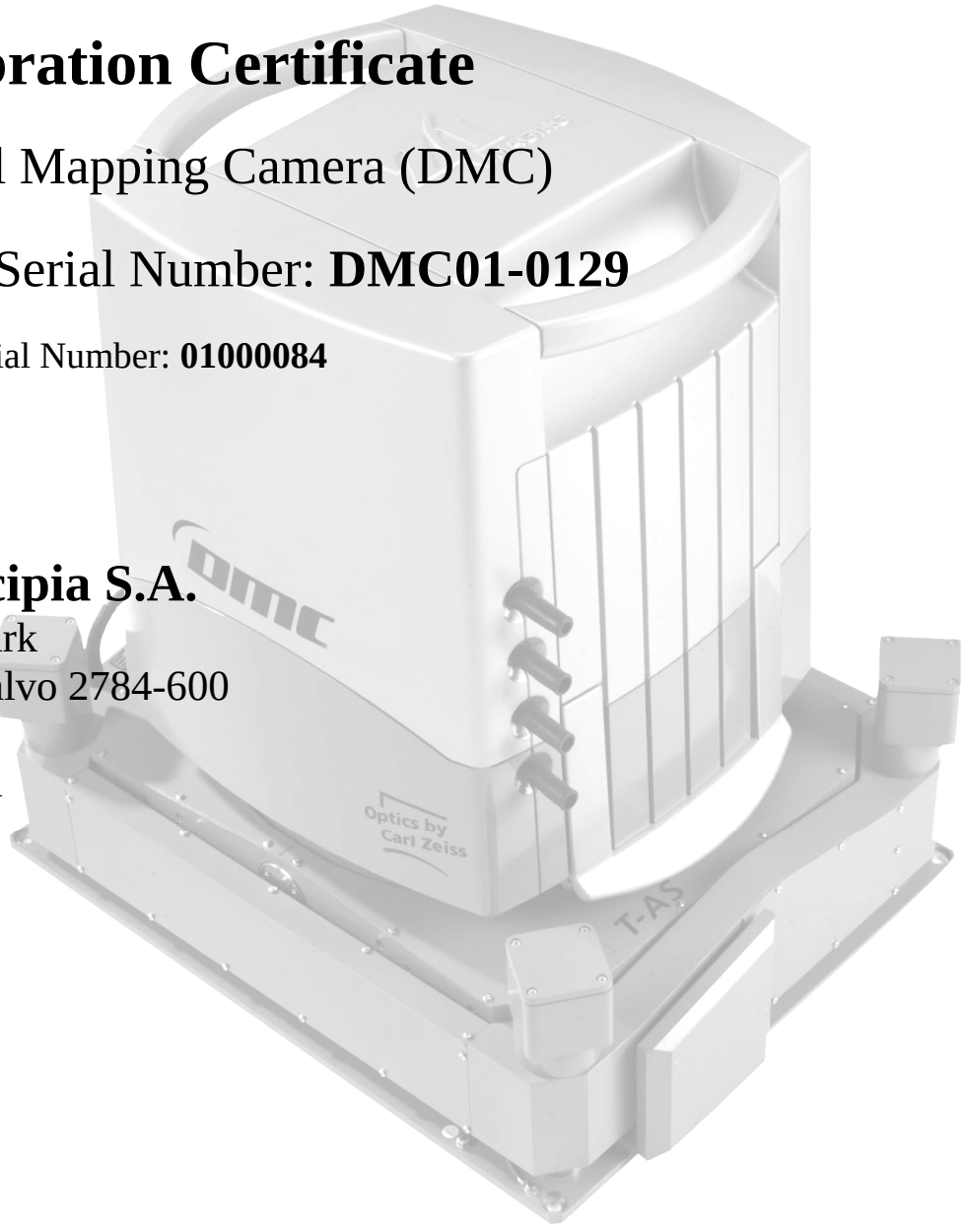
Calibration Certificate

Digital Mapping Camera (DMC)

DMC Serial Number: **DMC01-0129**

CBU Serial Number: **01000084**



For

Municipia S.A.
Taguspark
Porto Salvo 2784-600

Portugal

System Overview

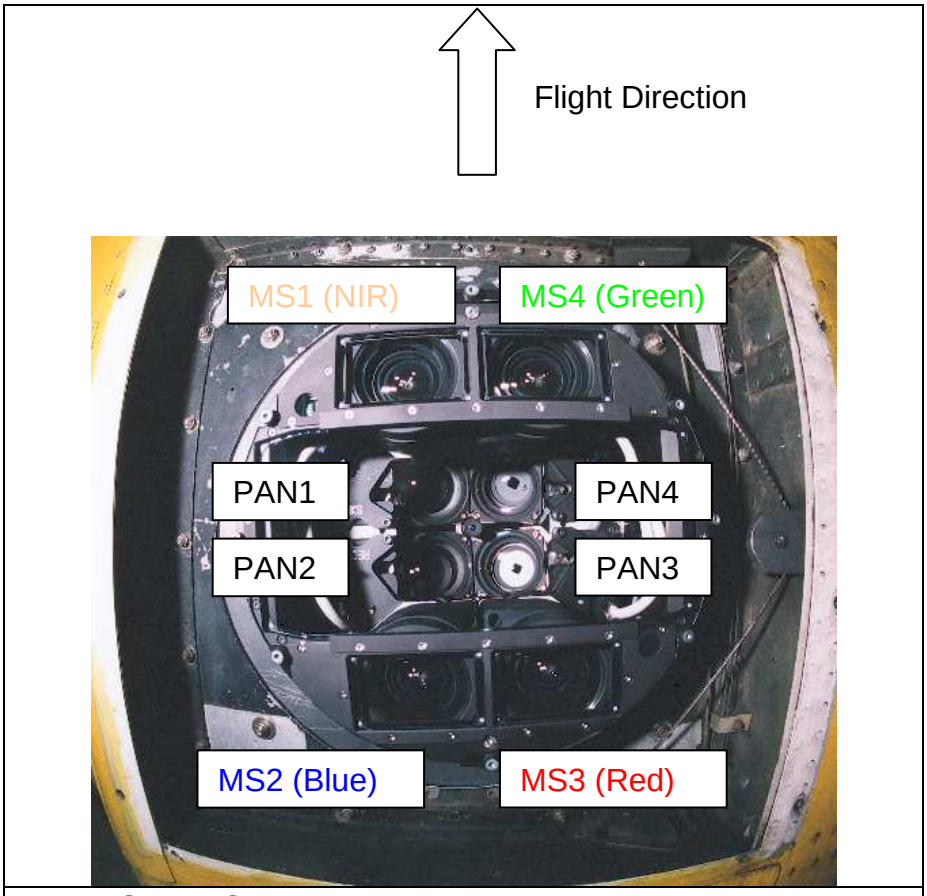


Figure: System Overview

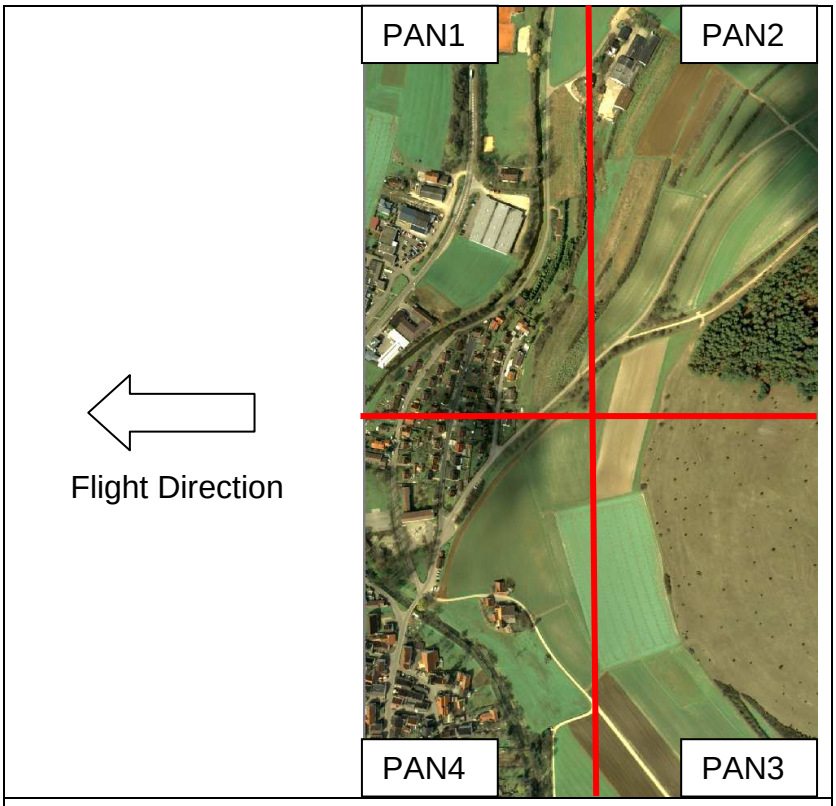


Figure Image Overview (Pan Camera)

Camera Parameter for Virtual Image (High Resolution)

Virtual Focal Length [m]	0.12
Virtual Sensor Size [Pixel]	13824 x 7680
Virtual Pixel Size [µm]	12
Virtual Principle Point [mm]	X = 0.0 Y = 0.0
Distortion Parameter	Distortion Free

Camera Parameter for Virtual Image (Color Resolution) before Version PPS 5.0.10.3

Virtual Focal Length [m]	0.12 / 4.75
Virtual Sensor Size [Pixel]	3072 x 2048
Virtual Pixel Size [µm]	12
Virtual Principle Point [mm]	X= -0.646 Y=0.646
Distortion Parameter	Distortion Free

Camera Parameter for Virtual Image (Color Resolution) after Version PPS 5.1.10.3

Virtual Focal Length [m]	0.030
Virtual Sensor Size [Pixel]	3456x1920
Virtual Pixel Size [µm]	12
Virtual Principle Point [mm]	X = 0.0 Y = 0.0
Distortion Parameter	Distortion Free

Camera Serial Number and Burn-In flights

	Burn In Flight: 11.08.2008					
Camera	Serial Number	Calib. Date				
PAN1	00115568	10.07.2008				
PAN2	00115567	11.07.2008				
PAN3	00117306	31.07.2008				
PAN4	00115565	08.07.2008				
MS1 (NIR)	00116836	22.07.2008				
MS2 (Blue)	00114966	22.07.2008				
MS3 (Red)	00116837	11.07.2008				
MS4 (Green)	00116840	22.07.2008				

Calibration Protocol
DMC01 - 0129

Camera Orientation PAN-Cameras (Burn-In Flight 11.08.2008)

Camera (Serial Number)	X [m] (Accuracy)	Y [m] (Accuracy)	Z [m] (Accuracy)	Omega [Deg] (Accuracy)	Phi [Deg] (Accuracy)	Kappa [Deg] (Accuracy)
PAN1 (00115583)	0.064 (0)	-0.079 (0)	1000 (0)	18.009 (0.001)	10.045 (0.001)	86.923 (0.001)
PAN2 (00115584)	-0.064 (0)	-0.079 (0)	1000 (0)	17.908 (0.001)	-10.225 (0.001)	93.462 (0.001)
PAN3 (00115546)	-0.064 (0)	0.079 (0)	1000 (0)	-18.003 (0.001)	-10.041 (0.001)	-93.242 (0.001)
PAN4 (00115794)	0.064 (0)	0.079 (0)	1000 (0)	-17.914 (0.001)	10.220 (0.001)	-87.282 (0.001)

The data is connected to the virtual projection center of the virtual image.
The above Platform calibration values are initial values and are be liable to slight fluctuations between project images and between different projects. The position is fix and error free. The rotation axes of the angles are (in this order)

Omega	x-Axis
Phi	y-Axis
Kappa	z-Axis

The results of the Platform calibration were generated with DMC Postprocessing SW (PPS), Version 5.4, from Intergraph Z/I Imaging photogrammetric product suite.

Platform calibration performed by

Dipl. Ing. C. Müller

14.08.2008
Date

Calibration Protocol
DMC01 - 0129

Aerotriangulation Results (Burn-In Flight 11.08.2008)

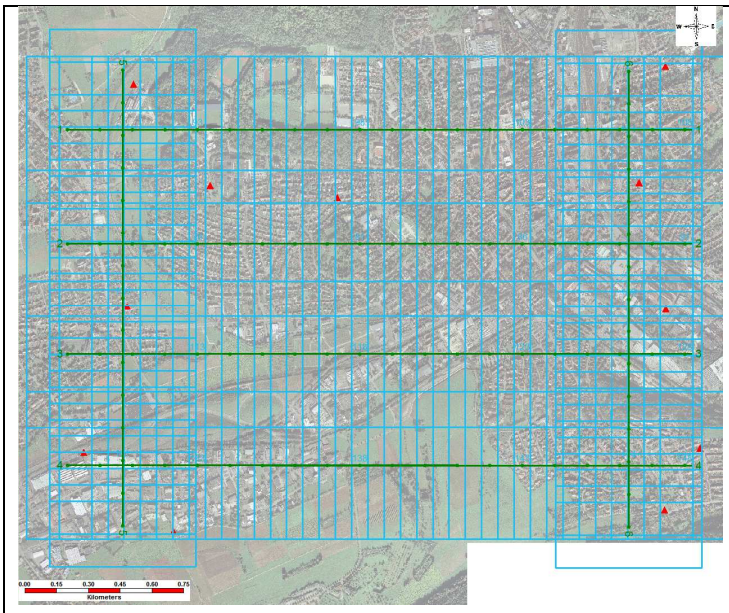


Photo Scale	1:5000
Flying Height [m]	600 AGL
Flying Altitude [m]	1060 AMSL
Run-Spacing [m]	580.6
Base-Length [m]	184.3
Number of Exposures	98
Side-lap [%]	30
End-lap [%]	60
Terrain Height [m]	460
Number of strips	6
Photos in one strip	2 x 15 N-S 4 x 17 W-E
Photos Used	98
Control Points Used	63
Check Points Used	
GSD [cm]	6

Statistic results:

Matching results: 0 Weak Areas – covered with clouds
Whole Block 98 exposures used
0 exposures not used

Whole Block Sigma relativ: 2.857 um

Whole Block Sigma absolut: 2.894 um

Whole Block

Photo-T Parameters and Results for Project Aa_6cm_DMC129

PhotoT Triangulation Options

```
Adjustment Mode             : Absolute
Precision Computation       : Enabled
Error Detection             : Disabled
Camera Calibration          : Disabled
Self-Calibration            : Disabled
Given EO/GPS                : Disabled
Antenna Offsets             : Disabled
GPS Shift/Drift Correction  : Disabled
INS Shift/Drift Correction  : Disabled
```

Parameters

Parameter	X/Omega	Y/Phi	Z/Kappa	XY
RMS Control	0.031	0.032	0.041	0.031
RMS Check				
RMS Limits	0.060	0.060	0.080	
Max Ground Residual	0.082	0.079	0.116	
Residual Limits	0.100	0.100	0.120	
Mean Std Dev Object	0.015	0.016	0.042	
RMS Photo Position				

Calibration Protocol
DMC01 - 0129

```
          RMS Photo Attitude
 Mean Std Dev Photo Position   0.031  0.030   0.018
 Mean Std Dev Photo Attitude   0.002  0.003   0.001

Key Statistics

       Sigma:         2.9  um
       Number of iterations: 4
       Degrees of Freedom:   15588
```

The results of the Aerotriangulation were generated with ImageStation Automatic Triangulation (ISAT), Version 5.3, from Intergraph Z/I Imaging photogrammetric product suite.

Aerotriangulation performed by

Dipl. Ing. C. Müller

14.08.2008
Date

Calibration Protocol
DMC01 - 0129

Calibration Certificate N^{O} 00115568

Object	Digital Aerial Survey Camera
Manufacturer	Z/I Imaging D-73431 Aalen
Type	DMC-Panchromatic
Serial Number	00115568

Calibration performed at:
Carl Zeiss Jena

Number of pages of the certificate 68

Date of Calibration 10.Jul.2008

CertifiedDate	Division Head	Person in Charge
12.Aug.2008	(H. Sohnle)	(S. Schröder)

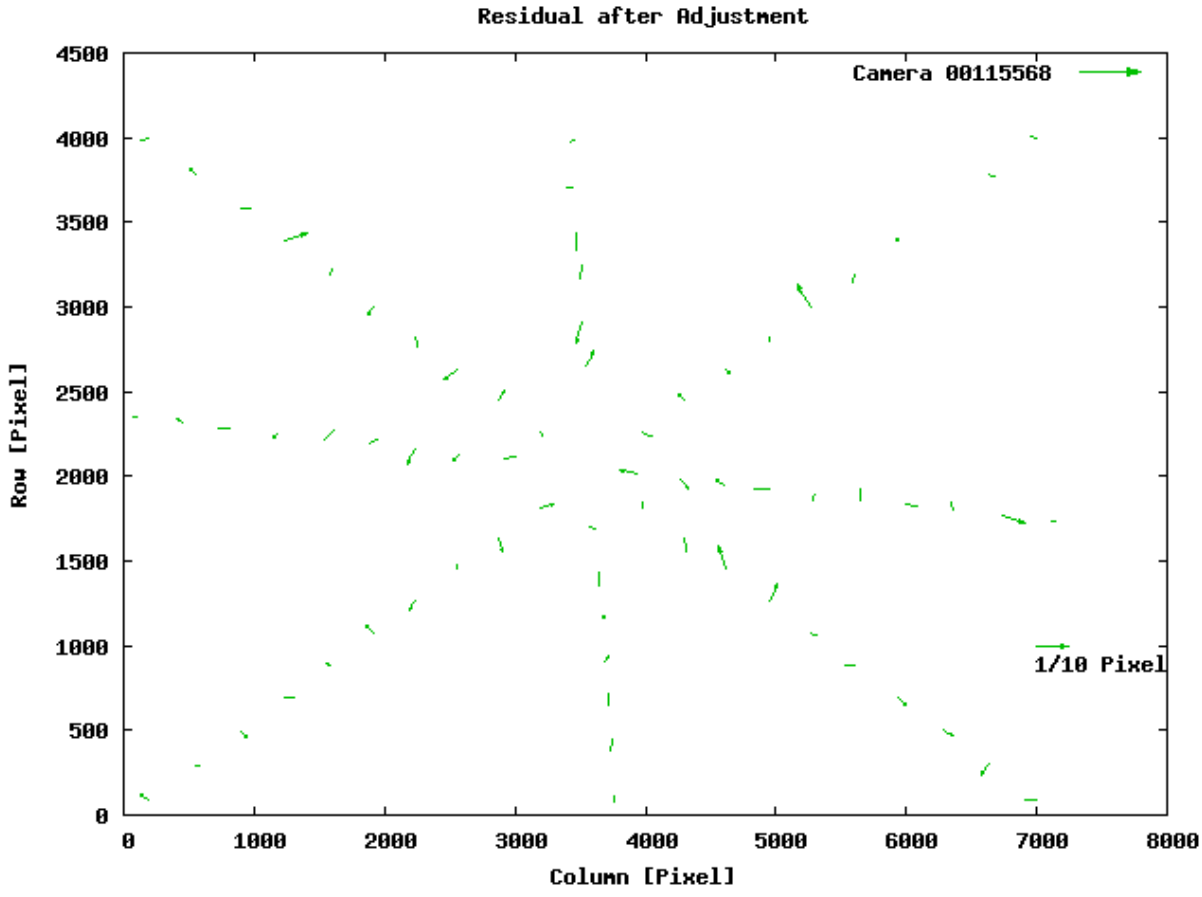
Geometric Calibration Protocol

Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00115568

	Param	Adjusted	Std.dev.
Principal Point [m]	x_0	0.0001267	5.683E-06
	y_0	6.771E-05	3.439E-06
Focal Length [m]	Δf	-0.0003868	9.917E-07
Radial Distortion	K_1	0.7293	0.02547
	K_2	-320.1	22.95
	K_3	-18910	6045
Decentring distortion	P_1	0.0002035	0.0001295
	P_2	9.903E-05	6.522E-05
In Plane Distortion	B_1	2.857E-06	6.615E-06
	B_2	1.061E-05	3.803E-06

Adjusted Focal length = 0.12+ dc =0.1196132 [m]



Residuals in Image after Adjustment

Max Residual [µm]: 0.9

Threshold [µm]: 8.5

Remarks:

The images after the post processing are distortion free. For interior orientation parameters of the DMC virtual image see section: “Calibration Parameter of the virtual images”.

