# Application of GIS technologies in the improvement of geodetic and cartographic works in land cadastre

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**Abstract.** Increasing the accuracy of geodetic measurement tools and methods used in land surveying, topographic mapping, and other works is one of the requirements of the current era. In this case, it is important to develop measures aimed at increasing the speed of geodetic surveying, increasing the accuracy of measuring land areas, and reducing labour productivity, time, and human resource costs. The use of electronic geodetic measuring devices in implementing these works is very convenient for implementing the above requirements. The difference between the current electronic geodetic measuring instruments and the previous ones is that they are designed to measure the angle, distance, and height of points simultaneously.
**Keywords:** survey, topographic map, GPS, application, database, cartographic.

## 1 Introduction

Geodetic and cartographic work in land cadaster performance is important[1]. The use of modern GIS technologies is one of the most important issues[2]. In the creation of land cadastral maps, geodetic works are carried out to create the boundaries of land areas, coordinate turning points, and land cadastral plans and maps[3–5]. Geodetic works are mainly carried out in the state, local, and conventional coordinate systems. In addition, the connection of the local and conditional coordinate system with the state coordinate system is very important[6,7]. In order to determine whether the contour record is correctly compiled, the border of the contours on the agricultural map was decoded to the orthophotoplane in geographic information systems (GIS) software was determined and the area was calculated. When determining the area using the GIS program, it was equal to the sum of contours, i.e.[8]. 1005.9 hectares, as can be seen from the calculation results, the contours were correctly calculated[1,9]. However, in order to increase the accuracy of measurement in calculating the surface of the area, work was carried out to determine the

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surface of the area. In modern tools used today, when performing topographical work in the area, the initial base points were determined and the border points were determined using the GPS STONEX S9 II measuring device based on the coordinates[10–12]. Station points were marked on the site (Table 1) and the sides of the field were taken along the boundary of this field, the field started from one point around the boundary of the field and returned to the first point, resulting in the formation of a closed polygon.
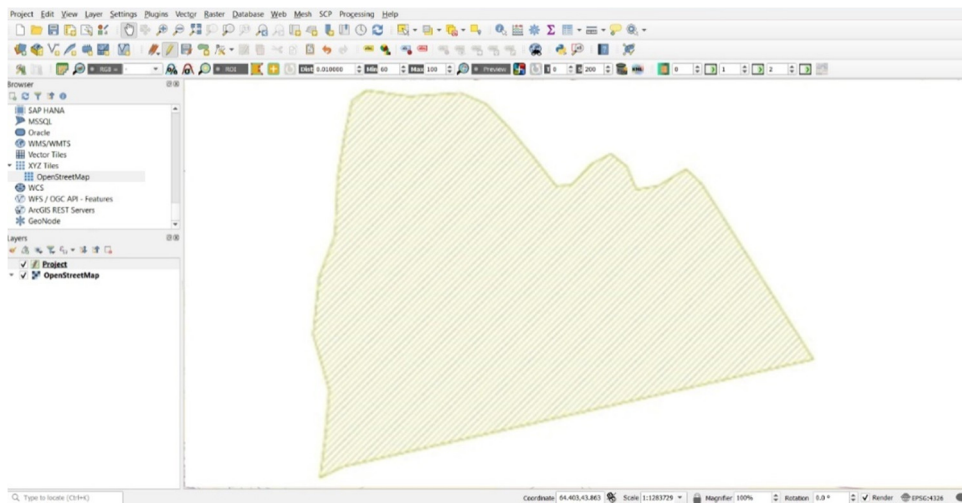


