



# ULTRACAM

## Calibration Report

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Bahia, Brasil 2013

Photo on page 1 courtesy of Hiparc Geotecnologia, Brasil

[www.hiparc.com](http://www.hiparc.com)

UltraCam Lp, GSD25 cm, RGB



# **ULTRACAM**

## **Geometric Calibration**

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**Camera:** UltraCam Xp  
**Serial:** UC-SXp-1-40118219

**Panchromatic Camera:** ck = 100.500 mm  
**Multispectral Camera:** ck = 100.500 mm

**PPA Information:** X: 0.000  
Y: 0.240

**Calibration Date:** Sep-09-2019  
**Date of Report:** Sep-23-2019  
**Camera Revision:** Rev05.00  
**Version of Report:** V01



## Panchromatic Camera

### Large Format Panchromatic Output Image

<b>Image Format</b>	long track cross track	67.860mm 103.860mm	11310pixel 17310pixel
<b>Image Extent</b>		(-33.930, -51.930)mm	(33.9300, 51.930)mm
<b>Pixel Size</b>		6.000µm*6.000µm	
<b>Focal Length</b>	ck	100.500mm	± 0.002mm
<b>Principal Point (Level 2)</b>	X_ppa	0.000mm	± 0.002mm
	Y_ppa	0.240mm	± 0.002mm
<b>Lens Distortion</b>	Remaining Distortion less than 0.002mm		

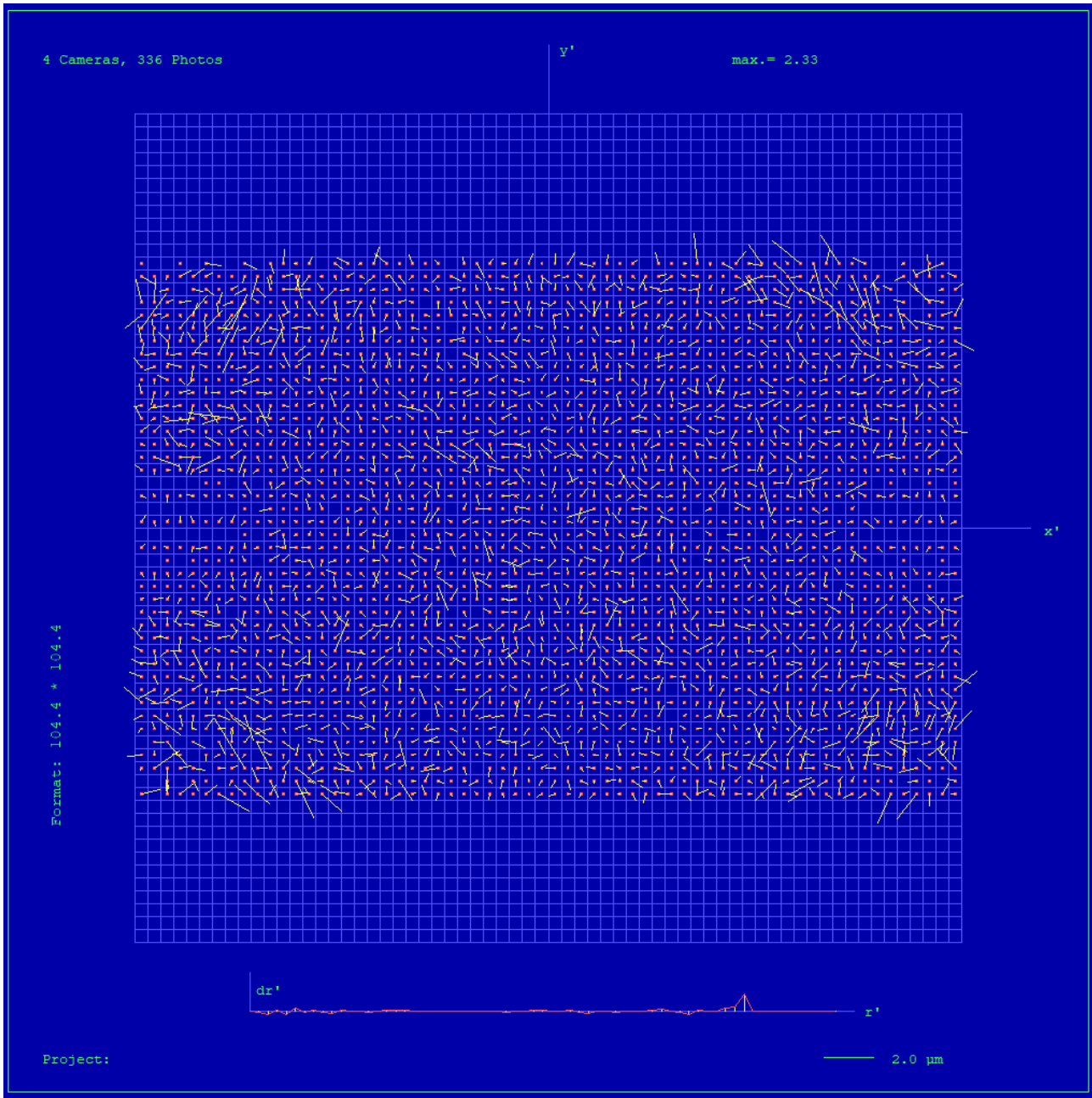
## Multispectral Camera

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

<b>Image Format</b>	long track cross track	67.860mm 103.860mm	3770pixel 5770pixel
<b>Image Extent</b>		(-33.930, -51.930)mm	(33.930, 51.930)mm
<b>Pixel Size</b>		18.000µm*18.000µm	
<b>Focal Length</b>	ck	100.500mm	± 0.002mm
<b>Principal Point (Level 2)</b>	X_ppa	0.000mm	± 0.002mm
	Y_ppa	0.240mm	± 0.002mm
<b>Lens Distortion</b>	Remaining Distortion less than 0.002mm		



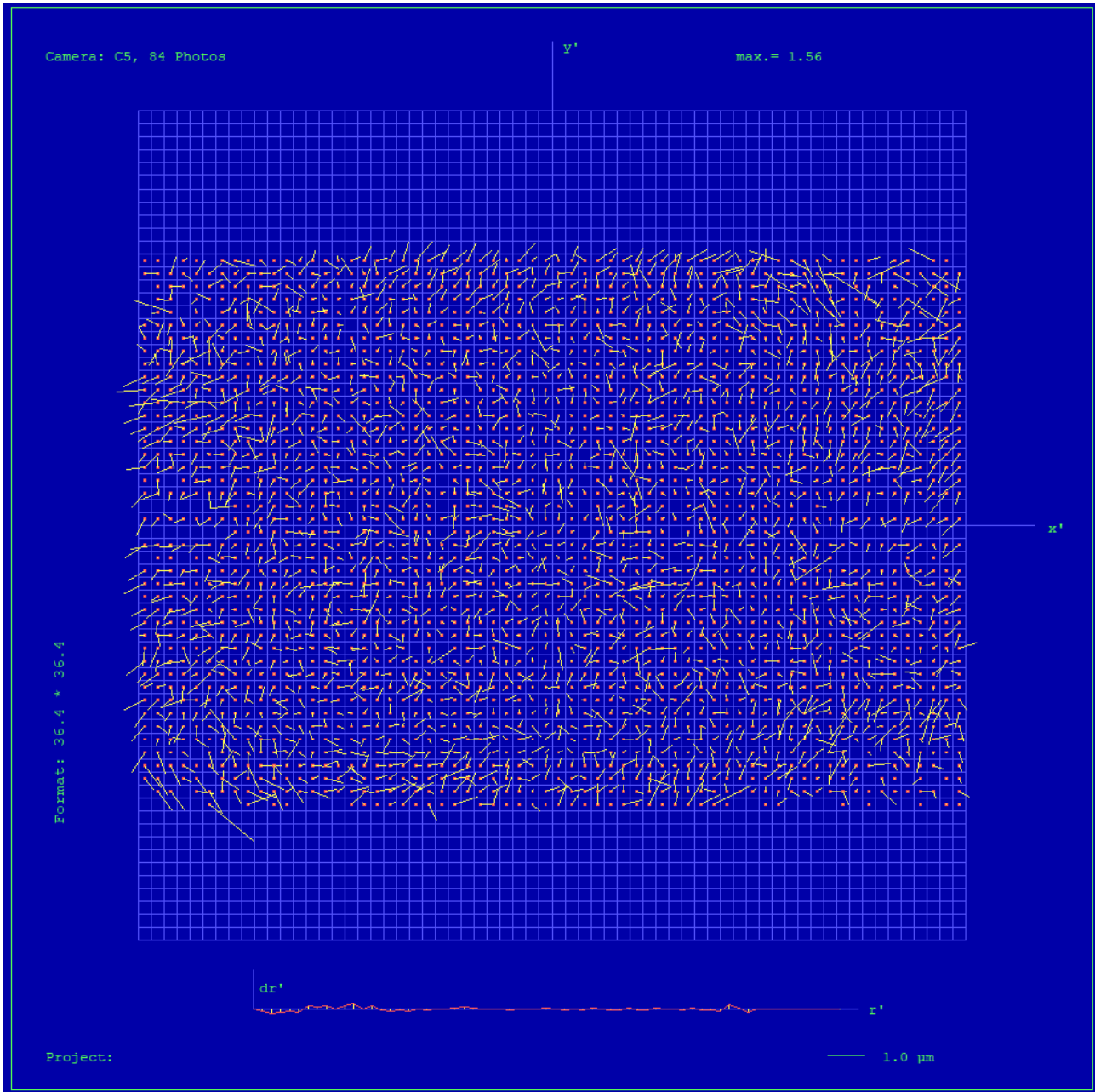
# Full Panchromatic Image, Residual Error Diagram



