CREATION OF RELIEF MODEL IN THE NORTHERN PART OF JELGAVA CITY

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Earth is the fifth largest planet in the solar system, and was created about 4.54 billion years ago.

Humanity has long been interested in the shape of the Earth. This is the best we can see from satellite imagery. These images provide a visual insight into the shape of the Earth, the terrain, and the location of the various objects. With satellite imagery, we can predict and model various situations that may occur on Earth, or even threaten Earth's existence, such as natural disasters, volcanic eruptions, hurricanes.

Nowadays, new technologies are coming into the surveying industry, which can be done in a safer, faster and more interesting way. One of the latest technologies is laser scanning, which results in a point cloud that can be used to create various three-dimensional models.

By combining both photogrammetry and laser scanning techniques, it is possible to obtain high-quality, versatile digital material for design, project monitoring, making human work easier and easier, especially in areas where access is difficult or life-threatening. Digital material, in this case a relief model, allows all of the above operations to be performed remotely.

Photogrammetry and remote sensing are the art, science, and technology for obtaining reliable information about the Earth, its environment, and other physical objects and processes through the acquisition, measurement, analysis, and imaging of non-contact imaging and other sensor systems.

Photogrammetry can be considered as one of the methods of remote sensing, the main task of which is geometric reconstruction of objects. This is possible with photogrammetric measurements in scenes. They can be done in a single scene, a pair of scenes, or multiple scenes or a block of scenes. Scenes can be photographic or digital. Measurements are usually made with special instruments or on a computer screen and are based on the principle of stereoscopic vision and measurement. They can also be performed automatically using specific correlation algorithms. Depending on how the photogrammetric measurements are performed and the geometric reconstruction of the objects, photogrammetry can be divided into analog, analytical and digital photogrammetry.

Digital photogrammetry uses a powerful, high-memory computer. The software is similar to the software used in analytical photogrammetry. The main difference is that measurements are made in digital scenes. The use of digital photogrammetry allows you to automate many measurement processes.

Depending on the distance to the subject and the location of the camera, a distinction is made between aerial photography and terrestrial or close-up photogrammetry.

The main application of aerial photography is in the production of topographic maps and plans as well as orthophoto maps. For topographic maps and plans, photogrammetric data is called a digital terrain model that can form the basis of geographic information systems. The required precision can be achieved by choosing the appropriate scale for the scene.

Terrestrial or close-up photogrammetry has relatively short distances to the subject. It is used in architecture, surveying of structures and other engineering objects, supervision of construction, etc. [1.].

In 1827 Joseph Nicephoce Niepce (pronounced Nee-ps) reportedly took the first photograph. He developed a product called a heliograph. His first picture shows a view from his studio window and required eight hours of exposure. The image is difficult to decode. With the heliograph operating for eight hours, the sun had time to move from east to west, so it shone on both sides of the building [2.].

During World War I, aircraft were so advanced that they could be used for aviation. However, aerial photographs of planes were often very distorted because the shutter speed was too slow in relation to the plane speed. At the end of the war, Sherman M. Fairchild set up a camera with a shutter inside the lens. This design significantly reduced the problem of interference. Fairchilds also designed an intercom that allowed photography at any interval. Combining these new features, the Fairchild camera became the best available camera system. With modifications, the Fairchild camera retained its preferred air camera system for the next fifty years [2.].

The French Colonel A. Losedo is considered the founder of photogrammetry. In 1859 he gave a lecture to the commission of the Paris Academy of Sciences on the method of determining the coordinates of an object from a pair of scenes with a spatial beam [1.].

The first 3D scanning technology was developed in the 1960s. The original scanners used lights, cameras and projectors to accomplish this task. Equipment limitations often required a great deal of time and effort to accurately scan objects. After 1985, they were replaced by scanners that could use white light, lasers and shadows to capture a specific surface.

The 3D laser scanner works by first projecting laser light onto an object or surface, then detecting the reflected light. Based on where the illumination is facing each other, the scanner calculates their positions and creates data points [3.].

The laser scanner uses laser light to systematically measure distances from the sensor to the subject. The Aspect of Distance Measurement - The range depends on the laser light to perform this measurement. Measurement range measurements are obtained by directing strongly collimated laser energy, i.e. light, in different directions.