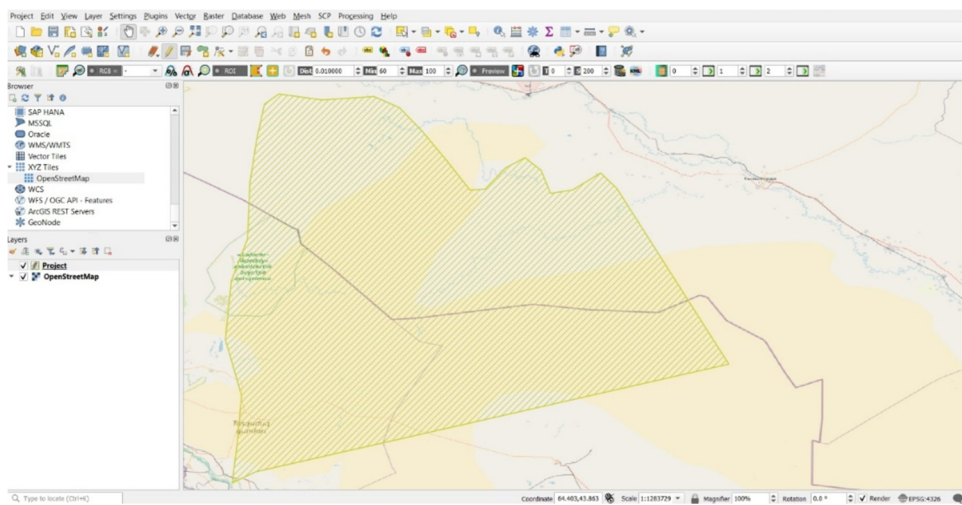**Fig. 1.** Fragment of an agricultural map.



**Fig. 2.** Calculation of area surface using GIS programs.

## 2 Materials and methods

A complete topographical image of the object area was taken from the obtained point. The process of topographic imaging was performed as follows[13,14]. Using the SurPad SurvX android software to prepare the GNSS receiver for topographic imaging, connect SurvX and Surfpad GNSS receivers and perform field work in Real Time Cinematic mode work was carried out with the help of special Android software designed for execution (Figure 3).

The software can be installed and used on any android device. The device with the SurvX application is connected to the GNSS receiver via Bluetooth, and the receiver is prepared for the surveying process. When we start the SurPad 4.0 program, the program window will open and thus the operating process will begin. From this section, we enter the "project" section, go to the "new project" section and give a name to the project we want to open.
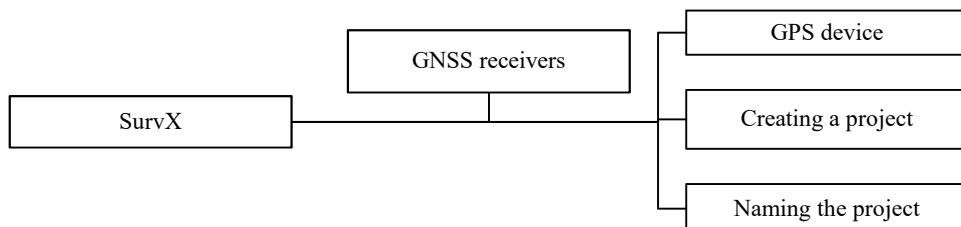


**Fig. 3.** Flow chart preparing the GNSS receiver for the survey process.

In the area measurement work, the above-mentioned contour record was drawn up and the contour areas were determined based on the data of the "Samvilloyiha" division of Uzbek state Scientific land planning management Institute "Uzdavyerloyiha" (Table 1). The sum of calculated contours was 1005.9 hectares.