**Residual Error (RMS):**            **1.15 μm**



## Green Cone (Cone 5), Residual Error Diagram



**Residual Error (RMS):**            **0.96  $\mu\text{m}$**





## 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

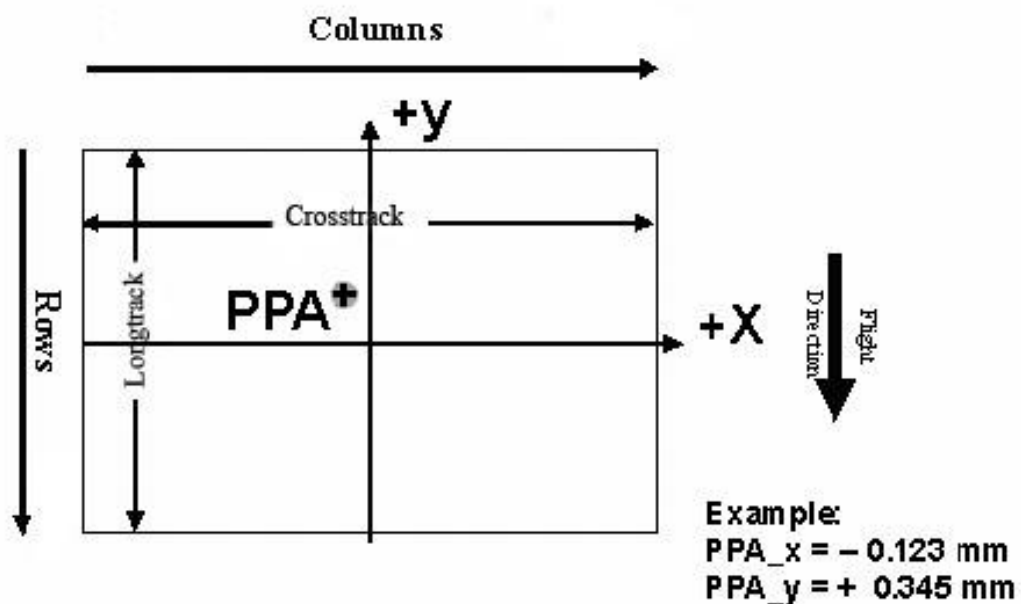
Number of point measurements for the multispectral camera : >60000

Determination of the image parameters by Least Squares Adjustment.

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

### Level 2 Image Coordinate System:

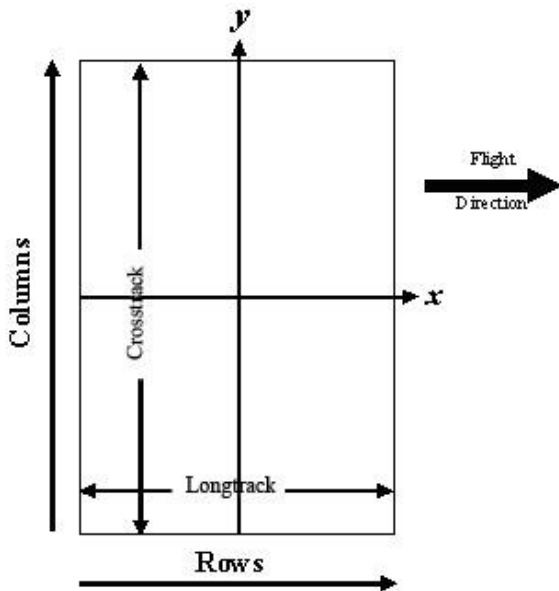
## Lvl2, Camera prop. Orientation



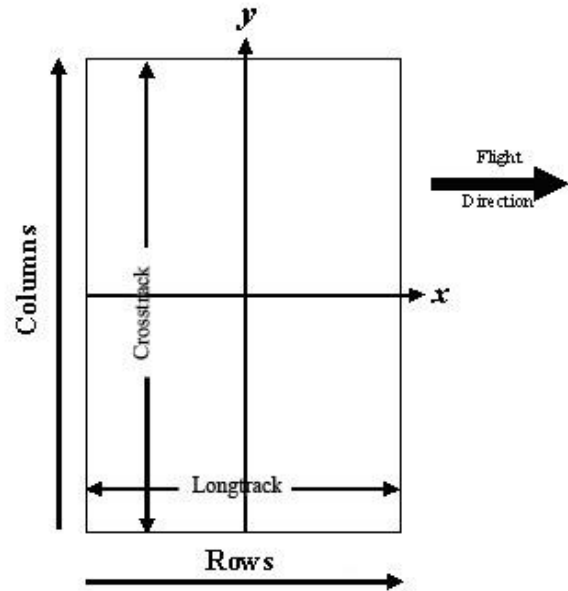
The image coordinate system of the Level 2 images is shown in the above figure. The basic image format and coordinate of the principal point in the level 2 image is given on page 4 of this report. The above figure shows the position of an example principal point at the coordinate (-0.123 / 0.345).



**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.

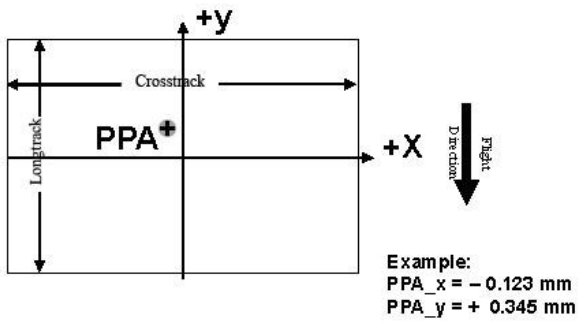
Image Format	Clockwise Rotation (Degree)	PPA	
		X	Y
Level 2	-	0.000	0.240
Level 3	0	0.000	0.240
Level 3	90	0.240	0.000
Level 3	180	0.000	-0.240
Level 3	270	-0.240	0.000



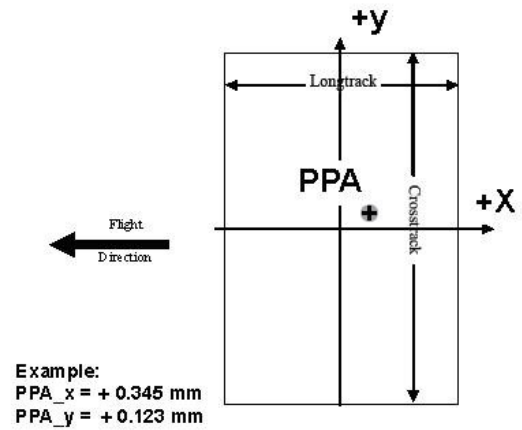


The coordinates in the figure below are only example values to illustrate the effect of image rotation on the principal point position, and do **not** correspond to the camera described in this report.

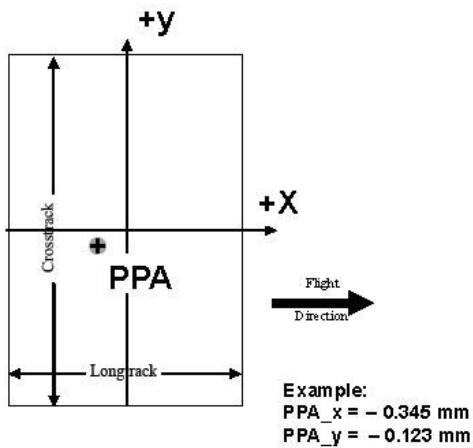
Lvl3, Rotation 0 deg clockwise



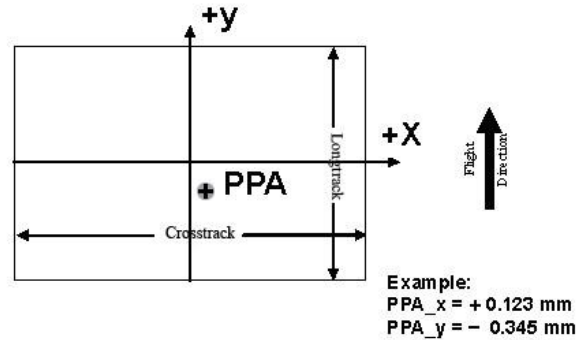
Lvl3, Rotation 90 deg clockwise



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 sagittal (radial) component of signals at frequencies of 12.5, 25, 50 and 100 line pairs per millimeter.

