OBLIQUE IMAGE COLLECTION – CHALLENGES AND SOLUTIONS

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ABSTRACT

For over a decade now oblique images are collected from airborne platforms on a regular basis. Several camera products have been presented from distinct camera vendors and their image products are well known. The UltraCam Osprey is the new oblique sensor by Microsoft / UltraCam Business Unit and was introduced into the market at the ASPRS 2013. This camera combines a metric nadir subsystem creates one panchromatic high resolution image, one true-color RGB image, one near-infrared image and six oblique true-color wing images taken at an off-nadir angle of 45°. This specific camera design supports exceptional productivity and quality during acquisition and processing. Camera specification parameters as well as results from aero-triangulation, DSM production, and oblique image processing are presented in this article.

INTRODUCTION

The UltraCam Osprey was presented for the first time at the ASPRS 2013 conference and exhibition in Baltimore, MD, March 2013. While this is not the first oblique camera introduced to the market, the UltraCam Osprey incorporates several new and unique concepts with a clear emphasis on professional photogrammetry and collection productivity. First there is the metric nadir component which has been derived from the well-known UltraCam Lp camera. This nadir camera constitutes the "geometry backbone" of the UltraCam Osprey and enables traditional photogrammetric processing from an oblique aerial camera system. For example, Osprey images are compatible with the UltraMap software supporting the full workflow from aero-triangulation to dense surface modelling and ortho image creation. Secondly, adding the six oblique camera heads makes the pixel harvest extremely productive. The wing cones are pointing in the four cardinal direction at 45° off-nadir. There are dual cones forwards and backwards, and single cones left and right.

THE ULTRACAM OSPREY DESIGN

There are 10 independent camera cones integrated into a single camera system. Four such cones constitute the classical nadir camera for creating one 90 Mpixel panchromatic image, as well as one true-color RGB and one near-infrared image (cf. Fig. 1). The remaining six camera cones are equipped with 80 mm lenses and high-quality optical prisms. The forward and backward looking cones are assembled pairwise, greatly enlarging the cross-track FOV of these twin cones. Table 1 describes the principal parameters of the camera system and the UltraCam Osprey design.

Figure 1: UltraCam Osprey (left) and cone layout (right)

Focal Lens/ Pixel Size					
Nadir PAN	51.0 mm		Oblique Sensor Heads	80.0 mm	
Nadir RGB and NIR	25.5 mm				
Frame Format / Pixel Size					
Nadir PAN	11674 * 7514	6.0 µm	Oblique Sensor Heads	6870 * 4520	5.2 µm
Nadir RGB and NIR	6735 * 4335	5.2 µm			
FOV/ deg	**cross track**	**along track**			
Nadir PAN (RGB)	+/- 34.48 °	+/- 23.85 °			
Nadir RGB (PAN) and NIR	+/- 34.48 °	+/- 23.85 °			
FOV / deg					
Oblique Forwd/Bckwd	-	+/- (53,36° / 36,64°)			
Oblique Left/Right	+/- (57,59° / 32,41°)	-			

Table 1: Principal design parameters of the UltraCam Osprey

The camera design is geared towards productivity in the air. Thus the extent of the nadir footprint and the cross track dimension of the wings are well tuned to each other. At a flying altitude of 1275 m and a nadir GSD of 15 cm the nadir looking image covers the area of 1750 m by 1127 m. The corresponding left and right wings overlap with the nadir image, yielding a combined and seamless image footprint of 115° FOV. The cross-track footprint size of the forward and backward wings is more than 1135 m. This supports a flight pattern where the flight line distance is 60% of the nadir footprint (40% side overlap). At a speed over ground of 60 m/sec the UltraCam Osprey frame rate of about 0,45 images /second (2,2 seconds TBFR) allows achieving a forward nadir overlap of 80% at a minimum GSD of 8,5 cm and less than 5 cm GSD with 60% endlap.

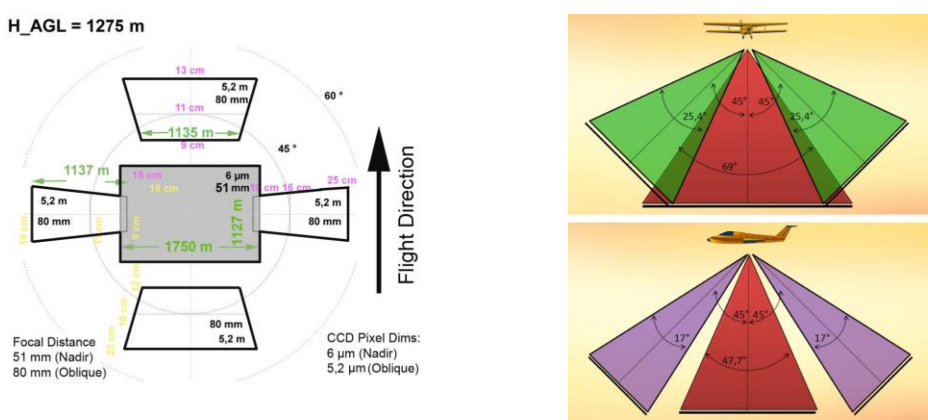

Figure 2: UltraCam Osprey footprint (left) and FOV diagram (right)

