NEWS FROM ULTRACAM SENSORS – AN UPDATE

Michael Gruber, Alexander Wiechert

Vexcel Imaging GmbH
Anzengrubergasse 8/4, 8010 Graz / Austria
{michael.gruber, alexander.wiechert}@vexcel-imaging.com

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Abstract

In our contribution we highlight brand new information about the new member of our UltraCam Sensor family as well as the photogrammetric processing software UltraMap. One year after the separation from Microsoft, Vexcel Imaging did strive for a continuation in quality and a new corporate design which is well visible from our new camera outfit. We also show news from our photogrammetric software – the UltraMap V4, which includes several new options to improve color processing as well as processing images from new UltraCam sensors like the Condor. Beside the product offering of Vexcel Imaging GmbH we present our new service and calibration facility in Centennial / Denver. The new laboratory is well equipped for all service and calibration tasks of UltraCam Sensors and replaces the facility in Boulder, Colorado.

Introduction

The UltraCam sensor brand stands for high quality digital camera systems specifically designed and optimized for acquiring digital aerial images as well as images taken from our terrestrial sensors.
Efficiency is not just defined by the footprint size of the camera, efficiency is defined by the flexibility and capability of the whole system. Cameras are reaching asymptotically their practical limitations and thus not only image format and footprint size is the parameter to define the user benefit. So Vexcel Imaging is focusing on the efficiency of the complete solution of the photogrammetric workflow to maximize customer benefit in practical scenarios.

Our aerial UltraCam sensors represents the broadest photogrammetric digital aerial camera family. The nadir cameras consist of our ultra-large nadir sensor UltraCam Eagle, the nadir sensor UltraCam Falcon, the nadir and oblique sensor UltraCam Osprey and the new wide area mapping sensor UltraCam Condor. The UltraCam Eagle features a unique exchangeable lens system for upmost flexibility and customer benefit.
UltraCam Osprey is the photogrammetric oblique camera system, combining two cameras in one housing, a photogrammetric nadir camera system including high-resolution PAN, RGB, NIR and an oblique RGB camera consisting of four tilted RGB color cones (Wiechert et al., 1013).
The UltraCam Condor with its 38000 pixels by 5000 pixels RGB footprint is the wide area mapping sensor and offers highest productivity. The photogrammetric quality is derived from the panchromatic camera head and its traditional frame image format.

UltraCam Sensor Family

After 10 exciting years under the ownership of Microsoft, Vexcel Imaging GmbH operates again as an independent company and thus a new and modern arrangement. This includes new sensors with stunning characteristics and a completely new outfit. Figure one shows our set of aerial sensors – the high performance nadir photogrammetric cameras Ultracam Eagle and UltraCam Facon, the Nadir and Oblique sensor UltraCam Osprey (Gruber et al., 2013) and the wide area mapping sensor UltraCam Condor.

Fig. 1: UltraCam Aerial Sensor Family: UltraCam Falcon, UltraCam Condor, UltraCam Eagle and UltraCam Osprey. (from left to right). With the Eagle we offer 4 different lens package, the Osprey is available in two different versions.

Beside our aerial camera products for efficient aerial data acquisition we do have terrestrial sensors in our portfolio. The UltraCam Mustang is our street-side system which was developed to contribute to the Bing Maps data acquisition and is now available as a sensor product for a huge variety of applications. The UltraCam Panther, our portable system for all off road and indoor mapping projects is now under development and will be available by end of the calendar year.

Fig. 2: The UltraCam Mustang is a powerful system to capture data from the street level. UltraCam Panther allows to operate off road, in doors and pedestrian zones.

UltraCam Condor

Mapping of large areas – of whole countries if not continents – is no longer a small scale application. Based on aerial operations a powerful and efficient sensor system needs to be in place. UltraCam Condor is the answer to enable such large photogrammetric activities. It is the most recent offering in Vexcel Imaging's suite of high-performance UltraCam digital aerial systems.
UltraCam Condor addresses a very specific application: high altitude ortho image generation with exceptional image quality. Producing a camera system that meets all the requirements of high altitude ortho production presented several complex challenges in the design of the lens system, the electronics and the storage system, as well as significant investment in the UltraMap processing software to handle necessary radiometric corrections and eliminate artifacts. The UltraCam Condor is positioned to redefine the efficiency/quality ratio in large area/nationwide collection efforts and transform user expectations for project timelines and refresh cycles.