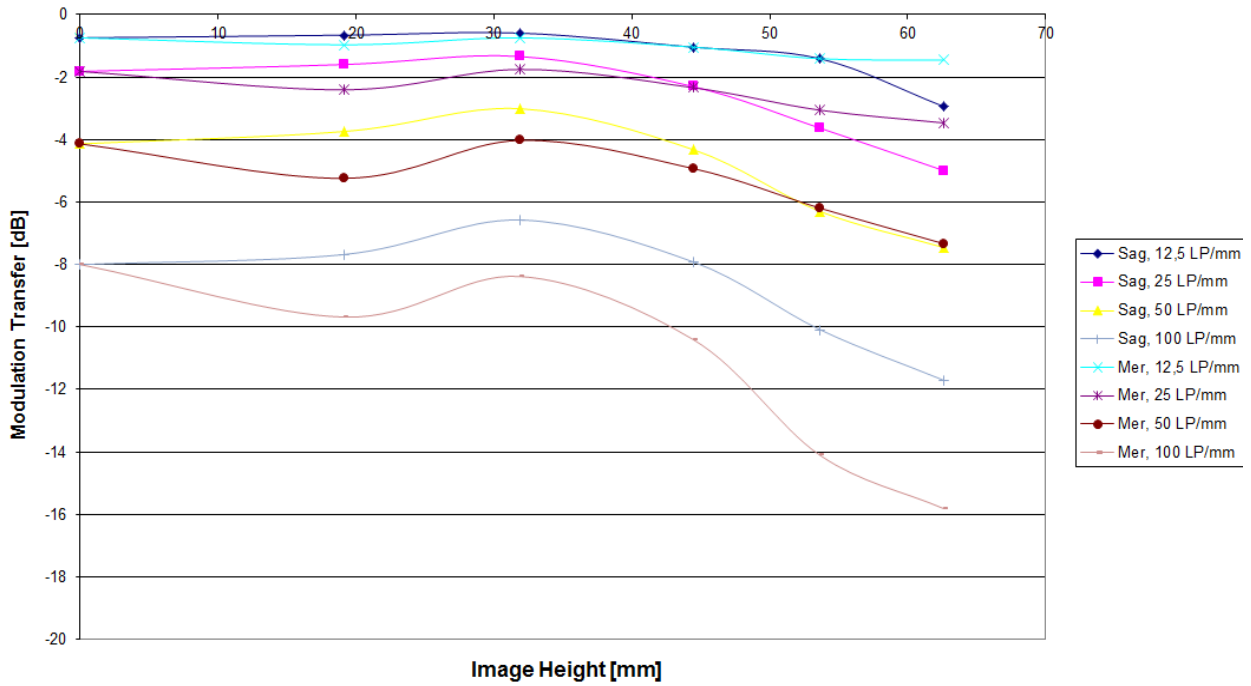
As the MTF is a function of the specific aperture size used, one set of curves is given for each aperture size.

### Lens types

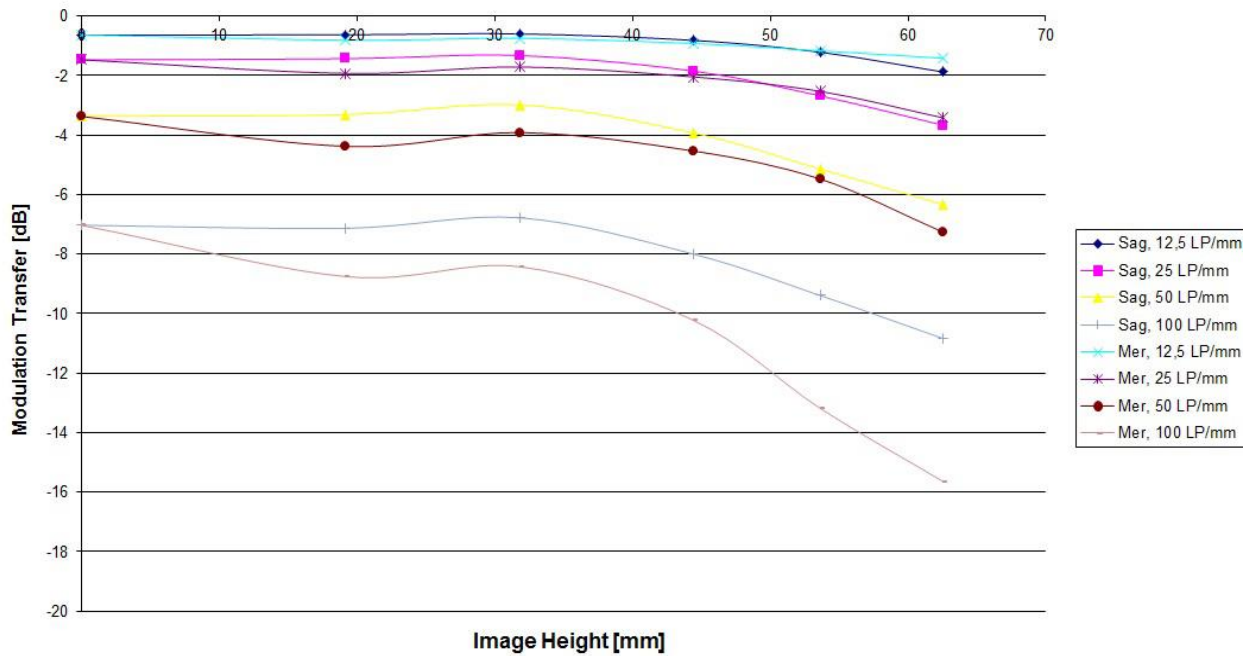
Cone	Lens
C0	Linos Vexcel Apo-Sironar Digital HR 1:5,6/100mm, Linos GmbH, Germany
C1	Linos Vexcel Apo-Sironar Digital HR 1:5,6/100mm, Linos GmbH, Germany
C2	Linos Vexcel Apo-Sironar Digital HR 1:5,6/100mm, Linos GmbH, Germany
C3	Linos Vexcel Apo-Sironar Digital HR 1:5,6/100mm, Linos GmbH, Germany
C4 (RED)	Linos Vexcel Apo-Sironar Digital HR 1:4/33mm, Linos GmbH, Germany
C5 (GREEN)	Linos Vexcel Apo-Sironar Digital HR 1:4/33mm, Linos GmbH, Germany
C6 (BLUE)	Linos Vexcel Apo-Sironar Digital HR 1:4/33mm, Linos GmbH, Germany
C7 (NIR)	Linos Vexcel Apo-Sironar Digital HR 1:4/33mm, Linos GmbH, Germany



