Calibration Certificate

Digital Mapping Camera (DMC)

DMC Serial Number: **DMC01-0053**

CBU Serial Number: **0100053**

For

MPPG AERO Sp. z. o. o., ul. Kaczkowskiego 6
33-100 Tarnow

Poland

System Overview

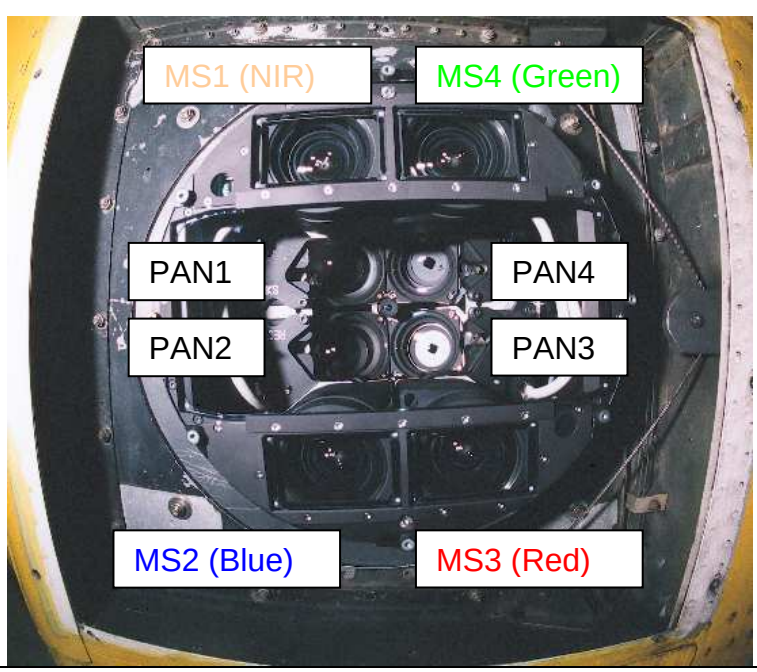


Figure: System Overview

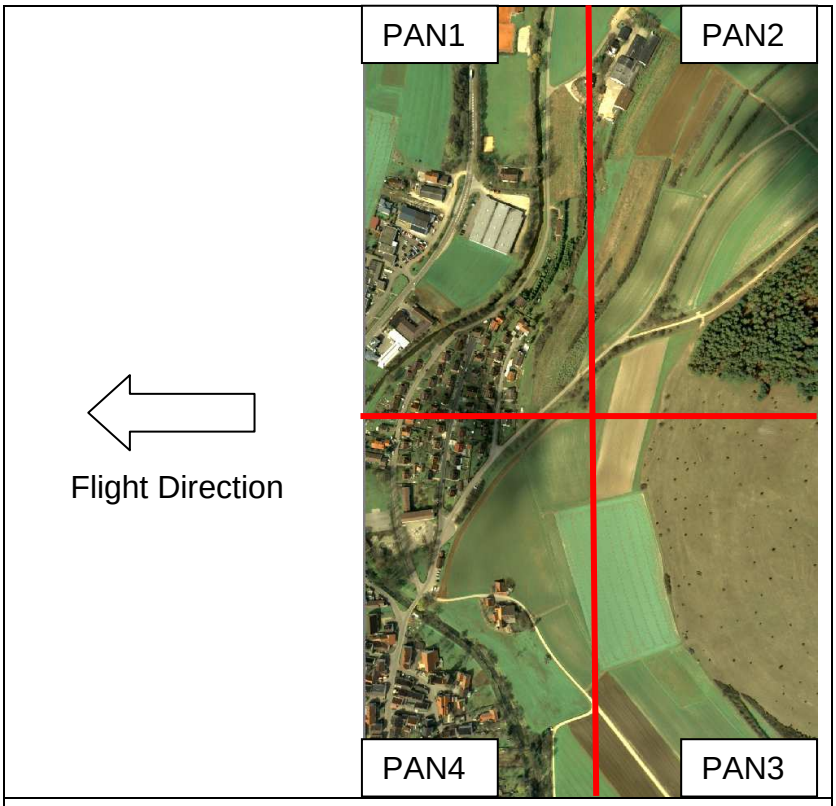


Figure Image Overview (Pan Camera)

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: 21.05.2007					
Camera	Serial Number	Calib. Date				
PAN1	00114289	13.12.2006				
PAN2	00115722	14.02.2007				
PAN3	00115726	12.02.2007				
PAN4	00115778	29.01.2007				
MS1 (NIR)	00115710	19.02.2007				
MS2 (Blue)	00115818	14.02.2007				
MS3 (Red)	00115823	14.03.2007				
MS4 (Green)	00115715	14.02.2007				

Calibration Protocol
DMC01 - 0053

Camera Orientation PAN-Cameras (Burn-In Flight 21.05.2007)

Camera (Serial Number)	X [m] (Accuracy)	Y [m] (Accuracy)	Z [m] (Accuracy)	Omega [Deg] (Accuracy)	Phi [Deg] (Accuracy)	Kappa [Deg] (Accuracy)
PAN1 (00114289)	0.064 (0)	-0.079 (0)	1000 (0)	18.005 (0.001)	10.054 (0.001)	86.773 (0.001)
PAN2 (00115722)	-0.064 (0)	-0.079 (0)	1000 (0)	17.904 (0.001)	-10.247 (0.001)	93.391 (0.001)
PAN3 (00115726)	-0.064 (0)	0.079 (0)	1000 (0)	-17.999 (0.001)	-10.045 (0.001)	-93.080 (0.001)
PAN4 (00115778)	0.064 (0)	0.079 (0)	1000 (0)	-17.909 (0.001)	10.237 (0.001)	-86.853 (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 5.2, from Intergraph Z/I Imaging photogrammetric product suite.

Platform calibration performed by

Dipl. Ing. C. Müller

21.05.2007
Date

Calibration Protocol
DMC01 - 0053

Additional System Components (Burn-In Flight 21.05.2007)

Component	X [m] (Accuracy)	Y [m] (Accuracy)	Z [m] (Accuracy)	Omega [Deg] (Accuracy)	Phi [Deg] (Accuracy)	Kappa [Deg] (Accuracy)
IMU	??? (0)	??? (0)	??? (0)	??? (0.001)	??? (0.001)	??? (0.001)

The results of the orientation of the IMU were generated with support of ImageStation Automatic Triangulation (ISAT), Version 5.1, from Intergraph Z/I Imaging photogrammetric product suite.

Calibration performed by

Dipl. Ing. C. Müller

Date

Calibration Protocol
DMC01 - 0053

Aerotriangulation Results (Burn-In Flight 21.05.2007)

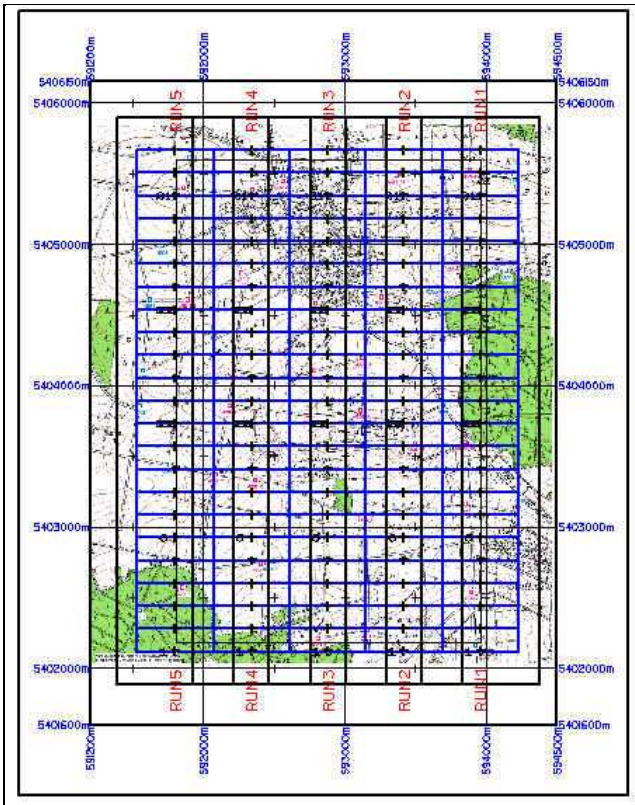


Photo Scale	1:5000
Flying Height [m]	600 AGL
Flying Altitude [m]	1200 AMSL
Run-Spacing [m]	539.1
Base-Length [m]	161.3
Number of Exposures	115
Side-lap [%]	35
End-lap [%]	65
Terrain Height [m]	600
Number of strips	5
Photos in one strip	23
Photos Used	115
Control Points Used	40
Check Points Used	
GSD [cm]	6

Statistic results:

Matching results: 0 Weak Areas – covered with clouds
Whole Block 116 exposures used
0 exposures not used

