High Altitude – High Volume – High Quality:

The UltraCam Condor from Vexcel Imaging

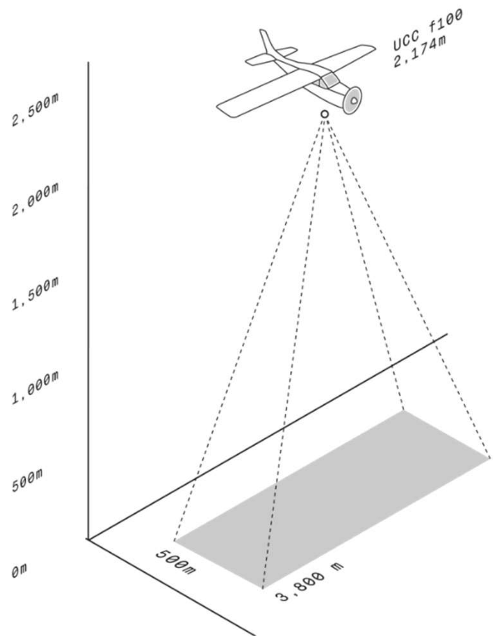
The UltraCam Condor is the most recent offering in Vexcel Imaging's suite of high-performance UltraCam digital aerial systems. Released in April 2016, the Condor addresses a very specific application: high altitude ortho image generation with exceptional image quality. Producing a camera system that 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.

Meeting the Technical Challenges

To reach its goal of manufacturing the best high altitude ortho image system on the market today, Vexcel Imaging started the development process with a set of requirements that the UltraCam Condor must address.

First, a larger footprint size was desirable to increase the volume of data collected. Given the extraordinary footprint size across the flight strip, a higher flight altitude was required to minimize lean at the edges of images and maintain full usability of the image footprint. The higher flight altitude created several challenges that needed to be resolved to ensure outstanding image quality.

Second, to provide additional flying efficiency and flexibility, the camera needed to be functional in turboprops and jets. The higher flight speed of jets requires a faster frame rate to capture the desired resolution with adequate forward overlap for DSM/DTM generation. The UltraCam Condor lens system



has been designed so that RGB, NIR and PAN data is collected simultaneously and all are exposed at the same fast frame rate.

Third, the system had to collect and store uncompressed raw data possessing a wide image dynamic range and high signal-to-noise ratio, so that the color shifts attributable to the atmosphere could be corrected without generating artifacts. The custom CCDs used in the UltraCam Condor, with a signal-to-noise ratio of >72dB, are key to the excellent image quality.

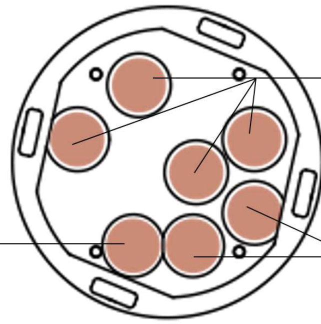
And last but not least, the camera had to fit into the existing environment of mounts and airplanes to minimize upfront costs to users.

Building on Existing Technology in Innovative Ways

The underlying technology of digital aerial camera systems has rapidly evolved since the introduction of the first UltraCam aerial platform, the UltraCamD, in 2003. Remarkable advances in electronics, storage, software, and lenses have revolutionized data collection by improving the quantity and quality of the imagery, and the efficiency and ease of use of the entire series of UltraCam products.

The UltraCam Condor is based on the 3rd generation UltraCam architecture, made available to the public in the UltraCam Eagle in 2011, featuring a modular housing with integrated SSD storage, exchangeable lenses, improved CCDs, low noise electronics, an integrated flight management and georeferencing system, and an ultra-large footprint. The UltraCam Condor also leverages the technology and operational experience gained during the Microsoft Bing Maps Global Ortho Program, during which an unprecedented 10.5 million km^2 were collected at 30cm and 15cm resolution in less than two years. This 2010–2012 imagery of Western Europe and the contiguous United States provided a continuous and consistent coverage acquired by ten UltraCam Giant (UCG) cameras. Although the UCG was exclusively developed and operated by Microsoft for its Global Ortho project and not sold commercially, the lessons learned provided an excellent basis with which to meet future product development challenges.

