

The Use of Unmanned Aircraft in Aerial Photography in Engineering Geodesy

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Abstract

In recent years developed a completely new method for recording and surveying the earth surface in order to explore the land and buildings. By using unmanned aircraft, it is possible to survey a large area in a very short period of time with a high accuracy. This method represents the Surveying future in geodesy and its areas. This paper describes the method of recording unmanned aircraft SenseFly Ebee as a way of getting a surveying network point clouds, a digital terrain models and a digital orthophoto plane, by implementing standards of NSSD for evaluation of spatial data. It was concluded the accuracy of the results depends on the resolution of the recording, the configuration of the terrain relief and the weather conditions.

Keywords: Unmanned aircraft, digital elevation model, digital orthophoto, aerial photogrammetry

الخلاصة

تم في السنوات الأخيرة تطوير طريقة جديدة لمسح وتصوير الأراضي والمباني باستخدام طائرات بدون طيار، إذ بات من الممكن تصوير وتسجيل مناطق واسعة في فترة من زمنية قصيرة جداً وبدقة عالية. وعلى فأن هذا الأسلوب يمثل مستقبل المساحة في الجيوديسيا وعلومها. يصف هذا البحث طريقة استخدام الطائرات بدون طيار مثل الطائرة Sense Fly eBee في مسح وتصوير المنشآت كوسيلة للحصول على شبكة نقاط مساحية للمنطقة المصورة تمثل شكل التضاريس الأرضية الرقمية والخرائط الرقمية المصححة المصورة لتلك المنطقة من خلال تنفيذ معايير (NSSDA) The National Standard for Spatial Data Accuracy لتقييم البيانات المكانية والظرافية للمنطقة، فقد استنتج أن دقة النتائج تعتمد على وقت لحظة التصوير بالطائرة، شكل وتكوين التضاريس الأرضية وظروف الأنواء لجويه.

الكلمات المفتاحية: طائرات بدون طيار، التضاريس الأرضية الرقمية، الخرائط الرقمية، التصوير الجوي .

1.Introduction

We are witnessing the expansion of technology development and scientific achievements in all spheres of life. However, the greatest achievements are reflected in the information technology and its closely related field. Particularly geodesy which follows the trend of technological achievements. The development of technology in surveying is evident through the development of modern instruments (laser scanners, robotic total stations, digital levels, etc.), software and new methods of recording the Earth's surface. In this paper, the focus is placed on the method of recording the Earth's surface in order to survey the land and buildings, and create a digital terrain model and a digital orthophoto map by using unmanned aircraft Sense Fly Ebee.

The concept of unmanned aircraft flight presented for the first time in 1915 by Nikola Tesla in his dissertation when he described an armed unmanned aircraft designed for the defense of the United States. The primary use of unmanned aircraft was by the military observation, reconnaissance and espionage. Due to rapid technological development, that invention began to have applications and civilian needs. In the field of geodesy, the method was first used by Professor Wester-Ebbinghaus 1980, when the unmanned aircraft was used in the form of helicopters for photogrammetric purposes. From then until now, the focus is on the construction of drones that could be applied in other areas of geodesy. The use of unmanned aircraft for photogrammetric data collection methods can be positioned between the terrestrial surveying methods, laser scanning and aerial photogrammetry, or in cases which demand the collection of a lot of information in a relatively small area (a few hundred square meters to several square kilometers) as show in (Figure 1).

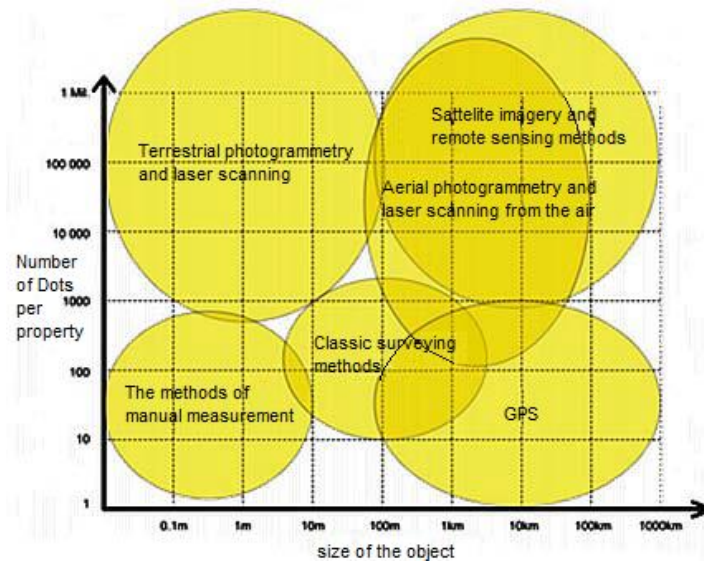


Figure 1: Selection of Geodetic Methods of Recording (Böhler and Heinz, 1999)