	Image size	**Physical pixel size**
Color (RGB Bayer pattern)	38,000 x 5,000 pixels	4.6 µm
PAN	13,400 x 8,650 pixels	5.2 µm
Color (NIR)	7,600 x 5,000 pixels	4.6 µm
Color capability (multi-spectral)	4 channels – RGB Bayer pattern & NIR	
Ratio RGB to PAN to NIR	1 : 2.83 : 4.35	
Frame rate (minimum inter-image interval)	1 frame per 1.75 seconds	
Weight	64 kg	
Power consumption	Max. 350 W	
	Focal distance	Lens aperture
Color (RGB Bayer pattern)	100 mm	f=1/5.6
PAN	40 mm	F=1/4.8
Color (NIR)	23 mm	F=1/5.6
Flying height for RGB pixel size @ 10 cm GSD	2,174 m	

Table 1: Key parameters of UltraCam Condor

Basic idea of the UltraCam Condor design:

The basic idea of the design is to use multiple detector arrays (CCD sensor arrays) and multiple optical systems of different optical length to build one large format camera system.
The output of such a camera is one single rectangular panchromatic image of 13 k by 9k at a smaller scale which serves as the photogrammetric backbone and a set of smaller color images which are stitched together by software and are co-registered onto the panchromatic image.
The set of color images build together a rectangular footprint on the ground with a very large cross track dimension of 38000 pixels and a smaller long track dimension of 5000 pixels. As the basic photogrammetric information can be derived from the panchromatic footprint via multiple overlaps and multi ray aerial triangulation the color (RGB) image allows smaller overlaps which cover the entire terrain along the flight path without gaps.
An additional camera head is used to capture NIR images as well and the NIR channel is co-registered onto the panchromatic images well.

The benefit of such a camera system is many folded:

- the use of multiple lens systems avoids the use of one expensive large format lens system;
- the camera can be operated within a standard environment (standard mount and single hole aircraft);
- the image of the panchromatic camera sub system is enhanced by the large format color image of the RGB camera sub system in such way that parts of the footprint of the panchromatic system are superimposed by the higher resolution RGB image to improve manual measurements
- The panchromatic backbone further enables automated dense matching, DSM/DTM and ortho image generation. That makes additional flights by other sensors obsolete as all necessary data sets cam be derived from one UltraCam condor flight
- the determination of the exterior orientation of the system based on standard AAT making use of the overlapping images from the panchromatic sub camera;
- The panchromatic and the RGB camera systems are triggered in such way, that the exposures of the multiple camera systems are taken at one and the same position exploiting the known speed of the aircraft over ground (syntophic exposure).

Results from a photo mission:

A photo mission near Graz was conducted to verify the potential of UltraCam Condor. The project layout consists of 126 photos and 7 flight-lines, 4 lines N-S, 3 lines E-W. Thus a strong set of observations could be achieved from1844 points on the ground and a total of 20000 image positions. The altitude of the mission is 2200 m above ground level and thus a GSD of 28 cm Pan and 10 cm RGB was achieved. The overall quality of the adjusted block is excellent, the sigma_o value of 0.77 corresponds with the RMS error of image measurements of 0.7 µm in x and y. On the ground the RMS value of check points and GCPs was below the 5 cm level for X, Y and Z. Since the geometric result of a UltraCam Condor flight mission is based on the PAN nadir image producing the larger pixels on the ground compared to the large RGB footprint we need to judge the geometric quality by means of RGB resolution. At the 10 cm level we are still satisfied with the result (0,5 GSD) from the aero-triangulation and bundle adjustment based on the panchromatic sensor head. All photogrammetric computations were done by the new version of UltraMap and UltraMap AT. In order to cross check the bundle-result we used the UltraMap export function to Bingo. As a final proof of the result of the adjustment we show the layout and the image residuals by using bingo graphics output (cf. 3).

