



VEXCEL
IMAGING

ULTRACAM

Calibration Report

Camera:
Serial:

UltraCam Eagle
UC-E-1-50016095-f80

Calibration Date:
Date of Report:
Camera Revision:
Version of Report:

June-21-2017
June-27-2017
Rev07.00
V01



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Bahia, Brasil 2013

Photo on page 1 courtesy of Hiparc Geotecnologia, Brasil

www.hiparc.com

UltraCam Lp, GSD25 cm, RGB



ULTRACAM

Geometric Calibration

Camera:	UltraCam Eagle
Serial:	UC-E-1-50016095-f80

Panchromatic Camera:	ck = 79.800 mm
Multispectral Camera:	ck = 79.800 mm

PPA Information:	X: 0.000 mm
	Y: 0.000 mm

Calibration Date:	June-21-2017
Date of Report:	June-27-2017
Camera Revision:	Rev07.00
Version of Report:	V01



Panchromatic Camera

Large Format Panchromatic Output Image

Image Format	long track cross track	68.016mm 104.052mm	13080pixel 20010pixel
Image Extent		(-34.008, -52.026)mm	(34.008, 52.026)mm
Pixel Size		5.200μm*5.200μm	
Focal Length	ck	79.800mm	± 0.002mm
Principal Point (Level 2)	X_ppa	0.000mm	± 0.002mm
	Y_ppa	0.000mm	± 0.002mm
Lens Distortion	Remaining Distortion less than 0.002mm		

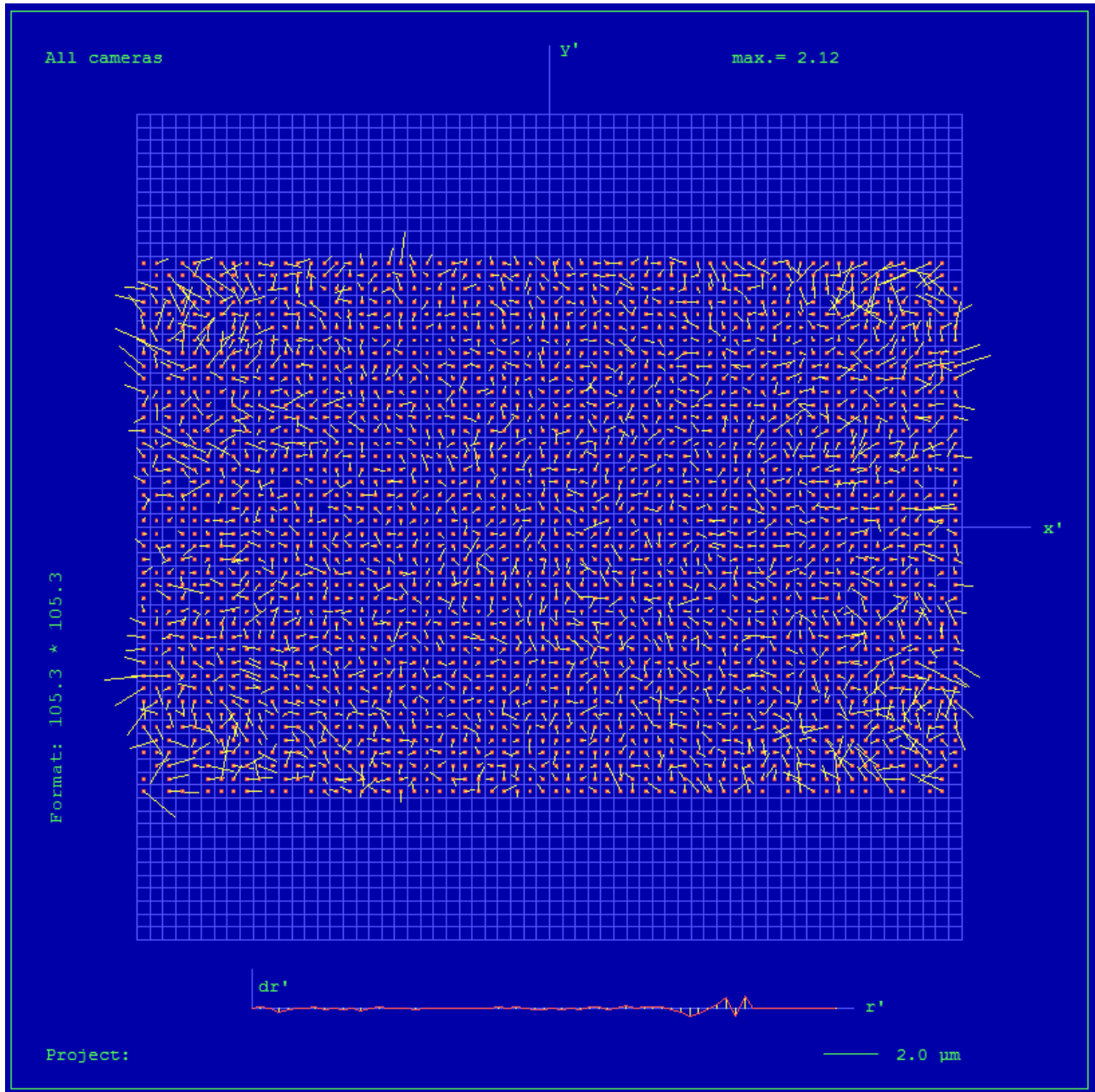
Multispectral Camera

Medium Format Multispectral Output Image (Upscaled to panchromatic image format)

Image Format	long track cross track	68.016mm 104.052mm	4360pixel 6670pixel
Image Extent		(-34.008, -52.026)mm	(34.008, 52.026)mm
Pixel Size		15.600μm*15.600μm	
Focal Length	ck	79.800mm	± 0.002mm
Principal Point (Level 2)	X_ppa	0.000mm	± 0.002mm
	Y_ppa	0.000mm	± 0.002mm
Lens Distortion	Remaining Distortion less than 0.002mm		



