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UltraCam and UltraMap – An Update

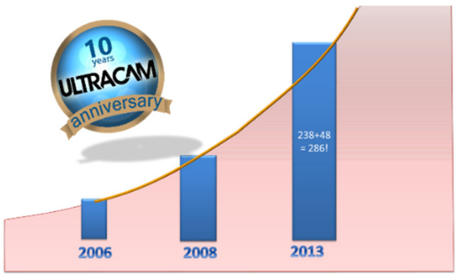
ALEXANDER WIECHERT, Graz

ABSTRACT

When UltraCam D was presented first at ASPRS 2003 in Anchorage, it was the beginning of an unmatched success story. As a newcomer to the market, UltraCam developed quickly into the world-wide leading large format digital camera system for aerial survey. The second generation UltraCam architecture was presented 2006 with the UltraCam X. After a kind of "facelift" in 2008 with the UltraCam Xp and UltraCam Xp Wide Angle, the next revolutionary step in the large format digital aerial segment took place March 2011 with the announce of the UltraCam Eagle at ASPRS. Since then two more cameras have been released based on the third generation architecture: the UltraCam Falcon and FalconP. This year, a specialized sensor has been added to the UltraCam camera family, the so called UltraCam Osprey. The Osprey is a unique sensor, combining a high performing photogrammetric nadir camera with oblique wing image collection capability. On the software side of the UltraCam solution, the UltraMap showed also an impressive roadmap of innovation, culminating in the latest release, UltraMap version 3 with outstanding features for point cloud generation, DSM and DTM generation as well as an automatized workflow for DSMOrtho and DTMOrtho image generation. This paper highlights the key milestones of the UltraCam development and dives into the details of the latest releases of cameras and software.

1. ULTRACAM

As of 2013, the UltraCam story represents a decade of success: 2006 already 47 cameras have been sold into the market, the counter went up to 101 cameras in 2008 and as of mid of 2013, 238 UltraCam have been sold with 48 upgrades in addition, leading to a total of 286 cameras manufactured and installed world-wide. Obviously the market has decided and as selected the UltraCam as the leading camera system.



Why? There are quite some good reasons why customer selected and continue to select UltraCam as the preferred camera system:

- Outstanding geometry: UltraCam provided always state-of-the-art geometric accuracy and has also first in the market introduced monolithic geometry by using a smart software solution
- Outstanding radiometry: the use of multiple smaller CCDs have a significant advantage in image dynamic over frame cameras using bigger CCDs or line scanners
- Continuous innovation: well thought milestones of evolution and revolutions in camera architecture lead to a best-in-class collection efficiency, driven by footprint size across the flight strip and a best-in-class frame rate to support image overlap along track
- Upgrade program: a user tailored and attractive upgrade program enables UltraCam customer to follow the path of innovation and benefit from the latest technology for their own business
- Camera family addressing different budget constraints and different project landscapes with best-in-class image quality and performance in each segment
- Strong sales and support infrastructure: a network of sales and support partners ensure that an UltraCam contact is "just around the corner". Three calibration labs in USA, Europe and Asia Pacific support customer in all three time zones 24/7.

The photogrammetric camera lineup of the UltraCam consist now of three major cameras: UltraCam Lp, UltraCam Falcon series and the UltraCam Eagle:

Figure 1: UltraCam camera family.

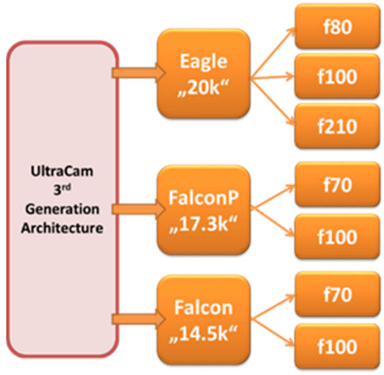


Figure 2: UltraCam Eagle and Falcon configurations.

UltraCam Falcon and UltraCam Eagle are based on the third generation UltraCam architecture and are available in multiple lens system configurations to address specific needs. Falcon and FalconP are available in two different sensor head configurations. UltraCam Eagle features a unique exchangeable lens system which allows the user to exchange the lens system without recalibration.