Whole Block Sigma relativ: 1.980 um

Whole Block Sigma absolut: 2.164 um

Whole Block

```
Photo-T Parameters and Results for Project EL5000_n

PhotoT Triangulation Options

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

Calibration Protocol
DMC01 - 0053

Parameters

Parameter	X/Omega	Y/Phi	Z/Kappa	XY
RMS Control	0.015	0.012	0.007	0.013
RMS Check				
RMS Limits	0.100	0.100	0.150	
Max Ground Residual	0.031	0.037	0.017	
Residual Limits	0.100	0.100	0.150	
Mean Std Dev Object	0.009	0.007	0.023	
RMS Photo Position				
RMS Photo Attitude				
Mean Std Dev Photo Position	0.016	0.022	0.010	
Mean Std Dev Photo Attitude	0.001	0.002	0.000	

Key Statistics

Sigma: **2.2 um**
Number of iterations: 9
Degrees of Freedom: 23316

The results of the Aerotriangulation were generated with ImageStation Automatic Triangulation (ISAT), Version 5.1, from Intergraph Z/I Imaging photogrammetric product suite.

Aerotriangulation performed by

Dipl. Ing. C. Müller

21.05.2007
Date

Calibration Protocol
DMC01 - 0053

Calibration Certificate N^{O} 00114289

Object	Digital Aerial Survey Camera
Manufacturer	Z/I Imaging D-73431 Aalen
Type	DMC-Panchromatic
Serial Number	00114289

Calibration performed at:
Carl Zeiss Jena

Number of pages of the certificate 70

Date of Calibration 14.Dec.2006

CertifiedDate	Division Head	Person in Charge
25.Jun.2007	(H. Sohnle)	(S. Schröder)

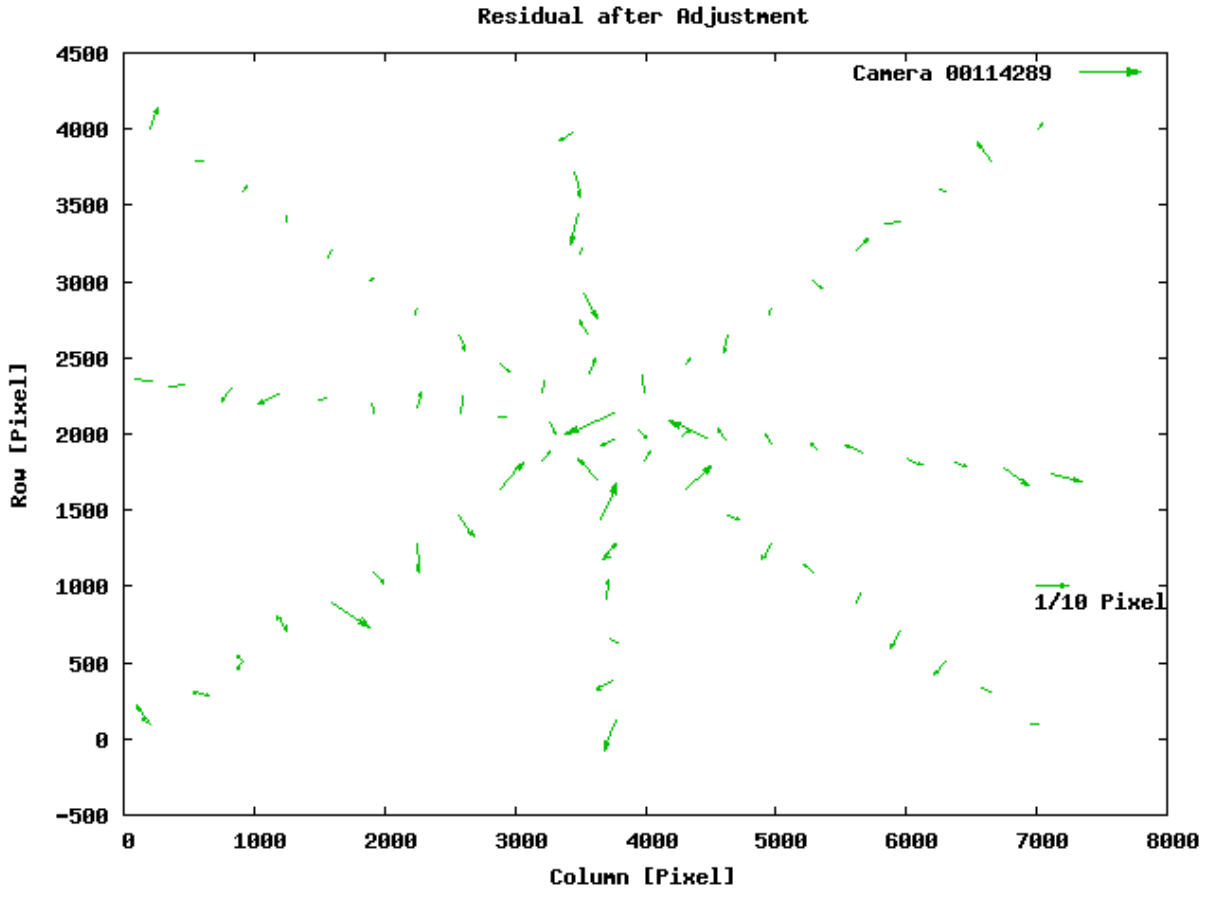
Geometric Calibration Protocol

Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00114289

	Param	Adjusted	Std.dev.
Principal Point [m]	x_0	0.00026	9.36E-06
	y_0	-4.211E-05	5.625E-06
Focal Length [m]	Δf	-0.0004171	1.584E-06
Radial Distortion	K_1	0.7334	0.04093
	K_2	-326.9	36.78
	K_3	-13130	9653
Decentring distortion	P_1	-0.0002739	0.0002135
	P_2	-0.0003423	0.0001071
In Plane Distortion	B_1	-2.03E-05	1.107E-05
	B_2	2.126E-05	6.491E-06

Adjusted Focal length = 0.12+ dc =0.1195829 [m]



Residuals in Image after Adjustment

Max Residual [µm]: 2.0

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”.

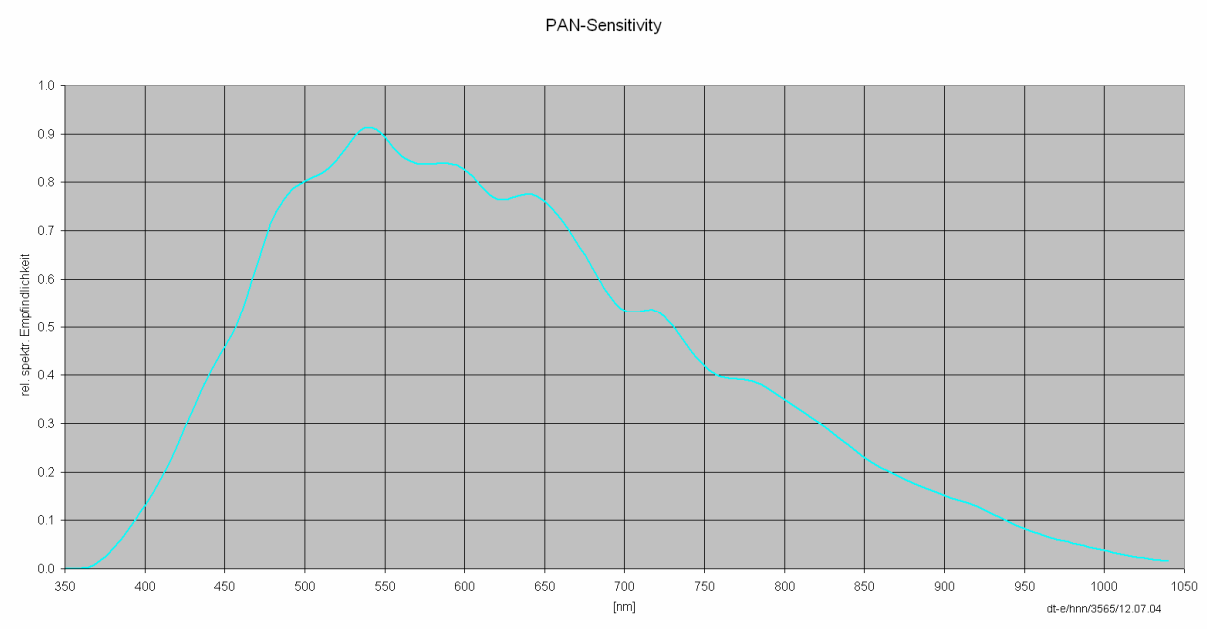
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

Radiometric Calibration Protocol

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

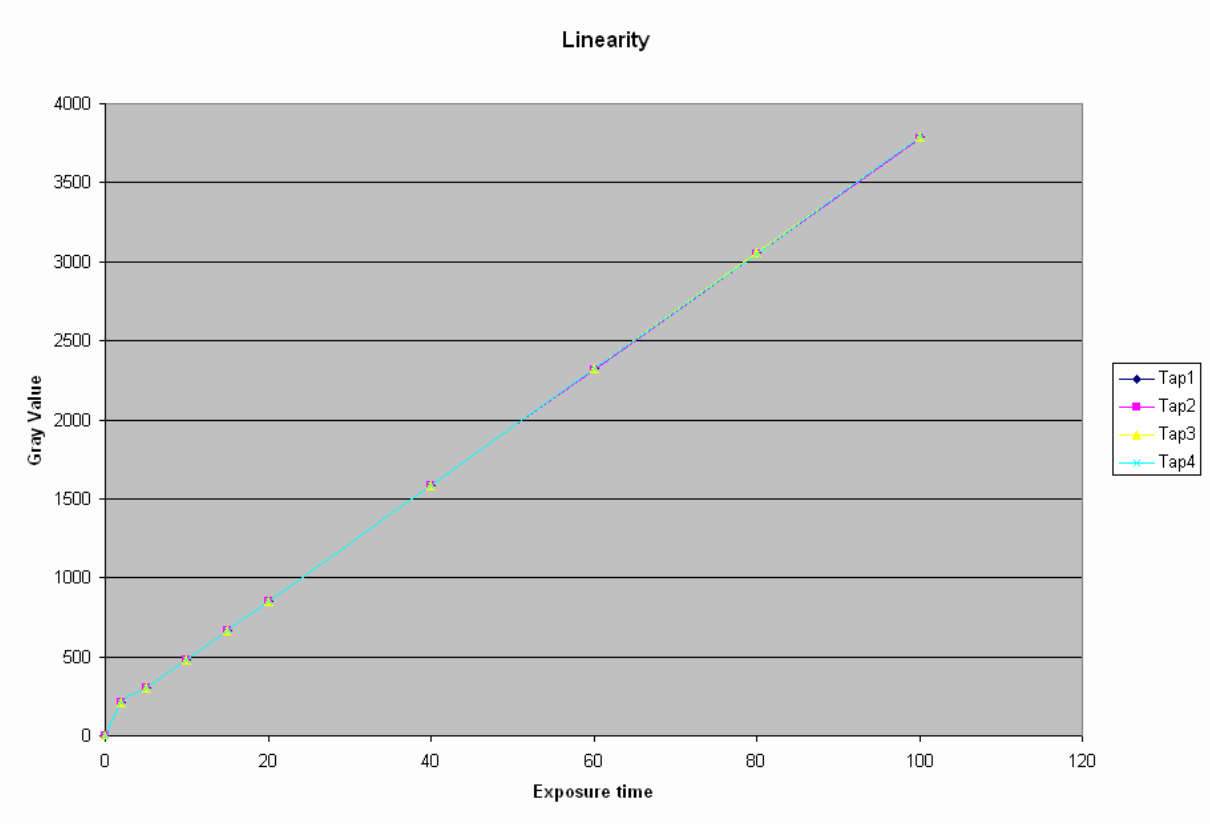
Camera ID	00114289