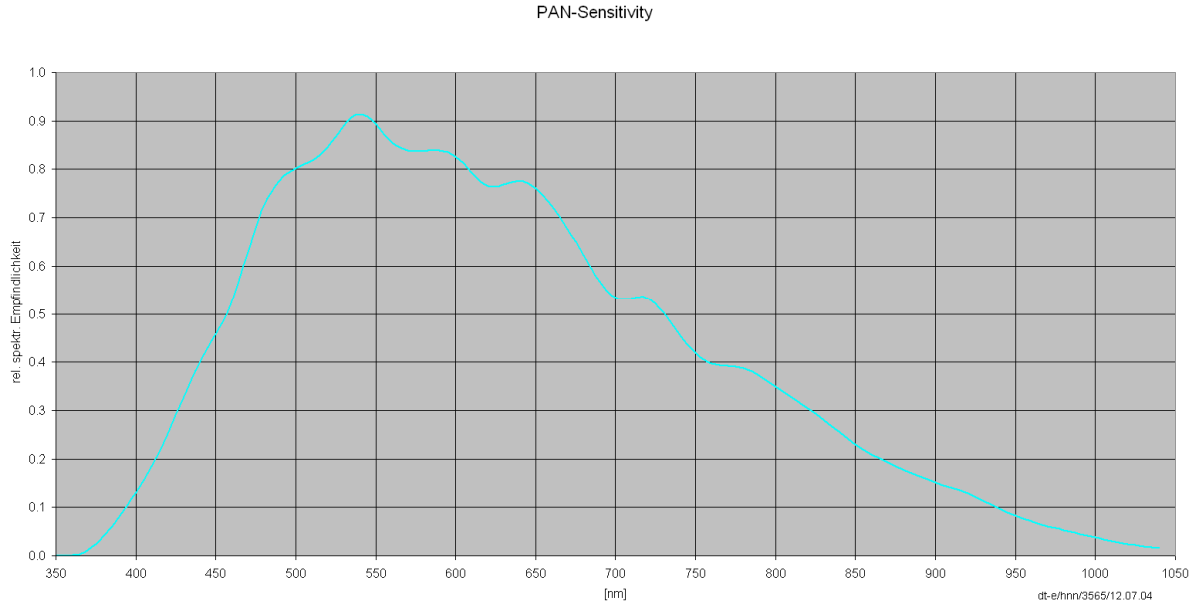
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

Radiometric Calibration Protocol

In this section you’ll find the radiometric calibration results.

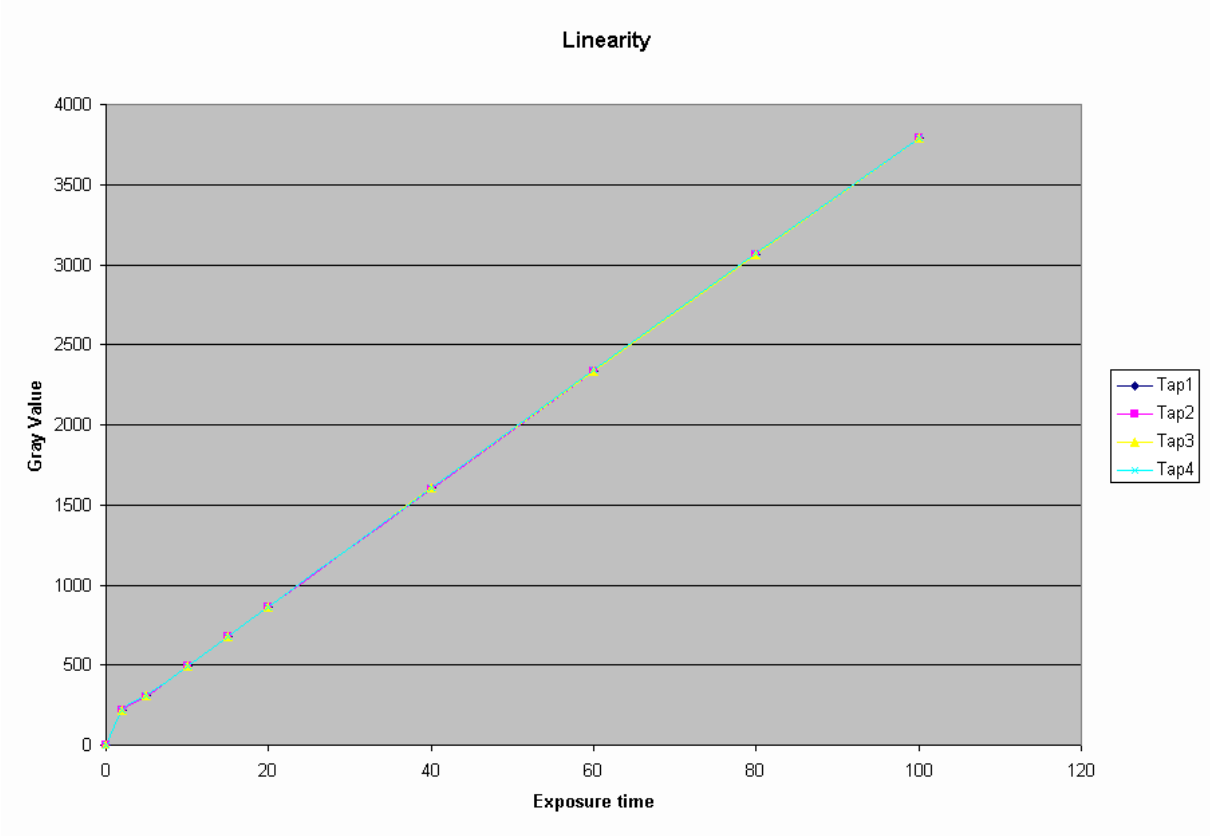
Camera ID	00115568
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

Sensitivity of camera



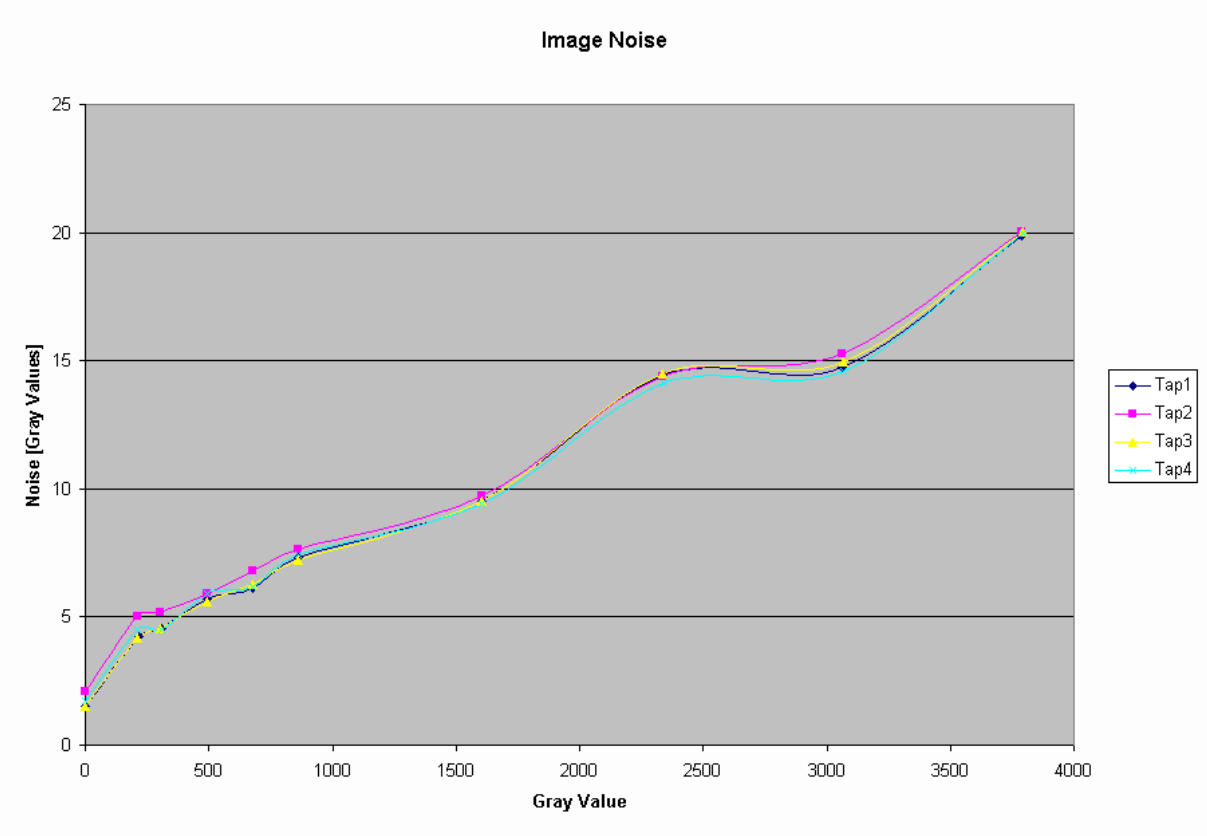
Remark:
Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Linearity



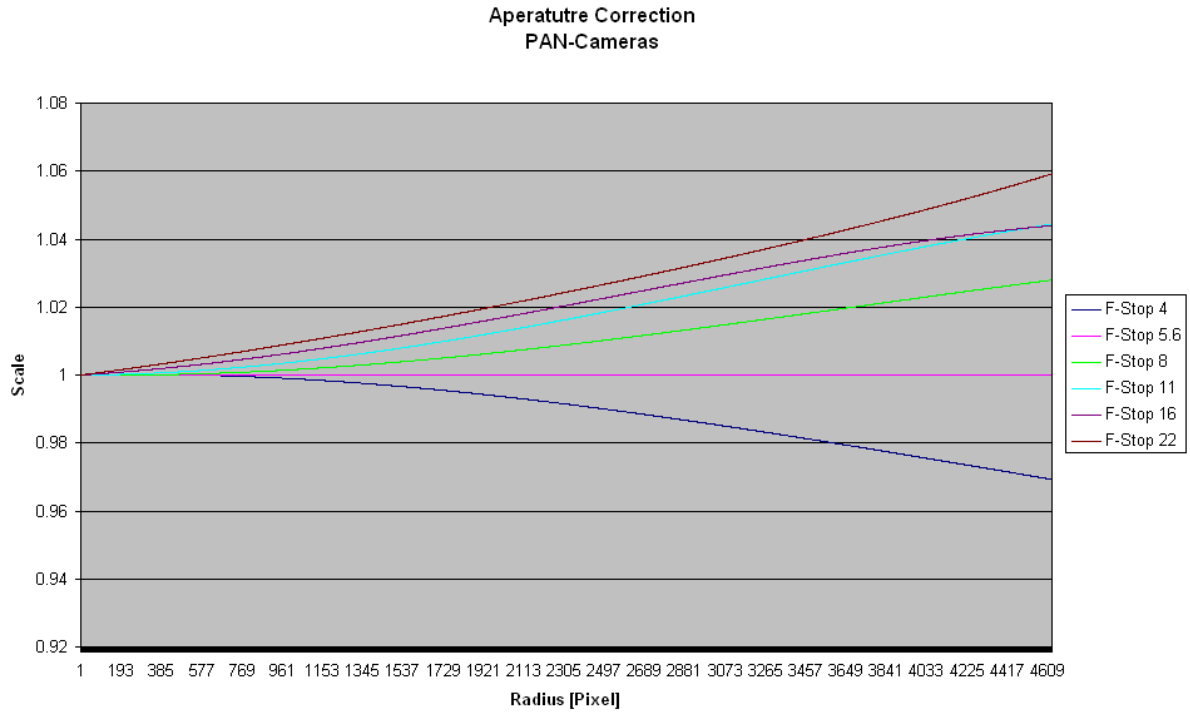
Remark:
The sensor linearity is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Noise



Remark:
The sensor noise is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

Aperture Correction



Remark:
This measurement is similar for the same aperture revision number. For more details see Appendix: "Radiometric Calibration Model".

Defect Pixel List

Number of defect pixels: 0

Number of defect clusters: 0

Number of defect columns: 0

Nr Row Column

Defect Column RowStart ColumnStart RowEnd ColumnEnd

Remark

See Appendix for definition of defect pixels and maximal allowed numbers.

Calibration Protocol
DMC01 - 0129

Calibration Certificate N^{O} 00115567

Object	Digital Aerial Survey Camera
Manufacturer	Z/I Imaging D-73431 Aalen
Type	DMC-Panchromatic
Serial Number	00115567

Calibration performed at:
Carl Zeiss Jena

Number of pages of the certificate 68

Date of Calibration 11.Jul.2008

CertifiedDate	Division Head	Person in Charge
12.Aug.2008	(H. Sohnle)	(S. Schröder)

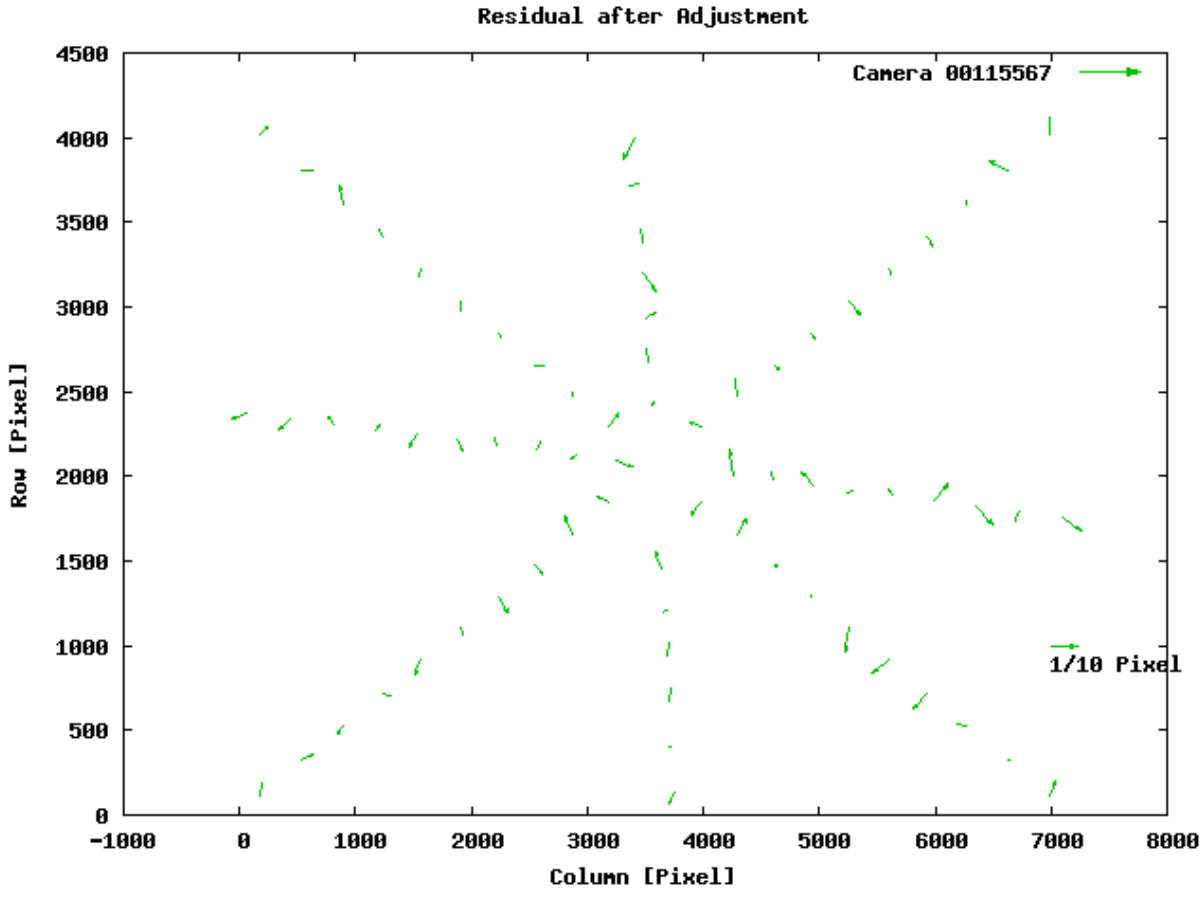
Geometric Calibration Protocol

Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00115567

	Param	Adjusted	Std.dev.
Principal Point [m]	x_0	-3.596E-05	7.014E-06
	y_0	-0.0002403	4.244E-06
Focal Length [m]	Δf	-0.0004561	1.224E-06
Radial Distortion	K_1	0.8706	0.03144
	K_2	-408	28.33
	K_3	5096	7461
Decentring distortion	P_1	-0.000683	0.0001599
	P_2	0.0002672	8.05E-05
In Plane Distortion	B_1	-5.773E-05	8.165E-06
	B_2	5.608E-06	4.693E-06

Adjusted Focal length = 0.12+ dc =0.1195439 [m]



Residuals in Image after Adjustment

Max Residual [µm]: 0.9

Threshold [µm]: 8.5

Remarks:

The images after the post processing are distortion free. For interior orientation parameters of the DMC virtual image see section: “Calibration Parameter of the virtual images”.

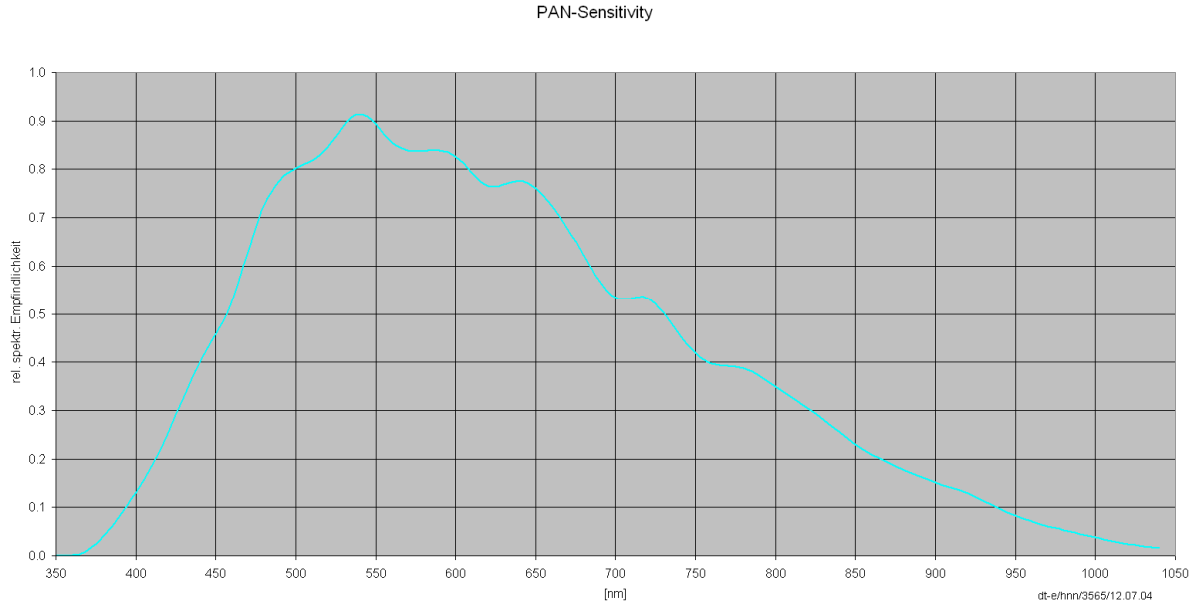
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

Radiometric Calibration Protocol

In this section you’ll find the radiometric calibration results.