The latest UltraCam based on the 3rd generation architecture is the UltraCam Osprey. The UltraCam Osprey combines a photogrammetric nadir camera with RGB oblique image collection capability. That unique sensor design makes the Osprey THE camera system for 3D city model applications for example as it collect the most versatile data set and serves two applications in one camera system.

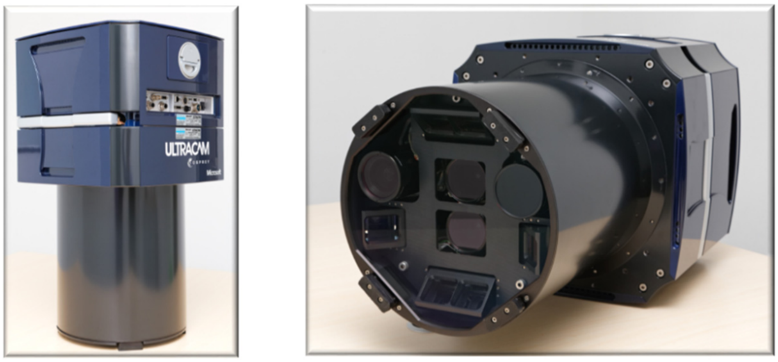


Figure 3: UltraCam Osprey.

Key parameters are:
Nadir

- 11,674 x 7,514 pixel
- PAN, RGB, NIR
- 1:2 pan-sharpen ratio
- 51 mm pan focal length
- FMC by TDI

Oblique

- RGB images
- 80 mm focal length
- FMC by TDI
- Tilted by 45 degree

Camera

- 2 seconds frame rate
- 350 Watts, 75kg
- SSD integrated (3.3 TB)
- UltraNav integrated (option)

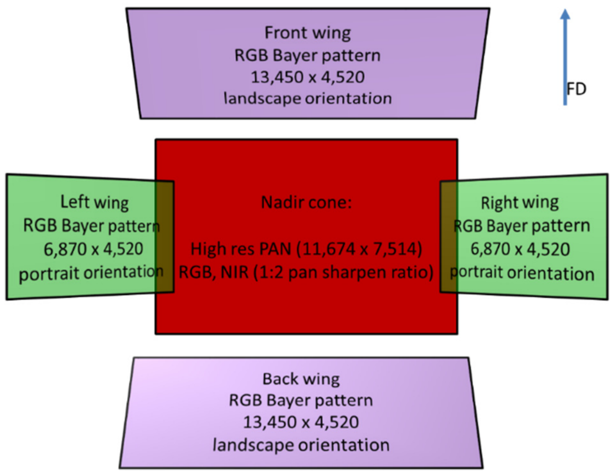


Figure 4: Footprint chart of UltraCam Osprey.

The footprint of the UltraCam Osprey allows to utilize the full footprint of 11,674 pixels across the flight strip for the project and ensures sufficient side and forward overlap for the wing images.

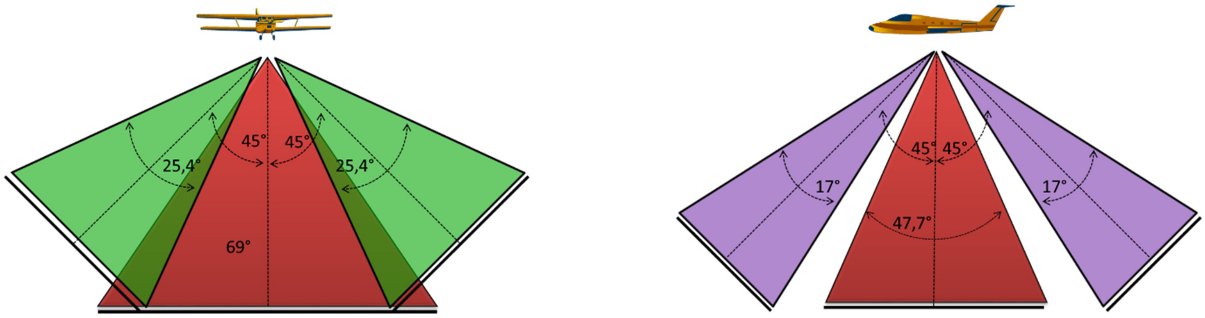


Figure 5: UltraCam Osprey image pattern (left/right and backward/forward).

