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Digital Surveying Map as a Basis for Landscape Design Illustrated by the Example of the Botanical Garden in Kragujevac

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Abstract: Digital surveying map should fulfill a number of conditions in order to serve as a basis for landscape design. This paper proposes the optimal model of geospatial data that can be applied in landscape architecture and in many other fields. A digital surveying map should provide the designer with a set of cartometric 2D and 3D measurements. Software was developed in the AutoCAD environment and the proposed methodology was tested within the project of The Botanical Garden in Kragujevac.

Keywords: digital surveying map, digital terrain model, geospatial data, landscape design.

1. INTRODUCTION

In order to create a Digital Surveying Map (DSM), a digital form of a high-grade surveying basis, intended for the professions that any stage use maps with or without elevation profiles, *Survey*, a software system for digital topography, was developed. Since digital maps are used for the design and management of space by a large number of users of other professions, AutoCAD was adopted as the most logical software environment.

In defining the terms of reference of the software system Survey, for the support of digital surveying maps, we started from the fact that a DSM should meet high demands of a wide range of users: spatial planners, urban planners, landscape architects and designers from other fields, at the same time serving as a basis for creating large-scale GIS-based maps.

In the AutoCAD environment, digital data of geospatial entities can be organized in dozens of different ways, so it is necessary to select the optimum for this aim. Of course, there is a specially organized database in which these geospatial entities are stored. Only the members of the Developer Network are familiar with the structure of the Autodesk database, not the final user. Therefore, AutoCAD software solutions and applications developed by individuals or companies that are not members of the Autodesk Developer Network are superficial and low quality. They usually make a limited set of functions intended for the final users, as well as `macros` that execute several existing AutoCAD commands.

Since the software authors, who are not members of the Developer Network, are not familiar with the structure of the database in the AutoCAD itself, it is understandable why each AutoCAD conversion of DSM is incorrect. This conversion is done using the DXF file, whose structure is also subject to change with each new version.

Geospatial entities and facilities in terms of site location can be presented in three ways:

• 2D representation of all entities (X and Y coordinate plane)

• 3D representation of all entities (coordinates X, Y and Z in 3D)

• 2.5D representation (only DTM is shown in 3D, everything else in the plane).

Each of the above listed representations of the entities and facilities has its advantages and disadvantages. If we want a DSM to meet the needs of the increasing number of users who use it for designing purposes, serving at the same time as the basis for GIS development, the third representation - 2.5D representation – proves to be the most appropriate. This kind of 2.5D representation of the real world is appropriate because there are some points that do not have coordinate Z determined. When we make a DTM for such points, we can determine coordinate Z as well.

Fig. 1 shows an isometric view of a part of DSM in the form of a correct 2.5D representation. On the other hand, Fig. 2 shows an incorrect 2.5D representation. The viewing point was determined by using AutoCAD command DDVPOINT. Fig. 2 shows the inconsistency in drawing a line between two points, one of which has coordinate Z determined and the other does not. In this case, either the beginning or the end of the line is at zero level elevation which cannot be observed in the first projection. Such lines present a problem for designers.