Modulation versus Image Height - Aperture f / 5.6

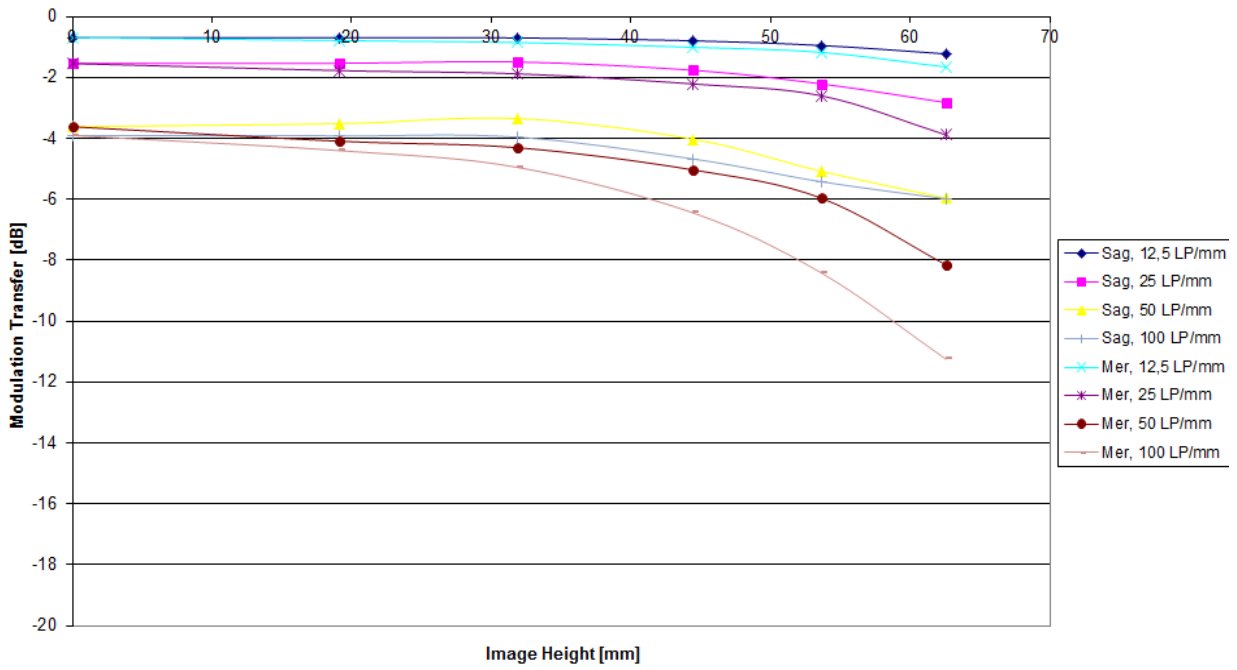


Modulation versus Image Height - Aperture f / 6.7

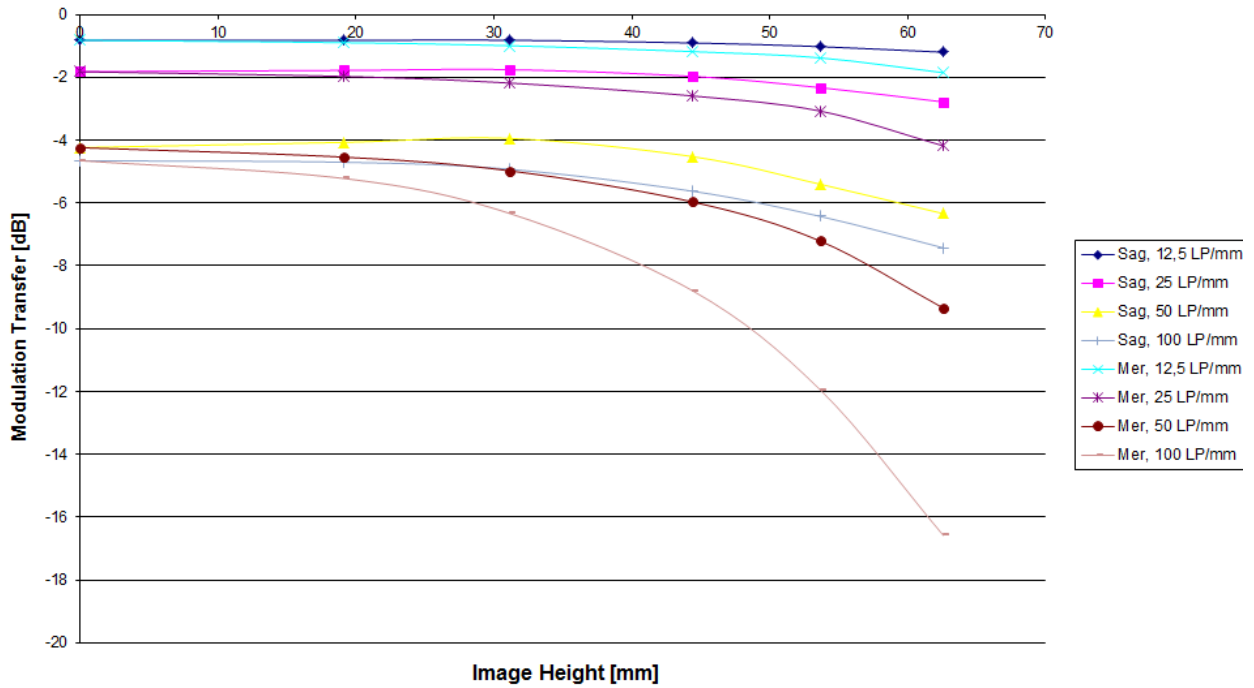




Modulation versus Image Height - Aperture f / 8



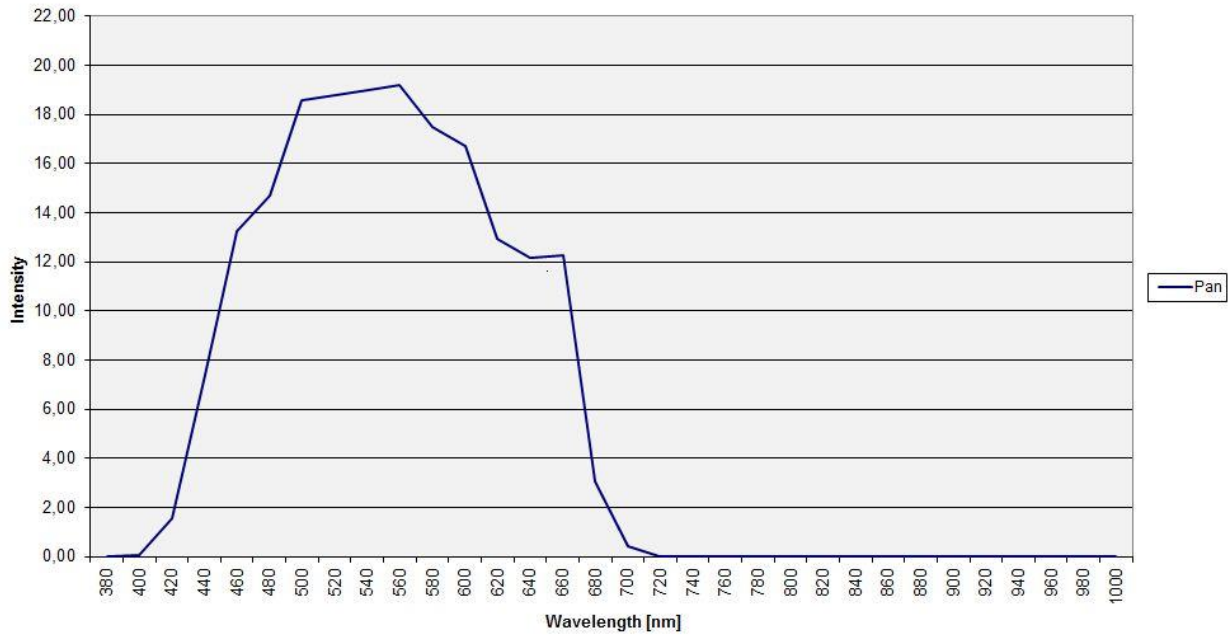
Modulation versus Image Height - Aperture f / 9.5



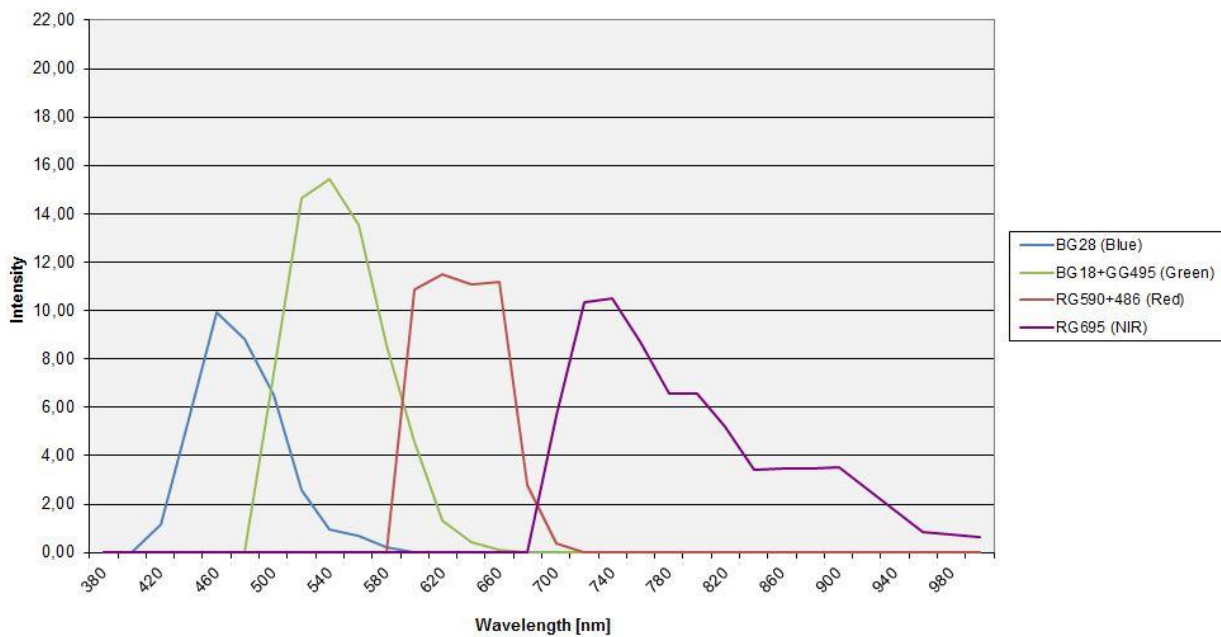


# Spectral Sensitivity

Spectral Sensitivity Vexcel UCX - Panchromatic with AR-106 Coating



Spektral Sensitivity Vexcel UCX - Multispectral with AR-106 Coating





# ULTRACAM

## Radiometric Calibration

Camera: UltraCam Xp  
Serial: UC-SXp-1-40118219

	PAN	R, G, NIR	B
Used Apertures	F5.6	F4	F2.8
	F8	F5.6	F4
	F11	F8	F5.6
	F16	F11	F8
	F22	F16	F11

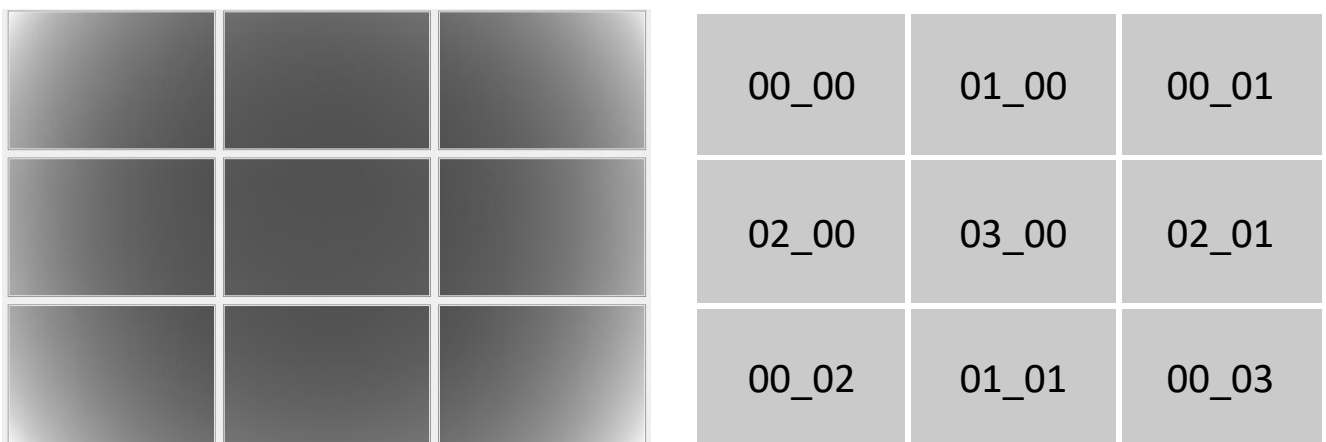
Calibration Date: Sep-09-2019  
Date of Report: Sep-23-2019  
Camera Revision: Rev05.00  
Version of Report: V01



