The Z/I DMC II – "Imaging Revolution"

KLAUS J. NEUMANN, Aalen

ABSTRACT

It had always been the philosophy of Z/I Imaging and Leica Geosystems to develop leading edge technology. At the XIX ISPRS congress 2000 in Amsterdam these two companies had been among the first launching large format digital aerial cameras for the commerical photogrammetry market. Now that both brands are combined under the Hexagon group this strategy will continue with development of new innovative sensor solutions. The two newest digital aerial frame cameras, the DMC II and RCD 30, demonstrate the development capabilities of Z/I and Leica by providing unique key features and revolutionary design.
The DMC II is actually a large format camera family consisting of three different configurations, the DMC II 140, the DMC II 230 and DMC II 250 where the RCD 30 is a medium format camera with a modular concept allowing to combine multiple camera heads and an exchangeable focal length. Both sensors had been delivered to customers around the globe and are already in operation. The paper describes in more detail the design of the DMC II large format camera family.

1. INTRODUCTION

Since the first introduction of digital aerial cameras during the year 2000 there had been always a demand from the market to match the image format of analogue film cameras. Where the RMK TOP film camera had a 9 inch x 9 inch square image format the DMC first generation used four 86,016 mm x 49,152 mm PAN CCDs with 28 Megapixel simply because these had been the largest commercially available CCDs at that time. By combining four camera heads via software the final image format had nearly the same swath width than an analogue film camera but only half the ground coverage in flight direction.
When the first DMC data became available, height accuracy was the biggest discussion topic in the scientific photogrammetric community. In theory a reduced image format and thus reduced base to height ratio leads to reduced height accuracy. But in reality the much improved digital image quality proofed different. By reducing geometric errors introduced by film distortion during development and scanning the overall accuracy was improved. Direct digitizing, with more bits per pixel and larger dynamic range of CCDs, comparing to film, generated much cleaner and more brilliant stereo models, which allowed the compiler to measure more precisely the vertical dimension.
But there was still the call for a larger single digital sensor to increase further geometric accuracy and radiometric quality of aerial images. Z/I Imaging finally found a solution for that requirement which led into the development of the new DMC II digital camera family.
Development of the DMC II camera family was planned in four phases and started end of 2006. At the XXI ISPRS congress in Beijing development phase 1 called RMK D was introduced. Designed as the base unit for DMC II without PAN camera head, the RMK D can be operated as multispectral medium format camera. At Photogrammetric Week 2009 the design of RMK D was presented in detail. (Doerstel) DMC II development phase 2 to 4 run from 2009 to 2011 and included design of the DMC II 140, DMC II 230 and DMC II 250.

2. THE DMC II CAMERA FAMILY

2.1. Design Concept

The basic idea for the development of the DMC II was to design a successor of the DMC first generation and to develop a digital aerial frame camera with a very large single monolithic CCD. Engineers from Z/I started technical discussion with the DALSA CCD designer team and explained the though requirements. After weeks of information exchange the feedback from DALSA was positive and the developers came up with a technical spec for a 140 Megapixel PAN CCD using 7.2 micron pixel size a world record for commercial frame CCDs. With the confidence Z/I had into the skills of the DALSA CCD designers that the technical spec for the new CCD will be met, development of the DMC II 140 was started on the Z/I side. The plan was to develop a large format frame camera with five camera heads, four multispectral cameras for RGB and NIR and one PAN camera using the new 140 Megapixel CCD.

