

Calibration Certificate

Digital Mapping Camera (DMC)

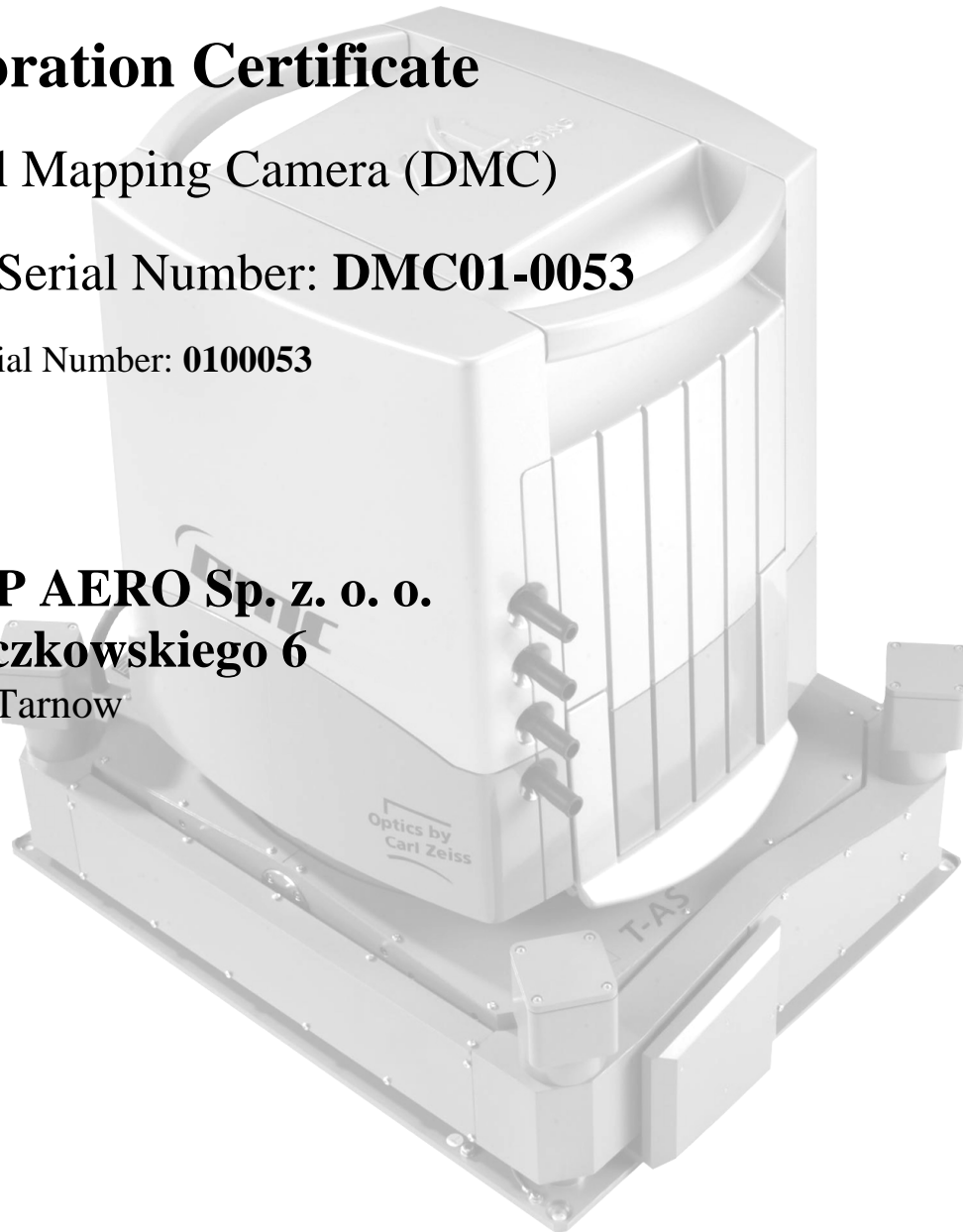
DMC Serial Number: **DMC01-0053**

CBU Serial Number: **0100053**

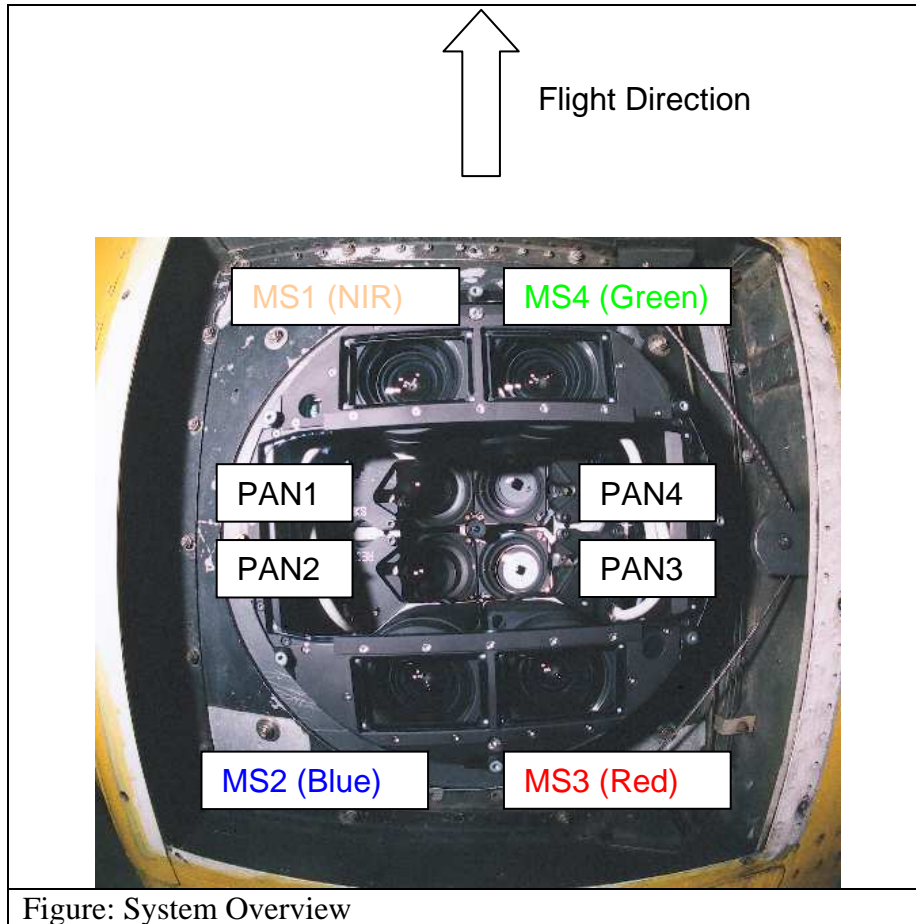
For

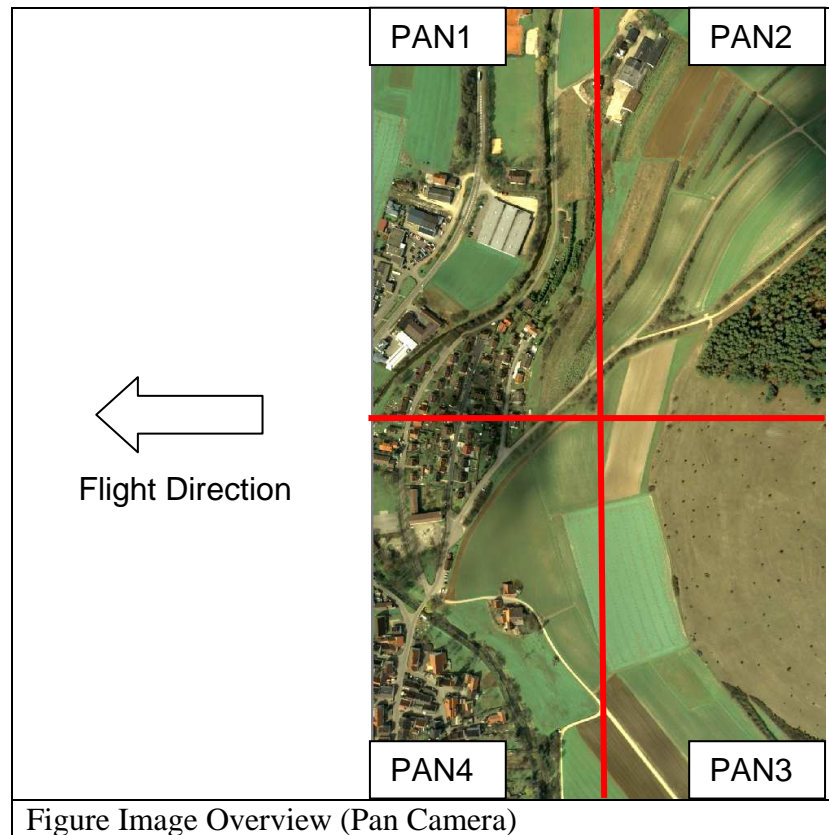
MGGP AERO Sp. z. o. o.
ul. Kaczkowskiego 6
33-100 Tarnow

Poland



System Overview





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



Calibration Protocol
DMC01 - 0053



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				

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 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