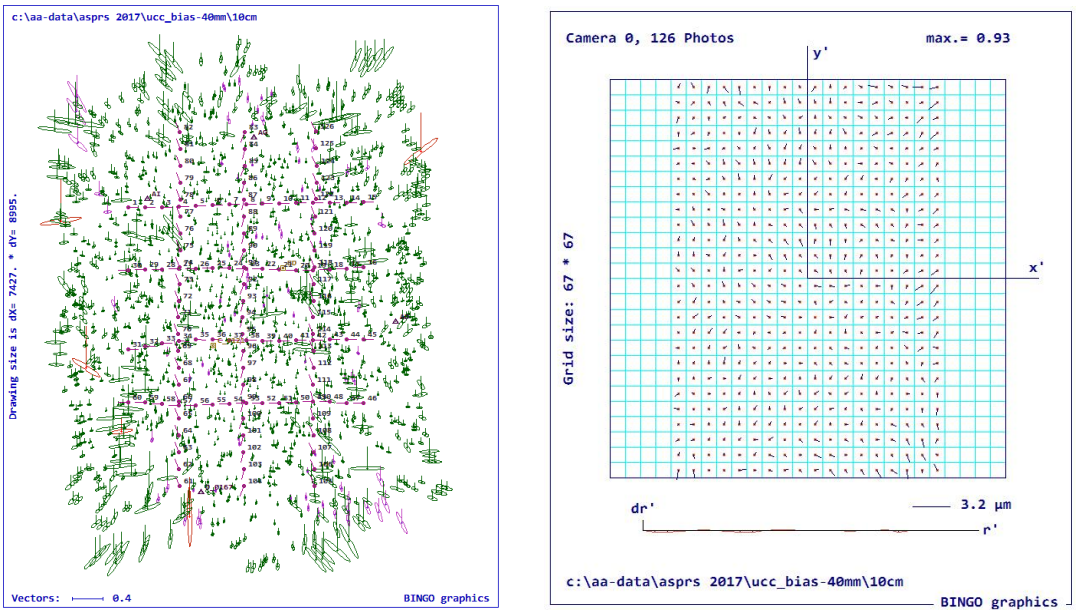

Fig.3: Results from a UltraCam Condor flight mission. The block layout on the left shows the 126 photo positions and the 1844 measured points on the ground. The geometric quality of the image coordinate measurement is illustrated on the right and shows the maximum distortion of < 1 µm.

Image quality of the UltraCam Condor:

At the 10 cm pixel size of the RGB sensor the UltraCam Condor produces a footprint of 3800 m cross the flight path. We illustrate the quality and the size of the large RGB image (cf. Fig. 4 and Fig. 5) at the 10 cm ground resolution of the flight mission near Graz.