GEOMETRIC PERFORMANCE

The geometric performance of the UltraCam Osprey nadir image is illustrated by the results of a redundant aerial triangulation project. This 313 image block shows high overlap and cross strips. Thus the redundancy is high and the investigation of the image quality is well supported. We show the block layout and the remaining image residuals after the least squares adjustment. The overall geometric quality is represented by the sigma_o value which was computed at 1.34. The RMS residuals of the image coordinate measurements were in the range of + /- 1.2 µm (x-direction) and + /- 1.1 µm (y-direction). Fig. 3 illustrates the pattern of small image residuals and the block layout. The RMS residuals of measured ground control points and independent check points was less than ½ pixel at a GSD value of 10 cm. The corresponding oblique images are well oriented with respect to their respective nadir images due to the known and calibrated lever arms. Such well-oriented oblique imagery is beneficial for further processing. The geometric accuracy of the oblique imagery has not yet been fully evaluated.

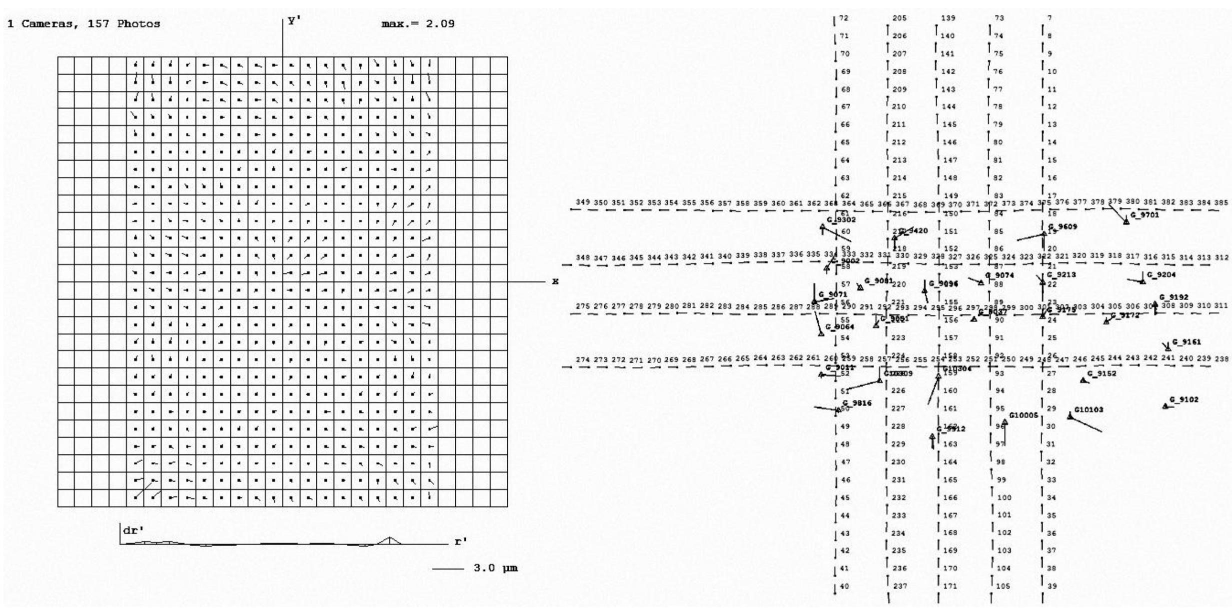

Figure 3: Image residuals of the nadir image and block layout of the aero-triangulation project.

IMAGE QUALITY

The sensor technology and related radiometric performance of the UltraCam Osprey is in line with the high radiometric quality level of all sensors of the UltraCam family. We show sample images from a recent test flight to highlight the quality of nadir and wing images. The test project was flown on May 28, 2013 over the city of Salzburg, Austria. The altitude over ground was roughly 900 m resulting in a mean GSD of 10 cm. The cross track dimension of the wing image is between 1150 m (foreground) and 1700 m (background).

Figure 4: Forward wing image (composite of twin cone) and part of nadir image (right).

The UltraCam Osprey camera heads are equipped with latest generation sensors and electronics which are optimized to exhibit very low signal-to-noise levels which manifests itself in virtually noise-free images of very high dynamic range. The analog to digital conversion is implemented at the 14-bit level and all digital image processing is implemented in 16 bit. The resulting image data quality is evident in Figure 5 which illustrates the large dynamic range of UltraCam Osprey images. Both, the bright walls of the Hohensalzburg Castle, as well as a dark shadow area, show fine details without saturation on either end of the spectrum. Further processing imagery of such high dynamic range will likely result in equally impressive final imager data products.

