Productivity Analysis for Medium Format Mapping Cameras

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Introduction

Since 2000, development and use of digital photogrammetric cameras for aerial survey has gained significant momentum. Many different cameras and systems designed for aerial photogrammetry were developed and presented to the market. After 15 years of intensive development, only a few of these products are in wide use in today's mapping market. One of the prominent systems being provided 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 medium format cameras in many different small and medium sized urban and rural mapping projects, corridor mapping, oblique projects, and monitoring of areal and linear infrastructure.

This article presents recent development in the approach to flight planning and aerial survey productivity analysis, firstly presented in Raizman (2012). The Raizman (2012) article referred only to large format cameras, whereas this article will compare large format cameras vs. medium format cameras, which are getting more and more popular in aerial survey. This approach is based on some pre-defined common characteristics of the required mapping products. It enables an equivalent comparison between cameras with different parameters – focal length, sensor form and size, and pixel size. Through this article we intend to demonstrate that for several types of urban mapping projects, medium format cameras and large format cameras have the same aerial survey productivity.

Image captured by Phase One iXU-RS1000, 70mm lens, Height 1,500ft, GSD 3cm.

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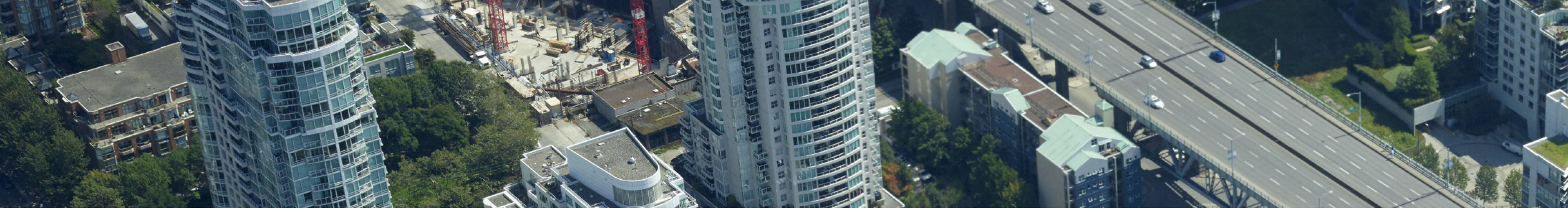


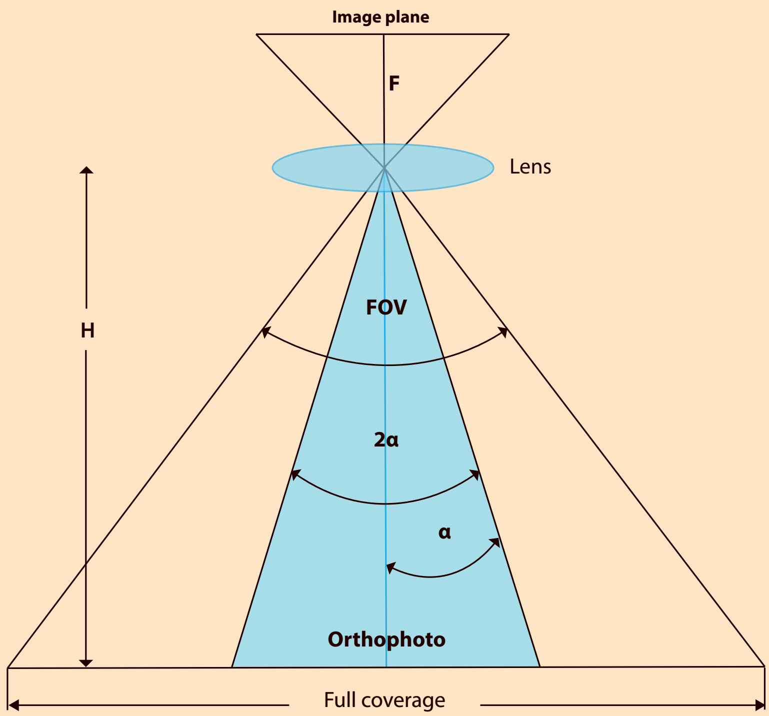
Common Denominator for Aerial Survey Cameras Comparison

There are two groups of aerial survey cameras – medium and large format metric cameras. There are also two main different types of mapping areas – urban and rural. There are three main photogrammetric products that are often required by the market – orthophoto, dense DSM (Digital Surface Model), and stereo mapping. We shall analyze the usage of these cameras for different applications.