Different principles can be used to measure the distance between the sensor system and the target. They differ in accuracy, but all have reason for a certain range. The largest range can be checked using the pulse flow time measurement principle to obtain cm accuracy. Shorter distances, for example up to 100 m, can be done faster and more accurately with the phase measuring method. The various range principles are described in detail with a "pulse-return" approach, including aspects that apply to all laser-range principles [4.].

Quite a large amount of technical support is required to fulfill the tasks set by remote sensing. First of all, you already need an unmanned aircraft with a camera to take photos, which will produce a photo visualization. Also unmanned aircraft with laser scanner is needed to scan and produce terrain model from the data.

Laser scanning technology has existed for decades, but only in the last decade have laser scanners and their software developed rapidly, replacing traditional surveying methods. This is mainly the case when detailed information is required about the object. Traditional methods are still relevant, where the location or distances of individual points need to be surveyed, site markings, etc. have to be done.

A wide variety of laser scanners are manufactured, depending on the application. An essential component of a laser scanner is a laser distance meter, which rejects laser beams and measures their distance to an object based on their reflection. If the location coordinates of the laser scanner are known, as well as the direction of the laser beam relative to the coordinate system, it is also possible to determine the coordinates of the point to be measured.

A state-of-the-art laser scanner enables you to send out up to 1,000,000 laser pulses per second, thus measuring the environment at up to 1,000,000 coordinated dots per second. It is important to know that the laser scanner does not "see" behind corners or through objects.

There are three types of laser scanning:

1. Laser scanning from a fixed position (Terrestrial laser scanning) - at the time of measurement the laser scanner is located on a stationary base (stand). Once the survey is done in one location, the laser scanner is moved to a new location several times until the whole object is covered with a "point cloud".

This method is mainly suitable for surveying compact objects such as buildings, bridges, parking lots, shorter road sections, etc. An accuracy of a few millimeters is ensured.

2. Mobile laser scanning - The laser scanner is located on a moving surface (car, wagon, boat, ATV). Even with a moving device, it is important to know the location of the laser scanner at each point in the survey, so the laser scanner must be synchronized with the GPS or IMU (Global Positioning System and Inertial Measurment Unit). This, however, increases the cost of the survey system.

Mobile laser scanning is suitable for large linear objects such as highways, railways, street networks, marinas, shorelines, etc. Precision in centimeters is ensured.

3. Aerial laser scanning - it often uses the term LIDAR (from the words Light and Radar). The equipment is attached to an airplane, helicopter or drone.

Aerial laser scanning also provides information on the soil beneath the vegetation, which is not provided by aerial photography, as some of the laser beams between plants reach the ground. Precision in decimetres is assured.

Laser scanning results in a point cloud, which is processed into a point cloud model and linked to a georeferencing system. A point cloud is made up of millions of points, each point containing information about its location coordinates and signal reflectance, often RGB information (when taking a scan along with scanning).

A point cloud is a document about the current state of a surveyed area or object. Point cloud can be used in many ways and for different purposes:

- point cloud as design input, as background reference for the design model being developed;
- you can create 2D sections from a point cloud and draw 2D drawings based on them;
- you can create various 3D models (soil models, solid models) from the point cloud;
- Change monitoring - By comparing point clouds obtained at different points in time, changes can be detected;
- Control measurements - Comparison of point clouds obtained from control measurements with the project can reveal deviations from the project.
- infrastructure inventory and analysis - in the cloud of points it is possible to filter road signs, barriers, road markings, etc., and to analyze the condition of road surfaces and road markings, to perform traffic safety analysis, etc.
- and much more.

Often, laser scanning also involves photography. As a result, you get a point cloud of realistic colors that make it easier to process information, for example in mobile and aerial scanning.

The accuracy and quality of laser scanning results depend on many factors, such as the equipment and method chosen, the number of core network and control points, the location and accuracy, the weather, etc. Most important is the knowledge and experience of the implementer. Keep in mind that the more accurate the results we want, the more expensive it will be. In practice, there is often a desire to receive data with an accuracy of 1 mm, although in reality an accuracy of 1 cm is also sufficient [5.].

The diploma project was about relief model creation in Jelgava city in Latvia.

