works, accuracy index of surveying (p.5), available equipment and other factors.

In the Russian Federation there is a satellite system of land surveying (SSLS) which has been developed with participation of foreign experts. It is applied at plot surveying and defining control points of the real estate objects in territories of Moscow, Leningrad and other regions. Basic purpose of SSLS is the creation of coordinate basis of land cadastre and the state cadastre of real estate that must provide with authentic and actual formation of the Uniform state registry of lands.
The satellite system of land surveying consists of reference stations RS with known coordinates, the phase centers established on RS antennas of satellite receivers, a computer center and communication channels. Reference stations are located in the capital buildings which are located at the distance of 30-80 km one from another. In premises supplied with electronic equipment of communication and satellite receivers, the set range of temperatures is supported and there is the block of accumulators providing with independent work of the equipment for 24 hours at the emergency switching-off power supplies. All equipment at the reference station operates off line and does not reguire constant presence of operators. The territory covered by satellite system of land surveying only in Moscow region, is 50000 sq.km. The reference station includes a two-frequency receiver of satellite signals whose antenna block is fixed on an external wall of a building and towers above its roof at about 1.5 m. up.

Results of satellite observations at 1 sec. discreteness, for all "visible" NSE (systems GLONASS and GPS), together with the official information are transferred on high-speed radiorelay and fiber-optical lines to the computer center. The information from reference stations to the computer center is transferred round the clock.

The structure of the computer center system includes the following servers:

- for gathering the measurement information delivered from all reference stations;
- for archiving information;
- for solving network problems and receiving the correct information providing with the definition of control points directly in a field in a mode of real time.

Besides the named equipment the structure of computer center includes a certain number of high-speed electronic computers for making a mode of postprocessing the satellite observation results. The system also contains an instrument pool which includes a two-frequency satellite receivers with GSM - modems and outdoor computers supplied will the proper software. The given equipment is leased for system users who can work with their own equipment as well. They can also get the measurement information collected at the reference station. In this case, the user independently fulfills the necessary postprocessing of the executed satellite observations. Practically the number of users is not limited. The time of determination of a point coordinates on land surface in local system of coordinates is 10-15 sec. Determination of plane coordinates of monuments in a mode of real time is carried out in a mean error of 20-30мм.

The best effect at the performance of geodetic works is produced in the case when stating a two-stage geodetic construction is applied. At the first stage there is a condensation of GNW stations for establishing control networks by means of satellite technologies. Then at the stations of a geodetic network the surveying of land plot boundaries and other real estate objects is conducted with an electronic tacheometer. The coordinates of monuments are defined on the accuracy index by the results of a survey in a mode of real time.

Currently the issue on applying the data of remote sensing the Earth (RSE) for receiving the spatial data about boundaries of land plots and other real estate objects is considered to be urgent. At present the rate of development of the Russian RSE data market is not restrained by any more regime restrictions, which took place in Russia, untill 2007. Now experimental engineering activities on creating orthophotoplans by the materials of RSE for the purpose the state land cadastre, including the coordinate description of land plot boundaries are conducted.

At surveying of land plots located in almost inaccessible regions the high accuracy for establishing their boundaries is not necessary. For determining plane rectangular coordinates of monuments it is possible to apply code GPS-receivers (GPS-navigators). Results of our operations demonstrate that definition of coordinates of monuments is carried out with a mean error of 1,8м (the reception of amendments WAAS/EGNOS in outdoor conditions). In this way by following

the developed technology of operations (2) GPS - navigators can be recommended for application at land management kinds of work for defining coordinates of monuments on the land plots intended for agricultural production and other types of land uses (see p.5).

3. MONITORING OF LAND PLOTS BOUNDARIES

In the process of monitoring the problem of timely revealing the changes in a position of monuments established on turning points of a land plot boundary and an estimation of these changes is solved. According to the adopted classification local monitoring on the basis of operative sample surveys for the purpose of data acquisition by the current time is carried out. Change of a boundary location is revealed by an absolute divergence *f* of the monument under control which is given as follows:

$$f = \left(\delta x^2 + \delta y^2\right)^{1/2},$$

Where δ x and δ y – correspondingly to the difference of abscissa and ordinates, calculated by the coordinates received by survey data and written out from the catalogue of monuments coordinates.
The estimation of changes on a position of monument is done by means of auxiliary quantity F - 2,5K, m, where K – is a factor which depends on a type of land use. For example, K=0,1 corresponds to the land plot in the limits of a city settlement, and K=0,2 - other settlements, etc. In more detail the issue connected with a choice of factor K, is stated in the book (4). If $f \leq F$ it is possible to consider, that changes in a monument position has not been revealed. Otherwise, when $f > F$, it is necessary to establish the reason of the change and to make corresponding decisions for further actions for specification of a site of land plot boundary.

4. ELECTRONIC BASE OF SPATIAL DATA

It is created as a result of performance of works on coordinate maintenance of spatial data about the land plot with the use of corresponding complex program systems, which solve the following primary goals:

- storage of materials of geodetic measurements, catalogues of GNW stations coordinates, geodetic networks and monuments;
- equalizing geodetic measurements and calculation of stations and monuments coordinates;
- formation of the base spatial data of monuments and the stations networks;
- transformation of digital materials into the uniform graphic database;
- statute-book of the documents adopted in the Russian Federation for conducting office-work at carrying out land management works, on external data carriers or in standard formats of databases and graphic objects, etc.

5. ACCURACY INDICES FOR LAND PLOTS BOUNDARY SURVEY

Currently in Russia indices of accuracy for defining the coordinates of monuments are accepted at carrying out land management operations for surveying land plots. Surveying land plots is carried out by the accuracy which is characterized by the mean error of defining the coordinates of a monument concerning the nearest station of GNW, but no more:

- in the limits of settlements: in cities - 0,07 m; in other settlements - 0,14 m;
- out of settlement limits on the lands intended:
- for gardening, cattle breeding, vegetable gardening as well as country and garage construction 0,14m;
- industrial and other kind of construction - 0,35 m;
- agricultural production - 1,8 m.
- at surveying the lands of wool, water and stocks - 3,6 m, etc.

In connection with the Federal law of the Russian Federation «About technical regulation» come into force in 2003 the given above characteristics of accuracy for a boundary survey can be only advisable. At the same time their application under production conditions with deviation from standard data is not excluded. The given circumstance can lead to distortion of reliability of geodetic data about the land plot boundaries with risk of incorrect decision acceptance in the field of land resources management.

Currently in Russia there is the development of special technical regulations - documents that establish obligatory requirements to the objects of technical adjustment and concern the processes of manufacture, terminology, etc. (3). They have direct influence in all territory of Russia and can be changed only by modification in the corresponding technical regulation. By the development of special technical regulation in the field of land management and cadastres technological features of operations at land plot boundary surveys will be considered, etc. The legislation in this case is adjusted by acceptance of federal laws and other statutory acts of the Russian Federation. Federal bodies of the executive power have the right to publish only advisory sertificates in the sphere of technical regulations, except for the cases established by the Federal law.

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BIOGRAPHICAL NOTES

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The honored scientist of Russia
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The rector of the State University of Land Use Planning (1980-1997)
Academic-practical experience: training engineer and academic staff in the field of geodesy, cadastre and land management; writing the educational, industrial and scientific literature on geodetic works for land management, cadastral and topographical surveys; supervision of research works on the development of normative and technical documents in the field of information maintanance of land management and cadastres, etc.
Member of National committee of geodesists of Russia (commission 7)
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