Digital Aerial Cameras

System Configurations and Sensor Architectures

Editor's note:
This issue includes an extensive product survey on digital aerial cameras, reprinted from our sister publication, GIM International. *In support of the specifications is additional information below on system configuration and sensor architecture of the camera systems from nine manufacturers.*

While film cameras still have their place and may stick around for awhile longer, digital aerial cameras are seeing increased use and offer clear advantages. For starters, this includes better radiometric performance and elimination of film processing and scanning costs. Availability of image content in digital format enables a highly automated workflow, creating the possibility of generating photogrammetry products such as orthophotos/mosaics with little delay between capture and end product. This might allow, for example, for rapid response after a disaster.

Linear and Area

Twelve-bit-per-pixel radiometric resolution, or even higher, ensures better light sensitivity. The use of image enhancement techniques means details can be made visible in parts of the imagery made bright by reflections or overcast and dark due to shadow or cloud. This relative insensitivity to unfavorable light conditions also enables extension of the daily time-span during which images can be taken and of flight season. It also allows data collection on overcast days, thus optimizing aerial survey productivity and area coverage.

Basically, the architecture of a digital area camera consists either of linear CCD arrays or area CCD chips placed in the focal plane. The linear-array architecture, also called the pushbroom scanner, principally employs a single lens head. Color (or multi-spectral band capture) is obtained by placing three or more linear arrays in the focal plane, upon each of which are projected different parts of the visible and near-infrared electromagnetic spectrum. Beam-splitters are used for this. The area CCD array solution is camera architecture consisting of several (multi-head) cones. Since linear- and area-array solutions are the most important features of camera architecture, the camera systems from various manufacturers are grouped accordingly.

Area Array

Applanix

The two Applanix Digital Sensor Systems (DSS) consist of completely integrated medium-sized digital camera, GPS-aided INS direct georeferencing system (POS AV), and flight-management system software for generating orthomosaics (**Figure 1**). POS AV provides the exterior orientation parameters in both real-time and post-mission mode. Although primarily used to generate high-resolution color and color infrared digital orthophotos/mosaics using POS AV data and an existing digital elevation model (DEM), the system also supports full stereo imagery for DEM extraction and visualization. The data interfaces directly and seamlessly with photogrammetry software to allow for fast map production.

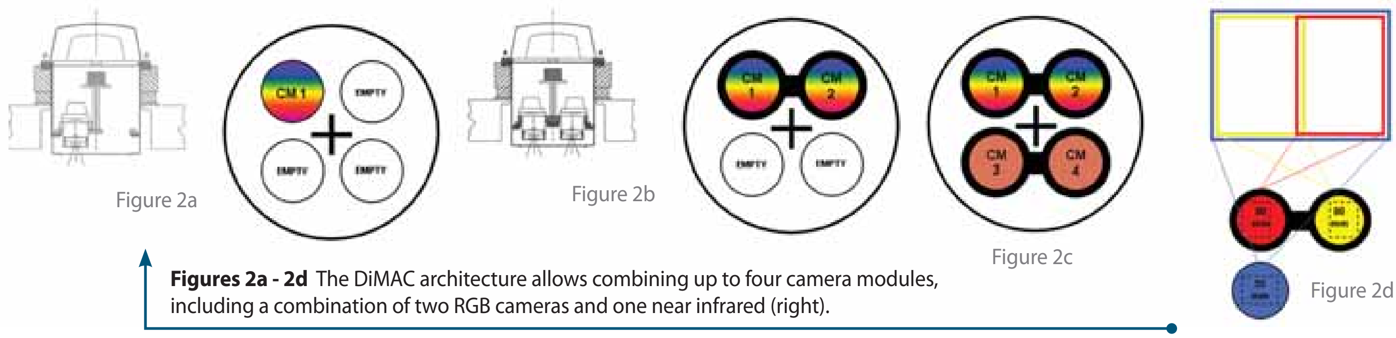
The DSS 322 array measures 5,436 pixels across and 4,092 along the flight line (in total 22MP); for the DSS 439 these figures are 7,216 and 5412 pixels respectively (39MP). The pixel size of the DSS 322 is 9µm and of the DSS 439 6.8µm, so that the field of view of both is the same. GSD ranges from 3.3cm to 1.0m, depending on platform and using 40mm and 60mm lenses. The DSS system sensor heads weigh about 7kg; they are thus medium-sized and presented by the manufacturer as complementary to large-format digital cameras. They can be flown in small, low-cost, light aircraft or helicopters. The application areas vary from updating and maintaining cadastral databases to rapid response for disaster management.