The planned Northern Transmission opening area was chosen as the object of the diploma project development, which is justified by the need for additional infrastructure object to reduce traffic volume in the central part of Jelgava city by shifting freight traffic bypass, thus improving the technical condition of carriers and manufacturers.

One of the main directions of Jelgava spatial development perspective is equal access to and use of infrastructure and services, which responds to the need to improve the city infrastructure, thus increasing the mobility of the city inhabitants, as well as improving the traffic volume in the main cities. With the development of industrial areas, more specifically the former aerodrome area, the creation of new areas for business and industrial development, there is a need to construct the North Passage over Driksa and the Lielupe, ensuring the flow of lorries from the city's main streets and improving links between cargo carriers and manufacturers. The Northern Transmission would provide links to city transit streets and the country's major motorways.

Considering the transport network as a single system, it can be concluded that there are no alternative routes for transit transport as well as for inner city traffic in Jelgava city. The increase in the number of road users contributes to the congestion and the reduction of road safety. In the central part of the city, especially in the morning and evening hours, it is difficult to take turns, especially on the left, and it is difficult to cross the main streets. The time spent on roads and intersections has increased, which has a negative impact not only on the road users themselves but also on the environment. This situation has developed in the existing Jelgava road network - due to the heavy traffic in the city center, the number of crashes is increasing, the average speeds of traffic flows are decreasing, the quality of road cover is deteriorating, environmental pollution is occurring. the noise level increases.

The purpose of the transport transmission is to expand the urban transport infrastructure and optimize traffic flows:

• A transport infrastructure network (trunk street with urban street connections) for the foreseeable development activities in the northern part of the city, former aerodrome and surrounding areas, incl. industrial development area of the city;

• connect the city's main transit streets with the TEN-T network;

• the bypass of the city will be closed, connecting the P97 Jelgava-Dobele-Annenieki (hereinafter Dobele highway) with Kalnciems road and Lok highway;

• Transit traffic flows from the city center to the less populated areas of the city;

• a traffic infrastructure will be created which will improve the connection between the north and the city center;

• the existing cycle path in the city will be expanded;

• additional Lielupe crossing in the territory of the city will be provided.

The prospective bridge over the River Lielupe and the Driksa River and the construction of motorways will provide: the brownfield site at the former aerodrome in the northern part of the city (which is, in fact, the only urban area to house new production sites); the relocation of transit traffic from the congested city center; traffic organization in accordance with the quality requirements specified in regulatory enactments; improvement of the territory of the municipality (creation of bicycle paths, bus stops, creation of noise barriers, greening of adjacent territory); facilitate access to a variety of public buildings, existing and prospective business locations in the northern part of the city, thereby contributing to the operation and development of local businesses, which are essential for the economic growth of the city; reduce travel times and transport maintenance costs, based on reduced distance, the number of street crossings that transit traffic has to do; improvement of road infrastructure and traffic organization in populated areas and at educational institutions (including improvement of stationary lighting in populated areas and dangerous places on roads, construction of pedestrians, bicycles, etc.).

After reviewing the environmental impact assessment report of Jelgava City Long-term Development Strategy, Jelgava City Development Program, as well as the construction of the transport bridge (bridge) over the Lielupe and Driksa rivers in Jelgava city, it can be concluded that Northern Transmission plays an important role in urban development. on the main streets, improve interconnection between freight carriers and manufacturers, and develop new industrial areas, improving the well-being of the city population, providing new jobs, and improving the economic situation of the city, thus increasing the city's potential for other directions.

Spatial data are data that indicate the location of an object, which means that the data must be linked to a specific coordinate system, in this case LKS-92 TM, which is defined in the territory of the Republic of Latvia according to the Cabinet of Ministers Regulation No. 879 'Rules for the geodetic reference system and the topographic map system'.

Spatial data mining can be done using a variety of methods, which are applied depending on the purpose and outcome you want to achieve.

Starting any action or significant process cannot be done without preparation.

As the model of the terrain surrounding the diploma project site was based on laser scanning data requested and received from the Latvian Geospatial Information Agency, no special preparations were needed for this phase.

This process took quite a bit of preparation to obtain spatial data using photogrammetry.