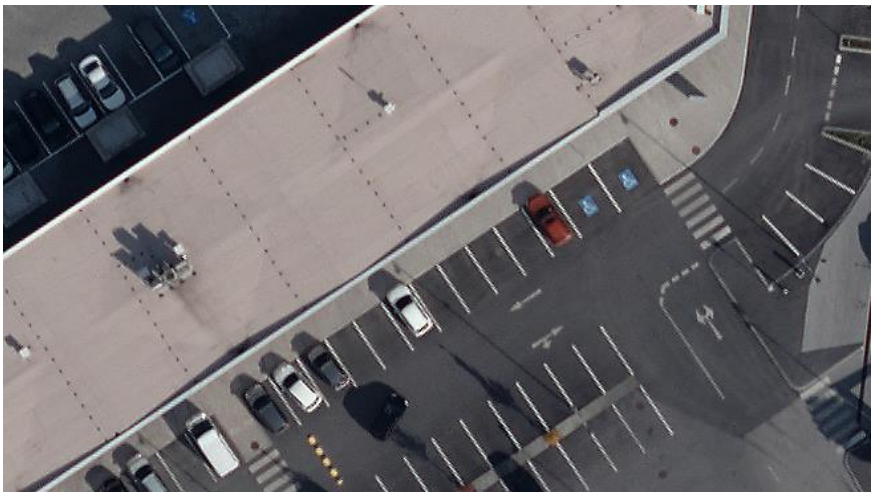

Fig. 4: Detail of a RGB image at 10 cm ground pixel size. The size of this area is 65 meter by 36 meter. This is only a small part of the entire footprint of 3800 meter by 500 meter (cf. Fig.5, yellow rectangle).

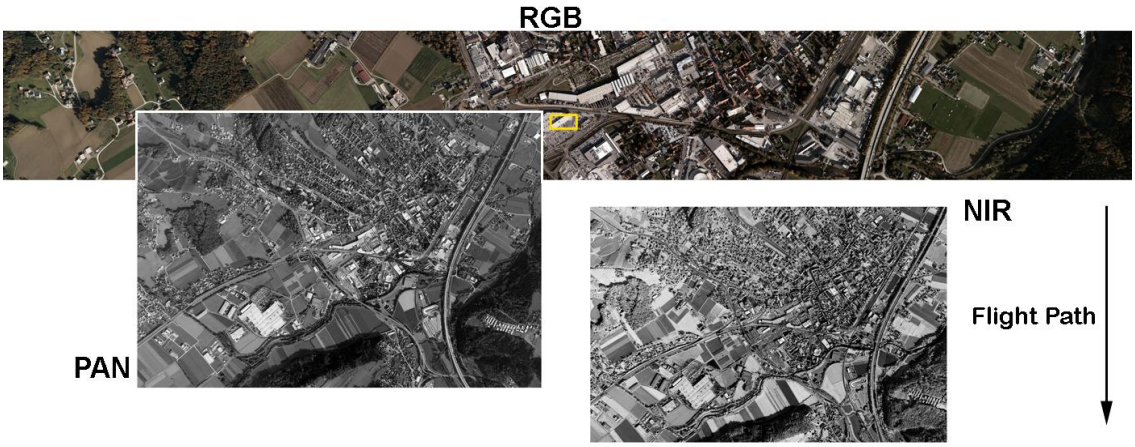

Fig. 5: Footprint of the RGB image at 10 cm ground pixel size. The panchromatic footprint covers a larger area in flight direction in order to server for multi ray measurements. On the lower right the footprint of the near infrared sensor is shown.

The high productivity of the UltraCam Condor is obvious when designing a flight mission at smaller scale and thus larger pixel-size on the ground. When operating the Condor at 25 cm GSD for the RGB sensor the footprint size cross flight path is about 9500 m. At a 30 % side-lap the strip distance is 6,6 km. A project area of 10 000 sqkm (100 km by 100 km) can be mapped in a one-day mission.

It is further noteworthy, that UltraCam Condor has a very successful predecessor, the UltraCam G. This sensor was developed in 2009 and successfully served the so-called Global Ortho Project where images covering an area of more than 10 million square kilometers have been captured by the UltraCam G cameras in about 24 months (Walcher et al., 2012).

UltraMap V4

UltraMap is Vexcel's software package which offers all modules to manage raw UltraCam image data, process UltraCam Images and introduce these data into the photogrammetric production chain (Reitinger et al., 2013).