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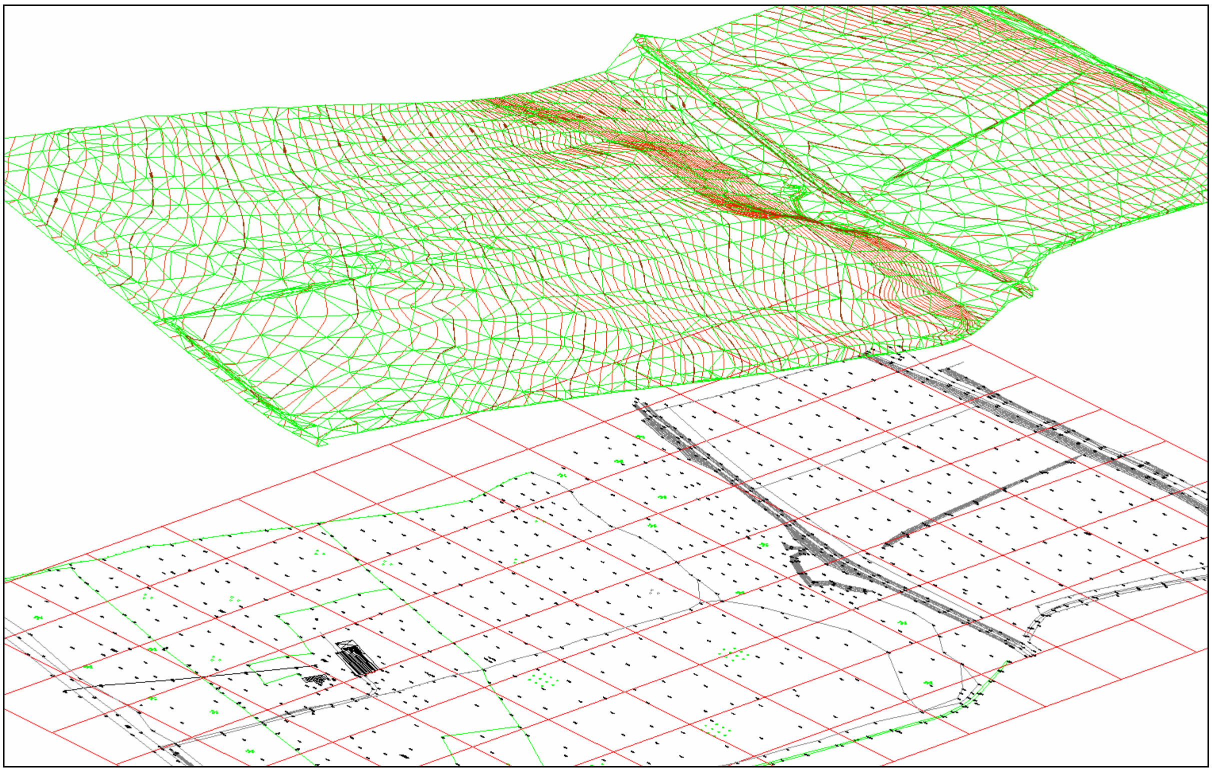

Fig. 1 Correct 2.5D representation of geospatial entities

We have emphasized this case, because the users of DSM have often complained about this problem, usualy with reason.

A very common and undetected error occurs in the construction of a perpendicular line from one point to an existing 3D line using OSNAP mode PERpendicular. This perpendicularity exists in space, but not in the first projection, which is difficult to observe if all three lines are at approximately the same level. This can be illustrated by constructing a perpendicular line to the axis of a street or a road, which results in a network of city streets that do not intersect at right angles.

Another typical example is the inability to use OSNAP INTersection mode, as the two lines do not intersect in space, although their first projections actually intersect.

2. DEVELOPED SOFTWARE

A list of software modules developed for the production of the digital surveying map and for civilengineering design is presented in Table 1.

Many software solutions developed to support the production of DSM provide surveying background, which is unusable in designing. DSM is a kind of progress within the framework of the surveying

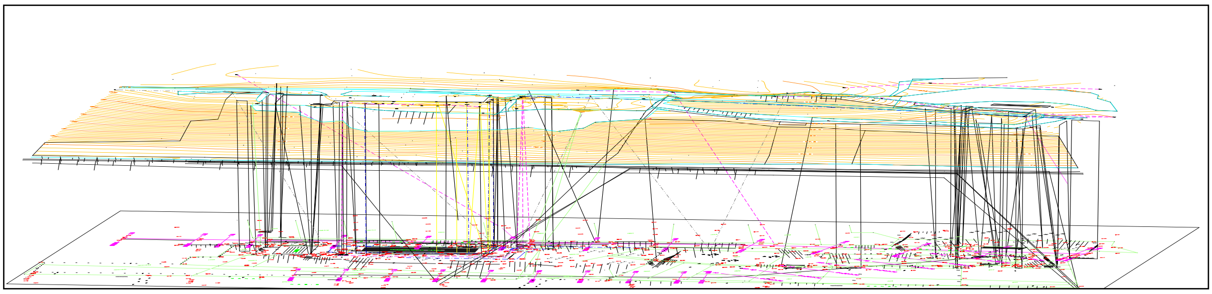

Fig. 2 - Incorrect 2.5D representation of geospatial entities

profession, but not for the users of other professions, whose number exceeds the number of surveyors several times. DSM does not facilitate the design process.

