

# Digital Aerial Cameras

*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 colour 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 colour (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 micrometre; 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 along-track 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.

The term GSD means Ground Sample Distance, or pixel size on ground. More information on types of camera architecture adopted by the various manufacturers can be found on page 18.◆

*Mathias Lemmens, editor-in-chief, GIM International*

N/A = Not Applicable  
 □ = No information received

Brand	Applanix	Applanix
Product	DSS 422 [1]	DSS 439
Name	Digital Sensor System	Digital Sensor System
Date of Introduction	May 2007	7-mei-07
Frame		
Dimensions (lxwxh) [cm]	18cm x 18cm x 36cm [2]	34cm x 37cm x 34cm [5]
Weight [kg]	7kg [3]	24kg [6]
Number of lenses	Custom AeroLens (Carl Zeiss)[4]	Custom AeroLens (Carl Zeiss) [7]
Focal length(s)	Standard: 60 mm Optional: 40mm and 250mm	Standard: 60 mm Optional: 40mm and 250mm
Number of CCD chips	1	1
Sensor		-
Sensor Format [mm x mm]	38.8mm x 50.0 mm	49.0mm x 36.0mm
Effective pixels per CCD	22MP	39MP
Pixel size (micrometre)	0.009mm	0.0068mm
Number of Pixels across track	5,436	7216
Number of Pixels along track	4,092	5412
Bit Depth (dynamic range)	12 bits	12 bits
Integration time	Not Applicable- Shutter speed up to 1/4000sec	Not Applicable- Shutter speed up to 1/4000sec
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	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
Hardware		
Computer Hardware[ii]	Embedded Windows Config OS	Embedded Windows Config OS
Hardware included (Y/N)	Y	YES
Data Unit	Ruggedised Disk Drive (Qty.2)	Ruggedized Disk Drive (Qty. 2)
Storage Capacity (Images & GB)	500GB (12,000 Images)	500 GB (7000 Images)
Exchangeable storage units? (Y/N)	Y, 2 supplied	YES- 2 Supplied
Data Collection Rate [pixels/sec]	Max Exposure Rate 2.5 Sec +/- 0.05 sec   sigma	Max Exposure Rate 2.8 Sec +/- 0.03 sec   sigma
Output formats[iii]	TIFF, JPG, and DNG	TIFF, JPG, and DNG
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	Orthophoto: max of 1.2 X [8]
In flight pre-view [Y/N]	Y, via thumbnail on pilot/operator touch screen interface	YES- via thumbnail on pilot/operator touch screen interface
FMC (Y/N)[iv]	N, not Required	No- Not Required
List typical application areas	High-resolution ortho map products for markets including utility and transportation corridor mapping and rapid response applications	High resolutions ortho map products in a variety of markets that include ortho mapping, utility and transportation corridor mapping and rapid response applications

[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



DIMAC Systems	IGI	IGI	Intergraph	Jena-Optronik	Leica Geosystems
DiMAC 2.0 [9]	DigiCAM-H/39	DigiCAM-H/70	Digital Mapping Camera (DMC)	Airborne Scanner	Airborne Digital Sensor
			Intergraph Digital Mapping Camera (DMC)	JAS 150s	ADS40 2nd Generation
2006	Spring 2007	Spring 2008	July 2003	September 2007	October 2006
49cm x 48cm x 82cm	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
100kg	1.8kg	3.6lg	88kg	65kg	61-65kg (depending on integrated IMU)
2 to 4	1	2	8	1	1 telecentric lense
55, 80, 120	35,50,80,100,150,300 mm	50,80,100,150 mm	[10]	150 mm	Camera constant 62.5mm (f-number 4)
2 to 4	1	2	4	9 CCD lines	Depending on focal plate; SH51: 8, SH52: 12
50.7 x 39.0	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 micrometre x 72mm
7256 x 5452	7216 x 5412	7216 x 5412	28 Mpixel	12,000 per CCD line	12000 per line
6.8	6,8 µm	6,8 µm	12 microns x 12 microns	6.5 µm	6.5µm
10,500	7216 or 5412	13,500 or 10,000	13,824	12	12,000
7,200	5412 or 7216	10,000 or 13,500	7,680	Line sensor; push-broom	1 per line (SH51: 8 lines; SH52: 12 lines)
16	14 bit	14 bit	Greater than 12 bit	16	16-Bit data
250 ms	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)
Red, green, blue, infrared	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
24 to 28 volts	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	Y (see above)	Y	Y
Pressurised Hard Drive	2x Hard Disc or 2x Solid State Disk	4x Hard Disc or 4x Solid State Disk	Solid State Device	Y	MM40
10,000 images in 500GB	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
Y	Y	Y	Y	Y	Y
15 000 000	20 Megapixel/s	40 Megapixel/s	65 Mpixel / sec	86,400,000	115.2 Megapix/sec
Tiff, JPG	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
0.15 pixel RMS	1/4 pixel	1/4 pixel	0.5 pixel	<1 pixel	0.6 pixels
Y	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
Accurate photogrammetric work and (true) ortho map production, depending on type of lens	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.