Unlike classical aero photogrammetry it is important to mention, that the area of recording, and the time dimension of data with drones gives a more realistic view of the actual situation on the ground because the relatively low altitudes eliminate the negative impact of weather conditions such as clouds or bad fog, and enables fast reaction and current data collection.

2. The Use of Unmanned Aircraft in Geodesy.

The use of unmanned aircraft in geodesy is still an insufficiently explored area. However, one of the most common applications of unmanned aircraft in the field of geodesy is for the photogrammetric purposes, i.e. to create 3D object models, digital terrain models and digital orthophoto maps. It is very difficult to accurately specify the applications of unmanned aircraft in geodesy, but the most prominent one is the preparation of survey maps that can be used in many areas (Kolarek, 2010).

2.1. Design and Development of Concept Designs

The use of pads is necessary for the design and the conceptual design of future buildings because the former provide a sufficient amount of information. Unlike traditional methods, the advantages of obtaining geodetic recording unmanned aircraft are summarized in the very short period of time needed to have the results, the cost effectiveness and the comprehensive filming of almost all kinds of terrain. The combination of the digital terrain model and the digital orthophoto map can get different geodetic, both in a vector format and in a raster format. Figure (2a, 2b) illustrates the digital orthophoto map with contour lines area of Bethany (Freiburg), unmanned aircraft SenseFly Ebee, all are used in the design.



Figure 2-a: Results Recording Unmanned Aircraft: Basis for Design

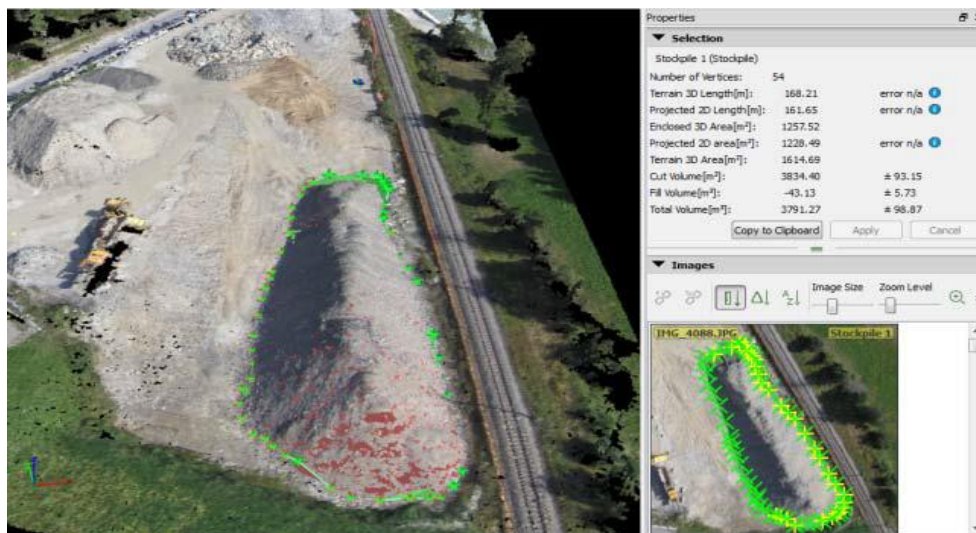


Figure 2-b: The Volume of Earth Masses.

Figure (2-b) below shows an example of recording and calculating the volume of earthen mass using unmanned aircraft SenseFly Ebee.

2.2. Mining

The use of unmanned aircraft in the mining sector is apparent in calculating the volume of earth masses outside digs. It is possible to calculate volume or volume of anybody. Unlike traditional methods, where the land mass captures the profiles, the advantage of recording with drones is reflected in the fact that it gets hundreds of thousands of points, with all the characteristic fractures, which significantly affect the volume of that earth mass. Figure (2-a) shows an example of recording and calculating volume of earthen mass using unmanned aircraft SenseFly Ebee.