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

Sensitivity of camera



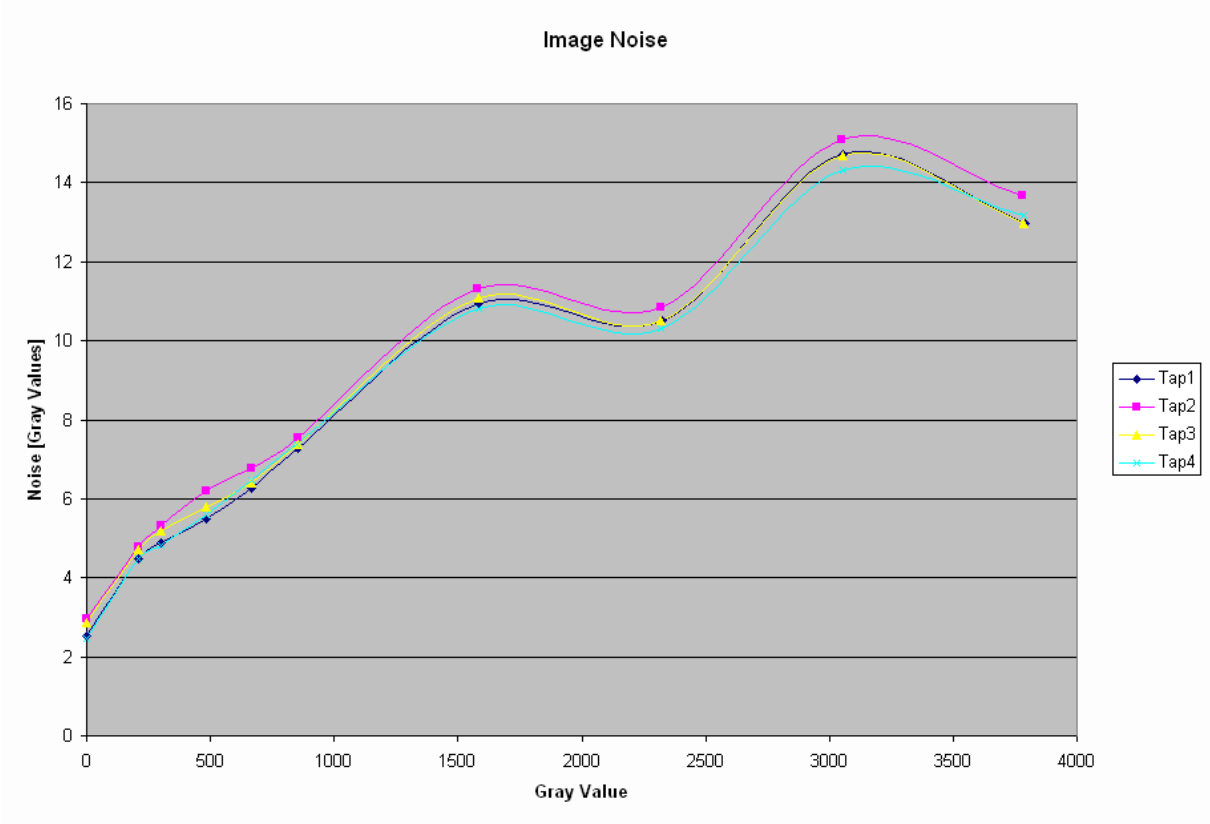
Remark:
Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Linearity



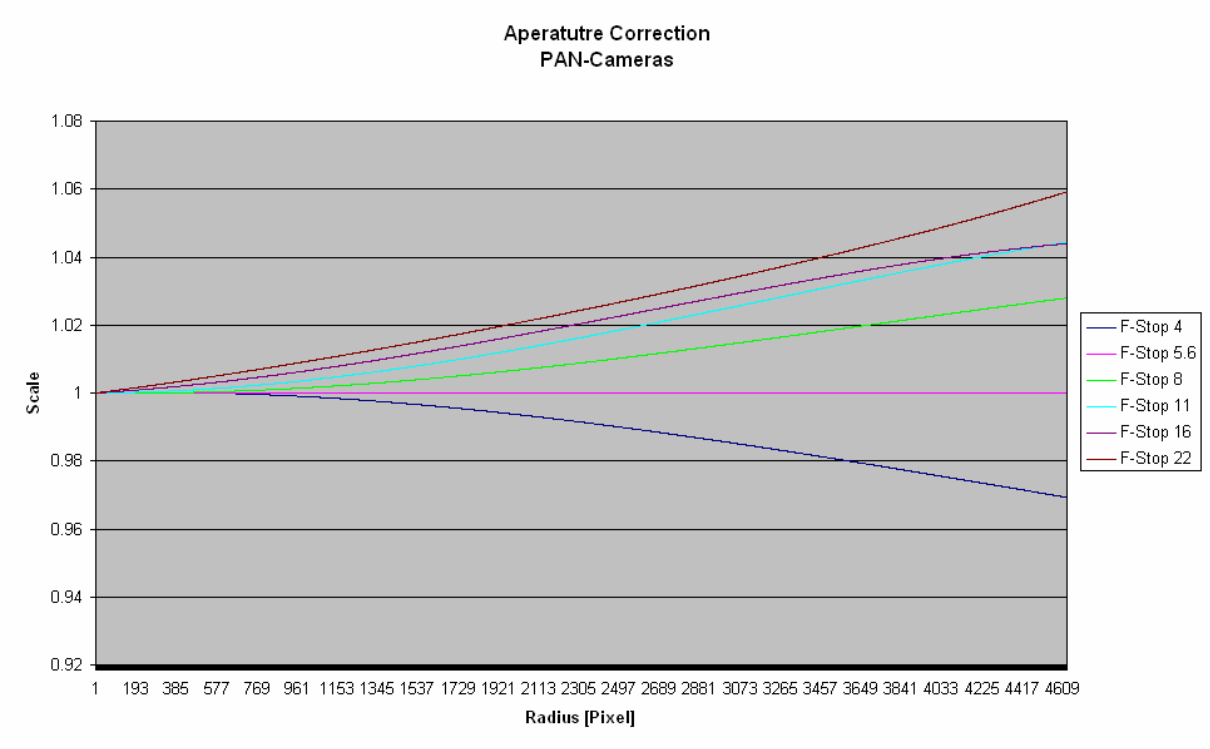
Remark:
The sensor linearity is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

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: 3

Number of defect clusters: 0

Number of defect columns: 0

Nr	Row	Column
0	2048	3591
1	3289	5283
2	3289	5284

Defect	Column	RowStart	ColumnStart	RowEnd	ColumnEnd

Remark

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

Calibration Protocol
DMC01 - 0053

Calibration Certificate N^{O} 00115722

Object	Digital Aerial Survey Camera
Manufacturer	Z/I Imaging D-73431 Aalen
Type	DMC-Panchromatic
Serial Number	00115722

Calibration performed at:
Carl Zeiss Jena

Number of pages of the certificate 70

Date of Calibration 20.Feb.2007

CertifiedDate	Division Head	Person in Charge
25.Jun.2007	(H. Sohnle)	(S. Schröder)

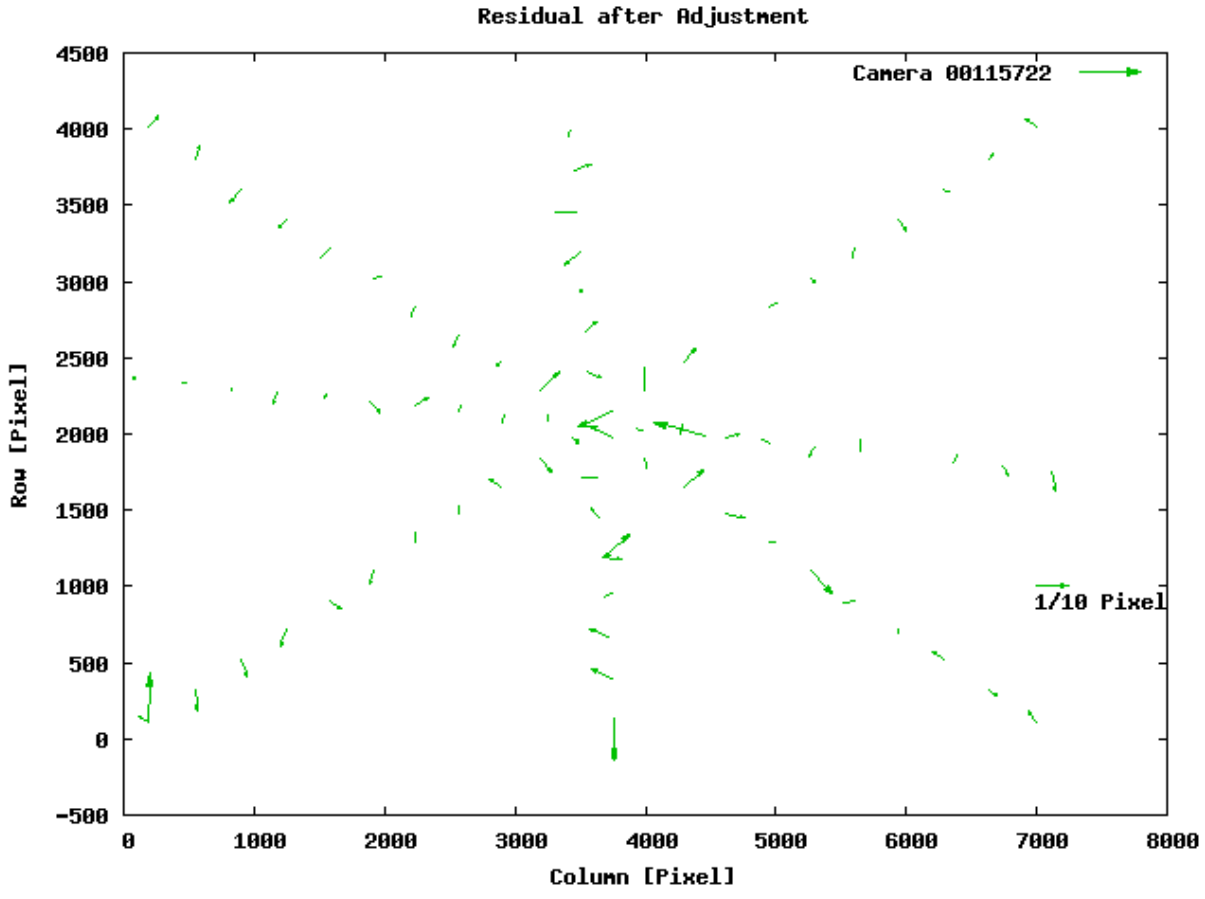
Geometric Calibration Protocol

Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00115722

	Param	Adjusted	Std.dev.
Principal Point [m]	x_0	0.0001066	8.311E-06
	y_0	-0.0002176	4.942E-06
Focal Length [m]	Δf	-0.0004648	1.436E-06
Radial Distortion	K_1	0.7904	0.03744
	K_2	-320.5	33.94
	K_3	-20080	8960
Decentring distortion	P_1	-0.0002119	0.0001897
	P_2	-0.0002472	9.548E-05
In Plane Distortion	B_1	-4.844E-05	9.964E-06
	B_2	1.797E-05	5.768E-06

Adjusted Focal length = 0.12+ dc =0.1195352 [m]



Residuals in Image after Adjustment

Max Residual [µm]: 2.0

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”.

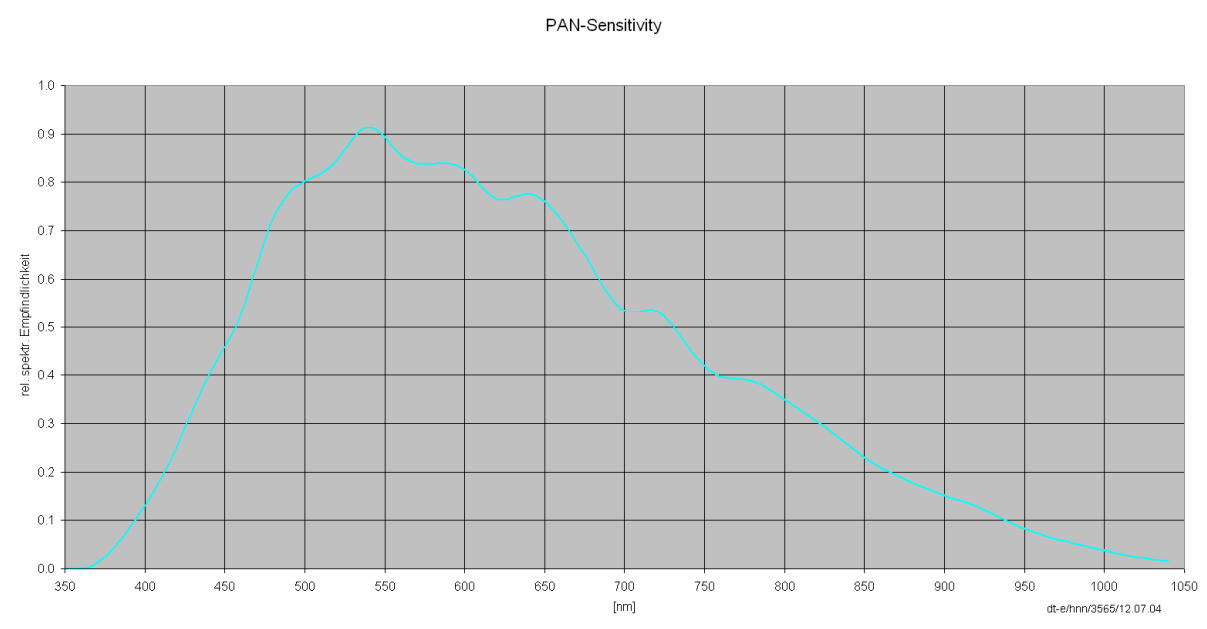
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

Radiometric Calibration Protocol

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

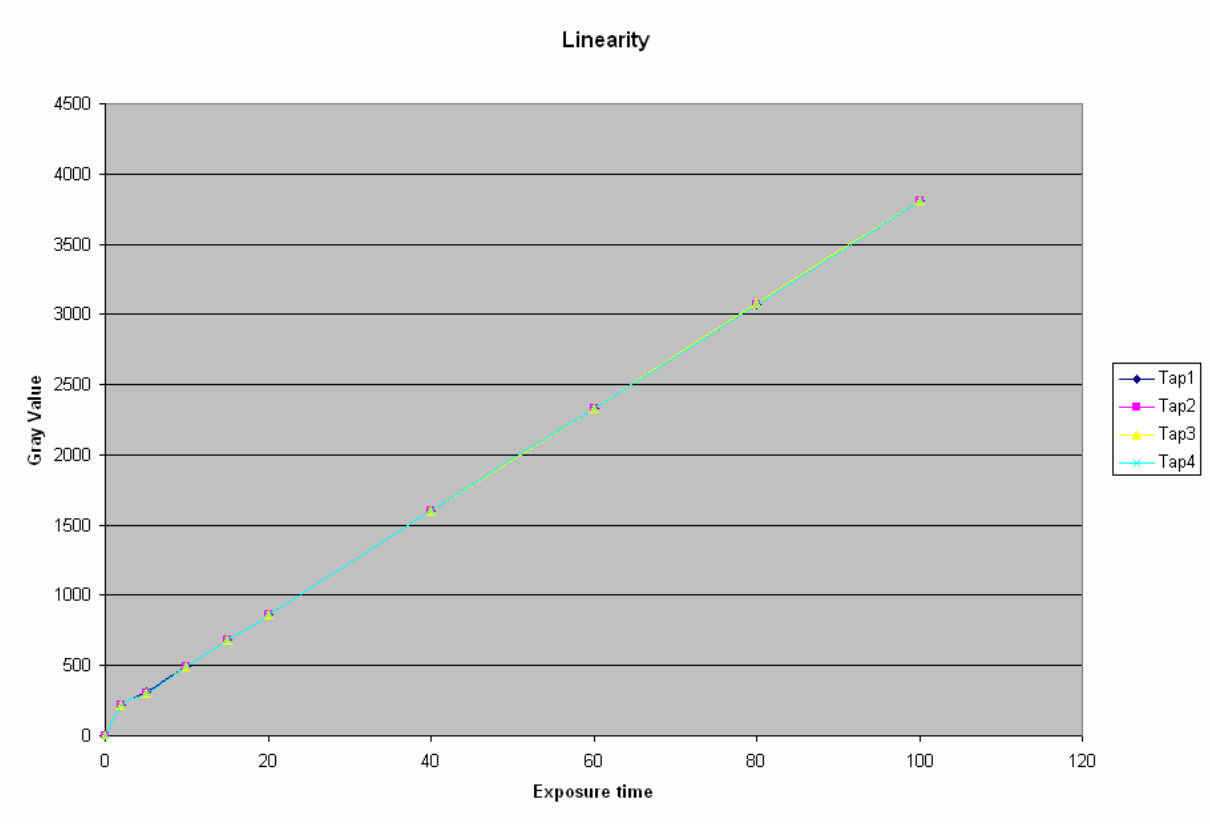
Camera ID	00115722
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

Sensitivity of camera



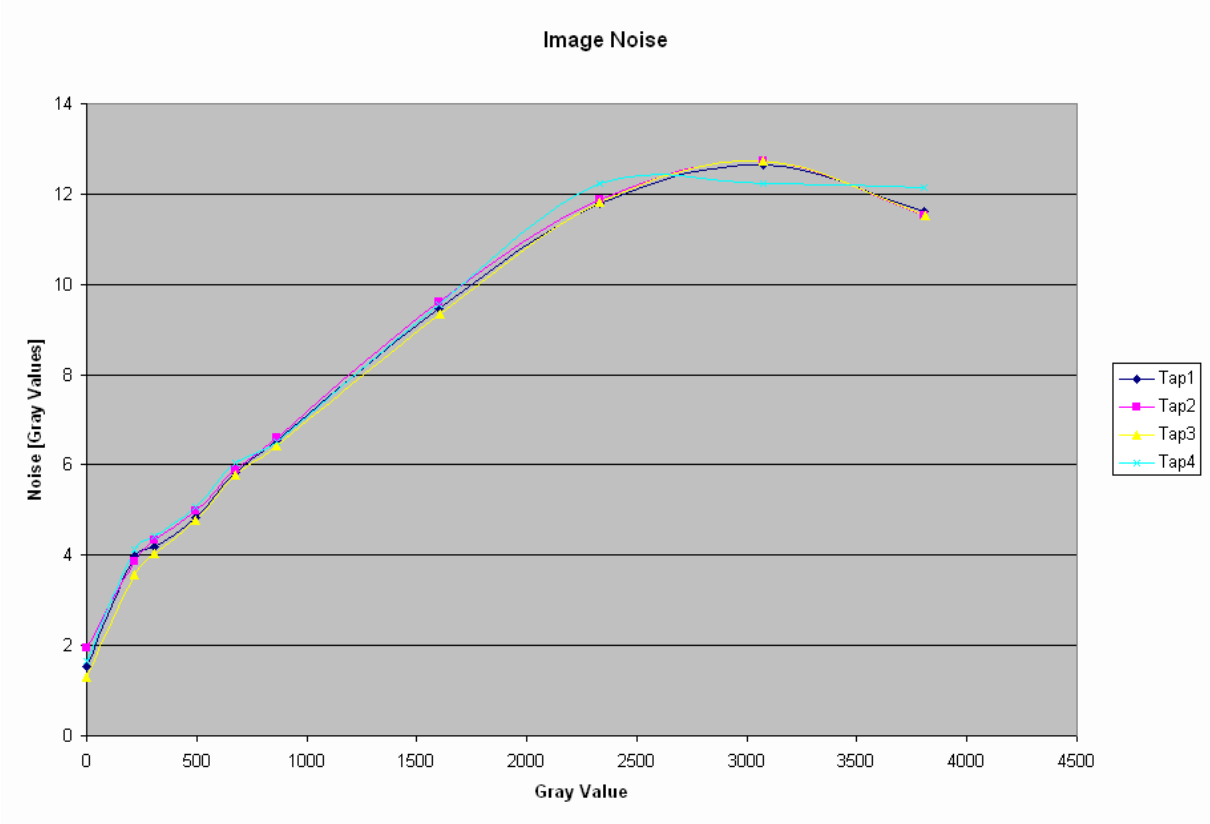
Remark:
Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Linearity



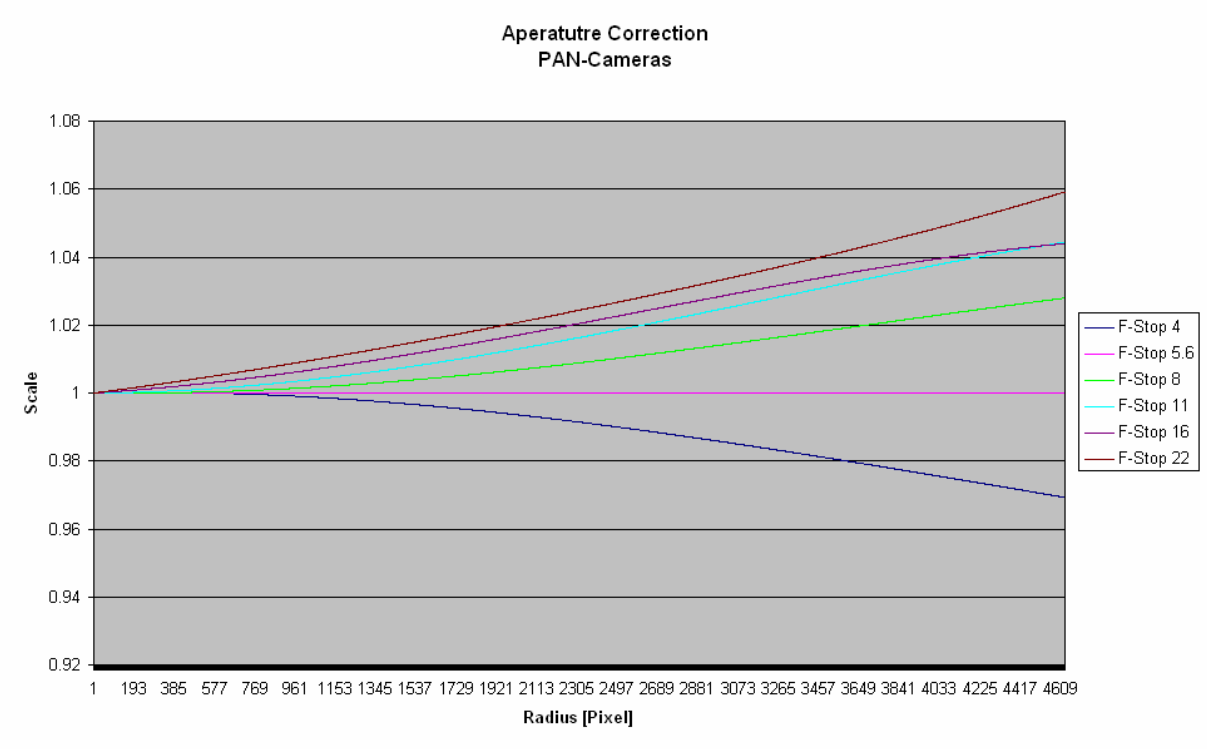
Remark:
The sensor linearity is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