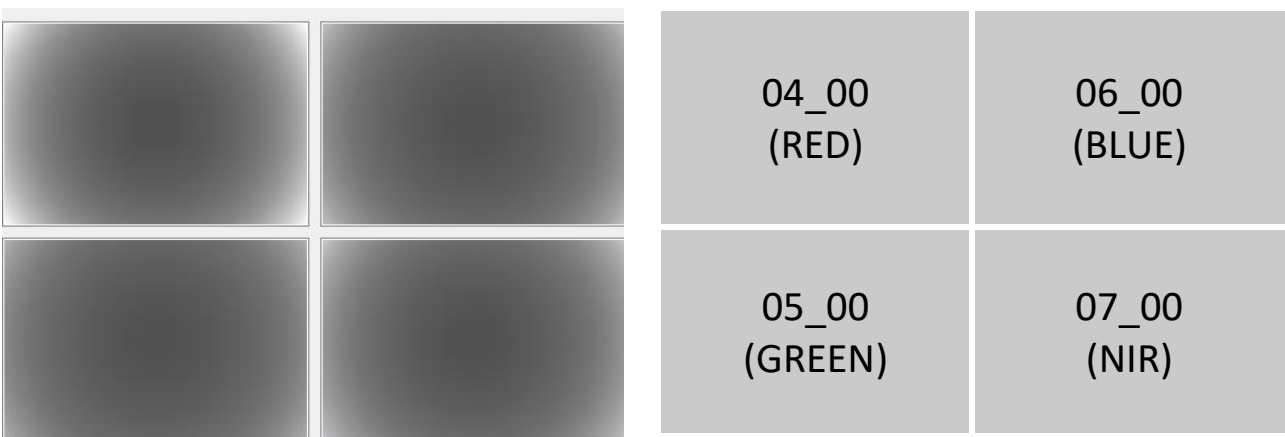
## Calibration of Vignetting for working Aperture F8

	PAN	R, G, NIR	B
Aperture	F8	F5.6	F4

### Graphical Overview of Pan Sensors:



### Graphical Overview of Multispectral Sensors:







## Dead Pixel Report:

Sensor number	Anomaly type	X-Coordinate	Y-Coordinate
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### C00-00

- PIXEL: 101/ 159
- PIXEL: 211/1700
- PIXEL: 278/3575
- PIXEL: 328/2209
- PIXEL: 354/3892
- PIXEL: 533/3525
- PIXEL: 691/2451
- PIXEL: 696/2612
- PIXEL: 696/2613
- PIXEL: 802/2780
- PIXEL: 837/3860
- PIXEL: 877/1666
- PIXEL: 882/1073
- PIXEL: 883/ 651
- PIXEL: 969/ 492
- PIXEL: 1042/2232
- PIXEL: 1042/2233
- PIXEL: 1133/ 794
- PIXEL: 1171/3465
- PIXEL: 1209/1426
- PIXEL: 1480/2614
- PIXEL: 1520/2226
- PIXEL: 1561/3742
- PIXEL: 1606/2636
- PIXEL: 1702/2685
- PIXEL: 1827/3940
- PIXEL: 1945/1217
- PIXEL: 1978/3873
- PIXEL: 2002/ 955
- PIXEL: 2032/1257
- PIXEL: 2047/2527
- PIXEL: 2352/ 295
- PIXEL: 2365/3406
- PIXEL: 2396/ 624
- PIXEL: 2438/ 87
- PIXEL: 2438/2072
- PIXEL: 2458/1817
- PIXEL: 2700/3565
- PIXEL: 2713/1590
- PIXEL: 2768/2688
- PIXEL: 2795/3009
- PIXEL: 2821/ 843
- PIXEL: 2843/1181
- PIXEL: 2915/1699



PIXEL: 2947/3983  
PIXEL: 2978/1424  
PIXEL: 3013/2942  
PIXEL: 3063/2147  
PIXEL: 3116/1990  
PIXEL: 3164/3841  
PIXEL: 3164/3842  
PIXEL: 3241/3026  
PIXEL: 3609/3545  
PIXEL: 3828/2812  
PIXEL: 3834/2470  
PIXEL: 3882/2610  
PIXEL: 3910/2211  
PIXEL: 3931/2667  
PIXEL: 3956/3761  
PIXEL: 4075/3210  
PIXEL: 4188/3025  
PIXEL: 4237/3433  
PIXEL: 4287/ 581  
PIXEL: 4433/ 576  
PIXEL: 4667/2450  
PIXEL: 4688/2945  
PIXEL: 4907/3670  
PIXEL: 4910/2630  
PIXEL: 4990/3524  
PIXEL: 5069/3548  
PIXEL: 5098/2213  
PIXEL: 5160/2702  
PIXEL: 5258/2915  
PIXEL: 5270/1661  
PIXEL: 5304/ 363  
PIXEL: 5317/2641  
PIXEL: 5345/2793  
PIXEL: 5350/1804  
PIXEL: 5437/3348  
PIXEL: 5504/ 748  
PIXEL: 5541/1876  
PIXEL: 5573/1491  
PIXEL: 5583/1934  
PIXEL: 5655/1722  
PIXEL: 5737/2171  
PIXEL: 6022/ 545  
PIXEL: 4780/2206  
PIXEL: 4781/2206  
PIXEL: 5956/ 249

**C00-01**

PIXEL: 158/3914  
PIXEL: 226/1580  
PIXEL: 260/ 779  
PIXEL: 424/2668  
PIXEL: 565/1643  
PIXEL: 865/ 414  
PIXEL: 892/2846  
PIXEL: 992/ 604



PIXEL: 996/3767  
PIXEL: 1046/1113  
PIXEL: 1076/1804  
PIXEL: 1121/2891  
PIXEL: 1122/3721  
PIXEL: 1147/1176  
PIXEL: 1169/1473  
PIXEL: 1372/1750  
PIXEL: 1414/ 947  
PIXEL: 1511/1514  
PIXEL: 1539/3970  
PIXEL: 1713/ 489  
PIXEL: 1717/1783  
PIXEL: 1750/1306  
PIXEL: 1777/ 845  
PIXEL: 1780/2407  
PIXEL: 1866/3116  
PIXEL: 2293/2384  
PIXEL: 2293/2774  
PIXEL: 2330/3430  
PIXEL: 2380/1984  
PIXEL: 2560/3411  
PIXEL: 2563/ 70  
PIXEL: 2587/ 577  
PIXEL: 2724/1743  
PIXEL: 2839/1274  
PIXEL: 2873/ 634  
PIXEL: 2999/3832  
PIXEL: 2999/3880  
PIXEL: 3132/1079  
PIXEL: 3206/1130  
PIXEL: 3222/2769  
PIXEL: 3230/3855  
PIXEL: 3364/1797  
PIXEL: 3439/3562  
PIXEL: 3520/ 282  
PIXEL: 3669/3726  
PIXEL: 3804/2275  
PIXEL: 3847/3571  
PIXEL: 3868/ 294  
PIXEL: 3959/2069  
PIXEL: 4021/ 456  
PIXEL: 4082/2341  
PIXEL: 4117/3102  
PIXEL: 4215/ 553  
PIXEL: 4250/1949  
PIXEL: 4364/ 364  
PIXEL: 4450/1471  
PIXEL: 4460/3193  
PIXEL: 4504/3973  
PIXEL: 4604/2840  
PIXEL: 4612/3140  
PIXEL: 4650/1872  
PIXEL: 4716/1684  
PIXEL: 4780/3181  
PIXEL: 4791/3651



PIXEL: 4977/2313  
PIXEL: 5032/2462  
PIXEL: 5151/3551  
PIXEL: 5198/3625  
PIXEL: 5272/ 228  
PIXEL: 5835/ 724  
PIXEL: 5895/2276  
PIXEL: 5949/3364  
PIXEL: 6002/2564  
PIXEL: 2144/2504  
PIXEL: 2144/2505  
PIXEL: 2145/2504  
PIXEL: 2145/2505

**C00-02**

PIXEL: 50/2570  
PIXEL: 228/ 907  
PIXEL: 296/1371  
PIXEL: 323/3253  
PIXEL: 474/2520  
PIXEL: 600/2459  
PIXEL: 617/ 263  
PIXEL: 657/1002  
PIXEL: 660/1838  
PIXEL: 783/ 570  
PIXEL: 808/3022  
PIXEL: 831/1590  
PIXEL: 894/ 330  
PIXEL: 925/2429  
PIXEL: 987/2157  
PIXEL: 1232/2143  
PIXEL: 1251/3383  
PIXEL: 1273/3310  
PIXEL: 1337/ 251  
PIXEL: 1410/2982  
PIXEL: 1536/ 531  
PIXEL: 1675/ 812  
PIXEL: 1786/ 591  
PIXEL: 1838/2243  
PIXEL: 1889/3794  
PIXEL: 1967/3818  
PIXEL: 1990/1281  
PIXEL: 2008/ 48  
PIXEL: 2028/2270  
PIXEL: 2048/3877  
PIXEL: 2167/1850  
PIXEL: 2191/2975  
PIXEL: 2480/2424  
PIXEL: 2505/1176  
PIXEL: 2516/2972  
PIXEL: 2725/3357  
PIXEL: 2737/1016  
PIXEL: 2768/2440  
PIXEL: 2808/3133  
PIXEL: 2878/2652



PIXEL: 2909/ 735  
PIXEL: 3074/3100  
PIXEL: 3086/3082  
PIXEL: 3111/1026  
PIXEL: 3148/2903  
PIXEL: 3148/2904  
PIXEL: 3160/ 115  
PIXEL: 3271/3174  
PIXEL: 3337/1406  
PIXEL: 3390/ 70  
PIXEL: 3406/ 47  
PIXEL: 3429/ 109  
PIXEL: 3532/3769  
PIXEL: 3567/1799  
PIXEL: 3582/3613  
PIXEL: 3621/ 658  
PIXEL: 3670/2608  
PIXEL: 3704/1712  
PIXEL: 3732/3779  
PIXEL: 3756/2910  
PIXEL: 3783/3069  
PIXEL: 3831/ 719  
PIXEL: 3924/1298  
PIXEL: 3963/ 563  
PIXEL: 3964/ 52  
PIXEL: 4040/2491  
PIXEL: 4064/2444  
PIXEL: 4090/3510  
PIXEL: 4265/1749  
PIXEL: 4321/3433  
PIXEL: 4373/ 464  
PIXEL: 4426/3812  
PIXEL: 4592/1798  
PIXEL: 4594/3010  
PIXEL: 4657/1227  
PIXEL: 4668/3791  
PIXEL: 4752/ 481  
PIXEL: 4757/1306  
PIXEL: 4794/3948  
PIXEL: 4795/3627  
PIXEL: 4854/1979  
PIXEL: 4931/ 113  
PIXEL: 4949/3704  
PIXEL: 5052/2724  
PIXEL: 5214/3121  
PIXEL: 5409/2314  
PIXEL: 5502/1311  
PIXEL: 5630/ 144  
PIXEL: 5685/1421  
PIXEL: 5689/1222  
PIXEL: 5709/ 424  
PIXEL: 5762/3580  
PIXEL: 5869/2511  
PIXEL: 5967/ 678  
PIXEL: 5985/ 431  
PIXEL: 5996/1941