The following example is the best illustration of this situation: How much effort does it take designers to determine the elevation of just one point of the terrain, which is a vertex of a sewage route, using a non-functional DSM?

Designers should be focused on solving the following problems: selection of the type, diameter and material for the pipes, burial depth, slope, shaft type, cascades etc. They should not deal with the interpolation of the elevations with DSM. The imposibility of direct reading the elevation values at certain points slows down the design process and makes the designer tired because spatial interpolation is a difficult task if performed by using classical interpolation formulas.

Table 1 List of the most important modules of the software SURVEY

Software product	*Product purpose*
Survey (basic module)	Digital Surveying Map Production
DMT	Digital Terrain Modelling
RIC	Calibration and georeferencing of scanned maps
ViDigi	Video digitization of scanned maps (on screen)
Trasa	Design of transport routes – roads and streets
Kanal	Design of canals and river flow regulation
Volume	Calculation of quantities of excavation and embankment from DTM and terrain profile
EDB	Design of power lines (overhead and underground)
Telekom	Making datasheet of the PTT communication lines
Vod	Design of waterworks
Kan	Design of sewerege system
Cev	Design of pipelines, gas pipelines and heat pipelines

Thus, the most common problem in designing is to determine the elevation when the Digital Terrain Model is not adequately represented in the form of 3D triangulated irregular network – TIN (Fig. 3). Today, there is a great number of software applications for digital terrain modeling, but there is general acceptance that the work should be done by surveyors, as they have the best sense of topography of the terrain which they survey and record using surveying terrestrial methods.

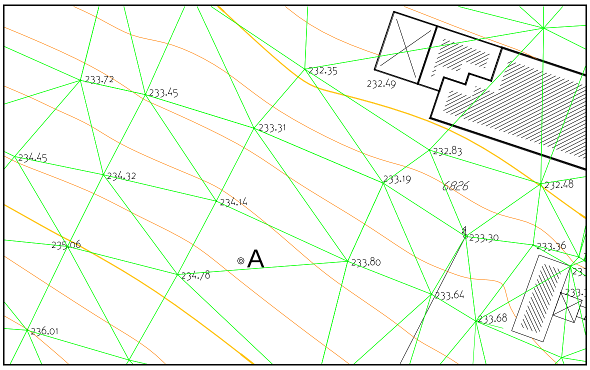

Fig. 3 A segment of DSM of the Botanical Garden Kragujevac as a basis for designing

As for design, DSM is mainly used for civil engineering design of the following facilities:

1. Roads and streets
2. Canals, regulation of rivers and torrents
3. Waterworks
4. Sewerege systems
5. Pipelines, gas pipelines, heating systems, etc.
6. Pits
7. Overhead and underground power lines (transmission lines and cable lines).

Bearing in mind the possibilities of organizing geospatial data and taking into account the needs of designers, such a concept of DSM with a correct 2.5D representation of geospatial entities, can provide the following functions:

- Obtaining all three coordinates X, Y, and Z for each point that is clicked with the mouse,
- Obtaining horizontal and sloping length, and the height difference between two points that are clicked with the mouse,
- Obtaining 2D and 3D length on DTM between a range of points that are clicked with the mouse,
- Obtaining the slope expressed as a percentage, degree and in the form of 1: n,
- Obtaining a written longitudinal profile and its drawing on a desired scale on any line or polyline, no matter if it is broken or with circular curves, with clothoids or cubic parabolas,
- Stationing a selected (poly) line that is the route of a linear object,
- Generating cross-section profiles in the written form and drawing them at desired interval,
- Calculating the area in the first projection and the area of the terrain in space - topographic surface,
- Calculating the quantities of excavation and embankment between two DTM or a designed area.

