

Vexcel Imaging GmbH – Innovating in Photogrammetry: UltraCamXp, UltraCamLp and UltraMap

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ABSTRACT

This article describes how Vexcel Imaging GmbH (a Microsoft Company) is driving the remote sensing industry and photogrammetry ahead by a constant stream of innovations. The new world-wide largest digital aerial frame camera UltraCamXp is being explained as well as the newly launched large medium format mapping camera UltraCamL which sets the standard in the medium format camera segment. An additional section presents the new processing software UltraMap and its aero triangulation extension UltraMap/AT.

1. INTRODUCTION

Vexcel Imaging GmbH, located in Graz, Austria, was founded in 1993, focusing on photogrammetric technologies that included the UltraScan 5000 precision photogrammetric scanner, culminating with the development of the UltraCam line of digital aerial cameras. The company was acquired by Microsoft in May 2006, largely for its camera technology, photogrammetric know-how and 3D modeling innovations and to further the advancement of Microsoft's Virtual Earth mapping initiative.



Led today by Alexander Wiechert, General Manager of Vexcel Imaging GmbH, the company provides the aerial mapping community with state-of-the-art photogrammetric products based on the latest and most advanced technological developments. Vexcel Imaging GmbH has become the market leader in the large format camera market due to its unparalleled technology and first class support which results in a maximum of customer benefit. The company's flagship product, the UltraCamXp, has been announced in July 2008 and is the world-wide largest large format digital aerial mapping camera. Most recently, Vexcel Imaging announced its entry into the medium format camera market through the UltraCamL which is a medium format digital photogrammetric system. In working towards a more complete photogrammetric solution, Vexcel Imaging also recently announced its UltraMap workflow software for managing and distributing data collected with the UltraCam systems.

2. ULTRACAM-XP

2.1. Overview

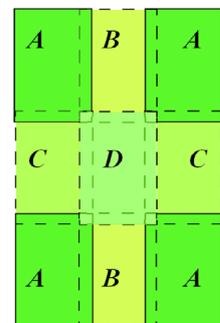
The UltraCamXp has been announced in July 2008 and it has been shipped to first customers in August 2008. It is the direct successor of the very successful large format camera UltraCamX. Main improvements have been an increased footprint of 196 Mega pixels (was 134 Mega pixels in the UltraCamX) and an improvement of the in-flight exchangeable storage system, now lasting for 6,600 images (was 4,700 images with the UltraCamX). The footprint of 17,310 pixels across flight strip outperforms the competition significantly and makes the UltraCamXp the largest and thus most

efficient large format camera systems. This lowers the acquisition costs and reduces the project risk due to less flight hours which care are being required to finish a job.



The camera consists of the camera head and the computing and storage unit. The camera head is carrying the 13 CCDs (9 for high resolution PAN image collection and 4 for R, B, G and NIR image collection). The pan-sharpen ratio is industry-leading with 1:4. All cones have forward motion compensation (FMC) by time delayed integration (TDI) for motion blur free imagery under extended flight conditions (speed, duration). The lenses are a specific development for Vexcel Imaging by Linos/Rodenstock to support the high resolution of the 6 μ m CCD. The shutter is also a specific development for Vexcel Imaging by Prontor, making the UltraCam shutter the best and most reliable shutter system in the world.

The PAN image is being stitched together by nine sub-images. Due to the syntopic exposure, invented and patented by Vexcel Imaging, all sub-images are being taken from the same position. This leads to completely parallax free sub-images and the stitched final image is the perfect representation of a single CCD, single lens, and one perspective center image but with 196 Mega pixels.



The radiometric dynamic of the PAN image is best in class with a range of almost 13 bit. That's leads to around 7,500 grey values for the PAN image representation which is almost double the range of other large format cameras. In addition to the geometric accuracy and stability, this increases the stitching and matching quality and thus the accuracy of the photogrammetric measurements, quality of mapping applications and DSM generation.