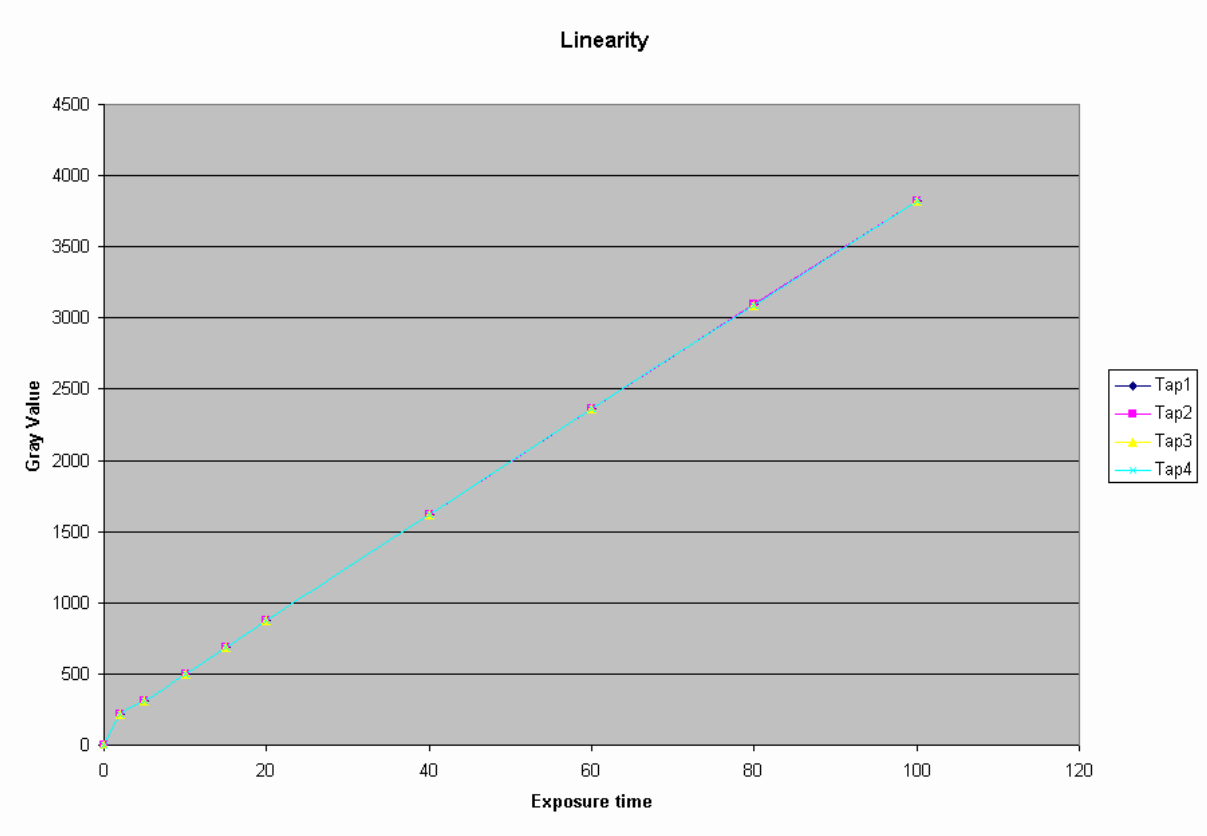
Camera ID	00115567
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

Sensitivity of camera



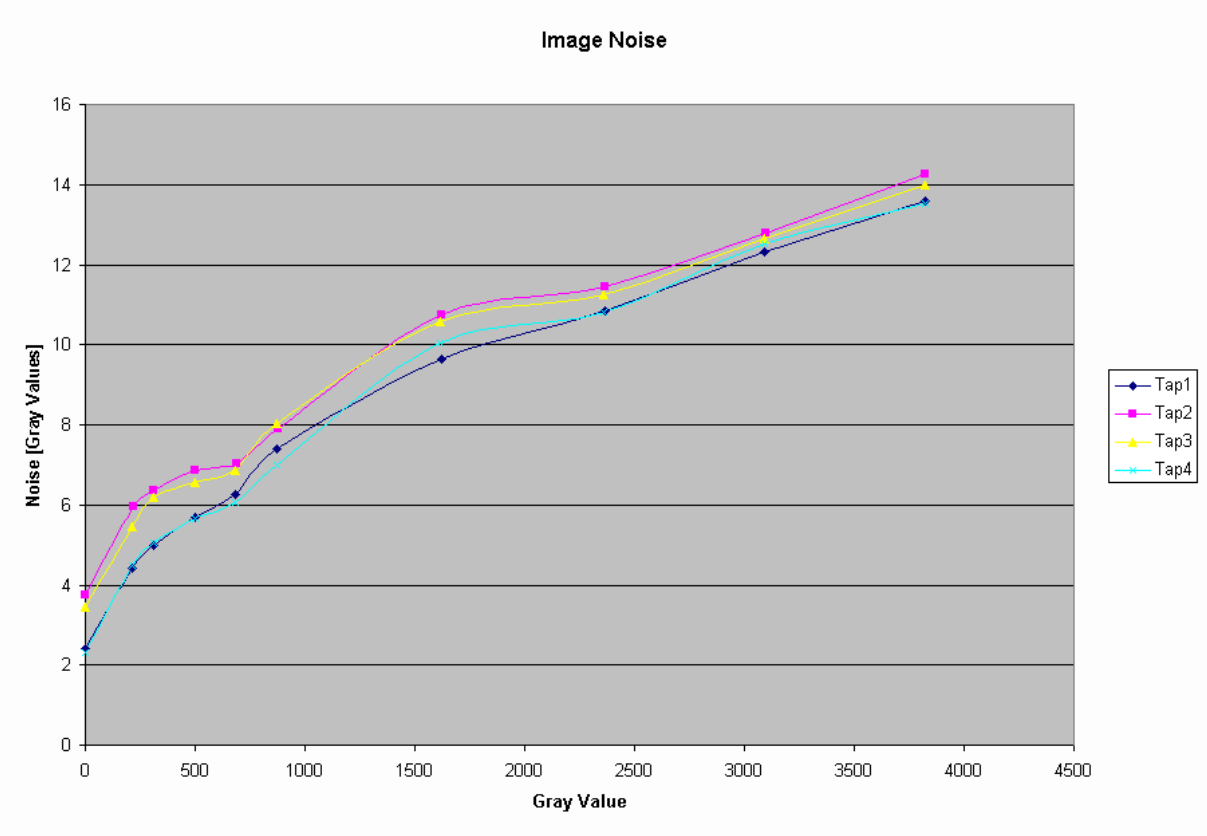
Remark:
Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Linearity



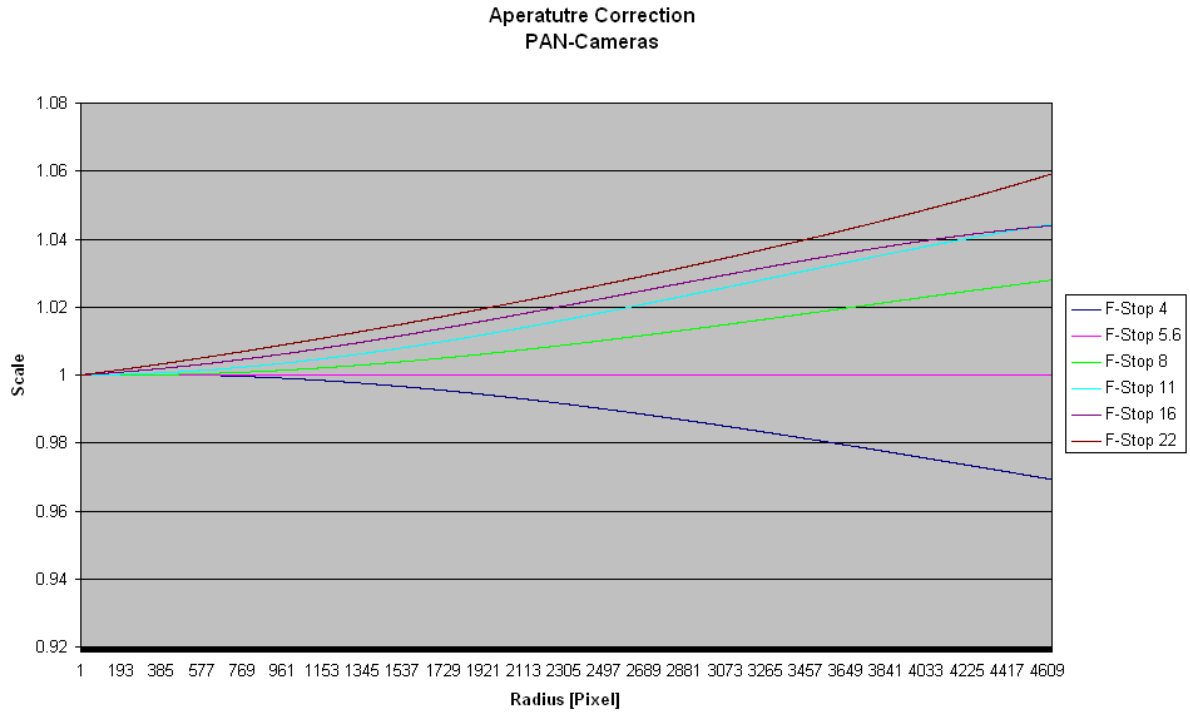
Remark:
The sensor linearity is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Noise



Remark:
The sensor noise is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

Aperture Correction



Remark:
This measurement is similar for the same aperture revision number. For more details see Appendix: "Radiometric Calibration Model".

Defect Pixel List

Number of defect pixels: 7

Number of defect clusters: 0

Number of defect columns: 0

Nr	Row	Column
0	3968	2520
1	3968	2521
2	1225	2748
3	1224	2749
4	1225	2749
5	538	5348

6 539 5348

Defect	Column	RowStart	ColumnStart	RowEnd	ColumnEnd

Remark

See Appendix for definition of defect pixels and maximal allowed numbers.

Calibration Protocol
DMC01 - 0129

Calibration Certificate N^{O} 00117306

Object	Digital Aerial Survey Camera
Manufacturer	Z/I Imaging D-73431 Aalen
Type	DMC-Panchromatic
Serial Number	00117306

Calibration performed at:
Carl Zeiss Jena

Number of pages of the certificate 68

Date of Calibration 31.Jul.2008

CertifiedDate	Division Head	Person in Charge
12.Aug.2008	(H. Sohnle)	(S. Schröder)

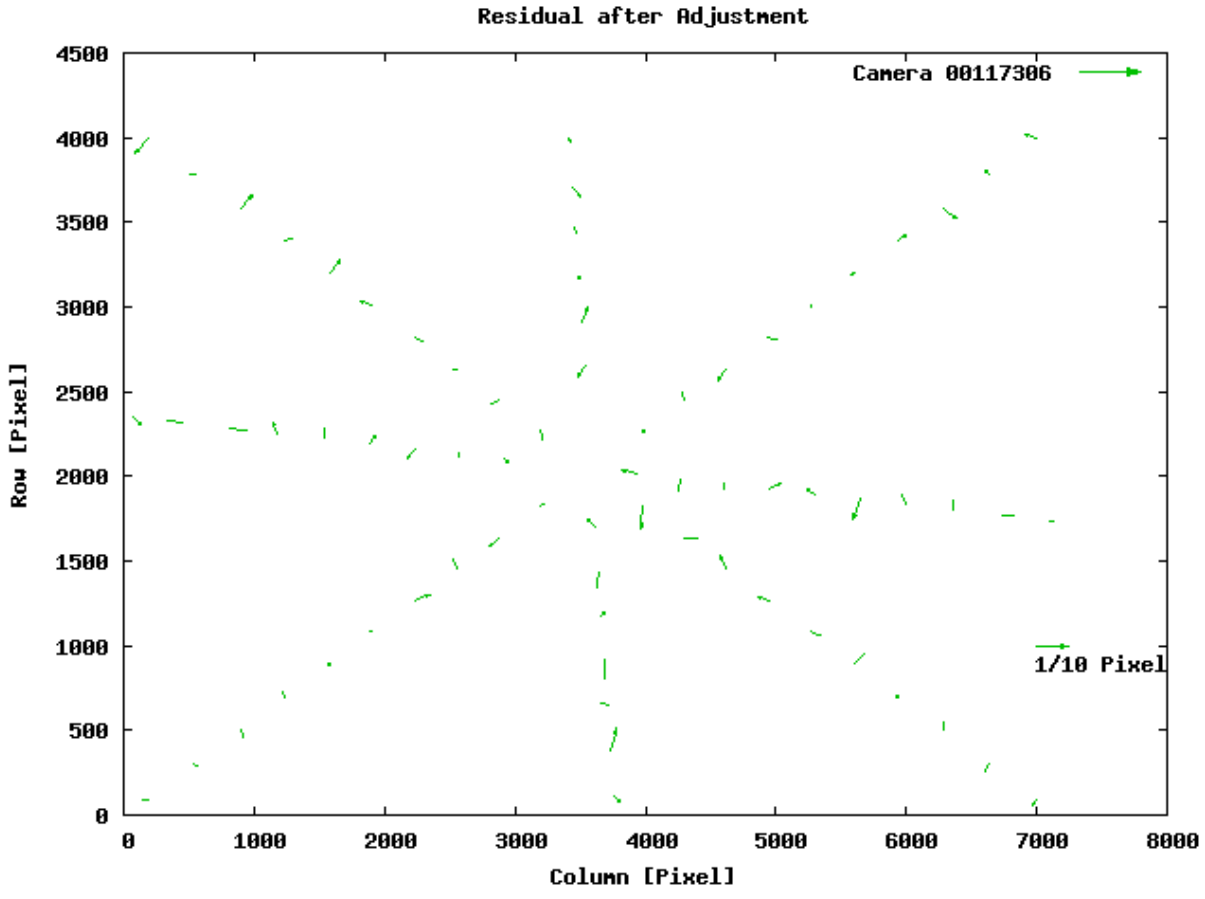
Geometric Calibration Protocol

Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00117306

	Param	Adjusted	Std.dev.
Principal Point [m]	x_0	6.434E-05	5.405E-06
	y_0	-1.559E-05	3.27E-06
Focal Length [m]	Δf	-0.0004456	9.431E-07
Radial Distortion	K_1	0.8527	0.02423
	K_2	-399.1	21.83
	K_3	-1916	5749
Decentring distortion	P_1	0.0002541	0.0001232
	P_2	-0.0002529	6.203E-05
In Plane Distortion	B_1	-3.268E-05	6.292E-06
	B_2	-1.187E-05	3.617E-06

Adjusted Focal length = 0.12+ dc =0.1195544 [m]



Residuals in Image after Adjustment

Max Residual [µm]: 0.7

Threshold [µm]: 8.5

Remarks:

The images after the post processing are distortion free. For interior orientation parameters of the DMC virtual image see section: “Calibration Parameter of the virtual images”.

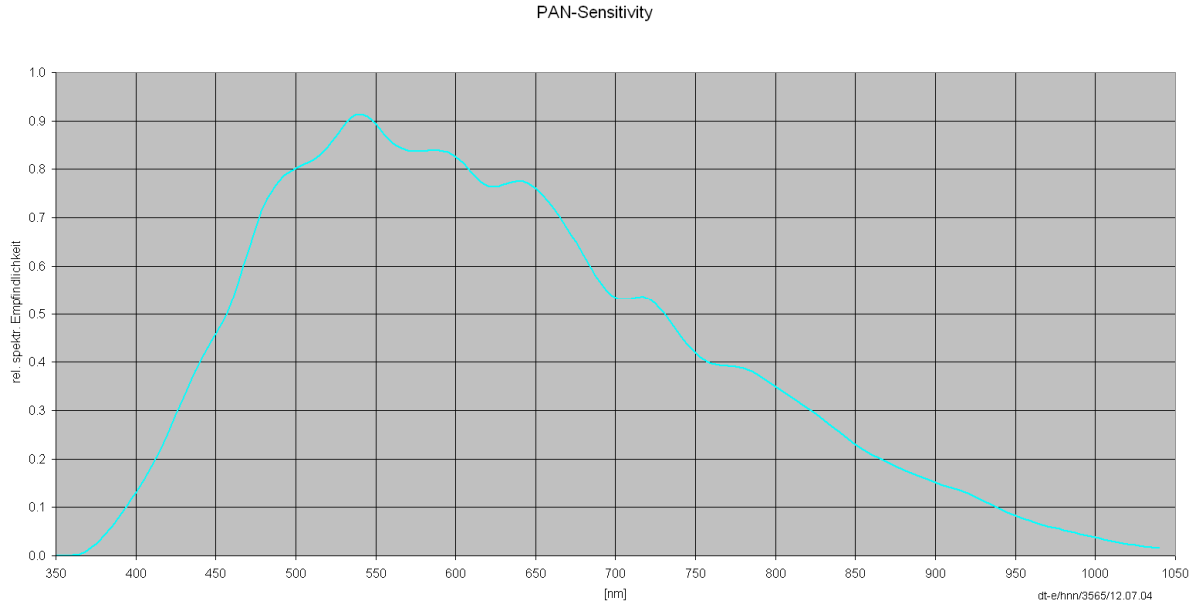
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

Radiometric Calibration Protocol

In this section you’ll find the radiometric calibration results.

