THE USE OF PAMS (PERSONAL AERIALMAPPINGSYSTEM) SYSTEM TO COLLECT AERIAL GEOSPATIAL IMAGERY FOR THE DEVELOPMENT OF CADASTRAL PLANS

Octavian POTINGA, Senior Lecturer, State Agrarian University of Moldova, Faculty of Cadastre and Law, Chişinău, 42 Mirceşti St., Republic of Moldova, phone: +37379274796, e-mail: o.potinga@uasm.md
Valeriu SEINIC, Senior Lecturer, State Agrarian University of Moldova, Faculty of Cadastre and Law, Chişinău, 42 Mirceşti St., Republic of Moldova, phone: +373069305073, e-mail: v.seinic@uasm.md

Abstract. *This article reflects the advantages of using unmanned aerial vehicles (UAV) in cadastral surveying as compared to classical data collection methods. The advantage of UAV systems lies in their high flexibility and efficiency in capturing the surface of an area from a lowflight altitude. In addition, further information such as orthoimages, elevation models and 3D objects can easily be gained from UAV images. The benefits of using UAVs in cadastral elevations and the new opportunities they offer for cadastral activity are impressive.*

Keywords: *UAVs, Surveying, Measurement, Mapping, LiDAR, cadastral, dron.*

1.Introduction

In the 21st century technologies do not remain the same. As it happens in all areas, in cadastre classical equipment is replaced by computerized technologies equipped with different types of sensors that simplify the acquisition of field data and the development of maps and cadastral plans.

Due to the increased interest in geospatial data, especially in georeferenced 3D data for the development of information systems in various fields of the state activity, there is a problem of applying a new method of fast acquisition of these data. To quickly and efficiently acquire georeferenced data we use UAV (Unmanned Aerial Vehicle) systems.

GNSS (Global Navigation Satellite System) tachometers and receivers are commonly used in the cadastral activity. These tools provide a high level of accuracy when determining milestones. Unlike traditional methods, photogrammetric applications are used to update maps and plans, especially for large areas. Anyway, ORTOPHOTO images are limited for the use in the cadastral activity, mainly due to their low image resolution.

The rapid development of robotic systems over the past few years has allowed the use of unmanned aerial vehicles to get photogrammetric data. These autonomous flying UAV systems are usually equipped with different sensors for navigation, positioning and mapping, such as cameras, LiDAR systems, etc. (Manyoky et al., 2011).

2. Material and Methods

The data used in the studies were gathered to be processed within massive cadastral works in Panasesti, district of Straseni. In order to facilitate the development process of geometric plans, an aerial collection system of geospatial images and their automatic PAMS (Personal Aerial Mapping System) processing were used.

The dimensions of the aerophotography area were established within the boundaries of the above mentioned urbanized area and countryside areas that were presented in the memorandums on the ARFC collaboration, the regional land service and the LPA for the real estate massive primary registration. The estimated area of the aerospace territory is 335 ha.

The space resolution is 10-20 cm GSD (ground sampling distance).

Precision requirements are set by the regulations on the execution of cadastral works that do not exceed 40 cm. According to PAMS technical characteristics, the accuracy will vary between 10-20 cm at the ground level depending on the altitude of the aircraft.

The system includes both hardware and integrated software. The generation of images (hardware) and their processing (software) are combined into an application system that produces OrthoMosaics and DSM (Digital Surface Model) images.