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: 3

Number of defect clusters: 0

Number of defect columns: 0

Nr	Row	Column
0	624	6099
1	623	6100
2	624	6100

Defect	Column	RowStart	ColumnStart	RowEnd	ColumnEnd

Remark

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

Calibration Protocol
DMC01 - 0053

Calibration Certificate N^{O} 00115726

Object	Digital Aerial Survey Camera
Manufacturer	Z/I Imaging D-73431 Aalen
Type	DMC-Panchromatic
Serial Number	00115726

Calibration performed at:
Carl Zeiss Jena

Number of pages of the certificate 70

Date of Calibration 12.Feb.2007

CertifiedDate	Division Head	Person in Charge
25.Jun.2007	(H. Sohnle)	(S. Schröder)

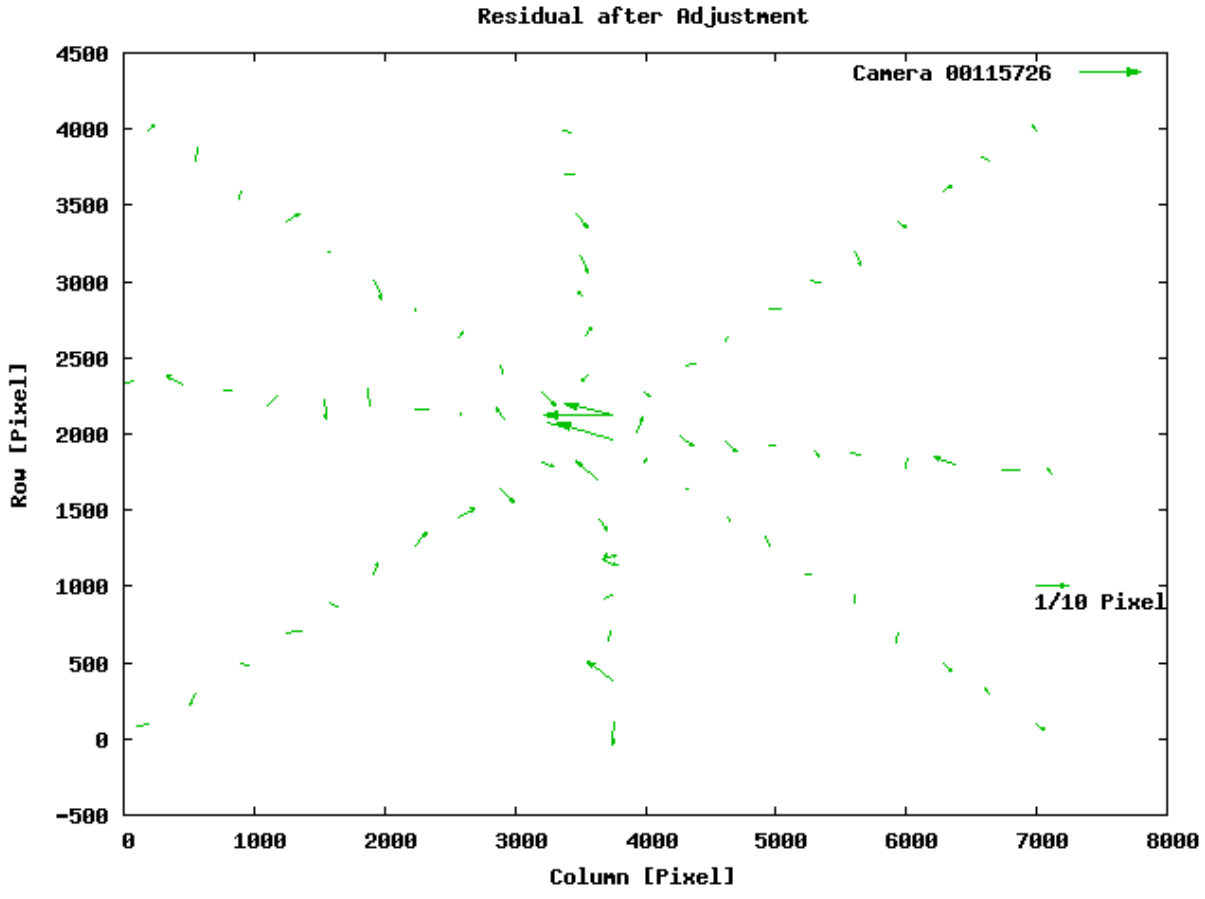
Geometric Calibration Protocol

Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00115726

	Param	Adjusted	Std.dev.
Principal Point [m]	x_0	0.0001149	8.491E-06
	y_0	2.66E-05	5.15E-06
Focal Length [m]	Δf	-0.0004231	1.481E-06
Radial Distortion	K_1	0.6461	0.03892
	K_2	-314	35.22
	K_3	-17750	9309
Decentring distortion	P_1	-0.0002547	0.0001935
	P_2	0.0001045	9.8E-05
In Plane Distortion	B_1	-2.673E-05	1.025E-05
	B_2	5.782E-06	5.968E-06

Adjusted Focal length = 0.12+ dc =0.1195769 [m]



Residuals in Image after Adjustment

Max Residual [µm]: 2.6

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”.

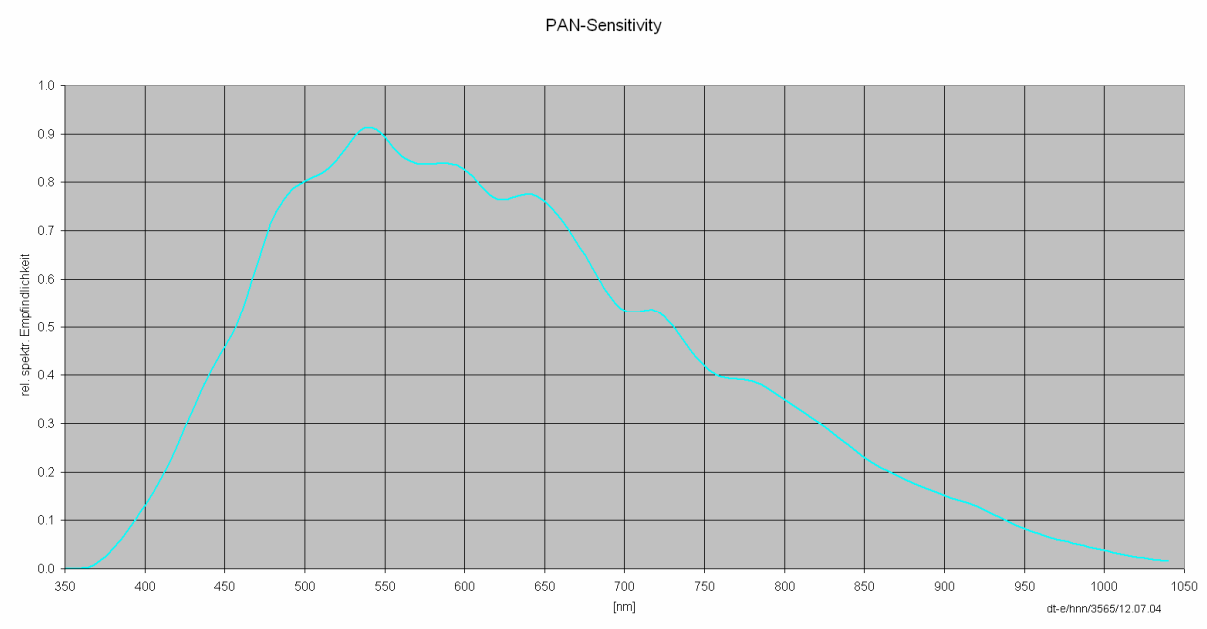
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

Radiometric Calibration Protocol

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

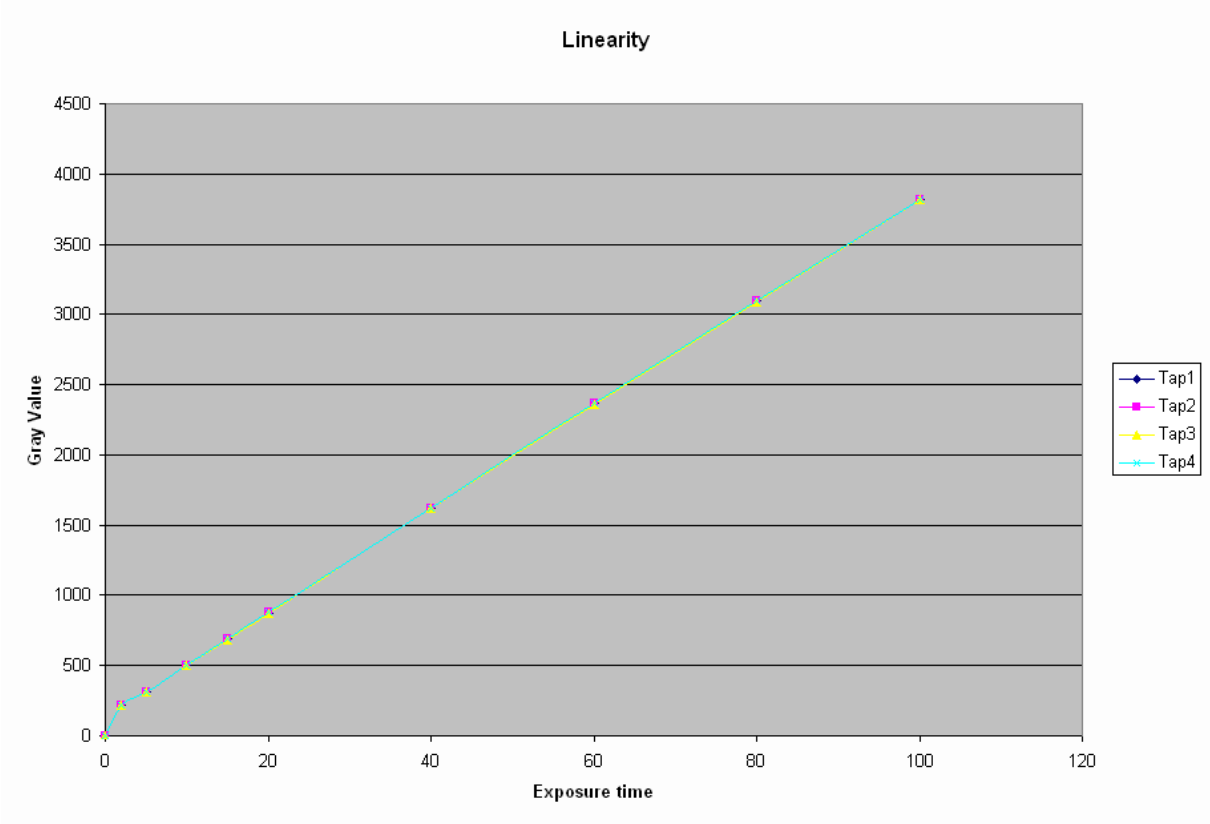
Camera ID	00115726
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

Sensitivity of camera



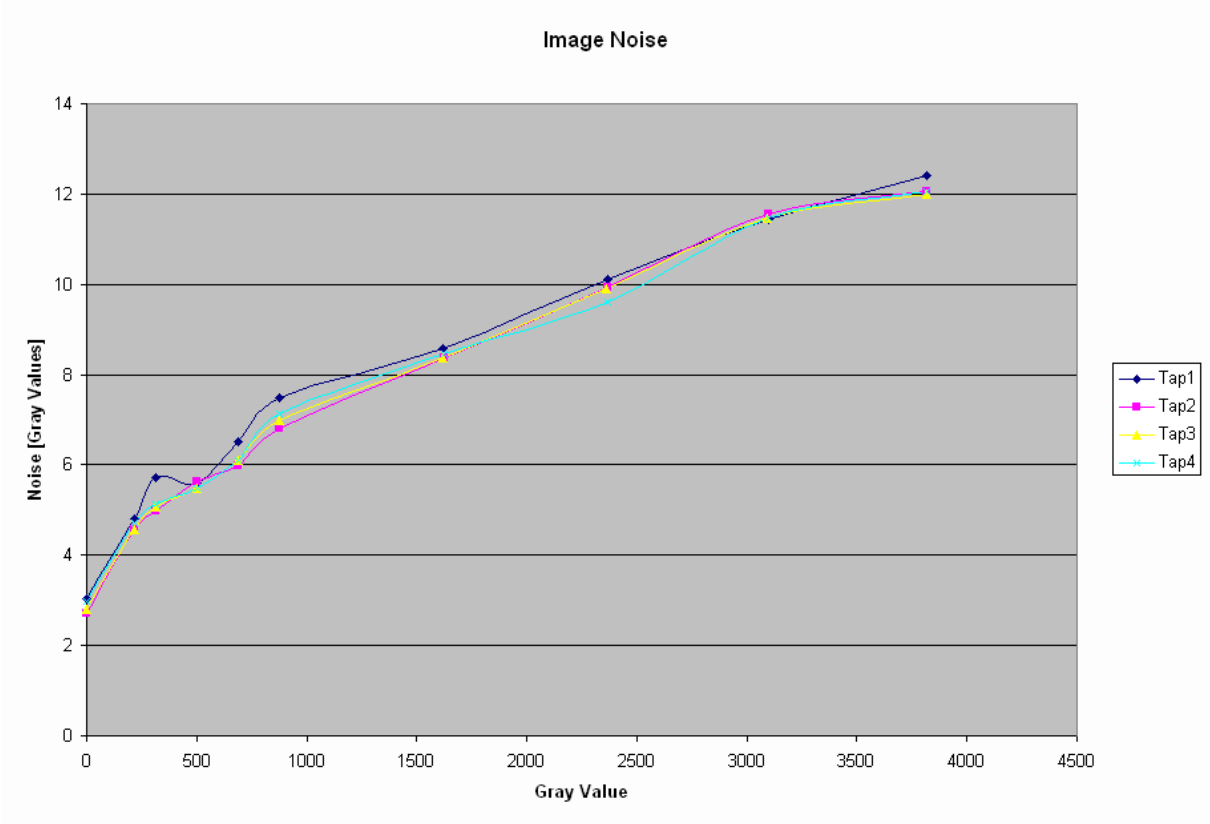
Remark:
Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Linearity



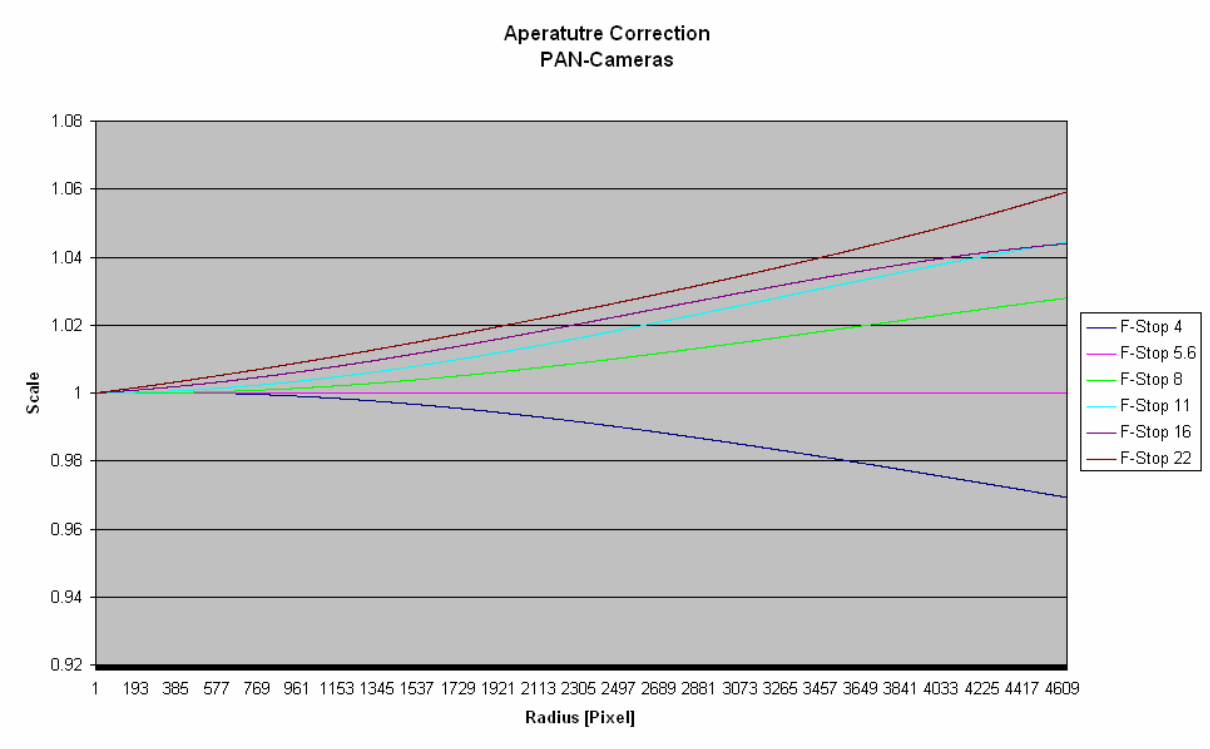
Remark:
The sensor linearity is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

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: 3
Number of defect clusters: 0
Number of defect columns: 0

Nr	Row	Column
0	922	2422
1	922	2423
2	923	2423

Defect	Column	RowStart	ColumnStart	RowEnd	ColumnEnd

Remark

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

Calibration Protocol
DMC01 - 0053

Calibration Certificate N^{O} 00115778

Object	Digital Aerial Survey Camera