The basic idea of the UltraCam Condor design uses multiple detector arrays (CCD sensor arrays) and multiple optical systems of different lengths to build one large-format camera system. Due to the compact size of this design, the camera can be operated with a standard mount and single-hole aircraft.



The output of the camera is a single rectangular panchromatic image of 13,400 x 8,650 pixels at a smaller scale, which serves as the photogrammetric backbone to enable automated aero-triangulation (AAT). A set of smaller color images are stitched together by software and co-registered onto the panchromatic image. The color images together form a rectangular footprint on the ground with a very large cross-track dimension of 38,000 pixels and a smaller long-track dimension of 5,000 pixels. The panchromatic image is enhanced by the large format color image in such a way that parts of the footprint of the panchromatic system are superimposed by the higher resolution RGB image to improve manual measurements.

The basic photogrammetric information can be derived from the panchromatic image via multiple huge forward overlaps (85%), which support robust automated dense-matching and DSM/DTM generation and make additional LiDAR data collection obsolete. This capability ensures utmost data consistency between the elevation and image data. The color (RGB) images are collected with a smaller forward overlap (20%) and cover the entire terrain along the flight path without gaps. An additional camera head is used to capture NIR images, and the NIR channel is co-registered onto the panchromatic images as well. The 80% overlap of the NIR channel further supports classification.

In addition to the hardware and electronics improvements incorporated into the UltraCam Condor, significant changes were made in the UltraMap processing software to better accommodate high altitude data. The highly automated workflow eliminates artifacts and performs all the radiometric corrections necessary. This was an especially crucial endeavor for the team, as the color shifts attributed to high altitude and changing atmospheric conditions needed to be modeled precisely in the UltraMap software, thus allowing the software to correct the color shifts without generating artifacts. In addition to developing the software algorithms, it was essential that the team design the UltraCam Condor with the ability to store uncompressed raw images that maintain full color information of all color channels. This enables the user to apply color corrections as necessary.

Key Technical Parameters

Thanks to multiple optical lenses, custom CCDs, and in-house developed electronics, the technical challenges of high altitude ortho image generation have been successfully addressed in the UltraCam Condor aerial system. The following specifications illustrate the productivity and efficiency of the UltraCam Condor.

	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	

Long Term Value to Geospatial Professionals and the Public

The UltraCam Condor provides the ability to capture digital data for the production of ortho images over large geographic areas in a fraction of the time it takes with smaller cameras. For example, a 1° by 1° area at 45 ° Latitude (e.g., Minneapolis, 8,700 km^2) can be covered by 10 flight lines in four or five hours. These base maps are used by commercial businesses and government organizations for a multitude of applications, including public safety, planning, emergency response, construction, transportation, oil and gas and real estate.

The cost of acquiring large area coverage with frequent updates has been a long-standing problem for public and private entities with limited budgets. Costs associated with collecting statewide/nationwide data should decrease as a result of the UltraCam Condor's larger footprint and faster flying times. At lower cost, there is also the potential for more frequent updates. Benefits of up-to-date imagery include improved situational awareness for first responders and more accurate change detection for applications such as environmental analysis and crop monitoring.

Customer expectations change as technology changes. This camera collects data for wide-area mapping faster than smaller cameras, so the marketplace will create a new benchmark for how long a project should take and how much a project should cost. While higher altitude cameras for ortho image collections are not new, the existing cameras suffer from significant issues. The UltraCam Condor is redefining the efficiency / quality ratio in this segment. High quality nationwide capture is attainable, as demonstrated in the Bing Maps Global Ortho Program.

The current 3rd generation UltraCam architecture will be used as a platform and further developed in future UltraCam products. The software algorithms developed for the UltraCam Condor, primarily de-hazing and improved color balancing, are now included in the UltraMap suite and other sensors will benefit from the same processes. Digital aerial mapping has seen tremendous growth and progress in the past 13 years, and the technological innovation is not likely to stop anytime soon.