Acronyms	
CIR	Color Infrared
GSD	Ground Sample Distance
MP	Mega pixels
PDA	Personal Digital Assistant
RGB	Red, Green, Blue

DIMAC Systems

Each camera of the DiMAC system acquires one RGB or one near infrared image via one CCD (7,216 x 5,412 pixels) through one lens. The lens may be one of three focal lengths: 55mm, 80mm, 100m or 120mm. GSD ranges from 2cm to 1m. The camera cylindri-

Figure 1 Configuration of the Applanix Digital Sensor System DSS



Figures 2a - 2d The DiMAC architecture allows combining up to four camera modules, including a combination of two RGB cameras and one near infrared (right).

cal frame (CCF) allows for combining up to four camera modules (CM). A light architecture may be constructed using just one camera in the CCF (**Figure 2a**), but two cameras (CM1 and CM2) may also be placed here, creating a RGB image of slightly less than twice 5,412 pixels (10,500 pixels) by 7,200 pixels (**Figure 2b**). Two additional CMs may be placed in the vacant holes (**Figure 2c**), resulting in an image of 10,500 by 14,400 pixels. Another configuration is formed by adding a near infrared in CM2 covering the same area as that in CM1 or by placing a 55-mm near infrared camera in CM3 covering the same area as CM1 and CM2 together (**Figure 2d**).

IGI

With dimensions of 10cm x 13cm x 12 cm and weighing 1.8kg, the IGI DigiCAM system is a medium-sized system which combines modified professional digital cameras with a graphical user interface for real-time preview together with the CCNS/AEROcontrol (**Figure 3**). Two or more DigiCAMs can be coupled to increase image size. Each 39 MP area CCD chip (7,216 x 5,412 pixels) pixel is sized 6.8µm. Camera settings are adjusted by checking quick-views and histograms of images in real time. For pre-planned flight missions the camera is triggered by the CCNS4 system. Determination of exterior orientation parameters is done using the AEROcontrol GPS/IMU system, each capable of monitoring one or more cameras mounted in a pod. In the case of multiple cameras, synchronisation can be carried out within a few microseconds.

Each of the two storage units onboard can store 1,800 images in 16-bit color and full resolution and be exchanged during flight to extend storage capacity. Standard units may be replaced for high-altitude flights by flash memory units with 1,150-image capacity. The DigiControl computer itself does not operate any hard disks. The lenses include (maximal aperture/focal length): 4.5/300mm, 3.2/150mm, 2.2/100mm, 2.8/80mm, 3.5/50mm, 3.5/35mm and 4.0/28mm. The modular design enables a change from RGB mode to color-infrared within minutes for all lenses. The maximum image repetition rate is 0.52 images per second; a higher rate can be reached for a small number of subsequent images ("burst mode").

Intergraph

The architecture of Intergraph's digital mapping camera (DMC) amalgamates eight individual CCD array camera modules into autonomous units (**Figure 4**). Separate lenses are used for each of the eight camera heads, and a rigid optics frame ensures precise alignment of the optical axes. Four of the eight camera modules are equipped with 120-mm lenses and capture panchromatic images on four area-CCD chips 7,000 x 4,000 pixels. The other four cameras simultaneously capture the three color bands (RGB) and the near infrared band on 3,000 x 2,000 CCD chips. The multi-spectral cameras are equipped with 25-mm lenses (wide-angle).