Prior to the commencement of photographic scenes, a request was made to the Jelgava City Council to obtain permission to perform such works, that is, to obtain photographic scenes with an unmanned aircraft equipped with a passive sensor - a camera. The request was sent 3 times based on planned flight dates - January 1, 2019, March 2 and 3, and March 30 and 31, 2019. On 2 and 3 March 2019, the flight with an unmanned aircraft was not possible due to bad weather - rain, strong wind.

Jelgava City Council issues the permit with reference to Cabinet Regulation No.737 of November 22, 2016 “Procedures for Flight of Unmanned Aerial Vehicles and Other Aircraft Which Are Not Qualified as Aircraft” .

On March 30, 2019, no props or brands were installed because the flight was performed with the unmanned aircraft DJI Phantom 4RTK, which provides real-time flight, resulting in photo scenes with accuracy of up to 1 cm.

One of the most important stages of preparation is the preparation of the flight route. The route is created in the Drone Deploy application.

The scope of the diploma project object was divided into 3 separate stages, taking into account both the object configuration and the ability of the unmanned aircraft to carry out a certain amount of work per flight (residence time in the air). First, the route to the largest part - the castle island - was drawn up (see Figure 1). The application automatically suggests a flight path layout, but it can be manually edited if the proposed layout does not meet the user's wishes. The key is to ensure that there is sufficient overlay between the scenes to provide a higher quality and more accurate final product - in this case, photo-visualization. In the particular situation, the front coverage is 75% and the side or side coverage is 65%.

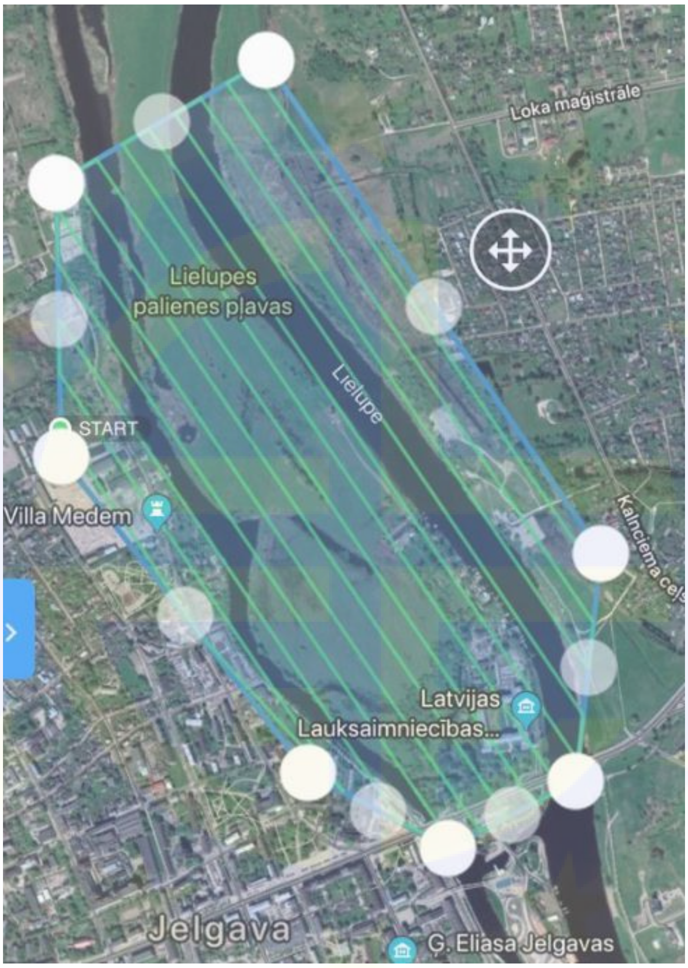

Fig.1. Flight route created by Drone Deploy to the Castle Island.

All flights were made at a height of 120 m, which is also the allowed height specified by Cabinet regulations. As shown in Figure 3.2, the estimated flight time is 47.10 minutes, the covered flight area is 167 ha, in total the unmanned aircraft with camera will take 944 photo shots and 3 batteries will be required for the flight. As the wind speed was slightly higher than expected on the day of the flight (March 30), more batteries were used than previously anticipated as the unmanned aircraft had to overcome higher air resistance.

Similarly, the two remaining routes were constructed, one for the Arc Highway and the other for the Atmodas Street area.