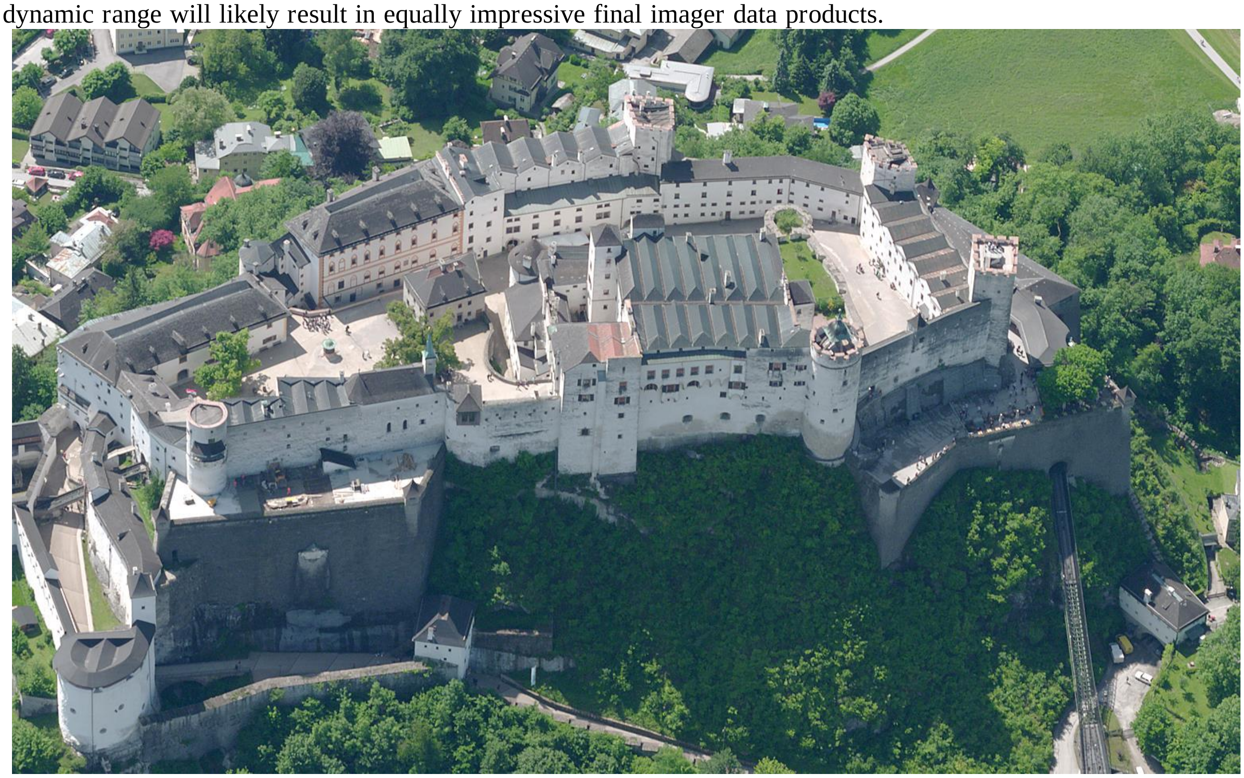

Figure 5: A prominent object – Castle Hohensalzburg – acquired by UltraCam Osprey

WORKFLOW AND 3D RESULTS

Since every nadir photo is accompanied by six additional oblique images, the UltraCam Osprey produces a rather large number of images during a flight mission. Thus it is obvious that a highly automated processing chain is needed to economically extract the full value of the image harvest. The combination of highly-redundant and highly-accurate imagery allows to create digital surface models (DSM) of amazing fidelity and accuracy. One such example DSM, created from the mission to Salzburg, is illustrated in Figure 6 (green = low, brown = high).

Figure 6: DSM of the castle and the historic center of the City of Salzburg – automatically extracted from UltraCam Osprey images.

Having available such high-fidelity DSM data and the well-known camera geometry makes it rather straight-forward to then apply the oblique images in order to produce fully textured 3D models. Especially for urban environments, the quality of the source images combined with the ability to acquire all vertical faces of manmade structures are crucial ingredients for creating the desired 3D models at high degrees of automation. Figure 7 illustrates the results of a fully automated 3D modeling workflow.

Figure 7: 3D Geometry and photo texture from UltraCam Osprey wing images.

CONCLUSIONS

The principal design parameters and the main goal of the development of the UltraCam Osprey were presented and some results from photogrammetry and 3d modeling were illustrated. We have shown the productivity of the camera and the ability to simultaneously acquire high quality nadir images and oblique images. Finally we show the digital workflow to process images and to produce value added products.

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