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	

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

02.Jul.2007

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

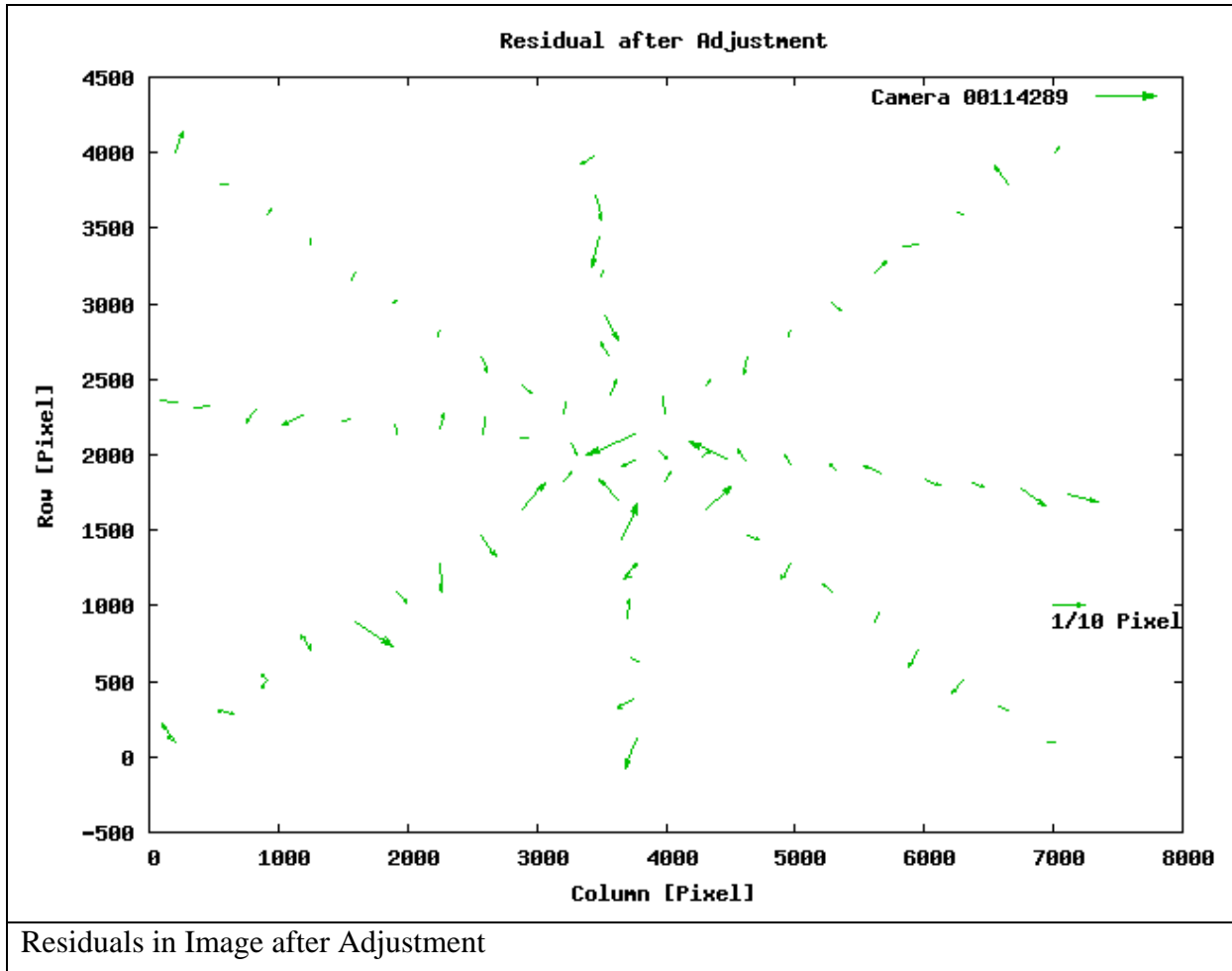
Geometric Calibration Protocol

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
Decentering 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]



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".

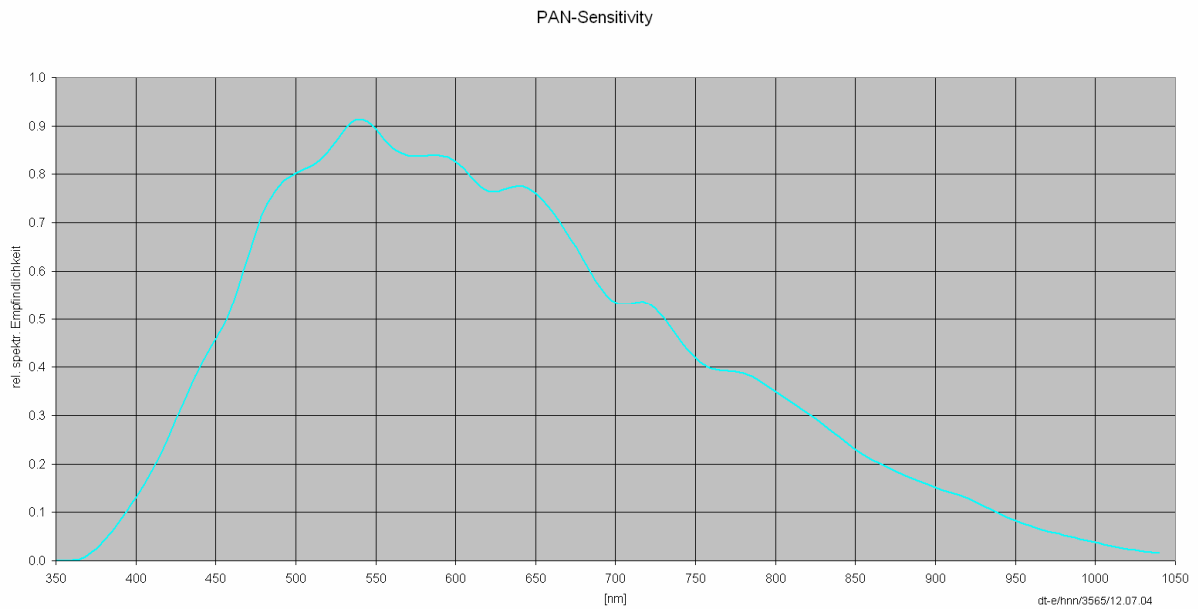
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