PIXEL: 39/3947

**C00-03**

- PIXEL: 28/2391
- PIXEL: 89/ 360
- PIXEL: 260/1878
- PIXEL: 320/2532
- PIXEL: 418/1108
- PIXEL: 489/1023
- PIXEL: 504/2097
- PIXEL: 519/ 444
- PIXEL: 531/2538
- PIXEL: 594/ 521
- PIXEL: 632/1223
- PIXEL: 674/2835
- PIXEL: 685/1840
- PIXEL: 686/3125
- PIXEL: 706/ 533
- PIXEL: 752/ 482
- PIXEL: 870/2323
- PIXEL: 880/3020
- PIXEL: 927/3562
- PIXEL: 944/2330
- PIXEL: 968/2321
- PIXEL: 1089/3400
- PIXEL: 1093/ 311
- PIXEL: 1096/3081
- PIXEL: 1109/1900
- PIXEL: 1185/3939
- PIXEL: 1211/3274
- PIXEL: 1233/3523
- PIXEL: 1238/2011
- PIXEL: 1323/3494
- PIXEL: 1386/2500
- PIXEL: 1528/2798
- PIXEL: 1538/2430
- PIXEL: 1610/2401
- PIXEL: 1658/1033
- PIXEL: 1874/2266
- PIXEL: 1980/1426
- PIXEL: 1997/1169
- PIXEL: 2070/ 713
- PIXEL: 2187/3872
- PIXEL: 2288/1318
- PIXEL: 2322/1468
- PIXEL: 2474/ 658
- PIXEL: 2484/3884
- PIXEL: 2526/3827
- PIXEL: 2646/1979
- PIXEL: 2707/2206
- PIXEL: 2724/2882
- PIXEL: 2727/ 151
- PIXEL: 2770/2660
- PIXEL: 2807/2438
- PIXEL: 2857/3415



PIXEL: 2905/3508  
PIXEL: 3053/ 640  
PIXEL: 3208/1967  
PIXEL: 3279/2388  
PIXEL: 3348/3757  
PIXEL: 3400/3831  
PIXEL: 3406/ 91  
PIXEL: 3418/1501  
PIXEL: 3427/3049  
PIXEL: 3480/1559  
PIXEL: 3488/1572  
PIXEL: 3497/1334  
PIXEL: 3524/3188  
PIXEL: 3584/2409  
PIXEL: 3668/1091  
PIXEL: 3694/2526  
PIXEL: 3822/3267  
PIXEL: 3822/3268  
PIXEL: 3901/1436  
PIXEL: 3903/2652  
PIXEL: 3905/ 432  
PIXEL: 3953/3861  
PIXEL: 3969/ 857  
PIXEL: 4109/ 399  
PIXEL: 4181/2944  
PIXEL: 4205/1394  
PIXEL: 4272/ 956  
PIXEL: 4659/2160  
PIXEL: 4667/ 458  
PIXEL: 4673/2380  
PIXEL: 4715/ 261  
PIXEL: 4751/3878  
PIXEL: 4763/3660  
PIXEL: 4820/2247  
PIXEL: 4844/3407  
PIXEL: 4965/3799  
PIXEL: 5036/2143  
PIXEL: 5056/1349  
PIXEL: 5129/2437  
PIXEL: 5271/3812  
PIXEL: 5273/2398  
PIXEL: 5330/3059  
PIXEL: 5358/ 878  
PIXEL: 5365/1243  
PIXEL: 5383/3520  
PIXEL: 5440/3303  
PIXEL: 5501/2931  
PIXEL: 5533/ 603  
PIXEL: 5547/2744  
PIXEL: 5609/3884  
PIXEL: 5652/3310  
PIXEL: 5678/3043  
PIXEL: 5738/1230  
PIXEL: 5745/3991  
PIXEL: 5801/1163  
PIXEL: 5989/2732





PIXEL: 188/3802  
PIXEL: 2783/3951

**C01-00**

PIXEL: 89/1470  
PIXEL: 138/1772  
PIXEL: 254/2276  
PIXEL: 283/2907  
PIXEL: 450/3137  
PIXEL: 455/ 432  
PIXEL: 475/3060  
PIXEL: 492/3959  
PIXEL: 682/1601  
PIXEL: 776/2102  
PIXEL: 798/2057  
PIXEL: 837/2027  
PIXEL: 888/3799  
PIXEL: 998/ 648  
PIXEL: 1059/ 108  
PIXEL: 1155/ 507  
PIXEL: 1300/2881  
PIXEL: 1470/1699  
PIXEL: 1526/ 329  
PIXEL: 1544/1027  
PIXEL: 1560/ 59  
PIXEL: 1632/1310  
PIXEL: 1874/3372  
PIXEL: 1875/1771  
PIXEL: 2001/ 710  
PIXEL: 2003/1803  
PIXEL: 2151/2469  
PIXEL: 2187/3660  
PIXEL: 2294/1583  
PIXEL: 2352/1100  
PIXEL: 2480/ 76  
PIXEL: 2838/ 757  
PIXEL: 3043/3202  
PIXEL: 3070/3889  
PIXEL: 3101/3918  
PIXEL: 3141/2111  
PIXEL: 3217/2450  
PIXEL: 3280/1843  
PIXEL: 3366/3904  
PIXEL: 3454/1796  
PIXEL: 3541/2666  
PIXEL: 3580/ 992  
PIXEL: 3616/2711  
PIXEL: 3684/3511  
PIXEL: 3916/2235  
PIXEL: 3951/ 228  
PIXEL: 4037/2702  
PIXEL: 4083/ 965  
PIXEL: 4147/3105  
PIXEL: 4193/2805  
PIXEL: 4207/2595



PIXEL: 4256/3053  
PIXEL: 4280/ 993  
PIXEL: 4297/1396  
PIXEL: 4325/3829  
PIXEL: 4357/2369  
PIXEL: 4364/3917  
PIXEL: 4591/1347  
PIXEL: 4594/2377  
PIXEL: 4599/1555  
PIXEL: 4686/1318  
PIXEL: 4702/3253  
PIXEL: 4745/3558  
PIXEL: 4887/3617  
PIXEL: 4890/1080  
PIXEL: 5050/3638  
PIXEL: 5057/ 692  
PIXEL: 5077/ 876  
PIXEL: 5105/ 292  
PIXEL: 5325/ 888  
PIXEL: 5341/ 840  
PIXEL: 5369/2003  
PIXEL: 5439/ 399  
PIXEL: 5518/2827  
PIXEL: 5583/2409  
PIXEL: 5618/ 783  
PIXEL: 5672/2874  
PIXEL: 5694/3930  
PIXEL: 5726/ 345  
PIXEL: 5734/ 766  
PIXEL: 5866/ 237  
PIXEL: 5946/1714  
PIXEL: 5999/3347  
PIXEL: 469/1739  
PIXEL: 469/1740  
PIXEL: 613/1074  
PIXEL: 933/1960  
PIXEL: 1092/2044  
PIXEL: 1165/3103  
PIXEL: 1405/2693  
PIXEL: 1427/2056  
PIXEL: 1473/2905  
PIXEL: 1474/2905  
PIXEL: 1543/3564  
PIXEL: 1649/2938  
PIXEL: 1685/3494  
PIXEL: 1685/3495  
PIXEL: 2192/1394  
PIXEL: 2193/1394  
PIXEL: 1427/2057  
COLUMN: 5040/3774



**C01-01**

- PIXEL: 103/2734
- PIXEL: 166/3756
- PIXEL: 529/ 530
- PIXEL: 797/2634
- PIXEL: 834/1103
- PIXEL: 891/1616
- PIXEL: 912/ 519
- PIXEL: 1037/ 351
- PIXEL: 1081/2639
- PIXEL: 1086/ 223
- PIXEL: 1094/1539
- PIXEL: 1101/1377
- PIXEL: 1162/ 300
- PIXEL: 1279/3174
- PIXEL: 1308/ 554
- PIXEL: 1321/1776
- PIXEL: 1440/3090
- PIXEL: 1577/1421
- PIXEL: 1579/2613
- PIXEL: 1638/ 281
- PIXEL: 1742/2540
- PIXEL: 1791/2795
- PIXEL: 1839/ 245
- PIXEL: 2041/1086
- PIXEL: 2158/1676
- PIXEL: 2289/1097
- PIXEL: 2634/1333
- PIXEL: 2800/1296
- PIXEL: 2894/2685
- PIXEL: 3066/1284
- PIXEL: 3102/1210
- PIXEL: 3194/2974
- PIXEL: 3572/2935
- PIXEL: 3772/3753
- PIXEL: 3858/3527
- PIXEL: 4077/ 963
- PIXEL: 4385/3543
- PIXEL: 4558/1840
- PIXEL: 4587/1460
- PIXEL: 4603/ 197
- PIXEL: 4642/ 63
- PIXEL: 4790/1936
- PIXEL: 4926/1360
- PIXEL: 4939/3176
- PIXEL: 4943/3931
- PIXEL: 5037/1220
- PIXEL: 5100/1316
- PIXEL: 5347/ 975
- PIXEL: 5409/2969
- PIXEL: 5425/1982
- PIXEL: 5598/ 849
- PIXEL: 5672/1555
- PIXEL: 5731/1541
- PIXEL: 5805/1785



