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MEDIUM FORMAT CAMERAS FOR MAPPING – ANALISIS OF PRODUCTIVITY FOR ORTHOPHOTO PRODUCTION

KAMERY ŚREDNIOFORMATOWE – ANALIZA WYDAJNOŚCI DLA PRODUKCJI ORTOFOTOMAPY

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KEY WORDS: medium format, camera, evaluation, productivity, PhaseOne

ABSTRACT: The paper presents a productivity comparative analysis of PhaseOne cameras and two other main groups of cameras widely used in the mapping market. Analysis was carried out in comparison with UltraCam Eagle and Leica DMC III referring to flight mission parameters influencing on productivity. The analysis was conducted with various spatial resolution of images in the context of creating final orthophotomap for urban areas, taking into account the influence of the center projection on the appearance of buildings. The time of the flight missions was also analyzed. In the presented studies, it has been proven that, on the example of PhaseOne cameras, a medium format camera can be less expensive and effective alternative for large format cameras for small and medium size urban and rural mapping projects.

1. INTRODUCTION

Since the year 2000, development and use of digital photogrammetric cameras for aerial survey has gained significant momentum. Many different cameras and systems designed for aerial photogrammetric survey were developed and presented to the market, but today, after 15 years of intensive development, only few of these products are in wide use in the mapping market. Cameras are also evaluated by end users and scientists (Cramer, 2010; Rieke-Zapp, 2010; Jacobsen, 2011). One of the prominent systems' being provided today is the medium format frame camera from Phase One Industrial.

With the development of CCD and CMOS technology, medium format cameras have come a long way from 40-60 Mpix to 80-100 Mpix cameras. Additionally, high quality metric lenses with a wide range of focal lengths were developed and implemented. This enabled an effective utilization of PhaseOne cameras in many different small and medium sized urban and rural mapping projects, corridor mapping, oblique projects, and usage for area and line infrastructure monitoring purposes.

This document presents a productivity comparative analysis (Kurczyński, 2007) of PhaseOne cameras (Tölg *et al*., 2016) and two other main groups of cameras widely used in the mapping: UltraCam Eagle (Gruber *et al.*, 2012) and Leica DMC III (leica-geosystems.com)

2. AERIAL CAMERAS FOR MAPPING – PRODUCTIVITY ANALYSIS

There are two groups of aerial survey cameras used for mapping – medium and large format metric cameras. There are also two main different types of mapping areas – urban and rural, and there are three main photogrammetric products required by the market – orthophoto, dense DSM and stereo mapping. Let’s try to analyze the usage of these cameras for different purposes.

The most popular product for urban area is a semi-true orthophoto. It features by very narrow orthophoto angle (an effective angle, part of FOV (Field of View), which is used for orthophoto production, or that is the same -predefined small building lean) and provides orthophoto with very high level of visibility with minimizing hidden, shaded or obscured areas in the dense urban environment.

Ground resolution of 3 to 15 cm is commonly used for urban mapping. Orthophoto angles for orthophoto production in urban environment lie in the range of 14 to 28 degrees, which corresponds to 12% to 25% of building lean. The predefined orthophoto angle (or building lean), GSD and minimal allowable side overlap, are the three geometric parameters of the aerial survey which enable a geometrically identical orthophoto (with the same building lean) from different aerial survey cameras. These three parameters may be, and should be used as a common denominator for a productivity comparison of different cameras of different types.

Productivity comparison is commonly based on the following parameters: aerial survey productivity (image coverage per hour of flight), distance between flight lines, time required to fly AOI (Area of Interest) or number of flight lines per AOI. The more objective criteria, not depending on the ground speed of the plane is the distance between flight lines.

The following orthophoto geometrical parameters were used for the comparison calculations (table 1).