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

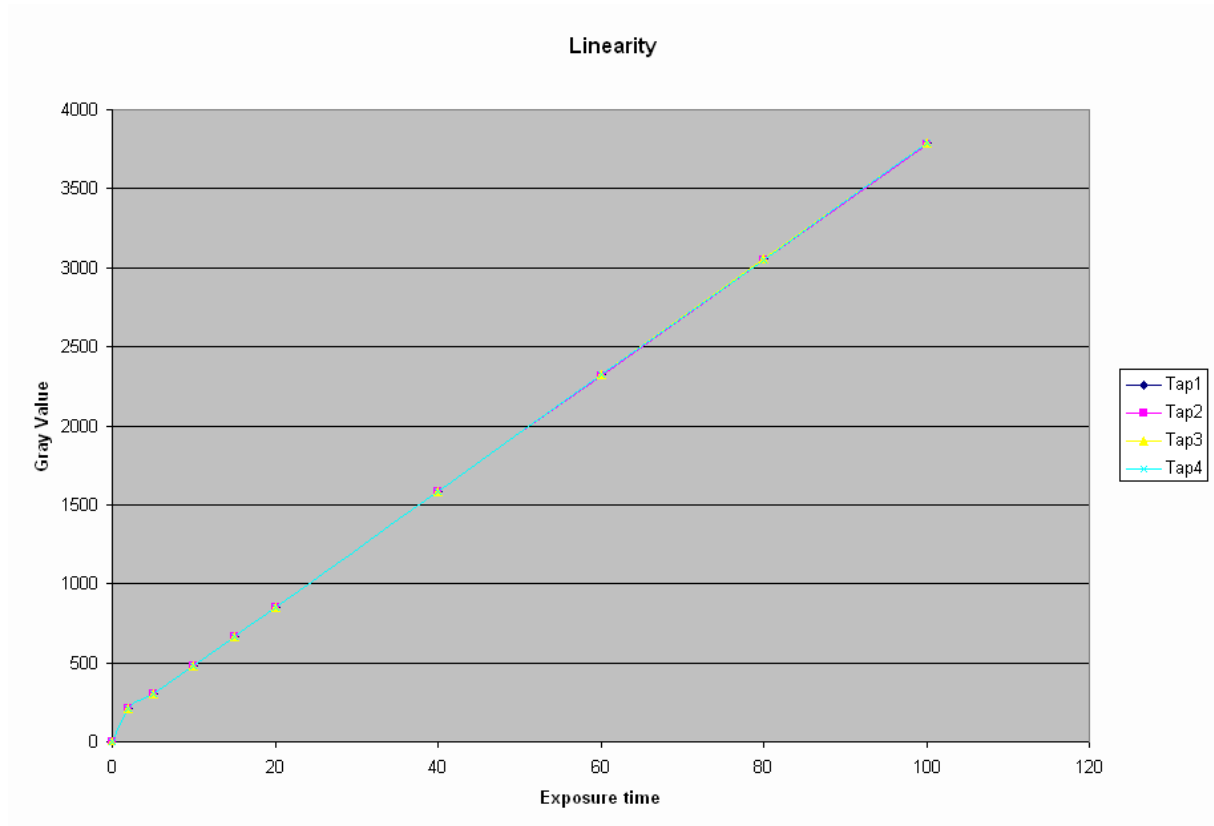
Sensitivity of camera



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".