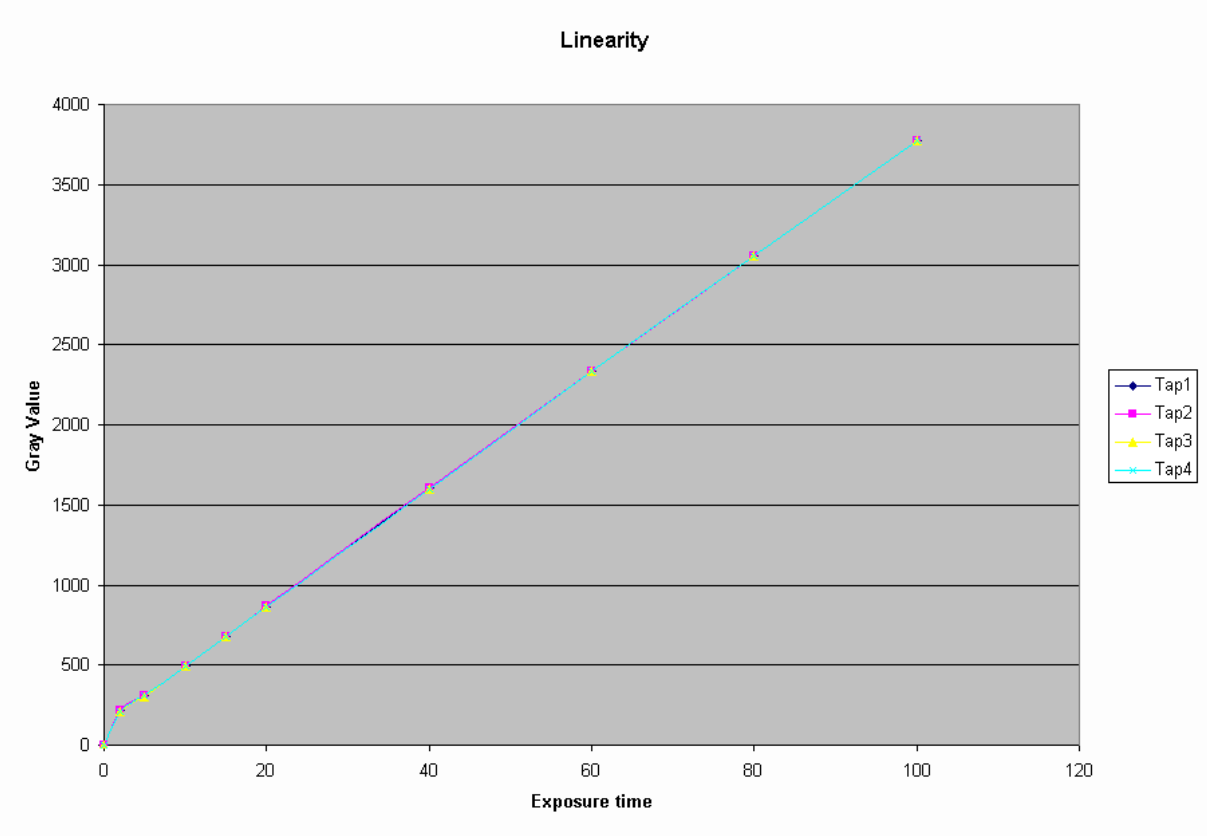
Camera ID	00117306
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

Sensitivity of camera



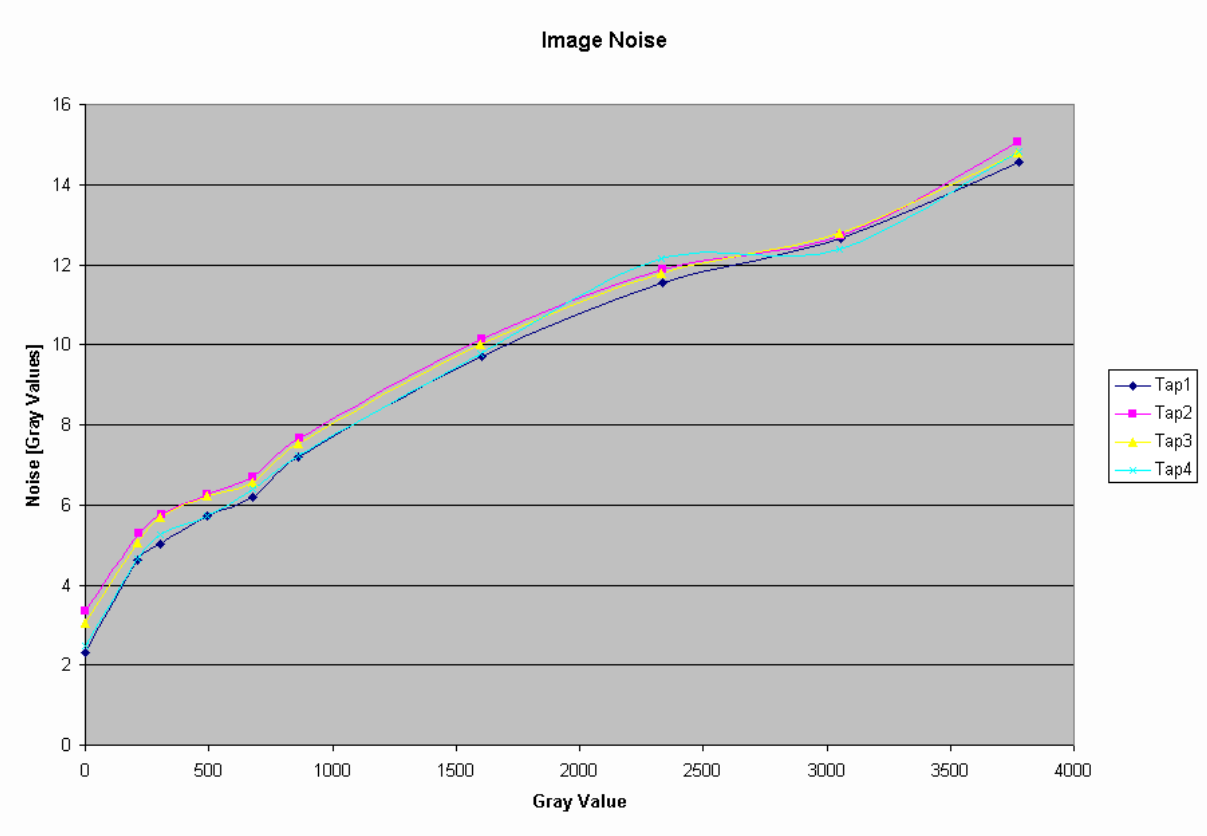
Remark:
Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Linearity



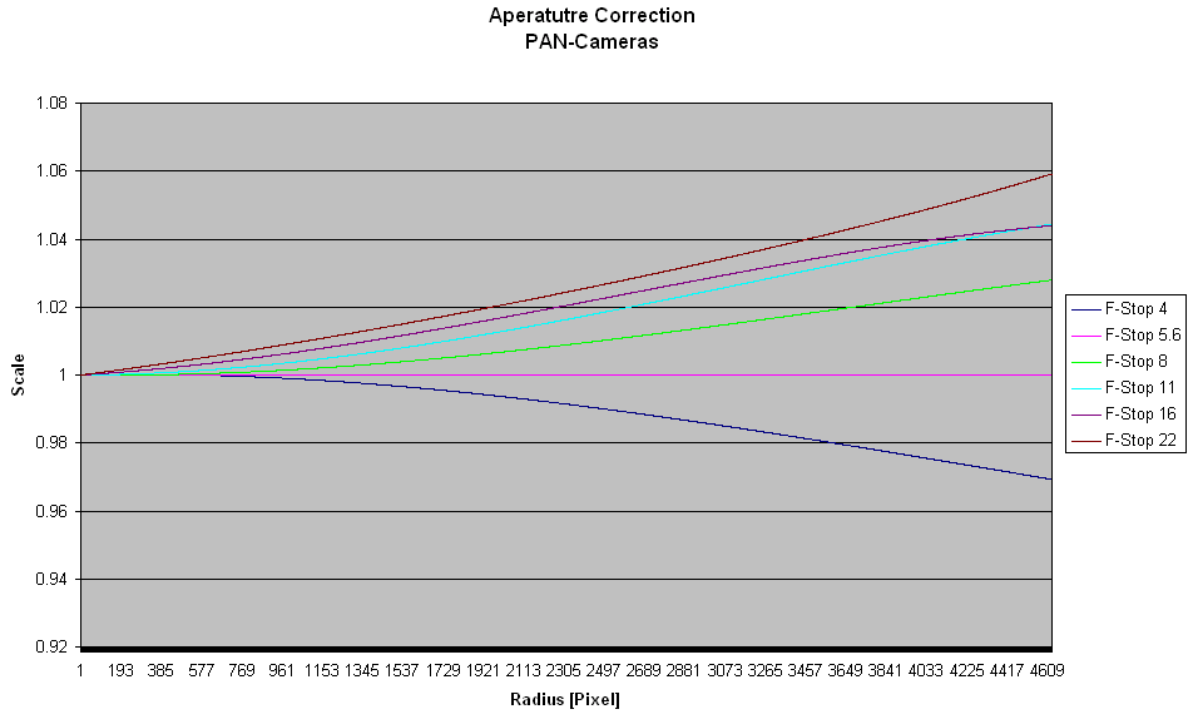
Remark:
The sensor linearity is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Noise



Remark:
The sensor noise is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

Aperture Correction



Remark:
This measurement is similar for the same aperture revision number. For more details see Appendix: "Radiometric Calibration Model".

Defect Pixel List

Number of defect pixels: 6

Number of defect clusters: 0

Number of defect columns: 0

Nr	Row	Column
0	2154	1606
1	2154	1607
2	2042	6315
3	2042	6316
4	2043	6316
5	2043	6317

Defect Column	RowStart	ColumnStart	RowEnd	ColumnEnd

Remark

See Appendix for definition of defect pixels and maximal allowed numbers.

Calibration Protocol
DMC01 - 0129

Calibration Certificate N^{O} 00115565

Object	Digital Aerial Survey Camera
Manufacturer	Z/I Imaging D-73431 Aalen
Type	DMC-Panchromatic
Serial Number	00115565

Calibration performed at:
Carl Zeiss Jena

Number of pages of the certificate 68

Date of Calibration 08.Jul.2008

CertifiedDate	Division Head	Person in Charge
12.Aug.2008	(H. Sohnle)	(S. Schröder)

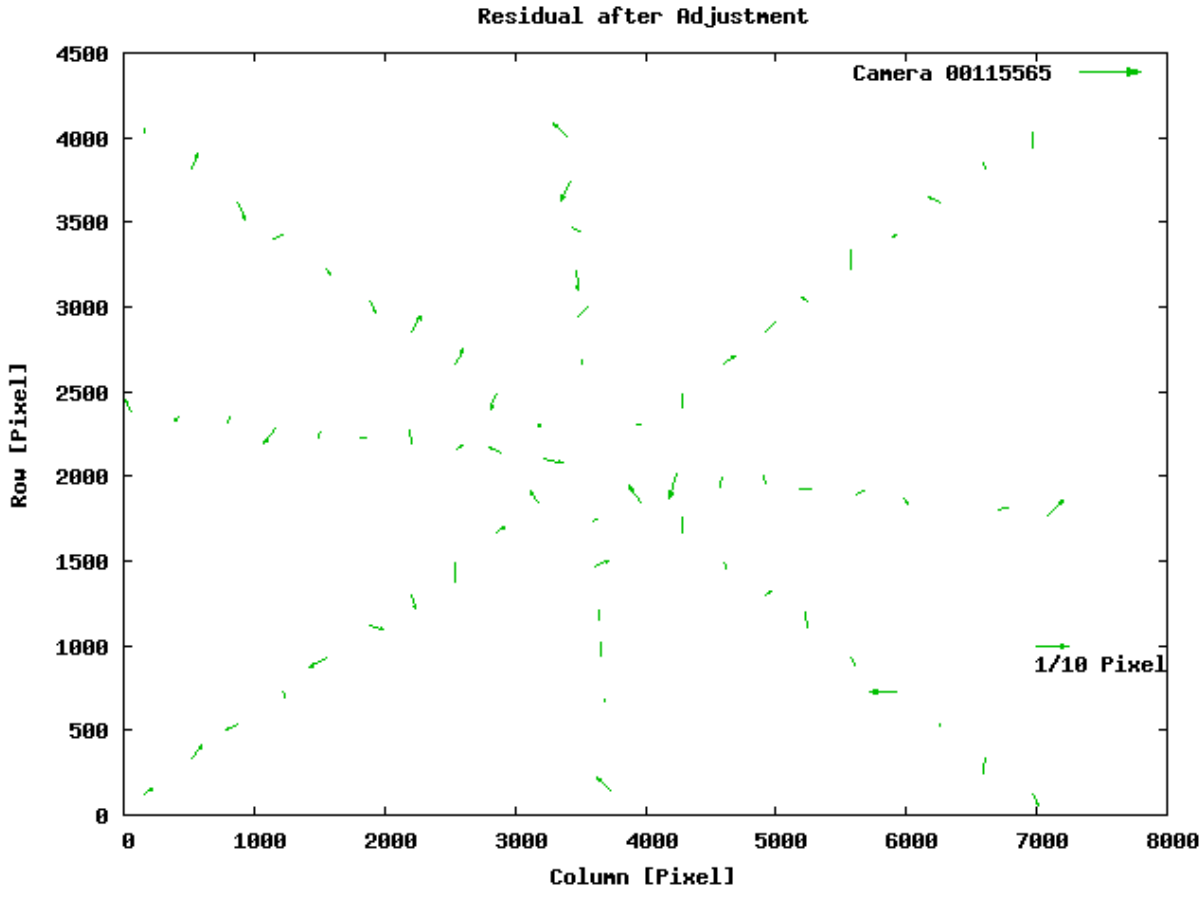
Geometric Calibration Protocol

Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00115565

	Param	Adjusted	Std.dev.
Principal Point [m]	x_0	-0.0002414	6.261E-06
	y_0	-0.000372	3.788E-06
Focal Length [m]	Δf	-0.0004592	1.092E-06
Radial Distortion	K_1	0.8322	0.02806
	K_2	-389.3	25.28
	K_3	2081	6659
Decentring distortion	P_1	-0.0006278	0.0001427
	P_2	0.0002183	7.186E-05
In Plane Distortion	B_1	-3.158E-05	7.289E-06
	B_2	-9.395E-06	4.19E-06

Adjusted Focal length = 0.12+ dc =0.1195408 [m]



Residuals in Image after Adjustment

Max Residual [µm]: 1.0

Threshold [µm]: 8.5

Remarks:

The images after the post processing are distortion free. For interior orientation parameters of the DMC virtual image see section: “Calibration Parameter of the virtual images”.

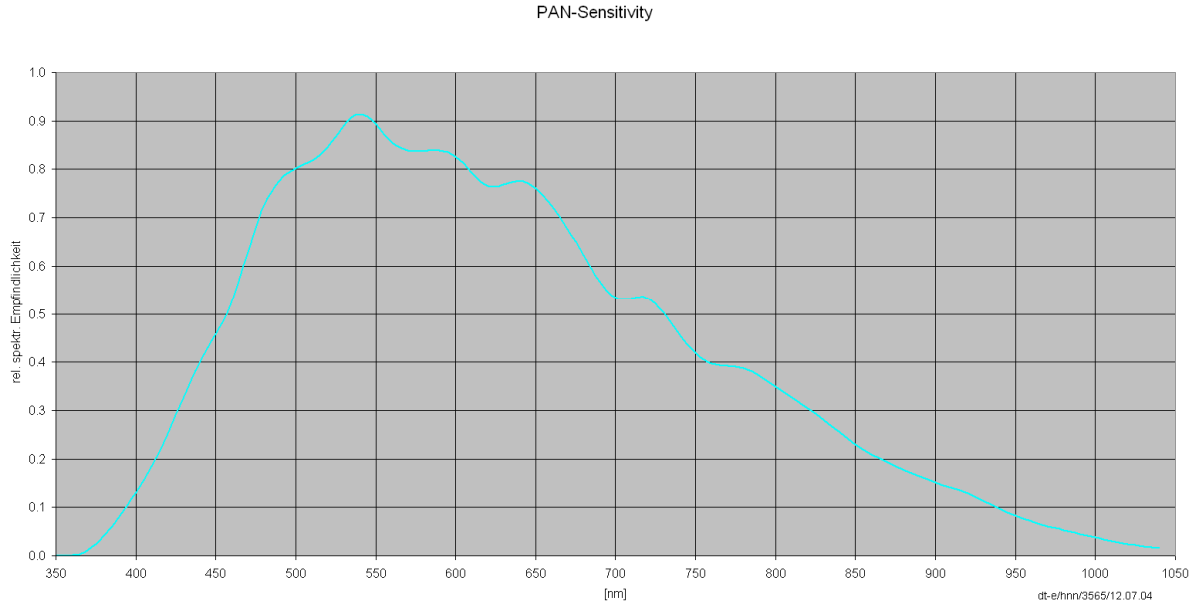
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

Radiometric Calibration Protocol

In this section you’ll find the radiometric calibration results.

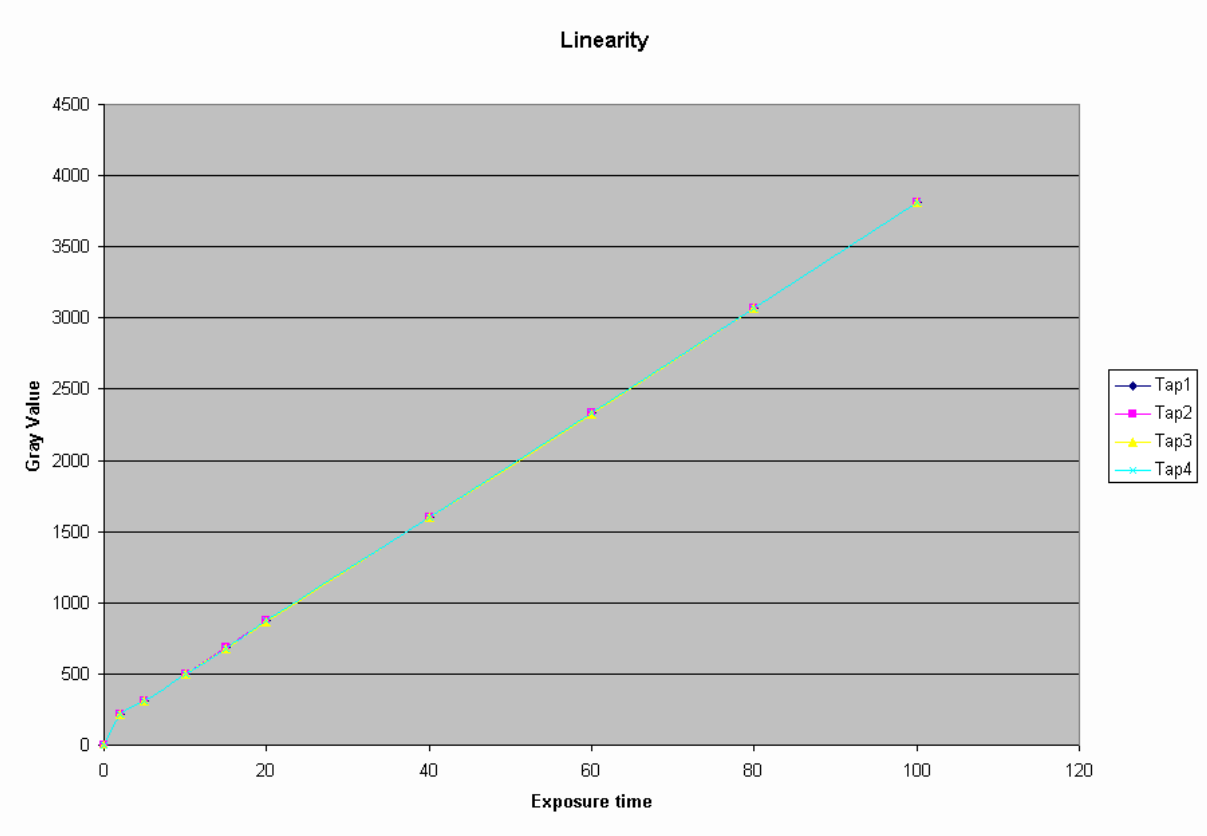
Camera ID	00115565
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