Microsoft/Vexcel

The Vexel UltraCamX camera consists of sensor unit, onboard storage and capture system, operators interface panel, a removable data storage unit, and software to operate the camera and for processing image data after flight. The sensor head comprises eight independent camera cones, four contributing to the large-format panchromatic image and four to the multi-spectral image (**Figure 5**). The sensor head is equipped with 13 CCD sensor units, each producing 16MP. This set of lenses also supports a pan-sharpening ratio of 1:3. The storage system contains two independent data units for redundant image capture, each replaceable by spare units within a few minutes. Downloading of image data is supported by a docking station which exploits four parallel data-transfer channels to allow complete data transfer of 4,000 images within eight hours. A 24-hour cycle of flying, copying and QC can be achieved.

RolleiMetric

The Aerial Industrial Camera (AIC) series of RolleiMetric is designed for aerial and industrial purposes and is presented by the manufacturer as an alternative

Figure 3 Configuration of IGI DigiCAM system

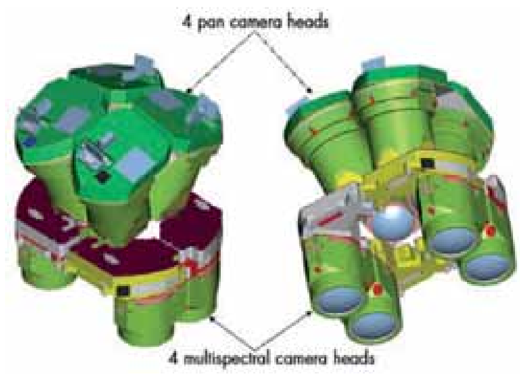


Figure 4 Design concept for Intergraph's DMC

Figure 5 The UltraCamX sensor head (left) consists of eight camera heads, four equipped with 9 CCD sensors in their four focal planes and contributing to the large-format panchromatic image. The focal plane of the Master Cone carries four CCDs (right).

Figure 6 RolleiMetric's AIC can combine several cameras to produce RGB, (C)IR, or oblique images

Figure 7 Jena Airborne Scanner (JAS 150s) is based on pushbroom technology.

Figure 8 Cross-section of the Leica-Geosystems ADS40 2nd-generation Airborne Digital Sensor

to large-format cameras. The camera body (electronic) and the lenses are Rollei products; the focal lengths of the medium-format lenses are 50mm, 80mm, 90mm, 120mm and 150mm, while the pro lenses have focal lengths of 35mm, 47mm, 60mm and 72mm respectively. Both are optimised for photogrammetric use, with fixed focal length and stabilised bayonet.

Their high-speed iris shutters, up to 1/1,000 second, enable compensation for forward motion during flight. Pro lenses are symmetrical lenses designed for digital-camera sensors and small pixel size; they allow high-resolution imagery and minimise color aberration. The focal plane contains Kodak RGB CCDs (22MP or 39MP) with Bayer pattern and IR cut filters fronting the sensor. Filter change allows acquisition of images in RGB, NIR and CIR.

RolleiMetric carries out geometric calibration and Phase One executes radiometric calibration of the sensor. The camera electronically controls all settings such as shutter speed, aperture, and black calibration from the PC and interfaces with IMU/GPS systems (event signal) and FMS (trigger signal). The AIC xN architecture allows joint fitting of up to eight standard AICs in one frame, using electronic boards for accurate synchronization and daisy chain connections (**Figure 6**). All AICs are in full communication with each other. The AIC x2 combines two cameras and the AIC x4, four. Depending on desired overlap, the footprint may cover up to 13,000 x 10,000 pixels.

Linear Array

Jena

The Jena Airborne Scanner (JAS 150s, **Figure 7**) is based on pushbroom (linear-array) technology. The GSD width depends on flying height and its length on flight speed. To preserve (almost) square pixels sampling, there are 29 exposure times ranging from 1.25ms, that is 800Hz sampling frequency, to 10.112ms and four binning modes so that eight pixels may be combined into one. This allows great flexibility in selecting aircraft height and speed.