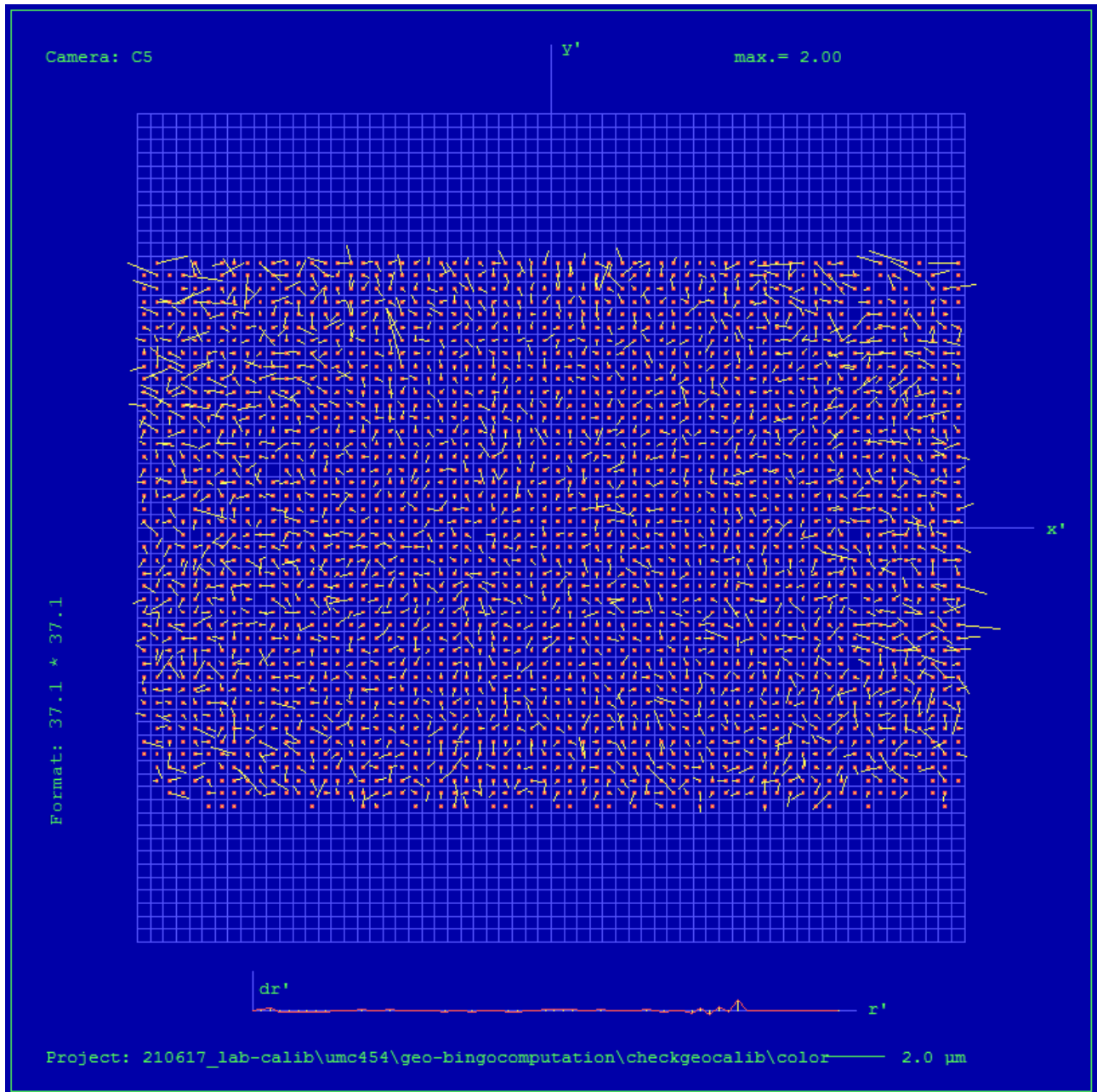
Full Panchromatic Image, Residual Error Diagram



Residual Error (RMS): 1.03 μm



Green Cone (Cone 5), Residual Error Diagram



Residual Error (RMS): 0.89 μm



Explanations

Calibration Method:

The geometric calibration is based on a set of 84 images of a defined geometry target with 394 GCPs.

Number of point measurements for the panchromatic camera : >16000

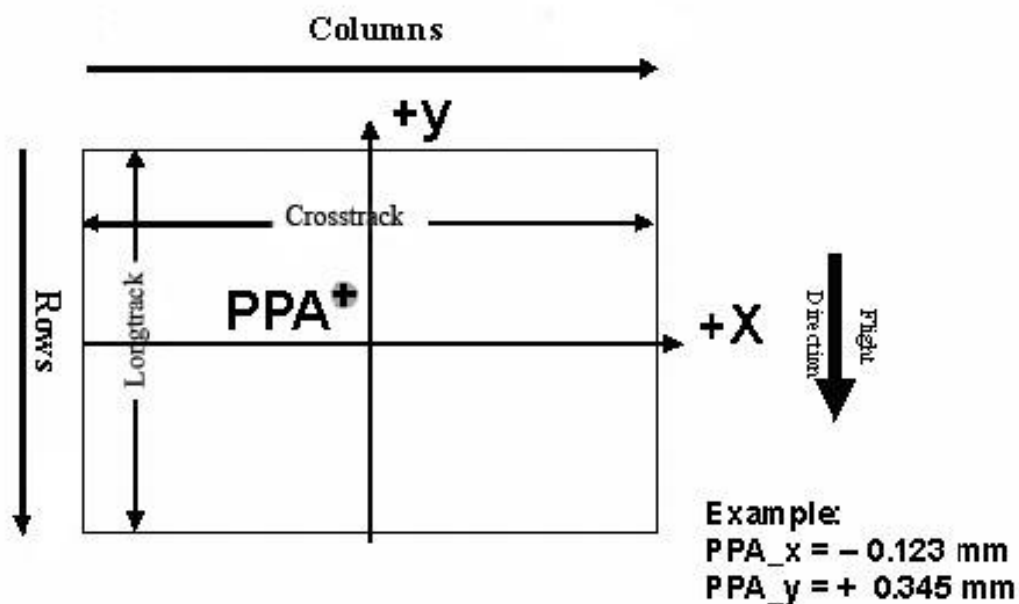
Number of point measurements for the multispectral camera : >60000

Determination of the image parameters by Least Squares Adjustment.

Software used for the adjustment: BINGO (GIP Eng. Aalen, Germany)

Level 2 Image Coordinate System:

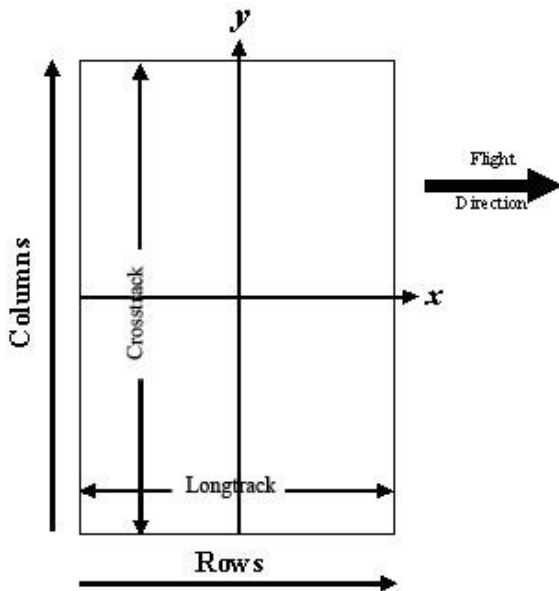
Lvl2, Camera prop. Orientation



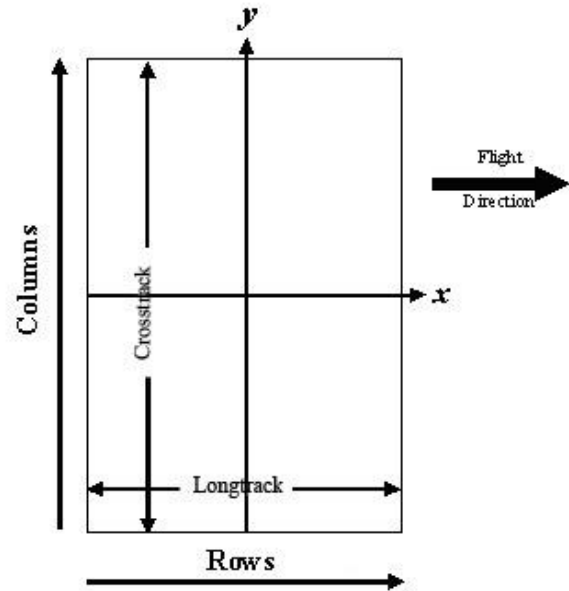
The image coordinate system of the Level 2 images is shown in the above figure. The basic image format and coordinate of the principal point in the level 2 image is given on page 4 of this report. The above figure shows the position of an example principal point at the coordinate (-0.123 / 0.345).