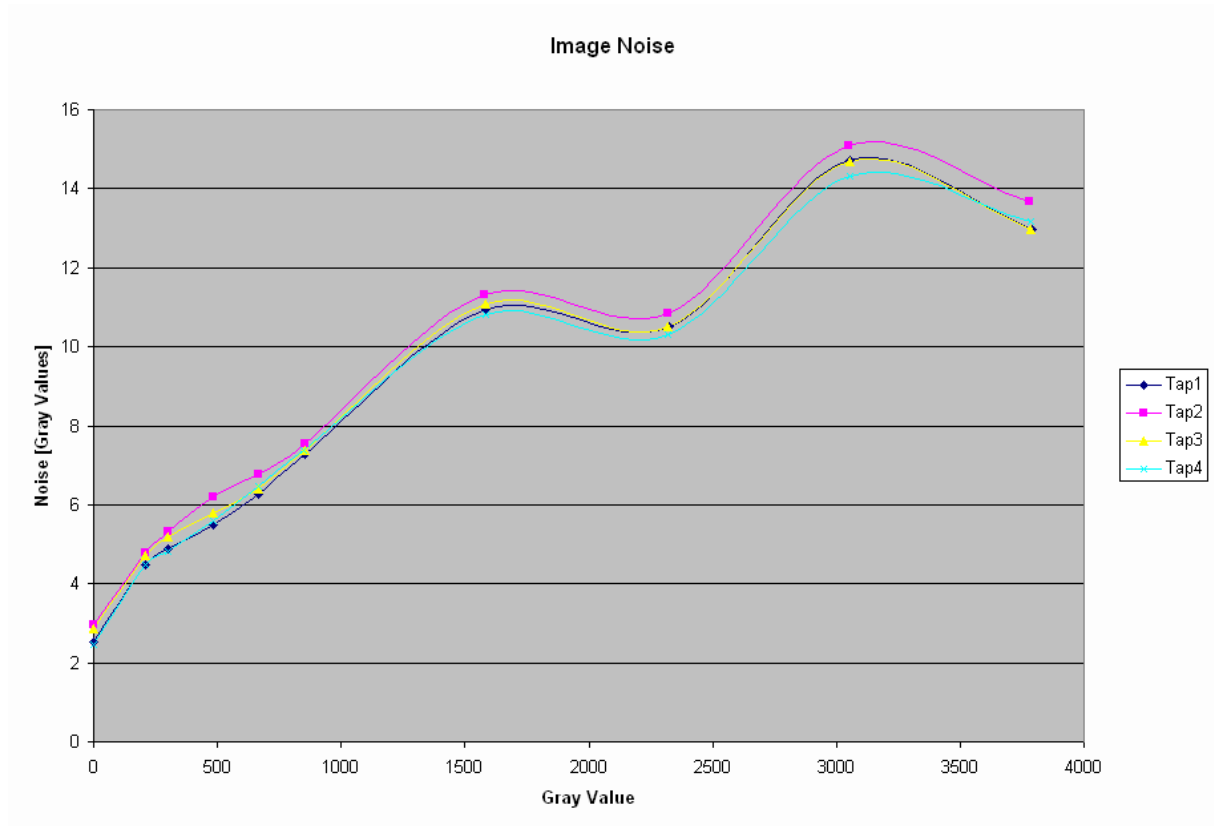
Sensor Linearity



Remark:

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

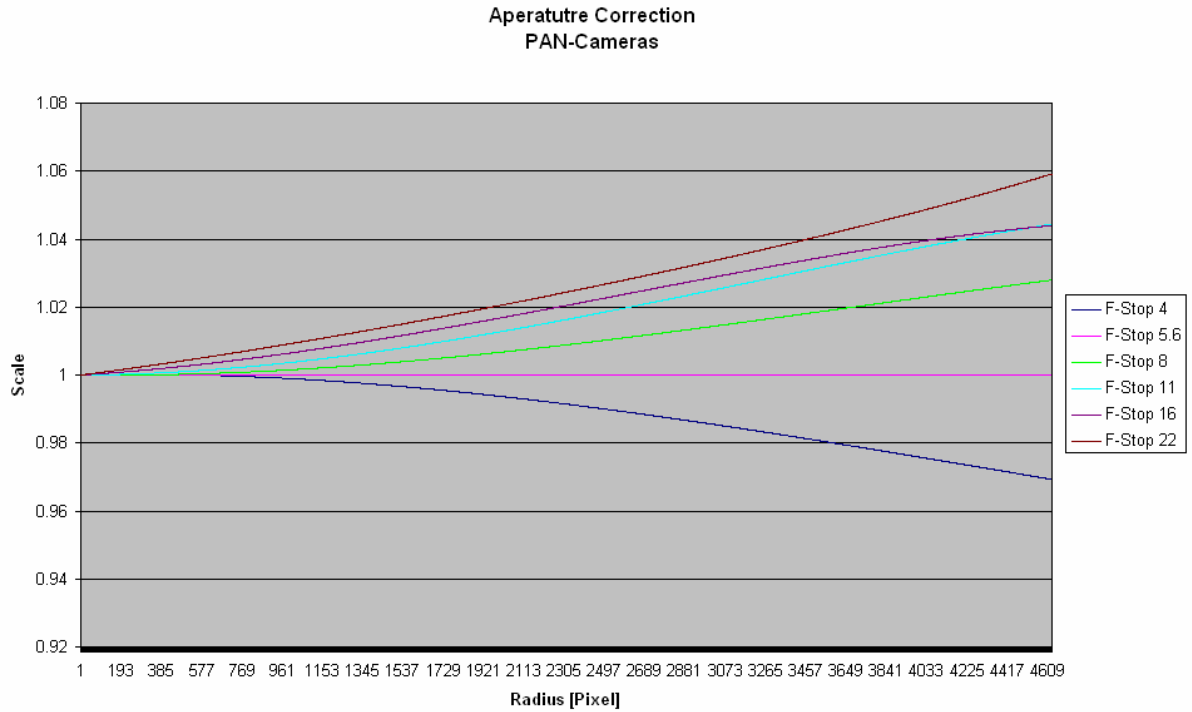
Sensor Noise



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
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0	2048	3591
1	3289	5283
2	3289	5284

Defect Column	RowStart	ColumnStart	RowEnd	ColumnEnd
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Calibration Protocol DMC01 - 0053



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

02.Jul.2007

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

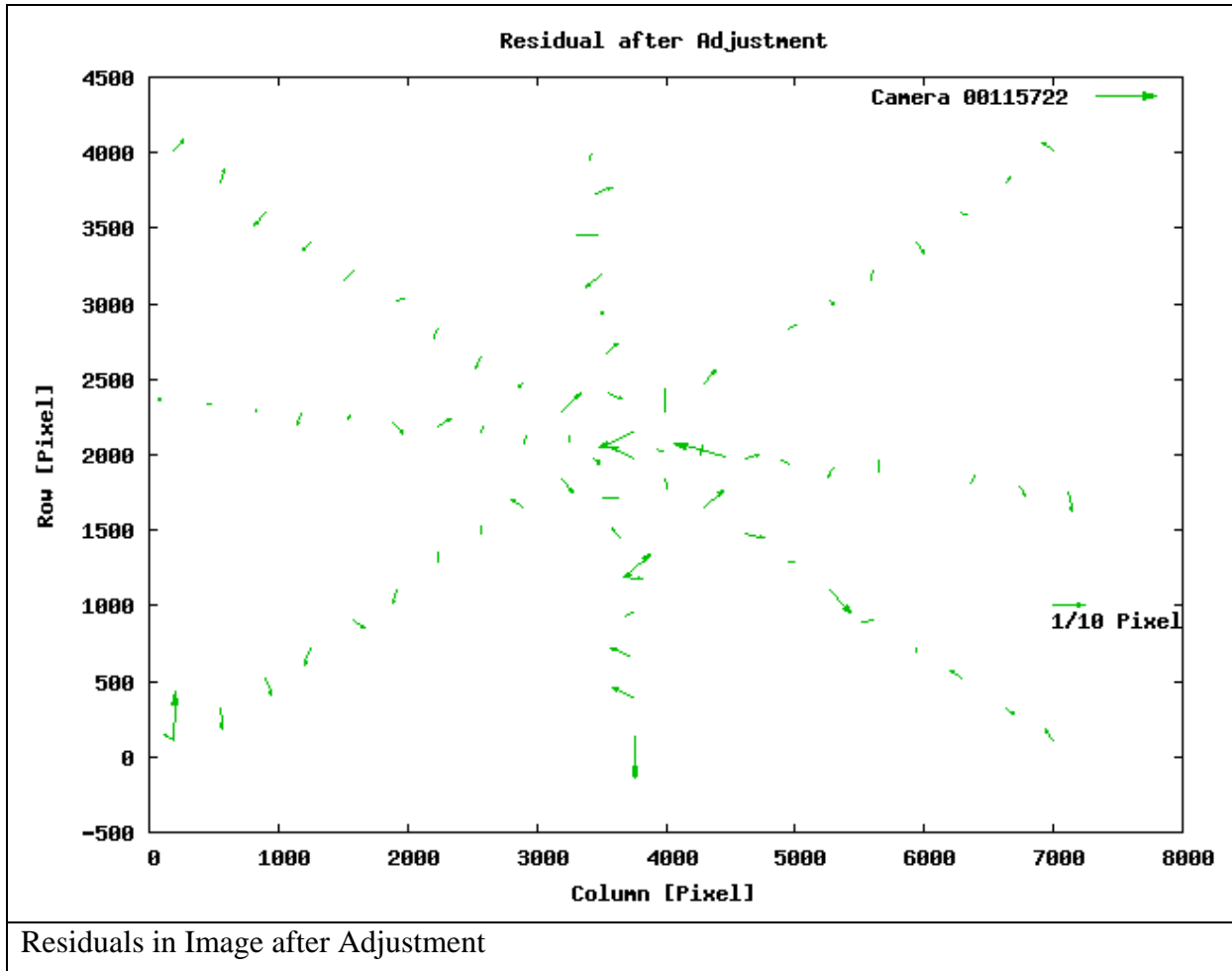
Geometric Calibration Protocol

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
Decentering 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]



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".