2.3. Geology

In the field of geology, unmanned aircraft can be applied to provide a variety of information obtained from products of unmanned aircraft. This depends on the ability of the digital orthophoto map to identify zones of landslides, and floodplains caused

by bad weather. The combination of a digital terrain model with an ortho-photo plan can carry out various computations like computation of volume started mass, surface area and volume of landslides by calculating the slope of the terrain and the orientation of the slope. Figure (3) shows the surveyed area with unmanned aircraft SenseFly Ebee, where the recording is done immediately after the weather conditions (floods) that have taken place in Croatia in mid-2014 year.

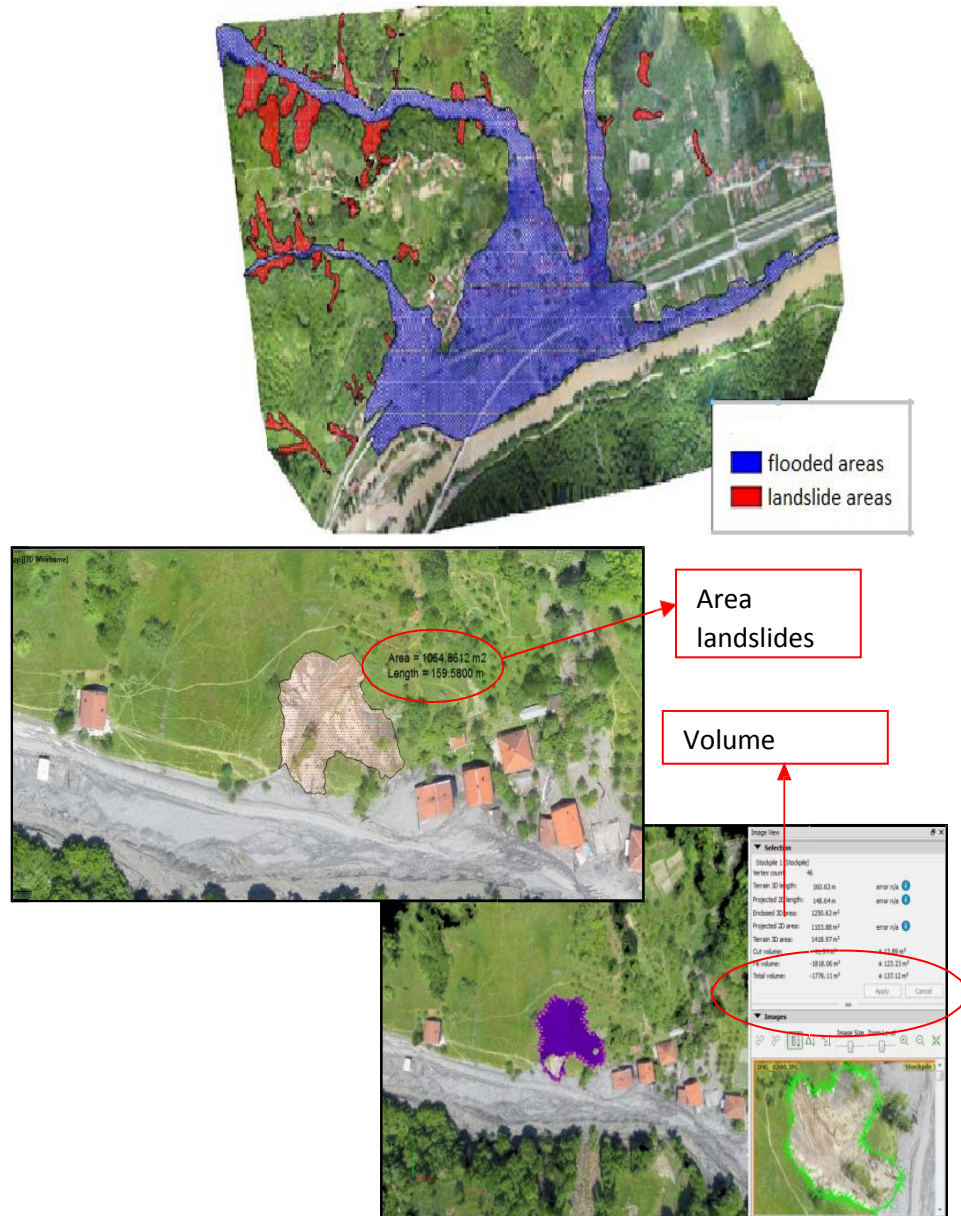


Figure 3: The Area that Recorded Unmanned Aircraft Sensefly Ebee

2.4. Forestry

Due to their high-resolution, the aerial photographs can be integrated into the digital orthophoto map to be use in forestry (Figure 4). In addition to calculating the surface, digital orthophoto map can be used for the analysis of illegal logging. Installing the camera on the drone with NIR (Eng. Near Infrared) spectrum can help in the analysis of forest health based on NDVI (Eng. Normalized Differenced Vegetation Index) vegetation index.

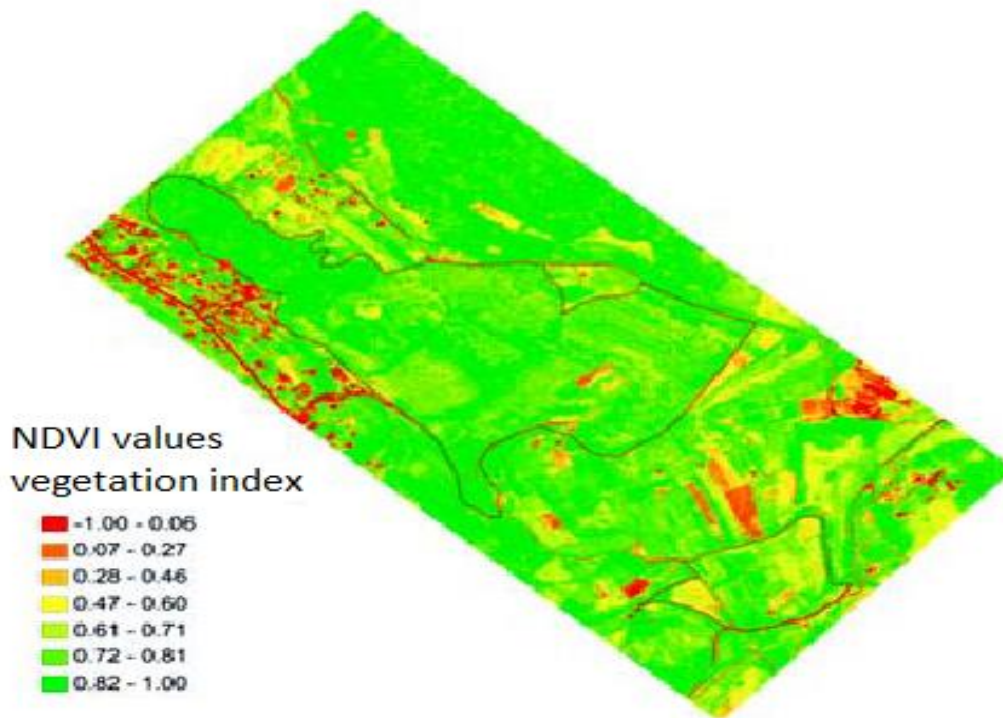


Figure 4: Recording Areas with Unmanned Aircraft SenseFly Ebee and the NDVI Vegetation Index, Shows the Health of Forests (values close to +1 indicates a healthier forest)

3. Development of a Digital Terrain Model Ortho Map Using Unmanned Aircraft SenseFly Ebee.

Creating a digital terrain model (abbreviated DTM) and digital orthophoto plans (short DOF) on the second level, represents the daily activities of a large number of surveyors. There are different methods for preparing these products, from traditional to modern methods. The use of unmanned aircraft is one of the modern methods of obtaining DTM and DOF, which are characterized by the speed of data collection, cost effectiveness, and obtaining update* digital terrain model and digital orthophoto map.

(*The term up-date means getting updated products related to the day of recording unmanned aircraft.)

3.1 Elements of Unmanned Aircraft SenseFly Ebee

The eBee is a powerful tool. It is a flexible and efficient way of gathering environmentally relevant information at the landscape scale and at the desired spatio-temporal resolution, figure (5).



Figure 5: Elements of Unmanned Aircraft Ebee (sensefly, 2015)

The following explanation describes an example of the digital terrain models and orthophotos map areas of Civil Engineering in Freiburg, using the unmanned aircraft SenseFly Ebee.