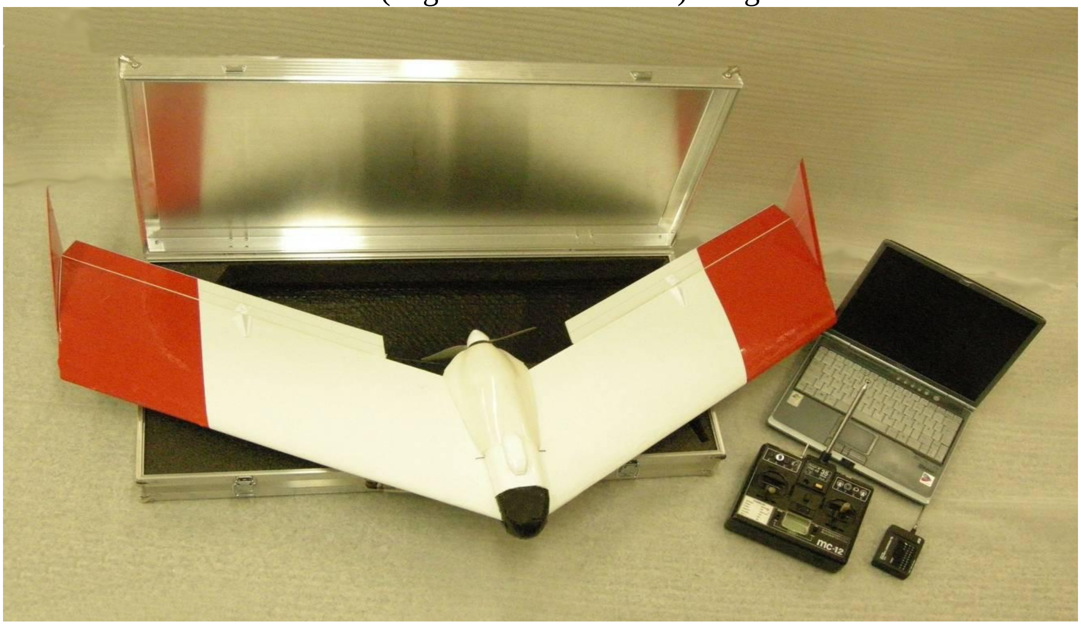

Figure 1. Equipment and software application PAMS – personal aerial mapping system Sourse [3]

The equipment consists of an unmanned plane „SmarToneUAV" that is able to fly autonomously according to the flying schedule, Figure 1.

The aircraft carries a compact photocalibrate and weighs a total of 1.1 kg. Its wings are detachable so that all equipment can be transported in a case of 85x40 x15 cm^3, Figure 2.

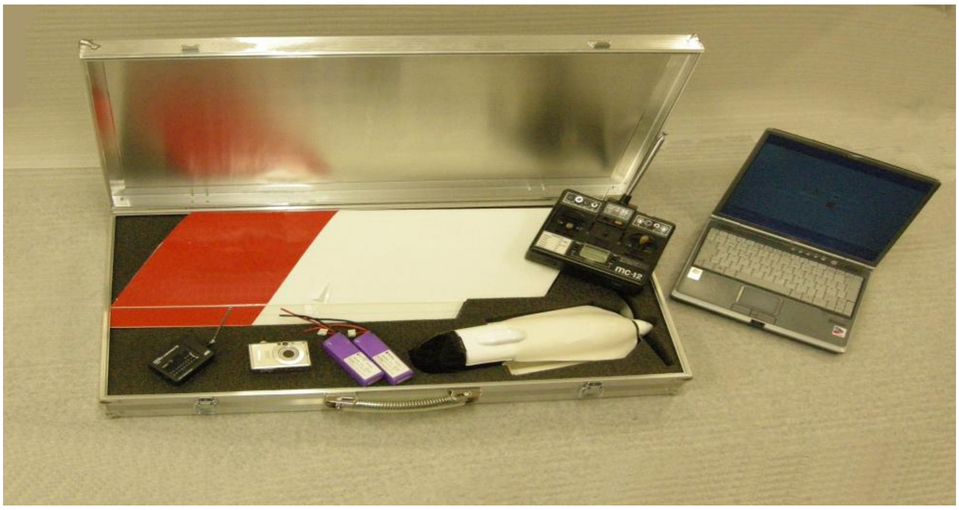

Figure 2. The case to transport a PAMS Source: [3]

The ground station consists of a detemmetry unit, a remote control for manual flight control and a computer to plan flight missions and automated image processing. The data of the mission may be subsequently processed with the help of the PAMService Internet to get a high density resolution OrthoMosaic and / or a high density of DSM.