Sensitivity of camera



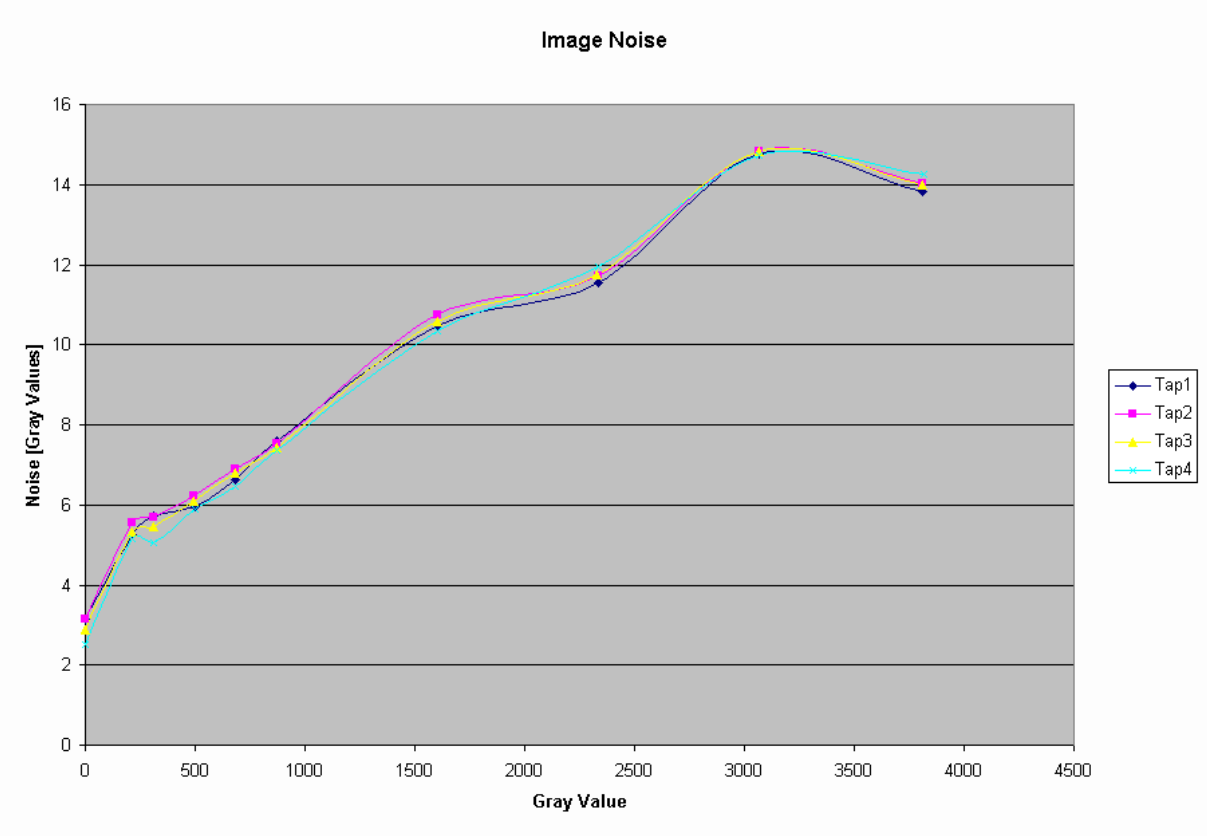
Remark:
Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Linearity



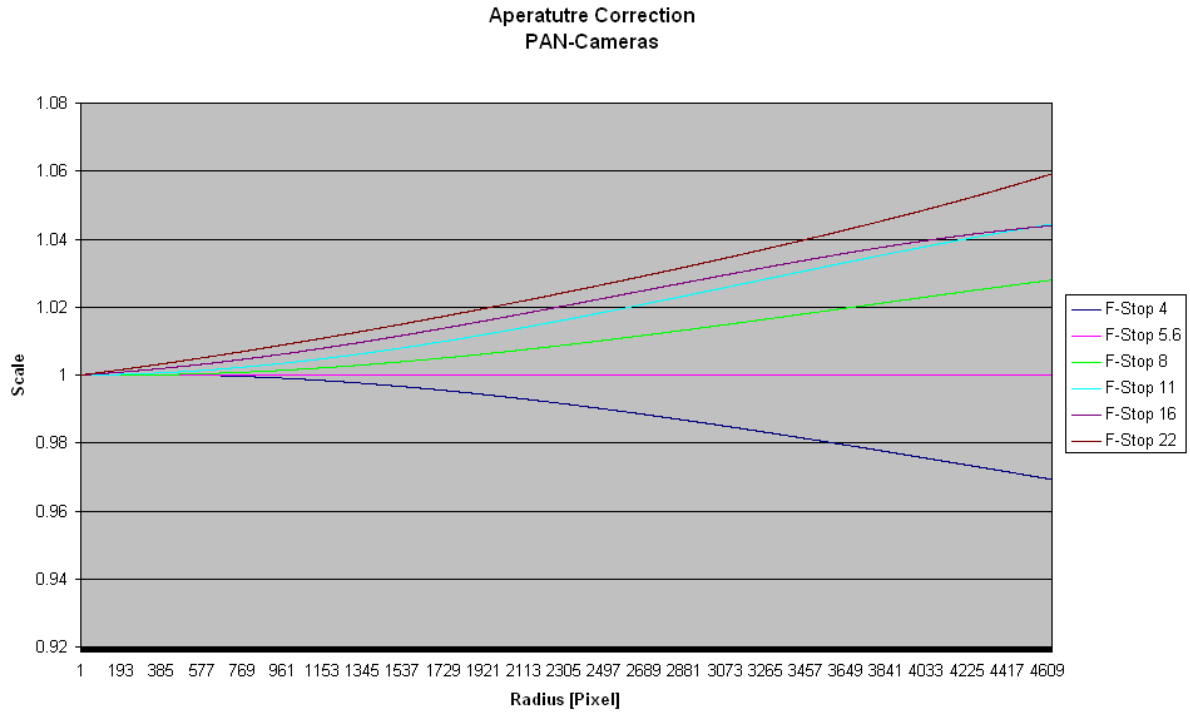
Remark:
The sensor linearity is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Noise



Remark:
The sensor noise is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

Aperture Correction



Remark:
This measurement is similar for the same aperture revision number. For more details see Appendix: "Radiometric Calibration Model".

Defect Pixel List

Number of defect pixels: 0

Number of defect clusters: 0

Number of defect columns: 0

Nr Row Column

Defect Column RowStart ColumnStart RowEnd ColumnEnd

Remark

See Appendix for definition of defect pixels and maximal allowed numbers.

Calibration Protocol
DMC01 - 0129

Calibration Certificate N° 00116836

Object	Digital Aerial Survey Camera
Manufacturer	Z/I Imaging D-73431 Aalen
Type	DMC-MS-NIR
Serial Number	00116836

Calibration performed at:
Carl Zeiss Jena

Number of pages of the certificate 68

Date of Calibration 22.Jul.2008

CertifiedDate	Division Head	Person in Charge
12.Aug.2008	(H. Sohnle)	(S. Schröder)

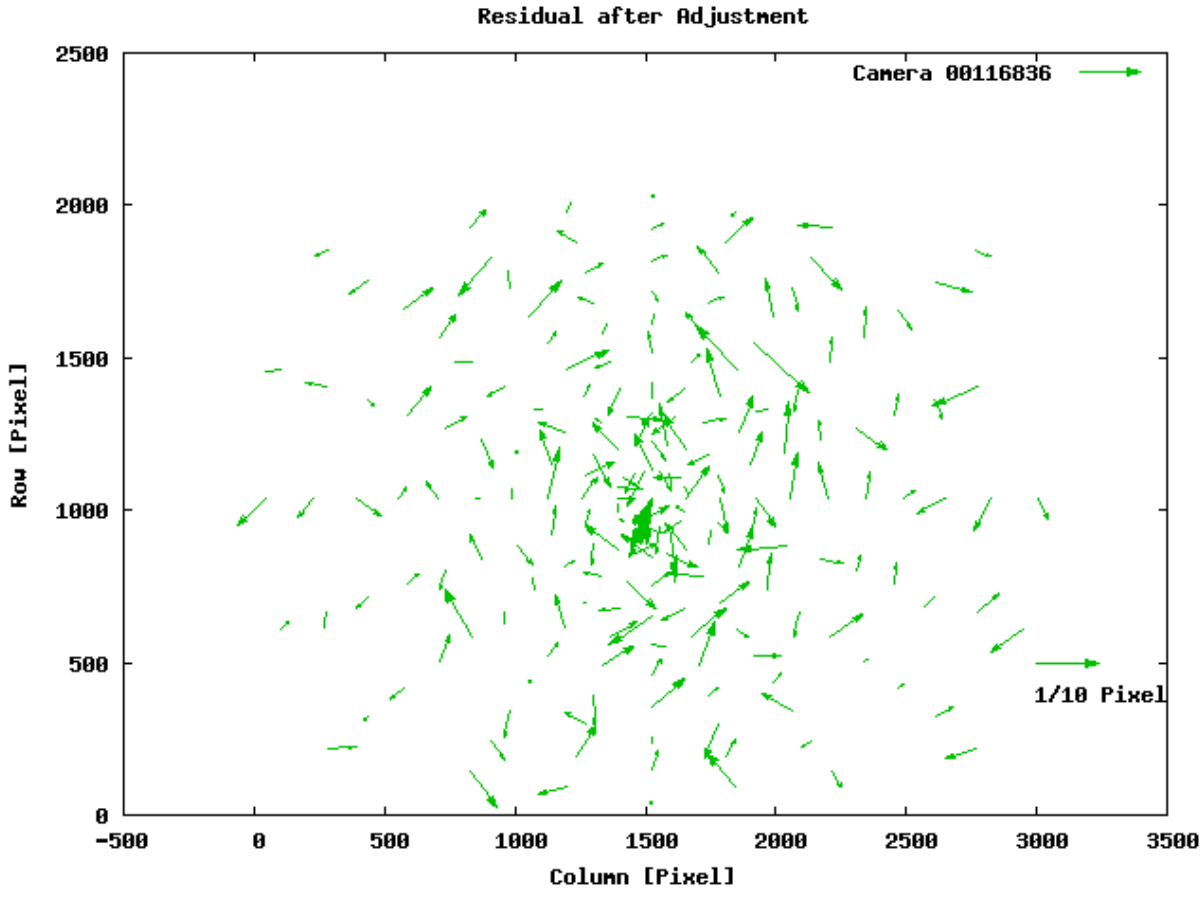
Geometric Calibration Protocol

Calibration Parameters for single camera head

Camera Type	DMC-MS-NIR
Nominal Focal Length	0.025 m
Serial Number	00116836

	Param	Adjusted	Std.dev.
Principal Point [m]	x_0	-0.0001474	1.121E-06
	y_0	-0.0001497	8.022E-07
Focal Length [m]	Δf	-1.077E-05	4.121E-07
Radial Distortion	K_1	-143.8	0.3468
	K_2	224900	2217
	K_3	-151900000	4002000
Decentring distortion	P_1	-0.001138	0.000582
	P_2	-0.003929	0.0003688
In Plane Distortion	B_1	6.141E-06	1.019E-05
	B_2	-4.413E-05	8.294E-06

Adjusted Focal length = 0.025+ dc =0.02498923 [m]



Residuals in Image after Adjustment

Max Residual [µm]: 1.3

Threshold [µm]: 8.5

Remarks:

The images after the post processing are distortion free. For interior orientation parameters of the DMC virtual image see section: “Calibration Parameter of the virtual images”.

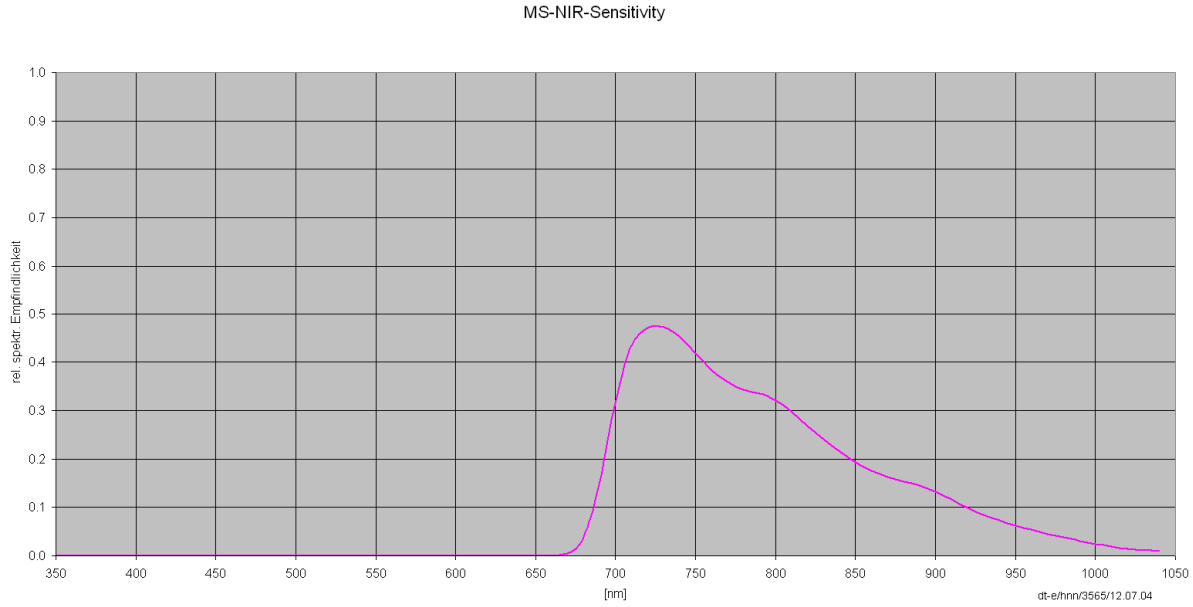
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

Radiometric Calibration Protocol

In this section you’ll find the radiometric calibration results.

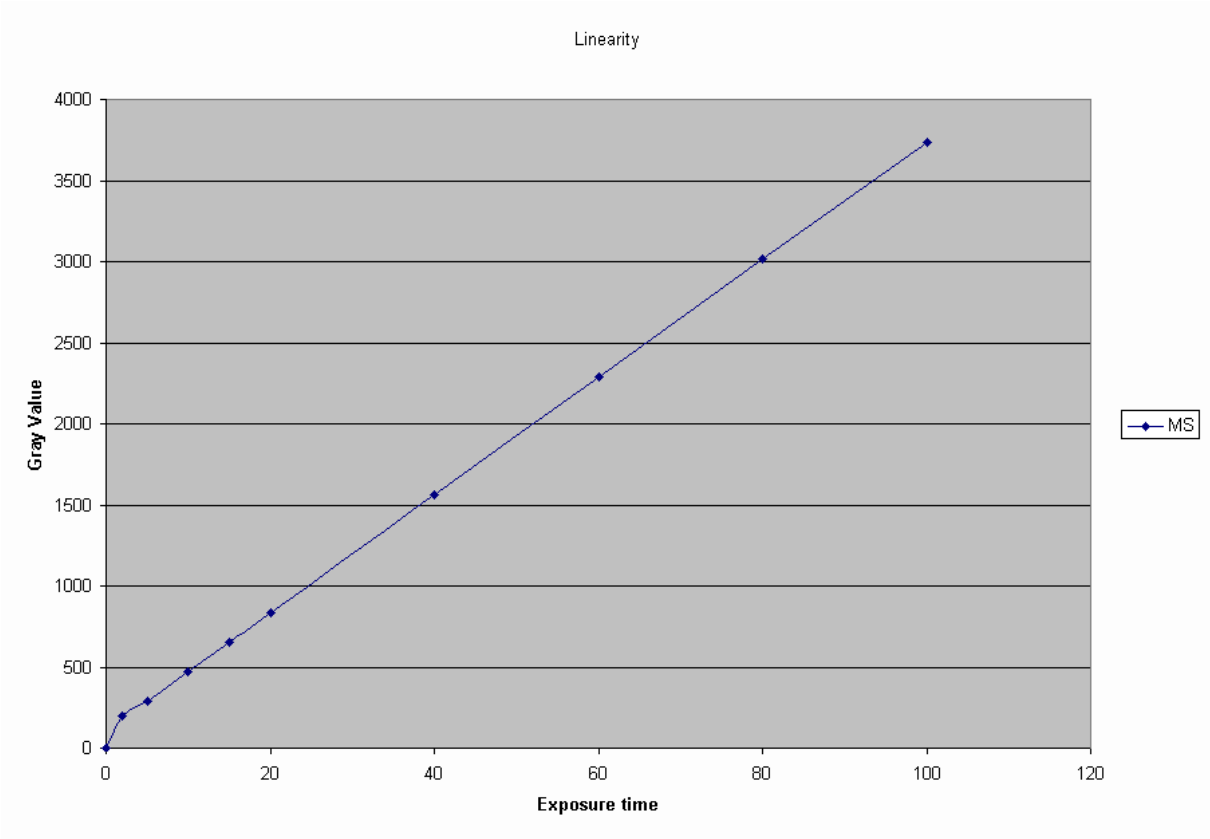
Camera ID	00116836
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1

Sensitivity of camera



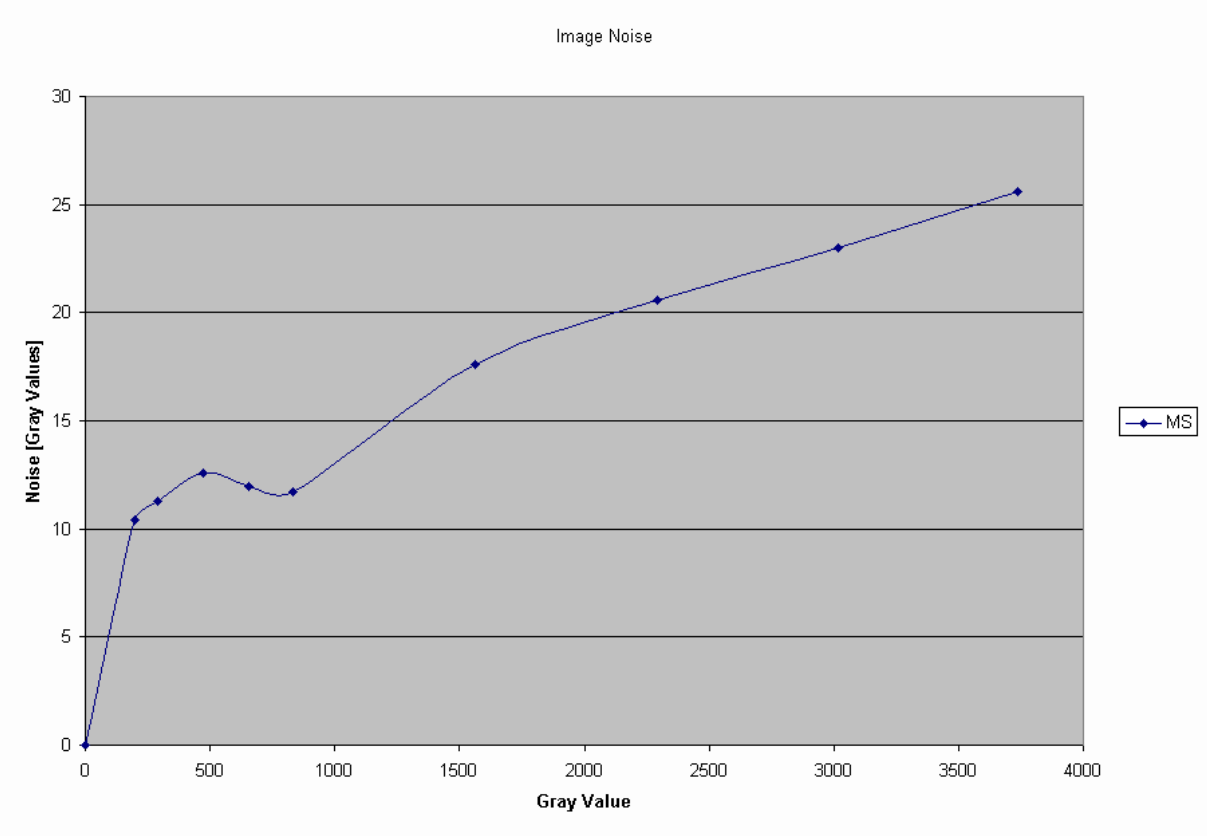
Remark:
Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Linearity