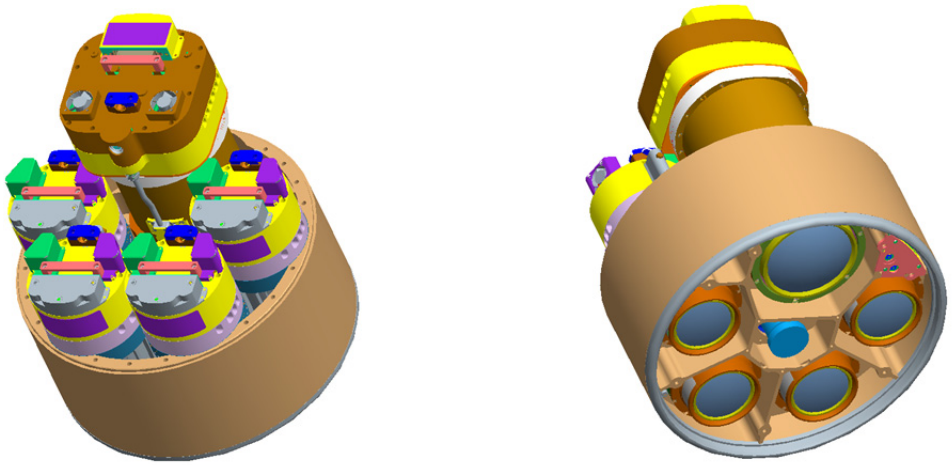

Figure 1: DMC II Camera Design

2.2. CCD Design

The four multispectral camera heads use 42 Megapixel PAN CCDs with 7.2 micron pixel size exclusively designed by DALSA for the new DMC II camera family. The physical sensor size is 43.9 mm x 49.3 mm, the number of imaging pixels is 6096 (H) x 6846 (V). The color information is generated by external color filters for each band. Therefore electronic forward motion compensation is implemented using TDI Time Delay Integration. This important feature cannot be applied for color CCDs using BAYER filters.
The 140 megapixel PAN CCD has 12240 (H) x 11418 (V) pixel with 7.2 micron pixel size, the physical size is 88 mm x 82 mm which leads nearly to a square image format. These impressive single monolithic CCD marked a world record for commercial frame CCDs.
But the Z/I development team and DALSA CCD designers did not give up and came out with a technical spec for a second even larger monolithic CCD comprising 250 megapixel at 5.6 micron pixel size. The CCD has 17216 (H) x 15556 (V) pixels and a physical size of 90 mm x 84 mm.

A technical challenge for the engineers had been the requirement for fast data readout. The solution for a high frame rate was the implementation of 16 parallel readout data ports directly on the CCD chip.
Until today this 250 megapixel CCD is the largest monolithic single frame sensor available in the world. Z/I Imaging has exclusive rights from DALSA to use this sensor for digital aerial cameras applications.

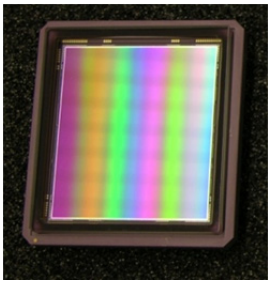

Figure 2: Multispectral CCD

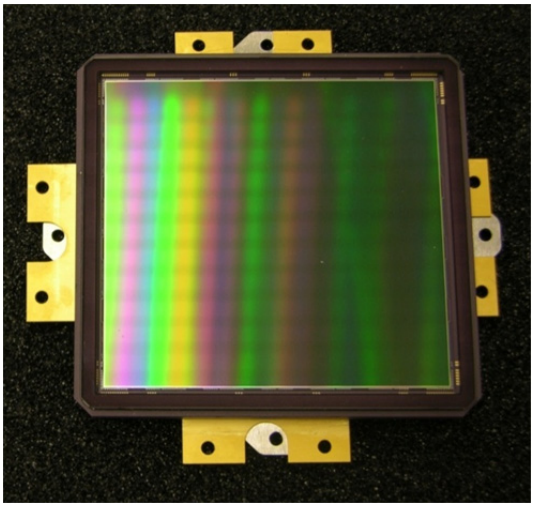

Figure 3: Large format PAN CCD

2.3. Optical System

In cooperation with Carl Zeiss Jena new optical lens systems had been designed from scratch. An objective design with 45 mm focal length for the multispectral cameras and 92 mm for the DMC II 140 PAN camera was selected. All four multispectral cameras have identical lens systems with dedicated color filters for each color spectrum. The PAN camera head includes an infrared cut-off filter to block all wave length larger than 710 nm.
When the design of the 92 mm PAN lens for the DMC II 140 was completed DALSA provided Z/I with technical specs for the larger 250 megapixel CCD. Z/I development team did a parameter analysis where the outcome was that the 92 mm lens (originally designed for the 140 megapixel CCD) can be used also for the 250 megapixel CCD with some limitation on the usable field of view. That was the start of the DMC II 230.
But the goal was to take full advantage of the large 250 megapixel CCD and therefore Z/I decided to design a second PAN lens with 112 mm focal length which led to the DMC II 250 design.
At photogrammetric week 2009 Holger Doering explained the advantages of a customized optical design for aerial survey cameras. The large success of the Z/I DMC first generation proved that and therefore it was a logical step to continue with special optic development for the new DMC II.
In the long tradition of Leica and Zeiss the new Z/I DMC II design makes no compromises on the image quality.