At a typical flight altitude (AGL) of 200 m and a 7Mpix calibrated camera you get orthophoto images of GSD (Ground Sampling Distance) equal to 10 cm and at AGL of 100 m, you get a GSD of 5 cm.

The accuracy of images (OrthoMosaic) in X and Y is 10 cm on the ground. The accuracy of the altitude is 20 cm. The flight duration of the aircraft is 45 minutes. The generalized technical data of PAMS (English version) is shown below.

Table 1. *Generalized technical data of PAMS*

Aircraft “SmartOne”	Airframe: span 1.2 m, disassembles into 3 pieces for transport
	Propulsion: electric motor 200W, Li-Po cells 11.1V
	Mass: 1.1 kg incl. Battery and camera
	Performance: cruise speed 15 m/s, mission endurance 45 min
	Autopilot: Autonomous mission capable Flightmodes: auto, suspend, abort, land, and manual
	Cameras: Natural-color 7 Mpix or CIR 6 Mpix compact camera with calibrated optics
Groundstation	Rugged computer (Windows XP or Vista)
	Data link: 868 MHz, 28800 bps
	RC-control: 35 MHz, 7 channels
Transport case	Aluminum case 85cm x 45cm x 15cm (L x W x H), 4 kg 8 kg withairframe, remote control, radio modem, accupacks, camera; notebook extra
Operation	Setuptime ca. 10 min
	Take-off and recovery: bungee or hand launch, skidlanding
	Operating range: 500 m – 2.5 km (depends on nationa lairspace regulations)
	Ceiling: 150 m – 600 m AGL (depends on national airspace regulations)
	Weather: Light or moderate winds, not during heavy rainfall, snowfall or

	similar
	Temperature: -5°C – 30°C
	Safety: Non-lethal on impact, bird-like mass
	Airworthiness; approved for operationa luse in Sweden, Finland and Germany, complies with small-UAV regulation in the UK
Software	Flight planning Flight monitoring and control AirMosaic PAMS Internet processing services for OrthoMosaic and DSM and special requests
Products	AirMosaic: georeferenced image mosaic OrthoMosaic: high precision orthophoto mosaic (see below) DSM: Digital Surface Model (see below)
OrthoMosaic	High precision digital orthomosaic generation
	Upload of PAMS aerialimages, missionlogfile camera calibration, orthoparameters
	Data processing on PAMS Servers – Download of OrthoMosaic
	PAMS Data Processing Agreement required
DSM	High quality Digital Surface Model (DSM) generation
	Upload of PAMS aerialimages, missionlogfile, camera calibration, DSM parameters
	Data processing on PAMS Servers – Download of DSM
	PAMS Data Processing Agreement required

Source [3]

3. Description of aerophotography stages and image acquisition

3.1. The mission of flying

The mission consists of four phases:

- flight planning and necessary training;
- taking off
- collecting images;
- landing.

Upon launching sensors on board detect the taking off stage and the airplane starts reaching a programmed altitude. Then it collects images of a given area forming parallel benzies of the flight. The system detects wind conditions and makes the necessary compensations so that the image is accurately adjusted.

After landing the aerial images are transferred to a computer to check whether the images have been taken successfully. At the second stage, the data are processed using the advanced image processing and photogrammetric techniques to produce georeferentiated images (AirMosaic), ready to be used in geographic information systems (GIS).

Figure 3. OrthoMosaic of Panasesti village with GCP points representation for georeferencing in the Moldref 99 system Source [1]

On the ground the PAMS system takes over aerial images, their GPS log files and other data. This allows automatic image georeference and attachment to an image called AirMosaic / orthomosaic.

In Panasesti village there were 7 flying missions of some adjacent blocks that were then combined into a broader orthomosaic image (see above). There were taken 1324 images.