Level 3 Image Coordinate System:
(after rotation of 270° CW)



Panchromatic Image Format



Multispectral Image Format

Position of Principal Point in Level 3 Image

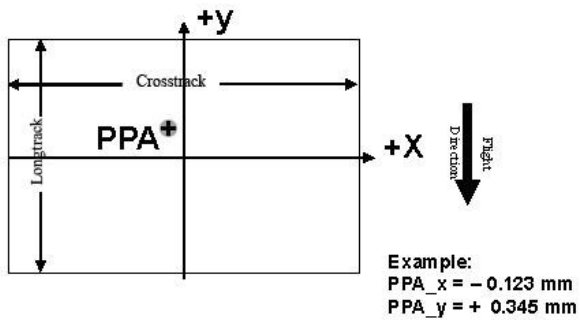
The position of the principal point in the level 3 image depends on the “rotation” setting used in UltraMap during the pan-sharpening step. The exact position relative to the image center is given in the table below as a function of the rotation setting used in UltraMap. The coordinates are specified for clockwise (CW) rotation in steps of 90 degrees, according to the principal point coordinate given on page 4 for high- and low resolution images.

Image Format	Clockwise Rotation (Degree)	PPA	
		X	Y
Level 2	-	0.000	0.000
Level 3	0	0.000	0.000
Level 3	90	0.000	0.000
Level 3	180	0.000	0.000
Level 3	270	0.000	0.000

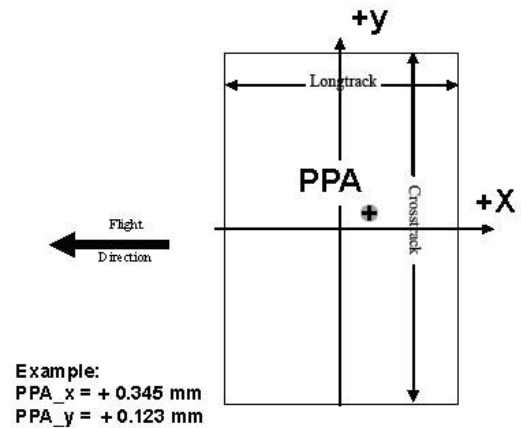


The coordinates in the figure below are only example values to illustrate the effect of image rotation on the principal point position, and do **not** correspond to the camera described in this report.

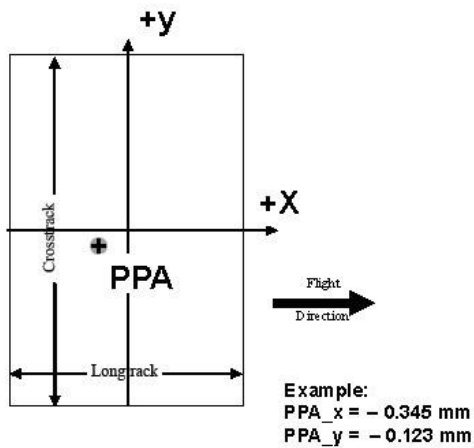
Lvl3, Rotation 0 deg clockwise



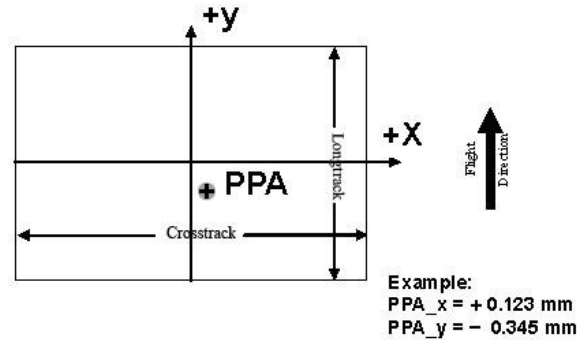
Lvl3, Rotation 90 deg clockwise



Lvl3, Rotation 270 deg clockwise



Lvl3, Rotation 180 deg clockwise





Lens Resolving Power

The following curves show the development of the modulation transfer function across different image heights of the panchromatic cones.

Please note that these values have been calculated and can vary up to 10% with optics from production (especially at high LP's).

The curves are given for the meridional (tangential) and sagital (radial) component of signals at frequencies of 12.5, 25, 50 and 100 line pairs per millimeter.

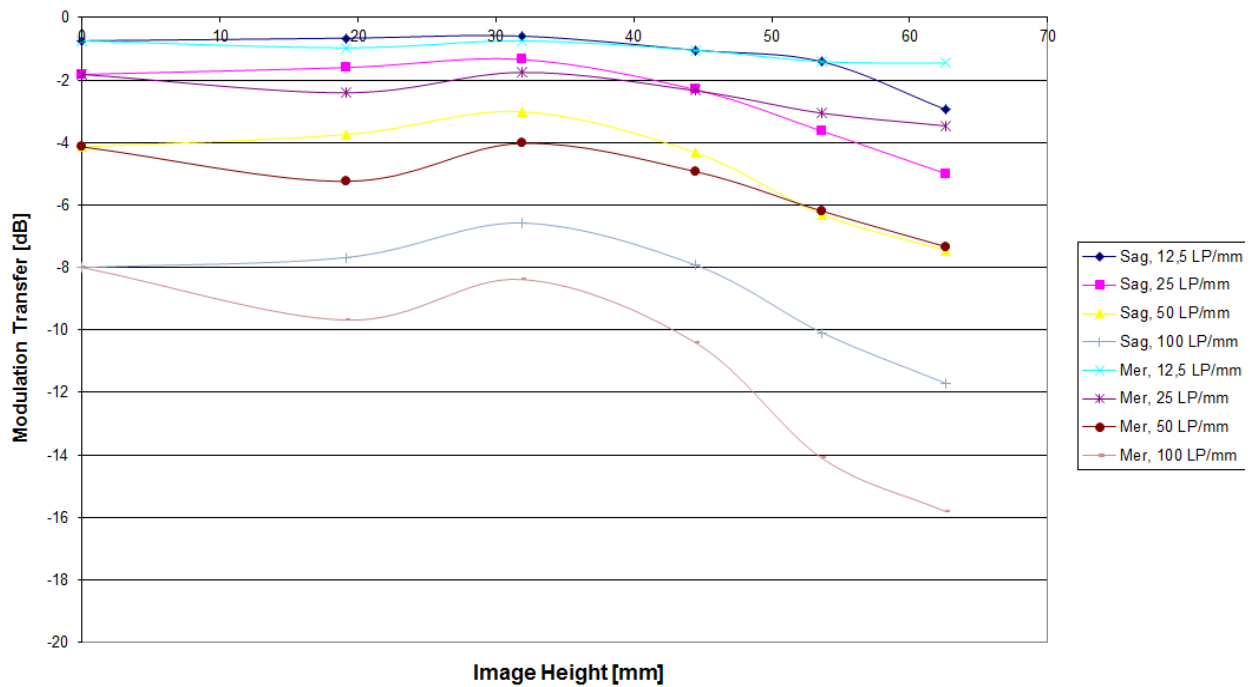
As the MTF is a function of the specific aperture size used, one set of curves is given for each aperture size.