2.2. Main Parameters of UltraCamXp

Panchromatic image size	17,310 * 11,310 pixels
Panchromatic physical pixel size	6 μ m
Panchromatic lens focal distance	100 mm
Color (multi-spectral capability)	4 channels (R, G, B, NIR)
Color image size	5,770 * 3,770 pixels
Pan sharpening ratio	1:3

Forward-motion compensation (FMC) for PAN, R, G, B, NIR	TDI controlled
Maximum FMC-capability	50 pixels
Pixel size on the ground (GSD) at flying height of 500 m	3.0 cm
Frame rate per second (minimum inter-image interval)	1 frame per 2 seconds
Analog-to-digital conversion at	14 bits
Radiometric resolution in each color channel	>12 bit
Physical dimensions of the camera unit	45 cm x 45 cm x 60 cm
Weight of the camera unit	~ 55 kg
Power consumption at full performance (camera unit)	~ 150 W
In Flight Data Storage	Exchangeable Data Units (DXp)
In-flight capacity	Unlimited with multiple DXp; per DXp 4.2 TB, ~ 6600 images
Physical dimensions of the computing and storage unit	50 cm x 36 cm x 65 cm
Weight of the CXp unit and DXp units	~ 92 kg
Power consumption at full performance (camera unit)	~ 700 W

3. ULTRACAM-LP

3.1. Introduction

The UltraCamL has been announced in July 2008 and it has been shipped to first customers in May 2009. It will be updated to the UltraCamLp late 2009 to early 2010, providing an increased footprint of 92 Mega pixel (was 64 Mega pixels with the UltraCamL). All current customer benefit from this improvement by a free upgrade. This so called large medium format mapping camera addresses the smaller segment without sacrificing any image quality. Its unique camera design utilizes the concept of the large format camera system UltraCamX and UltraCamXp for the medium format market. By that, an affordable integrated mapping solution with a very high productivity without scarifying any image quality became now available to the remote sensing market. The UltraCamLp defines the industry standard in the medium format mapping market.

The UltraCamL/Lp provides the same geometric accuracy, the same radiometric dynamic, the same matching mapping and photogrammetry capability and the same forward motion compensation by TDI than the large format cameras but it comes in a medium format package and price.



The camera is designed to allow smaller companies to go digital by replacing their film cameras with the affordable UltraCamLp. Also big flyers may add the UltraCamLp to their sensor portfolio to be able to serve smaller projects more efficiently.

3.2. Concept

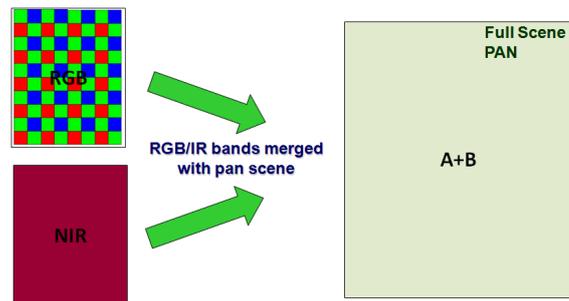
The camera concept differs from the standard concept of the medium format market to address the requirements for a mapping grade camera and also to increase the productivity. It utilizes the unique and patented concept of the large format camera UltraCamXp and has two cones for PAN image

collection. This ensures mapping grade geometric accuracy and radiometric dynamic as well as superior collection efficiency.

The high resolution PAN image is being stitched together out of the two sub-images collected by the PAN cones. It has 64 Mega pixel final images size (UCL) or 92 Mega pixels for UCLp (which was almost the format of the UltraCamD, introduced in 2003). The high resolution PAN image is being used for the mapping and photogrammetric work. It is supported by one lower resolution RGB cone and one additional NIR cone.



The RGB cone acquires the color information to color the pixels of the PAN image by the well know pan-sharpening methodology with a ratio of 1:2. The NIR cone collects NIR imagery with the same resolution than the RGB cone to support classification work. The PAN cones are lined up in flight direction and utilize the syntopic exposure for parallax free imagery, invented and patented by Vexcel for its large format cameras UltraCamD, X and Xp.