Project aerial unmanned aircraft SenseFly Ebee begins with the creation of Flight plan for the planned area. Flight plan to test the area of construction University of Sarajevo covers an area of 25 km² or 0.25 ha. When you are planning to consider a switch between the image and the resolution for recording. Lines parallel to the contour lines, and in order to obtain the required recording resolution. Based on the flight plan, defines the schedule of orientation points that are used to model orientation and Reconstruction (Republic Geodetic Administration, 1974), and control the point spread on the basis of which is made of horizontal and vertical drop in the rating accuracy of DTM and DOP (Figure 6).

Determination of coordinates signaling points officially is done by GNSS methods. The coordinates are determined with a two-frequency GNSS receiver Topcon Hiper II, using high-precision positioning service (VPSP) to reach a permanent station FBIHPOS.

The resulting coordinates are referenced to frame ETRF 2000 epoch 2011.307, and have transformed the old Germany national coordinate system in the ratio of 1: 1000.

Localization is done on the basis of certain parameters formally similar 3D transformation, based on the GPS coordinates campaign SARAREF 06.

All work on determining the coordinates of points have been conducted according to the Regulations on the Application of satellite measurements in geodesy (FBiH Official newspaper, 2012).

After a certain area of the recording and done preliminary field work, carried out the survey of the terrain from the air drones, in accordance with applicable regulations (Official Gazette, 2013, the Federal Geodetic Administration, 1962).

Processing and processing data recording is done in a professional photogrammetric software Postflight Terra 3D. The software is based on recordings

and coordinate point, compares the common pixels that after Block equalization (Kraus 2006) produced photogrammetric point cloud.

Photogrammetric point cloud of the first result, accurate data processing, and each of the points is defined by three coordinates (i, k, h). Model digital terrain generated raster interpolated points of the cloud, and in order to obtain digital elevation model was necessary to classify point clouds. Plan digital orthophoto is based on a digital terrain model.

Photogrammetric point cloud of the first result, accurate data processing, and each of the points is defined by three coordinates (Y, X, H). The terrain model digital generated clouds raster interpolation point, and in order to obtain digital elevation model was necessary to classify point clouds. Plan digital orthophoto is based on a digital terrain model.

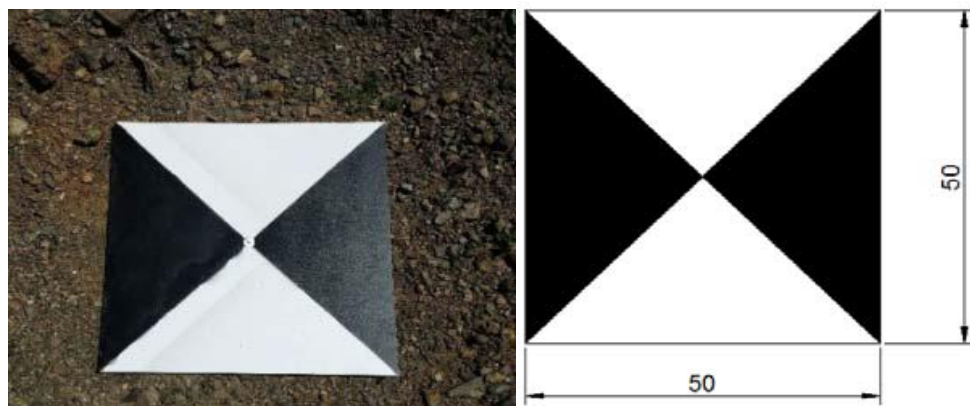
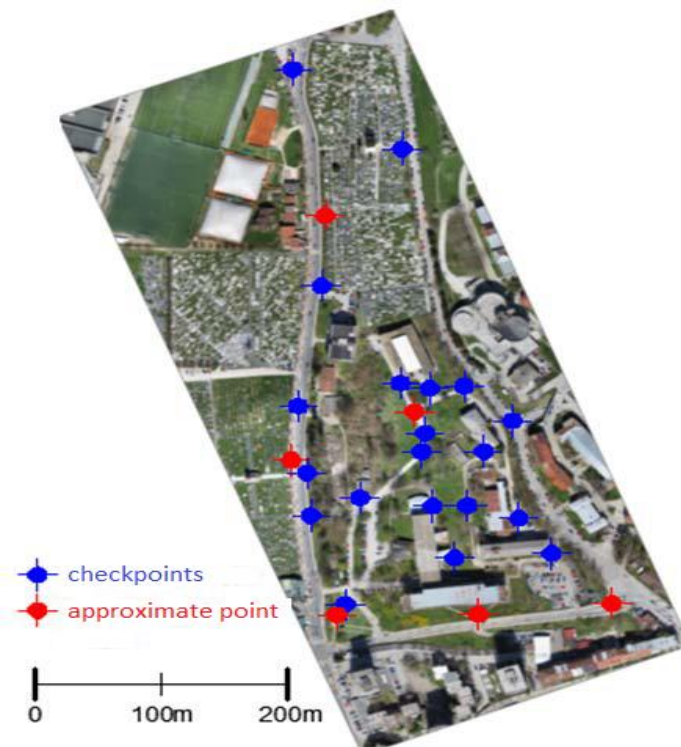