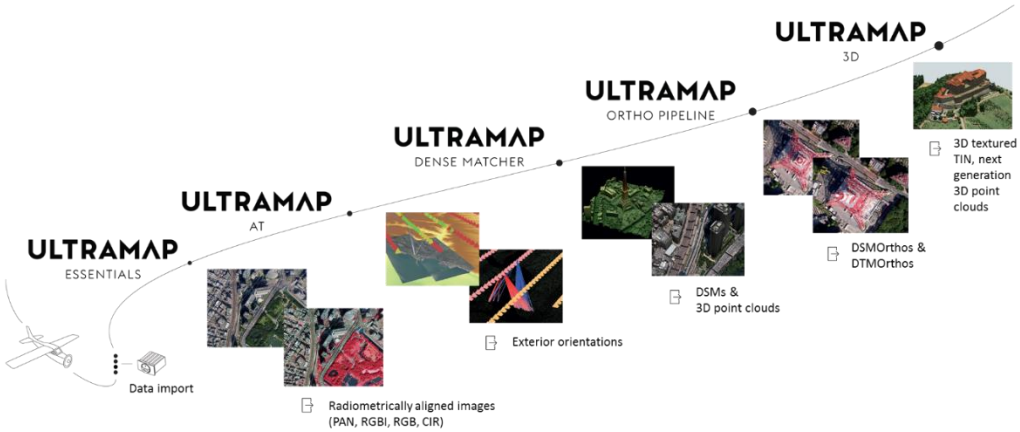

Fig. 6: UltraMap modules and workflow overview

UltraMap consists of several modules which are integrated into a seamless workflow, use a seamless user interface and operate on a joined database:

UltraMap/Essentials: *The RawDataCenter* is responsible for processing the raw UltraCam imagery into a so-called Level-2 data format which is then radiometrically and geometrically calibrated; The *Radiometry* module of UltraMap/Essentials includes the Project Based Color Balancing software – a fully automated radiometric mosaicking approach;

UltraMap/AT: The *Aerial Triangulation* module consists of the image matching function in order to automatically produce image correspondence, the interactive tool to add manual measurements and the least squares adjustment software in order to generate a precise exterior orientation for a whole image block as well as the new option to interactively control the result exploiting the new visual analytics component;

UltraMap/DenseMatcher: The *Dense Matching* module creates automatically high-density point clouds and DSMs from level-2 images by extrapolating precise exterior orientation data to generate per-pixel height values. The 3D point cloud and the DSM data can be exported in standard file formats for further 3rd party processing

UltraMap/OrthoPipeline: The *Ortho Generation* module makes use of the Level-2 images and the exterior orientation information. It generates the final ortho mosaic from all available inputs such as level-2 imagery, AT results, radiometric settings, and height field. Two different ortho images can be generated: DSMOrthos and DTMOrthos (based on an internally generated DTM);

UltraMap/3DTIN: The latest module added to the chain is the *3DTIN* module. It provides 3D textured TIN functionality. The module processes automatically 3D TINS and comes with an interactive viewer, sophisticated 3D editing tools and an export module

Fig. 7: 3D data generated by UltraMap: DSM (right), 3DTIN (left) and textured TIN (middle)

The photogrammetric processing chain UltraMap was updated and offers all capabilities to handle all new Vexcel cameras like UltraCam Condor.

Service and Calibration

Vexcel Imaging has always placed its emphasis on excellent service and support for our UltraCam user community. To ensure this and enable us to make a long term commitment for our customer base in North America Vexcel has decided to establish a new facility.
Our new service and calibration facility is operated by Vexcel Imaging US Inc., a subsidiary of Vexcel Imaging GmbH (Graz, Austria). The office and lab is situated south of Denver, 12503 E Euclid Drive Unit 20, Centennial CO. It consists of office space, mechanical lab and calibration lab und enables the team to offer best service and calibration for UltraCam sensors. Situated close to the Centennial Airport it is well accessible.

Fig. 8: Some impressions from the new service and calibration facility close to Centennial airport.

Conclusion

In this contribution we have focused on the new design and new sensor products from Vexcel Imaging since the separation from Microsoft in 2016. The portfolio of Vexcel's sensors covers aerial and terrestrial products well designed and tuned to serve in a huge variety of application. The UltraMap software product is our tool to process image data and offer the functionality of a photogrammetric processing chain. Focusing on the UltraCam Condor we illustrated the potential of this high performance digital aerial sensor.

Beside the sensor products we introduce our new service and calibration facility in Centennial, CO. The new lab is well equipped and the support crew offers service and calibration for all UltraCam sensors.

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