Brand	RolleiMetric	RolleiMetric	RolleiMetric	Microsoft Vexcel	Wehrli/Geosystem
Product	Aerial Industrial camera	Aerial Industrial camera	Aerial Industrial camera	Large Format Digital Aerial Frame Camera	Digital Airborne Scanner
Name	AIC x1	AIC x2	AIC x4	UltraCam X	3-OC-1 [11]
Date of Introduction	2004	2007	2008	April 2006	2006
Frame					
Dimensions (lxwxh) [cm]	11cm x 14cm x 15cm	30cm x 27cm x 36cm	31x39 (diameter)	43cm x 43cm x 73cm	56cm x 26 cm x 42cm
Weight [kg]	AIC 0.65kg, without lens; AICPro 1.4kg without lens	12kg without lenses	38kg incl. Lenses	54kg	25kg
Number of lenses	One PQS lens or one pro lens	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: 35mm, 47mm, 60mm, 72mm	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	One	Two	Four	13 (9 x pan, R, G, B, NIR)	3
Sensor					
Sensor Format [mm x mm]	22MP 8,9mmx36,9mm; 39MP 49,1mmx36,9mm	22MP 8,9mmx36,9mm; 39MP 49,1mmx36,9mm	22MP 8,9mmx36,9mm; 39MP 49,1mmx36,9mm	104 x 68.4	72.018x0.216
Effective pixels per CCD	22MP 5440x4080; 39MP 7228x5428	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)	9 µm with 22 MP and 6,8 µm with 39 MP	9µm with 22MP and 6,8µm with 39MP	9µm with 22MP and 6,8µm with 39MP	7.2	9
Number of Pixels across track	5,440 or 4,080 depending on installation with 22 MP	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	7,228 or 5,428 depending on installation with 39 MP	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	16bit per colour	>12	14
Integration time	Depening on storage medium around 3,2 seconds	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 or IR	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	Optional	Y	Y, computing and Data Unit	Y
Data Unit	PC or CF card	PC or CF card	PC	Included, 2 x 14x160 GB	RAID3
Storage Capacity (Images & GB)	Optional (standard for 10000 images)	Optional (standard for 10000 images)	Optional (standard for 10,000 images)	4,700 images / 2.0TB	1800GB
Exchangeable storage units? (Y/N)	Optional	Optional	Optional	Y, in flight	Y
Data Collection Rate [pixels/sec]	N/A	N/A	N/A	100 Mpixel/sec	18M-54M
Output formats[iii]	Raw Tif JPG	Raw Tif JPG	Raw Tif JPG	TIFF, JPEG	RAW, Tiled TIFF, Tiled TIFF with JPEG compression
Miscellaneous					
Accuracy [pixel units]	N/A	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	Y
FMC (Y/N)[iv]	N/A	N	N	Y, TDI controlled	N
	Corridor survey, Orthophoto, combination with Lidar systems, cadastre and mapping applications, DTM generation and others.	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, Applinix 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 micrometre; 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] Computer System c/w FMS, POS AV, Data Logger: 34cm x 37cm x 34cm Sensor Head: 18cm x 18cm x 36cm Azimuth Mount: 43cm x 36cm x 58cm
- [6] 24kg (Computer system) 7kg (sensor head) 15kg (Az mount)
- [7] Custom AeroLens (Carl Zeiss) 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)
- [8] 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, GSD = Ground Sample Distance, or pixel size on ground
- [9] 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.
- [10] Four lenses with 120 millimeter focal length for the panchromatic channel and four lenses with 25 millimeter focal length for each color channel.
- [11] 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

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□ = No information received

