ULTRACAM EAGLE, UNDERSTANDING THE NEW SENSOR

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KEY WORDS: Photogrammetry, Digital, Camera, Large Format

ABSTRACT

UltraCam is the name of the Microsoft/Vexcel camera family which was introduced into the market in May 2003 by the digital aerial camera product UltraCam D. This digital frame camera did show a very unique design and offered an image format of almost 90 MegaPixels. Since these 9 years the manufacturer of this camera was able to continuously develop and enhance the camera product, the software to operate the camera and to process images as well as the photogrammetric production software. In May 2011 the new flagship product, the UltraCam Eagle – a 260 MegaPixel digital aerial framing camera was presented. A completely new camera electronic, new lens systems and a CCD sensor array which was designed for this camera are the most important improvements of this new camera. After the first few months of operation we present our experience and results from photo missions and focus on the specific features of this camera. The innovation in software enables UltraCam users to streamline their production chain. This is supported by the new functions which are offered within the UltraMap software suite. The new DSM and Ortho image functionality is part of UltraMap V3.0, the latest version of Vexcel's software product.

INTRODUCTION

With the presentation of the UltraCam Eagle at the ASPRS 2011 conference in Milwaukee Microsoft/Vexcel Imaging opened a new basket in the digital aerial camera product portfolio. The 260 Mega Pixel frame size of the Eagle and its 20010 Pixel cross track image format did answer the need for higher productivity in the air and the reduction of flying costs. Figure 1 shows the camera system including the sensor head with the interface panel and SSD storage module. The docking station and the office power supply are used for data download and operation outside the aircraft and are part of the package.

Figure 1: UltraCam Eagle digital aerial frame camera. Sensor Head, Interface Panel, Office Power Supply, Docking Station and SSD On Board Storage Component.

The UltraCam Eagle does not only show a new frame format but also offers a number of innovative design solutions to the customer. Most important is the reduced weight and the ease of operation even if the sensor is in line with the UltraCam design principle. This was implemented firstly for the UltraCam D (11500 Pix cross track) and then for the 136 MPix UltraCamX and the 196 MPix UltraCam Xp
The large frame format of the UltraCam Eagle offers an increase of efficiency of +70% compared to the UltraCam D (cf. Figure 2).

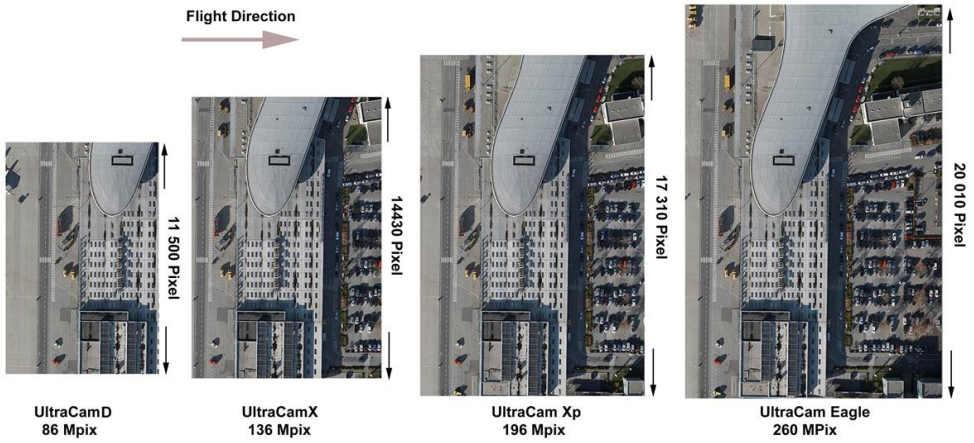

Figure 2: UltraCam frame format: From left to right UltraCam D, UltraCam X, UltraCam Xp and UltraCam Eagle offering 11.500 Pixel (UltraCam D) to 20010 Pixels (UltraCam Eagle) cross track.

THE ULTRACAM DESIGN CONCEPT

The photogrammetric design concept of the UltraCam Sensor Family is based on four camera heads for the large panchromatic frame and four additional camera heads for multi spectral sensing (red, green, blue and near infrared). The basic idea was introduced in (Leberl et al., 2003) and shows a 4 cone concept for the large format panchromatic image (cf. Figure 3). Even when the hardware design basics did not change during these years the software to post process images was continuously improved. The outcome of that software development are a smooth workflow and high quality production images from a robust and accurate post processing namely the so called "Monolitic Stitching" which was introduced in 2010 (Ladstädter et al., 2010).