One of the most popular products for urban area is a semi-true orthophoto. It features very narrow orthophoto angle (an effective angle, which is part of the Field of View used for orthophoto production and is equivalent to the required small building lean; see Figures 1 and 2) and very high level of visibility with minimizing hidden, shaded or obscured areas in the dense urban environment (Raizman, 2012). Figure 1 illustrates the central projection camera, FOV, orthophoto angle dedicated for orthophoto area on the images.

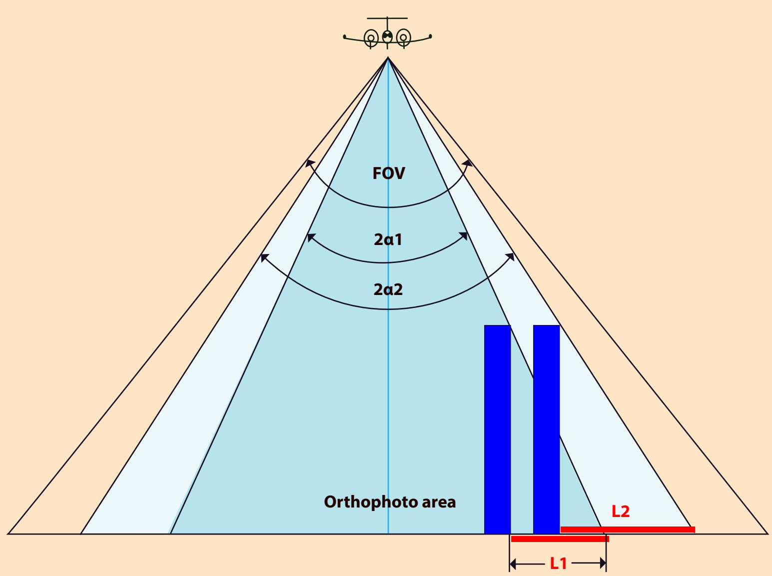
The concept of building lean and its importance for orthophoto is presented in Figure 2.

Ground resolution (or ground spacing distance, GSD) of 5 to 15 cm is commonly used for urban mapping. Orthophoto angles for orthophoto production in urban environment lie in the range of 14° to 25°, which corresponds to 12% to 22% of building lean. This predefined orthophoto angle (or building lean), GSD and minimal allowable side overlap are the three geometric parameters of aerial survey which enable a geometrically identical orthophoto (with the same building lean) from different aerial survey cameras. These three parameters are considered as a common denominator for a productivity comparison of different cameras of different types.



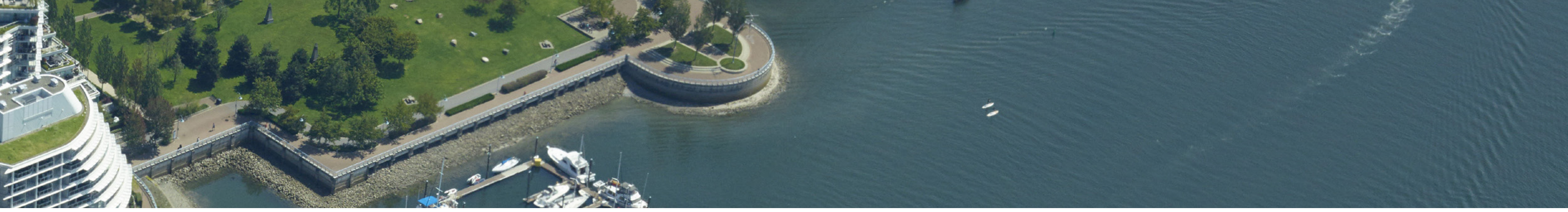
- F – Focal length;
- H – Flight altitude;
- FOV – Field of View, generally 27° - 110° for different aerial survey cameras;
- 2a – orthophoto angle;
- Tg(a) * 100% - Building lean.

