

Calibration Report



Camera:	UltraCam D, S/N UCD-SU-1-0029
Manufacturer:	Microsoft Photogrammetry, A-8010 Graz, Austria
Date of Calibration:	Jun-27-2007
Date of Report:	Jun-29-2007
Camera Revision:	5.0
Revision of Report:	5.0

Calibration Report

Geometric Calibration



Camera:	UltraCam D, S/N UCD-SU-1-0029
Manufacturer:	Microsoft Photogrammetry, A-8010 Graz, Austria
Panchromatic Camera:	ck = 105.200mm
Multispectral Camera:	ck = 105.200mm
Date of Calibration:	Jun-27-2007
Date of Report:	Jun-29-2007
Camera Revision:	5.0
Revision of Report:	5.0

Panchromatic Camera

Large Format Panchromatic Output Image

Image Format	long track	67.5mm	7500 pixel
	cross track	103.5mm	11500 pixel
Image Extent		(-33.75, -51.75)mm	(33.75, 51.75)mm
Pixel Size		9.000μm*9.000μm	
Focal Length	ck	105.200mm	± 0.002mm
Principal Point	X_ppa	-0.180 mm	± 0.002mm
(Level 2)	Y_ppa	0.000 mm	± 0.002mm
Lens Distortion	Remaining Distortion less than 0.002mm		

Multispectral Camera

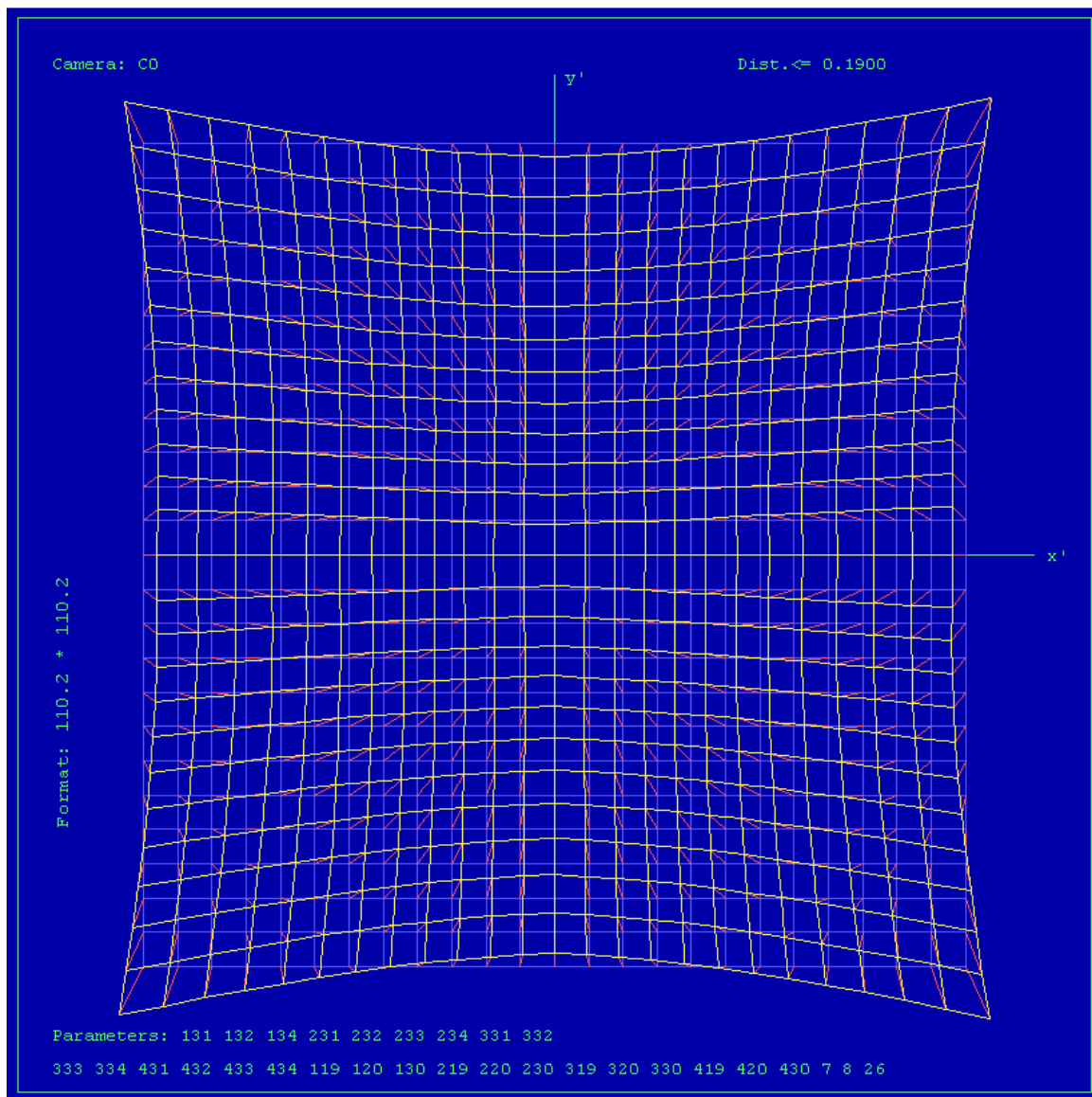
Medium Format Multispectral Output Image (Upscaled to panchromatic image format)

Image Format	long track	67.5mm	2400 pixel
	cross track	103.5mm	3680 pixel
Image Extent		(-33.75, -51.75)mm	(33.75, 51.75)mm
Pixel Size		28.125μm*28.125μm	
Focal Length	ck	105.200mm	
Principal Point	X_ppa	-0.180 mm	± 0.002mm
(Level 2)	Y_ppa	0.000 mm	± 0.002mm
Lens Distortion	Remaining Distortion less than 0.002mm		

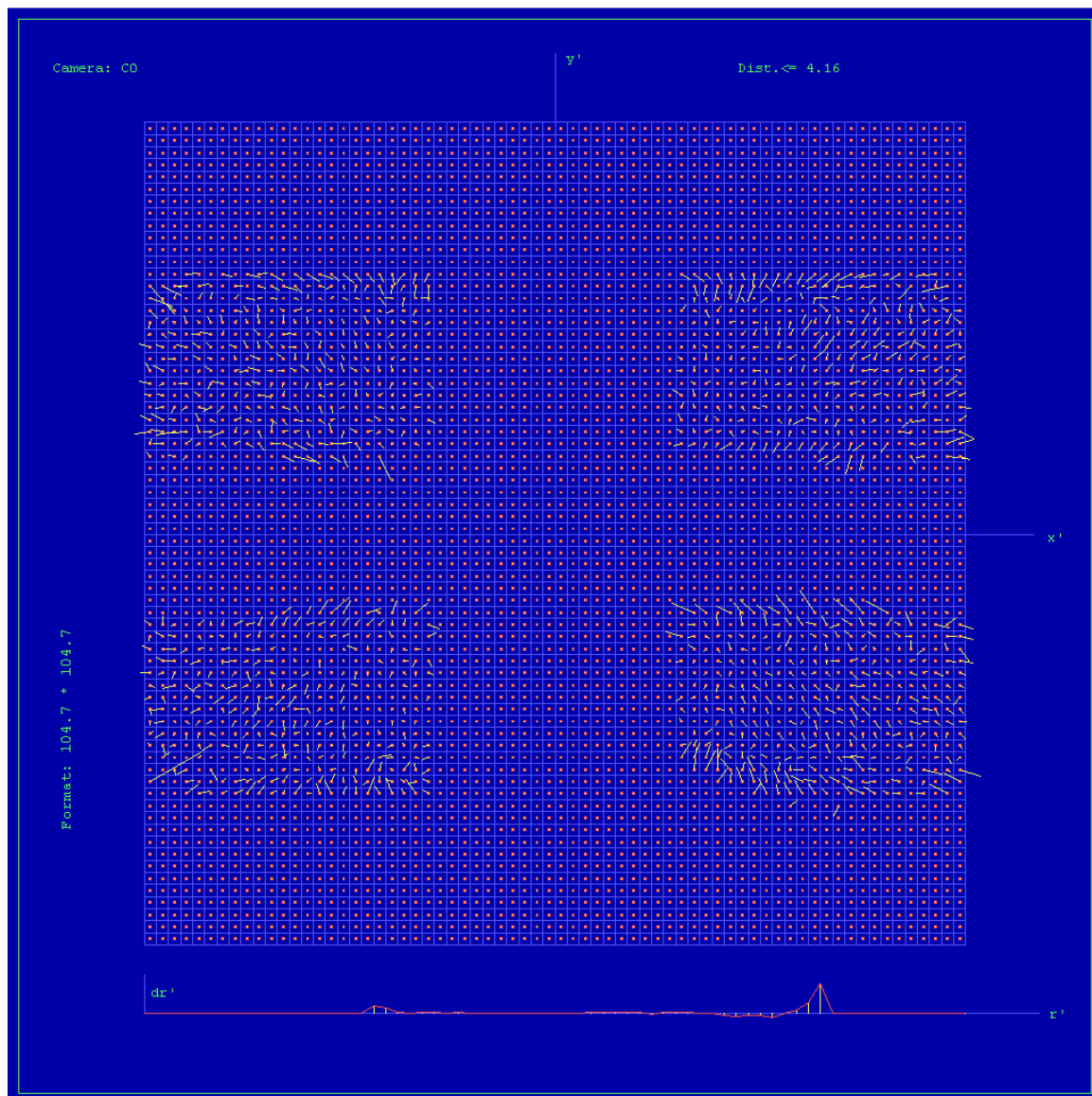
Individual Panchromatic Cone Data

Cone 0, Parametric Description, Not Effective in Output Image

Cone # C0														
Lens	Rodenstock Apo-Sironar Digital 105mm Linios GmbH, Germany													
Shutter	Prontor Magnetic Prontor-Werk Alfred Gauthier GmbH													
Image Extent (nominally)		(-33.75, -51.75)mm	(33.75, 51.75)mm											
Extent CCD 0		(-33.75, -51.75)mm	(-9.75, -15.75)mm											
Extent CCD 1		(-33.75, 15.75)mm	(-9.75, 51.75)mm											
Extent CCD 2		(9.75, -51.75)mm	(33.75, -15.75)mm											
Extent CCD 3		(9.75, 15.75)mm	(33.75, 51.75)mm											
Parameters	Shift X	ShiftY	Rotation	Scale										
CCD0	1,6556350E-01 mm ± 0.0010 mm	-7,2244485E-02 mm ± 0.0017 mm	9,5675631E-02 gon ± 0.0001 gon	1,0055363 ± 0.00005										
CCD1	2,0864596E-01 mm ± 0.0010 mm	-1,4109173E-01 mm ± 0.0017 mm	0.00000000 gon	1,0066465 ± 0.00005										
CCD2	1,9288099E-01 mm ± 0.0010 mm	-1,8369967E-02 mm ± 0.0017 mm	2,7250188E-02 gon ± 0.0001 gon	1,0058243 ± 0.00005										
CCD3	1,6210920E-01 mm ± 0.0010 mm	-1,6023434E-01 mm ± 0.0017 mm	1,4082882E-01 gon ± 0.0001 gon	1,0068835 ± 0.00005										
Radial Distortion														
R [mm]	5.0 10.0 15.0 20.0 25.0 30.0 35.0 40.0 45.0 50.0 55.0 60.0 65.0													
dr [µm]	-13.9 -29.4 -45.3 -60.2 -72.9 -82.3 -87.2 -86.8 -80.0 -65.9 -43.6 -12.6 28.1													

