Possibilities of Use of UAVS for Technical Inspection of Buildings and Constructions

Anna Banaszek 1, Sebastian Banaszek 2, Anna Cellmer 3
1 Department of Real Estate Resources, The Faculty of Geodesy, Geospatial and Civil Engineering, University of Warmia and Mazury, ul. Prawocheńskiego 15, 10-720 Olsztyn, Poland
2 Dron House S. A, ul. Twarda 18, 00-105, Warsaw, Poland
3 Department of Geoinformatics, The Faculty of Civil Engineering, Environmental Engineering and Geodesy, Koszalin University of Technology, ul. Śniadeckich 2, 75-453 Koszalin, Poland
anna.cellmer@tu.koszalin.pl

Abstract. In recent years, Unmanned Aerial Vehicles (UAVs) have been used in various sectors of the economy. This is due to the development of new technologies for acquiring and processing geospatial data. The paper presents the results of experiments using UAV, equipped with a high resolution digital camera, for a visual assessment of the technical condition of the building roof and for the inventory of energy infrastructure and its surroundings. The usefulness of digital images obtained from the UAV deck is presented in concrete examples. The use of UAV offers new opportunities in the area of technical inspection due to the detail and accuracy of the data, low operating costs and fast data acquisition.

1. Introduction
In recent years, research has developed following the use of digital images acquired through UAVs to monitor the technical condition of real estate and inventories of technical infrastructure. Conventional state-of-the-art inspections are primarily based on visual research methods. Large structures such as large-scale structures, bridges, chimneys, towers, dams, industrial power plants, power lines are often difficult to access for detailed technical inspection. In most cases, periodic inspections of such facilities are technically complex. New UAV data acquisition technologies offer new opportunities in this field. The technical condition of buildings and buildings using high resolution digital images can be divided into two stages: in-flight and post-flight. The data acquisition process is the most time-consuming, technically complex and therefore the most costly part of the audit [1]. UAV case studies to monitor the technical condition of objects of different sizes (residential building, dam, retaining wall at the runway) [2] have shown that high resolution image quality enables visual identification of cracks of 0.3 mm at approx. 10 m from the test surface. The technology of unmanned aerial vehicle for power line inspection is drawing increasing attention from the power industry [3], [4], [5]. UAVs are generally used for visual inspections, the principle of which is to fly close to the transmission line to perform the visual inspection [6]. The Electric Power Research Institute (EPRI) has promoted the development of a more cost-effective airborne inspection method for the inventory and inspection of electric power lines. High-speed aerial patrols have typically only been used to identify the most visible conditions on transmission lines...
[7]. An evaluation of using an UAV for power line inspection indicated that this approach could be faster than foot patrol and would yield the same or even better accuracy than costly helicopter inspection [7]. The problem of detection and tracking of power lines in complex environments is presented in [8].

The paper presents the results of experiments using UAV, equipped with a high-resolution digital camera, for a visual assessment of the technical condition of the building roof and for the inventory of energy infrastructure and its surroundings.

2. Research experiment description
The experiment uses the DJI Inspire One lightweight quadcopter with the following specifications:
- weight: 2935g,
- vertical GPS accuracy: 0.5 m (accuracy determination),
- horizontal GPS accuracy: 2.5 m (accuracy of X, Y coordinates)
- Climb speed: 5 m / s, max.
- Drop speed: 4 m / s, max.
- Cruising speed: 22 m / s (ATTI mode, no wind),
- maximum flight height: 4500 m ASL (Above Sea Level), max.
- Wind force: 10 m / s, flight time: 18 minutes,
- operating temperature: -10 ° to 40 ° C,
- size: 438x451x301 mm.

Digital camera (RGB sensor) has been used to obtain digital images with the following specifications:
- 12Mpix resolution (4000x3000),
- physical size 6.170mm x 4, 628mm,
- focal length: 3.55mm.

Using UAV for commercial and scientific purposes requires in Poland a qualification certificate of UAVO unmanned aircraft operator. This requires Art. 95 of the Law of July 3, 2002, aviation law, and the detailed rules for obtaining the certificate are contained in the Regulation of the Minister of Transport, Construction and Maritime Economy of 3 June 2013 on certificates of qualification. Basic Visual Sight of Sight operation (VLOS) deals with the operation of UAV sightings. It is received by the operator after the completion of theoretical and practical training and passes the state examination, which is conducted by an examiner appointed by the Polish Civil Aviation Office.