PIXEL: 5819/1328

**C02-00**

- PIXEL: 146/1722
- PIXEL: 155/2017
- PIXEL: 257/3042
- PIXEL: 529/1714
- PIXEL: 815/3105
- PIXEL: 832/3920
- PIXEL: 1106/2977
- PIXEL: 1241/2450
- PIXEL: 1456/1034
- PIXEL: 1467/1577
- PIXEL: 1655/2399
- PIXEL: 1670/2281
- PIXEL: 1733/ 802
- PIXEL: 1753/ 967
- PIXEL: 1803/2307
- PIXEL: 1816/2801
- PIXEL: 1993/ 342
- PIXEL: 2018/3173
- PIXEL: 2021/ 969
- PIXEL: 2071/3212
- PIXEL: 2422/ 970
- PIXEL: 2611/3658
- PIXEL: 2668/1003
- PIXEL: 2842/ 510
- PIXEL: 2986/1618
- PIXEL: 3020/ 716
- PIXEL: 3230/3562
- PIXEL: 3267/2436
- PIXEL: 3321/ 127
- PIXEL: 3533/3511
- PIXEL: 3591/2208
- PIXEL: 3642/2071
- PIXEL: 3857/3884
- PIXEL: 3912/ 280
- PIXEL: 3955/2894
- PIXEL: 4007/ 135
- PIXEL: 4088/ 664
- PIXEL: 4114/1788
- PIXEL: 4261/ 767
- PIXEL: 4352/ 163
- PIXEL: 4367/3447
- PIXEL: 4436/2301
- PIXEL: 4472/1562
- PIXEL: 4498/1938
- PIXEL: 4644/3779
- PIXEL: 4683/2547
- PIXEL: 4723/ 483
- PIXEL: 4748/2171
- PIXEL: 4939/3375
- PIXEL: 4989/ 423
- PIXEL: 5130/ 175
- PIXEL: 5323/1443



PIXEL: 5399/1946  
PIXEL: 5414/3599  
PIXEL: 5489/2280  
PIXEL: 5489/2281  
PIXEL: 5504/2286  
PIXEL: 5548/ 646  
PIXEL: 5696/3352  
PIXEL: 5717/ 407  
PIXEL: 5785/2008  
PIXEL: 5791/1291  
PIXEL: 5798/ 255  
PIXEL: 5902/ 192  
PIXEL: 5915/3816  
PIXEL: 5922/2730  
PIXEL: 5954/2861  
PIXEL: 431/1544  
PIXEL: 431/1545  
PIXEL: 2017/3253  
PIXEL: 2017/3254  
PIXEL: 2017/3255

**C02-01**

PIXEL: 125/1332  
PIXEL: 145/ 346  
PIXEL: 158/3839  
PIXEL: 170/ 28  
PIXEL: 283/2795  
PIXEL: 319/2543  
PIXEL: 352/3684  
PIXEL: 447/1419  
PIXEL: 588/ 690  
PIXEL: 771/3482  
PIXEL: 802/ 621  
PIXEL: 817/1112  
PIXEL: 827/ 982  
PIXEL: 870/1841  
PIXEL: 885/1575  
PIXEL: 1023/1161  
PIXEL: 1080/3116  
PIXEL: 1082/1034  
PIXEL: 1192/3586  
PIXEL: 1197/1501  
PIXEL: 1268/1180  
PIXEL: 1287/1999  
PIXEL: 1414/3630  
PIXEL: 1756/2473  
PIXEL: 1769/3883  
PIXEL: 1835/3067  
PIXEL: 1905/ 897  
PIXEL: 1948/3180  
PIXEL: 2085/1581  
PIXEL: 2120/1047  
PIXEL: 2138/2511  
PIXEL: 2215/1125  
PIXEL: 2352/3791



PIXEL: 2449/2671  
PIXEL: 2637/1343  
PIXEL: 2687/1446  
PIXEL: 2731/ 478  
PIXEL: 2827/1907  
PIXEL: 2881/3306  
PIXEL: 2945/ 383  
PIXEL: 3053/ 231  
PIXEL: 3099/3066  
PIXEL: 3104/1944  
PIXEL: 3257/1211  
PIXEL: 3319/3306  
PIXEL: 3438/3619  
PIXEL: 3601/3854  
PIXEL: 3613/1316  
PIXEL: 3833/1836  
PIXEL: 3867/3749  
PIXEL: 3868/3837  
PIXEL: 3901/3679  
PIXEL: 3911/3304  
PIXEL: 3995/2606  
PIXEL: 4023/2445  
PIXEL: 4082/2812  
PIXEL: 4165/ 330  
PIXEL: 4286/3668  
PIXEL: 4317/ 634  
PIXEL: 4434/1075  
PIXEL: 4439/1255  
PIXEL: 4439/1256  
PIXEL: 4494/ 849  
PIXEL: 4786/3225  
PIXEL: 4850/3913  
PIXEL: 4865/2373  
PIXEL: 4972/3216  
PIXEL: 5055/1545  
PIXEL: 5155/2556  
PIXEL: 5257/1467  
PIXEL: 5476/2661  
PIXEL: 5519/1805  
PIXEL: 5535/1320  
PIXEL: 5564/1913  
PIXEL: 5685/1975  
PIXEL: 5703/ 317  
PIXEL: 5837/3451  
PIXEL: 5921/2307  
PIXEL: 5976/1406  
PIXEL: 6019/3507  
PIXEL: 2172/1955  
PIXEL: 3700/ 824  
PIXEL: 3700/ 825



**C03-00**

- PIXEL: 39/2874
- PIXEL: 98/1846
- PIXEL: 264/3089
- PIXEL: 405/2934
- PIXEL: 520/1446
- PIXEL: 529/2568
- PIXEL: 681/ 104
- PIXEL: 682/ 151
- PIXEL: 766/ 420
- PIXEL: 979/ 956
- PIXEL: 1116/ 658
- PIXEL: 1118/1235
- PIXEL: 1149/1688
- PIXEL: 1635/2133
- PIXEL: 1721/ 756
- PIXEL: 1793/1683
- PIXEL: 1993/2745
- PIXEL: 2068/2780
- PIXEL: 2164/2160
- PIXEL: 2206/1134
- PIXEL: 2247/3011
- PIXEL: 2268/ 957
- PIXEL: 2536/2983
- PIXEL: 2536/2984
- PIXEL: 2613/3459
- PIXEL: 2629/2529
- PIXEL: 2648/1042
- PIXEL: 2771/ 255
- PIXEL: 2930/ 509
- PIXEL: 2935/ 823
- PIXEL: 2967/1637
- PIXEL: 3064/3536
- PIXEL: 3211/3794
- PIXEL: 3259/1211
- PIXEL: 3285/2411
- PIXEL: 3325/3570
- PIXEL: 3377/3659
- PIXEL: 3478/3688
- PIXEL: 3490/1194
- PIXEL: 3688/2980
- PIXEL: 3724/1727
- PIXEL: 3836/1540
- PIXEL: 4044/3952
- PIXEL: 4060/2177
- PIXEL: 4062/ 530
- PIXEL: 4193/3691
- PIXEL: 4245/2224
- PIXEL: 4265/2541
- PIXEL: 4291/2463
- PIXEL: 4407/ 187
- PIXEL: 5196/2851
- PIXEL: 5217/ 31
- PIXEL: 5228/1445
- PIXEL: 5554/3314





PIXEL: 5644/3728  
PIXEL: 5659/2934  
PIXEL: 5678/3722  
PIXEL: 5772/ 307  
PIXEL: 5795/3687  
PIXEL: 5805/3006  
PIXEL: 490/1627  
PIXEL: 4641/2579  
PIXEL: 5567/3088  
PIXEL: 5568/3088

**C04-00**

PIXEL: 29/2427  
PIXEL: 362/2326  
PIXEL: 404/1753  
PIXEL: 505/2574  
PIXEL: 558/2861  
PIXEL: 1361/3544  
PIXEL: 1705/1434  
PIXEL: 1751/ 83  
PIXEL: 1986/2335  
PIXEL: 2068/1427  
PIXEL: 2279/2620  
PIXEL: 2385/2622  
PIXEL: 2472/1011  
PIXEL: 2501/2447  
PIXEL: 2630/1014  
PIXEL: 2652/ 239  
PIXEL: 2877/ 137  
PIXEL: 3163/2401  
PIXEL: 3300/2644  
PIXEL: 3380/3196  
PIXEL: 3459/1538  
PIXEL: 3560/3742  
PIXEL: 3676/ 183  
PIXEL: 3684/3920  
PIXEL: 3813/1148  
PIXEL: 3910/2232  
PIXEL: 4086/1228  
PIXEL: 4366/1583  
PIXEL: 4838/1161  
PIXEL: 4877/3850  
PIXEL: 4995/3022  
PIXEL: 4995/3023  
PIXEL: 5016/2870  
PIXEL: 5085/1807  
PIXEL: 5114/ 97  
PIXEL: 5213/ 974  
PIXEL: 5218/3046  
PIXEL: 5226/3493  
PIXEL: 5396/3962  
PIXEL: 5405/ 793  
PIXEL: 5435/ 524  
PIXEL: 5562/ 255  
PIXEL: 5594/1033