Table 1. Orthophoto geometrical parameters used in the experiment

GSD	Orthophoto angle	Building lean	Ground Speed	Minimal side overlap
3 cm	14°	12%	100 knot	20%
5 cm	17°	15%	120 knot	20%
8 cm	20°	18%	140 knot	20%
10 cm	23°	20%	160 knot	20%
15 cm	28°	25%	180 knot	20%

Based on the above assumptions, the following figure 1 and table 2 present the productivity comparison for PhaseOne medium format frame cameras and two other groups of the most popular large format frame cameras. Corresponding focal lengths of the cameras are presented in parenthesis. Results demonstrate that with the requirement for orthophoto angle/building lean for urban orthophoto, medium and large format cameras provide similar distance between flight lines.

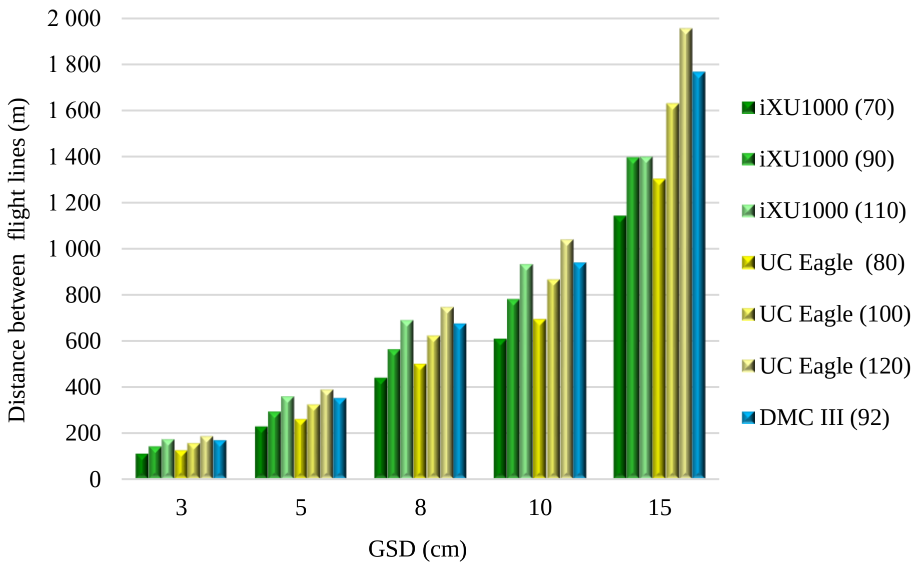

Fig. 1. Distance between flight lines with PhaseOne, UC Eagle and DMC III for orthophoto with 3 - 15 cm GSD.

Table 2. Distance between flight lines with PhaseOne, UC Eagle and DMC III for orthophoto with 3 - 15 cm GSD

GSD (cm)	3	5	8	10	15
iXU1000 (70)	110	228	438	609	1 141
iXU1000 (90)	141	293	563	783	1 397
iXU1000 (110)	172	359	689	933	1 399
UC Eagle (80)	125	261	501	696	1 304
UC Eagle (100)	157	326	626	870	1 630
UC Eagle (120)	188	391	751	1 043	1 956
DMC III (92)	170	354	679	944	1 769

Figure 2 and table 3 present the time of flight needed to cover an AOI of size 5 by 5 km.

The same conclusion can be made from figure 2 and table 3. The requirement for orthophoto angle/building lean in urban environment equals the productivity of medium and large format cameras performing relation of flight time and GSD.