Lens types

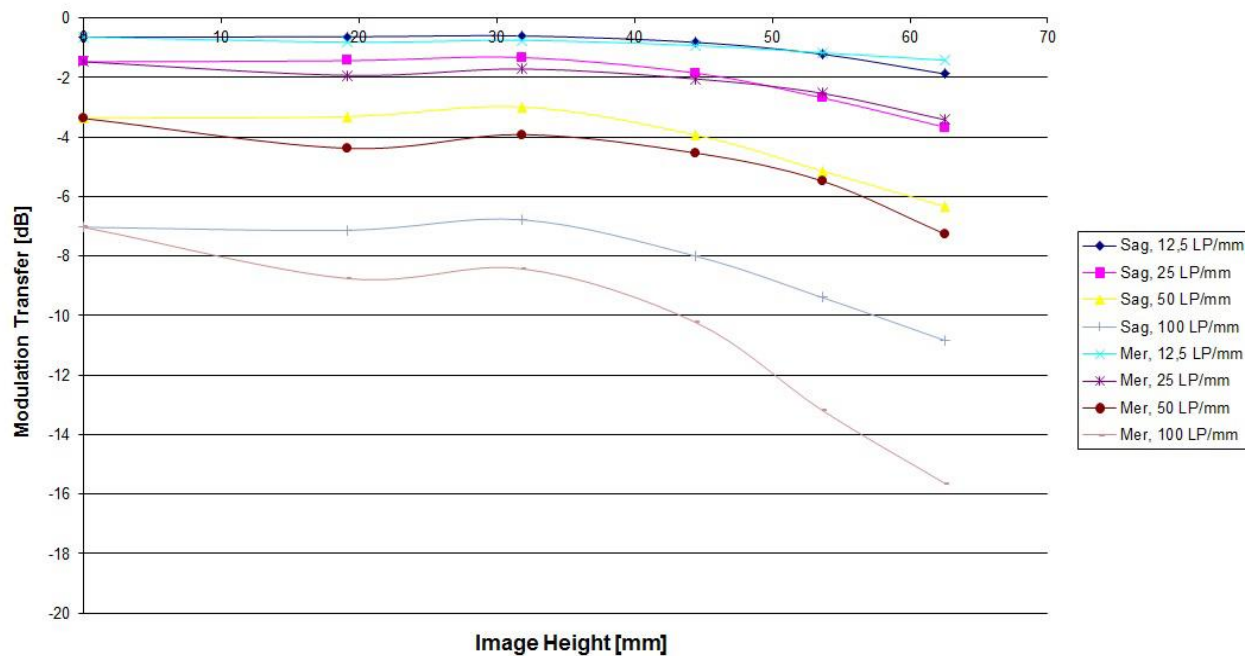
Cone	Lens
C0 (PAN)	Qioptic Vexcel HR Digaron 1:5,6/80mm, Qioptic GmbH, Germany
C1 (PAN)	Qioptic Vexcel HR Digaron 1:5,6/80mm, Qioptic GmbH, Germany
C2 (PAN)	Qioptic Vexcel HR Digaron 1:5,6/80mm, Qioptic GmbH, Germany
C3 (PAN)	Qioptic Vexcel HR Digaron 1:5,6/80mm, Qioptic GmbH, Germany
C4 (RED)	Qioptic Vexcel HR Digaron 1:4/27mm, Qioptic GmbH, Germany
C5 (GREEN)	Qioptic Vexcel HR Digaron 1:4/27mm, Qioptic GmbH, Germany
C6 (BLUE)	Qioptic Vexcel HR Digaron 1:4/27mm, Qioptic GmbH, Germany
C7 (NIR)	Qioptic Vexcel HR Digaron 1:4/27mm, Qioptic GmbH, Germany