PIXEL: 5618/1292  
PIXEL: 5669/3209  
PIXEL: 5754/2705  
PIXEL: 5904/2555  
PIXEL: 6021/ 662

**C05-00**

PIXEL: 37/ 725  
PIXEL: 56/2487  
PIXEL: 95/1630  
PIXEL: 177/3183  
PIXEL: 249/2658  
PIXEL: 388/3776  
PIXEL: 443/ 349  
PIXEL: 548/2778  
PIXEL: 571/3148  
PIXEL: 626/ 357  
PIXEL: 958/2908  
PIXEL: 1039/3592  
PIXEL: 1051/2045  
PIXEL: 1235/1778  
PIXEL: 1328/1449  
PIXEL: 1496/2899  
PIXEL: 1540/ 978  
PIXEL: 1838/3047  
PIXEL: 1990/ 127  
PIXEL: 1993/3804  
PIXEL: 2030/ 916  
PIXEL: 2077/ 59  
PIXEL: 2407/2304  
PIXEL: 2605/3307  
PIXEL: 2702/3823  
PIXEL: 2720/3436  
PIXEL: 2742/ 706  
PIXEL: 2847/ 577  
PIXEL: 2870/3499  
PIXEL: 2989/3377  
PIXEL: 3148/2989  
PIXEL: 3242/1593  
PIXEL: 3362/3126  
PIXEL: 3491/2178  
PIXEL: 3576/ 517  
PIXEL: 3580/1787  
PIXEL: 4025/ 44  
PIXEL: 4178/1225  
PIXEL: 4340/1450  
PIXEL: 4390/3525  
PIXEL: 4396/ 338  
PIXEL: 4596/1740  
PIXEL: 4755/3741  
PIXEL: 4887/2940  
PIXEL: 5073/2884  
PIXEL: 5271/2842  
PIXEL: 5465/2611  
PIXEL: 5586/2820



PIXEL: 5665/988  
PIXEL: 5854/1510  
PIXEL: 5866/1509  
PIXEL: 6015/3802  
PIXEL: 703/985  
PIXEL: 2311/290  
PIXEL: 2557/1956  
PIXEL: 2557/1957  
PIXEL: 3721/2379  
PIXEL: 703/986

**C06-00**

PIXEL: 30/3222  
PIXEL: 117/3259  
PIXEL: 223/349  
PIXEL: 310/1434  
PIXEL: 446/84  
PIXEL: 446/2467  
PIXEL: 749/2666  
PIXEL: 852/1663  
PIXEL: 964/232  
PIXEL: 1022/844  
PIXEL: 1051/1809  
PIXEL: 1188/2409  
PIXEL: 1200/1923  
PIXEL: 1220/2550  
PIXEL: 1282/696  
PIXEL: 1311/2673  
PIXEL: 1348/2133  
PIXEL: 1421/2419  
PIXEL: 1475/1817  
PIXEL: 1581/1927  
PIXEL: 1727/2154  
PIXEL: 1804/2056  
PIXEL: 1888/2149  
PIXEL: 1888/2150  
PIXEL: 1968/111  
PIXEL: 2369/1989  
PIXEL: 2607/47  
PIXEL: 2921/2257  
PIXEL: 3019/2079  
PIXEL: 3257/3518  
PIXEL: 3274/3393  
PIXEL: 3420/3668  
PIXEL: 3540/3052  
PIXEL: 3692/3442  
PIXEL: 3707/1692  
PIXEL: 3711/3041  
PIXEL: 3984/2342  
PIXEL: 4281/633  
PIXEL: 4292/3621  
PIXEL: 4319/927  
PIXEL: 4556/2276  
PIXEL: 4613/3600  
PIXEL: 4624/1816



PIXEL: 4837/ 160  
PIXEL: 4856/3201  
PIXEL: 5282/2669  
PIXEL: 5554/2627  
PIXEL: 5789/2755  
PIXEL: 5796/3531  
PIXEL: 5911/1236  
PIXEL: 5998/3067  
PIXEL: 538/3277

**C07-00**

PIXEL: 65/ 536  
PIXEL: 97/1220  
PIXEL: 148/ 232  
PIXEL: 243/2498  
PIXEL: 326/ 138  
PIXEL: 368/2824  
PIXEL: 454/3667  
PIXEL: 579/ 628  
PIXEL: 595/ 530  
PIXEL: 612/3433  
PIXEL: 795/1284  
PIXEL: 898/1544  
PIXEL: 902/3215  
PIXEL: 925/ 717  
PIXEL: 970/3653  
PIXEL: 1216/3097  
PIXEL: 1233/ 465  
PIXEL: 1305/ 78  
PIXEL: 1474/3623  
PIXEL: 1556/2739  
PIXEL: 1766/ 697  
PIXEL: 2070/1270  
PIXEL: 2191/ 212  
PIXEL: 2336/2572  
PIXEL: 2341/ 841  
PIXEL: 2374/ 875  
PIXEL: 2380/3681  
PIXEL: 2505/ 143  
PIXEL: 3189/1840  
PIXEL: 3460/3883  
PIXEL: 3505/ 75  
PIXEL: 3839/2065  
PIXEL: 4020/ 400  
PIXEL: 4081/2058  
PIXEL: 4098/2563  
PIXEL: 4231/1578  
PIXEL: 4271/1079  
PIXEL: 4340/1286  
PIXEL: 4603/2473  
PIXEL: 4680/3852  
PIXEL: 4839/3060  
PIXEL: 4868/2095  
PIXEL: 4984/ 415  
PIXEL: 5216/3856



PIXEL: 5591/3625  
PIXEL: 5629/2991  
PIXEL: 5666/3616  
PIXEL: 5668/ 24  
PIXEL: 2672/3481  
PIXEL: 3087/3908  
PIXEL: 3087/3909  
PIXEL: 4763/2460  
PIXEL: 5696/3969

**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 Xp  
**Serial:** UC-SXp-1-40118219

**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:** Sep-09-2019  
**Date of Report:** Sep-23-2019  
**Camera Revision:** Rev05.00  
**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 F8 [ms]	SRT F11 [ms]	SRT F16 [ms]	SRT F22 [ms]	Measurement Tolerance [ms]
C0 (Pan)	11 82 14 89	10.71	11.68	12.59	13.14	13.30	+/- 0.2
C1 (Pan)	11 86 19 59	10.26	11.05	11.61	12.00	12.25	+/- 0.2
C2 (Pan)	11 86 19 76	10.91	11.91	12.51	12.98	13.21	+/- 0.2
C3 (Pan)	11 86 19 24	10.48	11.59	12.19	12.58	12.82	+/- 0.2
C4 (Red)	11 86 49 79	10.92	11.47	12.06	12.49	12.64	+/- 0.2
C5 (Green)	11 86 49 77	11.77	12.42	12.99	13.38	13.71	+/- 0.2
C6 (Blue)	11 86 49 86	11.46	11.69	12.36	12.73	13.03	+/- 0.2
C7 (NIR)	11 86 49 97	11.64	12.34	12.72	13.06	13.16	+/- 0.2





# **ULTRACAM**

## Electronics and Sensor Calibration

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**Camera:** UltraCam Xp  
**Serial:** UC-SXp-1-40118219

**Panchromatic Camera:** 9 \* FTF6040-M Area CCD Sensor by DALSA  
**Multispectral Camera:** 4 \* FTF6040-M Area CCD Sensor by DALSA

**Calibration Date:** Sep-09-2019  
**Date of Report:** Sep-23-2019  
**Camera Revision:** Rev05.00  
**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	FTF6040-M	13 1859/25	22.30
00_01	FTF6040-M	13 1106/36	22.30
00_02	FTF6040-M	13 1106/67	22.30
00_03	FTF6040-M	13 1106/43	22.50
01_00	FTF6040-M	13 1106/58	22.50
01_01	FTF6040-M	13 1106/05	22.30
02_00	FTF6040-M	13 1106/66	22.30
02_01	FTF6040-M	13 1106/45	22.60
03_00	FTF6040-M	13 1106/47	22.50
04_00 (red)	FTF6040-M	13 1106/53	22.60
05_00 (green)	FTF6040-M	13 1106/02	22.60
06_00 (blue)	FTF6040-M	13 1859/28	22.10
07_00 (NIR)	FTF6040-M	13 1859/23	22.10



## 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	FTF6040-M	13 1859/25	7250
00_01	FTF6040-M	13 1106/36	6590
00_02	FTF6040-M	13 1106/67	6540
00_03	FTF6040-M	13 1106/43	7340
01_00	FTF6040-M	13 1106/58	7470
01_01	FTF6040-M	13 1106/05	4520
02_00	FTF6040-M	13 1106/66	6770
02_01	FTF6040-M	13 1106/45	6570
03_00	FTF6040-M	13 1106/47	7190
04_00 (red)	FTF6040-M	13 1106/53	7460
05_00 (green)	FTF6040-M	13 1106/02	6790
06_00 (blue)	FTF6040-M	13 1859/28	7450
07_00 (NIR)	FTF6040-M	13 1859/23	7870



# ULTRACAM

## Summary

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<b>Camera:</b>	<b>UltraCam Xp</b>
<b>Serial:</b>	<b>UC-SXp-1-40118219</b>
<b>Calibration Date:</b>	<b>Sep-09-2019</b>
<b>Date of Report:</b>	<b>Sep-23-2019</b>
<b>Camera Revision:</b>	<b>Rev05.00</b>
<b>Version of Report:</b>	<b>V01</b>

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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