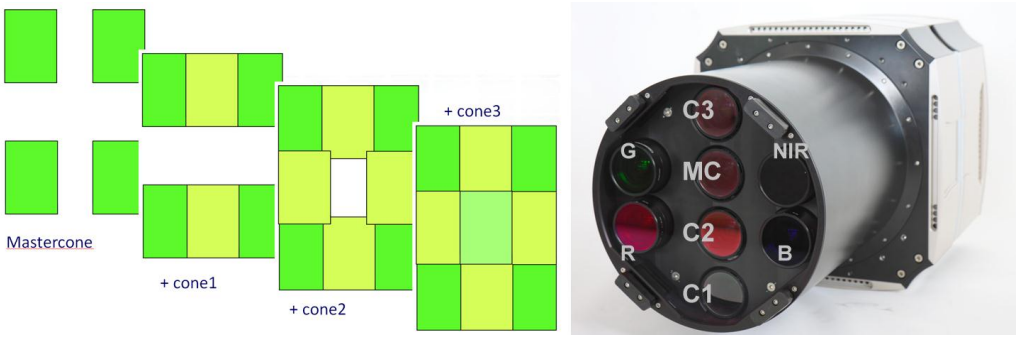

Figure 3: UltraCam frame design concept with 4 cones for the panchromatic image and 4 cones for multispectral acquisition.

ULTRACAM EAGLE – DETAILS AND FEATURES

UltraCam Eagle offers a number of new features and design details. This separates the sensor from its predecessor models and makes it a completely new camera system. The most important newly developed components of the UltraCam Eagle may be listed in this order:

- The new proprietary electronic components have been developed at Vexcel Imaging to optimize the CCD sensor management and to enable a fast readout. Thus a frame rate of 1/ 1.8 seconds is achieved.
- The OEM CCD detector arrays at 5.2 µm pixel pitch and > 12 bit dynamic range allow to build the large 260 Megapixel frame format.
- The OEM optical system with 80 mm focal distance for PAN and 27 mm focal distance for RGB/NIR resolving the fine structure of the CCD detector arrays at 100 lp/mm.
- The ability to make use of exchangeable lens cones supported by the new precision lens mount and tools to enable the users to exchange lenses on site.
- The integration of all on board IT components including SSD storage and computer boards as well as the integrated navigation solution UltraNav.

Key parameters of the UltraCam Eagle are listed in Table 1.

- Panchromatic image size: 20,010 x 13,080 pixels
- Panchromatic physical pixel size: 5.2 µm
- Input data quantity per image: 842 megabytes, 260 megapixels
- Lens system 1: 80 mm PAN and 27 mm RGBNIR
- Lens system 2: 210 mm PAN and 70 mm RGBNIR, exchangeable by a trained end user, no recalibration required
- Maximum frame rate <1.8 seconds per frame
- CCD signal to noise ratio: 72 dB
- CCD image dynamic: 14 bit; workflow dynamic: 16 bit
- Physical dimensions with 80 mm (210 mm) PAN lenses, including computer and storage module: 43 cm x 43 cm x 76 cm (86 cm)
- Weight with 80 mm (210 mm) PAN lenses, including computer and storage module: approximately 75 kg (80 kg)
- Power consumption at full performance, including computer and storage module: 350 watts
- Solid-state disc pack, effective storage concept for fully redundant stored data
- Unlimited with use of multiple data units with approximately 3.3 terabytes (3,800 images) per unit
- Data recording time @ 10 cm GSD, 60 percent forward overlap, 140 kts @ 8 hours per data unit
- Maximum forward overlap @ 10 cm GSD (@ 5 cm GSD) with 140 kts @ 90 percent (80 percent)

Table 1: UltraCam Eagle Features and Technical Details

Geometric Performance

We have used the Gleisdorf test area near Graz, Austria in order to analyze the geometric performance of the UltraCam Eagle by means of a least squares bundle adjustment of a block of images. The block from Jan-10-2012 consists of 230 images, 5 flight lines North-South and 3 flight lines East-West. The flying altitude was about 1900 m ASL, thus an image scale of 1 / 23700 and a GSD of about 12 cm was achieved. The overlap was high at 80% / 60% in order to achieve high redundancy. (cf. Figure 4).