Modulation versus Image Height - Aperture f/ 5.6

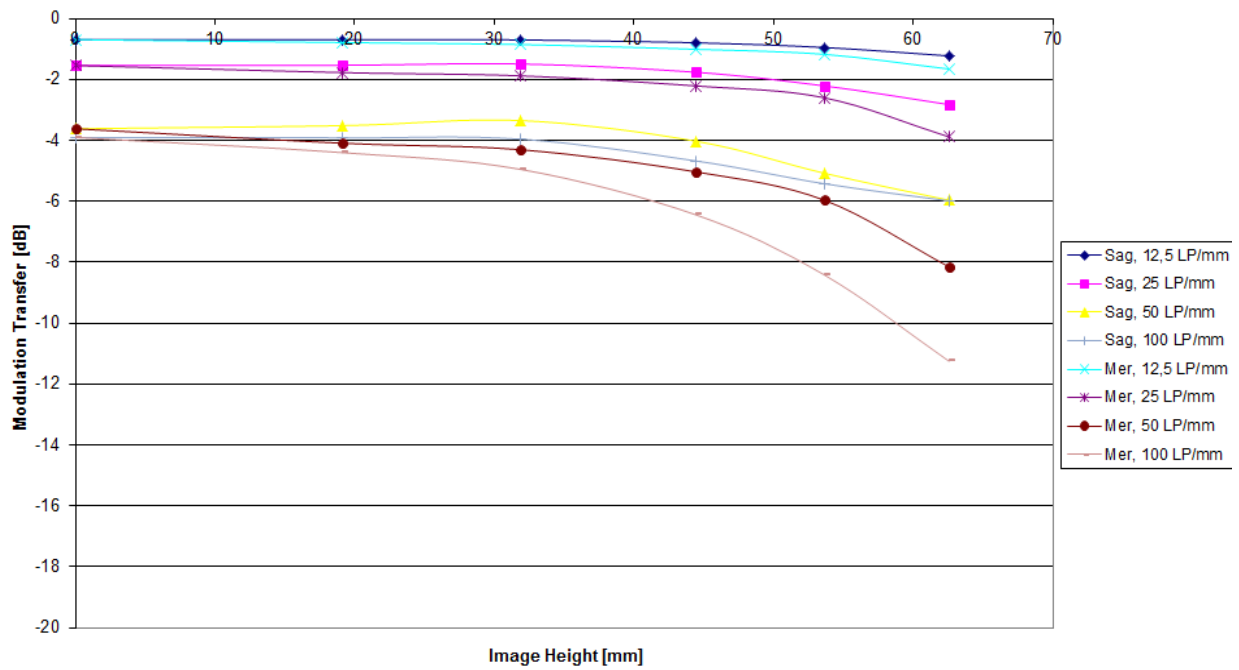


Modulation versus Image Height - Aperture f/ 6.7

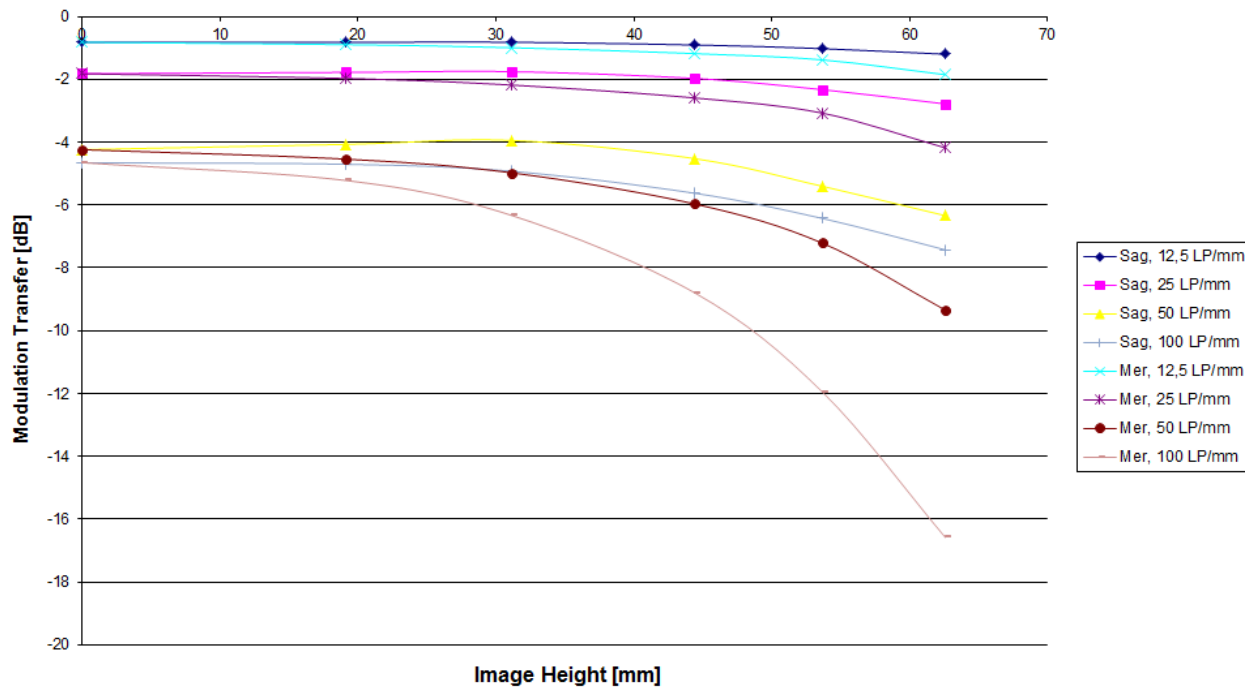




Modulation versus Image Height - Aperture f / 8

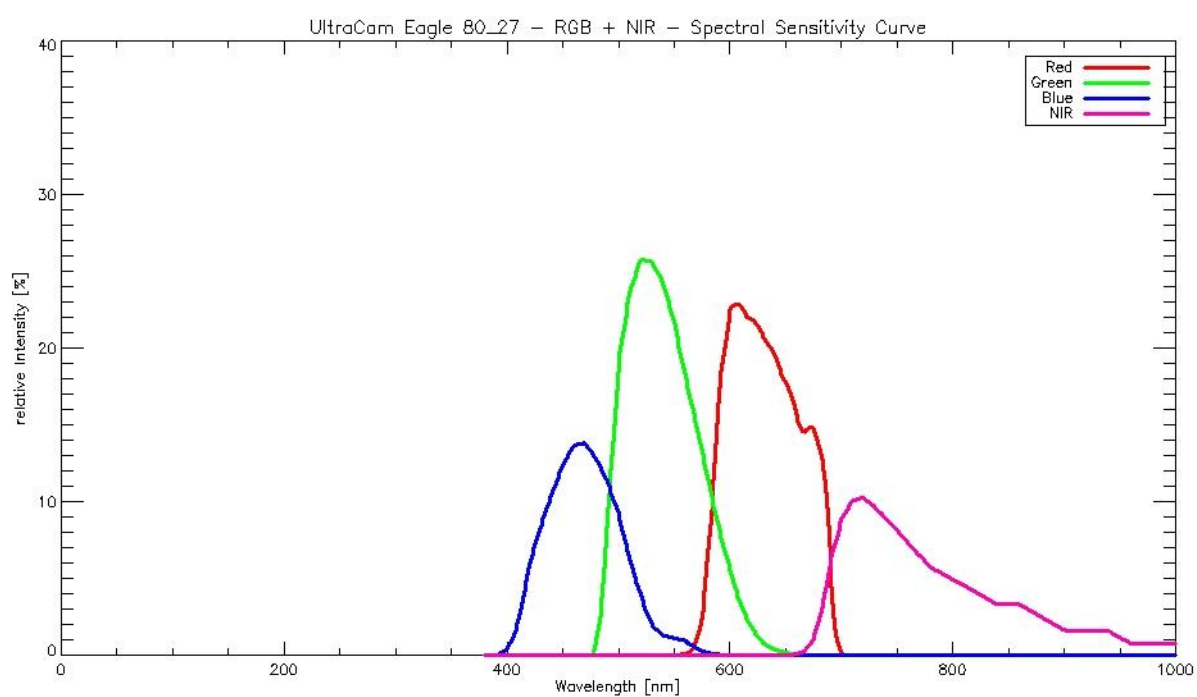
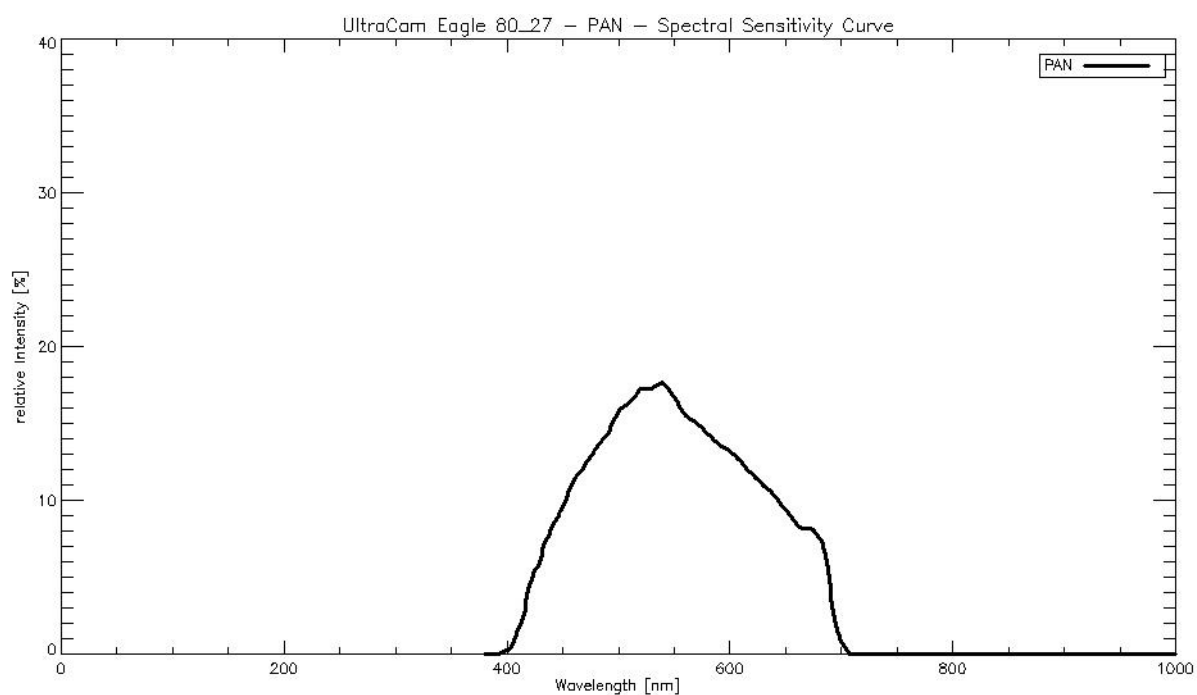


Modulation versus Image Height - Aperture f / 9.5





Spectral Sensitivity





ULTRACAM

Radiometric Calibration

Camera: UltraCam Eagle
Serial: UC-E-1-50016095-f80

Used Apertures	PAN	R, G, NIR	B
	F5.6	F4.8	F4.8
	F6.5	F5.4	F4.8
	F8	F6.7	F4.8
	F9.5	F8	F5.6
	F11	F9.5	F6.7
	F13	F11	F8
	F16	F13	F9.5
	F22	F19	F13



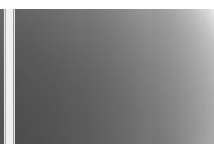

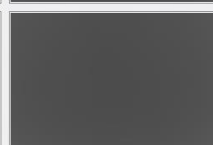
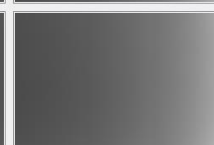



Calibration Date: June-21-2017
Date of Report: June-27-2017
Camera Revision: Rev07.00
Version of Report: V01







Calibration of Vignetting for working Aperture F6.7

	PAN	R, G, NIR	B
Aperture	F6.5	F5.4	F4.8

Graphical Overview of Pan Sensors:

Graphical Overview of Multispectral Sensors:



Dead Pixel Report:

Sensor number		
Anomaly type	X-Coordinate	Y-Coordinate

C00-00

PIXEL: 80/2857
PIXEL: 709/3144
PIXEL: 2676/2235
PIXEL: 2913/1672
PIXEL: 3267/3402
PIXEL: 4075/3087
PIXEL: 4104/2900
PIXEL: 4551/4535
PIXEL: 5149/1904
PIXEL: 5446/1419
PIXEL: 6435/1274
PIXEL: 6435/1275
PIXEL: 6538/3071
PIXEL: 6831/1792
PIXEL: 6846/3410
PIXEL: 6847/3409
PIXEL: 6845/3409
PIXEL: 6846/3409
PIXEL: 6846/3408
PIXEL: 2339/4588
PIXEL: 2340/4588

C00-01

PIXEL: 144/ 219
PIXEL: 542/3235
PIXEL: 596/2426
PIXEL: 1018/ 958
PIXEL: 1383/4184
PIXEL: 1470/1644
PIXEL: 1503/ 303
PIXEL: 1545/1222
PIXEL: 2513/ 839
PIXEL: 2747/4398
PIXEL: 2951/3532
PIXEL: 3379/1053
PIXEL: 4187/1082
PIXEL: 5814/3062
PIXEL: 5907/2921
PIXEL: 6506/2784
PIXEL: 6597/2412



PIXEL: 6705/3225
PIXEL: 1711/1461
PIXEL: 1745/1086
PIXEL: 1794/2114
PIXEL: 1794/2115
PIXEL: 1852/2243
PIXEL: 4437/1241
PIXEL: 6162/4595
PIXEL: 1711/1460
PIXEL: 1793/2115
PIXEL: 1795/2114
PIXEL: 4438/1241
PIXEL: 4437/1242
PIXEL: 6163/4595
PIXEL: 6946/4597

C00-02

PIXEL: 400/1584
PIXEL: 973/2672
PIXEL: 1065/ 765
PIXEL: 1095/1220
PIXEL: 1246/4415
PIXEL: 2081/1436
PIXEL: 2675/ 65
PIXEL: 2762/ 109
PIXEL: 3954/ 868
PIXEL: 4021/3259
PIXEL: 4083/3804
PIXEL: 4536/3365
PIXEL: 5206/3463
PIXEL: 5243/1146
PIXEL: 5295/3521
PIXEL: 5438/2856
PIXEL: 5462/2915
PIXEL: 6524/4175
PIXEL: 6589/1459
PIXEL: 4519/ 990
PIXEL: 3150/4562

C00-03

PIXEL: 578/4180
PIXEL: 706/2416
PIXEL: 756/2241
PIXEL: 1716/ 829
PIXEL: 2409/2158
PIXEL: 3351/1393
PIXEL: 3624/4049
PIXEL: 3631/ 830
PIXEL: 3751/3331
PIXEL: 3823/2941



PIXEL: 4014/3081
PIXEL: 5293/1777
PIXEL: 5504/ 466
PIXEL: 5504/1275
PIXEL: 5720/4196
PIXEL: 5856/1366
PIXEL: 6216/2556
PIXEL: 6519/2056
PIXEL: 6877/1788
PIXEL: 6896/3807
PIXEL: 368/4455
PIXEL: 3016/1646
PIXEL: 4470/3383
PIXEL: 6672/1737
PIXEL: 6673/1737
PIXEL: 4471/3383

C01-00

PIXEL: 560/3037
PIXEL: 1154/ 184
PIXEL: 2073/1745
PIXEL: 2088/3683
PIXEL: 2299/3983
PIXEL: 2666/1391
PIXEL: 3224/ 719
PIXEL: 4289/3769
PIXEL: 4568/2592
PIXEL: 4737/3495
PIXEL: 4931/ 916
PIXEL: 5037/3934
PIXEL: 5373/3873
PIXEL: 5568/ 356
PIXEL: 6306/ 737
PIXEL: 6416/ 331
PIXEL: 6923/2957
PIXEL: 90/3122
PIXEL: 170/1202
PIXEL: 459/ 984
PIXEL: 459/ 985
PIXEL: 598/3857
PIXEL: 2142/ 387
PIXEL: 2142/ 388
PIXEL: 2142/ 389
PIXEL: 2143/ 387
PIXEL: 3160/1214
PIXEL: 3161/1214
PIXEL: 3161/1215
PIXEL: 5257/1515
PIXEL: 5257/1516
PIXEL: 5258/1515



PIXEL: 5258/1516
PIXEL: 6669/4013
PIXEL: 169/1202
PIXEL: 460/ 984
PIXEL: 598/3856
PIXEL: 2141/ 388
PIXEL: 3160/1213
PIXEL: 3160/1215

C01-01

PIXEL: 219/ 209
PIXEL: 282/3582
PIXEL: 557/ 735
PIXEL: 923/1319
PIXEL: 1042/3538
PIXEL: 1557/3805
PIXEL: 1670/3060
PIXEL: 1789/3911
PIXEL: 2123/4444
PIXEL: 2149/ 360
PIXEL: 2370/4332
PIXEL: 2595/2033
PIXEL: 2834/ 765
PIXEL: 2839/ 487
PIXEL: 3175/4538
PIXEL: 4968/4018
PIXEL: 5430/3699
PIXEL: 6867/ 125
PIXEL: 352/3808
PIXEL: 466/3694
PIXEL: 467/3694
PIXEL: 467/3695
PIXEL: 5021/4496
PIXEL: 5021/4497
PIXEL: 5021/4498
PIXEL: 5022/4498
PIXEL: 5022/4499
PIXEL: 5785/3846
PIXEL: 5786/3846
PIXEL: 5787/3847
PIXEL: 5787/3848
PIXEL: 5788/3849
PIXEL: 6783/2700
PIXEL: 351/3809
PIXEL: 353/3807
PIXEL: 354/3806
PIXEL: 466/3695
PIXEL: 465/3694
PIXEL: 5786/3847
PIXEL: 5788/3848



PIXEL: 5786/3848
PIXEL: 6829/4348
PIXEL: 6799/4361
PIXEL: 6784/4450

C02-00

PIXEL: 658/ 870
PIXEL: 987/3894
PIXEL: 1271/2567
PIXEL: 1414/ 368
PIXEL: 1683/3427
PIXEL: 2225/4518
PIXEL: 2282/ 397
PIXEL: 2670/1364
PIXEL: 3614/3730
PIXEL: 4161/4177
PIXEL: 4187/2904
PIXEL: 5735/1332
PIXEL: 5868/3844
PIXEL: 5916/1321
PIXEL: 6105/ 34
PIXEL: 6482/1786
PIXEL: 6679/1139
PIXEL: 6756/ 958
PIXEL: 6805/3588
PIXEL: 6883/4100
PIXEL: 216/1468
PIXEL: 215/1468
PIXEL: 215/1467
PIXEL: 216/1467

C02-01

PIXEL: 910/1074
PIXEL: 1160/4260
PIXEL: 1235/ 100
PIXEL: 1300/4350
PIXEL: 1331/2627
PIXEL: 1432/ 884
PIXEL: 1548/4547
PIXEL: 1857/3282
PIXEL: 2324/2274
PIXEL: 2569/3831
PIXEL: 2826/3405
PIXEL: 2927/4097
PIXEL: 2986/3394
PIXEL: 3710/2433
PIXEL: 3761/2893
PIXEL: 4498/ 83
PIXEL: 4698/3382
PIXEL: 4698/3385