Cone 0, Distortion Diagram, Not Effective in Output Image

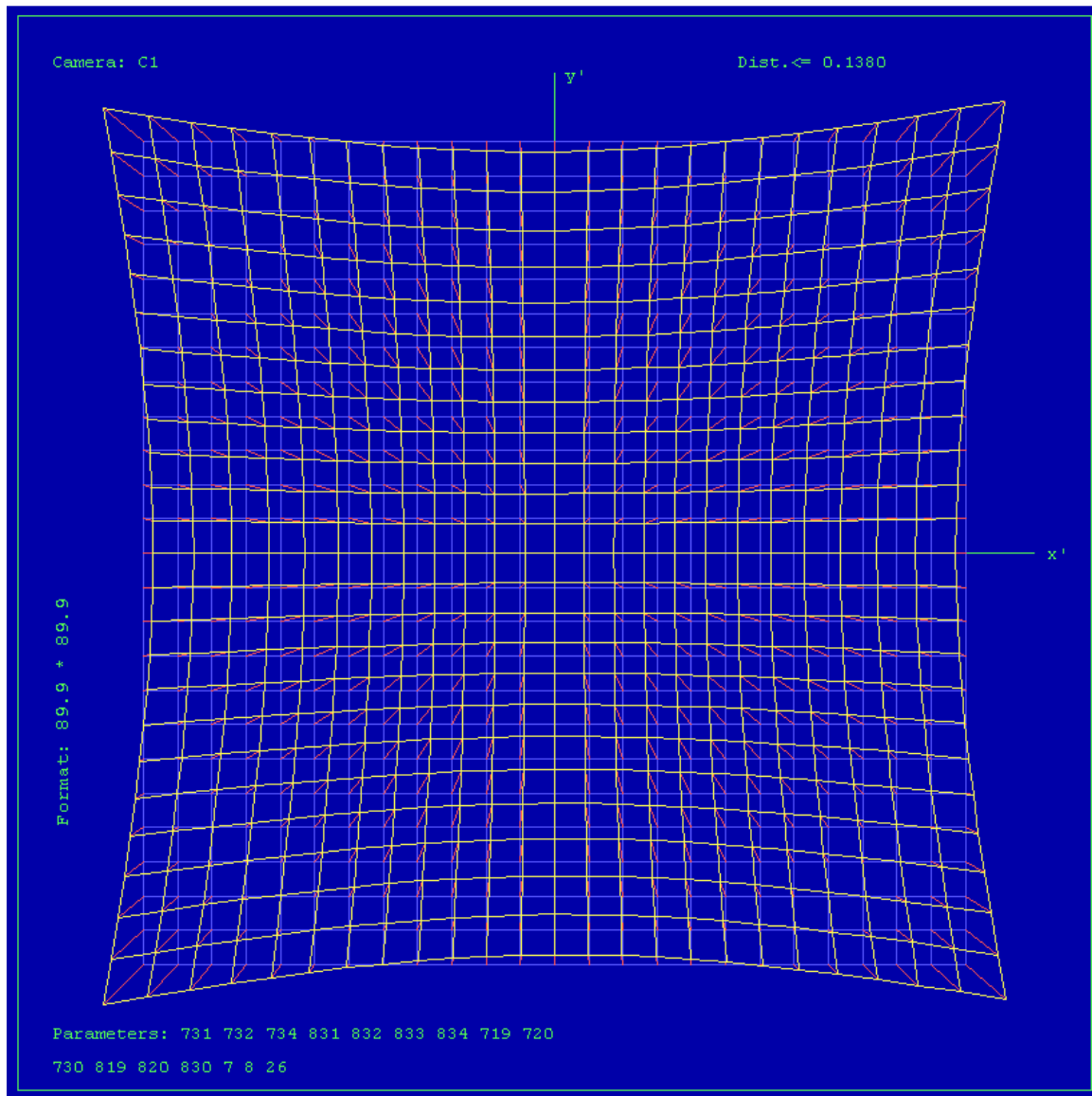
Cone 0, Residual Error Diagram

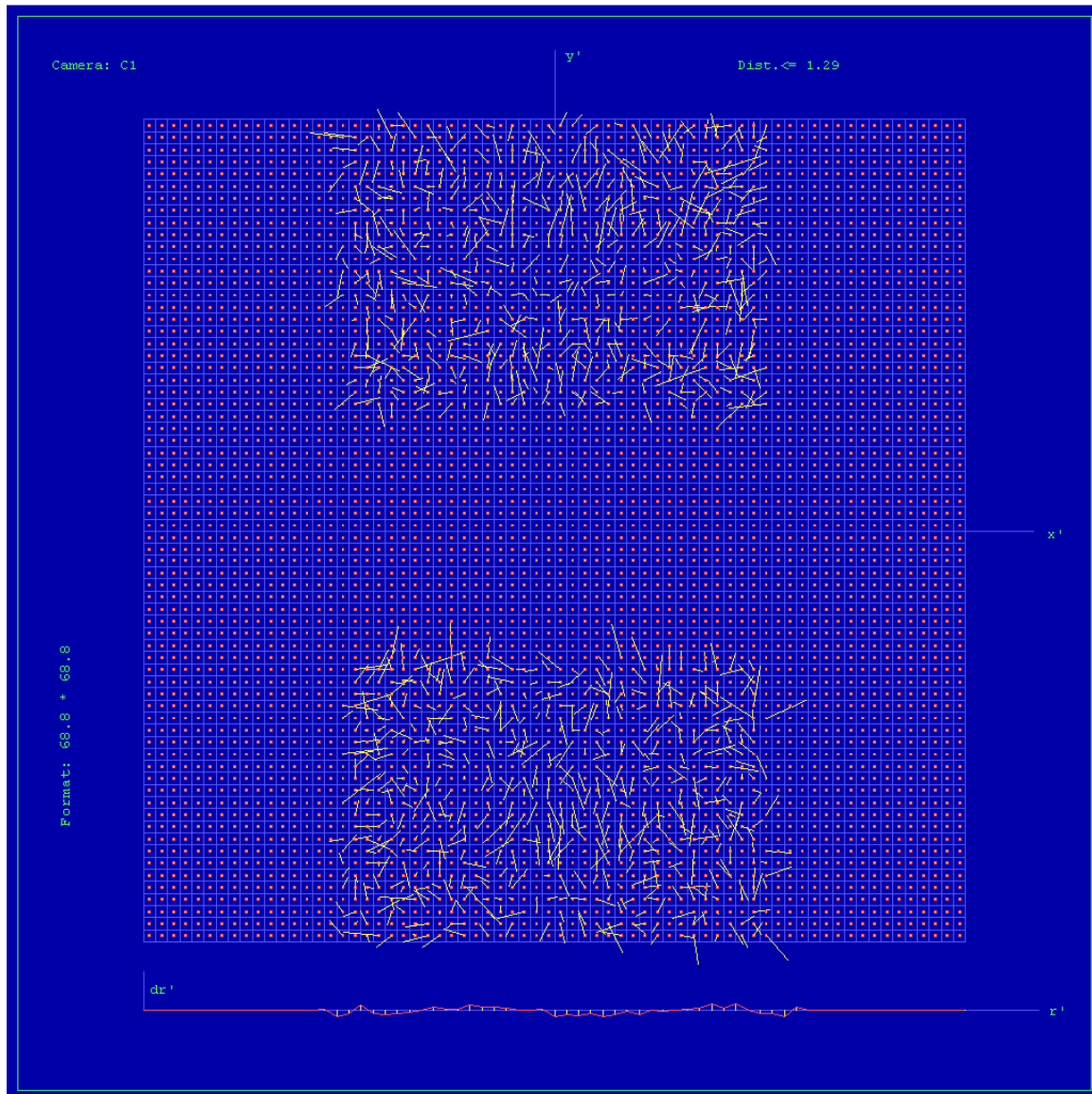


Residual Error (RMS): 0.58 μm

Cone 1, Parametric Description, Not Effective in Output Image

Cone # C1				
Lens	Rodenstock Apo-Sironar Digital 105mm Linos GmbH, Germany			
Shutter	Prontor Magnetic Prontor-Werk Alfred Gauthier GmbH			
Image Extent (nominally)		(-33.75, -18.04)mm	(33.75, 18.04)mm	
Extent CCD 0		(-33.75, -18.04)mm	(-9.75, 18.04)mm	
Extent CCD 1		(9.75, -18.04)mm	(33.75, 18.04)mm	
Parameters	Shift X	Shift Y	Rotation	Scale
CCD0	1,2616617E-01 mm ± 0.0017 mm	-1,4666152E-01 mm ± 0.0013 mm	0.00000000 gon	1,0089154 ± 0.00005
CCD1	3,0379486E-02 mm ± 0.0017 mm	-1,6626437E-01 mm ± 0.0013 mm	8,1609516E-02 gon ± 0.0001 gon	1,0097168 ± 0.00005
Radial Distortion				
R [mm]	5.0	10.0	15.0	20.0 25.0 30.0 35.0 40.0 45.0 50.0 55.0 60.0
dr [µm]	-15.0	-29.5	-42.1	-52.0 -58.0 -59.1 -54.4 -42.8 -23.5 4.6 42.3 90.6

Cone 1, Distortion Diagram, Not Effective in Output Image

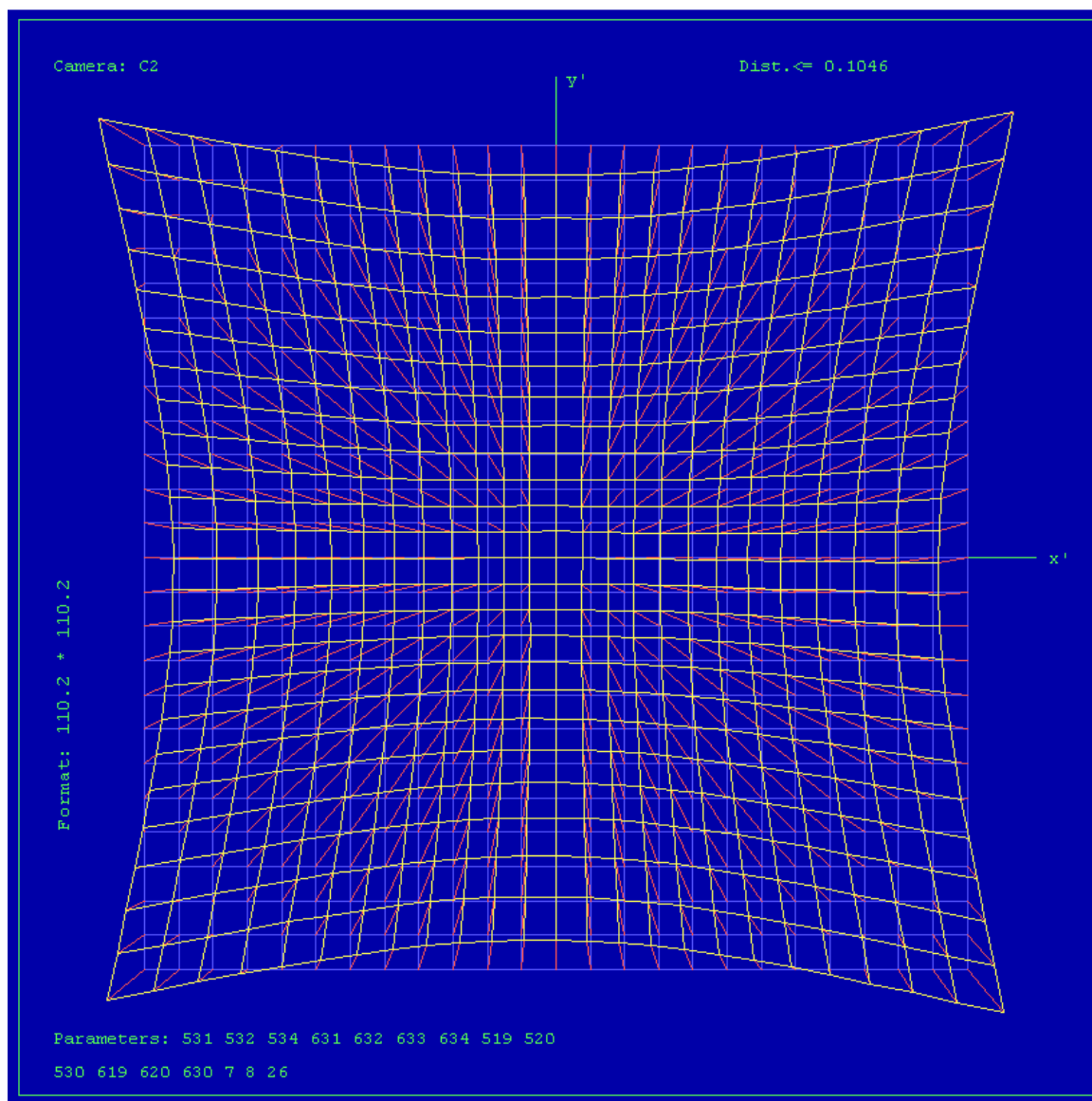
Cone 1, Residual Error Diagram

Residual Error (RMS): **0.46 μm**

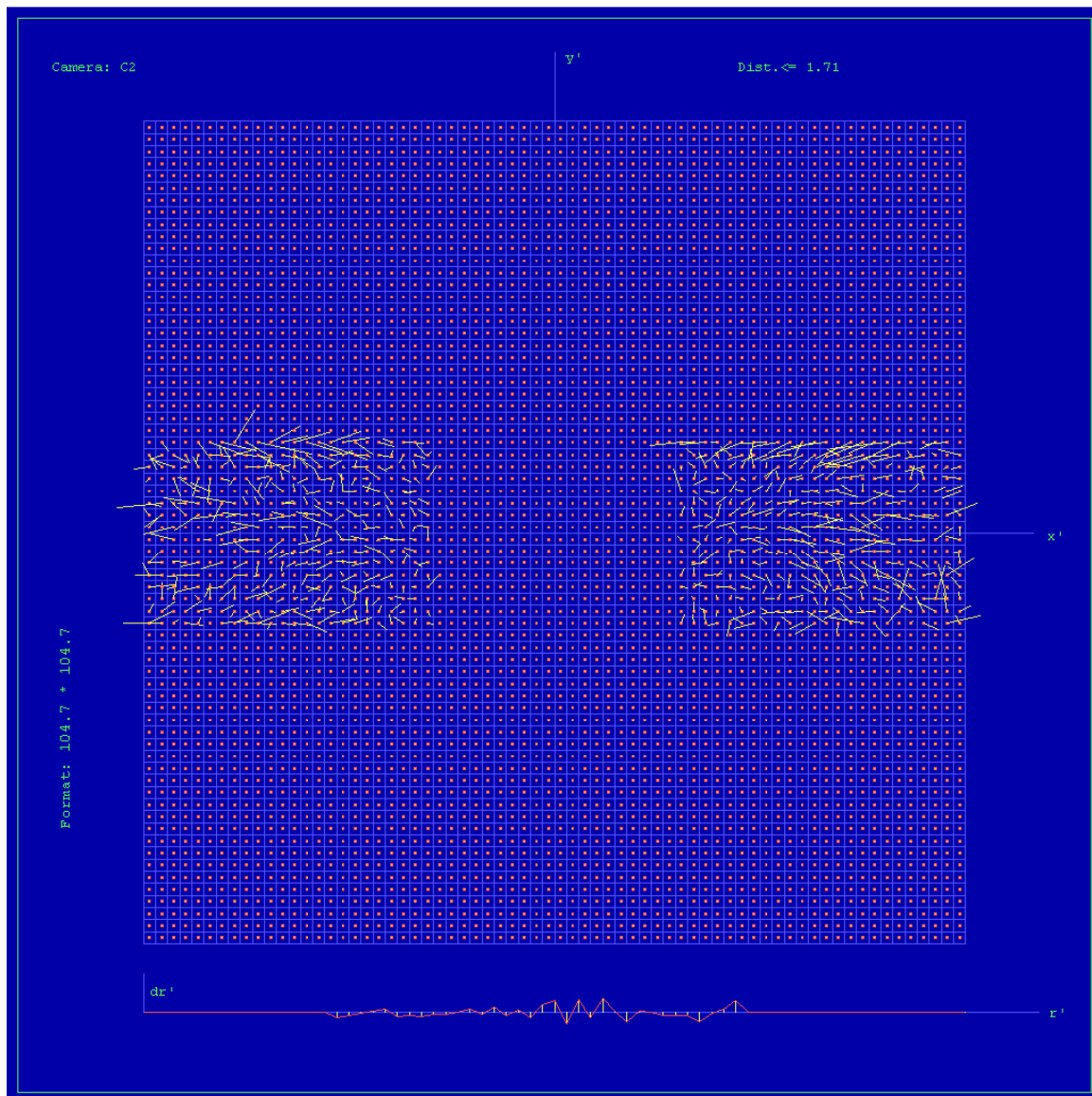
Cone 2, Parametric Description, Not Effective in Output Image

Cone # C2												
Lens	Rodenstock Apo-Sironar Digital 105mm Linos GmbH, Germany											
Shutter	Prontor Magnetic Prontor-Werk Alfred Gauthier GmbH											
Image Extent (nominally)		(-12.01, -51.75)mm	(12.01, 51.75)mm									
Extent CCD 0		(-12.01, -51.75)mm	(12.01, -15.75)mm									
Extent CCD 1		(-12.01, 15.75)mm	(12.01, 51.75)mm									
Parameters	Shift X	ShiftY	Rotation	Scale								
CCD0	-2,6067389E-03 mm ± 0.0011 mm	-2,1584870E-01 mm ± 0.0047 mm	-4,7974679E-02 gon ± 0.0001 gon	1,0034085 ± 0.00005								
CCD1	3,1735117E-01 mm ± 0.0012 mm	-2,6943411E-01 mm ± 0.0047 mm	0.00000000 gon	1,0051100 ± 0.00005								
Radial Distortion												
R [mm]	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0
dr [µm]	-16.4	-33.7	-50.7	-66.1	-78.7	-87.7	-92.2	-91.6	-85.4	-73.3	-55.0	-30.6

