Intergraph's DMC II Camera Range
New Large-Format Airborne Digital Frame Cameras

By Gordon Petrie

At the recent ASPRS Annual Conference held in San Diego at the end of April, Intergraph announced a major new development with the introduction of four new large-format airborne digital cameras under its Z/I Imaging brand. The use of a single large-format monolithic pan imaging sensor in each of these new cameras represents a major advance in digital airborne imaging technology.

Background

The *Z/I Imaging DMC* [Fig. 1(a)] was the first large-format airborne digital frame camera to appear on the market, having been introduced in its original prototype form at the ISPRS Congress held in Amsterdam in 2000. The first production versions of the DMC were delivered in 2003. Since then, it has proven to be a very successful product, with over 100 units having been sold world-wide since its introduction. The basic design comprised four oblique-pointing medium-format cameras [Fig. 1(b)] arranged in a block configuration that produced slightly overlapping *panchromatic images*. The resulting photos were then rectified and stitched together to produce a single "near-vertical" composite image in a rectangular format that could be delivered to users [Fig. 1(c)]. This final composite black-and-white pan image gave the required coverage of the ground from a single exposure station in a large format size – 13.5k x 8k = 108 Megapixels - as required for photogrammetric mapping purposes.

Figure 1 – (a) This DMC large-format digital camera is being operated on a T-AS gyro-controlled mount in conjunction with a Z/I InFlight FMS (flight management system), which is located to the left of the camera and its mount. A Solid State Disk (SSD) is shown being inserted into the side of the camera to record and store the exposed images.
(b) Showing the four oblique pointing cameras built by Carl Zeiss that are used to acquire the four overlapping medium-format pan images of the DMC camera simultaneously in a single synchronized exposure. Each set of four images is rectified and stitched together post-flight to form the final DMC large-format panchromatic image.

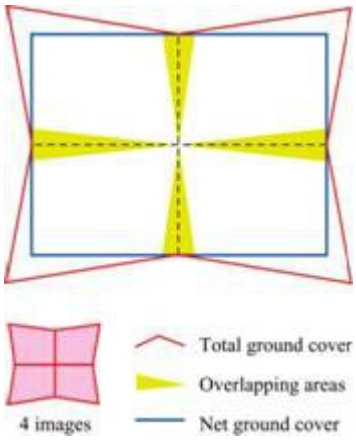

Fig. 1 (c) Showing the coverage and overlaps of the four medium-format pan images that are acquired by the DMC camera (in red and yellow) and the ground coverage of the rectified and stitched final large-format "near-vertical" image (in blue).
(d) The original DMC camera as seen from below, showing its eight lenses – four used for its large-format pan imaging channel and four for its small-format multi-spectral imaging channels.

The final DMC composite panchromatic images could also be colourized to form *colour (RGB*) or *false-colour (VIS + NIR) images* using the image data from four additional small-format (2k x 3k = 6 Megapixels) multi-spectral cameras that formed part of the overall DMC camera system [Fig. 1(d)]. These four additional cameras were all pointing in parallel in the near-vertical (nadir) direction and did not need to be rectified in the manner of the larger format pan images. With their large format and perspective geometry, the final composite pan or colour photos could readily be utilized in the existing digital photogrammetric workstations (DPWs) and software packages such as Intergraph's own ImageStation products that are designed for use with any type of aerial frame photography.

In 2008, Intergraph introduced a new airborne multi-spectral digital camera, called the ***RMK D***, which started to be delivered to customers during the second half of 2009. This unit [Fig. 2(a)] comprises four individual medium-format nadir-pointing cameras that generate simultaneous images in the blue, green, red and near infra-red (NIR) parts of the spectrum respectively. Each camera produces an image that is 6k x 6.8k = 42 Megapixels in size using a DALSA CCD array having a pixel size of 7.2 µm [Fig. 2(b)]. The RMK D camera also features electronic FMC (forward motion compensation) and TDI (time delay & integration) technologies. The resulting framing rate is one image per second. The acquired images can either be utilized separately as individual multi-spectral images or they can be used in combination (merged) to form full-resolution colour or false-colour images. A further feature of the RMK D camera is its use of an f = 45 mm lens for each of the four channels. This provides the large base:height ratio of 0.42 for good stereo-viewing and accurate measurement. The medium-format RMK D camera costs approximately 50% of the price of the larger-format DMC camera. Thus it is intended for use by those mapping companies and government agencies that have not yet adopted airborne digital imaging technology because of the very high level of investment that is required to purchase a large-format airborne digital imager. The RMK D camera's multi-spectral capabilities are also attractive to those agencies that are concerned with the imaging and mapping of limited areas for forestry and agricultural applications or for environmental monitoring and disaster response.