Manufacturer	Z/I Imaging D-73431 Aalen
Type	DMC-Panchromatic
Serial Number	00115778

Calibration performed at:
Carl Zeiss Jena

Number of pages of the certificate 70

Date of Calibration 29.Jan.2007

CertifiedDate	Division Head	Person in Charge
25.Jun.2007	(H. Sohnle)	(S. Schröder)

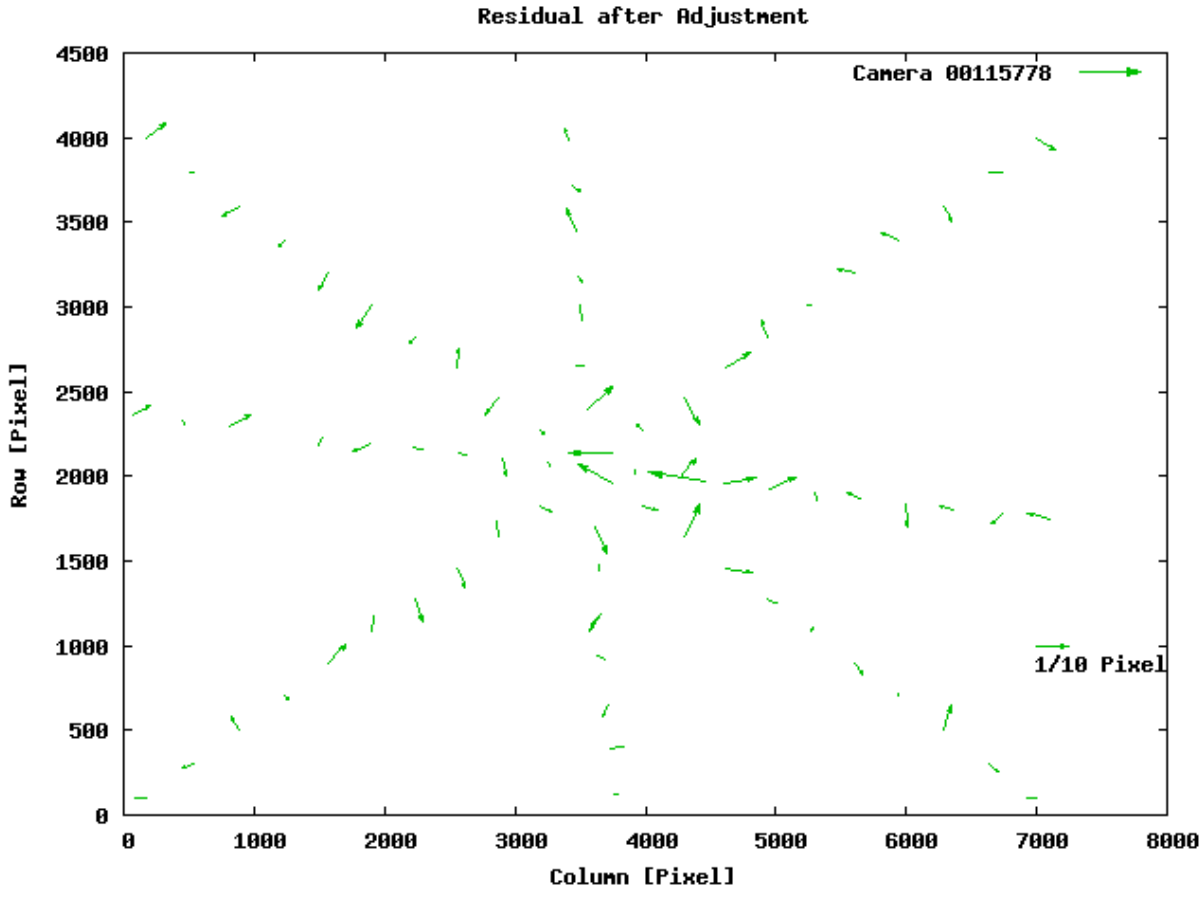
Geometric Calibration Protocol

Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00115778

	Param	Adjusted	Std.dev.
Principal Point [m]	x_0	3.006E-05	9.37E-06
	y_0	-6.317E-05	5.653E-06
Focal Length [m]	Δf	-0.0003847	1.603E-06
Radial Distortion	K_1	0.7824	0.04191
	K_2	-259.6	38.08
	K_3	-42000	10090
Decentring distortion	P_1	0.0001247	0.0002136
	P_2	-0.0005634	0.0001072
In Plane Distortion	B_1	9.477E-06	1.11E-05
	B_2	4.106E-05	6.499E-06

Adjusted Focal length = 0.12+ dc =0.1196153 [m]



Residuals in Image after Adjustment

Max Residual [µm]: 2.2

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”.

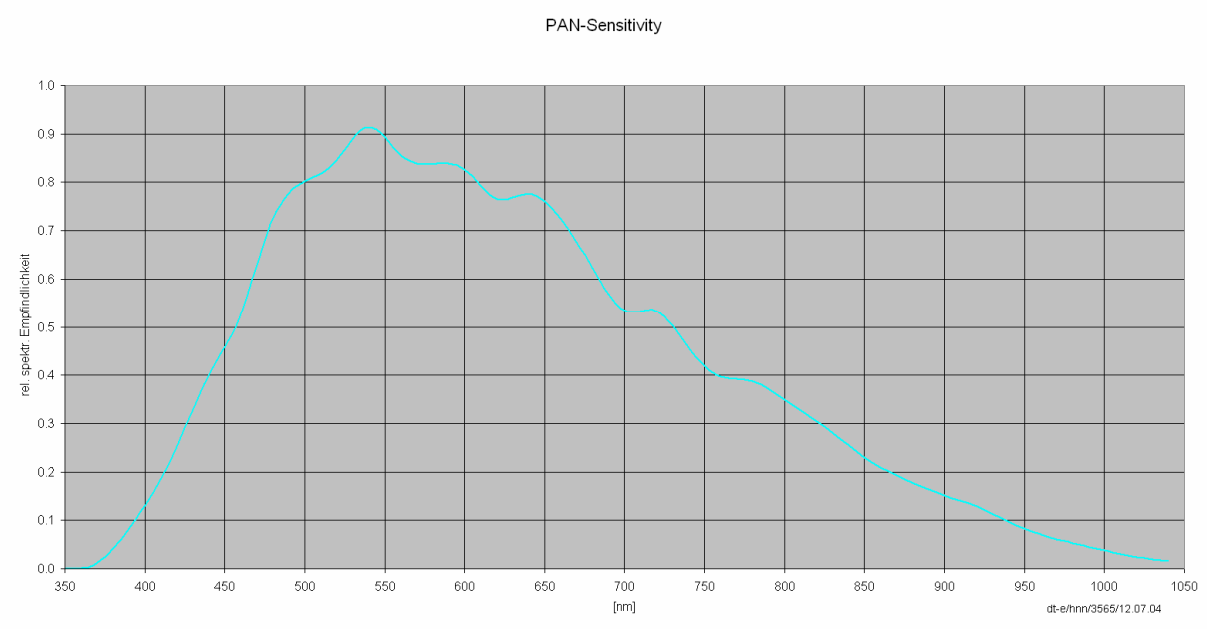
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

Radiometric Calibration Protocol

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

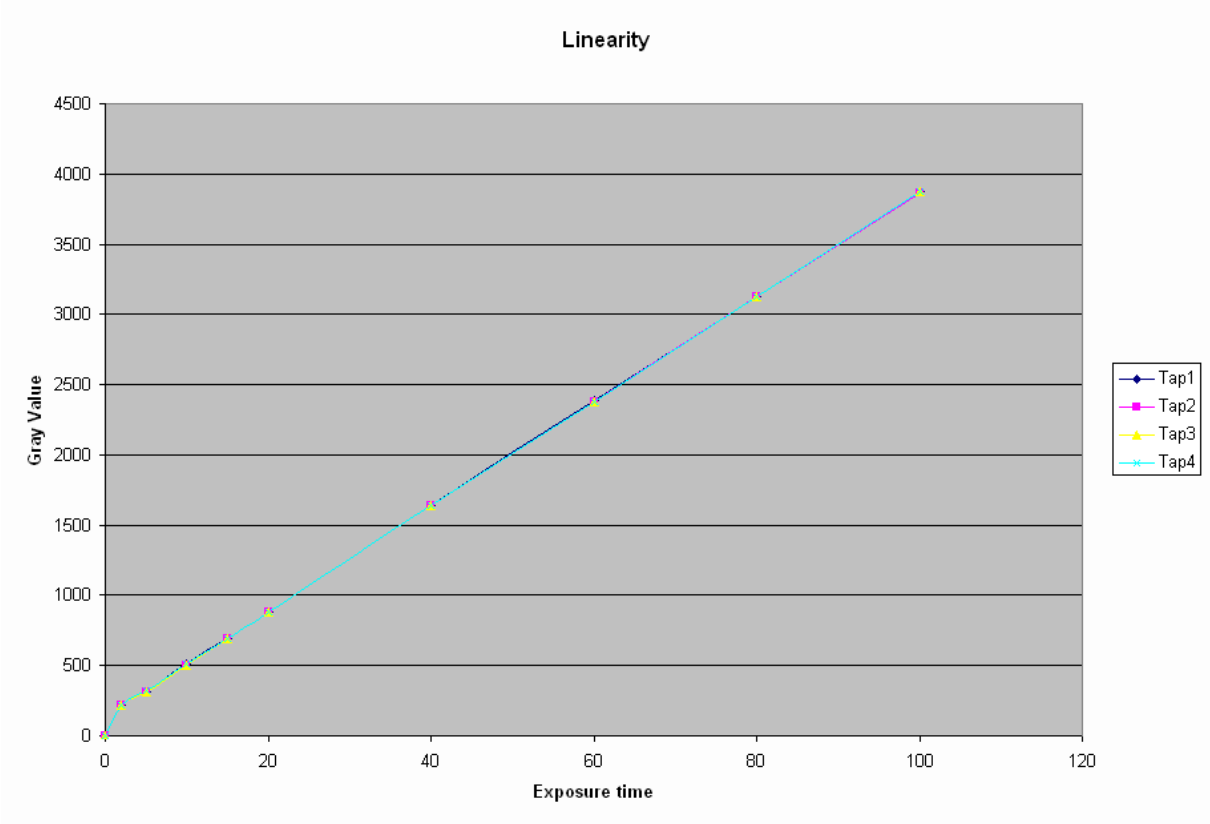
Camera ID	00115778
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

Sensitivity of camera



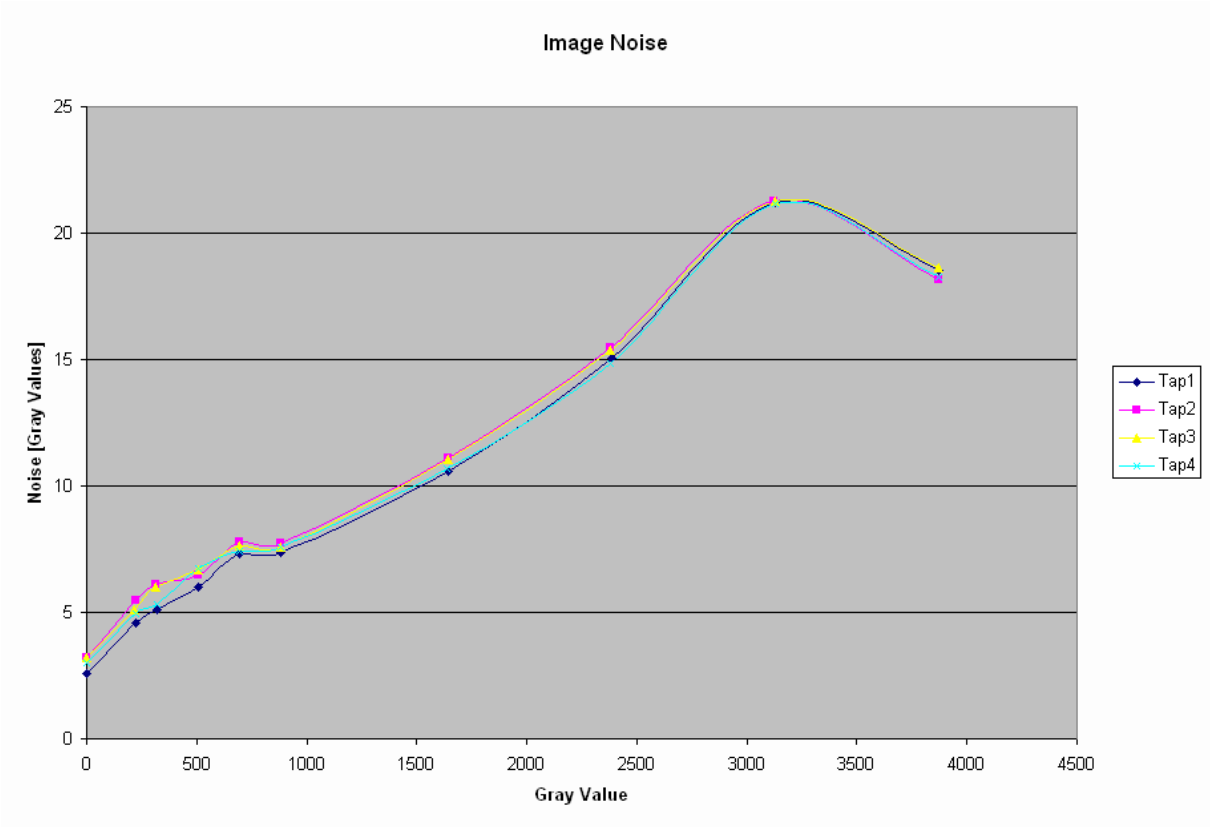
Remark:
Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Linearity



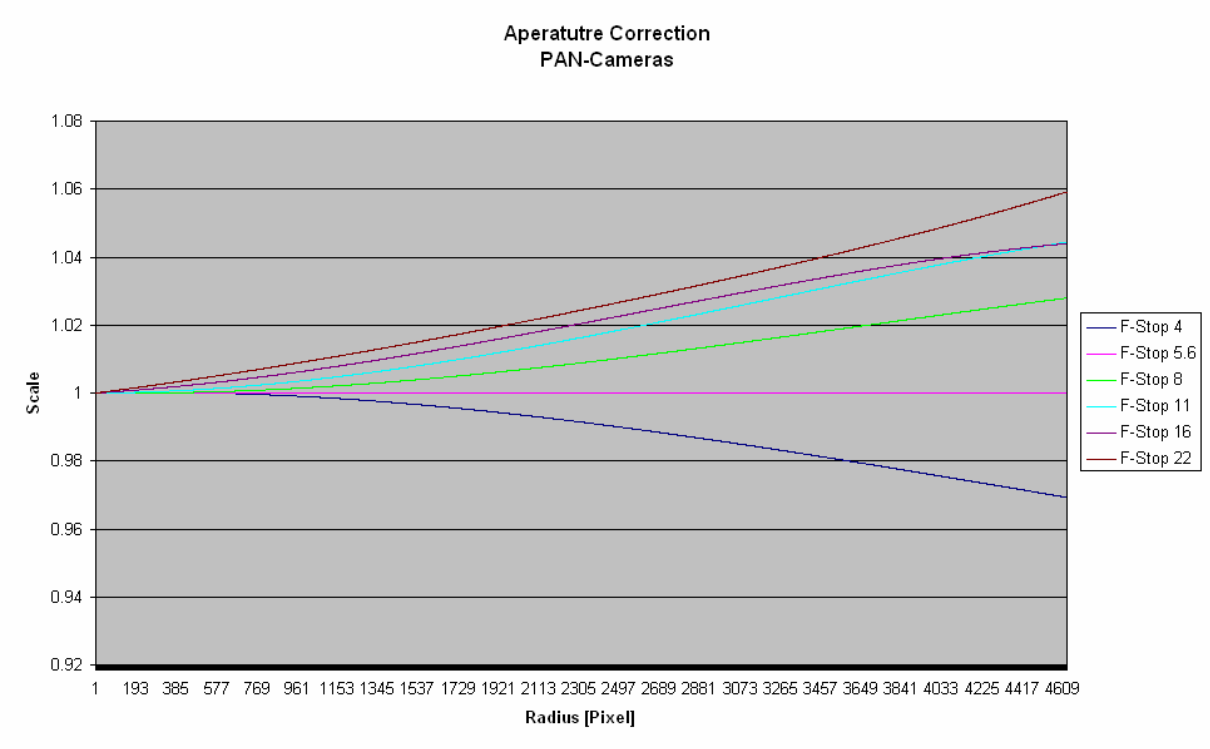
Remark:
The sensor linearity is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

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: 3

Number of defect clusters: 0

Number of defect columns: 0

Nr	Row	Column
0	1800	3494
1	3295	5301
2	3295	5302

Defect	Column	RowStart	ColumnStart	RowEnd	ColumnEnd

Remark

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

Calibration Protocol
DMC01 - 0053

Calibration Certificate N^{O} 00115710

Object	Digital Aerial Survey Camera
Manufacturer	Z/I Imaging D-73431 Aalen
Type	DMC-MS-NIR
Serial Number	00115710

Calibration performed at:
Carl Zeiss Jena

Number of pages of the certificate 70

Date of Calibration 20.Feb.2007

CertifiedDate	Division Head	Person in Charge
25.Jun.2007	(H. Sohnle)	(S. Schröder)

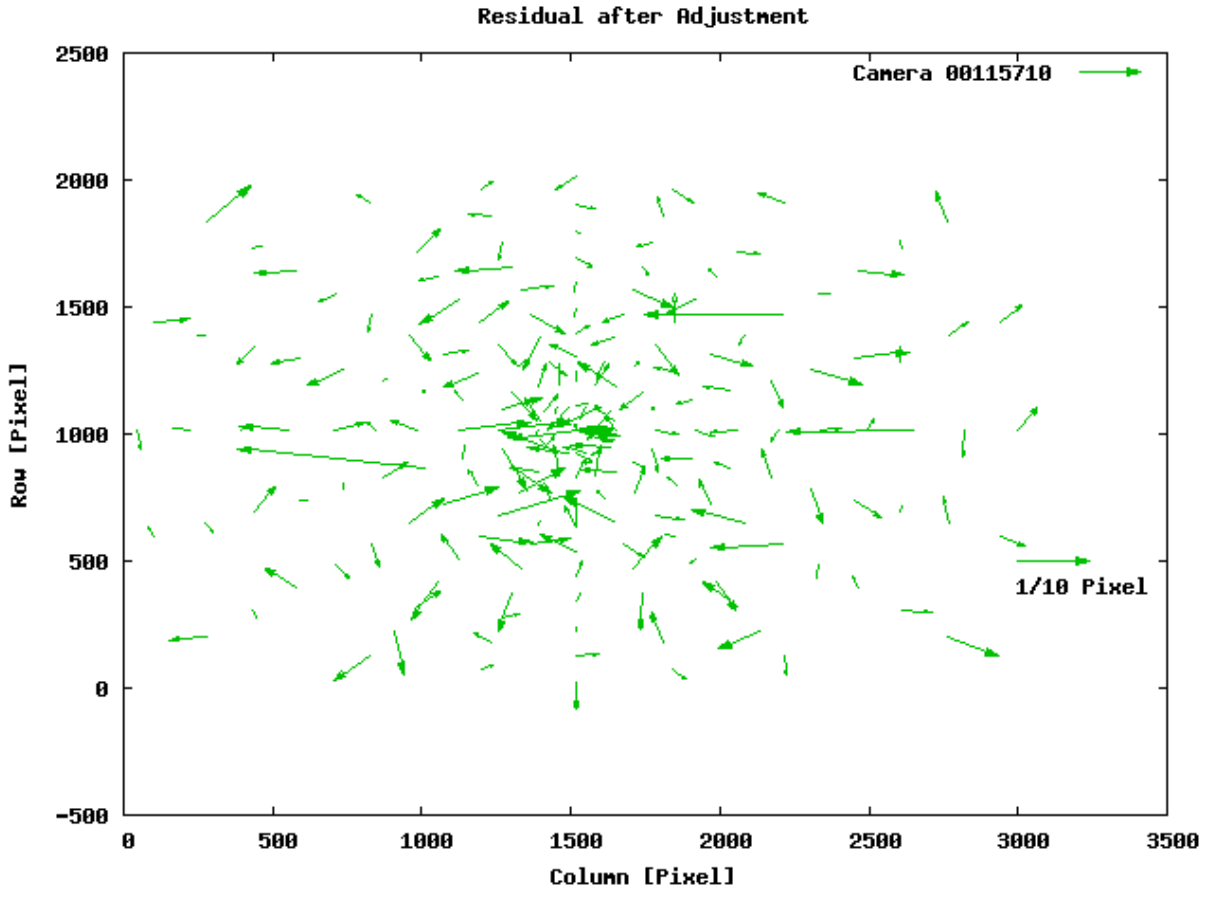
Geometric Calibration Protocol