Surface raids were designed and executed using Map Pilot software, an iOS application that enables the design of an automated UAV flight. Inspections were conducted in manual mode, based on the skills and experience of the UAV operator.

3. Results
3.1. Technical review of the roof of a large surface
The purpose of the experiment was to demonstrate the possibility of using UAV, a high-resolution digital camera for visual assessment of the technical condition of the roof of a large-area object.

At the time of the raid, 165 aerial images were made at an altitude of 80 m. The AGL was based on the orthophotomap with a resolution of 3.5 cm, a resolution of 10262x8649 and a point cloud of 69 686 413 points (159.86 points / m3). Pix4D software was used to generate orthophotomaps and point clouds. Quick Terrain Reader and Cloud Compare are used to view and analyze points.

The use of digital images made at different heights of 80, 60, 40, 20 m AGL allows for a visual assessment of the technical condition of the roof covering, installation on the roof and other components without the need for physical presence on the roof. As Figure 1 digital images show, due to their high resolution, they can see many details, such as roof tightness, gutter condition, skew, tearing, damage to components, condition and appearance of chimneys and ventilation.

Based on the obtained non-metric digital images, you can generate an orthophotomap on any scale. The product obtained can be used to assess the degree of roof wear (cracks, cavities). QGIS software was used to perform the vectorization of the identified failures.

On the analysed area shown in Figure 2, 20 lesions of the total area of almost 44 m2 were distinguished, of which the smallest lesion area is 8 cm2, the largest is 15.04 m2.
Figure 1. Analysis of individual roof elements - point cloud and digital images

Figure 2. Inventory of damage to the roofing on the basis of digital images acquired from the UAV deck
3.1. Inventory of energy infrastructure and its surroundings

The aim of the experiment was to demonstrate the possibility of using a UAV, equipped with a high resolution digital camera, for the inventory of medium and high voltage power lines.

During the study medium and high voltage power lines were surveyed (12 km) and technical inspections of 39 medium voltage poles and 16 high voltage poles were performed. During the implementation, 3 flights were deployed: automatic (photogrammetric), manual liner, and manual overrun. A photogrammetric inspection was made at 80 m AGL at 70% longitudinal and transverse coverage. Linear overlap was made at a height of 40 m AGL with a transverse coating at about 70%. The most demanding inspection flights were performed at distances of 3-5 m from the inventory columns. 84 flights with a total length of 17.5 hours were performed by a group of 5 UAV operators.

During the raids 4 594 aerial images were made. Based on those generated:
- point cloud X, Y, Z, R, G, B with a total point of 14 759 471 and a density of 40 points / m2,
- Orthophotomap with resolution of 25133x14845 and 43338x52 442, GSD of 5 cm, accuracy of 2m (orthophotomap) generated without GPS-RTK data),
- Digital Surface Model (DSM) with resolution 24764x37404, GSD of 10 cm, position accuracy 2m (DSM generated without GPS-RTK data), size 24764x37404 pix.

Pix4D software was used to generate orthophotomaps and point clouds. The orthophotomap processing time and the point clouds took 7 hours. 47 min. The recovered products may be used as shown in Figure 3 to control the deformations of power lines and control measurements. An example of the inventory of the power line environment is shown in Figure 4, which refers to the high green inventory of QGIS based on the generated point cloud.

![Figure 3](image-url)

**Figure 3.** Modelling the energy pole in the form of a point cloud - control of deformation and control measurements
4. Conclusions
On the basis of the conducted studies it can be stated that the use of UAVs for technical inspections is an alternative to costly photogrammetric measurements and time-consuming field measurements.

UAV strengths include high mobility in data acquisition, the ability to fly at different heights. Studies show that high-resolution digital images are useful for UAVs for inspection and inspection of buildings and structures. UAV Data Acquisition can be successfully used in the energy sector for inventories of power lines and inspecting the state of the energy infrastructure. Utilising UAVs for inspections of hard-to-reach or hazardous locations increases the safety of work.

Performing unmanned technical inspections requires several basic principles: the Polish UAV operator must have a VLOS qualification certificate and civil liability insurance; technical parameters of UAV and RGB sensor must be suitable for engineering; the operator must conduct a safety assessment of the site and obtain the necessary permits. In order to develop the use of unmanned technologies for technical inspections in Poland appropriate safety standards should be introduced; develop standards for cooperation between UAV operators and technical inspectors; develop rules for the implementation of UAV data into software that supports the inventory of buildings and technical infrastructure. The use of UAV provides new opportunities in the area of technical inspections due to the detail and accuracy of the data, low operating costs and fast data acquisition time.

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