PIXEL: 4698/3386
PIXEL: 4699/3385
PIXEL: 5562/1703
PIXEL: 5572/ 762
PIXEL: 6331/1021
PIXEL: 295/4230
PIXEL: 422/2513
PIXEL: 426/ 883
PIXEL: 516/3785
PIXEL: 599/3608
PIXEL: 601/1724
PIXEL: 666/ 145
PIXEL: 786/2490
PIXEL: 787/2489
PIXEL: 879/ 118
PIXEL: 932/2775
PIXEL: 1052/1457
PIXEL: 1108/1272
PIXEL: 1162/3194
PIXEL: 1393/4005
PIXEL: 1554/4116
PIXEL: 1555/3681
PIXEL: 1560/4128
PIXEL: 1650/2563
PIXEL: 1674/4419
PIXEL: 1755/1211
PIXEL: 1865/3034
PIXEL: 1946/ 824
PIXEL: 1954/ 153
PIXEL: 1968/2738
PIXEL: 1972/ 580
PIXEL: 1974/2246
PIXEL: 1988/3530
PIXEL: 2043/4087
PIXEL: 2072/3580
PIXEL: 2145/1935
PIXEL: 2427/2193
PIXEL: 2645/2424
PIXEL: 2650/3959
PIXEL: 2684/2873
PIXEL: 2736/4056
PIXEL: 2911/2537
PIXEL: 2996/3618
PIXEL: 3001/1313
PIXEL: 3013/1110
PIXEL: 3069/3112
PIXEL: 3486/ 373
PIXEL: 3565/2102
PIXEL: 3680/2102
PIXEL: 3694/1632
PIXEL: 3695/1631



PIXEL: 3804/3864
PIXEL: 3856/2698
PIXEL: 3919/2074
PIXEL: 3946/4115
PIXEL: 3999/1800
PIXEL: 4319/2723
PIXEL: 4472/1749
PIXEL: 4547/3991
PIXEL: 4850/1976
PIXEL: 4930/3302
PIXEL: 4967/2858
PIXEL: 5206/4335
PIXEL: 5320/2116
PIXEL: 5352/1672
PIXEL: 5489/3239
PIXEL: 5489/3240
PIXEL: 5506/2779
PIXEL: 5576/2025
PIXEL: 6179/4445
PIXEL: 6206/2298
PIXEL: 6407/2250
PIXEL: 6517/2220
PIXEL: 6572/4385
PIXEL: 6597/ 627
PIXEL: 6786/4024
PIXEL: 6806/4363
PIXEL: 2646/2423
PIXEL: 2647/2424
PIXEL: 2685/2873
PIXEL: 3564/2102
PIXEL: 4546/3991
PIXEL: 4547/3990
PIXEL: 4548/3991
PIXEL: 4967/2859
PIXEL: 5242/4335
PIXEL: 5473/3234
PIXEL: 5490/3238
PIXEL: 5491/3239
PIXEL: 5490/3240
PIXEL: 6206/2297
PIXEL: 6206/2299
PIXEL: 6207/2298
PIXEL: 6572/4384
PIXEL: 6597/ 628
PIXEL: 6598/ 627
PIXEL: 6598/ 630
PIXEL: 6806/4362
PIXEL: 3048/4599
PIXEL: 2381/4579



C03-00

PIXEL: 211/4330
PIXEL: 382/2886
PIXEL: 803/2689
PIXEL: 834/2888
PIXEL: 1010/ 67
PIXEL: 1455/4550
PIXEL: 1519/ 831
PIXEL: 1794/1821
PIXEL: 2348/1393
PIXEL: 2444/3180
PIXEL: 4174/3879
PIXEL: 5433/1586
PIXEL: 5853/3489
PIXEL: 6534/ 473
PIXEL: 293/2288
PIXEL: 5645/4478
PIXEL: 294/2287
PIXEL: 294/2286
PIXEL: 296/2287
PIXEL: 296/2286
PIXEL: 296/2285
PIXEL: 296/2284
PIXEL: 297/2286
PIXEL: 297/2287
PIXEL: 298/2286
PIXEL: 293/2289
PIXEL: 294/2288
PIXEL: 295/2287
PIXEL: 295/2286

C04-00

PIXEL: 428/2653
PIXEL: 530/3366
PIXEL: 748/ 82
PIXEL: 1093/ 983
PIXEL: 1106/3161
PIXEL: 1778/4197
PIXEL: 2250/2472
PIXEL: 2808/2097
PIXEL: 2935/2217
PIXEL: 3374/3400
PIXEL: 3634/4409
PIXEL: 3862/2983
PIXEL: 4216/2744
PIXEL: 5105/1018
PIXEL: 5843/2110
PIXEL: 5956/1791
PIXEL: 141/1541
PIXEL: 203/2696



PIXEL: 244/3419
PIXEL: 270/2230
PIXEL: 284/1550
PIXEL: 301/2415
PIXEL: 329/3260
PIXEL: 378/4279
PIXEL: 785/2904
PIXEL: 928/1106
PIXEL: 5277/2821
PIXEL: 5900/4568
PIXEL: 6010/4465
PIXEL: 6270/4500
PIXEL: 424/4277
PIXEL: 424/4278
PIXEL: 423/4278
PIXEL: 422/4277
PIXEL: 5277/4576
PIXEL: 5278/4576

C05-00

PIXEL: 100/3072
PIXEL: 455/2638
PIXEL: 482/2056
PIXEL: 1297/4458
PIXEL: 1315/4384
PIXEL: 2352/2618
PIXEL: 2404/ 975
PIXEL: 2617/ 791
PIXEL: 3640/3183
PIXEL: 4684/1427
PIXEL: 4712/3013
PIXEL: 4856/ 147
PIXEL: 6122/2069
PIXEL: 6251/ 548
PIXEL: 6777/1591
PIXEL: 35/ 802
PIXEL: 256/ 98
PIXEL: 271/ 271
PIXEL: 289/1145
PIXEL: 290/1145
PIXEL: 347/ 308
PIXEL: 348/ 308
PIXEL: 348/ 309
PIXEL: 405/ 692
PIXEL: 2722/ 130
PIXEL: 2722/ 131
PIXEL: 2825/ 263
PIXEL: 2848/2599
PIXEL: 2866/4614
PIXEL: 6849/3118



PIXEL: 80/4567
PIXEL: 36/ 803
PIXEL: 35/ 803
PIXEL: 225/ 82
PIXEL: 247/ 121
PIXEL: 201/ 130
PIXEL: 275/ 129
PIXEL: 286/ 270
PIXEL: 261/ 304
PIXEL: 229/ 279
PIXEL: 405/ 691
PIXEL: 404/ 692
PIXEL: 456/ 721
PIXEL: 456/ 722
PIXEL: 2722/ 132
PIXEL: 2694/ 106
PIXEL: 2732/ 114
PIXEL: 2825/ 262
PIXEL: 2824/ 262
PIXEL: 2824/ 263
PIXEL: 2849/2599
PIXEL: 6848/3119
PIXEL: 6850/3119
PIXEL: 6851/3119
PIXEL: 6852/3119
PIXEL: 6852/3120
PIXEL: 6851/3118
PIXEL: 6853/3119
PIXEL: 6853/3118
PIXEL: 6554/4579
PIXEL: 6553/4577
PIXEL: 6553/4578
PIXEL: 6554/4578

C06-00

PIXEL: 1184/4482
PIXEL: 1423/1934
PIXEL: 2201/2450
PIXEL: 3046/ 702
PIXEL: 3219/1748
PIXEL: 3384/4593
PIXEL: 3386/ 289
PIXEL: 3682/ 343
PIXEL: 5509/3073
PIXEL: 6358/1369
PIXEL: 6664/1370
PIXEL: 6793/2744
PIXEL: 215/ 934
PIXEL: 3552/ 756
PIXEL: 3552/ 757