Cone 2, Distortion Diagram, Not Effective in Output Image



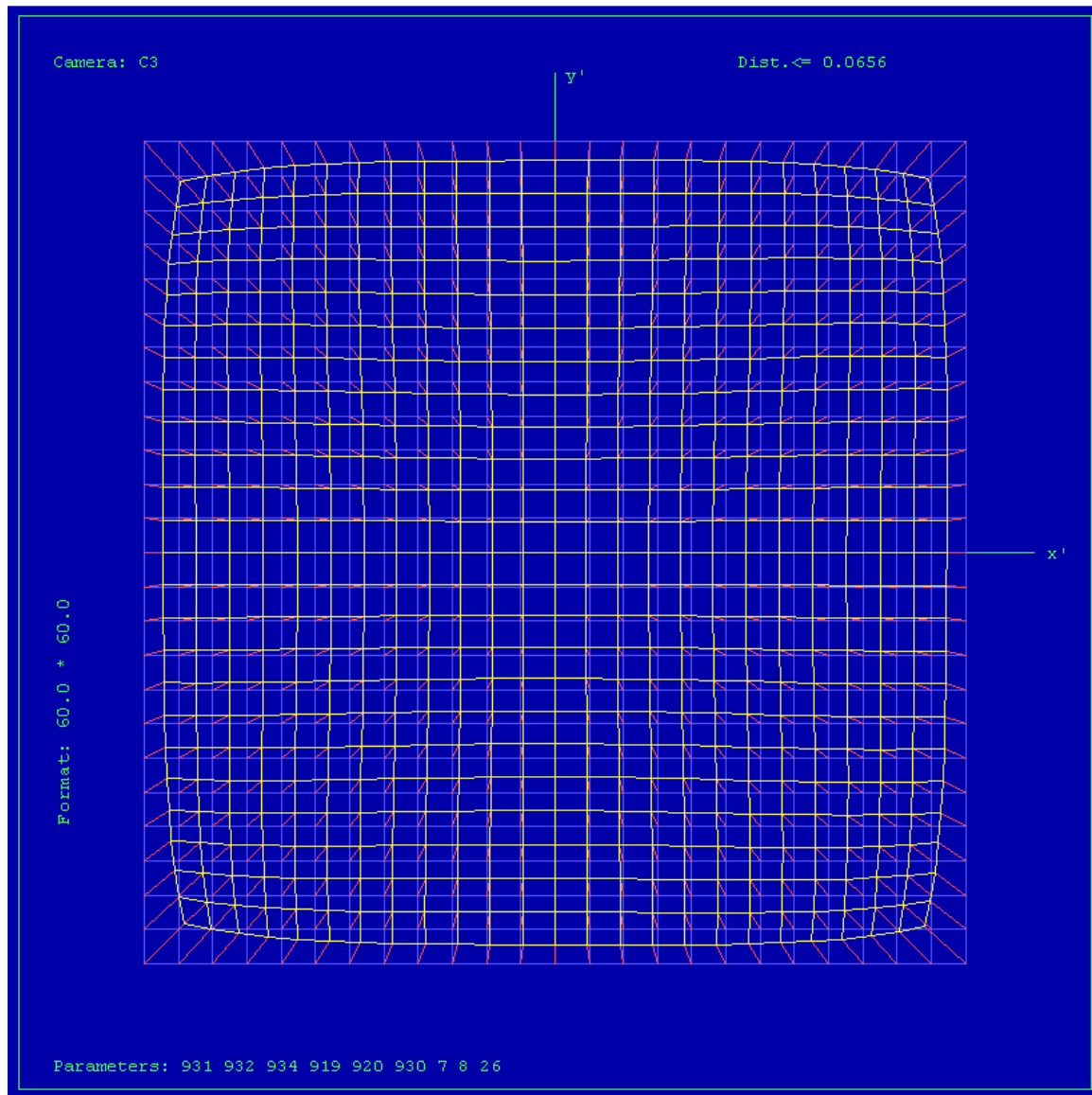
Cone 2, Residual Error Diagram



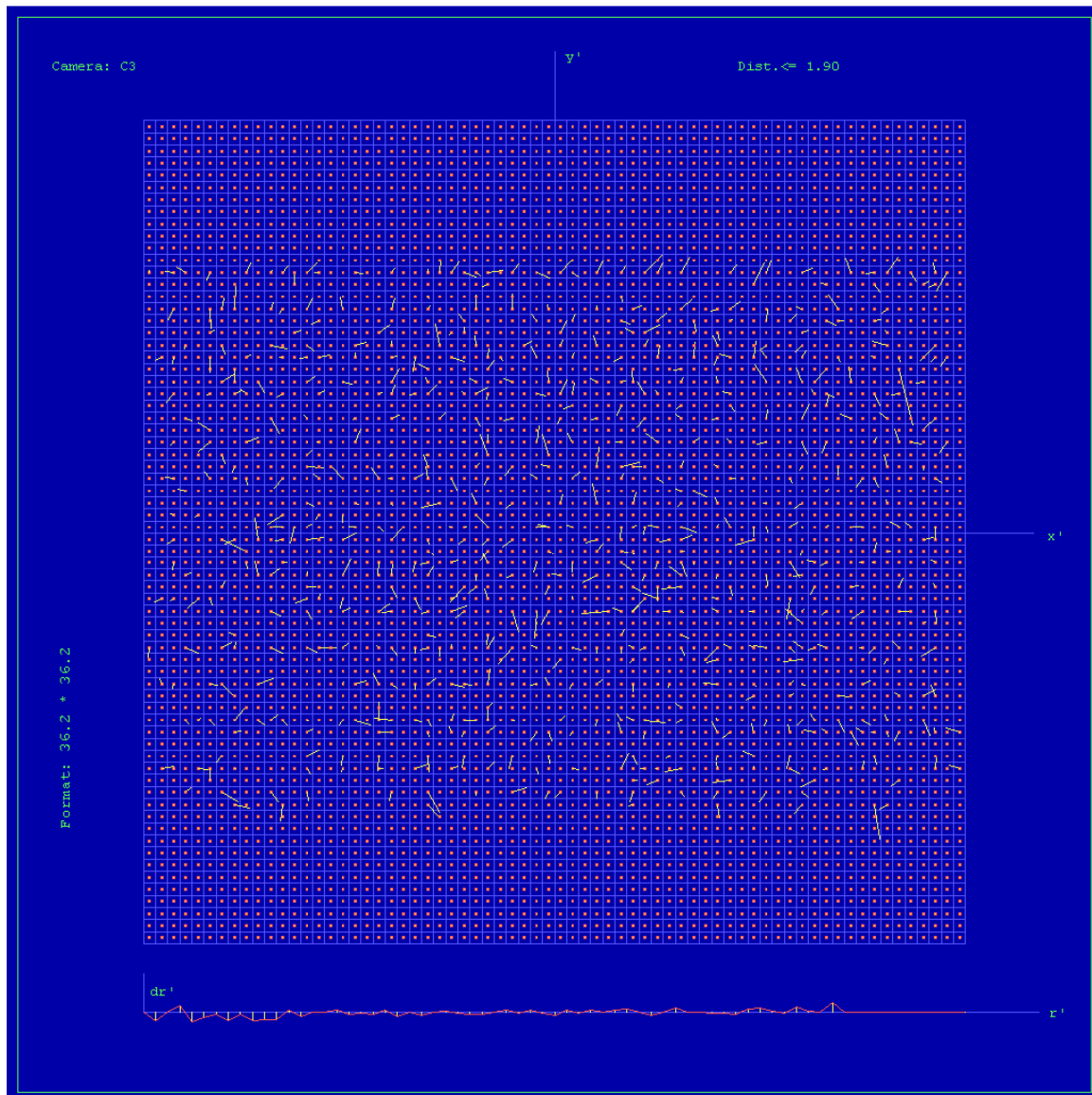
Residual Error (RMS): **0.56 μm**

Cone 3, Parametric Description, Not Effective in Output Image

Cone # C3										
Lens		Rodenstock Apo-Sironar Digital 105mm Linos GmbH, Germany								
Shutter		Prontor Magnetic Prontor-Werk Alfred Gauthier GmbH								
Image Extent (nominally)					(-12.01, -18.04)mm			(12.01, 18.04)mm		
Extent CCD 0					(-12.01, -18.04)mm			(12.01 , 18.04)mm		
Parameters		Shift X			ShiftY			Rotation		Scale
CCD0		4,6047338E-02 mm ± 0.0025 mm			1,1433660E-02 mm ± 0.0057 mm			0.00000000 gon		1,0114973 ± 0.00005
Radial Distortion										
R [mm]		2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5 25.0
dr [µm]		-1.4	-2.9	-4.3	-5.2	-5.5	-5.3	-4.4	-3.1	-1.6 -0.1

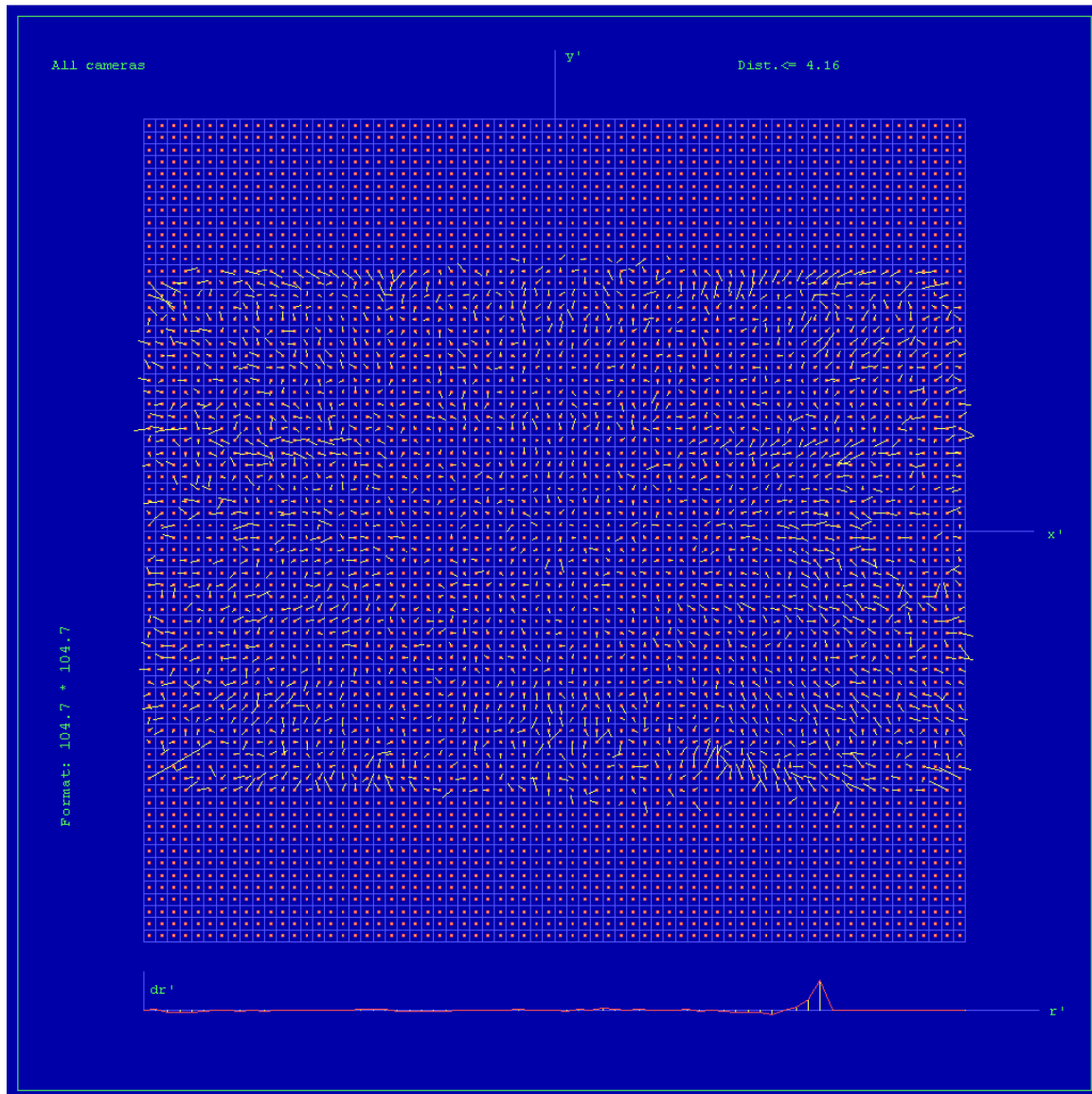
Cone 3, Distortion Diagram, Not Effective in Output Image