The figures below show some examples of an early flight of the UltraCam Osprey, taken in January 2013 over Valencia, Spain. GSD of the nadir part is 7.5cm, flight attitude was 640m AGL.

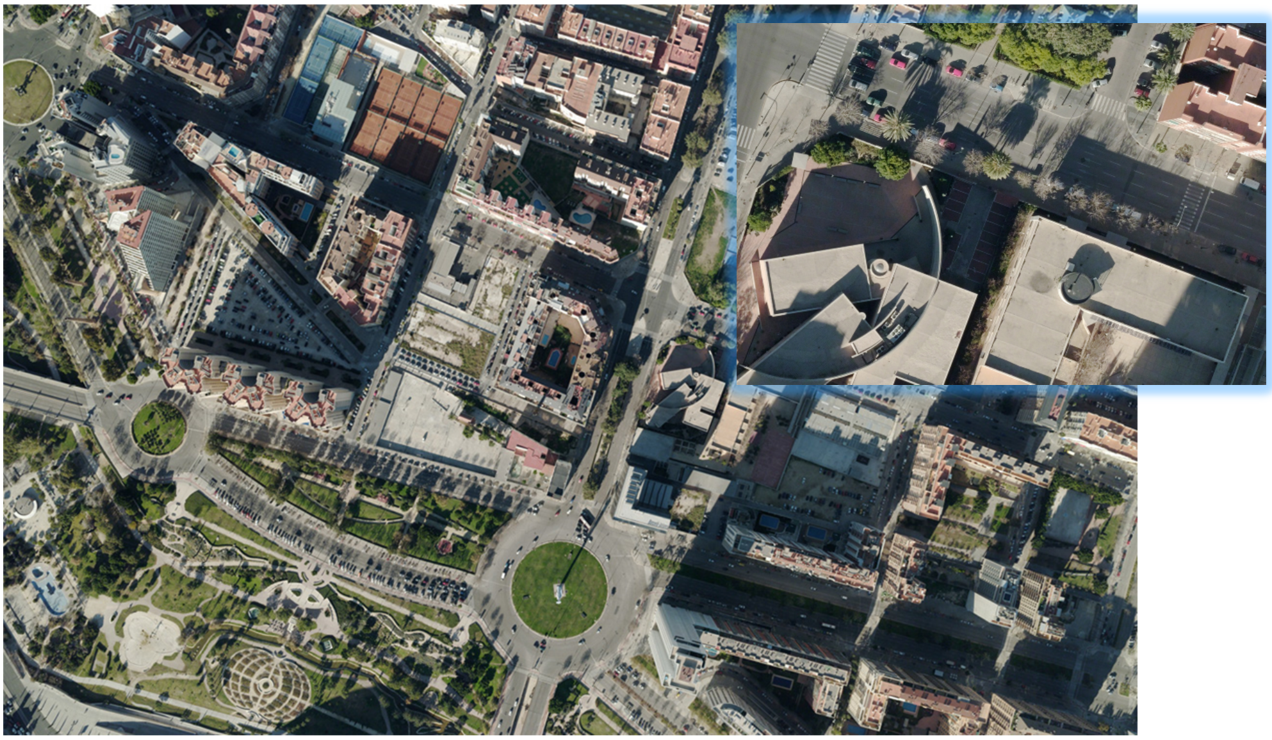


Figure 6: Nadir image and detail, GSD 7.5cm.