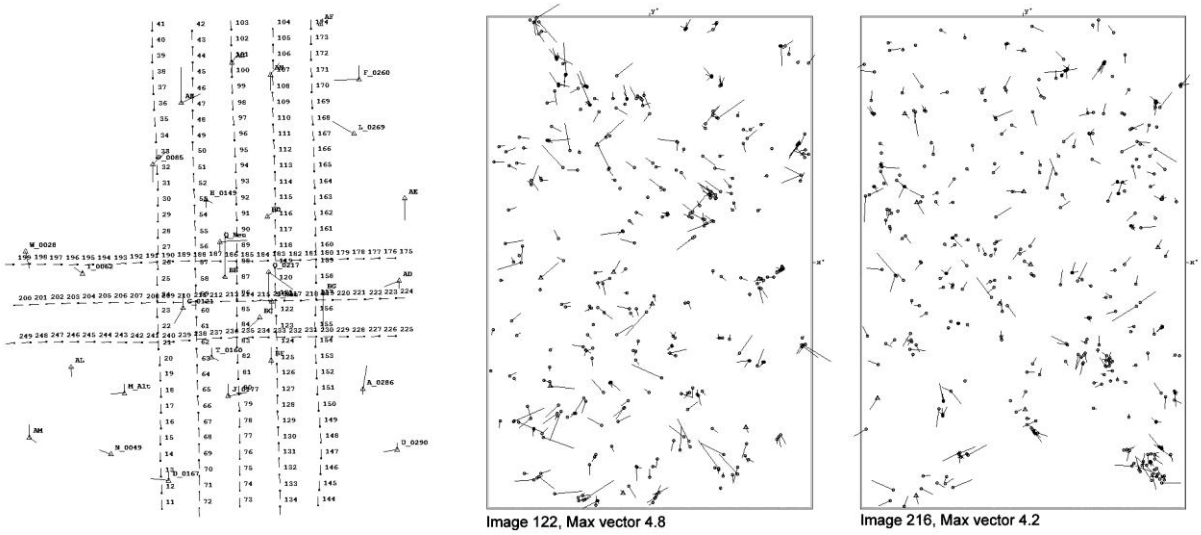

Figure 4: Aero-triangulation project from 230 UltraCam Eagle photos. The block layout shows high overlaps and cross strips (left). Image residuals of frames 122 and 216 (in the central part of the project area) are illustrated on the right.

The photo mission was supported by GPS and IMU. The residuals at ground control points and check points did show the high geometric quality of the camera. Root mean square residuals were recognized at the 1/3 to 1/4 GSD level.

Radiometric performance

UltraCam Eagle is equipped with completely new electronic components which are tailored to manage the new CCD sensor array and to allow high quality read out and convert to digital of the analog signal. The dynamic bandwidth and the small remaining noise have been investigated. A very high quality within the result could be identified. By the use of a single frame of UltraCam Eagle we demonstrate the inter scene dynamics and analyze the digital data (cf. Figure 5).
The dynamic range measured in the two subareas of frame 0230 show the ability of the camera to resolve dark and bright areas well in one single scene. The entire bandwidth of the sensor is at dynamic level of almost 13 bit, the onboard AD conversion works at 14 bit and the digital workflow of the UltraMap software makes use of the 16 bit data format. Thus the entire information acquired during the photo mission is well preserved throughout the entire processing chain.