Calibration Parameters for single camera head

Camera Type	DMC-MS-NIR
Nominal Focal Length	0.025 m
Serial Number	00115710

	Param	Adjusted	Std.dev.
Principal Point [m]	x_0	-0.0001742	1.343E-06
	y_0	6.419E-05	9.472E-07
Focal Length [m]	Δf	-2.878E-05	4.909E-07
Radial Distortion	K_1	-142.9	0.4143
	K_2	213700	2638
	K_3	-135400000	4746000
Decentring distortion	P_1	0.001448	0.0006984
	P_2	-0.0006103	0.0004331
In Plane Distortion	B_1	0.0001701	1.217E-05
	B_2	4.904E-05	9.976E-06

Adjusted Focal length = 0.025+ dc =0.02497122 [m]



Residuals in Image after Adjustment

Max Residual [µm]: 3.2

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”.

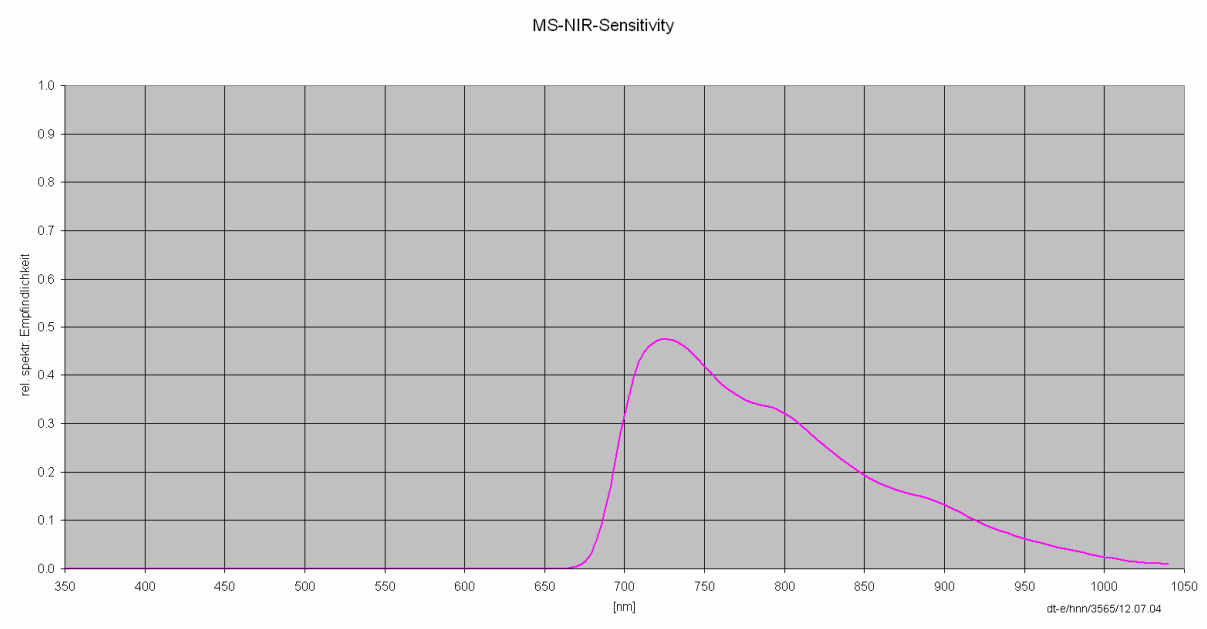
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

Radiometric Calibration Protocol

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

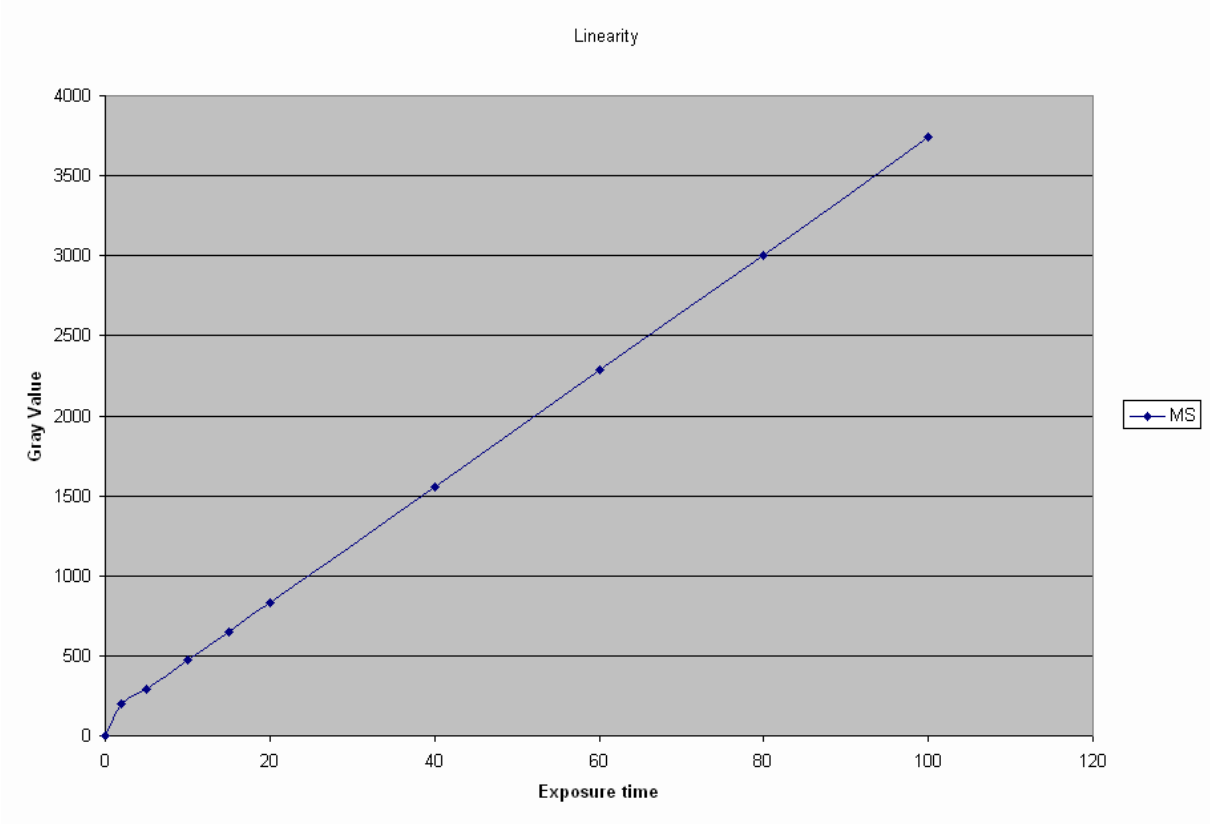
Camera ID	00115710
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1

Sensitivity of camera



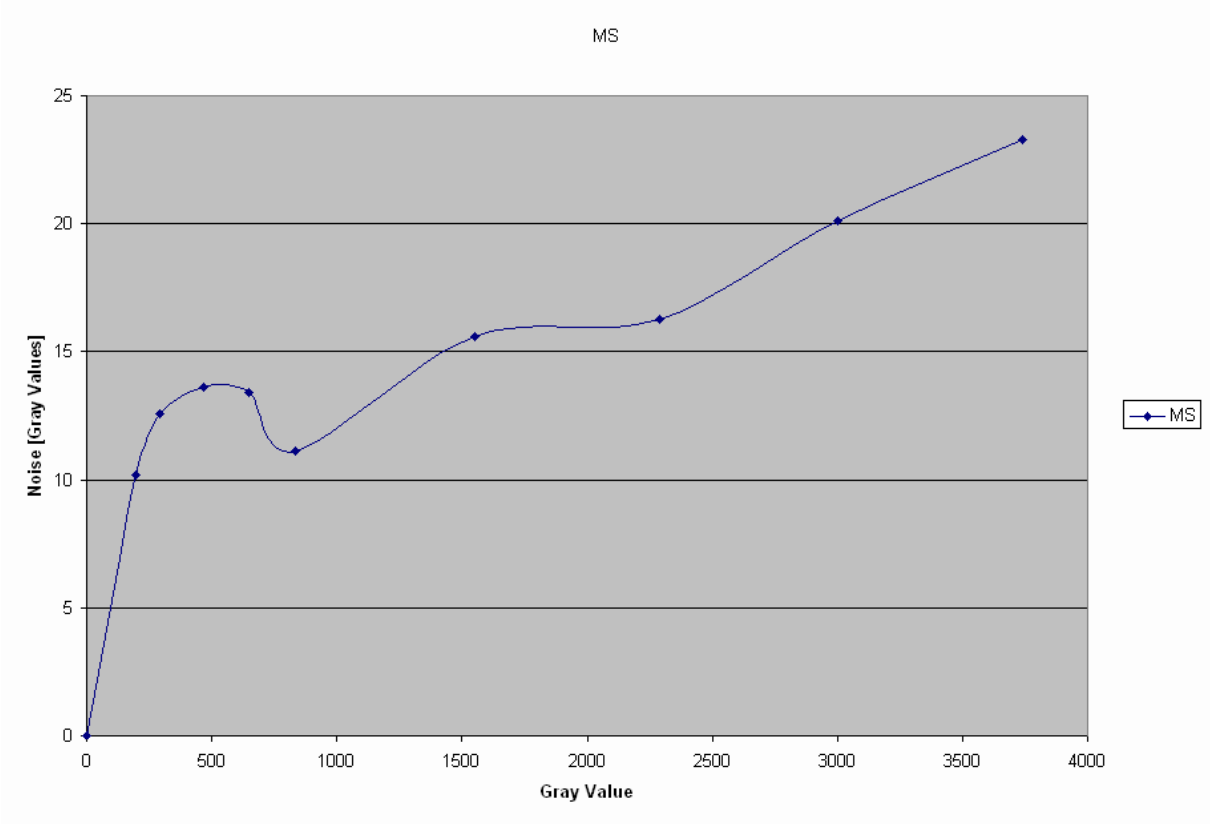
Remark:
Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Linearity



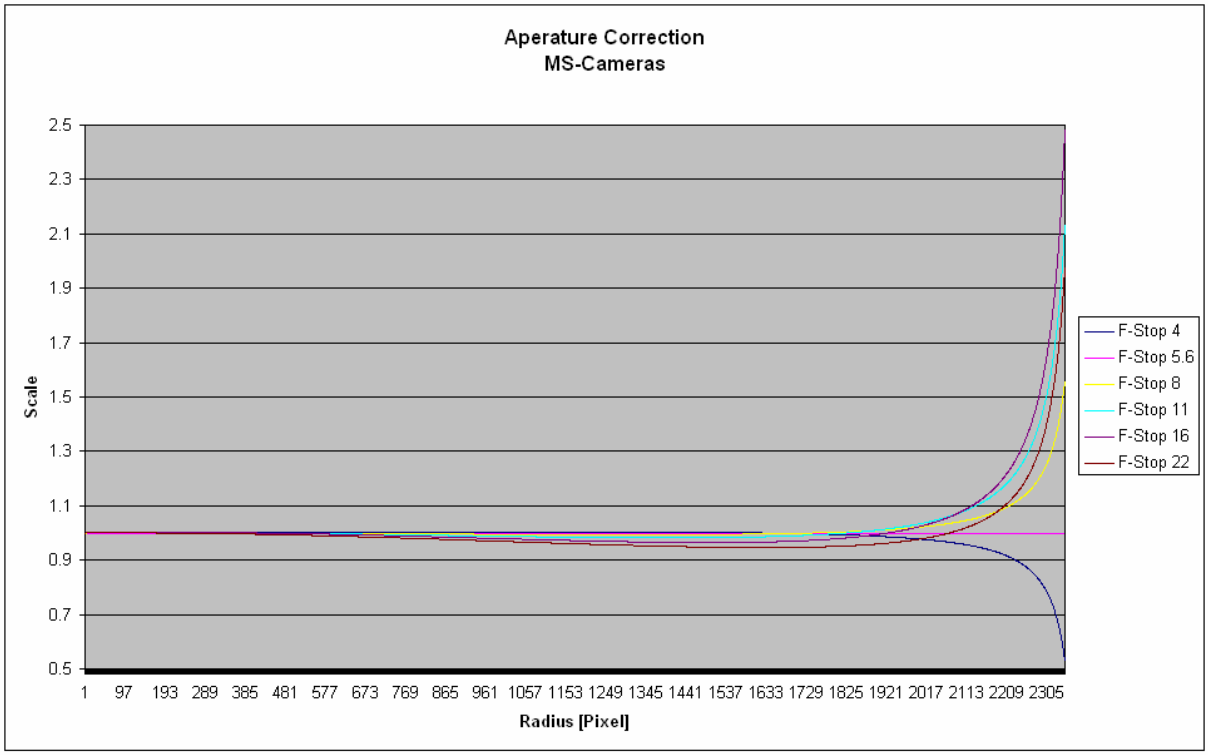
Remark:
The sensor linearity is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

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: 1

Nr Row Column

Defect	Column	RowStart	ColumnStart	RowEnd	ColumnEnd
0	193	391	2047	391	

Remark

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

Calibration Protocol
DMC01 - 0053

Calibration Certificate N^{O} 00115818

Object	Digital Aerial Survey Camera
Manufacturer	Z/I Imaging D-73431 Aalen
Type	DMC-MS-Blue
Serial Number	00115818

Calibration performed at:
Carl Zeiss Jena

Number of pages of the certificate 70

Date of Calibration 14.Feb.2007

CertifiedDate	Division Head	Person in Charge
25.Jun.2007	(H. Sohnle)	(S. Schröder)

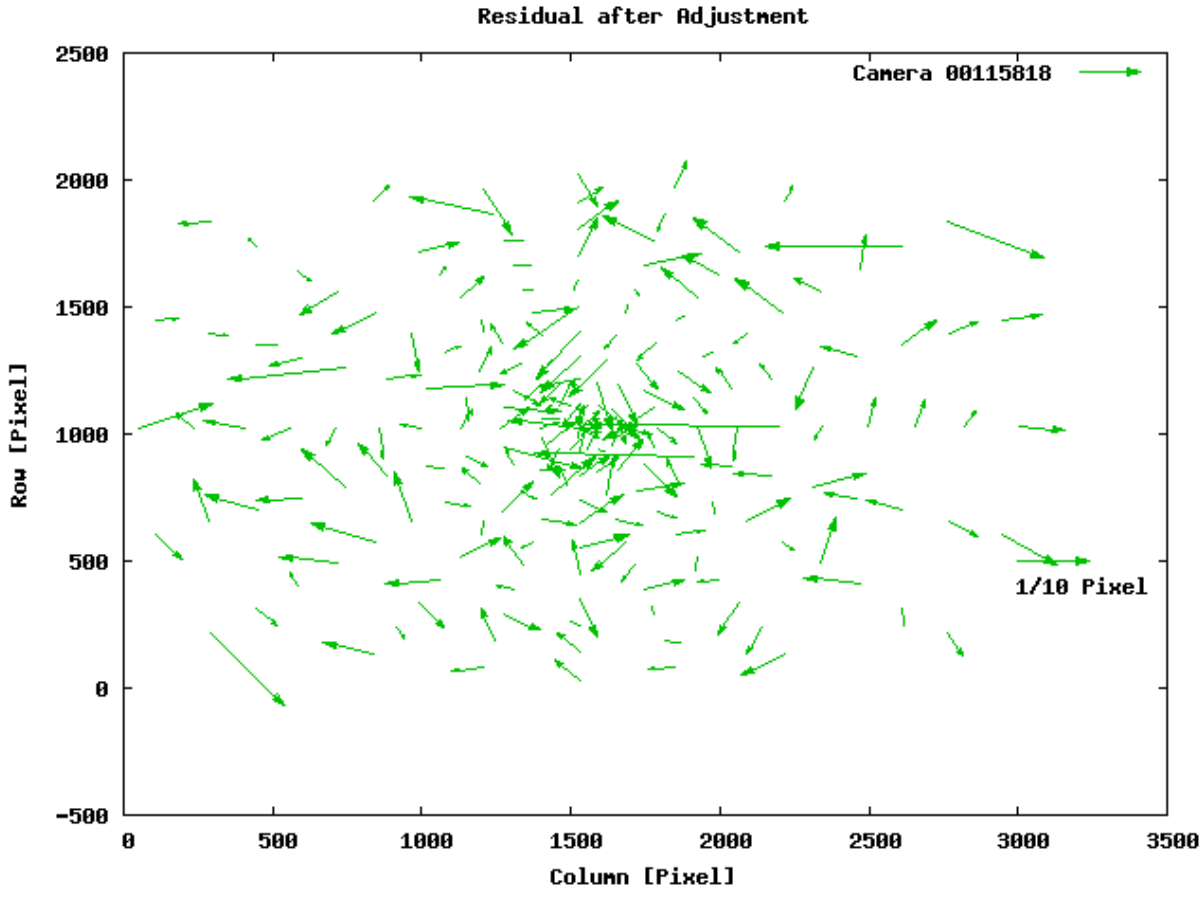
Geometric Calibration Protocol

Calibration Parameters for single camera head

Camera Type	DMC-MS-Blue
Nominal Focal Length	0.025 m
Serial Number	00115818

	Param	Adjusted	Std.dev.
Principal Point [m]	x_0	-9.432E-05	1.623E-06
	y_0	-2.449E-05	1.142E-06
Focal Length [m]	Δf	-0.0001226	5.904E-07
Radial Distortion	K_1	-142.1	0.4985
	K_2	220000	3176
	K_3	-146500000	5717000
Decentring distortion	P_1	0.0004333	0.0008446