2.4. DMC II Configurations

The DMC II camera family consists of three different configurations, the DMC II 140, the DMC II 230 and the DMC II 250. The base unit is called RMK D and is the same for all three configurations. The RMK D can be operated as medium format camera without PAN camera head

installed. As already explained all multispectral camera heads have their own color filter. Therefore the RMK D has a native 1:1 color resolution and forward motion compensation.
By adding a large format 140 megapixel PAN camera head to RMK D it will be converted into a DMC II 140. A multi spectral pixel of the DMC II 140 has half the ground sampling distance of the PAN pixel which leads to a Color to PAN ratio of 2:1 which provides excellent color resolution for remote sensing classification. First DMC II 140 camera systems had been delivered to customers in March 2010.
The next configuration is a DMC II 230 which includes the 250 megapixel CCD combined with the 92 mm PAN lens also used for the DMC II 140. The multispectral camera heads are identical with the RMK D and DMC II 140 configuration. The DMC II 230 is designed for high resolution 3 D mapping and large area Orthophoto programs. First DMC II 230 camera had been delivered to users in December 2010.
The final configuration of the camera family is the DMC II 250. It includes the 250 megapixel CCD combined with a new designed 112 mm PAN lens. Again multispectral cameras are identical with RMK D, DMC II 140 and DMC II 230. This allows an easy upgrade path from RMK D up to DMC II 250. The DMC II 250 is primarily designed for extreme high resolution and 3D mapping, high flying heights and urban area mapping. First DMC II 250 camera systems had been delivered to customers in June 2011.

2.5. Geometric Accuracy

The DMC II camera family was designed to meet highest geometric accuracy standards or even exceed all known requirements for geometric accuracy. The large single monolithic frame sensor is the base for high accuracy. The results achieved so far with all DMC II configurations had been exceeding expectations. The DMC first generation has an X,Y accuracy of 1.0 pixel and vertical accuracy of 0.7 pixel. The DMC II improved that level to 0.5 pixel planimetric accuracy and 0.7 pixel for vertical accuracy.
To verify these values DMC II test flight data had been provided to the University of Hannover for an assessment of the geometric accuracy of the DMC II family. Results about the DMC II 140 had been published the PFG magazine 2/2011. One of the conclusions from Jacobsen was that the systematic image errors of the DMC II 140 are nearly negligible and smaller as for other cameras. Results of the DMC II 230 and 250 accuracy assessment will be published later this year.

2.6. Technical Specifications of DMC II

The following table shows the technical parameters of the DMC II camera family.

Feature	DMC II 140	DMC II 230	DMC II 250
pixel across track	12096	15552	16768
pixel along track	11200	14144	14016
FoV across track	50,7 °	50,7 °	45,5 °
FoV along track	43,3 °	46,6 °	38,6 °
PAN focal length	92 mm	92 mm	112 mm
MS focal length	45 mm	45 mm	45 mm
GSD@500m	3,9 cm	3,0 cm	2,5 cm
B/H	0,35	0,34	0,28
number of PAN camera heads	1	1	1
number of MS camera heads	4	4	4
Color filter	True color	True color	True color
color channels	R,G,B and NIR	R,G,B and NIR	R,G,B and NIR
CCD pixel size	7,2 µm	5,6 µm	5,6 µm
PAN : Color ratio	1 : 2	1 : 2,6	1 : 3,2
frame rate	2,2 sec	2,3 sec	2,3 sec
resolution per pixel	14 bit	14 bit	14 bit
FMC	yes, TDI	yes, TDI	yes, TDI
CCD dynamic range	>70 dB	>70 dB	>70 dB
weight	66 kg	68 kg	68 kg
onboard storage (standard delivery)	1.5 TByte	2 TByte	2 TByte
power consumption	350 W	350 W	350 W
maximum operating altitude	8000 m	8000 m	8000 m
max airspeed at 10 cm GSD and 80% forward overlap	198 kts	239 kts	237 kts

3. REFERENCES

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