Four sub-systems take care of command and control, data recording, position and orientation, and flight control. The system is also equipped with an interface for on- and offline-quality-control of the raw image data, so that each sensor-line may be checked onboard the aircraft during flight. Setting of all camera parameters, such as exposure time, drift input, and INS-system command, as well as control of camera status parameters, can be done during flight. With an accuracy of up to 3cm at 1,000m altitude, full resolution in multi-spectral images, including CIR, can be captured.

Leica-Geosystems

ADS40 2nd-generation Airborne Digital Sensor from LeicaGeosystems (**Figure 8**) produces linear-array sensor images. Two sensor-head configurations are available: SH51 offers multi-spectral imagery and panchromatic stereo imagery with 100 percent forward overlap for orthophoto production, and SH52 produces fringe-free stereo imagery in panchromatic, color and near-infrared and simultaneously captures 115 MP per second across 12 CCD channels. The temperature-stabilised telecentric lens, focal plate, and IMU carrier are fused into one block, ensuring stability of calibration over long time-spans. Combining single-lens design with the newly patented Tetrachroid beam-splitter technology reduces energy loss and enables the production of co-registered five-band imagery at equal resolution, thus eliminating the need for pan-sharpening. Leica IPAS10, the integrated inertial position and attitude system, allows direct geo-referencing to sub-pixel accuracy. Depending on accuracy requirements, image data can also be processed without use of ground-control or reference stations. Applications include orthophoto production, feature extraction and remote sensing.

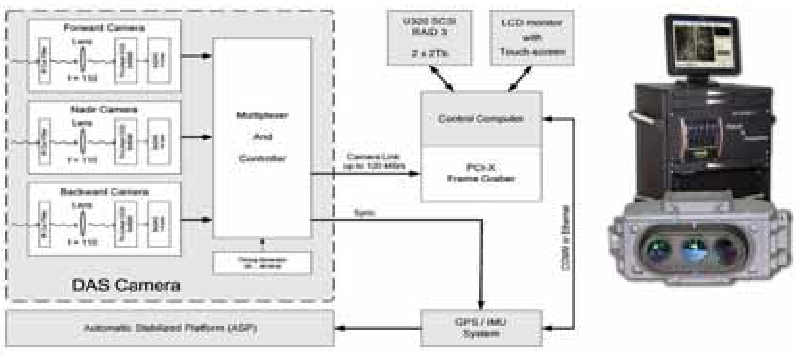


Figure 9 Configuration of Wehrli's 3-DAS-1 system (left); schematic outline of the system architecture (right)

Wehrli

Wehrli's 3-DAS-1 system consists of three cameras each equipped with 110mm lenses and mounted on a stabiliser, an inertial measurement unit (IMU) firmly attached directly above the cameras, and a GPS antenna (the lever-arm to the gimbal center of which is fixed in distance but not in attitude). The nadir camera faces downwards, the forward camera is tilted by 26 degrees, and the backward camera by -16 degrees in the direction of flight with respect to the nadir camera (**Figure 9-left**).

Each camera has three linear CCD arrays for color imaging. These belong to the Kodak family of KLI trilinear (RGB) CCD arrays and feature 8,002 pixels and pixel size 9µm x 9µm. Rather than attempting the use of a single, exotic objective lens to cover the entire field of view over the forward, nadir, and backward-looking arrays, a separate objective lens is used for each of the three cameras.

The software runs on Windows XP or Vista. The scanner electronics is in firmware and thus upwardly mobile to keep pace with technical developments and future requirements. Transfer of image data from the sensor electronics to the computer is by camera link standard, at 12 bits, to a PCI-X 64-bit line grabber (**Figure 9-right**). The camera link also provides a control channel and download of new firmware.

Thanks to all listed manufacturers of digital aerial cameras.

Digital Aerial Camera Comparisons

The first digital aerial cameras were presented to the photogrammetric community at the 2000 ISPRS congress in Amsterdam. Z/I Imaging (today Intergraph) and LH (today Leica Geosystems) were the two companies responsible for this innovation. Nine companies now manufacture digital aerial cameras.