	P_2	6.725E-05	0.0005214
In Plane Distortion	B_1	0.0001686	1.463E-05
	B_2	-6.234E-05	1.2E-05

Adjusted Focal length = 0.025+ dc =0.0248774 [m]



Residuals in Image after Adjustment

Max Residual [µm]: 3.2

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”.

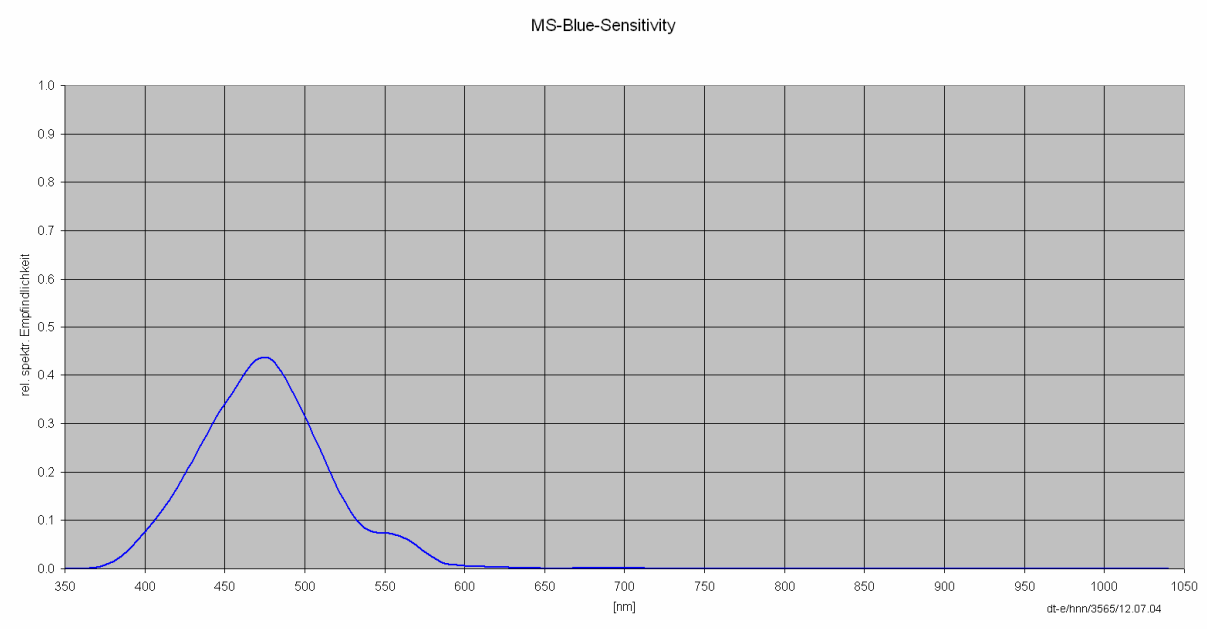
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

Radiometric Calibration Protocol

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

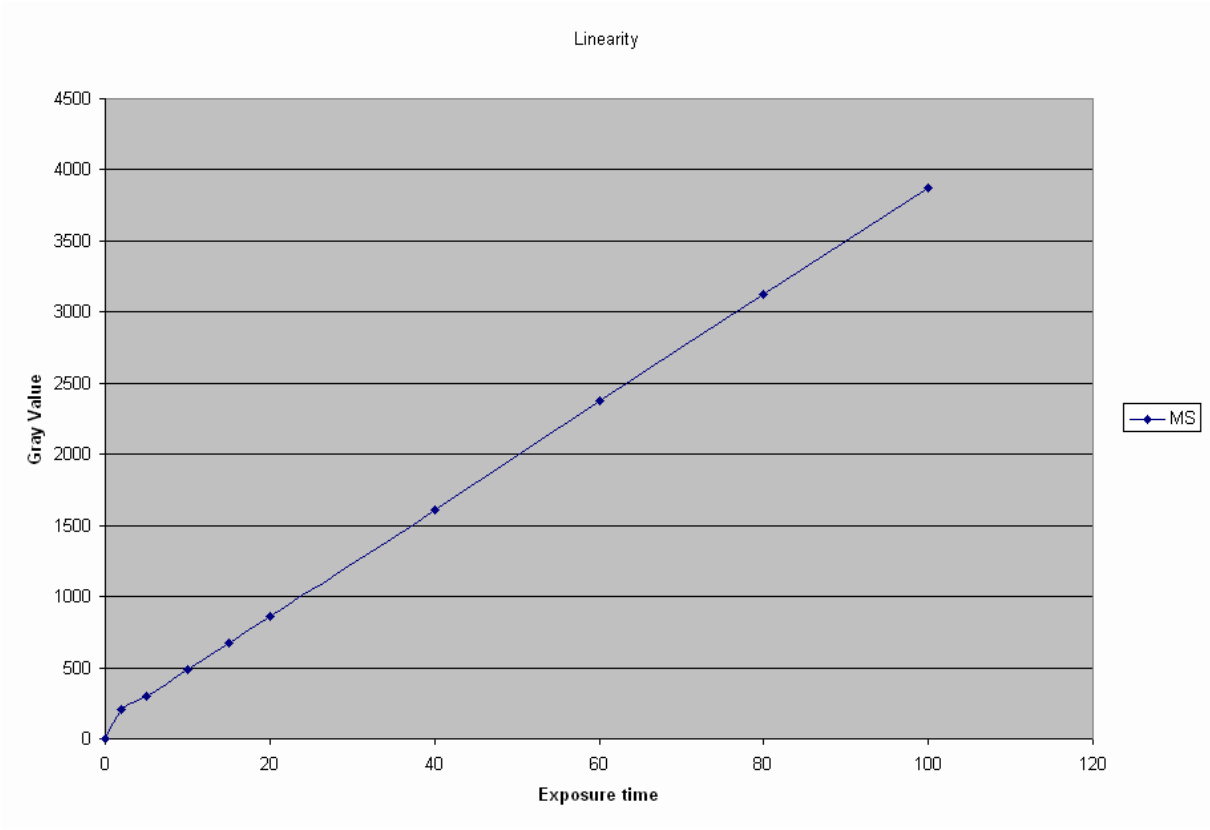
Camera ID	00115818
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1

Sensitivity of camera



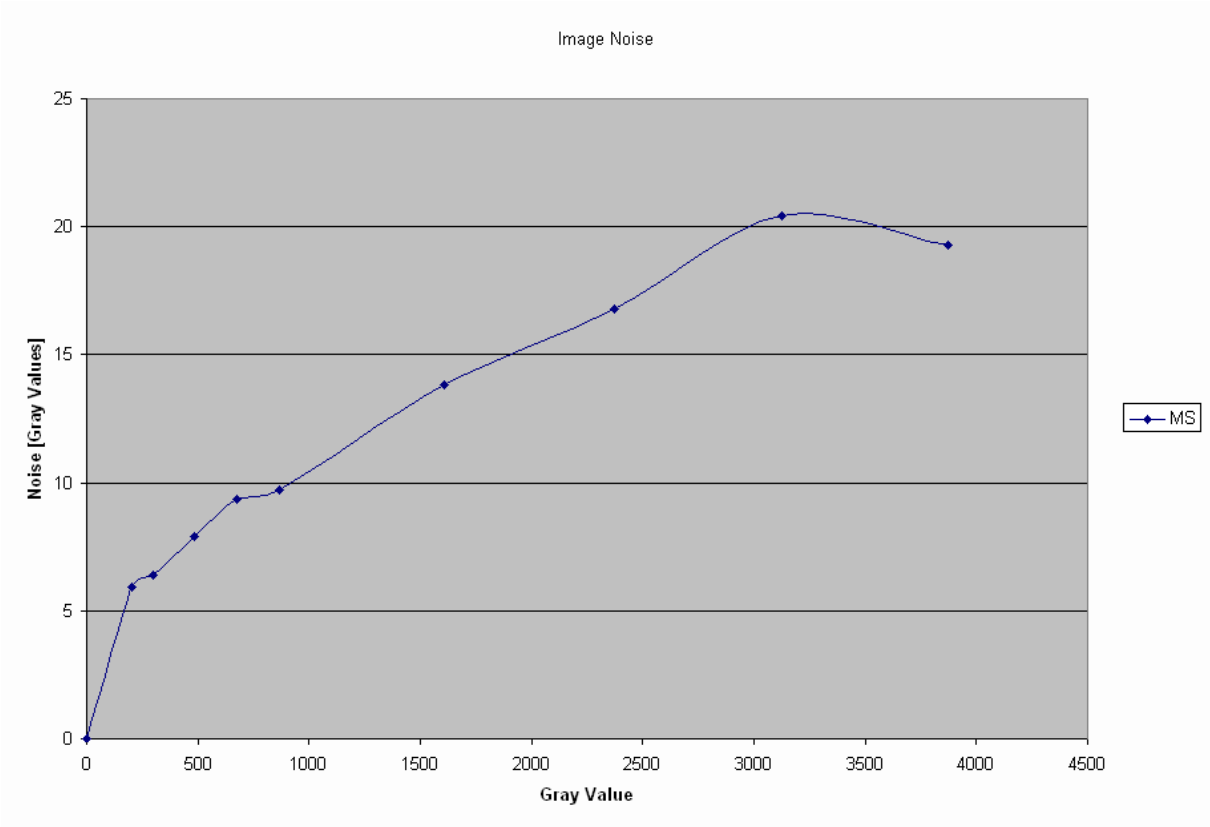
Remark:
Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Linearity



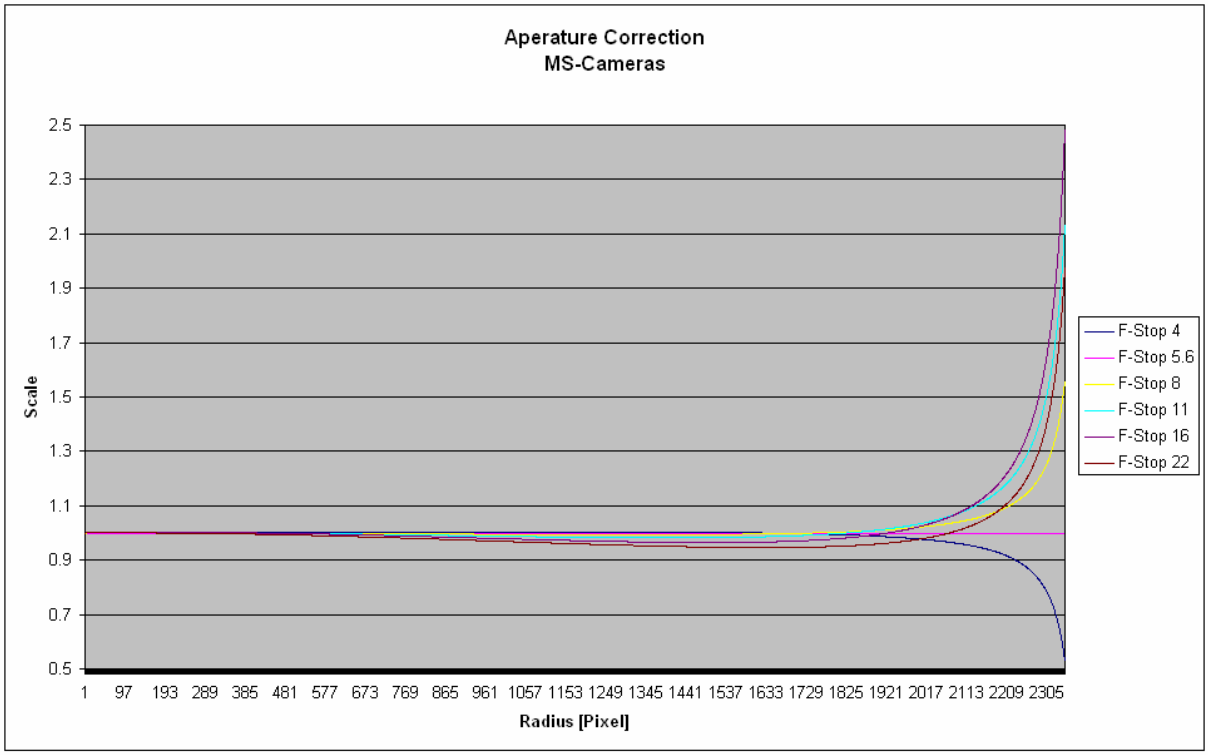
Remark:
The sensor linearity is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

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 - 0053

Calibration Certificate N^{O} 00115823

Object	Digital Aerial Survey Camera
Manufacturer	Z/I Imaging D-73431 Aalen
Type	DMC-MS-Red
Serial Number	00115823

Calibration performed at:
Carl Zeiss Jena

Number of pages of the certificate 70

Date of Calibration 15.Mar.2007

CertifiedDate	Division Head	Person in Charge
25.Jun.2007	(H. Sohnle)	(S. Schröder)

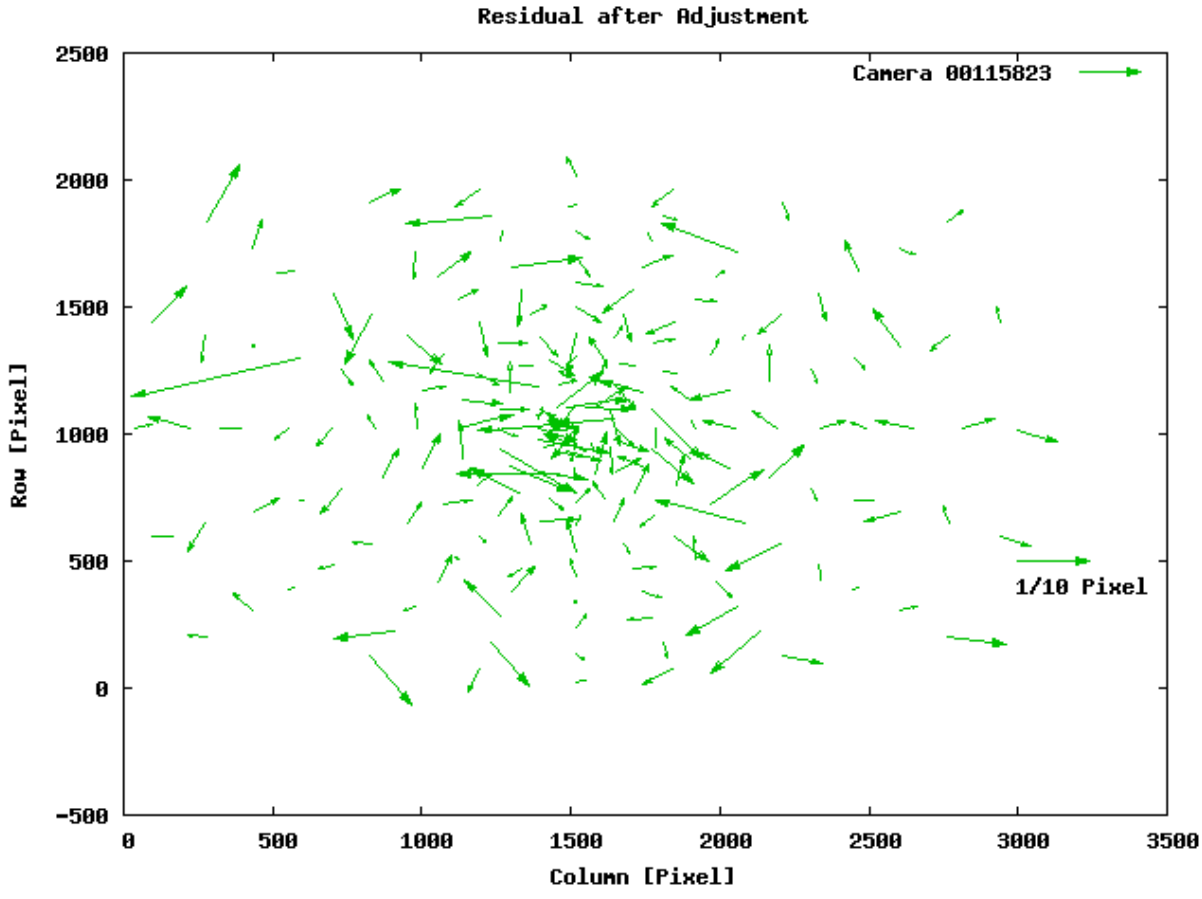
Geometric Calibration Protocol

Calibration Parameters for single camera head

Camera Type	DMC-MS-Red
Nominal Focal Length	0.025 m
Serial Number	00115823

	Param	Adjusted	Std.dev.
Principal Point [m]	x_0	-0.0001946	1.483E-06
	y_0	5.641E-05	1.039E-06
Focal Length [m]	Δf	-5.404E-05	5.393E-07
Radial Distortion	K_1	-140.6	0.455
	K_2	229300	2897
	K_3	-162300000	5211000
Decentring distortion	P_1	-0.0006944	0.0007712
	P_2	0.001271	0.0004738
In Plane Distortion	B_1	0.0001459	1.337E-05
	B_2	-9.582E-06	1.096E-05

Adjusted Focal length = 0.025+ dc =0.02494596 [m]



Residuals in Image after Adjustment

Max Residual [µm]: 2.9

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”.

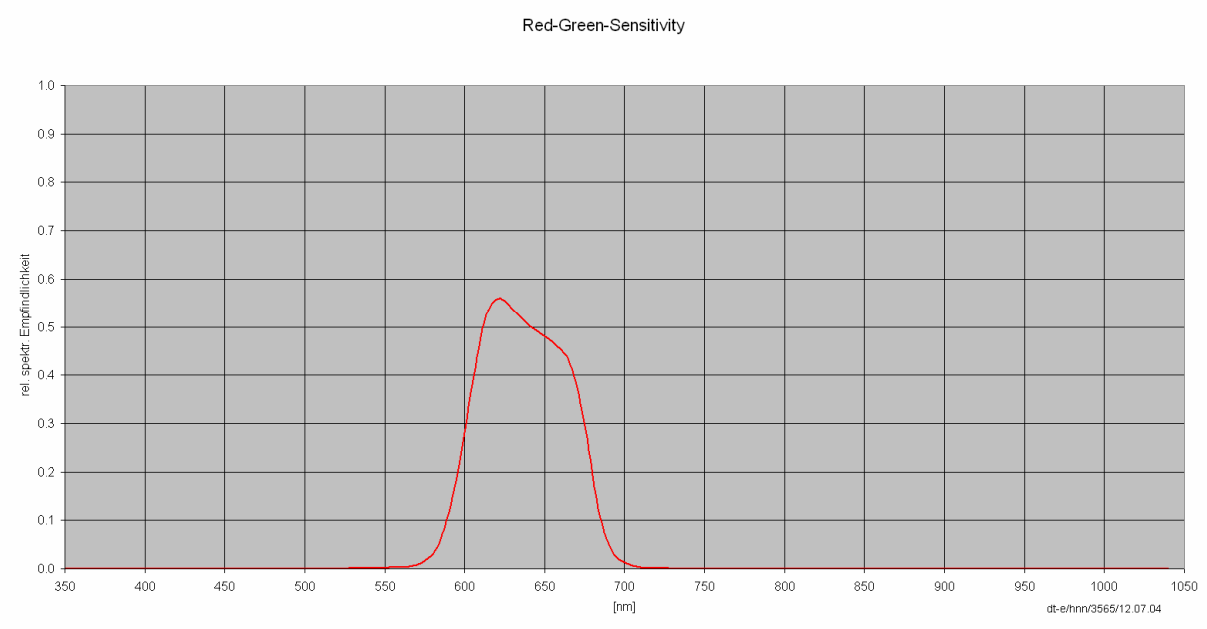
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

Radiometric Calibration Protocol

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

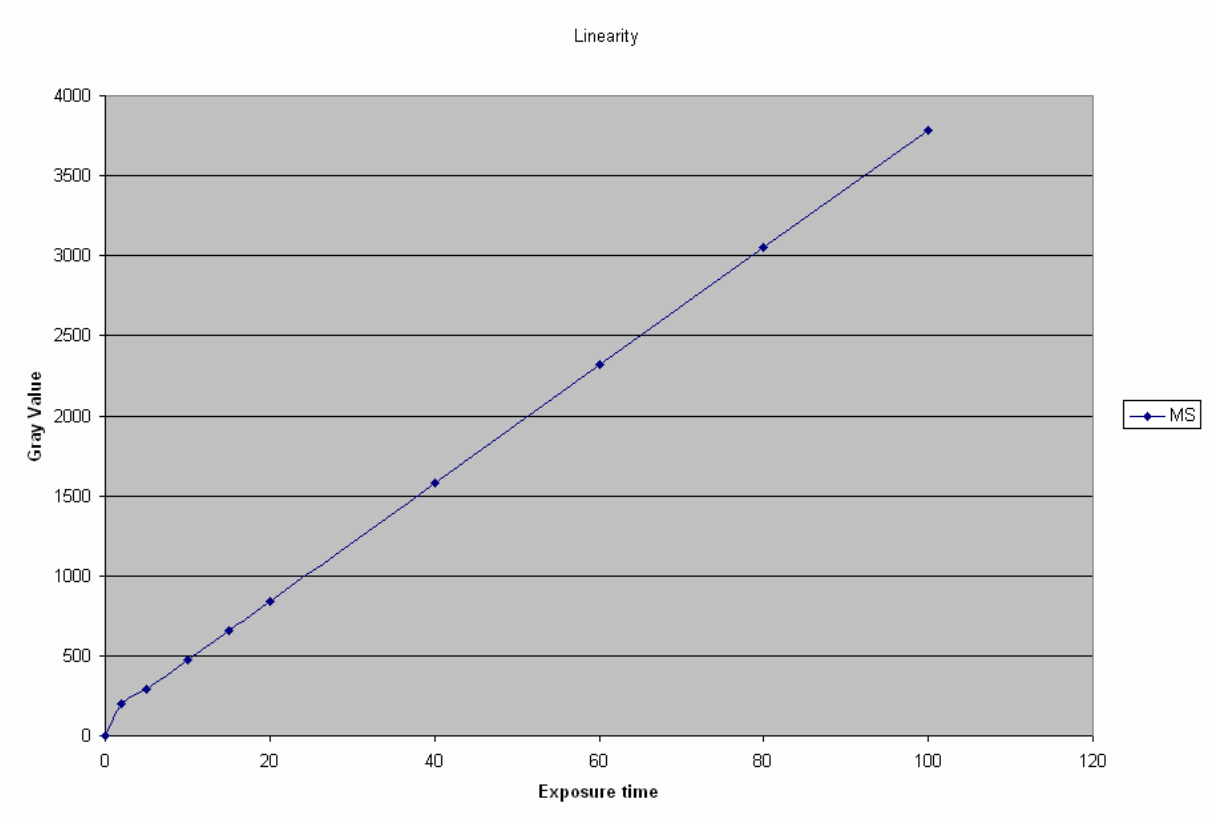
Camera ID	00115823
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1