Cone 3, Residual Error Diagram



Residual Error (RMS): **0.39 μm**

Full Pan Image, Residual Error Diagram

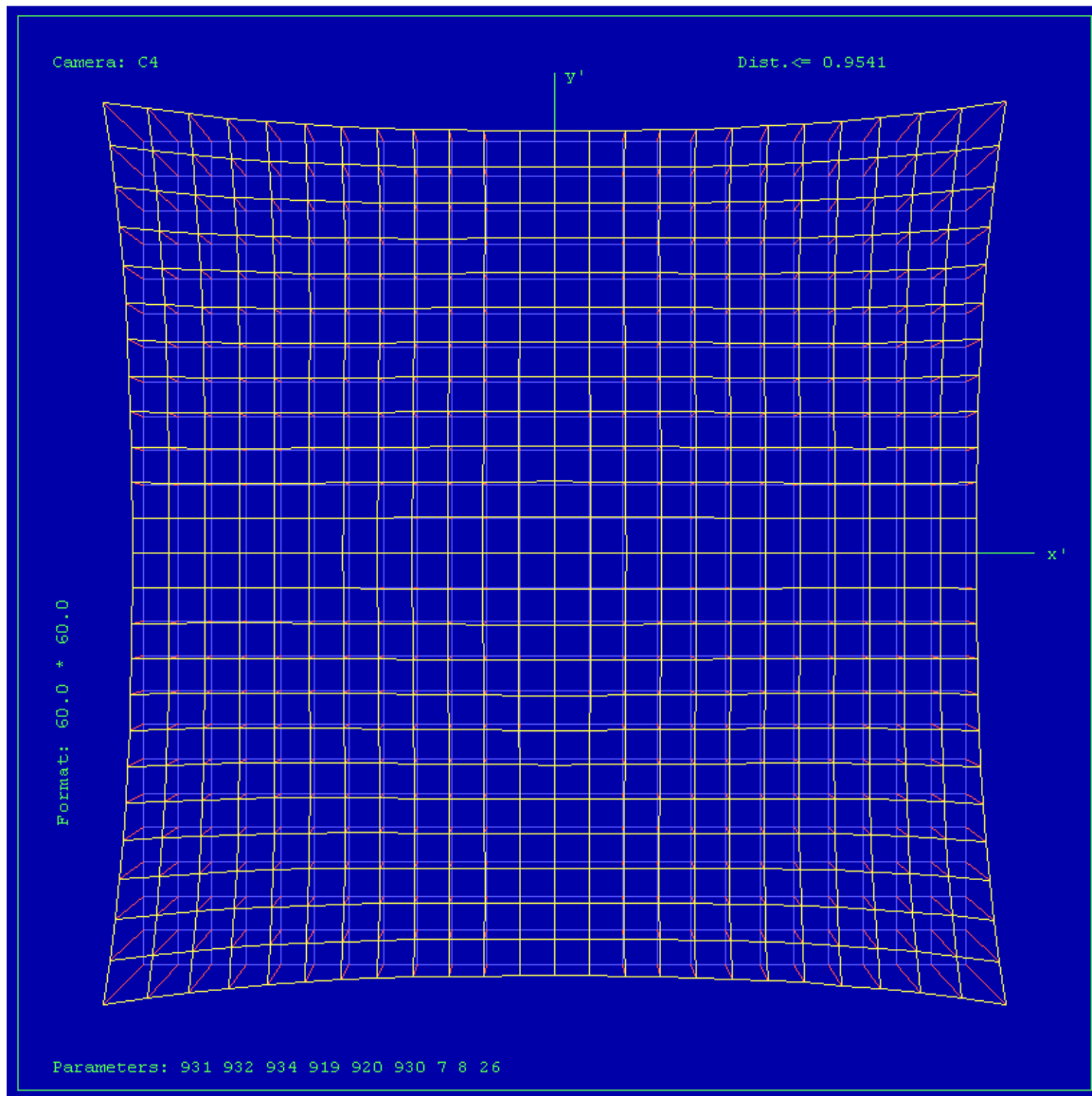


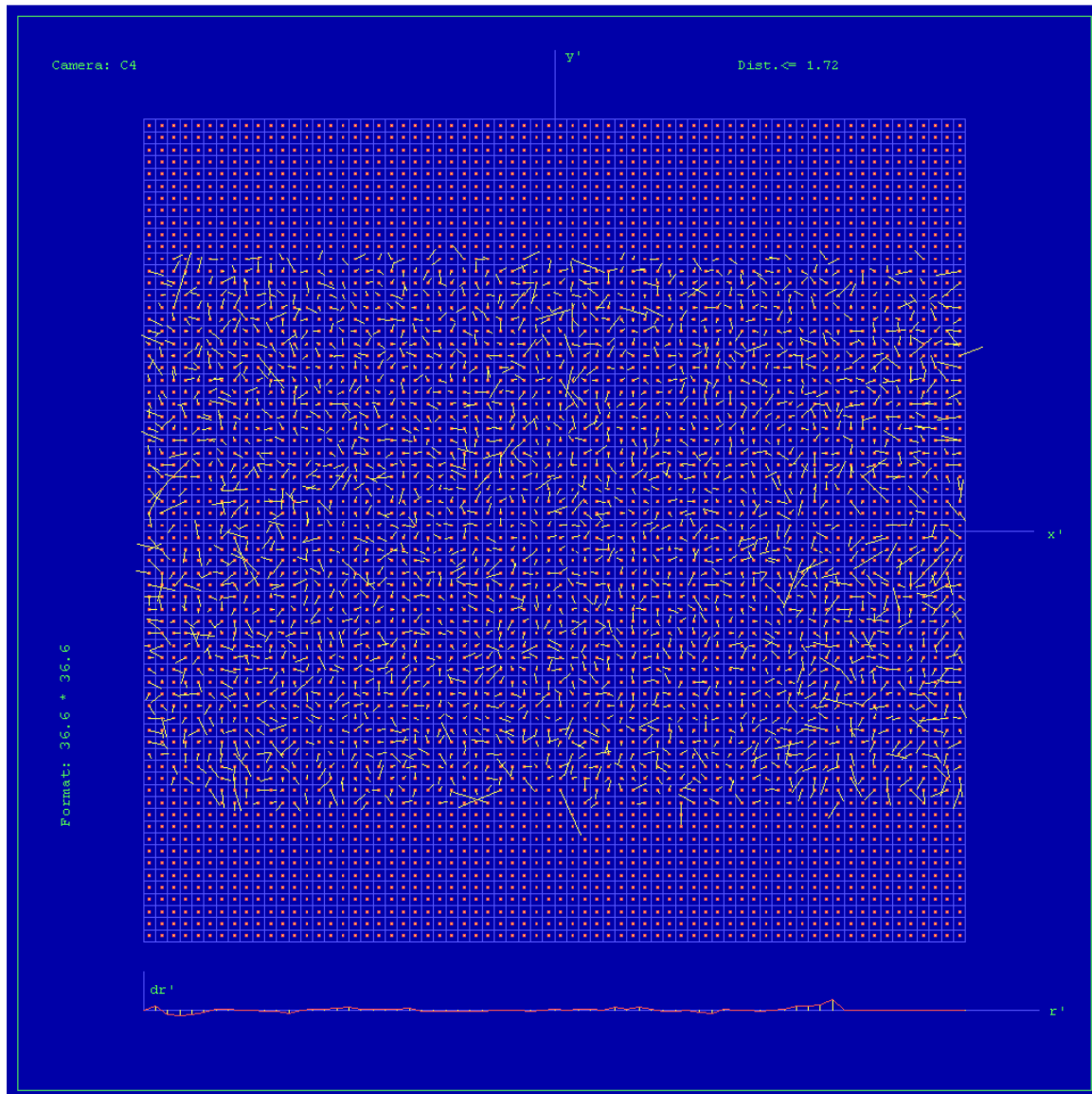
Residual Error (RMS): **0.53 μm**

Individual Multispectral Cone Data

Cone 4, Parametric Description, Not Effective in Output Image

Cone # C4 (red)						
Lens		Rodenstock Apo-Sironar Digital HR 35mm Linos GmbH, Germany				
Shutter		Prontor Magnetic Prontor-Werk Alfred Gauthier GmbH				
Image Extent (nominally)				(-10.08, -16.56)mm		(10.08, 16.56)mm
Extent CCD 0				(-12.08, -18.04)mm		(12.08, 18.04)mm
Parameters		Shift X		ShiftY		Rotation Scale
CCD0		7,2985128E-03 mm ± 0.0001 mm		-3,6727461E-03 mm ± 0.0002 mm		0.00000000 gon 1,0271645 ± 0.00005
Radial Distortion						
R [mm]		5.0	10.0	15.0	20.0	25.0
dr [µm]		36.2	54.2	50.3	36.4	40.2

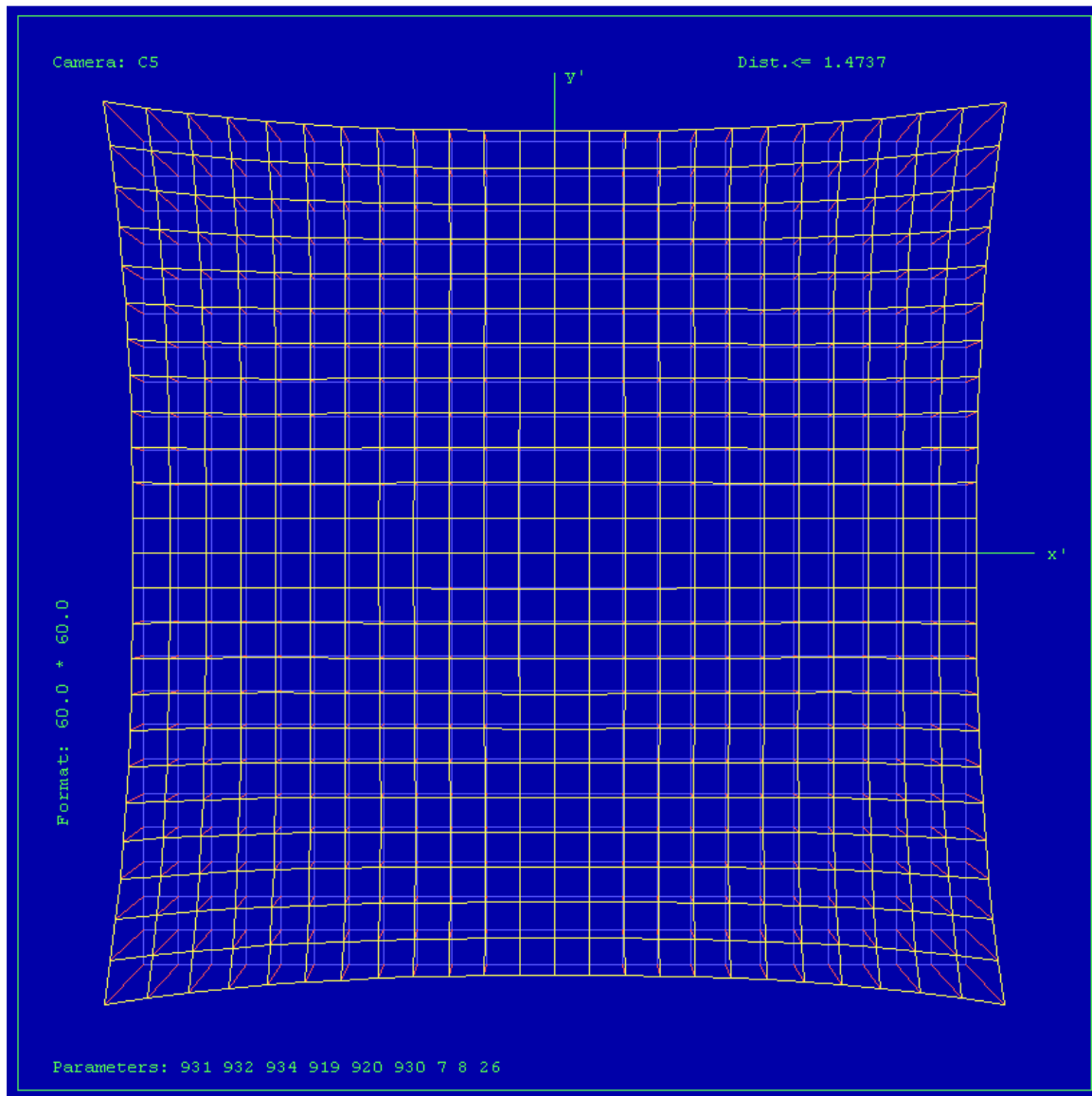
Cone 4, Distortion Diagram, Not Effective in Output Image

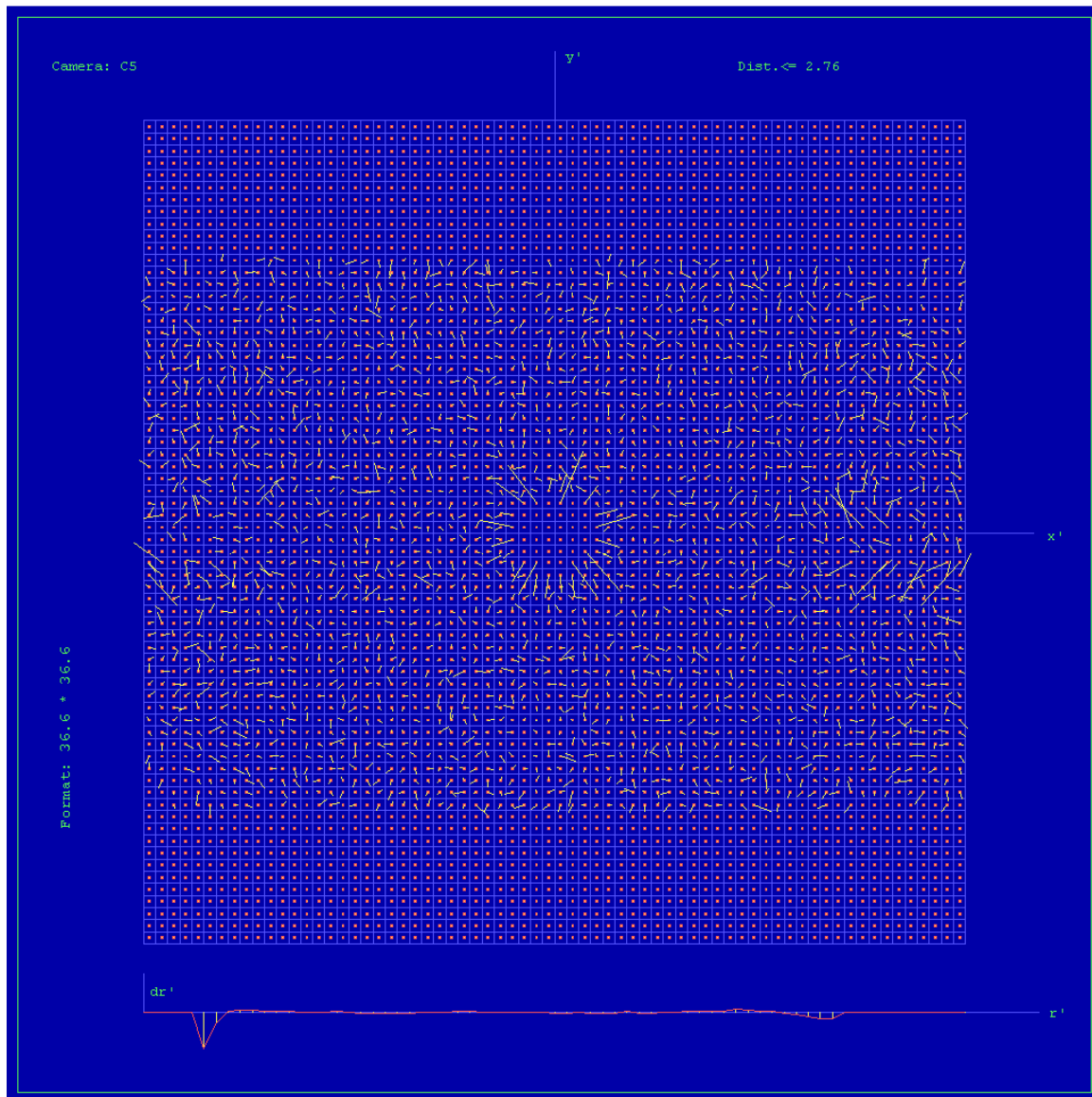
Cone 4, Residual Error Diagram

Residual Error (RMS): **0.40 μm**

Cone 5, Parametric Description, Not Effective in Output Image

Cone # C5 (green)				
Lens	Rodenstock Apo-Sironar Digital HR 35mm Linos GmbH, Germany			
Shutter	Prontor Magnetic Prontor-Werk Alfred Gauthier GmbH			
Image Extent (nominally)		(-10.08, -16.56)mm	(10.08, 16.56)mm	
Extent CCD 0		(-12.08, -18.04)mm	(12.08, 18.04)mm	
Parameters	Shift X	Shift Y	Rotation	Scale
CCD0	-4,7035824E-02 mm ± 0.0001 mm	1,3857854E-02 mm ± 0.0002 mm	0.000000 gon	1,0283075 ± 0.00005
Radial Distortion		Not effective in Production Image		
R [mm]	5.0	10.0	15.0	20.0 25.0
dr [µm]	40.3	64.4	64.5	56.6 80.5