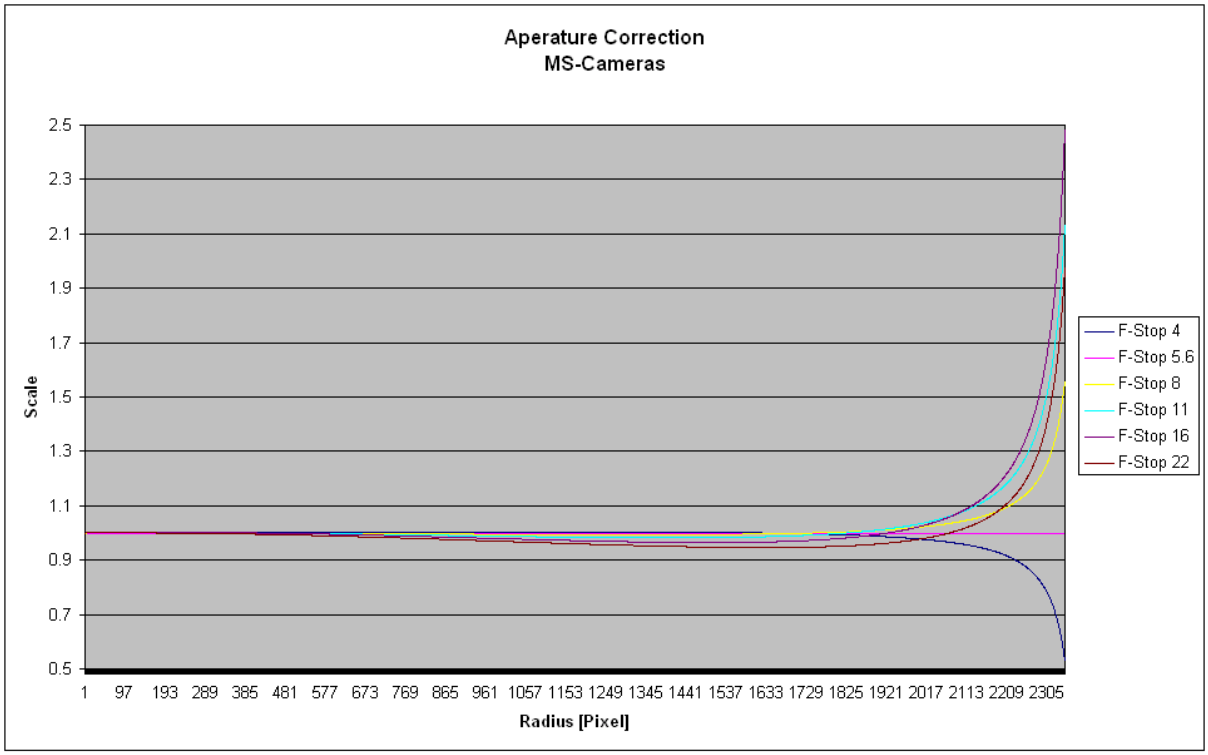
Remark:
The sensor linearity is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Noise



Remark:
The sensor noise is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

Aperture Correction



Remark:
This measurement is similar for the same aperture revision number. For more details see Appendix: "Radiometric Calibration Model".

Defect Pixel List

Number of defect pixels: 0

Number of defect clusters: 0

Number of defect columns: 0

Nr Row Column

Defect Column RowStart ColumnStart RowEnd ColumnEnd

Remark

See Appendix for definition of defect pixels and maximal allowed numbers.

Calibration Protocol
DMC01 - 0129

Calibration Certificate N^{O} 00114966

Object	Digital Aerial Survey Camera
Manufacturer	Z/I Imaging D-73431 Aalen
Type	DMC-MS-Blue
Serial Number	00114966

Calibration performed at:
Carl Zeiss Jena

Number of pages of the certificate 68

Date of Calibration 22.Jul.2008

CertifiedDate	Division Head	Person in Charge
12.Aug.2008	(H. Sohnle)	(S. Schröder)

Calibration Protocol
DMC01 - 0129

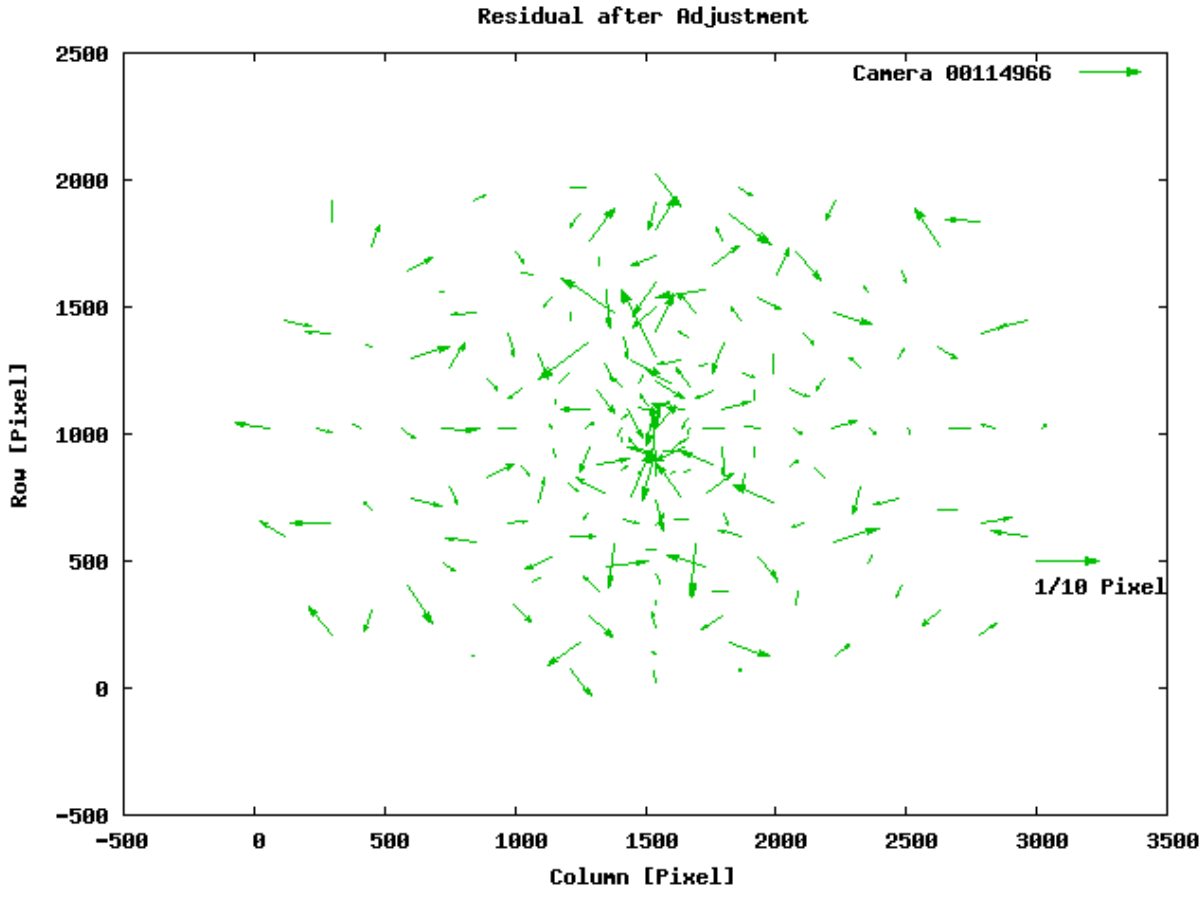
Geometric Calibration Protocol

Calibration Parameters for single camera head

Camera Type	DMC-MS-Blue
Nominal Focal Length	0.025 m
Serial Number	00114966

	Param	Adjusted	Std.dev.
Principal Point [m]	x_0	4.189E-05	1.086E-06
	y_0	4.441E-07	7.584E-07
Focal Length [m]	Δf	-2.197E-05	3.929E-07
Radial Distortion	K_1	-141	0.3325
	K_2	220400	2114
	K_3	-146700000	3797000
Decentring distortion	P_1	0.002033	0.0005647
	P_2	-0.002053	0.0003454
In Plane Distortion	B_1	6.331E-05	9.763E-06
	B_2	-1.448E-05	8.105E-06

Adjusted Focal length = 0.025+ dc =0.02497803 [m]



Residuals in Image after Adjustment

Max Residual [µm]: 1.4

Threshold [µm]: 8.5

Remarks:

The images after the post processing are distortion free. For interior orientation parameters of the DMC virtual image see section: “Calibration Parameter of the virtual images”.

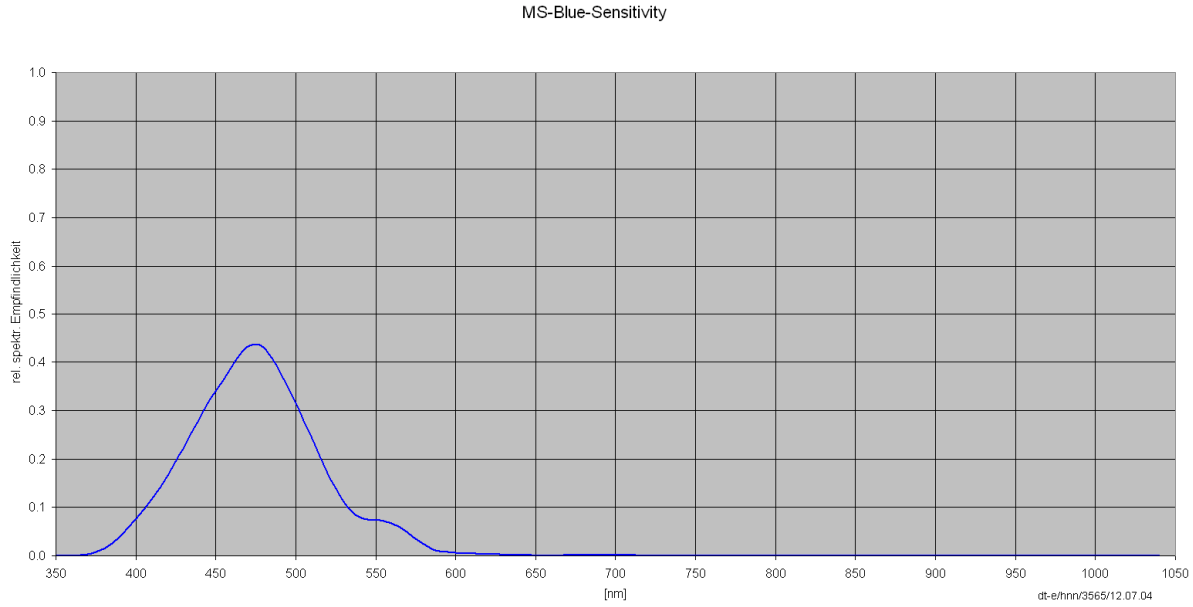
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

Radiometric Calibration Protocol

In this section you’ll find the radiometric calibration results.

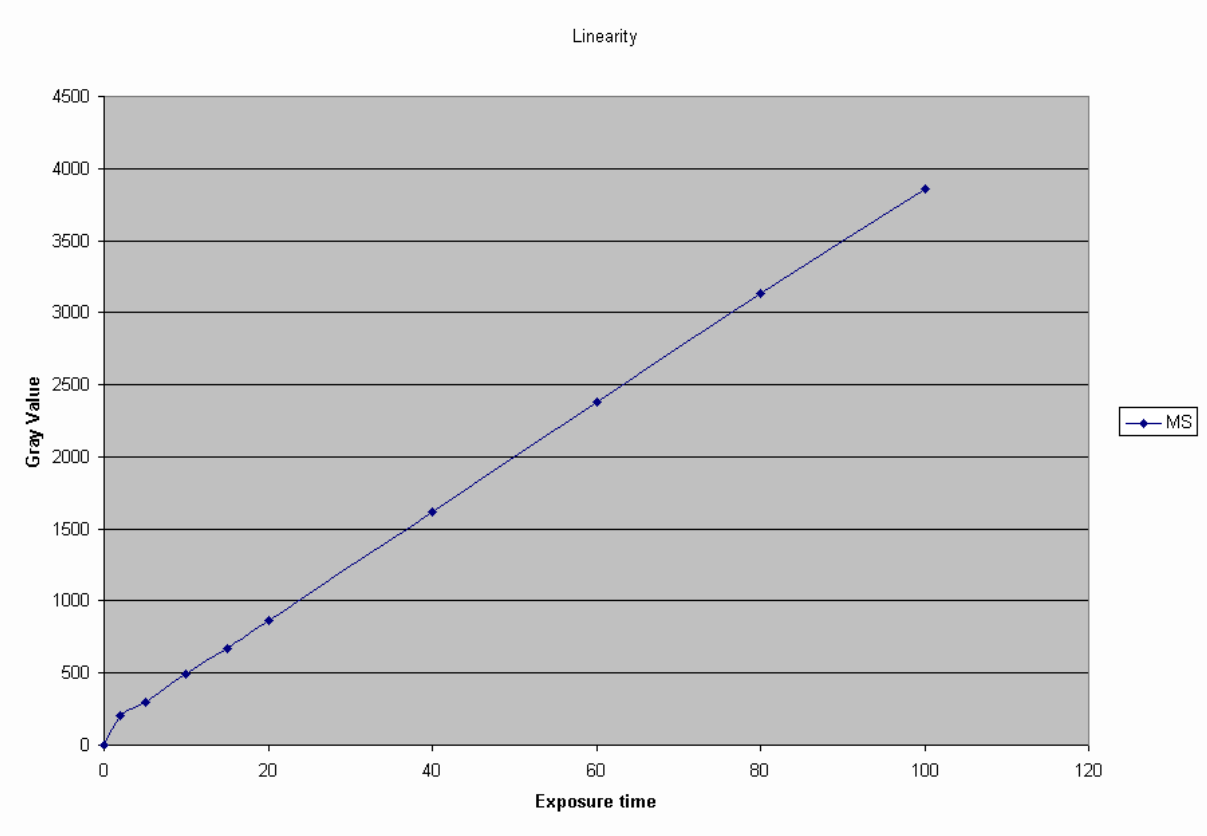
Camera ID	00114966
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1

Sensitivity of camera



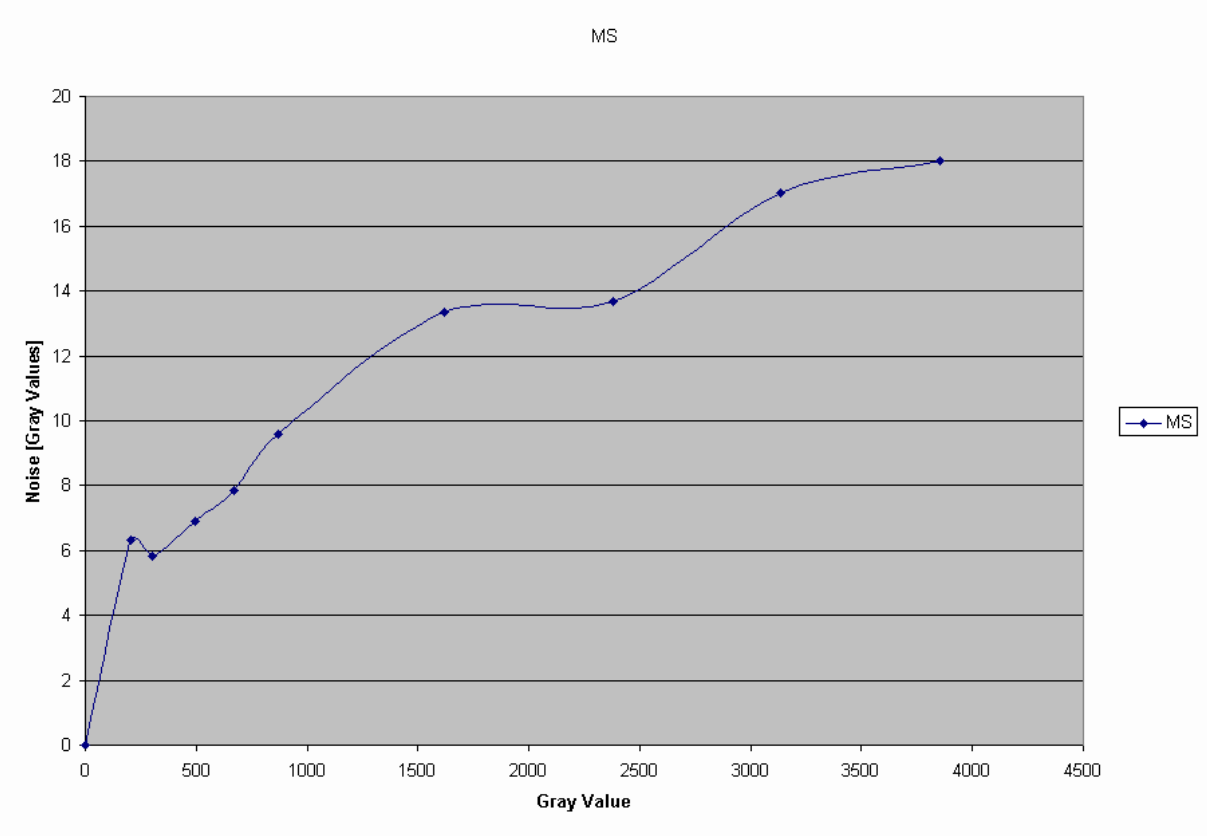
Remark:
Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Linearity



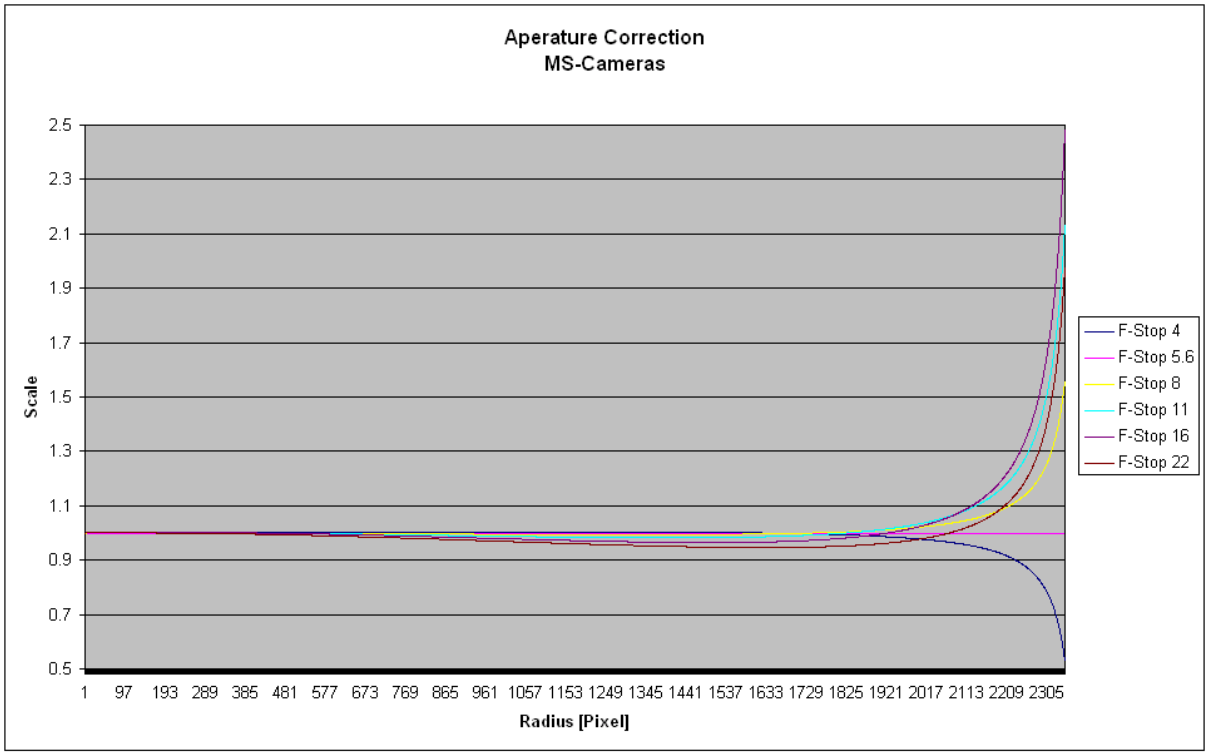
Remark:
The sensor linearity is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Noise



Remark:
The sensor noise is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

Aperture Correction



Remark:
This measurement is similar for the same aperture revision number. For more details see Appendix: "Radiometric Calibration Model".