Figure 2 - (a) The Intergraph RMK D medium-format airborne digital camera showing the handles of two of the solid-state disk (SSD) units on its left side and one of its carrying handles on its right side.
(b) The DALSA FT53 CCD frame-type image sensor that is used to record the 6k x 6.8k (= 42 Megapixels) images on each of the camera's four multi-spectral channels.

The new range of DMC II cameras that have just been introduced by Intergraph combine many of the features of the previous DMC and RMK D series, but they now offer much larger formats which eliminate the need for the rectification and stitching of the panchromatic images during their initial post-flight processing.

Imaging Sensors

The CCD imaging sensors that have been utilized in both the older and the new series of Intergraph DMC and RMK cameras have all been supplied by the Canadian ***DALSA*** company which has its headquarters in Bromont, Quebec. Its subsidiary, DALSA Semiconductor, is located in Waterloo, Ontario, while its main Image Sensor Solutions facility and offices are located within the High Tech Campus in Eindhoven in the Netherlands. The DALSA company has been a pioneer in the development of large-format imaging sensors. In 2006, it produced the first imaging sensor with a format of over 100 Megapixels. This CCD array [Fig. 3] was developed for an astronomical application on behalf of the Astrometry Department of the U.S. Naval Observatory (USNO) and had a format size of 10.5k x 10.5k pixels = 111 Megapixels, with each pixel being 9 µm in size over an active area of 4 x 4 inches (10 x 10 cm). The new family of CCD imaging sensors that have been developed by DALSA on an exclusive basis for Intergraph have still larger formats and they exhibit a number of quite different characteristics such as fast framing rates and forward motion compensation (FMC) that are designed to meet the specific requirements of airborne imaging rather than astronomical applications.

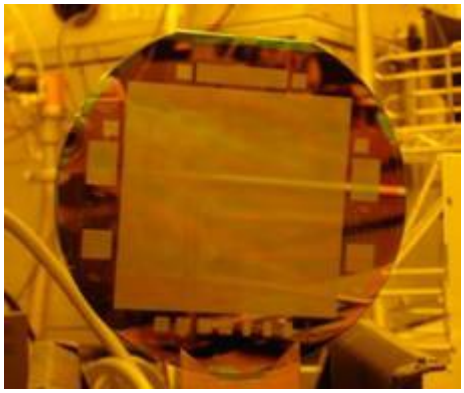

Figure 3 – The first 100+ Megapixel CCD imaging sensor that was built by DALSA SemiConductor in 2006 for use in an astronomical application by the U.S. Naval Observatory (USNO).
Figure 4 – The new DALSA 140 Megapixel CCD imaging sensor as packaged for use in the Intergraph DMCII140 large-format airborne digital camera.

The new DALSA CCD imaging sensors are still larger in size in terms of the number of pixels that they feature. In the case of the pan sensors that are being fitted to the new ***DMC II140*** cameras, their format size is 11.2k x 12k = 140 Megapixels, with each pixel being 7.2 µm in size. The physical size of the new sensors is 3.5 x 3.2 inches (8.8 x 8.2 cm). This customized packaging (Fig. 4) is designed exclusively for use in the ZI Imaging cameras in that they are hermetically sealed with a special cover glass to ensure that their geometric accuracy is maintained irrespective of the environmental conditions under which they are being used. Special holders within the special housing guarantee a thermal and mechanical long-term stability.

The DALSA CCD imaging sensors that will be used in the new ***DMC II230*** and ***DMC II250*** cameras will feature a still smaller pixel size (of 5.6 µm) and a still greater number of pixels in the area array. In the case of the DMC II230 model, the arrays will have 15k x 14.4k pixels = 230 Megapixels; while, in the case of the DMC II250 model, the number of pixels will be 17.2k x 14.7k = 250 Megapixels. DALSA claims that the imaging arrays exhibit a high sensitivity and a high dynamic range (of around 70 dB), that allows them to capture detail in shadow areas - while, at the same time, they possess anti-blooming characteristics that enable them to deal with bright highlight objects and areas.