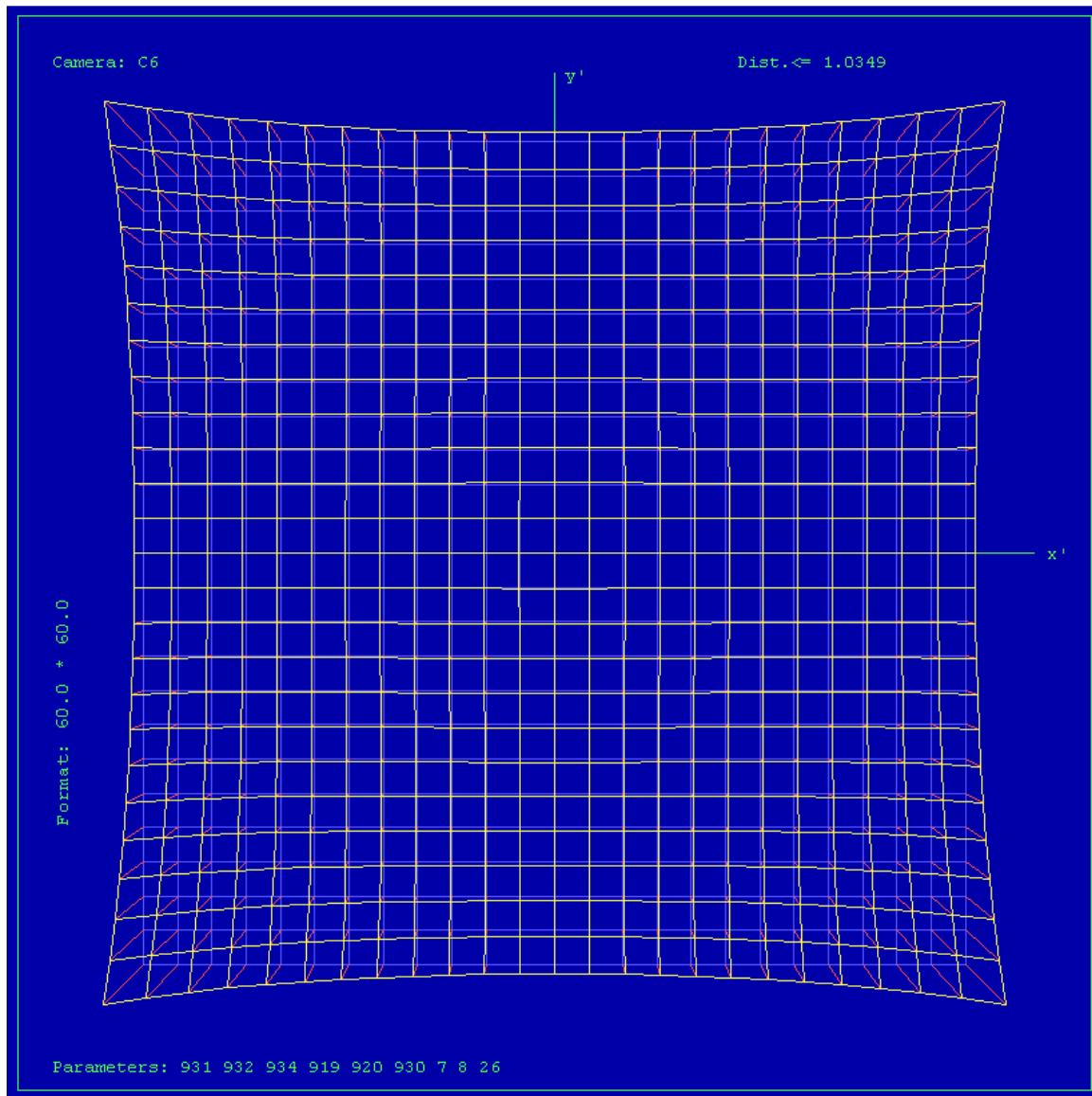
Cone 5, Distortion Diagram, Not Effective in Output Image

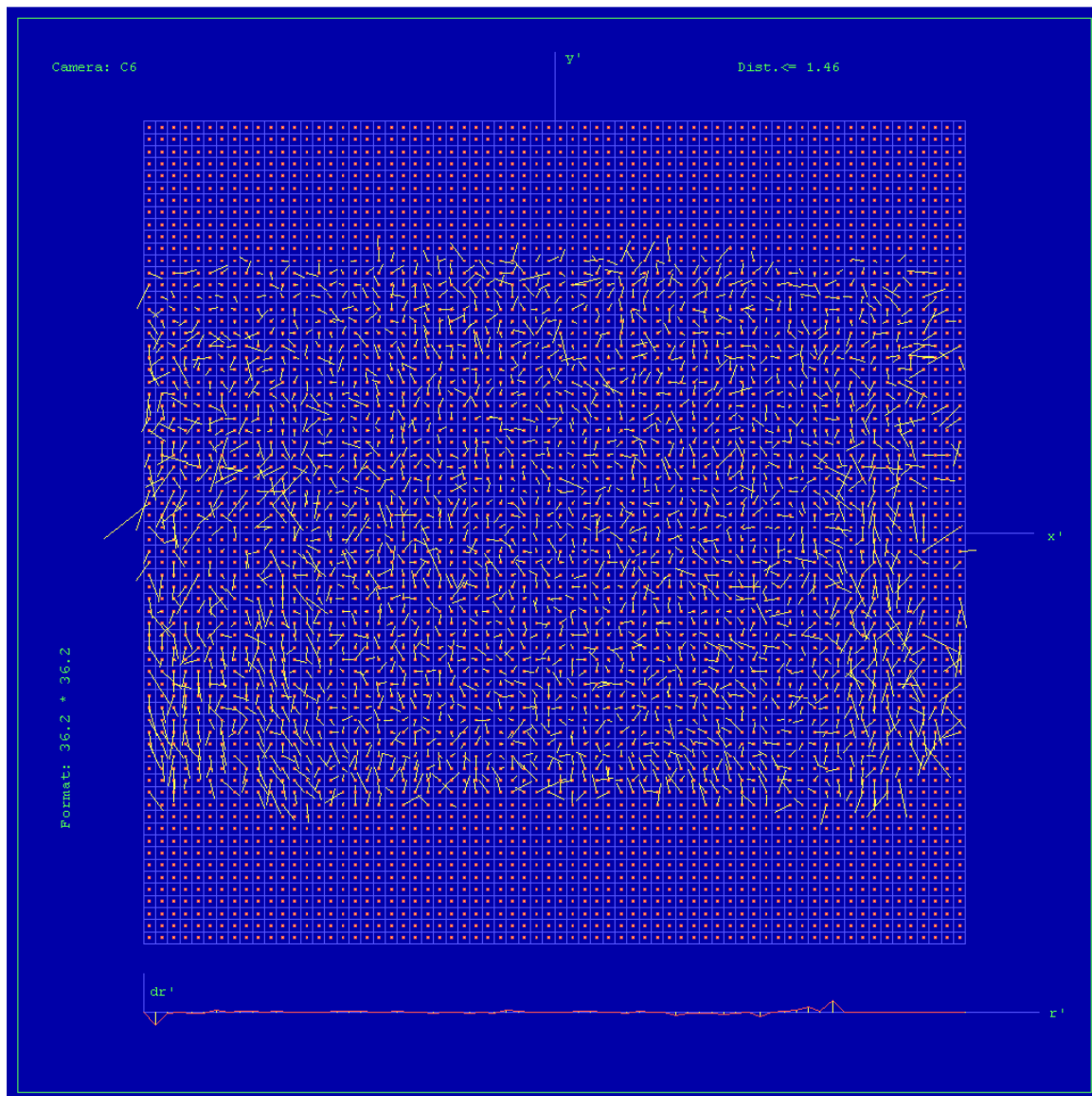
Cone 5, Residual Error Diagram

Residual Error (RMS): **0.42 μm**

Cone 6, Parametric Description, Not Effective in Output Image

Cone # C6 (blue)				
Lens	Rodenstock Apo-Sironar Digital HR 35mm Linos GmbH, Germany			
Shutter	Prontor Magnetic Prontor-Werk Alfred Gauthier GmbH			
Image Extent (nominally)		(-10.08, -16.56)mm	(10.08, 16.56)mm	
Extent CCD 0		(-12.08, -18.04)mm	(12.08, 18.04)mm	
Parameters	Shift X	ShiftY	Rotation	Scale
CCD0	-6,4710905E-02 mm ± 0.0001 mm	-5,3814057E-02 mm ± 0.0002 mm	0.00000000 gon	1,0121518 ± 0.00005
Radial Distortion		Not effective in Production Image		
R [mm]	5.0 10.0 15.0 20.0 25.0			
dr [µm]	28.9 43.3 41.2 35.3 53.5			

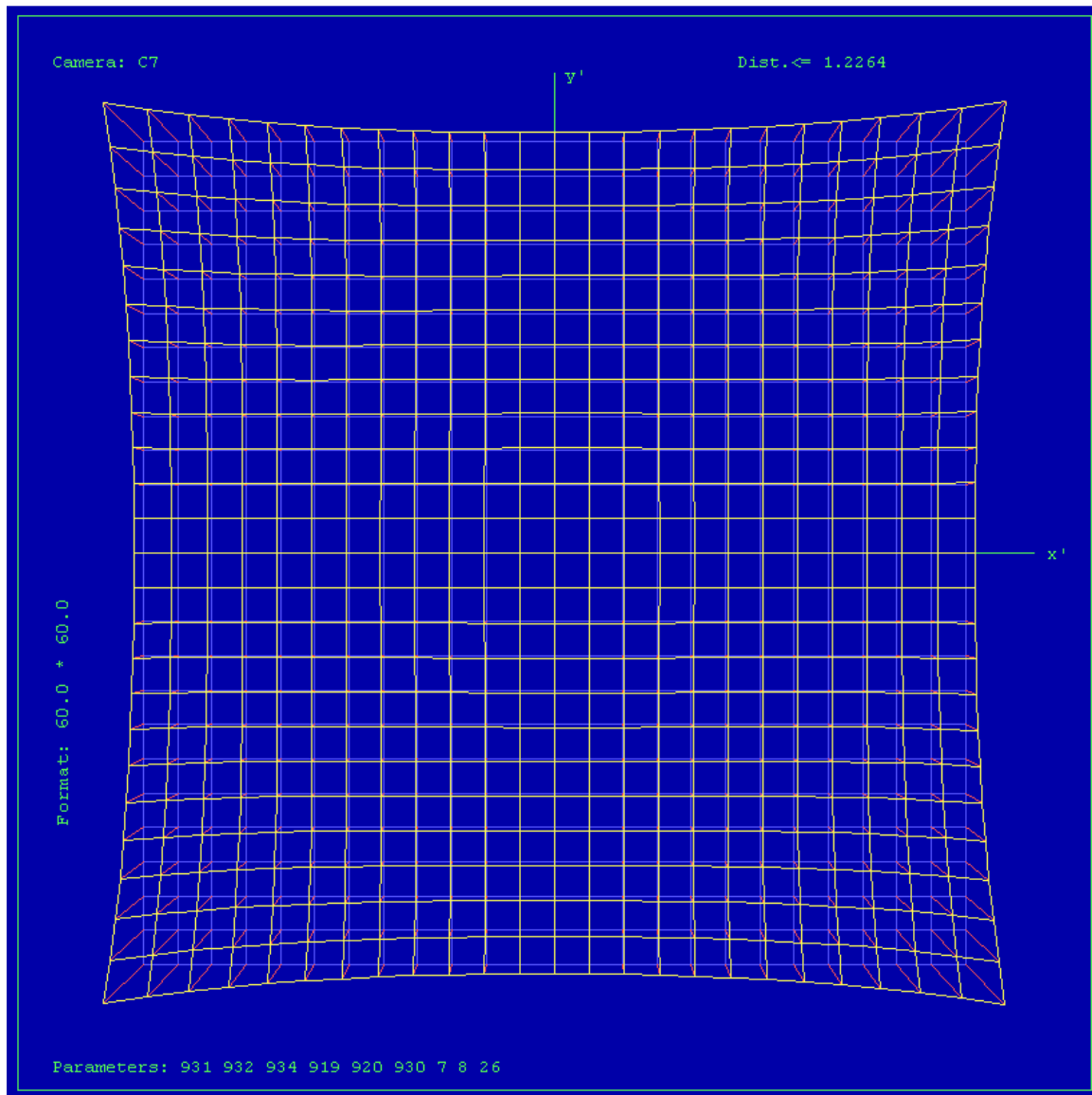
Cone 6, Distortion Diagram, Not Effective in Output Image

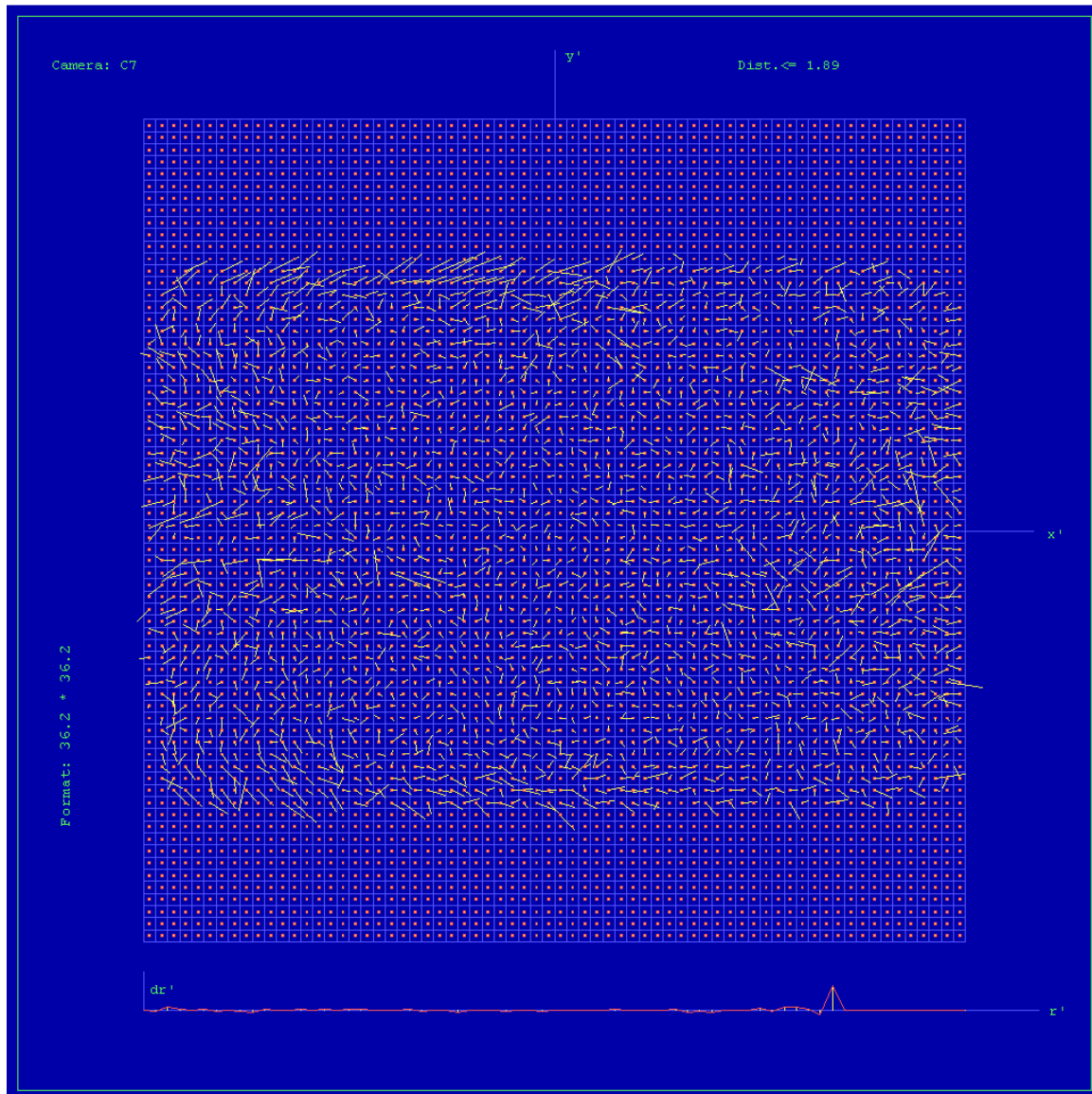
Cone 6, Residual Error Diagram

Residual Error (RMS): **0.40 μm**

Cone 7, Parametric Description, Not Effective in Output Image

Cone # C7 (NIR)				
Lens	Rodenstock Apo-Sironar Digital HR 35mm Linos GmbH, Germany			
Shutter	Prontor Magnetic Prontor-Werk Alfred Gauthier GmbH			
Image Extent (nominally)		(-10.08, -16.56)mm	(10.08, 16.56)mm	
Extent CCD 0		(-12.08, -18.04)mm	(12.08, 18.04)mm	
Parameters	Shift X	ShiftY	Rotation	Scale
CCD0	1,1147872E-01 mm ± 0.0001 mm	-1,2542787E-02 mm ± 0.0002 mm	0.00000000 gon	1,0096404 ± 0.00005
Radial Distortion		Not effective in Production Image		
R [mm]	5.0	10.0	15.0	20.0 25.0
dr [µm]	29.0	45.1	44.7	41.6 66.9