Figure 1. Field of View and the Orthophoto Angle.



- 2a1, 2a2 – Permissible orthophoto angles;
- L1, L2 – Occlusion
- Tg(a)*100% - Building lean
- If 2a2 > 2a1 then L2 > L1

Figure 2. Field of View, Orthophoto Angle and Building Lean.



Productivity Comparison Between Medium and Large Format Cameras

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 Area of Interest (AOI) or number of flight lines per AOI. A more objective criterion, not depending on the ground speed of the plane and the shape of AOI, is the distance between flight lines. The following orthophoto geometrical parameters were used for calculations:

GSD	Orthophoto angle	Building lean	Ground Speed	Minimal side overlap
5 cm	14°	12%	120 knot	25%
8 cm	17°	15%	140 knot	25%
10 cm	20°	18%	160 knot	25%
15 cm	25°	22%	180 knot	25%

Based on the above assumptions, the following charts and tables present the productivity comparison for Phase One medium format cameras, Vexcel UltraCam Eagle and Hexagon DMC III large format cameras. Corresponding focal lengths of the cameras are presented in parenthesis.

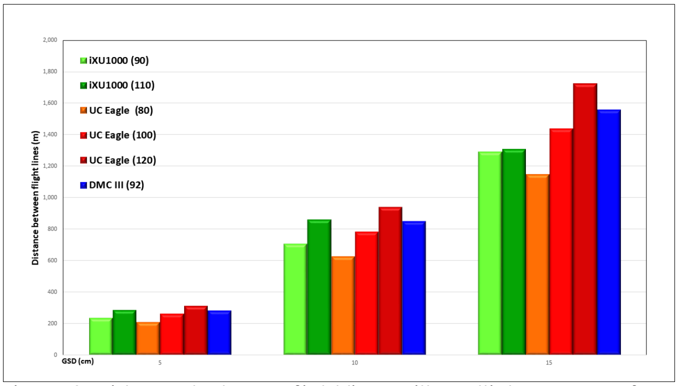


Figure 3. Distance between flight lines with multiple cameras from Phase One, UC Eagle and DMC III for orthophoto at 5 - 15 cm GSD.

Figure 3 demonstrates that with the requirement for orthophoto angle/building lean for urban orthophoto, medium and large format cameras provide similar distance between flight lines.

Figure 4 presents the time of flight needed to cover an area of 5 km by 5 km.

The same conclusion can be drawn from Figure 4. The requirement for orthophoto angle/building lean in urban environment equals the productivity of medium and large format cameras.

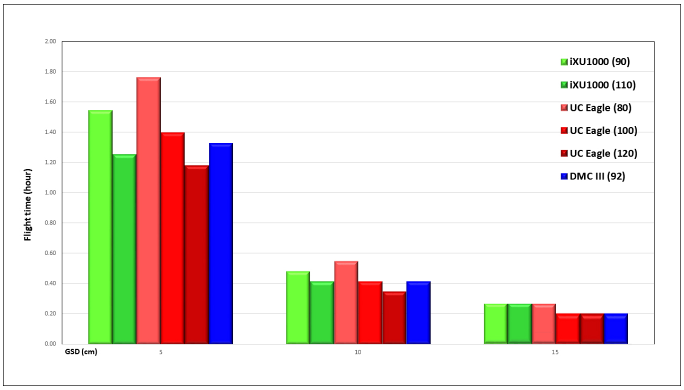


Figure 4. Flight time with Phase One, UC Eagle and DMC III for orthophoto at 5 - 15 cm ground sampling distance for an area of 5km x 5km.