Defect Pixel List

Number of defect pixels: 2

Number of defect clusters: 0

Number of defect columns: 0

Nr	Row	Column
0	764	1621
1	765	1621

Defect	Column	RowStart	ColumnStart	RowEnd	ColumnEnd

Remark

See Appendix for definition of defect pixels and maximal allowed numbers.

Calibration Protocol
DMC01 - 0129

Calibration Certificate N° 00116837

Object	Digital Aerial Survey Camera
Manufacturer	Z/I Imaging D-73431 Aalen
Type	DMC-MS-Red
Serial Number	00116837

Calibration performed at:
Carl Zeiss Jena

Number of pages of the certificate 68

Date of Calibration 11.Jul.2008

CertifiedDate	Division Head	Person in Charge
12.Aug.2008	(H. Sohnle)	(S. Schröder)

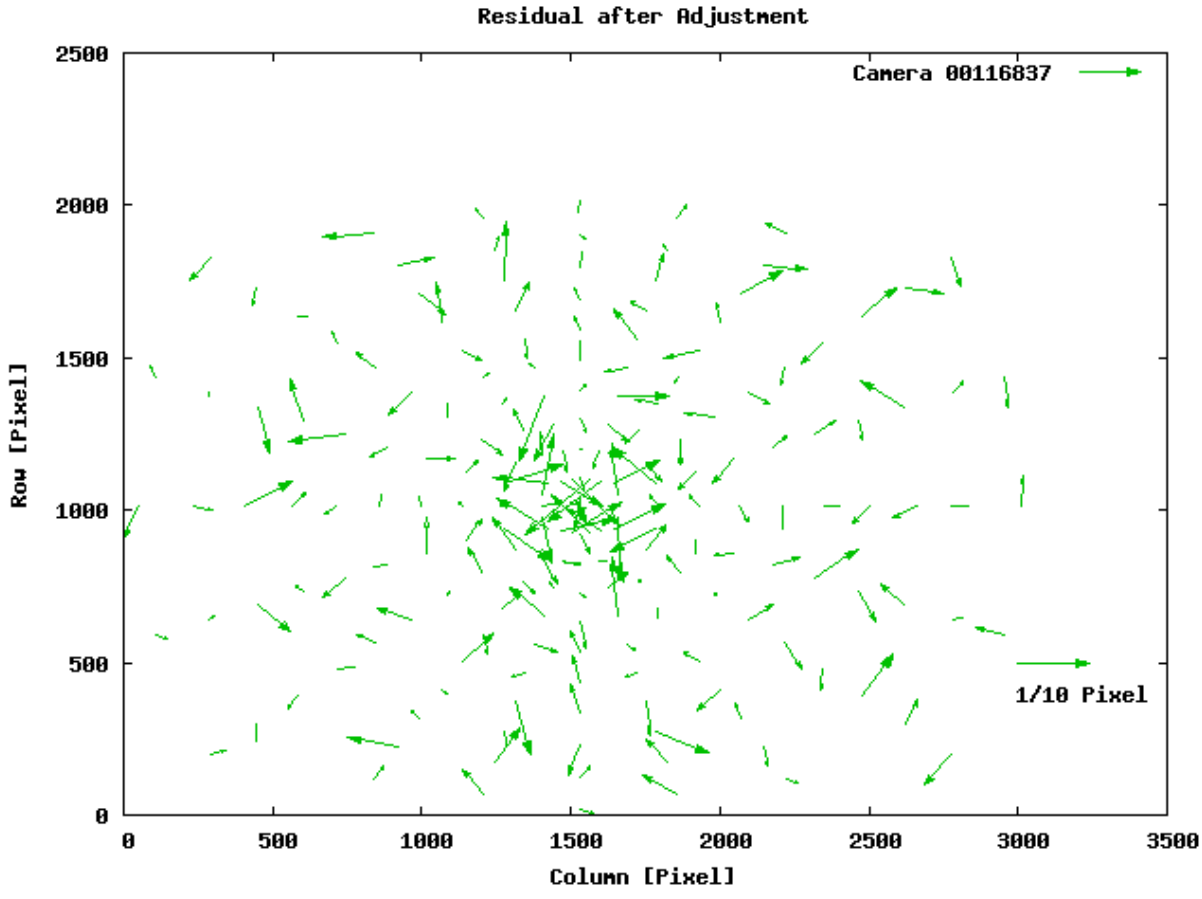
Geometric Calibration Protocol

Calibration Parameters for single camera head

Camera Type	DMC-MS-Red
Nominal Focal Length	0.025 m
Serial Number	00116837

	Param	Adjusted	Std.dev.
Principal Point [m]	x_0	-3.069E-05	1.089E-06
	y_0	0.0001177	7.691E-07
Focal Length [m]	Δf	-2.313E-05	4.032E-07
Radial Distortion	K_1	-142.7	0.339
	K_2	227200	2163
	K_3	-156100000	3894000
Decentring distortion	P_1	-0.0005202	0.0005663
	P_2	-0.001633	0.0003515
In Plane Distortion	B_1	4.362E-05	9.972E-06
	B_2	1.561E-05	8.061E-06

Adjusted Focal length = 0.025+ dc =0.02497687 [m]



Residuals in Image after Adjustment

Max Residual [µm]: 1.4

Threshold [µm]: 8.5

Remarks:

The images after the post processing are distortion free. For interior orientation parameters of the DMC virtual image see section: “Calibration Parameter of the virtual images”.

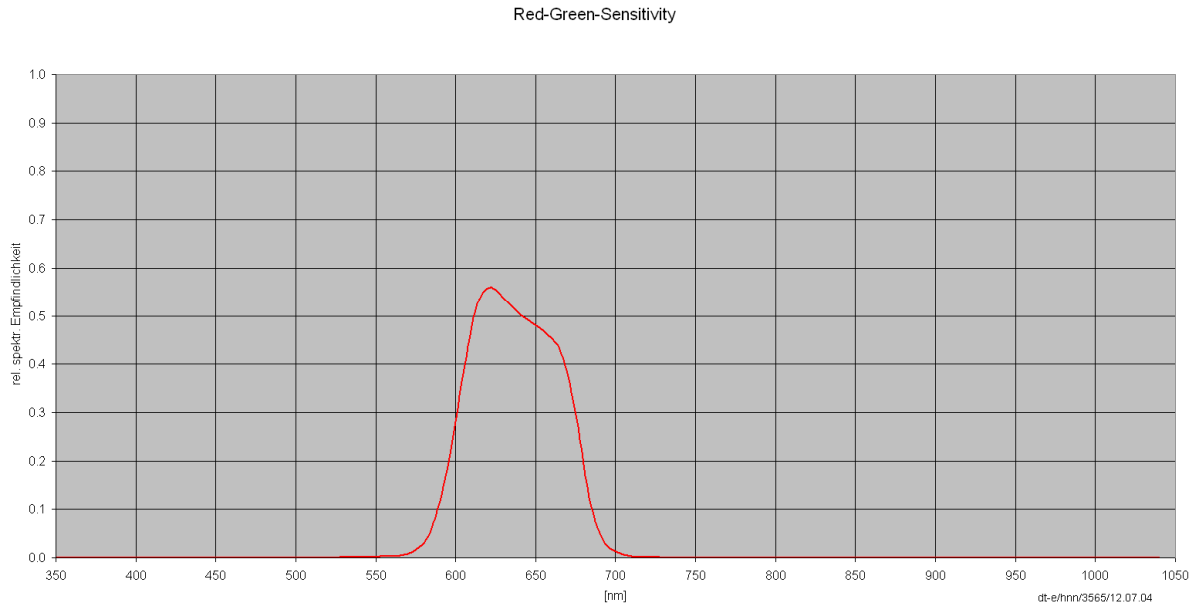
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

Radiometric Calibration Protocol

In this section you’ll find the radiometric calibration results.

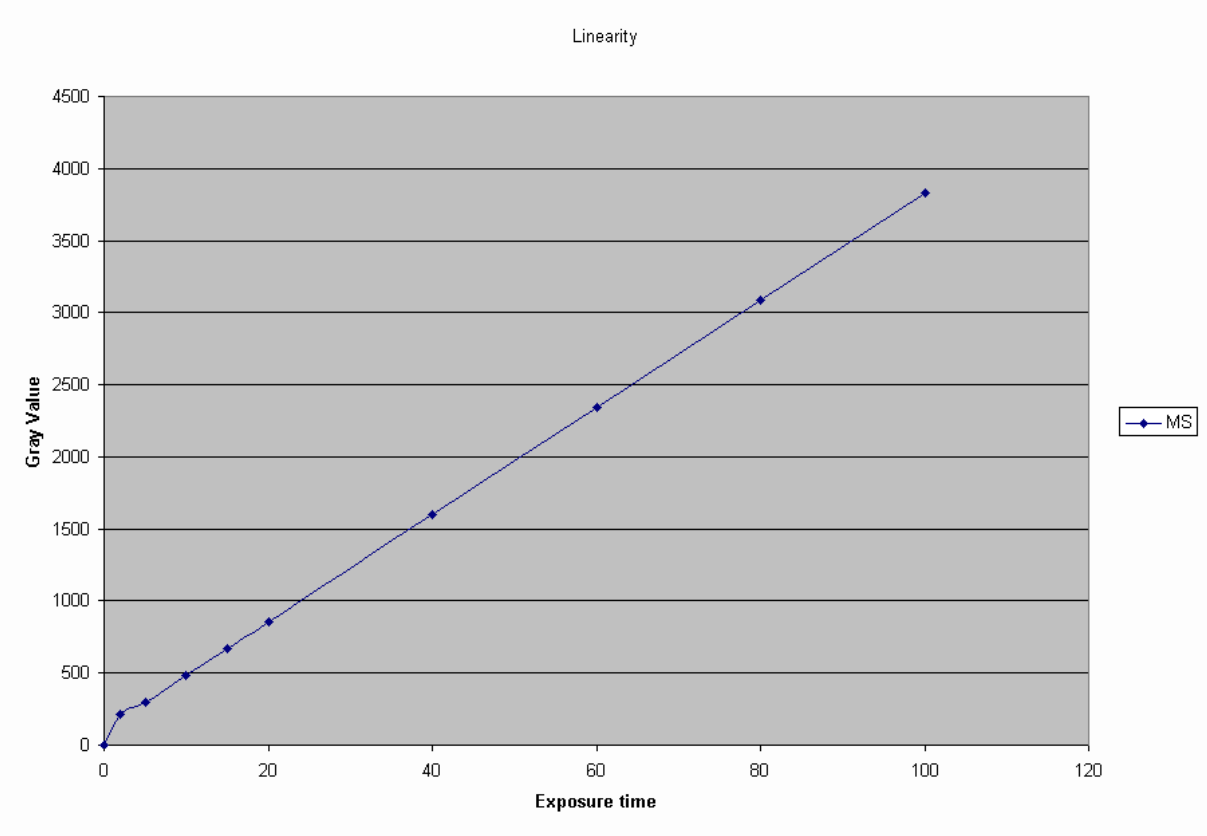
Camera ID	00116837
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1

Sensitivity of camera



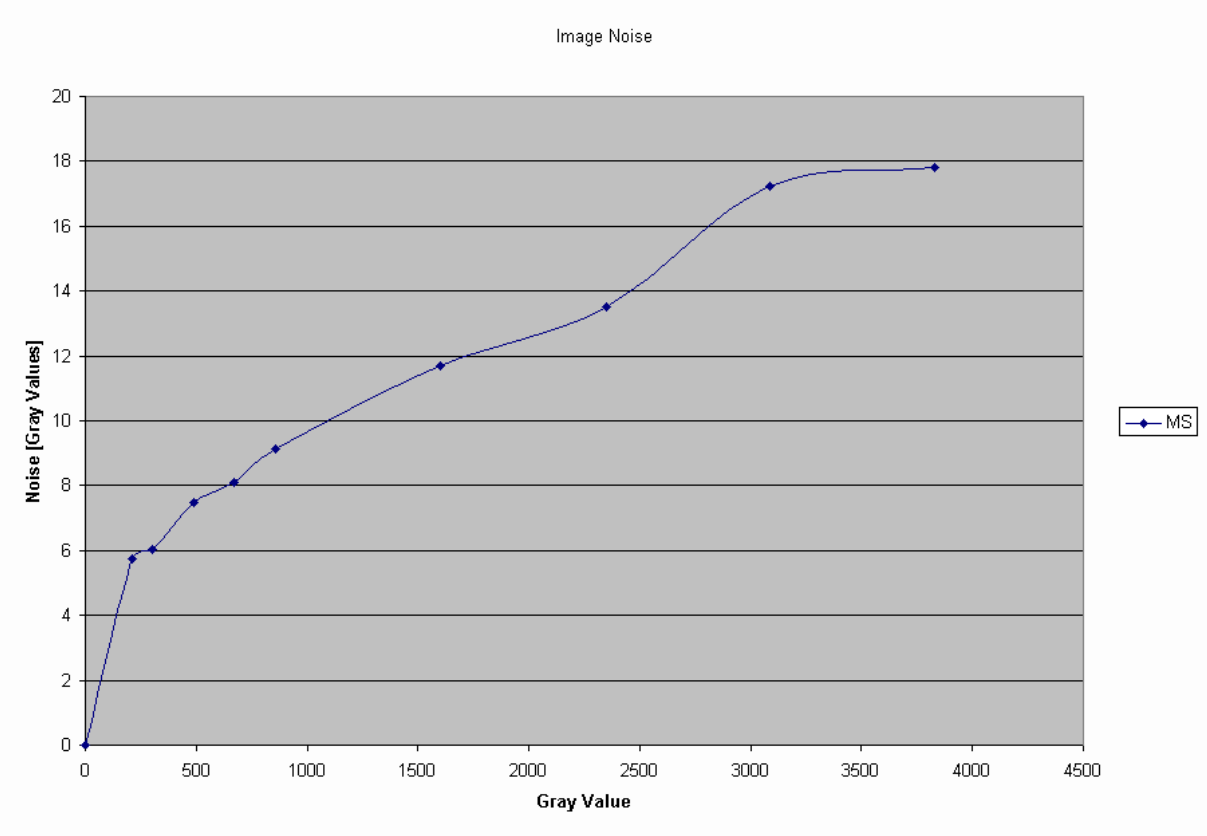
Remark:
Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Linearity



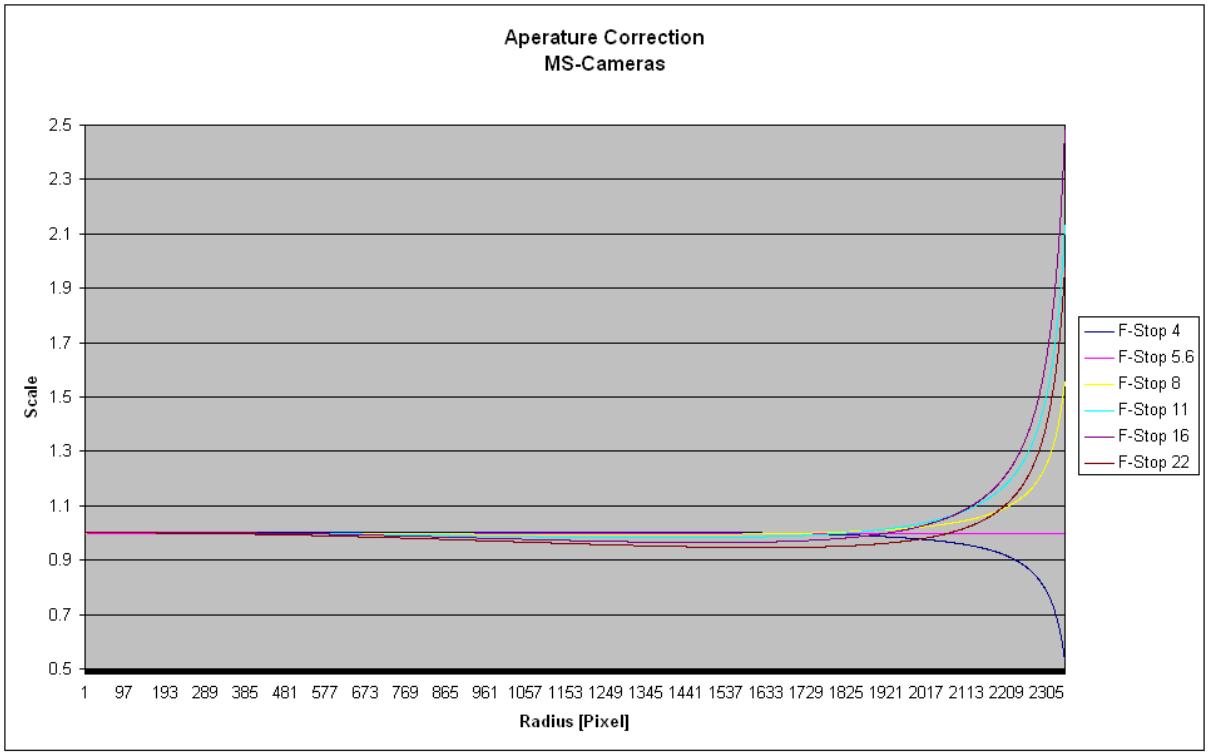
Remark:
The sensor linearity is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Noise



Remark:
The sensor noise is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

Aperture Correction



Remark:
This measurement is similar for the same aperture revision number. For more details see Appendix: "Radiometric Calibration Model".