Cone 7, Distortion Diagram, Not Effective in Output Image

Cone 7, Residual Error Diagram

Residual Error (RMS): **0.42 μm**

1) Calibration Method:

Number of point measurements for the panchromatic camera :	17477
Number of point measurements for the multispectral camera :	64864

2) Level 2 Image Coordinate System:

pan	11500 pixel by 7500 pixel
MS	3680 pixel by 2400 pixel

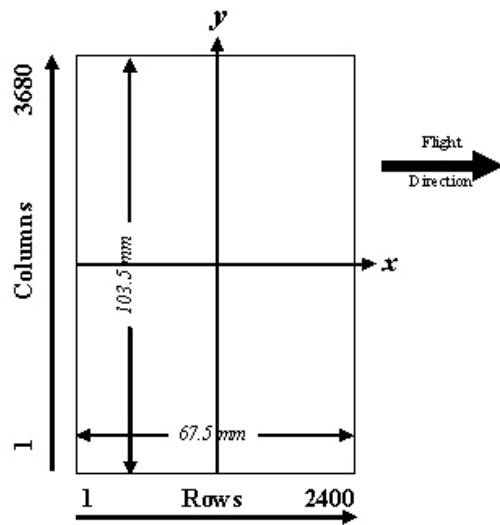
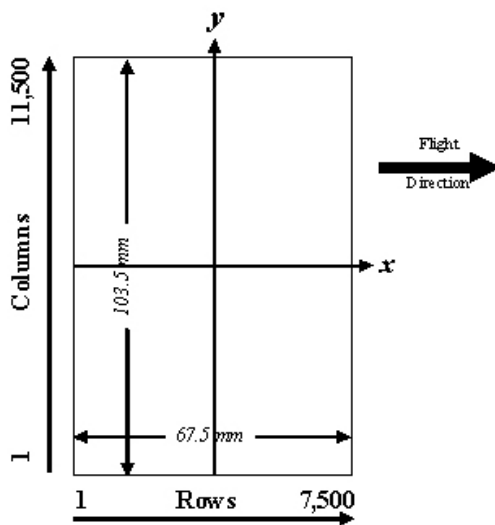
Diagram illustrating a 1x1 grid structure. The grid is defined by 1 Column and 1 Row. The total width is 11,500 and the total height is 7,500. The grid is divided into four quadrants by a vertical line at 103.5 mm from the left and a horizontal line at 67.5 mm from the bottom. The origin (+y, +x) is at the top-left corner. The label **PPA⁺** is located in the top-left quadrant. A downward arrow indicates the direction of flight.

Example:
 PPA_x = - 0.123 mm
 PPA_y = + 0.345 mm

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

pan 7500 pixel by 11500 pixel
MS 2400 pixel by 3680 pixel



Panchromatic Image Format

Multispectral Image Format

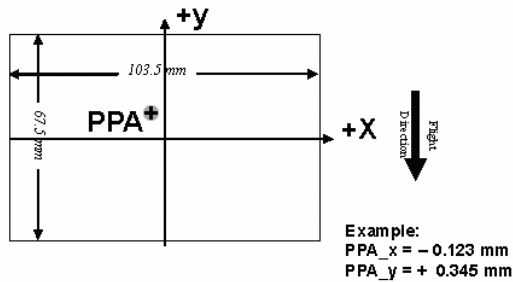
4) Position of Principal Point in Level 3 Image

The position of the principal point in the level 3 image depends on the “rotation” setting used in the OPC 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 the OPC. The coordinates are specified for clockwise (CW) rotation in steps of 90 degrees, according to the principal point coordinate given on page 3 for high- and low resolution images.

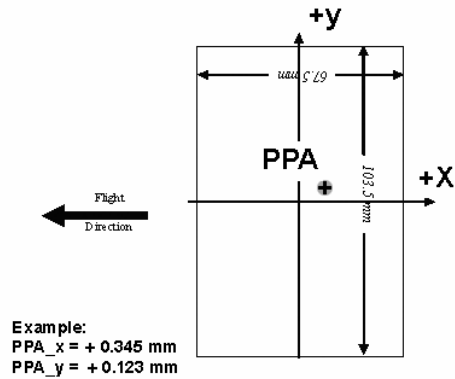
Image Format	Clockwise Rotation (Degree)	PPA	
		X	Y
Level 2	-	-0.180	0.000
Level 3	0	-0.180	0.000
Level 3	90	0.000	0.180
Level 3	180	0.180	0.000
Level 3	270	0.000	-0.180

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.

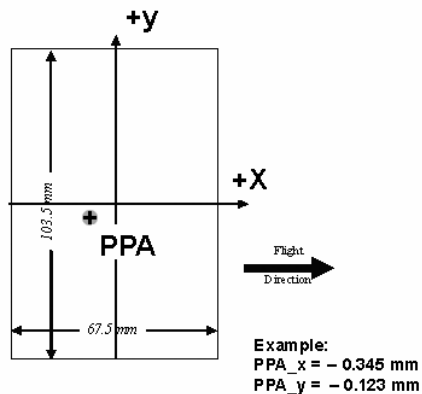
Lvl3, Rotation 0 deg clockwise



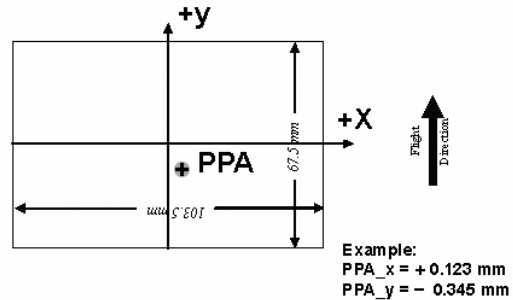
Lvl3, Rotation 90 deg clockwise



Lvl3, Rotation 270 deg clockwise



Lvl3, Rotation 180 deg clockwise

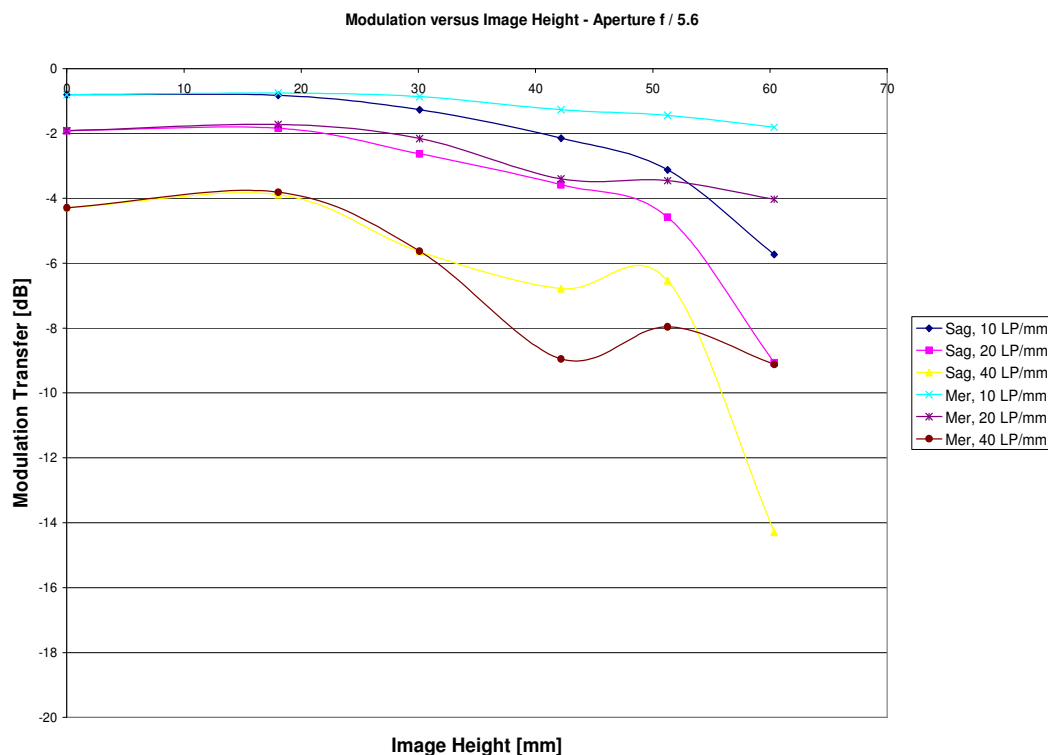


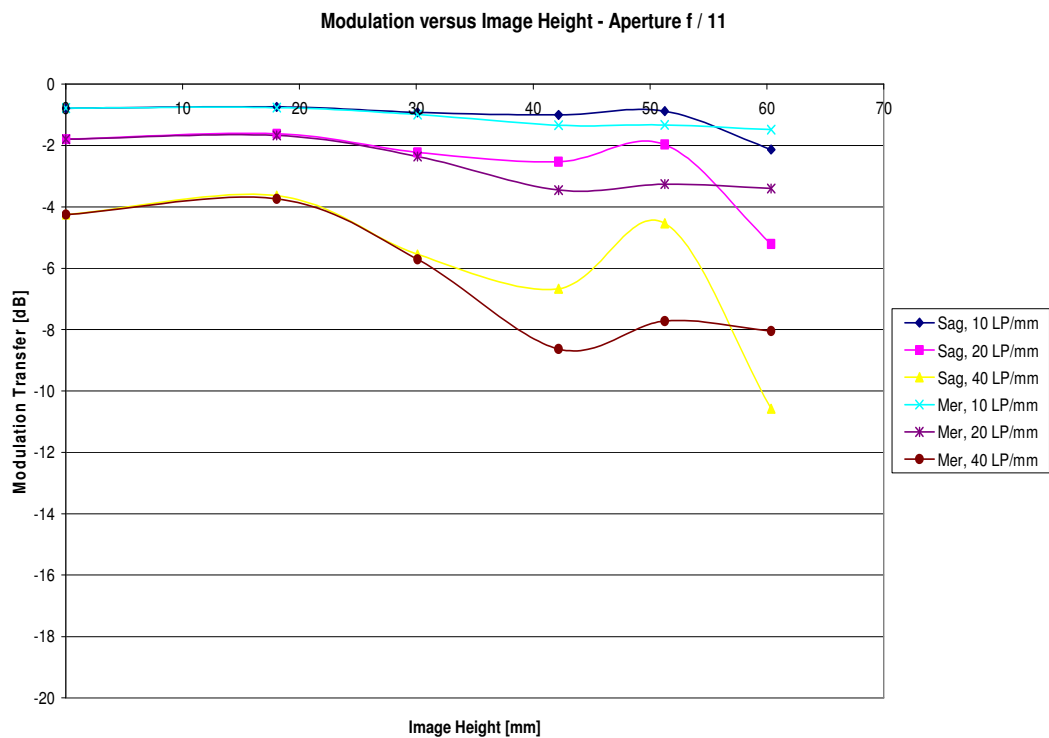
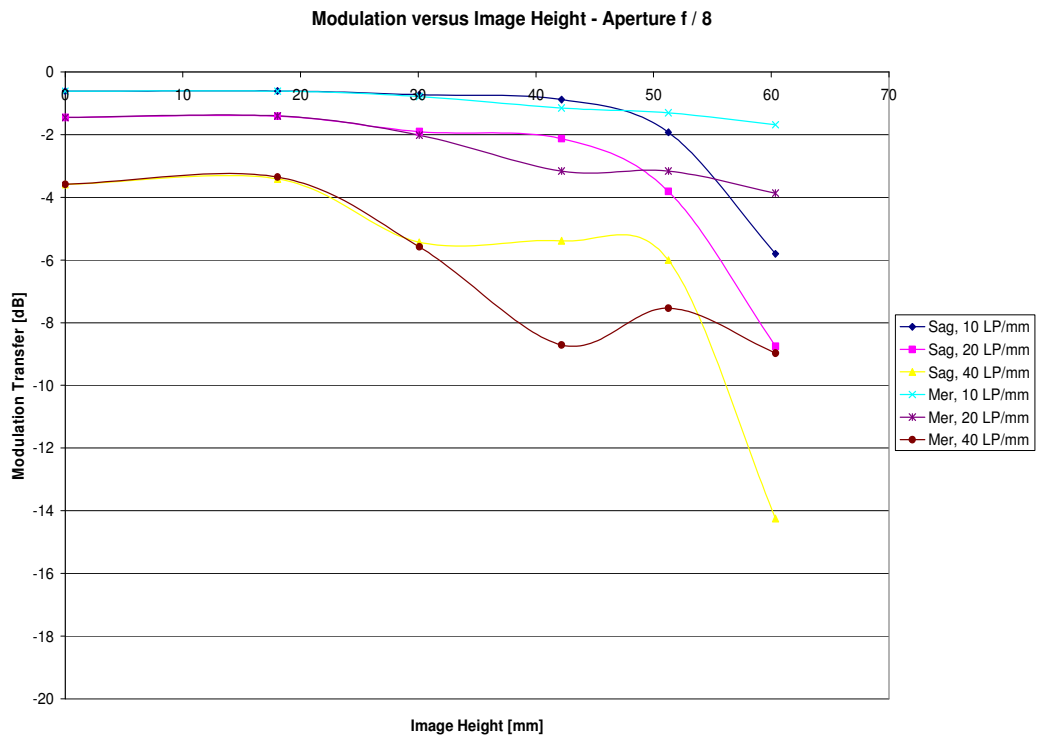
Lens Resolving Power