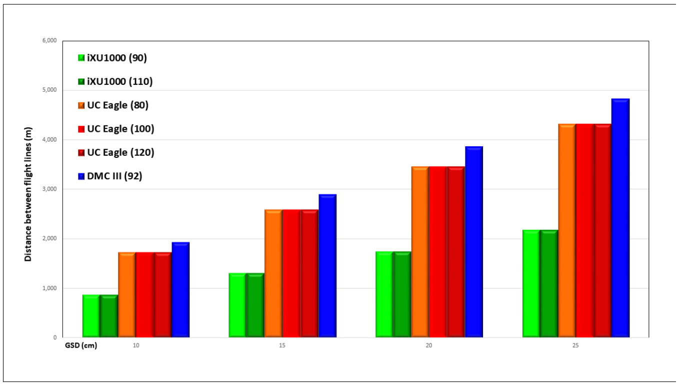
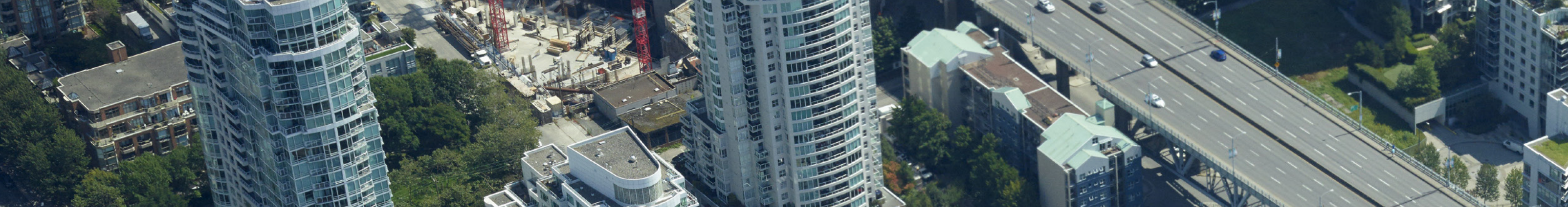


Figure 5. Distance between flight lines for rural area with 25% side overlap.

Figure 5 presents another situation common for other photogrammetric products: orthophoto for rural area, dense DSM or stereocompilation – flight without specific limitations on orthophoto angle with the minimal side overlap of 25% and with maximal use of the sensor (CCD/CMOS) area.

In this case, Phase One medium format cameras provide 50% of UC Eagle productivity and 45% of DMC III productivity, independently from the ground resolution. However, taking into consideration the relatively low purchase price of Phase One cameras, its utilization for medium size urban and rural mapping projects may be considered.

The wide range of exchangeable metric lenses with different focal lengths enables the use of Phase One cameras at different altitudes (Figure 6) with different flight platforms and for a variety of different purposes.



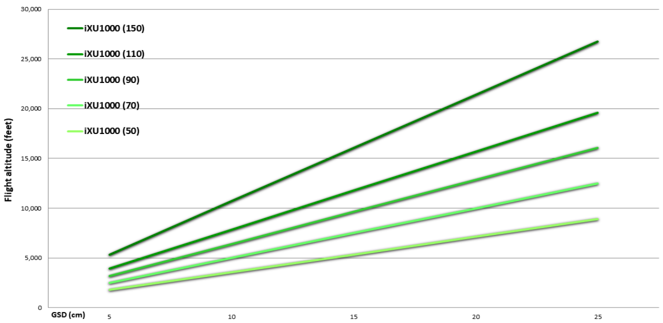


Figure 6. Flight altitudes with the wide range of Phase One metric lenses.

Conclusion

The last generation of Phase One medium format metric cameras with small pixel size (4.6 μ), large sensor area (100 Mpix), maximal frame-per-second (FPS) rate of 1.6 and exposure time of up to 1/2500 seconds, 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, which can significantly reduce operational cost of mapping projects.

The Phase One cameras present an effective alternative to large format cameras for small and medium size urban and rural mapping projects, corridor mapping, oblique projects, and monitoring of areal and linear infrastructure.

Reference

Raizman, Y., 2012, Leaning Instead of Overlap – Flight Planning and Orthophotos, GIM International, June, pp. 35-38. (https://www.gim-international.com/content/article/flight-planning-and-orthophotos)