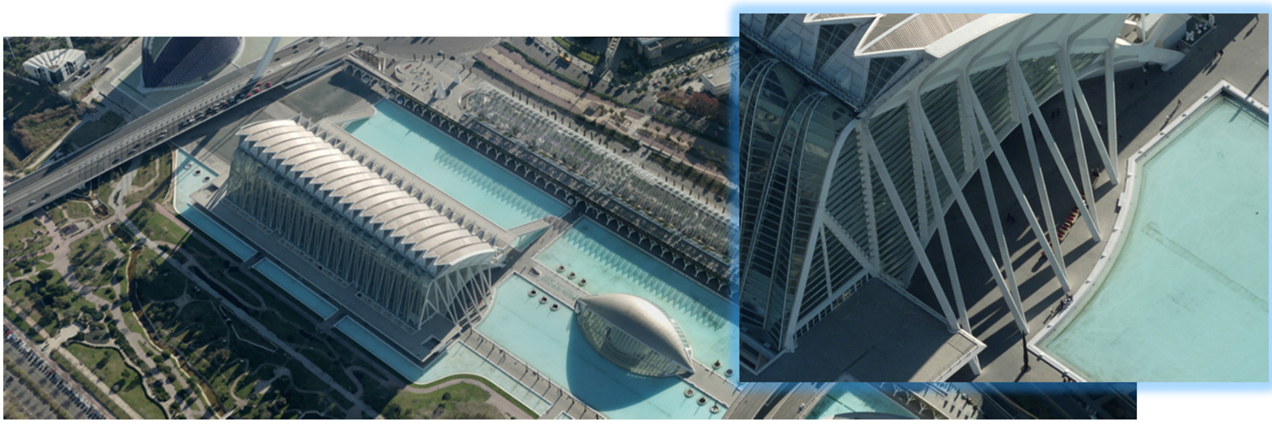


Figure 7: Frontward image and detail.

2. ULTRAMAP

2.1. Introduction

The same strong innovation path did also take place in the development of the UltraMap workflow system:

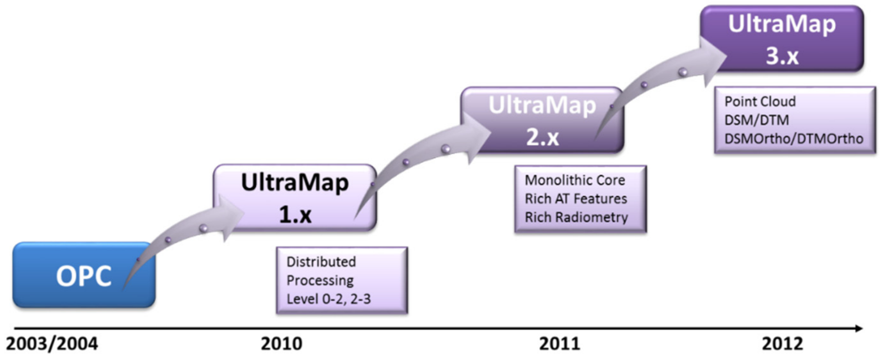


Figure 8: UltraMap roadmap.

Obviously the acquisition by Microsoft in 2006 gave a big push to the software development and opened up a wealth of access to the smartest algorithms available from the R&D centers of Microsoft around the globe. Many of them have been adopted and implemented into UltraMap, leading to a unique feature set and user interface. The key milestones of the UltraMap development have been:

- Version 1.x: change from the former processing software OPC to the new UltraMap system. Key features have been distributed processing level 0 to level 2 and level 2 to level 3 with automated load balancing in heterogeneous computer networks and the new GUI based on Microsoft's Dragonfly technology
- Version 2.x: first in industry a monolithic geometry has been introduced by the new monolithic stitching. Also a rich feature set for radiometry has been implemented such as automated hot spot removal, haze removal and automated project based color balancing which allows to color balance a whole block by just pressing a button. Furthermore, rich features for AT have been added such as automated tie point collection, reports, visualization such as link diagrams and progress diagrams and much more
- Version 3.x: the focus here was the automated generation of 3D data from images and based on that a completion of the workflow with automated DSMOrtho and DTMOrtho image generation

The figure below show the standard UltraMap workflow with the optional UltraMap/AT included. Third party software could also be used for the AT part but of course this then lacks the smooth integration into the workflow.

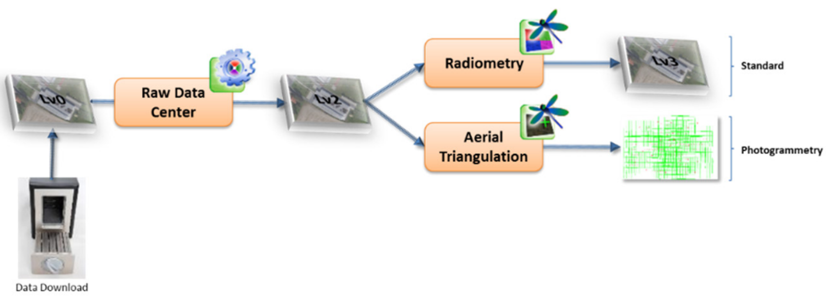


Figure 9: UltraMap image processing workflow.