DMC II140 Cameras

The ***DMC II140*** is derived directly from the previous RMK-D model, the main change being the addition of the new large-format pan camera to the existing four channel medium-format multi-spectral arrangement of the RMK-D [Fig. 5(a)]. Indeed it is possible for existing examples of the RMK-D camera to be upgraded to the DMC II140 specification [Fig. 5(b)]. For this upgrade the DMC II140 (as well as all other DMC II models) utilize a new single lens for the additional panchromatic channel that has been designed and built by ***Carl Zeiss*** exclusively for photogrammetric requirements within the DMC II cameras. These lenses are optimized for highest level of image quality and temperature stability. The focal length (f) of the new lens is 92mm which, in combination with the larger size of the CCD area array, gives an angular coverage of the terrain that approaches 50 degrees and provides a base:height ratio of 0.35. The pan camera has an infra-red cut-off filter that is designed to block radiation beyond 710 nm wavelength. Each

camera head uses a piezo-electric driven shutter that ensures the maximum degree of synchronization of the five camera heads during the simultaneous exposure of their images over the terrain.

Figure 5 – (a) The four lens cones of the Intergraph RMK D medium-format camera surround the lens of a small-format video camera at the centre of the supporting face plate. These four lens cones with their respective Red, Green, Blue (RGB) & NIR filters generate the individual images that provide the multi-spectral capability of the RMK D camera. The vacant space at the foot of the face plate will be occupied by the additional lens cone of the large-format panchromatic channel if the camera is to be upgraded to the DMC II140 standard.
(b) The five lens cones of an upgraded Intergraph DMC II140 camera surround that of the video camera at the central position. At the left side is the lens of the additional large-format imaging panchromatic channel; the remaining four lenses are those required to generate the four multi-spectral images as before.

Both cameras also feature the ***Solid State Disk (SSD)*** image storage technology that has been used in the existing DMC and RMK D cameras [Fig. 6]. This provides an on-board storage capacity of 1.5 Terabytes, allowing 2,000 separate images to be stored in-flight. The post-flight image processing is carried out using the basic software that has already been developed for the processing of the existing DMC and RMK-D digital image data and has been upgraded to accommodate the new camera models.

Fig. 6 - An DMC II140 camera with its two solid state disk (SSD) storage devices placed in front of it.

The new DMC II models have also been designed to be compatible with all the ***peripheral devices*** from Intergraph that are being utilized with the existing RMK-TOP (film), DMC and RMK D (digital) airborne cameras. These include the Z/I Mission planning software; the Z/I Inflight flight management system; the Readout Station; and the T-AS and Z/I gyro-stabilized camera mounts. The wide range of GNSS/IMU systems from third-party suppliers such as Applanix and IGI - which are used for the measurement of the camera position and orientation during flight operations - can all be employed with the DMC II cameras.

DMC II230 and DMC II250 Cameras

As noted above, the new ***DMC II230*** and ***DMC II250*** cameras [Fig. 6] feature the still smaller pixel size of 5.6 um and a substantially larger number of pixels in their CCD frame imaging arrays to generate pan images of 230 and 250 Megapixels respectively. In the case of the DMC II250 model, it also features a new longer focal length lens with f =112 mm instead of the f = 92 mm lens that is used in the other three models. This produces images having an improved GSD value from a given flying height, while the base:height ratio with the images acquired by the DMC II250 model (with this longer focal length lens) is reduced slightly to 0.29.