3. DATA COLLECTION FOR THE CREATION OF A DSM

The collection of geospatial data is a very complex, extensive, time-consuming and expensive process. The choice of DSM data collection methods depend on the degree of geometrical accuracy of the data that we want ot achieve and on the size of the area.

In practice, tacheometric, GPS survey and photogrammetric methods are used as primary methods of collecting geospatial data; scanning and vectorization of the existing maps are used as secondary methods.

In the tacheometric method, the position of any point is determined by measuring the angles and the distances from another known point. Total station, which is used in this method allows accurate and rapid measurment and recording of information (coordinates X, Y, Z). This method, although time consuming and expensive, is often used because it provides the most accurate data.

The global positioning system (GPS) is a set of satellites orbiting the Earth. To determine the position of a point on the Earth's surface it is necessary to receive signals from at least four satellites. GPS method is used to determine coordinates (X, Y, Z) of the points of surveying network and to determine detailed points of the DSM.

These two methods are quite different in character. Their use depends on specific conditions, but they are both very important because they provide collection of data in a digital form, with a very high degree of accuracy, which meets the needs of most users of geospatial data.

Photogrammetry enables collection of data for larger areas, both for the production of large-scale digital maps and for topographic mapping on a small scale. Stereo restitution on the Digital photogrammetric workstation is now a standard procedure for the production of digital surveying maps. The operator (restitutor) views the 3D stereo image of the terrain and moving the measuring mark from one point to another digitize the content of the recorded area. Digital photogrammetric workstation is a device for 3D digitization, which determines all three coordinates (X, Y, Z).

The scanned and georeferenced analogue maps can be combined with the existing vector data (hybrid maps) or the maps are scanned for the purpose of vectorization. Analogue maps that contain information on the topography can be used for making the DSM, with the 2.5D data type. Video digitizing (on the screen) is the easiest way of vectorization. The maps are in raster format manually digitized from the monitor screen using the mouse.

4. USE OF DIGITAL SURVEYING MAP IN DESIGNING

The location of the site intented for the establishment of The Botanical Garden is a setting of great significance within the Memorial Park "Šumarice" in Kragujevac, on the area of approximately 18ha. Apart from being connected to the city, it is characterized by favorable environmental conditions (favorable slope, the presence of water supply in the complex, north and south aspect, etc.), all of which increase the value of the area intended for the construction of The Botanical Garden. The first phase of the composition plan of the Botanical Garden covers an area of approximately 8 ha (Fig. 4).

The digital surveying map of the future Botanical Garden in Kragujevac is obtained on the basis of the existing analogue cadastral and topographic maps, on a scale 1:500. The maps were scanned, calibrated, georeferenced and merged into a continuous space. Vectorization of the map contents was performed by video digitation. The terrain elevations, which were an integral part of the maps, were for the purpose of terrain modeling, added to the linear content. Terrain modeling was carried out by TIN method, taking structural lines of the terrain (break lines) into consideration. A DSM developed in this way was used as the basis for designing: an access road, a car park, walkways, terraces, rose gardens and other garden-architectural elements. These elements should fit into the natural environment of the Garden, without disturbing it. They should further make the Garden functional, economical, durable and aesthetically appealing.

The central pedestrian passage of the complex is a footpath, which links the southern and the northern entrance gates. This path is the backbone in the concept of the whole project because the other elements of the garden are formed on or along it.

The solution for the levelling of free surfaces was based on DSM and the data from the composition plan of access roads and the grade levels of the existing facilities.