2.2. UltraMap 3.x

With UltraMap version 3, the algorithms for 3D data generation have been implemented into UltraMap. These algorithms have been developed by the UltraCam team for Microsoft's BING maps and have been used for many years exclusively to generate the city models for that platform. Obviously highest degree of automatization has been a prominent design criteria.

Two new modules have been added to the UltraMap workflow:

- UltraMap/DenseMatcher: automated processing of point cloud, DSM and DTM from a set of overlapping UltraCam images
- UltraMap/OrthoPipeline: automated processing of DSMOrtho or DTMOrtho from UltraCam images and the DSM or DTM of the UltraMap/DenseMatcher

The UltraMap 3 workflow implements both models into a smooth workflow with intuitive user interface and high performance computing, using distributed processing on CPUs as well as additional processing on GPUs.

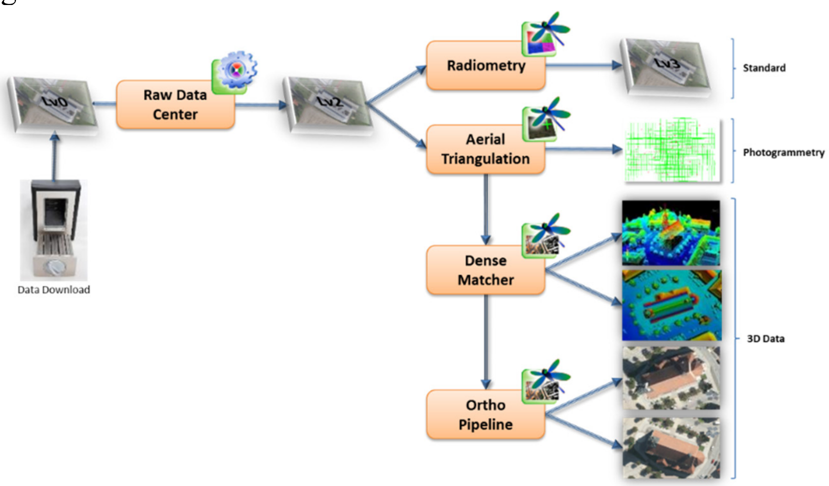


Figure 10: UltraMap 3.x Workflow.

2.3. UltraMap/DenseMatcher

The UltraMap/DenseMatcher uses a unique dense matching technology, developed by the UltraCam team, for the automated generation of an accurate point cloud with a very high point density. Point densities of 300 points per square meter or more are easily achieved. A stereo pairwise matching is applied to all pixels of an overlapping set of images. That leads to a highly redundant set of 3D points with multiple observations per pixel. This set is reduced by certain intelligent filter criteria and results in a highly accurate, very dense point cloud. The dense matcher has been developed by a team of researchers of world-wide reputation and is known as one of the leading dense matchers currently available.

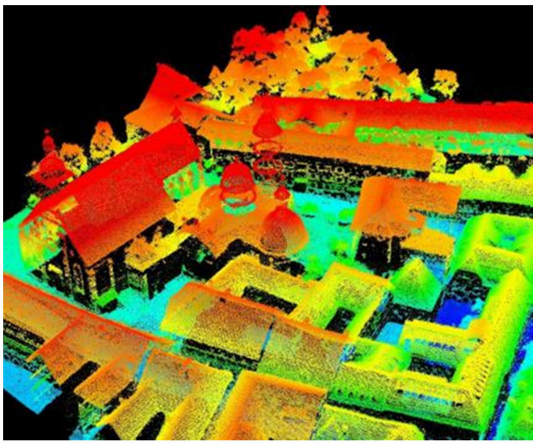


Figure 11: Point cloud generated by UltraMap/DenseMatcher.