Back in the 1990s, when experimentation began on developing digital aerial cameras, the basic design problems involved getting enough pixels into the focal plane to capture an adequate level of detail qua ground coverage, and how to acquire color images. The basic solutions were either to place linear CCD arrays in the focal plane or to use several, area CCD chips. In the linear-array architecture one single lens head can be used, while color (or multi-spectral-band capture) is obtained by placing three (or more) linear arrays in the focal plane, upon each of which are projected different parts of the visible electronic-magnetic spectrum; enabled by beam-splitters. The area-CCD-array solution is a camera consisting of several cones (multi-head). For example, the sensor head of Vexcel's UltraCamX consists of eight independent camera cones, four of which contribute to the large-format panchromatic image and four to the multi-spectral image: blue, green, red and infrared.

Applanix entered the digital aerial camera market as a provider of integrated GPS/INS systems which, mounted in the aircraft, made it possible directly to determine the six parameters of exterior orientation. The logical step now was complete integration of an imaging sensor into such a system. In addition to the here-listed DSS 422, in May 2007 Applanix introduced the DSS 439. This camera differs from the DSS 422 only in a few sensor characteristics. Sensor format is 49.0mm x 36.0mm; effective pixels per CCD is 39MP, pixel size is 0.0068 micrometer; number of pixels across track is 7,216 and along track 5,412. In addition to the DIMAC 2.0, since last year DIMAC Systems has also manufactured the DIMAC light, which differs slightly from DIMAC 2.0; there are one to two lenses and the number of across-track pixels is 7,216 and alongtrack 5,412. Wehrli's here-listed 3-OC-1 system represents a slight modification of the 3-DAS-1 and is specially designed for capturing oblique images, while the 3-DAS- 1 is designed for taking vertical images. Wehrli's camera architecture is based on linear-array CCD technology.

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Brand	Applanix	DIMAC Systems
Product	DSS 422 [I]	DiMAC 2.0 [5]
Name	Digital Sensor System	
Date of Introduction	May 2007	2006
Frame		
Dimensions (lxwxh) [cm]	18cm x 18cm x 36cm [2]	49cm x 48cm x 82cm
Weight [kg]	7kg [3]	100kg
Number of lenses	Custom AeroLens (Carl Zeiss)[4]	2 to 4
Focal length(s)	Standard: 60 mm Optional: 40mm and 250mm	55, 80, 120
Number of CCD chips	1	2 to 4
Sensor		
Sensor Format [mm x mm]	38.8mm x 50.0 mm	50.7 x 39.0
Effective pixels per CCD	22MP	7256 x 5452
Pixel size (micrometer)	0.009mm	6.8
Number of Pixels across track	5,436	10,500
Number of Pixels along track	4,092	7,200
Bit Depth (dynamic range)	12 bits	16
Integration time	Not Applicable- Shutter speed up to1/4000sec	250 ms
Spectral bands[i]	Colour Mode (60mm and 40mm): Red 600 - 700nm, Green 500-600nm, Blue 400 - 500 CIR (60mm): NIR 800 - 960nm, Red 600 - 720nm, Green 500 - 600 nm CIR (40mm): NIR 850 - 1100nm, Red 600 - 720nm, Green 500 -600nm	Red, green, blue, infrared
Hardware		
Computer Hardware[ii]	Embedded Windows Config OS	24 to 28 volts
Hardware included (Y/N)	Y	Y
Data Unit	Ruggedised Disk Drive (Qty.2)	Pressurised Hard Drive
Storage Capacity (Images & GB)	500GB (12,000 Images)	10,000 images in 500GB
Exchangeable storage units? (Y/N)	Y, 2 supplied	Y
Data Collection Rate [pixels/sec]	Max Exposure Rate 2.5 Sec +/- 0.05 sec 1 sigma	15 000 000
Output formats[iii]	TIFF, JPG, and DNG	Tiff, JPG
Miscellaneous		
Accuracy [pixel units]	Orthophoto: max of 1.2 X GSD RMS or POS AV Accuracy, Stereo: H: max of 1.2 X GSD (max) RMS or POS AV position accuracy, V: max of 3 X GSD (max) RMS or POS AV position accuracy, Effective GSD = (1.2 - 1.3) X Theoretical GSD	0.15 pixel RMS
In flight pre-view [Y/N]	Y, via thumbnail on pilot/operator touch screen interface	Y
FMC (Y/N)[iv]	N, not Required	Y
List typical application areas	High-resolution ortho map products for markets including utility and transportation corridor mapping and rapid response applications.	Accurate photogrammetric work and (true) ortho map production, depending on type of lens.