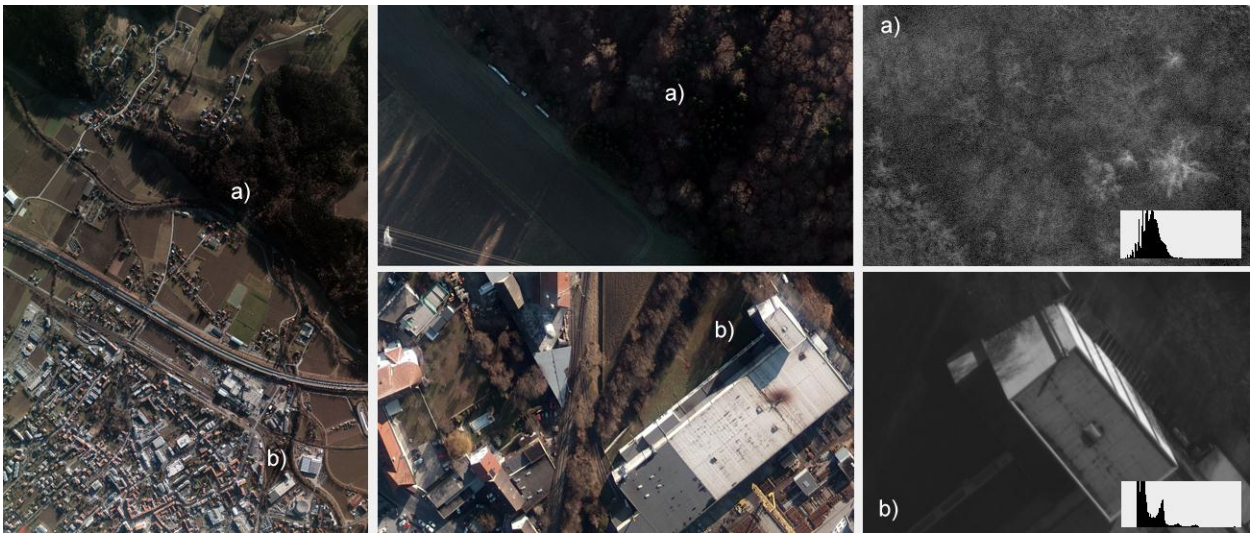

Figure 5: Investigating dark and bright areas within Frame 0230 from the flight mission on Jan-03-2012 (full frame on the left). The dark shadow area a) shows the structure of the tree canopies (256 grey levels), the bright building facades and surrounding area b) is mapped into 8301 grey levels. The histograms are presented on the right.

ULTRAMAP 3.0 – THE SOFTWARE PACKAGE FOR ULTRACAM

Starting 2007 a dense matching algorithm and an automated ortho/true-ortho workflow has been developed by Vexcel Imaging GmbH that has exclusively been used for the automated 3D city model production of Microsoft's Virtual Earth project and is now also in use for the production of the current BING maps platform. This famous automated workflow has now been disclosed and has been implemented into UltraMap 3.0. This makes the workflow commercially available for all UltraCam users world-wide. The dense-matching algorithm generates very dense surface models from overlapping aerial images by multi-ray photogrammetry, superior to airborne Lidar collection. Based on the results of the dense matcher, an automated workflow generates ortho images and true-ortho images automatically within UltraMap 3.0. The complete software package UltraMap enables the user of all UltraCam sensor models up to the UltraCam Eagle to post-process images and introduce these data into the photogrammetric workflow including Aero-Triangulation, Bundle Adjustment, Surface Modeling and Ortho Image Rectification (cf. Figure 6).

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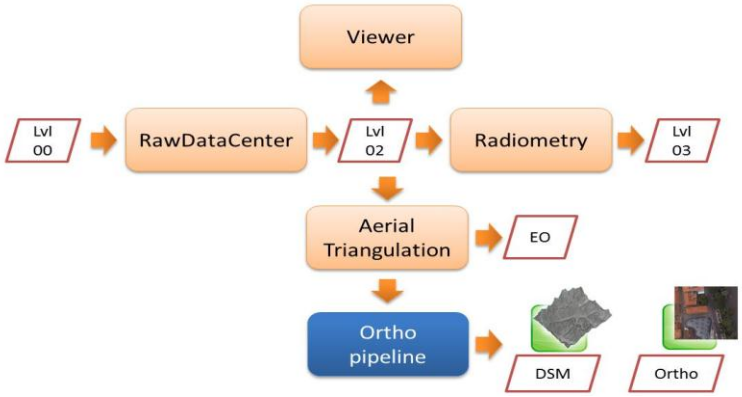

Figure 6: The UltraMap workflow offers functions to post processing the raw image data of UltraCam aerial missions, radiometric adjustment, aero-triangulation and the new DSM and Ortho pipeline.

CONCLUSIONS

The new UltraCam Eagle digital aerial sensor was successfully introduced into the market. Most important for the efficient aerial operation is the large frame format. The image format of 20010 pixels cross track allows to reduce flying costs and operating time in the air. The radiometric and geometric performance of the camera is at a very high quality level and enables the user to be productive and to produce high quality photogrammetry results. The advantage of this mature technology is well proven and accepted in the community. However, even if the basic photogrammetric design did not change this new camera system benefits from continuous improvements and rigor developments. Thus almost all major hardware components of the sensor have been newly developed and tuned to the new system. Not necessary to mention a continuous development of the software component and the ease of implementation into a product. This proves once more the power of Vexcel's concept of "Software Leveraged Hardware".

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