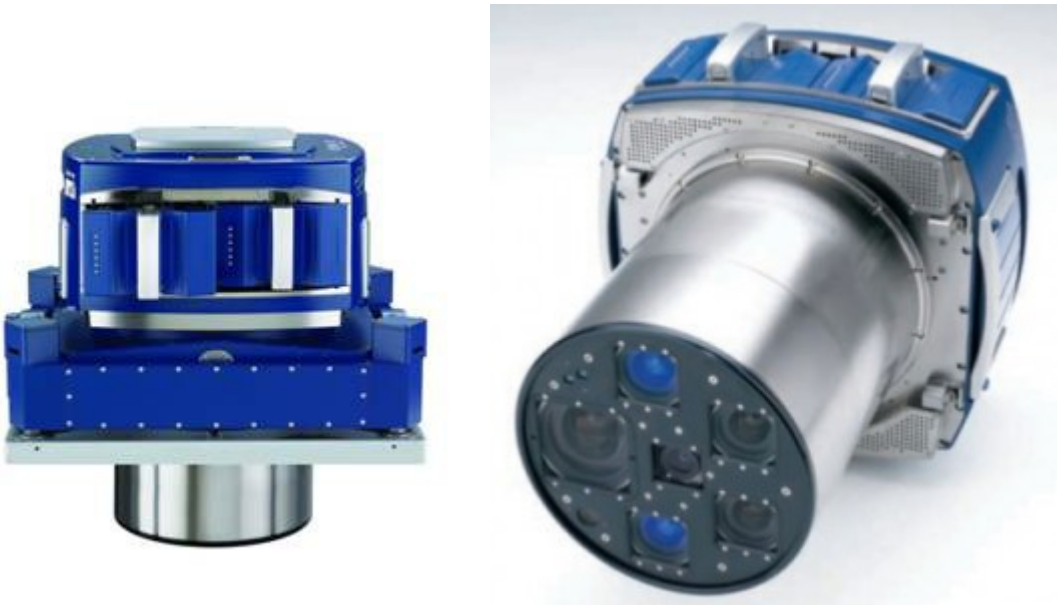

Figure 7 – (a) An Intergraph DMC II camera placed on a gyro-stabilized Z/I Mount that can be operated either in stand-alone mode or controlled using signals from an external IMU.
(b) A complete DMC camera with its five imaging lenses in the foreground and the two handles of its SSD storage units protruding from the upper (top) part of the camera.

The detailed performance characteristics and parameters of each of the four new camera models are summarized in Table I given below.

Feature	Camera		
	DMC II140	*DMC II230*	*DMC II250*
No. of Pixels Cross-track	12,096	15,104	17,216

No. of Pixels Along-track	11,200	14,400	14,656
FoV Cross-track (Degrees)	50.7	49,4	46,6
FoV Along-track (Degrees)	47.3	47,3	47,3
Focal Length (mm)	92	92	112
GSD@500m (cm)	3.9	3.0	2.5
B/H	0.35	0.35	0.29
Pixel Size (um)	7.2	5.6	5.6
No. of Camera Heads	5	5	5
PAN: Colour Resolution	1:2	1:2.6	1:3.2
Frame Rate (secs.)	2.0	1.7	1.7
Colour Channels	R,G,B,NIR	R,G,B,NIR	R,G,B,NIR
Resolution per Pixel (bits)	14	14	14
FMC	Yes	Yes	Yes
CCD Dynamic Range (dB)	>69	>67	>67
Standard On-board Storage (Tbyte)	1.5	1.5	1.5
Weight (kg)	66	66	68
Power Consumption (Watts)	350	350	350
Altitude (m) Non-pressurised	8,000	8,000	8,000
Operating Temperature (C)	-20 to +40	-20 to +40	-20 to +40

Table I

Initial Customers

In parallel with its announcement of the new camera models, Intergraph also released details of four companies that have already ordered DMC II cameras for their airborne imaging operations. In the case of the ***Beijing Guodian Jingwei Engineering Technology Co.***, [http://www.bjgdjw.com/EngLish/News/gsjj.asp] the company has purchased two of the new cameras for use in its aerial mapping operations. Another order for a DMC II camera from the Far East has been placed by the ***Kyodo Surveying Co. Ltd***., [http://www.kyo-soku.co.jp/index.php], which is based in Nagano, Japan. A third order has come from ***Midwest Aerial Photography,*** which is based in Galloway, Ohio in the United States, located just to the west of the city of Columbus. The company, whose Web site is

http://www.midwestaerialphoto.com/, is already an operator of RMK TOP film cameras and plans to use its new DMC II camera to acquire data for use in the USDA's National Resources Inventory (NRI) programme and other government and commercial imaging and mapping projects. Finally a German company – ***geoplana Ingenieure*** – based in Marbach, near Stuttgart has also acquired a DMC II camera. The company's Web site - http://www.geoplana.de/ - gives details of its photogrammetric, GIS and cartographic activities.

Summary & Conclusion

Undoubtedly the introduction of the new single-chip large-format imaging sensor to generate panchromatic images in the new Intergraph DMC II cameras represents a major advance in the design of airborne digital frame cameras. At a stroke, the new sensor allows a much simplified system design and it removes the previous requirement with the original DMC camera to provide multiple lenses, synchronized shutters and CCD arrays in order to generate the large-format panchromatic images. Besides which, the introduction of the new imaging sensor removes the necessity to calibrate each channel individually and collectively in favour of a much simplified single calibration procedure. Furthermore it also removes the need to carry out a preliminary rectification and stitching of multiple medium-format pan images that was a feature of the original DMC design. Simply said, the DMC II development brings us "Back to the Future" combining latest technology with the one-cone-only design known from the analogue times. Finally with its modular design and construction, the new DMC II camera offers a fairly simple path for users to upgrade their system through the purchase of an alternative lens or a denser CCD array.

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Figure 8 – A multi-spectral image of the Mercedes Benz Arena football stadium in Stuttgart, Germany that has been acquired by geoplana with a DMC II camera.