[i] Insert here the spectral bands which can be captured, e.g. pan, green, red, infrared

[ii] Required computer power to make the camera run.

[iii] Tiff, JPG, etc.

[iv] FMC: Forward Motion Compensation

IGI	IGI	Intergraph	Jena-Optronik	Leica Geosystems	RolleiMetric
DigiCAM-H/39	DigiCAM-H/70	Digital Mapping Camera (DMC)	Airborne Scanner	Airborne Digital Sensor	Aerial Industrial camera
		Intergraph Digital Mapping Camera (DMC)	JAS 150s	ADS40 2nd Generation	AIC x1
Spring 2007	Spring 2008	July 2003	September 2007	October 2006	2004
10cm x 13cm x 12cm	Two times 10cm x 13cm x 12cm	44cm x 44cm x 91cm	46cm x 57cm x 49cm	Diameter 39, Height 79	11cm x 14cm x 15cm
1.8kg	3.6lg	88kg	65kg	61-65kg (depending on integrated IMU)	AIC 0.65kg. without lens; AICPro 1.4kg without lens
1	2	8	1	1 telecentric lense	One PQS lens or one pro lens
35,50,80,100,150,300 mm	50,80,100,150 mm	[6]	150 mm	Camera constant 62.5mm (f-number 4)	PQS lenses: 50mm, 80mm, 90mm, 120mm, 150mm, 250mm; pro lenses: 35mm,47mm, 60mm, 72mm
1	2	4	9 CCD lines	Depending on focal plate; SH51: 8, SH52: 12	1
36.8 x 49 mm	36.8 x 49 mm	165.8 x 92.16	Line sensor wit 9 lines	12 lines x 6.5 micrometer x 72mm	22MP 48,9mmx36,9mm; 39MP 49,1mmx36,9mm
7216 x 5412	7216 x 5412	28 Mpixel	12,000 per CCD line	12000 per line	22MP 5440x4080; 39MP 7228x5428
6,8 µm	6,8 µm	12 microns x 12 microns	6.5 µm	6.5µm	9 µm with 22 MP and 6,8 µm with 39 MP
7216 or 5412	13,500 or 10,000	13,824	12	12,000	5,440 or 4,080 depending on installation with 22 MP
5412 or 7216	10,000 or 13,500	7,680	Line sensor, push-broom	1 per line (SH51: 8 lines; SH52: 12 lines)	7,228 or 5,428 depending on installation with 39 MP
14 bit	14 bit	Greater than 12 bit	16	16-Bit data	16bit per colour
1/250 s - 1/800 s	1/250 s - 1/800 s	varies from 3 to 30 ms	1/800 s or 1.26ms	>= 1.25msec (automatic)	Depening on storage medium around 3.2 seconds
Red, green, blue; infrared (optional)	Red, green, blue; infrared (optional)	Blue, green, red, near infrared, near infrared alternative, custom filters available	Pan, green, blue, red, infrared	Panchromatic (trapezoidal) 465-680nm, Red (rectangular) 608-662nm, Green (rectangular) 533-587nm, Blue (rectangular) 428-492nm, Near Infrared (rectangular) 833-887nm	RGB or IR
Specially designed control computer, Pentium M with 1.8GHz, Power consumption 25W at 24VDC	Two times: Specially designed control computer, Pentium M with 1.8GHz, Power consumption 25W at 24VDC	Integrated computer system eliminates need for external laptop computer	No extra computer required	Control Unit CU40, Mass Memory MM40, Operator Interface OI40, OC50 for pilot	
Y	Y	Y (see above)	Y	Y	Optional
2x Hard Disc or 2x Solid State Disk	4x Hard Disc or 4x Solid State Disk	Solid State Device	Y	MM40	PC or CF card
Each 100 Gigabyte = 1800 Images (Hard Disk). Each 64 Gigabyte = 1150 Images (Solid State Disk)	Each 100 Gigabyte = 1800 Images (Hard Disk) Each 64 Gigabyte = 1150 Images (Solid State Disk)	1,200 images	1.1 TB	0.9 TB	Optional (standard for 10000 images)
Y	Y	Y	Y	Y	Optional
20 Megapixel/s	40 Megapixel/s	65 Mpixel/sec	86,400,000	115.2 Megapixel/s	N/A
Tiff 16 bit, Tiff 8bit, DNG, JPG	Tiff 16 bit, Tiff 8bit, DNG, JPG	B/W, RGB, CIR, 4-channel TIFF	GeoTiff	Jpeg, Tiff tiled	Raw Tif JPG
-					
1/4 pixel	1/4 pixel	0.5 pixel	<1 pixel	0.6 pixel	N/A
Y	Y	Y	Y	Y	Y
Motion compensation by controlled illumination or mechanically by special mount	Motion compensation by controlled illumination or mechanically by special mount	Y	Not required	Y, inherent in system	N/A
Corridor mapping projects (highway, pipeline, railway, power line) city models, opencast pits, coastline protection, floods, landscape and more, especially in combination with LiteMapper (www.litemapper.eu).	Any colour mapping projects.	Agriculture, cadastral mapping, cartography, forestry, land use/land cover mapping, environmental studies, natural hazard assessment, flood risk management, transportation engineering, urban planning, civil engineering, oil and gas exploration, geology.	High-resolution aerial data from high altitudes for map production and remote sensing applications.	Photogrammetry; Orthophoto Production; Large Scale Engineering; City Modeling and Mapping; (Stereo) Feature extraction and Feature Mapping; Agriculture and Forestry; Biomass Mapping; Thematic Mapping; NDVI Classification.	Corridor survey, Orthophoto, combination with Lidar systems, cadastre and mapping applications, DTM generation and others.