Figure 6: Distribution and Signaling of Orientation and Control Points Shown on the Orthophoto Map Obtained by SenseFly Ebee

The figures below show the results of data processing recorded by unmanned aircraft SenseFly Ebee, in the field of Civil Engineering, (Figures 7 and 8).

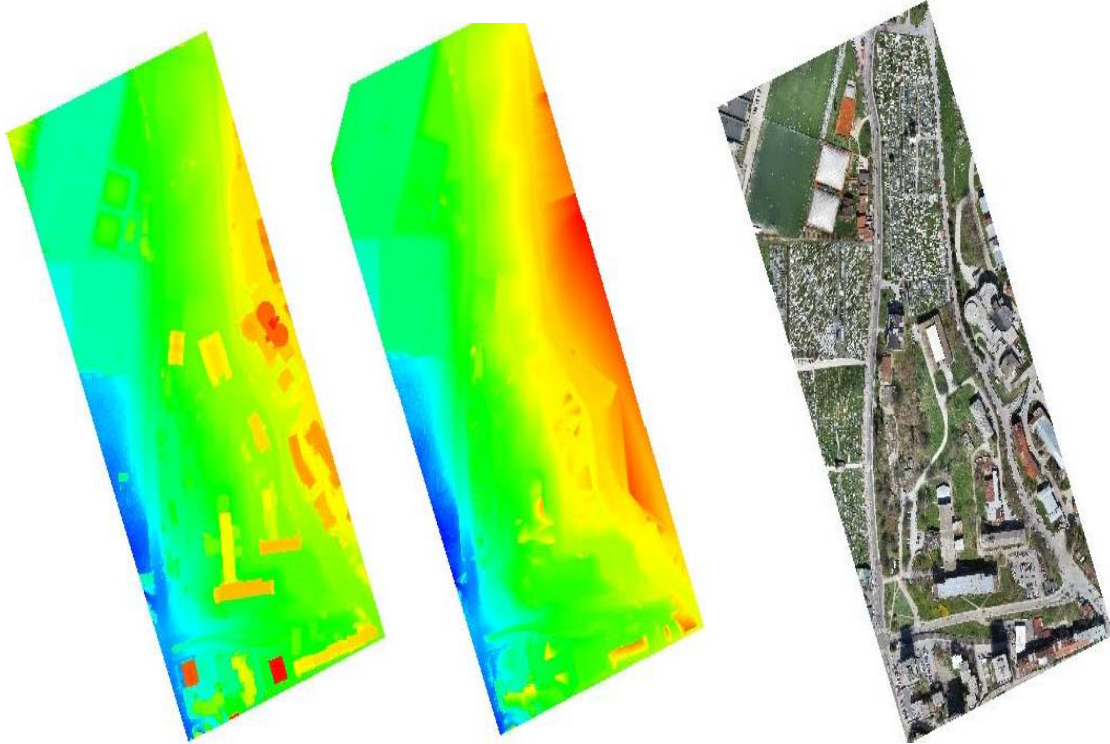


Figure 7: Digital Terrain Model, Digital Terrain Model and Digital Orthophoto Map.