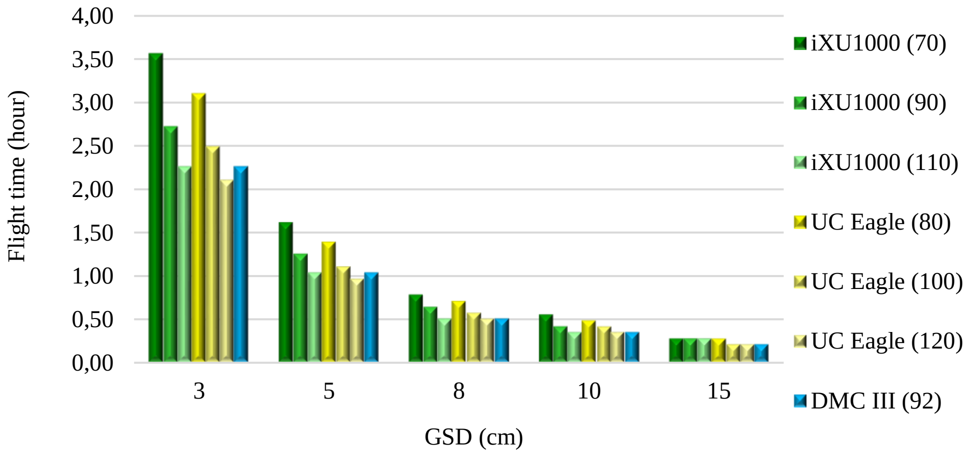

Fig. 2. Flight time with PhaseOne, UC Eagle and DMC III for orthophoto with 3 - 15 cm GSD for AOI of 5x5 km.

Table 3. Flight time with PhaseOne, UC Eagle and DMC III for orthophoto with 3 - 15 cm GSD for AOI of 5x5 km.

GSD (cm)	3	5	8	10	15
iXU1000 (70)	3,57	1,62	0,78	0,55	0,27
iXU1000 (90)	2,72	1,25	0,64	0,42	0,27
iXU1000 (110)	2,26	1,04	0,50	0,35	0,27
UC Eagle (80)	3,11	1,40	0,71	0,48	0,27
UC Eagle (100)	2,49	1,11	0,57	0,42	0,21
UC Eagle (120)	2,11	0,96	0,50	0,35	0,21
DMC III (92)	2,26	1,04	0,50	0,35	0,21

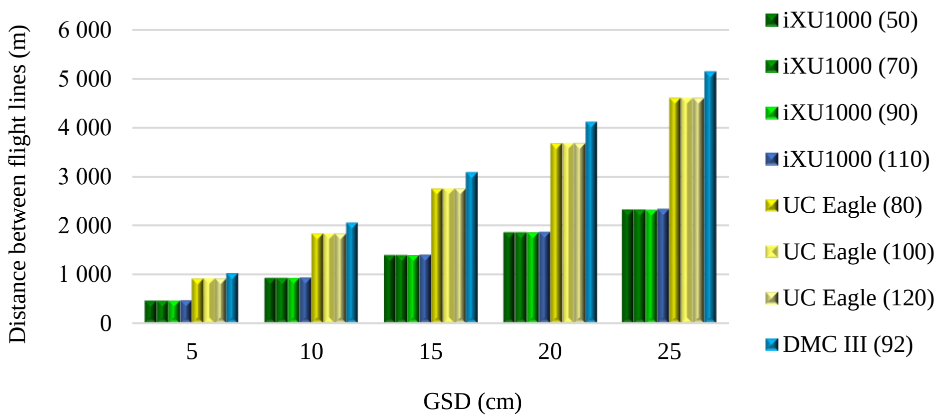

Fig. 3. Distance between flight lines for rural area flight with 20% side overlap.

Table 4. Distance between flight lines for rural area flight with 20% side overlap.

GSD (cm)	5	10	15	20	25
iXU1000 (50)	464	928	1 392	1 856	2 321
iXU1000 (70)	464	928	1 392	1 856	2 321
iXU1000 (90)	464	927	1 391	1 855	2 318
iXU1000 (110)	466	933	1 399	1 865	2 331
UC Eagle (80)	922	1 843	2 765	3 687	4 609
UC Eagle (100)	920	1 839	2 759	3 678	4 598
UC Eagle (120)	921	1 842	2 763	3 683	4 604
DMC III (92)	1 028	2 057	3 085	4 114	5 142

Figure 3 and table 4 present another situation normally common for other photogrammetric products: orthophoto for rural area, dense DSM or stereo compilation – flight without specific limitations on orthophoto angle with the minimal side overlap of 20% and with maximal use of the sensor (CCD/CMOS) area.

In this case PhaseOne medium format cameras provide 50% of UC Eagle productivity and 45% of DMC III productivity not depending on the ground resolution. However, taking into consideration the relatively low purchase price of PhaseOne cameras, its utilization for medium size urban and rural mapping projects is highly recommended.