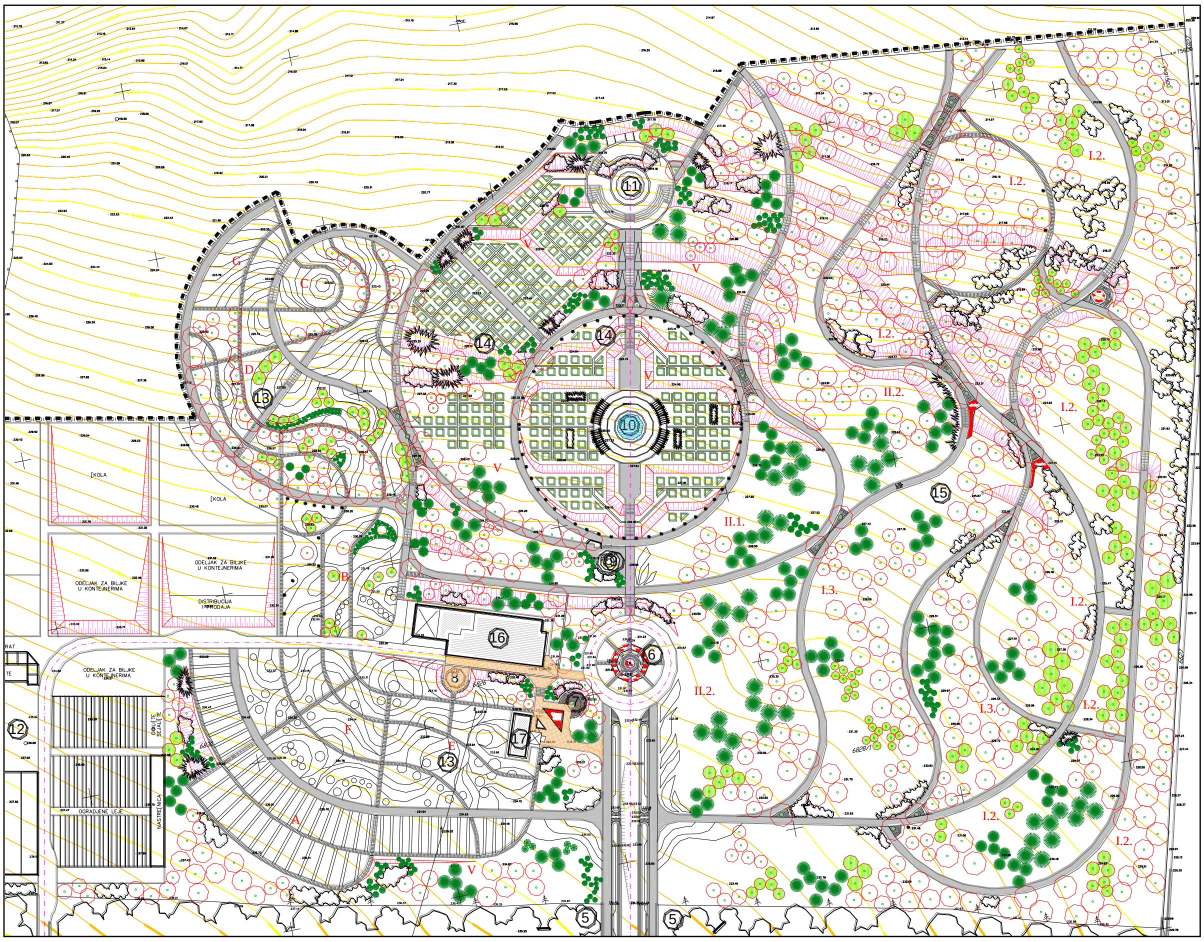

Fig. 4 – Composition plan of the Garden complex – I phase

5. CONCLUSION

The contemporary economic conditions put before the surveying profession the task of quick, accurate and efficient collection of geometry data on geospatial entities, their processing, presentation and development of Geo Information Systems and submission to the use of other professions. As for the geometry of construction objects, especially the communication lines - roads, streets, railroads and bridges, it is about the coordinate geometry in space for which the surveying experts are best qualified because they can perceive and feel the space.

Given the trend of modern planning, design and management of space, it is necessary to have a powerful software to support it. Survey is a comprehensive and highly developed software system for digital topography which enables the creation of digital topographic maps and other final surveying products. It includes a full set of application modules for designing in civil engineering.

Putting this advanced technology into practice enables us to meet the needs of not only surveying profession, but of all users of spatial data. It forms an excellent basis for landscape design, design of roads and canals, regulation of river flows, design of water supply, sewerage, pipelines, transmission lines, pits and other facilities, as well as for the management of space and natural resources.

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