**Table 1.** The coordinates of the turning points of a closed polygon

| Points | Coordination | | Points | Coordination | | Points | Coordination | |
|--------|--------------|--------------|--------|--------------|--------------|--------|--------------|--------------|
| № | ±Xi | ±Yi | № | ±Xi | ±Yi | № | ±Xi | ±Yi |
| 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| 1 | 61167,65 | 5008,33 | 25 | 64128,73 | 3558,08 | 49 | 61028,32 | 1558,08 |
| 2 | 61487,96 | 5046,19 | 26 | 64306,22 | 3229,14 | 50 | 61032,26 | 1689,54 |
| 3 | 61796,76 | 5072,54 | 27 | 64461,31 | 2938,06 | 51 | 61037,41 | 1839,16 |
| 4 | 61916,40 | 5094,35 | 28 | 64615,17 | 2656,67 | 52 | 61046,8 | 1965,47 |
| 5 | 61978,49 | 5107,07 | 29 | 64674,84 | 2546,42 | 53 | 61057,4 | 2125,4 |
| 6 | 62065,42 | 5044,98 | 30 | 64521,43 | 2471,76 | 54 | 61058,61 | 2239,59 |
| 7 | 62089,66 | 4934,12 | 31 | 64525,52 | 2457,52 | 55 | 61057,4 | 2377,71 |
| 8 | 62149,63 | 4882,93 | 32 | 64017,26 | 2218,39 | 56 | 61055,88 | 2453,73 |
| 9 | 62189,61 | 4825,38 | 33 | 63659,85 | 2043,92 | 57 | 61054,37 | 2593,06 |
| 10 | 62244,74 | 4782,67 | 34 | 63559,9 | 2001,21 | 58 | 61051,34 | 2727,55 |
| 11 | 62290,47 | 4768,44 | 35 | 63321,97 | 1875,66 | 59 | 61043,47 | 2866,88 |
| 12 | 62405,72 | 4626,68 | 36 | 62685,14 | 1565,20 | 60 | 61042,86 | 2971,98 |
| 13 | 62542,78 | 4548,69 | 37 | 62561,71 | 1515,98 | 61 | 61049,22 | 3150,08 |
| 14 | 62610,18 | 4528,24 | 38 | 62474,63 | 1472,06 | 62 | 61046,8 | 3263,97 |
| 15 | 62687,26 | 4646,37 | 39 | 62026,35 | 1245,65 | 63 | 61053,46 | 3362,71 |
| 16 | 62768,44 | 4739,06 | 40 | 61375,89 | 0918,52 | 64 | 61042,56 | 3509,62 |
| 17 | 63055,88 | 4713,92 | 41 | 61006,51 | 0704,83 | 65 | 61039,68 | 3764,20 |
| 18 | 63162,20 | 4527,03 | 42 | 61001,06 | 0757,23 | 66 | 61040,44 | 3764,96 |
| 19 | 63157,96 | 4504,32 | 43 | 61002,88 | 0880,51 | 67 | 61040,44 | 3767,23 |
| 20 | 63251,86 | 4343,18 | 44 | 61011,66 | 0949,57 | 68 | 61047,25 | 3964,86 |
| 21 | 63561,71 | 4601,54 | 45 | 61005,00 | 1073,45 | 69 | 61054,82 | 4333,64 |
| 22 | 63689,84 | 4358,02 | 46 | 61004,39 | 1138,88 | 70 | 61096,47 | 4561,56 |
| 23 | 63833,86 | 4103,44 | 47 | 61012,57 | 1287,90 | 71 | 61107,83 | 4664,55 |
| 24 | 63983,04 | 3824,78 | 48 | 61025,90 | 1432,08 | 72 | 61134,33 | 4946,99 |

## 3 Results and discussion

The sides of the field are straight lines, the coordinates of the corner points are known, the surface of the field was calculated analytically based on the coordinates of the corner points (Appendix 1). As a result, the calculated area was 1005.9 hectares. As a result of the measurement work, there is no error in the measurement methods.

A complete topographical image of the object area was taken from the obtained point. The process of topographic imaging was performed as follows. Using the SurPad SurvX android software to prepare the GNSS receiver for topographic imaging, connect SurvX and Surfpad GNSS receivers and perform field work in Real Time Kinematic mode work was carried out with the help of special Android software designed for execution (Figure 3). The software can be installed and used on any android device. The device with the SurvX application is connected to the GNSS receiver via Bluetooth, and the receiver is prepared for the surveying process. When we start the SurPad 4.0 program, the program window will open and thus the operating process will begin. From this section, we enter the "project" section, go to the "new project" section and give a name to the project we want to open.

During the topographical works in the area, the following GPS STONEX S9 II, LEICA TS 06 geodetic instruments were used and topogeodetic works were performed. The topogeodetic work, 9938 characteristic points were surveyed in the area, and the data was uploaded to the Autodesk Civil 3D program. As a result of processing the uploaded data in the program, all characteristic points obtained during the surveying process were drawn based on the program and brought to the state of a topographic map, and at the same time, the relief structure of the area was created based on the program (Figure 4).