3.3. Forward Motion Compensation

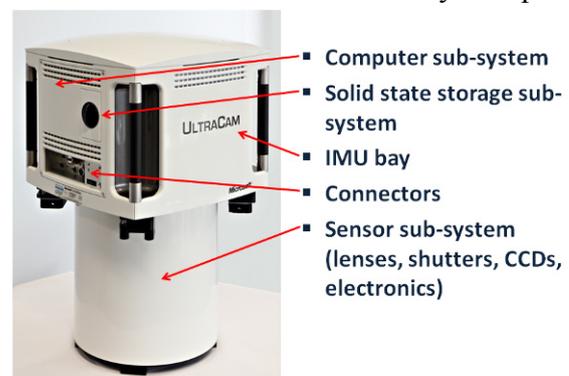
All cones (PAN, RGB and NIR) have forward motion compensation by time delayed integration (TDI). This feature of the UltraCamL/Lp is also unique to the medium format market. FMC by TDI has been proved and is the standard in the large format camera market where all frame based cameras use his concept to avoid motion blur and to increase flight envelope or duration. The UltraCamL/Lp uses the same technology for motion blur free PAN, RGB and NIR imagery and extended flight envelope or flight duration.

3.4. Design

The camera is a highly integrated system, integrating all subsystems into the camera head and no additional storage or computing units is required any more. The makes the camera very compact, easy to handle, easy to install and suitable for smaller planes, too.

The camera head includes:

- Computer sub-system
- Solid state storage sub-system
- IMU bay for third party GMP/INS systems
- Connectors for display, power, service
- Sensor sub-system (lenses, shutters, CCDs, electronics)





The storage system of the UltraCamL/Lp (left image) consists of an in flight exchangeable data unit with solid state devices. Each data unit has 1 TB of memory which lasts for around 2500 uncompressed images. The in flight exchange can be done in less than three minutes which leads to an “unlimited” storage in the aircraft due to multiple data units. So, there is no mission restriction due to the storage system of the camera.



The UltraCamL/Lp also introduces a new service concept to the camera market. The computing subsystem (right image) is fully integrated into the camera head and very easy to access by a pull-out rack for service and maintenance. This reduces down-time in case of a service or maintenance.

3.5. Main Parameters of UltraCamLp

Panchromatic image size	11,704 * 7,920 pixels
Panchromatic physical pixel size	6 µm
Panchromatic lens focal distance	70 mm
Color (multi-spectral capability)	True color & NIR
Color image size	5,320 * 3,600 pixels
Pan sharpening ratio	1:2
Forward-motion compensation (FMC) for PAN, RGB and NIR	TDI controlled
Maximum FMC-capability	50 pixels
Pixel size on the ground (GSD) at flying height of 900 m (at 500m)	8 cm (4.3 cm)
Frame rate per second (minimum inter-image interval)	1 frame per 2.5 seconds
Analog-to-digital conversion at	14 bits
Radiometric resolution in each color channel	>12 bit
Physical dimensions of the camera unit	45 cm x 45 cm x 80 cm
Weight	~ 55 kg
Power consumption at full performance	~ 220 W
In Flight Data Storage	Exchangeable Data Unit, consisting of Solid State Devices
In-flight capacity	Unlimited with multiple data units; per data unit 1TB, ~ 2500 images

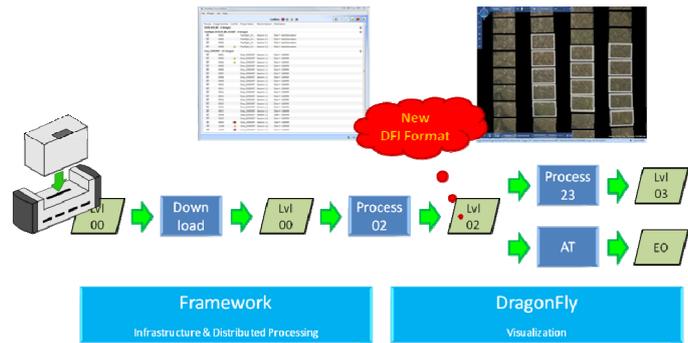
4. ULTRAMAP

UltraMap is the new processing software for the UltraCam series. It supports all UltraCam cameras and extends the workflow into a full photogrammetric workflow by a seamless integration of aero triangulation and bundle adjustment functionality into the existing image processing workflow.