Defect Pixel List

Number of defect pixels: 0

Number of defect clusters: 0

Number of defect columns: 0

Nr Row Column

Defect Column RowStart ColumnStart RowEnd ColumnEnd

Remark

See Appendix for definition of defect pixels and maximal allowed numbers.

Calibration Protocol
DMC01 - 0129

Calibration Certificate N^{O} 00116840

Object	Digital Aerial Survey Camera
Manufacturer	Z/I Imaging D-73431 Aalen
Type	DMC-MS-Green
Serial Number	00116840

Calibration performed at:
Carl Zeiss Jena

Number of pages of the certificate 68

Date of Calibration 22.Jul.2008

CertifiedDate	Division Head	Person in Charge
12.Aug.2008	(H. Sohnle)	(S. Schröder)

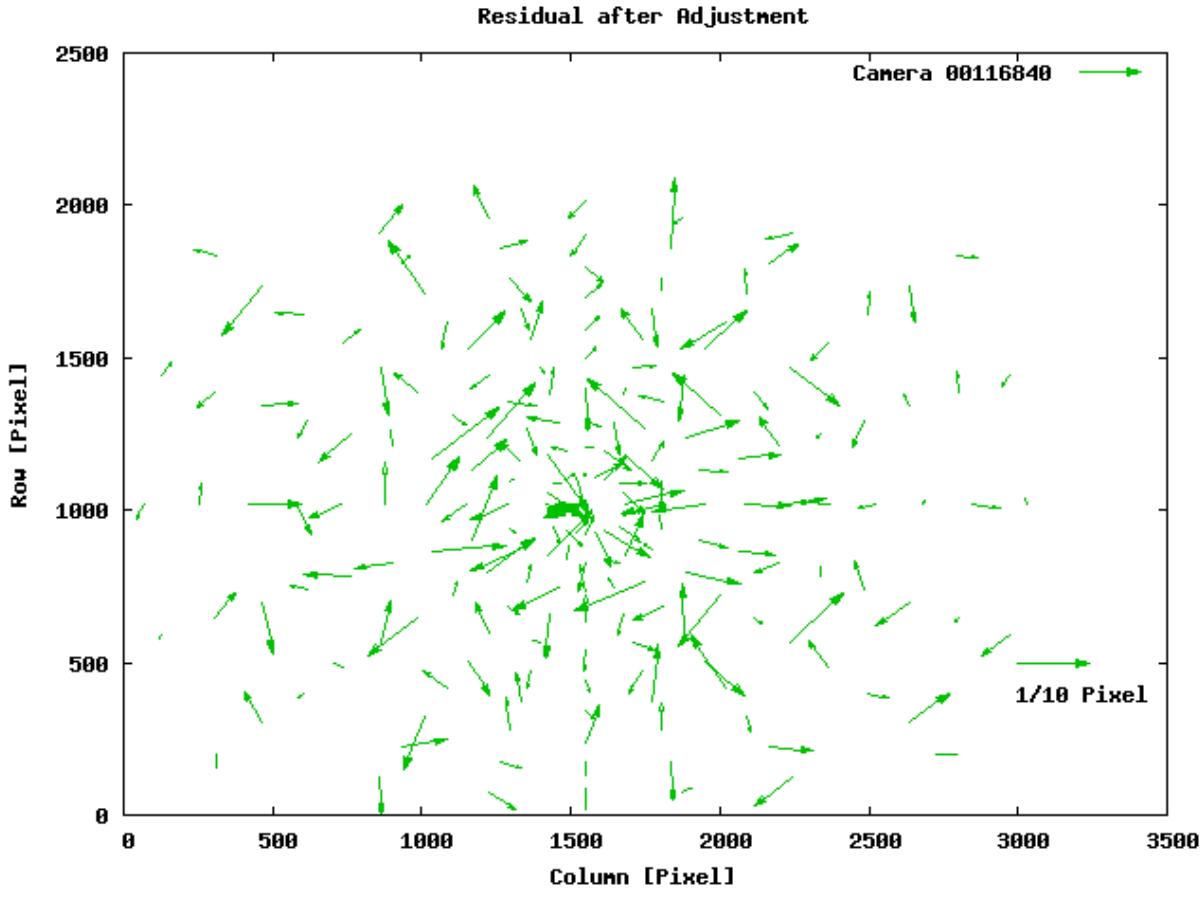
Geometric Calibration Protocol

Calibration Parameters for single camera head

Camera Type	DMC-MS-Green
Nominal Focal Length	0.025 m
Serial Number	00116840

	Param	Adjusted	Std.dev.
Principal Point [m]	x_0	0.0001895	1.29E-06
	y_0	6.521E-05	9.106E-07
Focal Length [m]	Δf	-3.073E-05	4.773E-07
Radial Distortion	K_1	-140.9	0.4014
	K_2	223700	2561
	K_3	-151000000	4610000
Decentring distortion	P_1	0.003941	0.0006705
	P_2	0.0007007	0.0004161
In Plane Distortion	B_1	2.99E-07	1.181E-05
	B_2	1.141E-05	9.545E-06

Adjusted Focal length = 0.025+ dc =0.02496927 [m]



Residuals in Image after Adjustment

Max Residual [µm]: 1.4

Threshold [µm]: 8.5

Remarks:

The images after the post processing are distortion free. For interior orientation parameters of the DMC virtual image see section: “Calibration Parameter of the virtual images”.

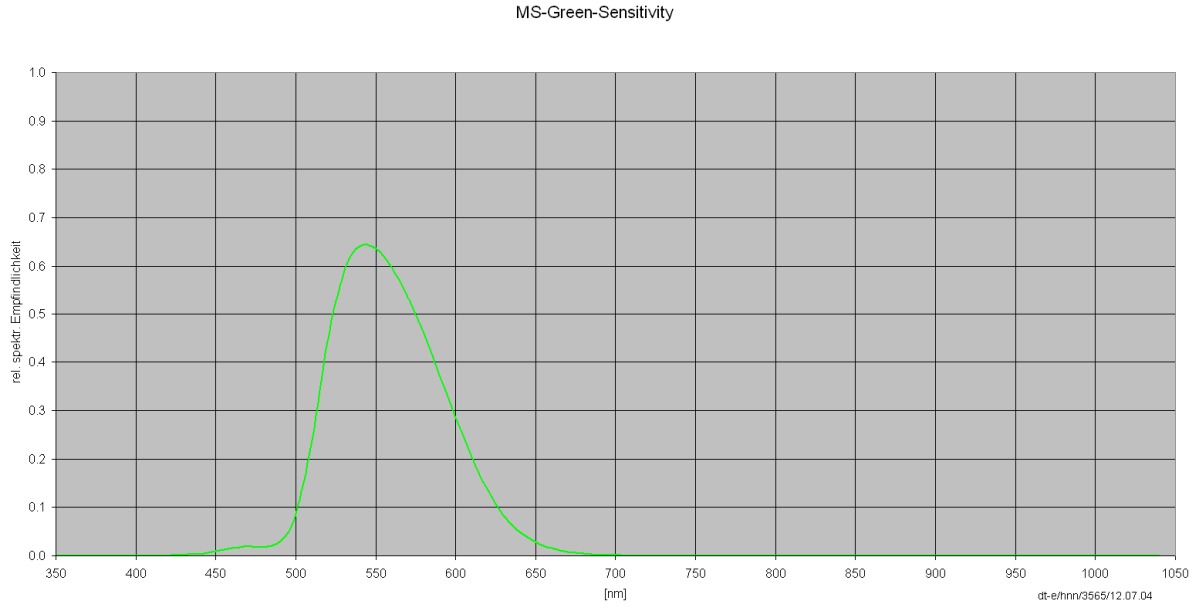
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

Radiometric Calibration Protocol

In this section you’ll find the radiometric calibration results.

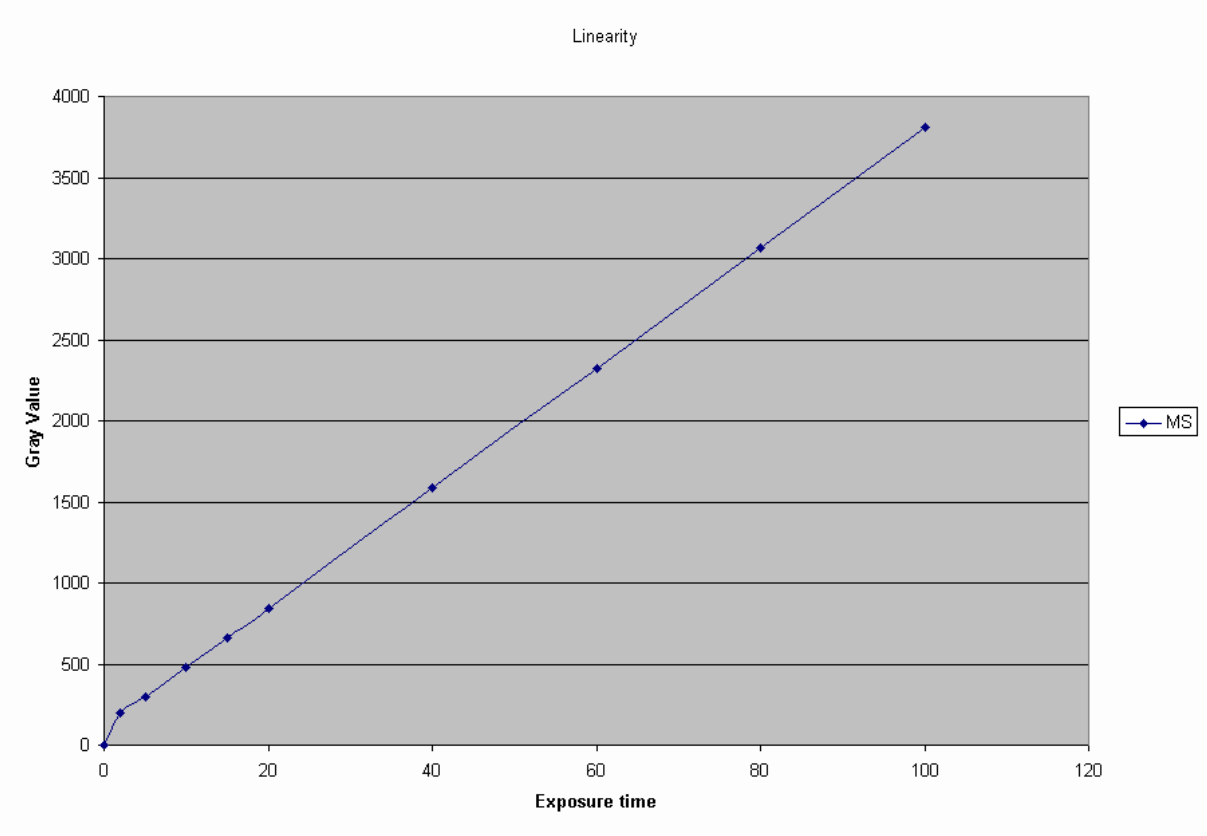
Camera ID	00116840
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1

Sensitivity of camera



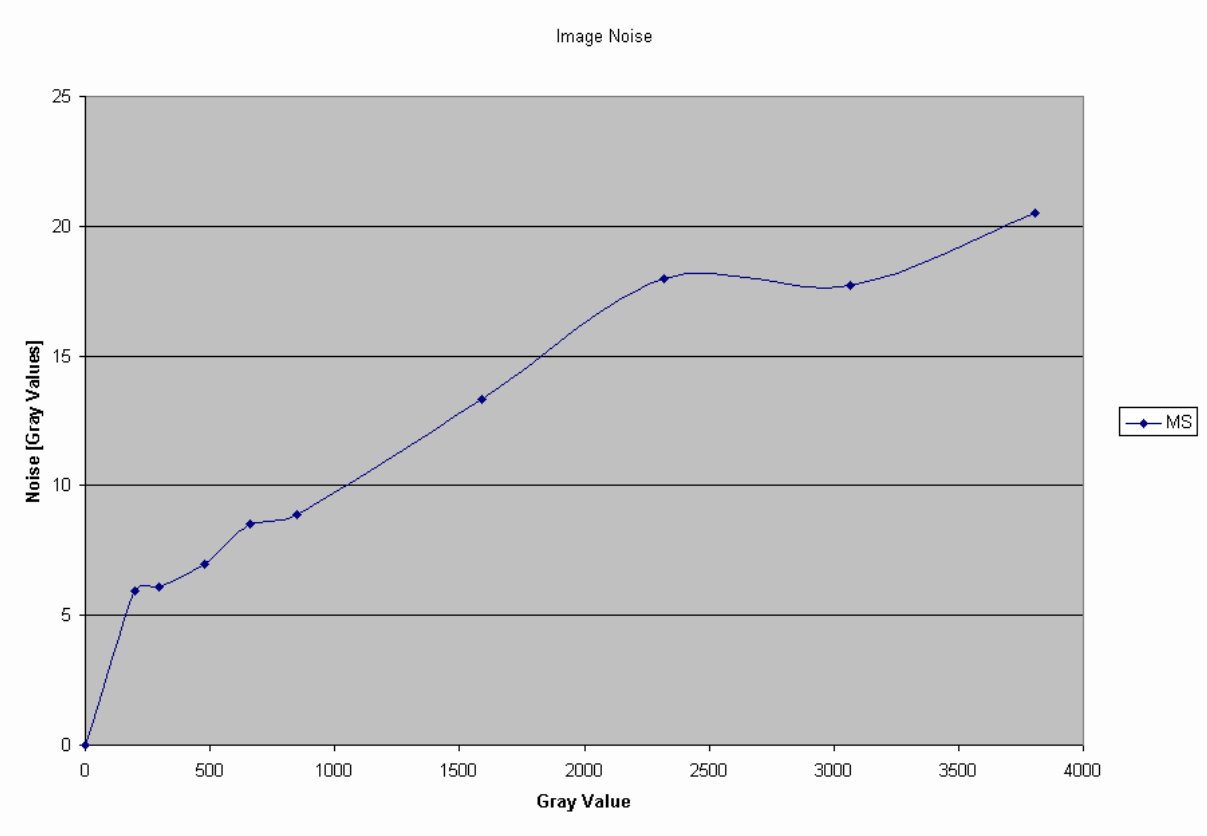
Remark:
Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Linearity



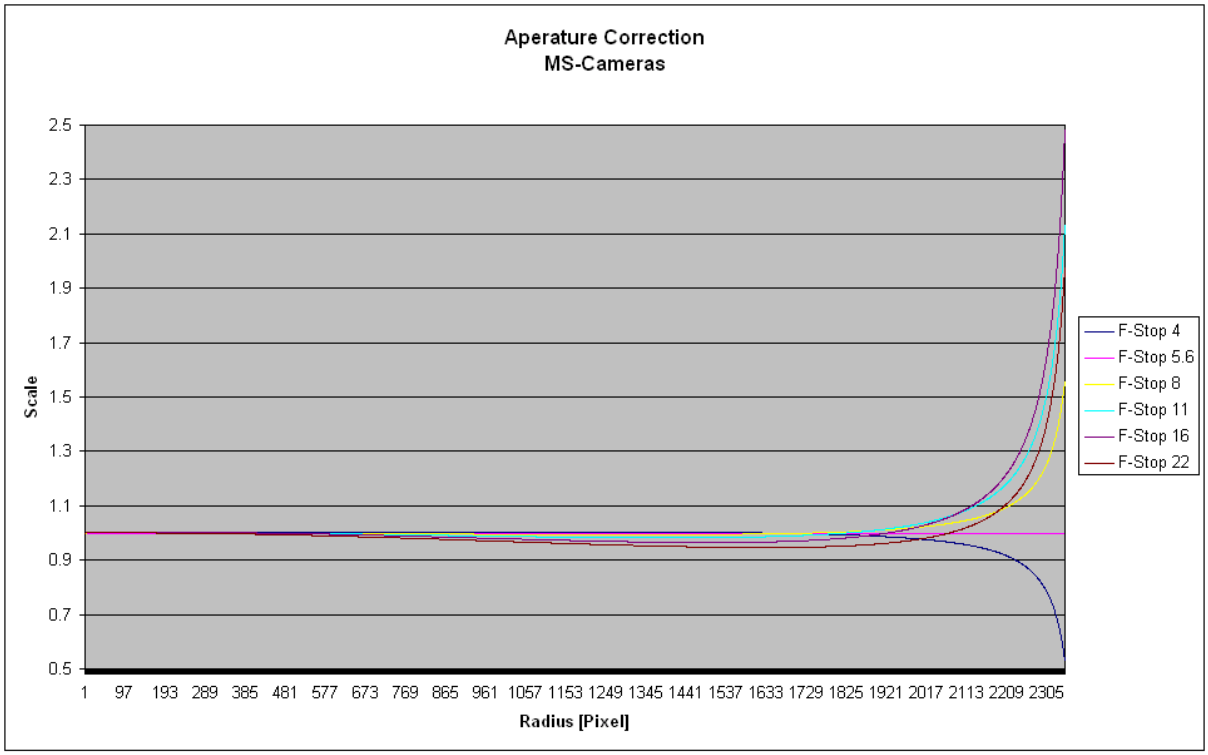
Remark:
The sensor linearity is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Noise



Remark:
The sensor noise is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

Aperture Correction



Remark:
This measurement is similar for the same aperture revision number. For more details see Appendix: "Radiometric Calibration Model".

Defect Pixel List

Number of defect pixels: 12

Number of defect clusters: 0

Number of defect columns: 0

Nr	Row	Column
0	296	66
1	297	66
2	296	67
3	297	67
4	370	1963
5	371	1963

6	372	1963
7	370	1964
8	371	1964
9	372	1964
10	371	1965
11	372	1965

Defect	Column	RowStart	ColumnStart	RowEnd	ColumnEnd

Remark

See Appendix for definition of defect pixels and maximal allowed numbers.

Defect Pixel Recognition

	Description	CCD Spec	Radiometric Calibration
Pixel	Bright image	Pixel whose signal, at nominal light (illumination at 50% of the linear range), deviates more than ±30% from its neighboring pixels.	Using a lower threshold for image quality
	Dark image	Pixel whose signal, in dark, deviates more than 6mV from its neighboring pixels (about 1% of nominal light).	
	Max Count	PAN < 1000 MS < 36	

	Description	CCD Spec	Radiometric Calibration
Column	Definition	A column which has more than 12 pixel defects. Column defects must be horizontally separated by 3 columns.	Using a lower threshold for image quality
	Recognition (bright and dark)	Same as defect pixel recognition	
	Max Single column	PAN ≤ 50 MS ≤ 1	
	Max double Column	PAN ≤ 4 MS ≤ 0	

Bibliography

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Fraser C., Digital Camera sel-f calibration. ISPRS Journal of Photogrammetry and Remote Sensing, (997, 5284): 149-159

Zeitler W., Dörstel C., Jacobsen K. (2002): Geometric calibration of the DMC: Method and Results, Proceedings ASPRS, Denver, USA.