PIXEL: 3568/1082
PIXEL: 5559/3887
PIXEL: 5560/3886
PIXEL: 5560/3887
PIXEL: 5561/3887
PIXEL: 5562/3887
PIXEL: 3566/ 759
PIXEL: 3567/ 758
PIXEL: 5561/3888
PIXEL: 5562/3888
PIXEL: 6905/4573

C07-00

PIXEL: 125/3329
PIXEL: 290/1581
PIXEL: 406/ 567
PIXEL: 880/4146
PIXEL: 1311/4383
PIXEL: 1371/1555
PIXEL: 3170/2261
PIXEL: 3267/4328
PIXEL: 3416/1234
PIXEL: 3658/3065
PIXEL: 3797/2489
PIXEL: 4728/4350
PIXEL: 5089/1549
PIXEL: 5313/3008
PIXEL: 5436/2963
PIXEL: 5841/3443
PIXEL: 6510/1553
PIXEL: 1130/2288
PIXEL: 3407/4314
PIXEL: 5825/ 688
PIXEL: 5825/ 689
PIXEL: 1130/2287
PIXEL: 1129/2288
PIXEL: 6945/4613
PIXEL: 6924/4591

Notes

COLUMN anomaly: all pixels below the Qmax detector at location (X,Y) may be affected.

PIXEL anomaly: single detector at location (X,Y) is not functioning within normal range

The Level0 coordinates exclude the two leftmost pixels containing the line index: the corresponding pixel can therefore be located at column (X+2,Y).



Explanations

Calibration Method:

The radiometric calibration is based on a series of 50 flat field images for each aperture size and sensor. The flat field is illuminated by eight normal light lamps with known spectral illumination curves.

These images are used to calculate the specific sensitivity of each pixel to compensate local as well as global variations in sensitivity. Sensitivity tables are calculated for each sensor and aperture setting, and applied during post processing from level 0 to level 1.

Outlier Pixels that do not have a linear behavior as described in the CCD specifications are marked as defective during the calibration procedure. These pixels are not used or only partially used during post processing and the information is restored by interpolation between the neighborhood pixels surrounding the defective pixels.

Certain pixels that are named Qmax pixels due to the fact that they can only store and transfer charge up to a certain maximum amount are detected in an additional calibration step. These pixels are treated differently during post processing, since their behavior can affect not only single pixel values but whole columns.



ULTRACAM

Shutter Calibration

Camera: UltraCam Eagle
Serial: UC-E-1-50016095-f80

Panchromatic Camera: 4 * Prontor Magnetic 0
Prontor-Werk Alfred Gauthier GmbH, Germany

Multispectral Camera: 4 * Prontor Magnetic 0
Prontor-Werk Alfred Gauthier GmbH, Germany

Calibration Date: June-21-2017
Date of Report: June-27-2017
Camera Revision: Rev07.00
Version of Report: V01



Calibration of Shutter Release Times:

The shutter release times measured during the calibration describe the time from the moment when the electrical current through the shutter is turned off by the electronics, until the shutter is mechanically closed.

This time is relevant for the exposure control and needs to be known before image recording can take place.

Cone Number	Lens Serial Number	SRT F5.6 [ms]	SRT F6.7 [ms]	SRT F8 [ms]	SRT F9.5 [ms]	SRT F11 [ms]	SRT F13 [ms]	SRT F16 [ms]	SRT F22 [ms]	Measurement Tolerance [ms]
C0 (Pan)	12091178	9.90	10.23	10.72	11.08	11.38	11.56	11.65	12.01	+/- 0.2
C1 (Pan)	12091189	10.64	11.06	11.50	11.78	12.11	12.24	12.31	12.77	+/- 0.2
C2 (Pan)	12091181	10.52	10.76	11.22	11.62	11.86	12.12	12.27	12.66	+/- 0.2
C3 (Pan)	12091176	9.39	9.80	10.24	10.55	10.81	11.01	11.13	11.55	+/- 0.2
C4 (Red)	12089937	11.43	11.57	11.81	11.92	11.97	12.10	12.22	12.30	+/- 0.2
C5 (Green)	12089940	11.89	12.09	12.32	12.52	12.68	12.82	12.84	13.04	+/- 0.2
C6 (Blue)	12089934	11.97	12.05	12.09	12.14	12.31	12.77	12.84	13.14	+/- 0.2
C7 (NIR)	12089930	12.15	12.59	12.59	12.73	13.02	13.02	12.89	13.14	+/- 0.2



ULTRACAM

Electronics and Sensor Calibration

Camera: UltraCam Eagle
Serial: UC-E-1-50016095-f80

Panchromatic Camera: 9 * FTF7046-M Area CCD Sensor by DALSA
Multispectral Camera: 4 * FTF7046-M Area CCD Sensor by DALSA

Calibration Date: June-21-2017
Date of Report: June-27-2017
Camera Revision: Rev07.00
Version of Report: V01



Calibration of Negative Substrate Voltage (VNS):

For optimum performance of the DALSA CCD sensors, the negative substrate voltage is adjusted to a value specified by DALSA.

This voltage value is measured to achieve the best anti-blooming performance possible for each particular sensor.

Cone_Sensor	Sensor Type	Sensor Serial Number	VNS Voltage [V]
00_00	FTF7046-M	148709/048	25.60
00_01	FTF7046-M	148493/034	25.00
00_02	FTF7046-M	146858/029	24.80
00_03	FTF7046-M	148709/042	25.00
01_00	FTF7046-M	148423/003	24.40
01_01	FTF7046-M	148424/018	24.40
02_00	FTF7046-M	148709/045	25.60
02_01	FTF7046-M	148424/012	24.40
03_00	FTF7046-M	146858/028	24.80
04_00 (red)	FTF7046-M	148424/020	24.80
05_00 (green)	FTF7046-M	148709/043	25.00
06_00 (blue)	FTF7046-M	148423/001	24.60
07_00 (NIR)	FTF7046-M	148493/028	25.40



Calibration of Intensity Threshold for Exposure Control:

Each CCD sensor and electronics module varies slightly in global sensitivity and intensity scale.

Therefore the maximum possible intensity of each sensor needs to be measured to evaluate the sensitivity behavior of the CCD and electronics.

This value is used as a threshold for the exposure control dialogue shown in the in-flight user interface of the Eagle.

Cone_Sensor	Sensor Type	Sensor Serial Number	Intensity Threshold [DN]
00_00	FTF7046-M	148709/048	13010
00_01	FTF7046-M	148493/034	13310
00_02	FTF7046-M	146858/029	13710
00_03	FTF7046-M	148709/042	13380
01_00	FTF7046-M	148423/003	13370
01_01	FTF7046-M	148424/018	13580
02_00	FTF7046-M	148709/045	13460
02_01	FTF7046-M	148424/012	13120
03_00	FTF7046-M	146858/028	13650
04_00 (red)	FTF7046-M	148424/020	13580
05_00 (green)	FTF7046-M	148709/043	12310
06_00 (blue)	FTF7046-M	148423/001	13400
07_00 (NIR)	FTF7046-M	148493/028	12860



ULTRACAM

Summary

Camera:	UltraCam Eagle
Serial:	UC-E-1-50016095-f80
Calibration Date:	June-21-2017
Date of Report:	June-27-2017
Camera Revision:	Rev07.00
Version of Report:	V01

The following calibrations have been performed for the above mentioned digital aerial mapping camera:

- Geometric Calibration
- Radiometric Calibration
- Shutter Calibration
- Sensor and Electronics Calibration

This equipment is operating fully within specification as defined by Vexcel Imaging GmbH.

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