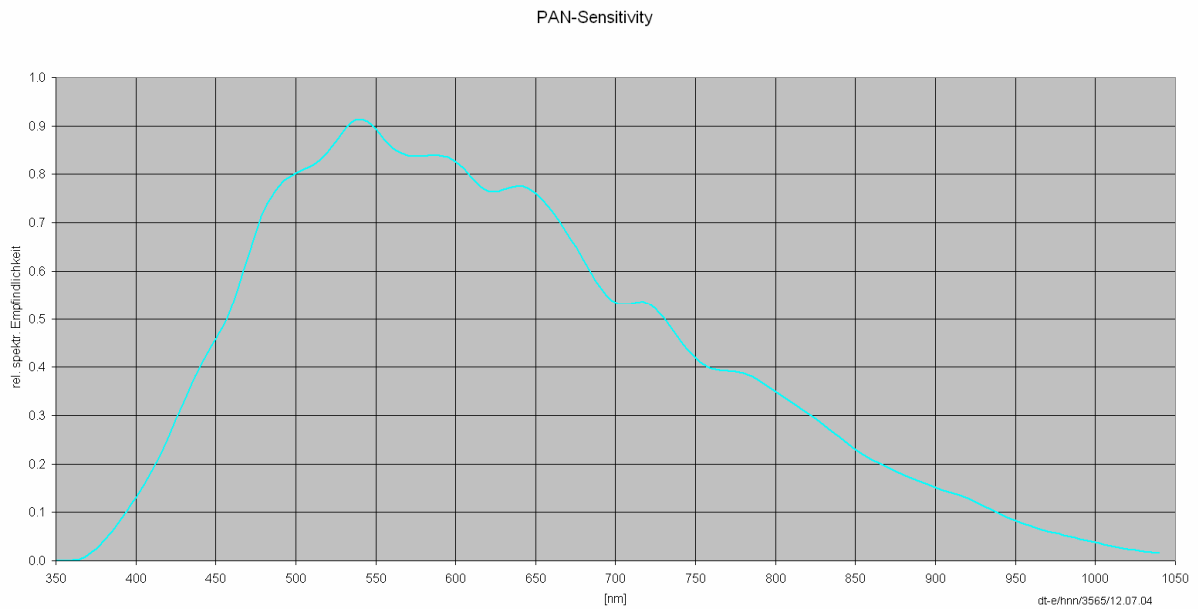
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