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

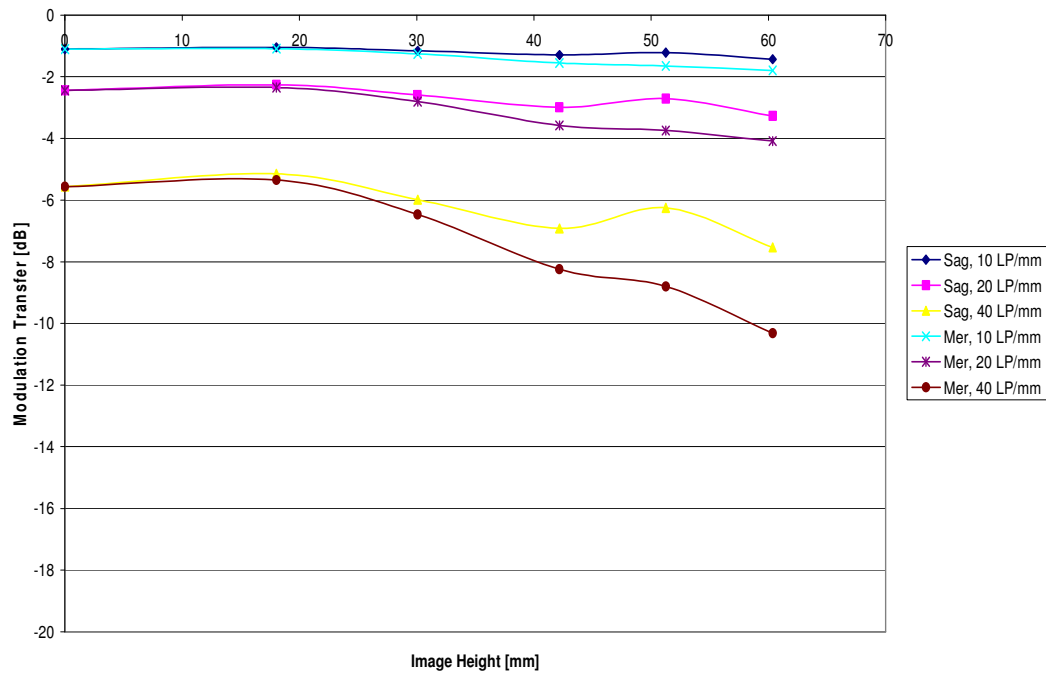
The curves are given for the meridional (tangential) and sagittal (radial) component of signals at frequencies of 10, 20 and 40 line pairs per millimeter.

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

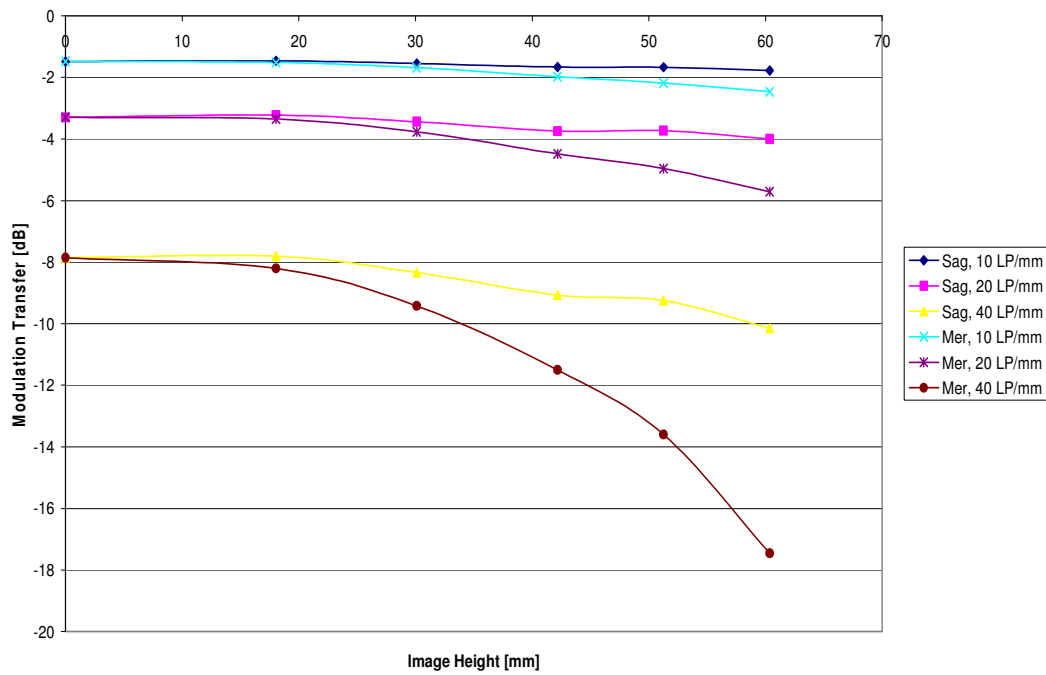




Modulation versus Image Height - Aperture f / 16



Modulation versus Image Height - Aperture f / 22



Calibration Report

Radiometric Calibration



Camera:	UltraCam D, S/N UCD-SU-1-0029
Manufacturer:	Microsoft Photogrammetry, A-8010 Graz, Austria
Panchromatic Camera:	Apertures: f/5.6, f/8, f/11, f/16, f/22 (All Pan)
Multispectral Camera:	Apertures: f/4, f/5.6, f/8, f/11, f/16 (Red, Green) f/4, f/4, f/5.6, f/8, f/11 (Blue, NIR)
Date of Calibration:	Jun-27-2007
Date of Report:	Jun-29-2007
Camera Revision:	5.0
Revision of Report:	5.0

Calibration of Vignetting for Aperture Setting 1

Panchromatic: f / 5.6
Red Channel: f / 4
Green Channel: f / 4
Blue Channel: f / 4
NIR Channel: f / 4

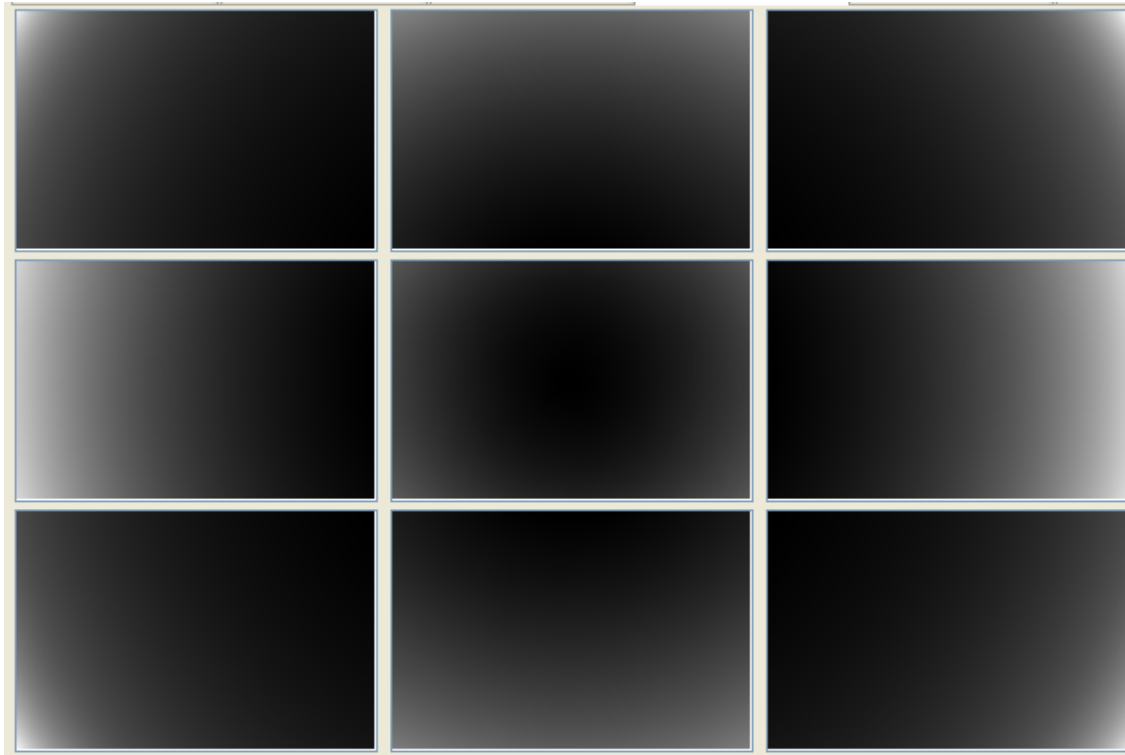
Stepper Motor Position: 1000h

Overview of Individual Sensor Gain Values:

Cone_Sensor	Aperture	Minimum Gain $\geq$	Maximum Gain $\leq$
00_00	f / 5.6	1.00	9.00
00_01	f / 5.6	1.00	8.00
00_02	f / 5.6	1.00	9.00
00_03	f / 5.6	1.00	8.00
01_00	f / 5.6	1.00	3.00
01_01	f / 5.6	1.00	3.00
02_00	f / 5.6	1.00	4.00
02_01	f / 5.6	1.00	4.00
03_00	f / 5.6	1.00	2.00
04_00 (red)	f / 4	1.00	3.00
05_00 (green)	f / 4	1.00	2.00
06_00 (blue)	f / 4	1.00	2.00
07_00 (NIR)	f / 4	1.00	2.00

Calibration of Vignetting for Aperture Setting 1

Graphical Overview of Pan Sensor Gain Values:



00_00	01_00	00_01
02_00	03_00	02_01
00_02	01_01	00_03

Calibration of Vignetting for Aperture Setting 1

Graphical Overview of Multispectral Sensor Gain Values:



04_00 (red)	06_00 (blue)
05_00 (green)	07_00 (NIR)

Calibration of Vignetting for Aperture Setting 2

Panchromatic: f / 8
Red Channel: f / 5.6
Green Channel: f / 5.6
Blue Channel: f / 4
NIR Channel: f / 4

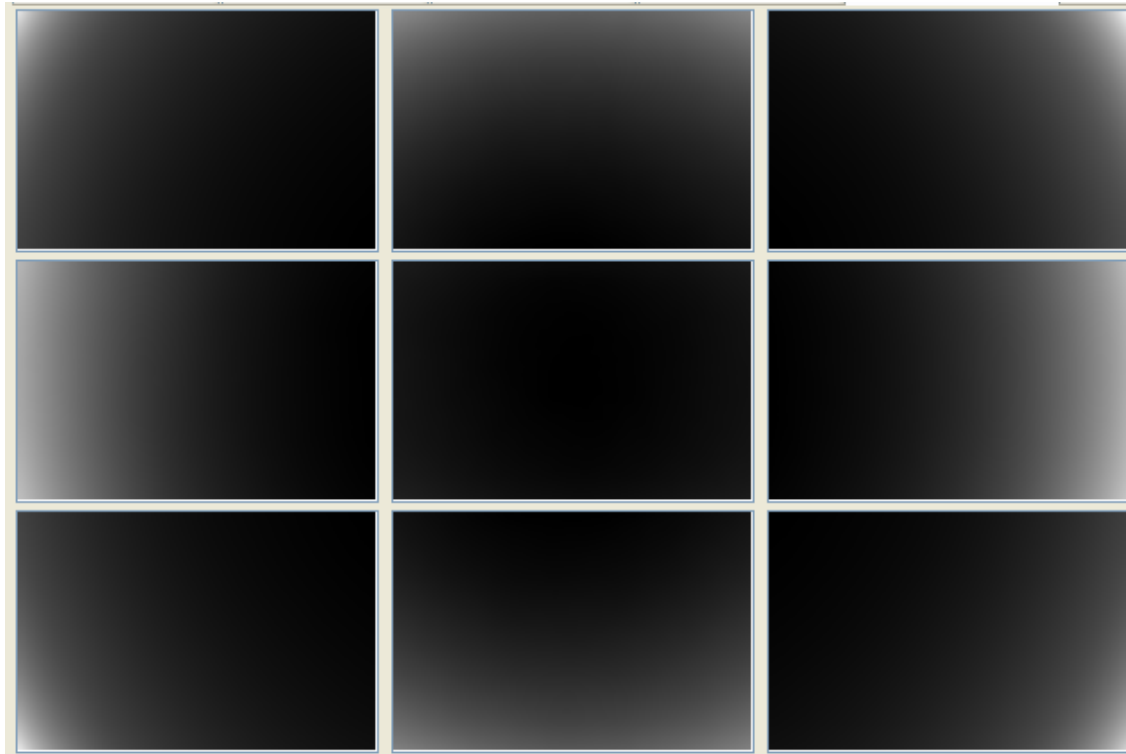
Stepper Motor Position: 1020h

Overview of Individual Sensor Gain Values:

Cone_Sensor	Aperture	Minimum Gain $\geq$	Maximum Gain $\leq$
00_00	f / 8	1.00	7.00
00_01	f / 8	1.00	6.00
00_02	f / 8	1.00	7.00
00_03	f / 8	1.00	7.00
01_00	f / 8	1.00	2.00
01_01	f / 8	1.00	2.00
02_00	f / 8	1.00	3.00
02_01	f / 8	1.00	3.00
03_00	f / 8	1.00	2.00
04_00 (red)	f / 5.6	1.00	2.00
05_00 (green)	f / 5.6	1.00	2.00
06_00 (blue)	f / 4	1.00	2.00
07_00 (NIR)	f / 4	1.00	2.00

Calibration of Vignetting for Aperture Setting 2

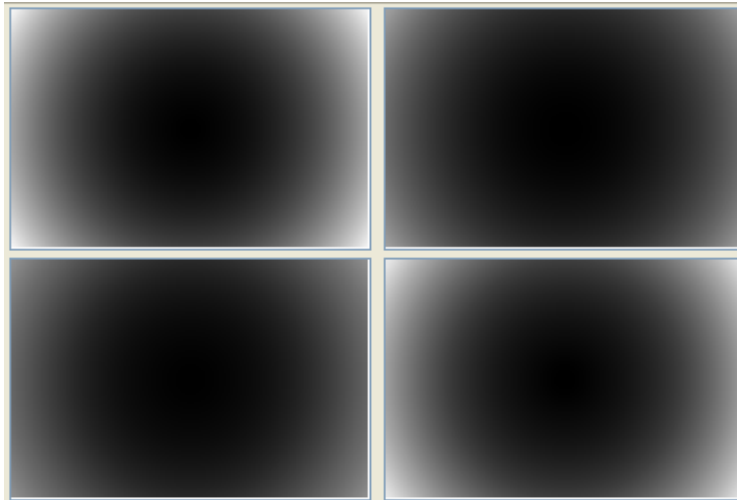
Graphical Overview of Pan Sensor Gain Values:



00_00	01_00	00_01
02_00	03_00	02_01
00_02	01_01	00_03

Calibration of Vignetting for Aperture Setting 2

Graphical Overview of Multispectral Sensor Gain Values:



04_00 (red)	06_00 (blue)
05_00 (green)	07_00 (NIR)

Calibration of Vignetting for Aperture Setting 3

Panchromatic: f / 11
Red Channel: f / 8
Green Channel: f / 8
Blue Channel: f / 5.6
NIR Channel: f / 5.6

Stepper Motor Position: 1039h

Overview of Individual Sensor Gain Values:

Cone_Sensor	Aperture	Minimum Gain $\geq$	Maximum Gain $\leq$
00_00	f / 11	1.00	5.00
00_01	f / 11	1.00	4.00
00_02	f / 11	1.00	5.00
00_03	f / 11	1.00	4.00
01_00	f / 11	1.00	2.00
01_01	f / 11	1.00	2.00
02_00	f / 11	1.00	2.00
02_01	f / 11	1.00	2.00
03_00	f / 11	1.00	2.00
04_00 (red)	f / 8	1.00	2.00
05_00 (green)	f / 8	1.00	2.00
06_00 (blue)	f / 5.6	1.00	2.00
07_00 (NIR)	f / 5.6	1.00	2.00

Calibration of Vignetting for Aperture Setting 3

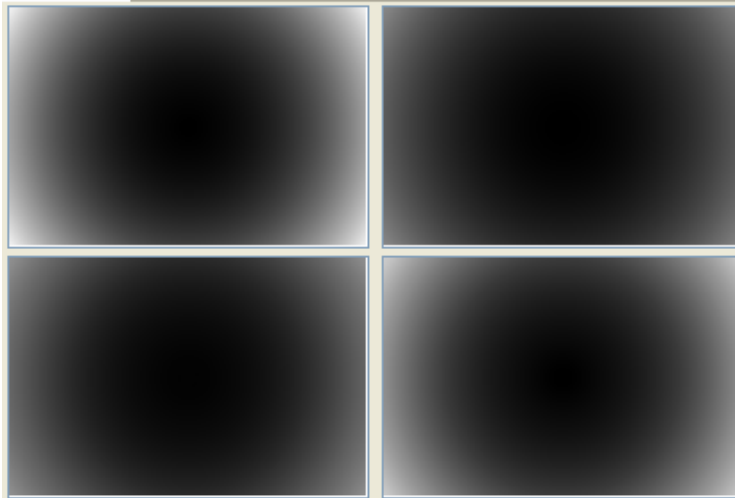
Graphical Overview of Pan Sensor Gain Values:



00_00	01_00	00_01
02_00	03_00	02_01
00_02	01_01	00_03

Calibration of Vignetting for Aperture Setting 3

Graphical Overview of Multispectral Sensor Gain Values:



04_00 (red)	06_00 (blue)
05_00 (green)	07_00 (NIR)

Calibration of Vignetting for Aperture Setting 4

Panchromatic: f / 16
Red Channel: f / 11
Green Channel: f / 11
Blue Channel: f / 8
NIR Channel: f / 8

Stepper Motor Position: 1055h

Overview of Individual Sensor Gain Values:

Cone_Sensor	Aperture	Minimum Gain $\geq$	Maximum Gain $\leq$
00_00	f / 16	1.00	4.00
00_01	f / 16	1.00	3.00
00_02	f / 16	1.00	4.00
00_03	f / 16	1.00	4.00
01_00	f / 16	1.00	2.00
01_01	f / 16	1.00	2.00
02_00	f / 16	1.00	2.00
02_01	f / 16	1.00	2.00
03_00	f / 16	1.00	2.00
04_00 (red)	f / 11	1.00	2.00
05_00 (green)	f / 11	1.00	2.00
06_00 (blue)	f / 8	1.00	2.00
07_00 (NIR)	f / 8	1.00	2.00

Calibration of Vignetting for Aperture Setting 4

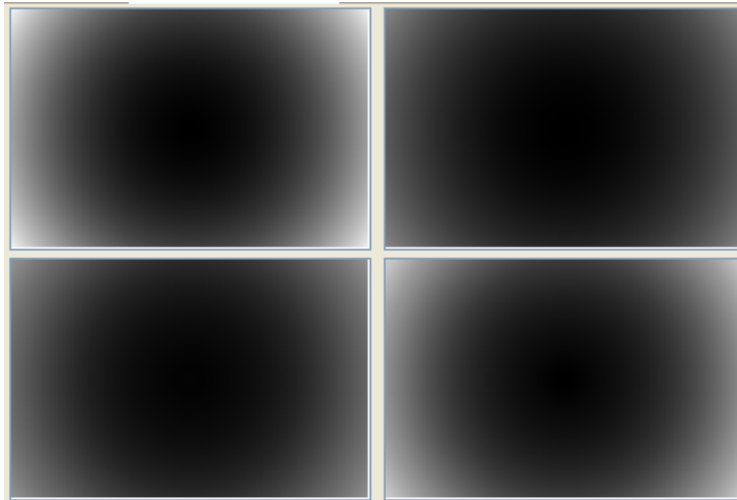
Graphical Overview of Pan Sensor Gain Values:



00_00	01_00	00_01
02_00	03_00	02_01
00_02	01_01	00_03

Calibration of Vignetting for Aperture Setting 4

Graphical Overview of Multispectral Sensor Gain Values:



04_00 (red)	06_00 (blue)
05_00 (green)	07_00 (NIR)

Calibration of Vignetting for Aperture Setting 5

Panchromatic: f / 22
Red Channel: f / 16
Green Channel: f / 16
Blue Channel: f / 11
NIR Channel: f / 11

Stepper Motor Position: 1075h

Overview of Individual Sensor Gain Values:

Cone_Sensor	Aperture	Minimum Gain $\geq$	Maximum Gain $\leq$
00_00	f / 22	1.00	3.00
00_01	f / 22	1.00	3.00
00_02	f / 22	1.00	3.00
00_03	f / 22	1.00	3.00
01_00	f / 22	1.00	2.00
01_01	f / 22	1.00	2.00
02_00	f / 22	1.00	2.00
02_01	f / 22	1.00	2.00
03_00	f / 22	1.00	2.00
04_00 (red)	f / 16	1.00	2.00
05_00 (green)	f / 16	1.00	2.00
06_00 (blue)	f / 11	1.00	2.00
07_00 (NIR)	f / 11	1.00	2.00

Calibration of Vignetting for Aperture Setting 5

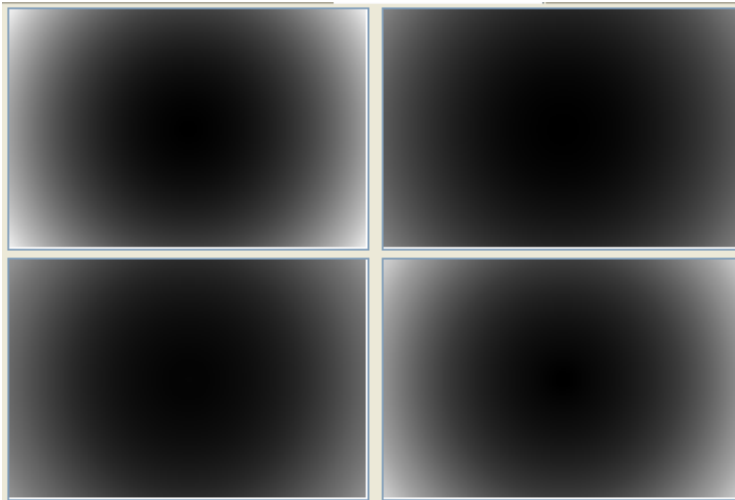
Graphical Overview of Pan Sensor Gain Values:



00_00	01_00	00_01
02_00	03_00	02_01
00_02	01_01	00_03

Calibration of Vignetting for Aperture Setting 5

Graphical Overview of Multispectral Sensor Gain Values:



04_00 (red)	06_00 (blue)
05_00 (green)	07_00 (NIR)

Defective Pixel Report:

Sensor		
Anomaly Type	X	Y

C00-00

PIXEL: 3989/ 891
PIXEL: 3989/ 890
COLUMN: 350/2187

C00-01

PIXEL: 1469/2278
PIXEL: 1503/1432
PIXEL: 3782/1131
PIXEL: 3811/1417
PIXEL: 3282/1095
PIXEL: 3282/1096
COLUMN: 253/1349

C00-02

PIXEL: 3031/ 388
PIXEL: 2251/ 541
PIXEL: 3988/ 30

C00-03

PIXEL: 3223/1657

C01-00

PIXEL: 310/1078
PIXEL: 393/ 933
PIXEL: 1674/2301
PIXEL: 666/1035
PIXEL: 666/1036
PIXEL: 3819/2635
PIXEL: 665/1035
PIXEL: 665/1036
PIXEL: 3818/2635
PIXEL: 3819/2636
PIXEL: 3818/2636
COLUMN: 292/2321

C01-01

PIXEL: 1837/2162
PIXEL: 1838/2161
PIXEL: 1837/2161
PIXEL: 1838/2162

C02-00

PIXEL: 1174/ 229
PIXEL: 1845/1341
PIXEL: 1922/1949
PIXEL: 2283/2097

C02-01

PIXEL: 1786/ 165
PIXEL: 3371/ 528
PIXEL: 3554/2500
PIXEL: 3555/2499
PIXEL: 3555/2500
PIXEL: 3556/2500

C03-00

PIXEL: 144/1936
PIXEL: 3734/1131
PIXEL: 3733/1131
PIXEL: 3734/1132

C04-00

PIXEL: 709/1761
PIXEL: 1349/ 770
PIXEL: 2202/1912
PIXEL: 2202/1913
PIXEL: 2203/1912
PIXEL: 2203/1913

C05-00

PIXEL: 240/2051
PIXEL: 1315/ 356
PIXEL: 2001/2001
PIXEL: 3019/1433
PIXEL: 2418/2158
PIXEL: 2418/2159
PIXEL: 2417/2159

C06-00

PIXEL: 1579/1317
PIXEL: 316/2025
PIXEL: 2029/1370
PIXEL: 316/2026
PIXEL: 2035/1371
PIXEL: 2047/1326
PIXEL: 2021/1312

C07-00

PIXEL: 560/2258
PIXEL: 1296/2022
PIXEL: 1364/ 657
PIXEL: 560/2258
PIXEL: 1296/2022
PIXEL: 3482/2384
PIXEL: 3722/2490

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 60 flat field images for each aperture size and sensor. The flat field is illuminated by two 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.

Calibration Report

Shutter Calibration



Camera:	UltraCam D, S/N UCD-SU-1-0029
Manufacturer:	Microsoft Photogrammetry, A-8010 Graz, Austria
Panchromatic Camera:	4 * Prontor Magnetic 0 Prontor-Werk Alfred Gauthier GmbH, Germany
Multispectral Camera:	4 * Prontor Magnetic 0 Prontor-Werk Alfred Gauthier GmbH, Germany
Date of Calibration:	Jun-27-2007
Date of Report:	Jun-29-2007
Camera Revision:	5.0
Revision of Report:	5.0

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	Shutter Release Time [ms]	Measurement Tolerance [ms]
C0 (Pan 4CCD)	11795376	12.8	+/- 0.2
C1 (Pan 2CCD V)	11478376	13.7	+/- 0.2
C2 (Pan 2CCD H)	11795368	13.4	+/- 0.2
C3 (Pan Central)	11478351	13.1	+/- 0.2
C4 (Red)	11638810	13.1	+/- 0.2
C5 (Green)	11 845 463	13.0	+/- 0.2
C6 (Blue)	11838142	11.7	+/- 0.2
C7 (NIR)	11638778	9.4	+/- 0.2

Calibration Report

Electronics and Sensor Calibration



Camera:	UltraCam D, S/N UCD-SU-1-0029
Manufacturer:	Microsoft Photogrammetry, A-8010 Graz, Austria
Panchromatic Camera:	4 * FTF4027-M Area CCD Sensor by DALSA
Multispectral Camera:	4 * FTF4027-M Area CCD Sensor by DALSA
Date of Calibration:	Jun-27-2007
Date of Report:	Jun-29-2007
Camera Revision:	5.0
Revision of Report:	5.0

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	FTF4027-M	87 607/89	25.80
00_01	FTF4027-M	87 607/68	25.40
00_02	FTF4027-M	87 607/85	25.40
00_03	FTF4027-M	87 604/31	25.40
01_00	FTF4027-M	87 607/22	25.60
01_01	FTF4027-M	87 607/38	25.40
02_00	FTF4027-M	87 607/27	25.40
02_01	FTF4027-M	87 607/35	25.80
03_00	FTF4027-M	87 607/87	25.40
04_00 (red)	FTF4027-M	87 607/39	25.80
05_00 (green)	FTF4027-M	83 639/03	26.20
06_00 (blue)	FTF4027-M	83 639/05	26.40
07_00 (NIR)	FTF4027-M	87 607/37	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 behaviour 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 UCD.

Cone_Sensor	Sensor Type	Sensor Serial Number	Intensity Threshold [DN]
00_00	FTF4027-M	87 607/89	7000
00_01	FTF4027-M	87 607/68	7000
00_02	FTF4027-M	87 607/85	7000
00_03	FTF4027-M	87 604/31	7000
01_00	FTF4027-M	87 607/22	7000
01_01	FTF4027-M	87 607/38	7000
02_00	FTF4027-M	87 607/27	7000
02_01	FTF4027-M	87 607/35	7000
03_00	FTF4027-M	87 607/87	7000
04_00 (red)	FTF4027-M	87 607/39	7000
05_00 (green)	FTF4027-M	83 639/03	7000
06_00 (blue)	FTF4027-M	83 639/05	7000
07_00 (NIR)	FTF4027-M	87 607/37	7000

Calibration Report

Summary



Camera: UltraCam D, S/N UCD-SU-1-0029

Manufacturer: Microsoft Photogrammetry, A-8010 Graz, Austria

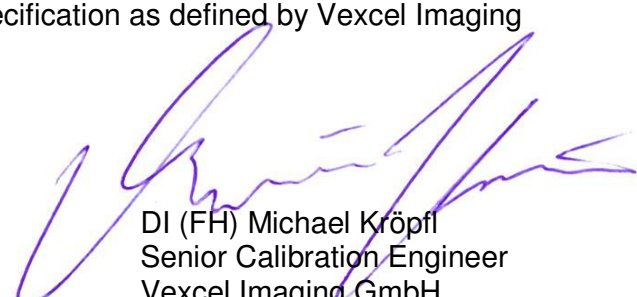
Date of Calibration: Jun-27-2007
Date of Report: Jun-29-2007
Camera Revision: 5.0
Revision of Report: 5.0

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

- Geometric Calibration
- Verification of Lens Quality and Sensor Adjustment
- Radiometric Calibration
- Calibration of Defective Pixel Elements
- Shutter Calibration
- Sensor and Electronics Calibration

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


Dr. Michael Gruber
Chief Scientist, Photogrammetry
Vexcel Imaging GmbH.


DI (FH) Michael Kröpfl
Senior Calibration Engineer
Vexcel Imaging GmbH