Brand	RolleiMetric	RolleiMetric	Microsoft Vexcel	Wehrli/Geosystem
Product	Aerial Industrial camera	Aerial Industrial camera	Large Format Digital Aerial Frame Camera	Digital Airborne Scanner
Name	AIC x2	AIC x4	UltraCam X	3-OC-1 [7]
Date of Introduction	2007	2008	April 2006	2006
Frame				
Dimensions (lxwxh) [cm]	30cm x 27cm x 36cm	31x39 (diameter)	43cm x 43cm x 73cm	56cm x 26 cm x 42cm
Weight [kg]	12kg without lenses	38kg incl. Lenses	54kg	25kg
Number of lenses	Two PQS lenses or two pro lenses	Four PQS lenses or four pro lenses	8 (4 x pan, R, G, B, NIR)	3
Focal length(s)	PQS lenses: 50mm, 80mm, 90mm, 120mm, 150mm, 250mm; pro lenses:47mm, 60mm, 72mm	PQS lenses: 50mm, 80mm, 90mm, 120mm, 150mm, 250mm; pro lenses: 47mm, 60mm, 72mm	100mm (pan). 33mm (multi-spectral)	2x110, 1x80
Number of CCD chips	2	4	13 (9 x pan, R, G, B, NIR)	3
Sensor				
Sensor Format [mm x mm]	22MP 48,9mmx36,9mm; 39MP 49,1mmx36,9mm	22MP 48,9mmx36,9mm; 39MP 49,1mmx36,9mm	104 x 68.4	72.018x0.216
Effective pixels per CCD	22MP 5,440x4,080; 39MP 7,228x5,428	22MP 5,440x4,080; 39MP 7,228x5,428	4,992 x 3,328	3x8,002
Pixel size (micrometre)	9µm with 22MP and 6,8µm with 39MP	9µm with 22MP and 6,8µm with 39MP	7.2	9
Number of Pixels across track	10,227 or 4,080 depending on installation with 22MP	10,227 or 7,670 depending on installation with 22MP	14,430 (pan)	8,002
Number of Pixels along track	13,588 or 5,428 depending on installation with 39MP	13,588 or 10,204 depending on installation with 39MP	9,420 (pan)	Unlimited
Bit Depth (dynamic range)	16bit per colour	16bit per colour	>12	14
Integration time	Depening on storage medium around 3.2 seconds	Depening on storage medium around 3.2 seconds	1/500 to 1/32	1.3-4.0 ms
Spectral bands[i]	RGB and IR / RGB or IR	RGB and IR / RGB or IR	Pan, R, G, B, NIR	R,G,B
Hardware				
Computer Hardware[ii]				
Hardware included (Y/N)	Optional	Y	Y, computing and Data Unit	Y
Data Unit	PC or CF card	PC	Included, 2 x 14x160 GB	RAID3
Storage Capacity (Images & GB)	Optional (standard for 10000 images)	Optional (standard for 10,000 images)	4,700 images / 2.0TB	1800GB
Exchangeable storage units? (Y/N)	Optional	Optional	Y, in flight	Y
Data Collection Rate [pixels/sec]	N/A	N/A	100 Mpixel/sec	18M-54M
Output formats[iii]	Raw Tif JPG	Raw Tif JPG	TIFF, JPEG	RAW, Tiled TIFF, Tiled TIFF with JPEG compression
Miscellaneous				-
Accuracy [pixel units]	N/A	N/A	<1 (z), <0.5 (x, y)	1.0 pix - in plan; 1.5 pix - in height
In flight pre-view [Y/N]	Y	Y	Y	Y
FMC (Y/N)[iv]	N	N	Y, TDI controlled	N
List typical application areas	Corridor survey, Orthophoto, combination with LIDAR systems, cadastre and mapping applications, DTM generation and others.	Corridor survey, Orthophoto, cadastre and mapping applications, DTM generation and others.	Largest camera for mapping, large scale images of urban areas, orthophotos, stereo models and 3D models.	Large scale mapping and orthophoto.