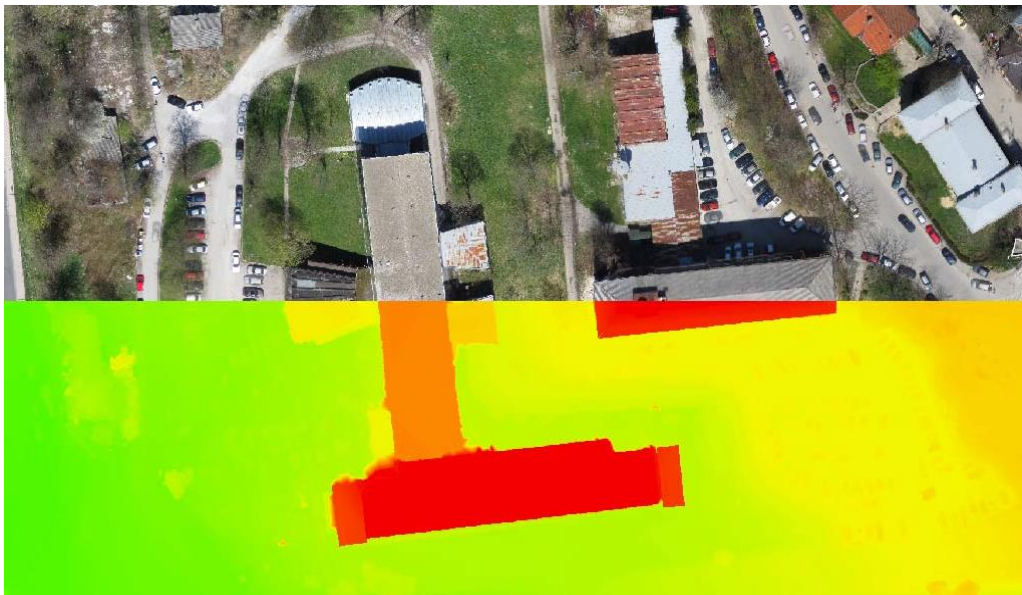


Figure 8: Clip DOF and DMR Areas.

The level of accuracy, is in accordance with the American national standard for evaluating the accuracy of spatial data (National Standard for Spatial Data Accuracy, abbreviated NSSD) (FDGC, 1998).

Table (1) shows the obtained and the expected values of RMSE (Root Mean Squared Error) for those products.

Table 1: Rating Accuracy

GSD = 3.47 cm/px	The values obtained				Expected Values
	RMSE _x [cm]	RMSE _y [cm]	RMSE _{xy} [cm]	RMSE _h [cm]	
Photogrammetric point cloud	3.9	2.6	4.7	9.4	positional accuracy: 3.47 < RMSE _{xy} > 6.94 Altitude accuracy: 6.94 < RMSE _h > 10.41
A digital terrain model	-	-	-	16.2	
The digital orthophoto map	3.7	3.1	4.8	-	

As it can be noticed, photogrammetric point cloud, which is the most accurate product recording result, is within the expected accuracy. Altitude accuracy digital elevation model deviates from the expected value, which means that when unmanned aircrafts are recorded the largest deviations occur in the height of points. Positional accuracy by the manufacturer is 1-2 x GSD, while the height accuracy specified by the manufacturer 2-3 x GMS (GMS is land resolution of the resulting orthophoto – (Ground Sample Distance) (FDGC, 1998).

4. Conclusion

The use of unmanned aircraft in geodesy is still in "infancy". However, its applications in specific geodetic works shows a level of accuracy comparable to that show in the field of technology. But the indisputable fact is unmanned aircraft is a very promising technology that certainly awaits "a bright future". Getting the final results in a very short period of time is the greatest advantage of unmanned aircrafts.

Further development of these technologies will surely have their implementation in everyday surveying work. Of course, with their own advantages, unmanned aircrafts have drawbacks, such as the strict legal regulations, i.e. ban on the use of aircraft without prior notice and approval of the competent structures. Inability measurements in all weather conditions unmanned aircraft is the second disadvantage. The final results of the recording unmanned aircrafts mostly depend on the quality of records, switching of records, and the number and distribution of orientation point, as well as the accuracy of determining their position.

Unmanned aircraft SenseFly Ebee is able to achieve positional (planimetric) accuracy of 3 cm and a height accuracy of 5 cm in the ideal weather conditions, i.e. when recording is done in a sunny weather, and when there is no wind and when there are properly spaced approximate points.

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