However, in the literature, the projection of a small piece of land on a horizontal plane is called a plan. From this it can be concluded that convex surfaces on the earth are not taken into account when calculating the surface area. In order to make sure that the calculation of the surface area is being performed correctly, since the state of the place is not flat in the created topographic plan, the profile of the place was drawn to determine the length of the line.

Longitudinal and transverse leveling method was used to draw the profile of the place during our research. During the leveling of the research object, the distance of 3900 meters was divided into 39 pickets of 100 meters. A LEICA TS 06 electronic tachymeter was used to place the pickets. If the starting and ending points of the pickets are connected to the geodetic reference network, the coordinates of the place and the elevation point are determined and marked with stakes, and the pickets are placed between the designated stakes with the coordinates. Starting from the starting point of pickets 0, these zero pickets was marked as PK 0 and the end point as PK 39 (Figure 5). The positions of the characteristic points on both sides of the designated picket piles were leveled at the time of leveling. Longitudinal and transverse profiles were drawn after leveling. Profiles are usually drawn according to the calculated marks in the leveling log.
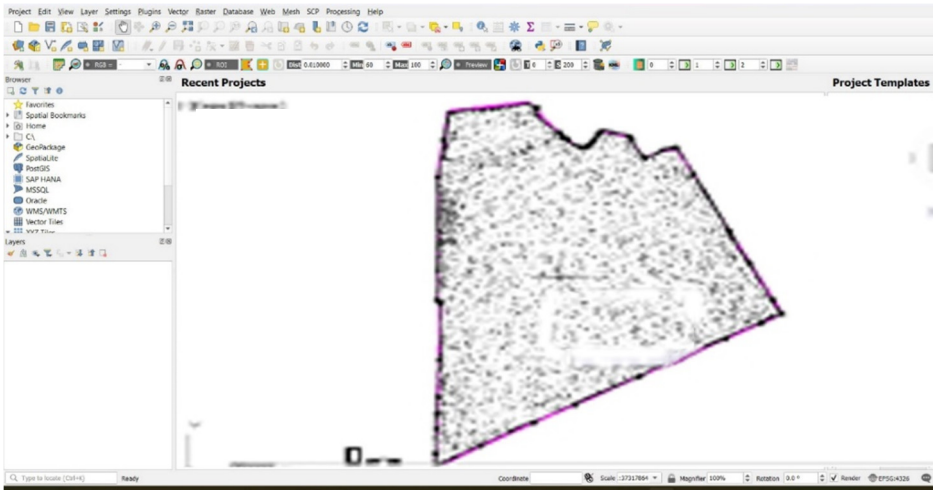
*a) elevation points of the area*
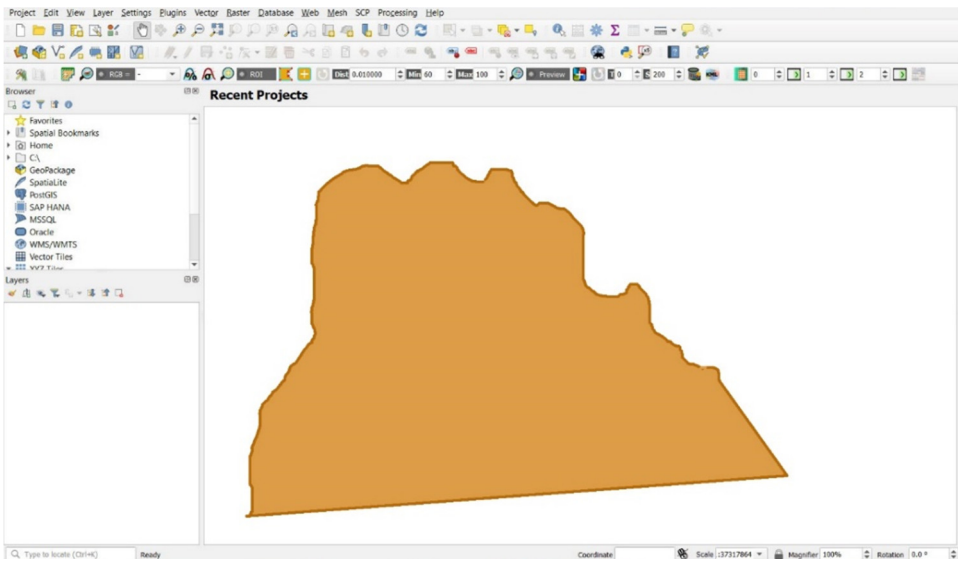