Notes

[1] In addition to DSS 422, Applanix also introduced May 2007 the DSS 439, which differs from the DSS 422 in a few sensor characteristics. Sensor format is 49.0mm x 36.0mm; effective pixels per CCD is 39MP, pixel size is 0.0068 micrometer; number of pixels across track is 7216 and along track 5412.

[2] Dimensions refer to sensor head. Dimensions of the computer system c/w FMS, POS AV and Data Logger are 34x37x34cm and of Azimuth Mount: 43x36x58cm.

[3] Weight refers to sensor head. Weight of computer system is 24kg and Azimuth Mount 15kg.

[4] Standard 60mm, F3.5 FOV (deg): crosstrack 44, alongtrack 34, diagonal 54 (CIR and VIS) Optional 40mm, F/4 FOV (deg): crosstrack 62, alongtrack 49, diagonal 74 (CIR and VIS).

[5] In addition to DIMAC 2.0, DIMAC Systems also manufactures since 2007 the DIMAC light which differs slightly from DIMAC 2.0. Number of lenses is 1 to 2, the number of pixels across track is 7216 and along track 5412.

[6] Four lenses with 120 millimeter focal length for the panchromatic channel and four lenses with 25 millimeter focal length for each color channel.

[7] Wehrli's 3-DAS-1, introduced in 2004, differs slightly from the 3-OC-1 presented here. Weight of 3-DAS-1 is 42kg and focal length 110mm. The 3- OC-1 system is specially designed for capturing oblique images, while the 3-DAS-1 is designed for taking vertical images.

[i] Insert here the spectral bands which can be captured, e.g. pan, green, red, infrared

[ii] Required computer power to make the camera run.

[iii] Tiff, JPG, etc.

[iv] FMC: Forward Motion Compensation