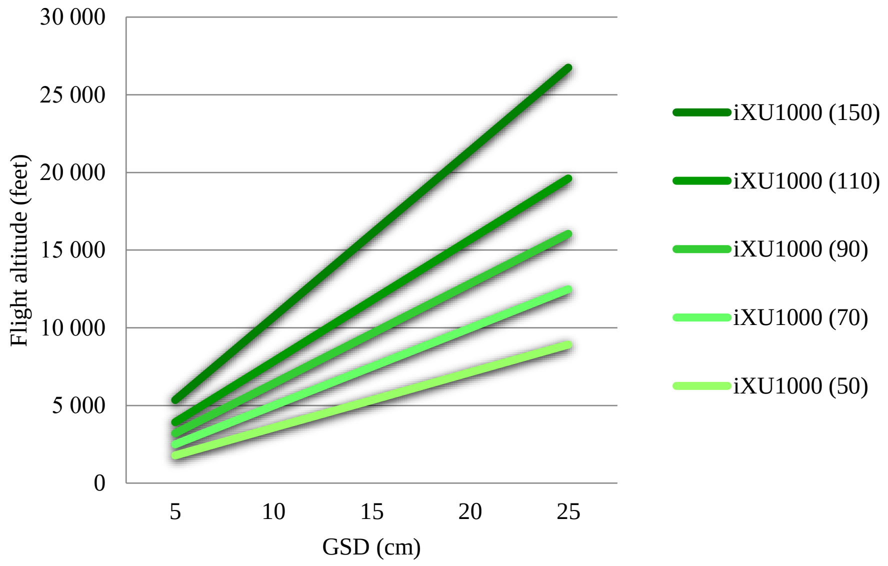

Fig. 4. Flight altitudes with the wide range of PhaseOne metric lenses.

The wide range of exchangeable metric lenses with different focal lengths enables the use of PhaseOne cameras at different altitudes with different flight platforms and for a variety of different purposes. The influence of focal length of lenses was shown in figure 4.

3. CONCLUSIONS

The last generation of PhaseOne medium format metric cameras with small pixel size (4.6 μm), large sensor area (100 Mpix), maximal frame-per-second (FPS) rate of 1.6 and exposure time of up to 1/2500, a set of metric lenses with different focal lengths (50, 70, 90, 110, 150 mm) and with relatively low price, provide an excellent alternative to large format cameras in many areas of aerial mapping and monitoring.

Additionally, these cameras are widely used for providing an oblique imagery and as a complementary camera for LiDAR systems. All these cameras, from oblique and from LiDAR systems, may be used as standalone cameras for mapping projects.

The very low weight (2 kg) and small size of the cameras enable their utilization with super-light planes, small helicopters, gyrocopters and UAVs that significantly reduces operational costs of mapping projects.

The PhaseOne cameras present an effective alternative for large format cameras for small and medium size urban and rural mapping projects, corridor mapping, oblique projects, and for area and line infrastructure monitoring purposes.

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SŁOWA KLUCZOWE: kamera średnioformatowa, ocena, efektywność, PhaseOne

Streszczenie

Artykuł prezentuje analizę wydajności kamer lotniczych zestawiających przykładową kamerę średnioformatową PhaseOne z dwoma innymi kamerami wielkoformatowymi powszechnie stosowanymi w pozyskiwaniu danych fotogrametrycznych. Analiza wykonana została w porównaniu z UltraCam Eagle i DMC III pod względem parametrów nalotu wpływających na wydajność prac fotolotniczych. Analizę przeprowadzono przy różnej rozdzielczości przestrzennej zdjęć w kontekście tworzenia wynikowej ortofotomapy terenów miejskich z uwzględnieniem wpływu rzutu środkowego na wygląd budynków na produkcie końcowym. Analizie podlegał również czas nalotu i inne parametry nalotu. W prezentowanych badaniach udowodniono, ze na przykładzie kamery PhaseOne średnioformatowa kamera może być mniej kosztowną efektywną alternatywą dla wielkoformatowych kamer lotniczych dla małych i średniej wielkości obszarów.

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