UltraMap is designed to handle all kind of projects ranging from projects with a few hundred images up to projects with ten thousands of images and it is optimized for UltraCam images. For this, it introduces a new, revolutionary technology and concept of image handling, a direct spin of from the latest available Microsoft technology.

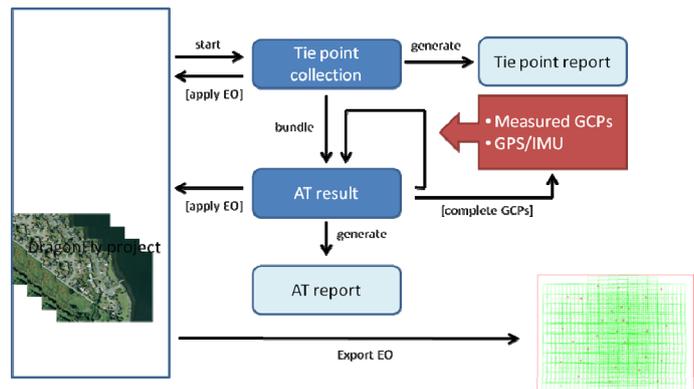
Main features of UltraMap are:

- Download manager, integrates the existing UltraCam download stations
- Distributed image processing level 0 to 2 and level 2 to 3
- New stitching methodology for level 0 to 2 processing
- Usage of multi core / multi CPU systems
- Automated load balancing, also in heterogeneous environments
- Supports field and main office environment
- Handling of huge image blocks
- Auto-calibration functionality
- Interactive quality control per image and per block
- 16 Bit visualization for Pan and RGB and NIR images
- Index map based visualization to identify missing images, crab angle issues, GPS/IMU accuracy, overlap, radiometry



Main features of the UltraMap/AT extension are:

- Aerial triangulation software package
- Supports unconstrained environments
- Usage of high redundancy imagery
- Combined feature-based and area-based methods
- Guided GCP measurement (documentation link support)
- Professional bundle adjustment by BINGO



The usage of high redundancy imagery makes UltraCam/AT very robust, very invariant to initial position errors, rotation and intensity variances. UltraMap is highly scalable and support much more than 50 cores in parallel. Tests have shown that a typical block with 2,000 images takes about 1-2 hours for tie point collection on a standard PC environment. This translates into approx. 90 seconds for one image on a single core standard PC.

The accuracy achieved by UltraMap/AT for large UltraCam blocks of images is in the range of a sigma naught value of around 1 micron.

5. CONCLUSIONS

We presented details about the digital aerial cameras UltraCamXp and UltraCamL/Lp, designed and manufactured by Vexcel Imaging GmbH (a Microsoft Company since May 2006) and UltraMap, the novel software package for post processing as well as aero triangulation and bundle adjustment.

Since 2003, when Vexcel Imaging GmbH introduced the UltraCamD large format digital camera system, the image format of the large camera models did increase by a factor of two where the new medium format UltraCamL/Lp is now offered at the similar image format like the large format UltraCamD in 2003. In the same time the on board storage capacity did increase from 2,500 frames to 6,600 frames which compares to almost five times the pixel storage capacity. It is obvious, that this enables mapping companies to acquire huge amounts of image data and software needs to be available to manage and process these data. The UltraMap software package is Vexcel's answer to support the needs of this growing mapping market.

6. REFERENCES

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