*b) relief structure*

**Fig. 4.** Processing of survey results in Autodesk Civil 3D software.

**Fig. 5.** Leveling line of the research object

Any profiles are drawn in two different horizontal and vertical scales. Horizontal distances are plotted on the horizontal scale, and vertical distances are plotted on the vertical scale. To draw the longitudinal and transverse profile, the length of the road and the scale of the profile were drawn based on the computer program. From the drawn profile, the length of three oblique lines and the horizontal distance D1-4054m, D2-4053m, D3-4054m, horizontal distance d-3900 meters were determined. Here, D1 is the length of the slant line, D2 is the length of the left slant line, D3 is the length of the right slant line, and d is the horizontal cast. As for the analysis results of the determined measurement works, the horizontal distance is calculated in the area calculation on the 1:10,000 scale maps used in the land cadastral work, that is, the calculation of the area surface is calculated in all programs only through x,u coordinates. As can be seen from the results of the above research, the length of the actual line is Д1-4054 meters, horizontal casting d-3900 meters, on the 1:10,000 scale map used in land cadastral work, when measuring the distance and area, the distance d-3900 meters, that is, the horizontal casting, is taken into account. In land cadastral maps, especially in places with complex terrain, errors may occur when performing such area measurements. We believe that it is appropriate to use 3D dimensional maps in the calculation of the area surface in the land cadastral maps. In 3D maps, x, u coordinate and h height are also calculated. As a result of our research, a 3D model with a profile of the site from three D1, D2, D3, oblique lines was developed (Figure 6). As you can see from the 3D model, when measuring the area on the maps, only the horizontal distance can be wrong, because our place is not flat as shown in the picture.
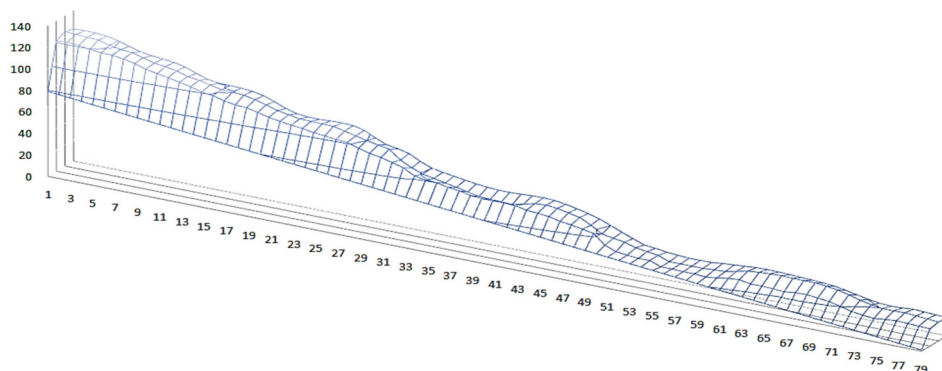
**Fig. 6**. D1, D2, D3, 3D model of oblique lines.

## 4 Conclusions

In conclusion, it can be said that the entire topographical image of the object area was obtained from the obtained point. The process of topographical imaging of land areas and the use of its SurPad, SurvX android software to depict the GNSS receiver on topographic maps will help complete topographical mapping of land resources. One of its advantages is that this software can be installed and run on any android device, and its data can be transferred to other devices and processed. GPS STONEX S9 II, LEICA TS 06 geodetic instruments were used for continuous monitoring of land areas and creation of land area models. The software used to create topographic maps of the land using the 3D model of the land helps to accurately and quickly analyse the data. Therefore, it is effective to use this program and software in the implementation of geodetic works when creating topographic maps of land areas.

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