Several intelligent filter exist to reduce the point density further for the export of the data. The point cloud can be exported as .las-file for upload into third party software for further application specific processing. Parameter setting allow to tailor the point cloud and export to specific needs.

Dense matching requires significant processing power. In addition to the distributed CPU processing, GPU based processing can be used as an option to speed up the processing.

Once the point cloud has been generated, the UltraMap/DenseMatcher generates a DSM and a DTM. The DSM quality is outstanding because of the extremely high point density of the underlying point cloud and highly sophisticated algorithms to generate the DSM from the point cloud. Microsoft has invested significant R&D resources into that and as a result, even small structures such as fine roof structures are represented precisely in the DSM. Also vertical walls appear straight vertical without a leaning effect as usually seen in airborne Lidar data. Edges are straight and sharp, quite uncommon for airborne Lidar data, too.

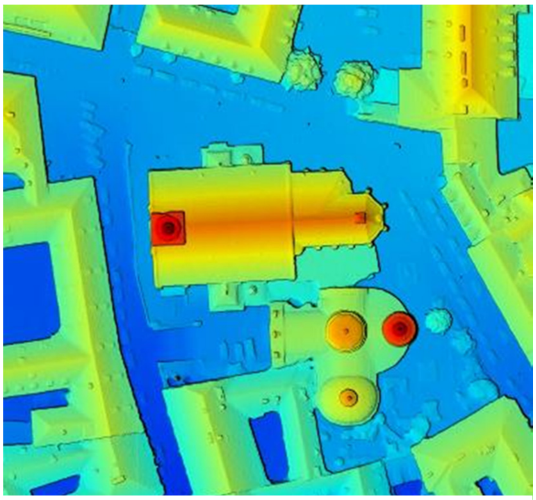


Figure 12: DSM generated by the UltraMap/DenseMatcher.

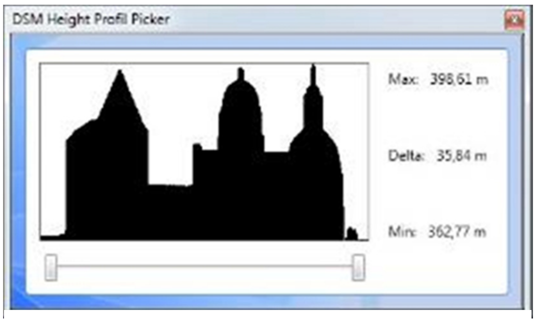


Figure 13: Profile of an UltraMap generated DSM.

The DSM can also be exported in tiles as 32bit floating GeoTIFF to be used in third party software systems for further use.

The DTM is generated by a specific filtering from the DSM and matches the accuracy and quality required for the DTMOrtho image generation. Whilst the current UltraMap version 3.1 does not provide export of the DTM, this is scheduled for further software releases.

2.4. UltraMap/OrthoPipeline

The UltraMap/OrthoPipeline allows to generate DSMOrtho images and DTMOrtho images.

For the DSMOrtho image, the images are rectified with the DSM, generated by the Dense Matcher. The result is an ortho image without any perspective view. That allows to clearly identify all objects on the ground as no lean blocks any visibility. Such ortho image usually suffer from some artifacts, inherent to the methodology, such as inhomogeneous projection at edges. Thanks to the outstanding quality of the DSM (sharp edges, vertical walls, etc.) such artifacts are barely not visible in the UltraMap solution and offer a completely different experience and quality compared to results by using DSMs from airborne Lidar scanning or other solutions.

Figure 14: DSMOrtho by UltraMap.

For the DTMOrtho (the traditional ortho image), the DTM is used to rectify the image. That results in an image with perspective view, but this solution is more robust concerning lower DTM quality and generates less artifacts. However, thanks to the perspective view, objects are hidden if they are behind the lean. Seamlines are generated automatically, using a combination of image analysis and DSM and DTM analysis.

Both products are generated automatically but the UltraMap/OrthoPipeline provides tools to set parameters and to manually fine tune the results by editing the DSM or DTM as well as manually fine tune the seamlines for example.

Figure 15: DTMOrtho by UltraMap.

Results of the UltraMap/OrthoPipeline can be exported as TIFF & TFW and GeoTIFF files for further use in third party software systems.

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www:
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