Sensitivity of camera



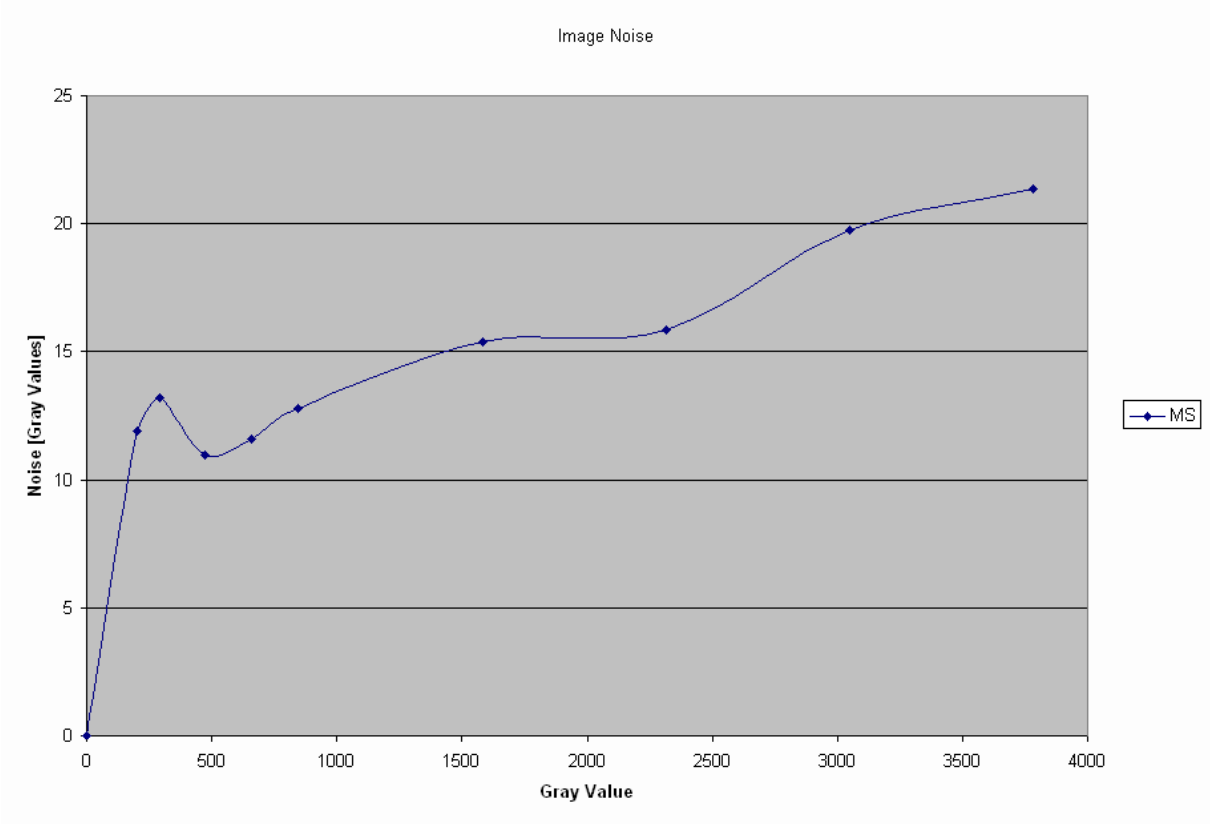
Remark:
Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Linearity



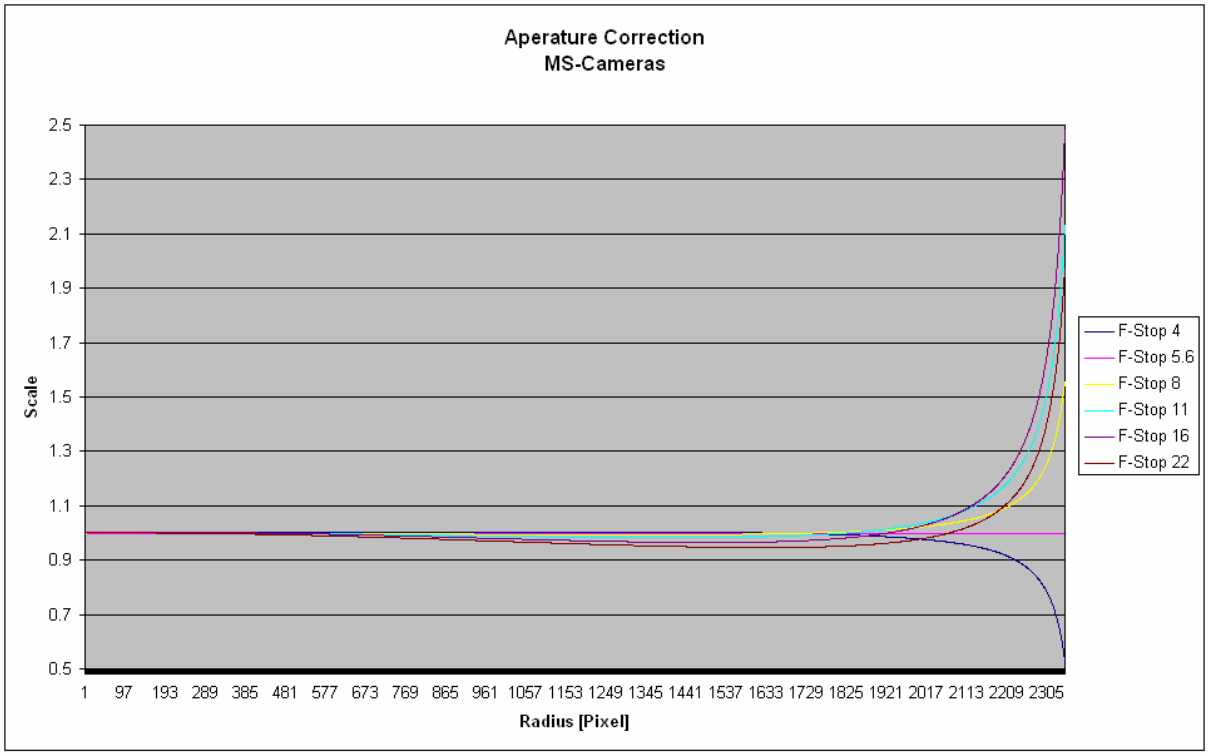
Remark:
The sensor linearity is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

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 - 0053

Calibration Certificate N^{O} 00115715

Object	Digital Aerial Survey Camera
Manufacturer	Z/I Imaging D-73431 Aalen
Type	DMC-MS-Green
Serial Number	00115715

Calibration performed at:
Carl Zeiss Jena

Number of pages of the certificate 70

Date of Calibration 15.Feb.2007

CertifiedDate	Division Head	Person in Charge
25.Jun.2007	(H. Sohnle)	(S. Schröder)

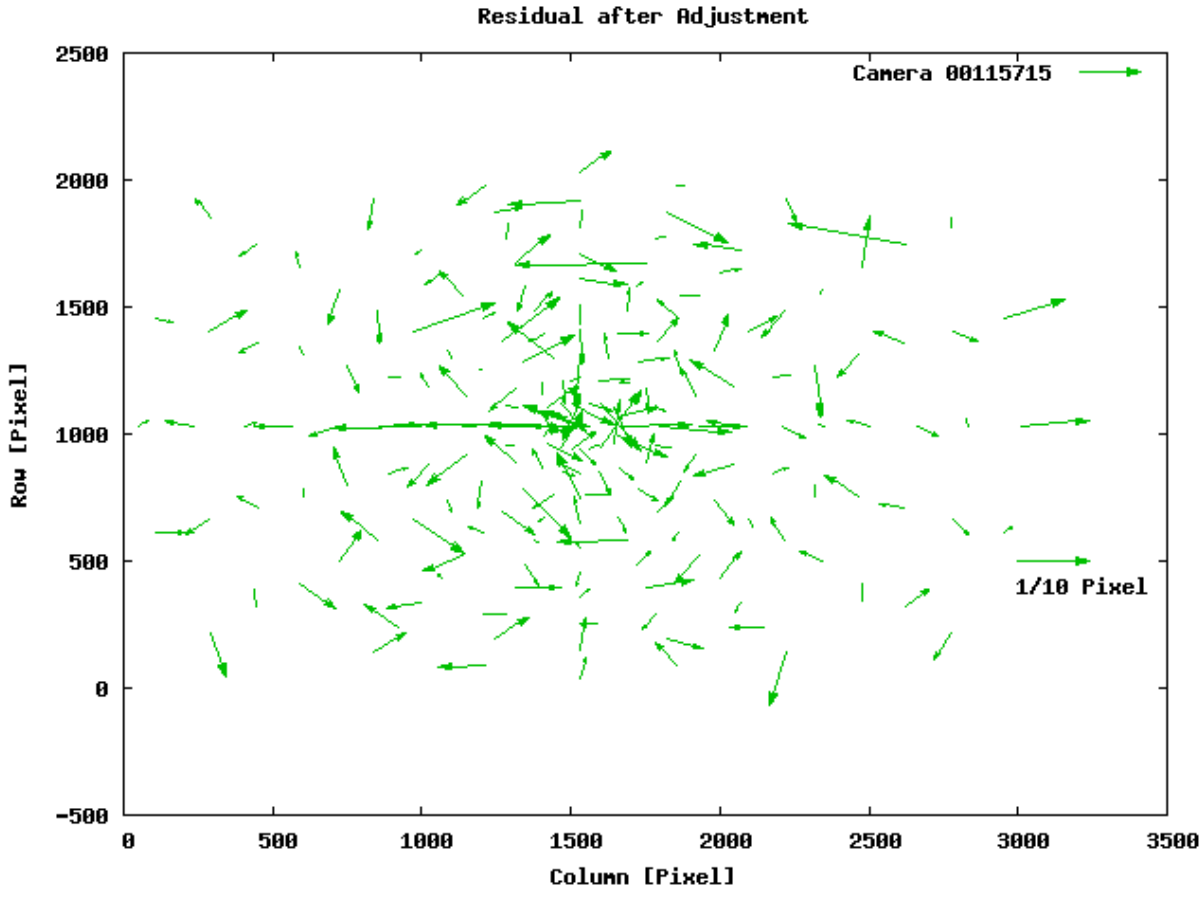
Geometric Calibration Protocol

Calibration Parameters for single camera head

Camera Type	DMC-MS-Green
Nominal Focal Length	0.025 m
Serial Number	00115715

	Param	Adjusted	Std.dev.
Principal Point [m]	x_0	-2.148E-05	1.457E-06
	y_0	-0.0001211	1.018E-06
Focal Length [m]	Δf	-6.261E-05	5.263E-07
Radial Distortion	K_1	-139.7	0.444
	K_2	227600	2827
	K_3	-159500000	5085000
Decentring distortion	P_1	-0.00244	0.0007582
	P_2	0.0001872	0.0004634
In Plane Distortion	B_1	0.0001625	1.305E-05
	B_2	-5.104E-05	1.07E-05

Adjusted Focal length = 0.025+ dc =0.02493739 [m]



Residuals in Image after Adjustment

Max Residual [µm]: 2.2

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”.

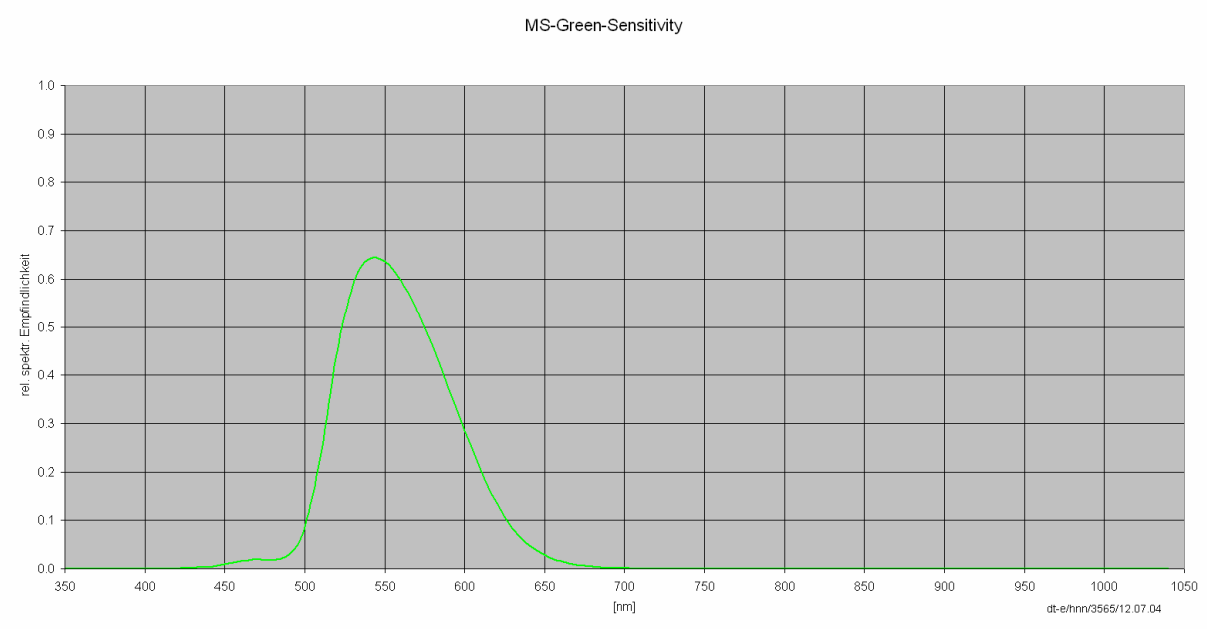
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

Radiometric Calibration Protocol

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

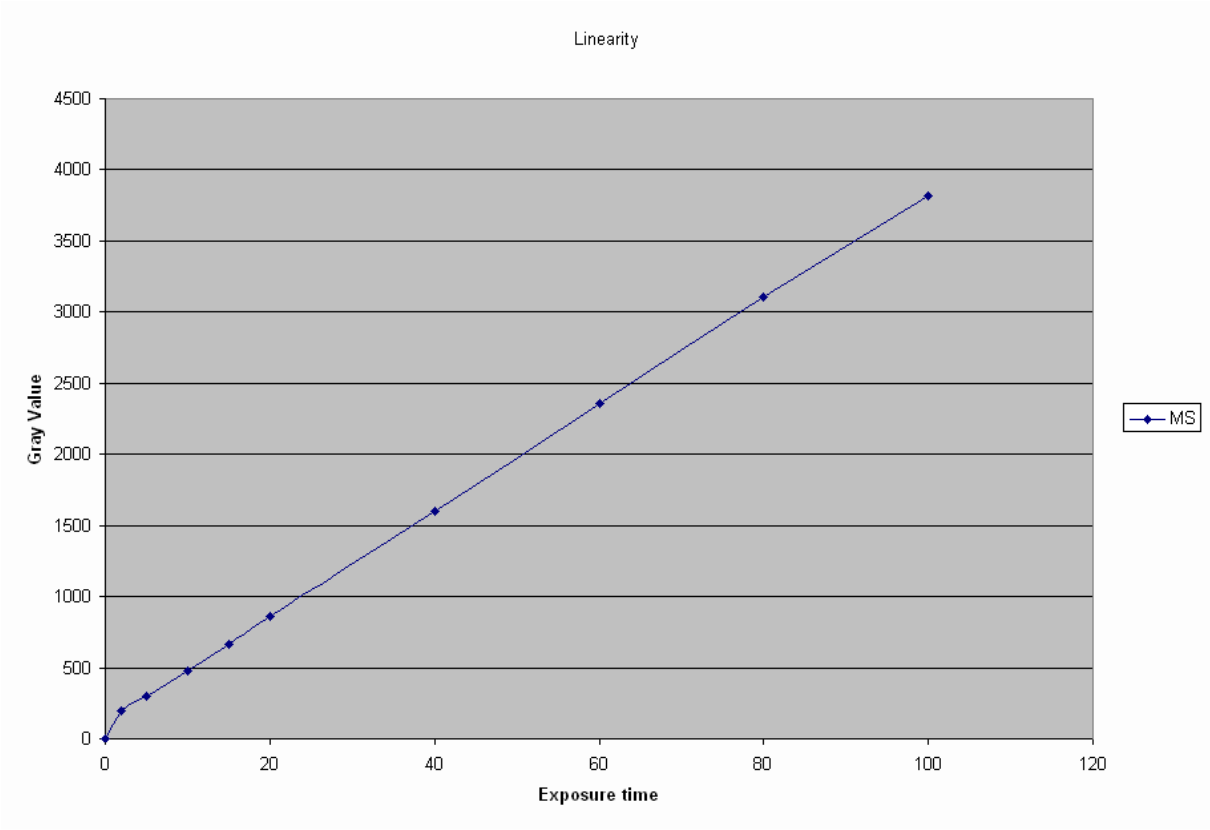
Camera ID	00115715
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1

Sensitivity of camera



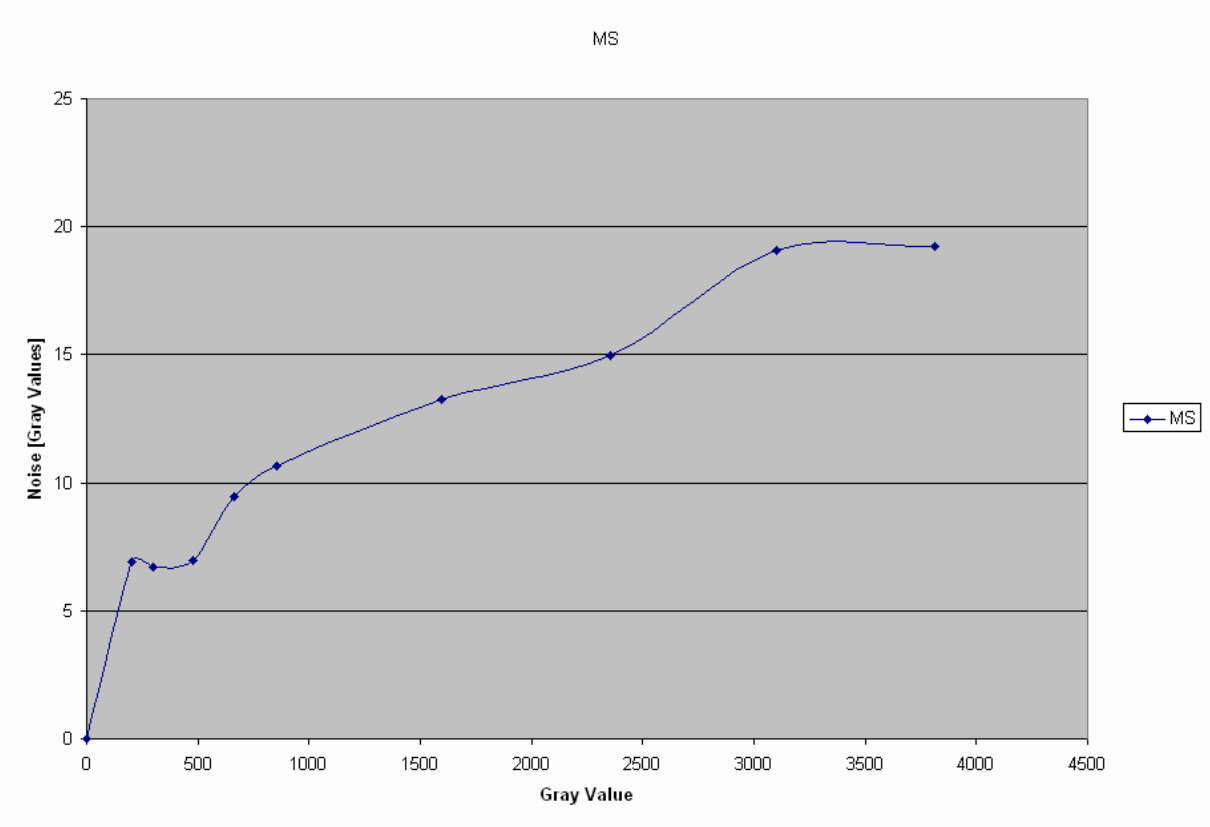
Remark:
Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: “Radiometric Calibration Model”.

Sensor Linearity



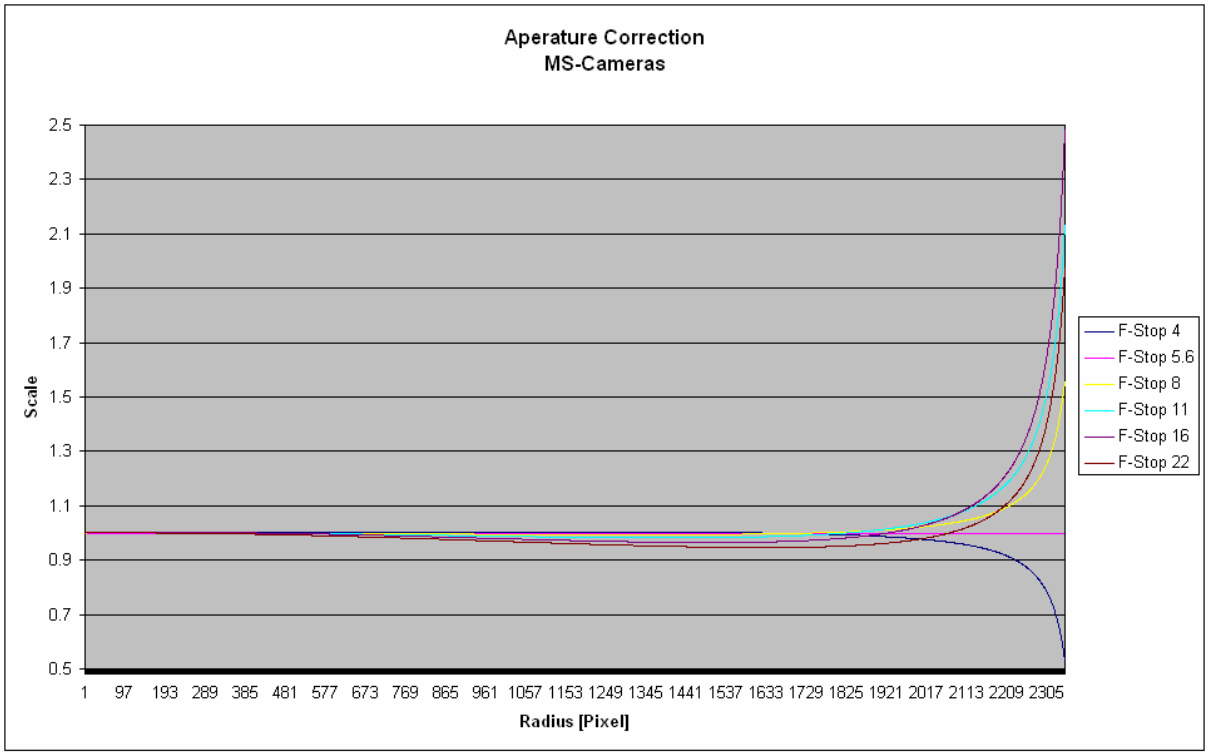
Remark:
The sensor linearity is measured for each camera. For more details see Appendix: “Radiometric Calibration Model”.

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: 1

Number of defect clusters: 0

Number of defect columns: 0

Nr	Row	Column
0	2047	801

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.