As these are linear objects, flights were planned on a reciprocal and reciprocal basis, providing both the required coverage and resources.

A total of 1,163 photo scenes were taken, which took 3.5 hours of work.

On January 12, 2019, the first photo shoot with unmanned aircraft DJI Inspare 2 was organized (see Figure 2). This unmanned aircraft is equipped with a Zenmuse X7 camera. The aircraft can reach speeds from 0 to 80 km / h in just 5 seconds, but its maximum flight speed is 94 km / h. The Inspare 2 can fly for up to 27 minutes and has its own autonomous heating system, which makes the aircraft usable even in low temperatures.

An attempt was made to make a photo-visualization of the resulting photo scenes, but unfortunately it failed because the editing program Pix4D could not match the images together. The main reason for this failure was that the scenes were captured while the subject deck was snowing, so the editing program was unable to find common points in the scenes that help to bring the scenes together.

Fig.2. DJI Inspire 2 unmanned aircraft.

On March 30, 2019, a photo was taken of a DJI Phantom 4 RTK unmanned aircraft with a 20 megapixel camera (see Figure 3).

Fig.3. DJI Phantom 4 RTK unmanned aircraft.

Further processing of the point clouds is done in the Bently MicroStation program, which is equipped with the TerraSolid program plug-in.

Bentley MicroStation is the most powerful professional computer-aided design (CAD) and three-dimensional (3D) modeling software, a Life Cycle maintenance tool for engineering projects. The MicroStation continues the best infrastructure design and documentation tradition from previous (95, SE, / J, and V8 / 2004 versions), and provides high quality and ease of use with other programs in every engineering workstation.

Laser scanning results in a point cloud (see Figure 4), which is processed into a point cloud model and linked to a georeferencing system. A point cloud consists of millions of points, each point containing information about the coordinates of its location and the intensity of the reflection of the signal.

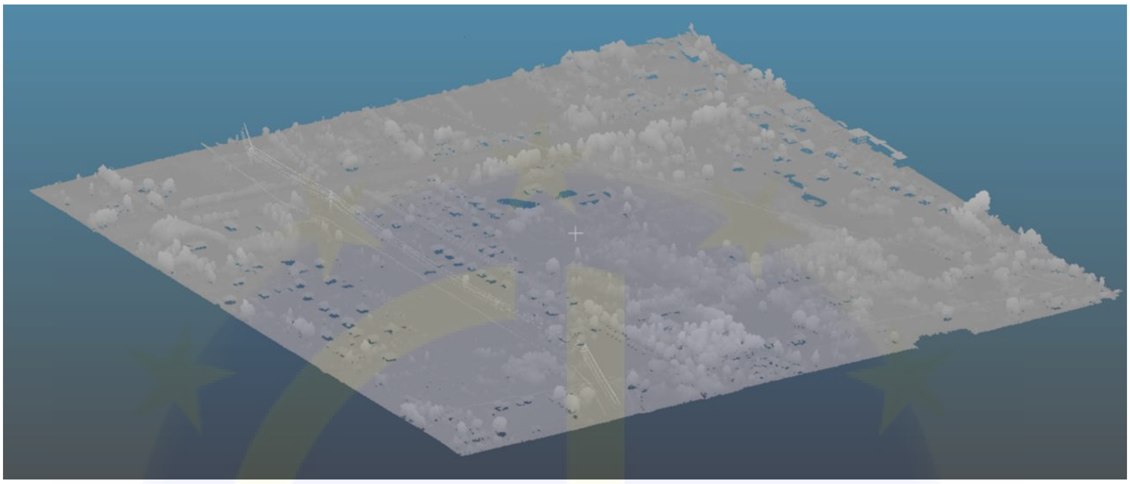

Fig.4. Dot cloud from Latvian Geospatial Information Agency laser scanning data.

The laser modeling data obtained from the Latvian Geospatial Information Agency - point clouds - was used to prepare the model of the diploma project territory. To cover the entire area, 14-point clouds were used. The size of one point cloud is 1 km x 1 km.

Prepared terrain model is possible look in figure 5.