3.2 Developing landmarks

At the next stage there were developed some landmarks for aerotriangulation, determining their coordinates in the systems Moldref99 and WGS84. Figure 4 below shows the images of the measured points where both the reference number and approximate coordinates in WGS 84 are registered.

Figure 4. Images with the points measured on the ground Source [1]

3.3. GNNS Point Observations in the Field

The GCP points were located in nature and GNSS observation activities were carried out.

As a result of the on-site analysis of the above-mentioned points, there were identified some inconsistencies of the flight situation as compared to the current one, as well as the points where GNSS observations could not be made. One has decided to replace them with other alternative points. The sketches of these changes are shown below (Figure 5).

GNNS observations of the points in the field.

Figure 5. The alternative point Source [1]

3.4. Advanced image processing

At the next stage, having determined the landmark (GCP), advanced image processing was carried out using photogrammetric techniques to produce georeferenced images (AirMosaic).

Table 2. Orthophotoplan accuracy

Control point	Measured		Ortophotoplan		Dif.(meas.-orto.)	
	Y	X	Y	X	ΔY	ΔX
GCP 1	222642.524	207974.126	222642.4200	207974.1600	0.10	-0.03
GcP2	223143.487	207463.721	223143.5200	207463.7300	-0.03	-0.01
GCP3	223696.627	209862.538	223696.6500	209862.6900	-0.02	-0.15
GCP4	224214.032	210217.297	224214.0500	210217.1600	-0.02	0.14
GCP5	224688.791	209679.958	224688.8300	209680.0800	-0.04	-0.12
GCP 6	224714.604	208576.360	224714.7000	208576.3000	-0.10	0.06
GCP 7	223949.315	209183.797	223949.3400	209183.7300	-0.02	0.07
GCP 8	223853.825	207825.103	223853.5900	207824.9700	0.24	0.13
GCP 9	223288.707	208385.850	223288.5800	208385.9200	0.13	-0.07
GCP 10	223378.986	207835.385	223379.1100	207835.4500	-0.12	-0.07
GCP 11	224043.632	208482.669	224043.7000	208482.6900	-0.07	-0.02
GCP 12	224186.040	209620.329	224186.06	209620.43	-0.02	-0.10
GCP 13	224561.960	209201.659	224561.9300	209201.6300	0.03	0.03
GCP 14	223673.375	208227.368	223673.4100	208227.4300	-0.04	-0.06
GCP 05_2	224667.423	209691.360	224667.35	209691.32	0.07	0.04
GCP 07_2	223959.246	209226.237	223959.3600	209226.1400	-0.11	0.10
GCP 11_2	224043.237	208489.380	224043.3300	208489.4400	-0.09	-0.06
				STDEV	-0.12	-0.13

Source[1]

Figure 6. A fragment of the cartographic material of Panasesti village, obtained with the help of the PAMS system, which serves as a basis for vectoring the real estate parcels. Source [1]

The internal control of the turning points of the plot boundaries was performed using the Leica Viva GS08 NetRover system total Topcon GTP 2005 and Leica TCR (A) 1101. The same equipment was used for field elevations to correct the errors in vectorized parcel boundaries and determine the turning points of the boundaries where they could not be determined in the orthophoto images.

4. Conclusion

In conclusion, we can represent the prospects and possibilities of applying UAV technologies in the cadastral activity. The advantage of using the UAV technology as compared to classic cartographic materials used to develop and update technologies is obvious, namely for hard-to-reach or economically unprofitable landscapes. 3D images of high resolution and accuracy enlarge the areas of the UAV technology application.

The areas in which drones are applied are infinite. Currently drones can be successfully applied to determine the area of the forest and water funds, etc.

Advantages of the UAV technology:

- Efficiency;
- Enhancing the accuracy of topo-geodetic data;
- Developing and updating different types of maps and plans;
- Developing 3D models of localities;
- Developing digital models of land plots;
- Land monitoring and inventory;
- Detection of unauthorized constructions, etc.

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