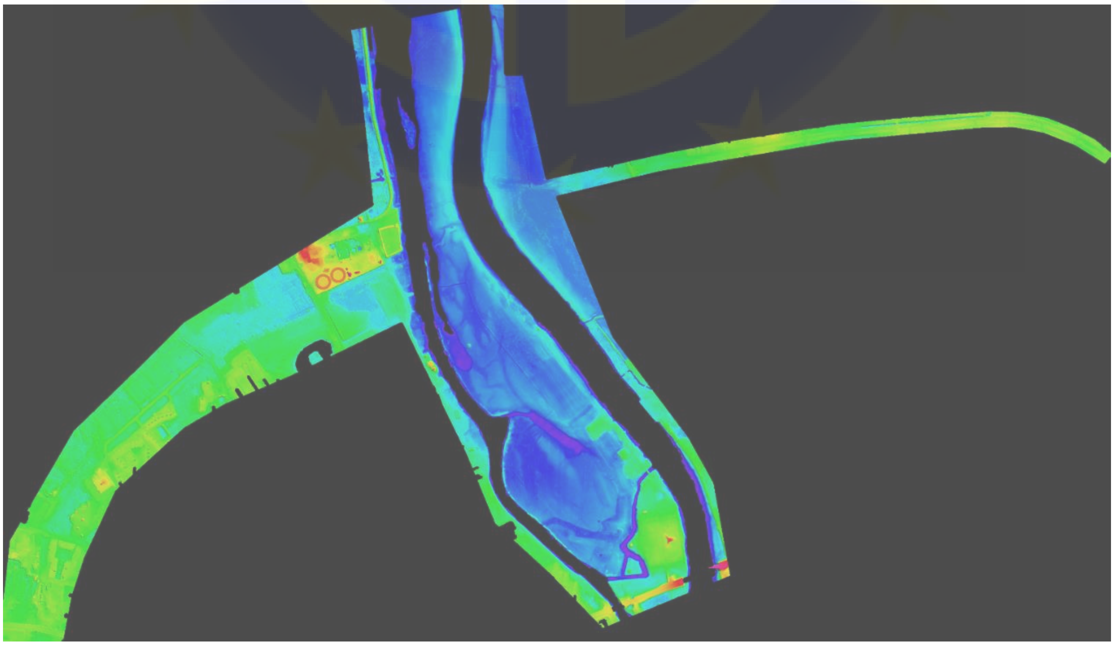

Fig.5. Prepared terrain model

The terrain model was prepared for an area of 281.26 ha, which covers both the streets of the planned Northern Road - Loka highway, the area of Atmodas street, as well as the part of the castle island where Jelgava Castle is located.

As the terrain model colors in different heights, virtually the entire castle island is lower (blue) than the rest of the area, so there is a risk of heavy flooding (heavy rain, floods, floods) underwater, thus putting the island's habitats at risk.

Analyzing the elevation markings on the 70 m x 70 m grid depicted in the terrain model, it can be concluded that the height differences are not very large with respect to particular areas. They range from 1.5 m to 2.0 m. Of course, when analyzing the whole territory altitude differences are about 0.06 m to more than 6.0 m.

Conclusions:

1. Remote sensing is a sophisticated and complex science, yet it provides versatile knowledge of geodesy, photogrammetry, etc. related industries.
2. Laser scanning offers a variety of opportunities to improve the modern surveying industry as well as to make human work easier and faster.
3. The planned Northern Transmission plays an essential role in the development of the city in order to reduce traffic on the main streets of the city, improve interconnection between freight carriers and manufacturers, develop new industrial areas, improve the well-being of citizens, create new jobs and thus increasing the opportunities for the city to develop in other directions as well.
4. The preparation of the terrain model requires additional knowledge of both geodesy and technical issues, which would in future be a challenge in the training process.
5. Terrain modeling is a time-consuming process because it is not only a task to assemble data, but it all begins with flight planning and ends with the final product preparation, but it is still faster than just human work in the field using traditional surveying techniques.
6. There are several factors that can affect the end result, such as weather or snow speed, including magnetic fields, so it is important to consider all of them and to avoid as much as possible the influence of these factors in the proper planning of your flight.
7. Because the area covered by the diploma project is quite large, it can be concluded that the terrain in the selected area is relatively flat and there is no sharp difference in height in certain areas of the site.

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