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

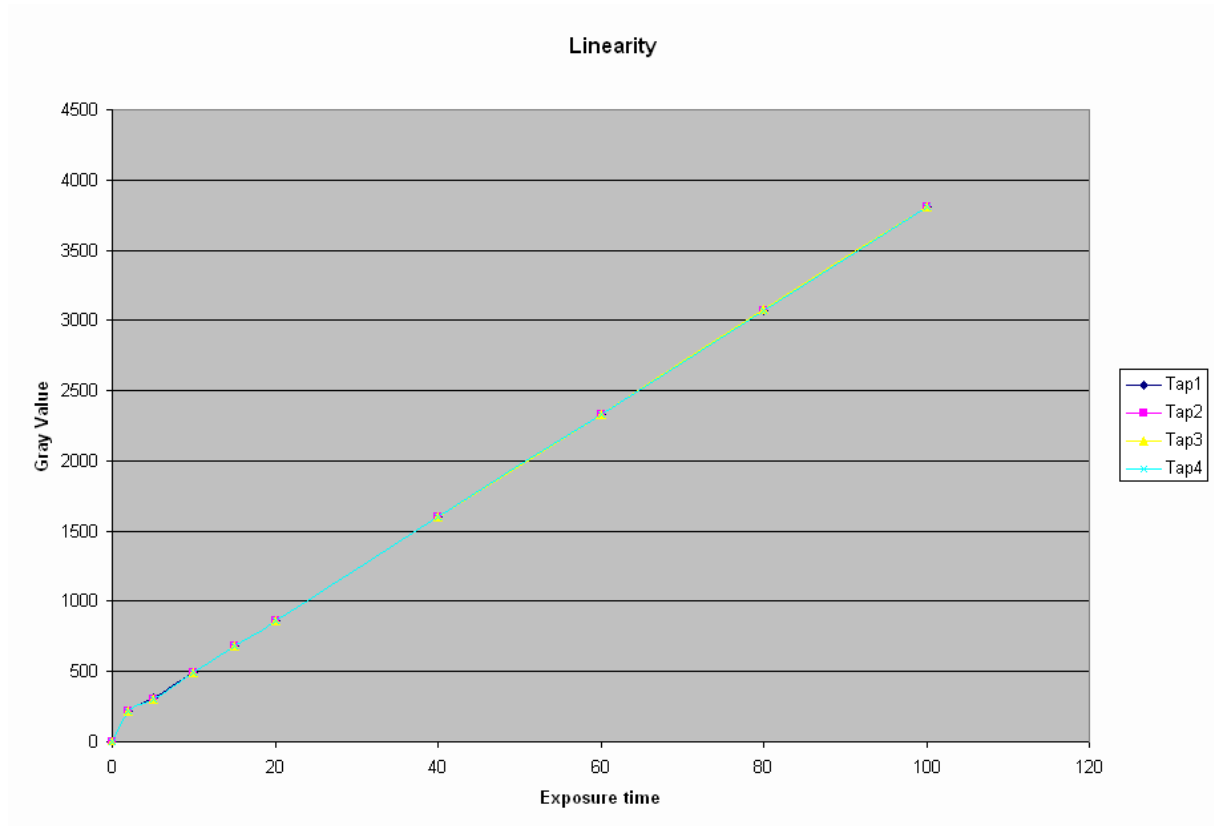
Sensitivity of camera



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".

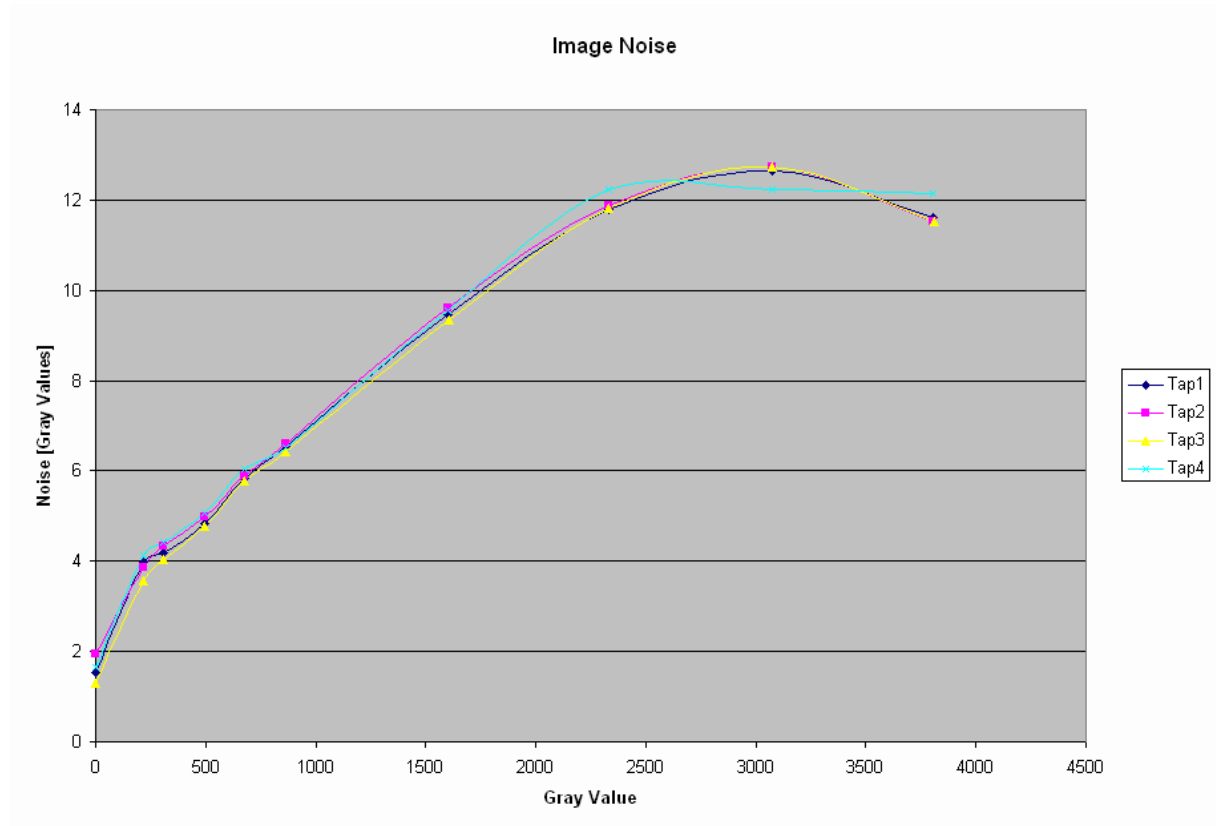
Sensor Linearity



Remark:

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

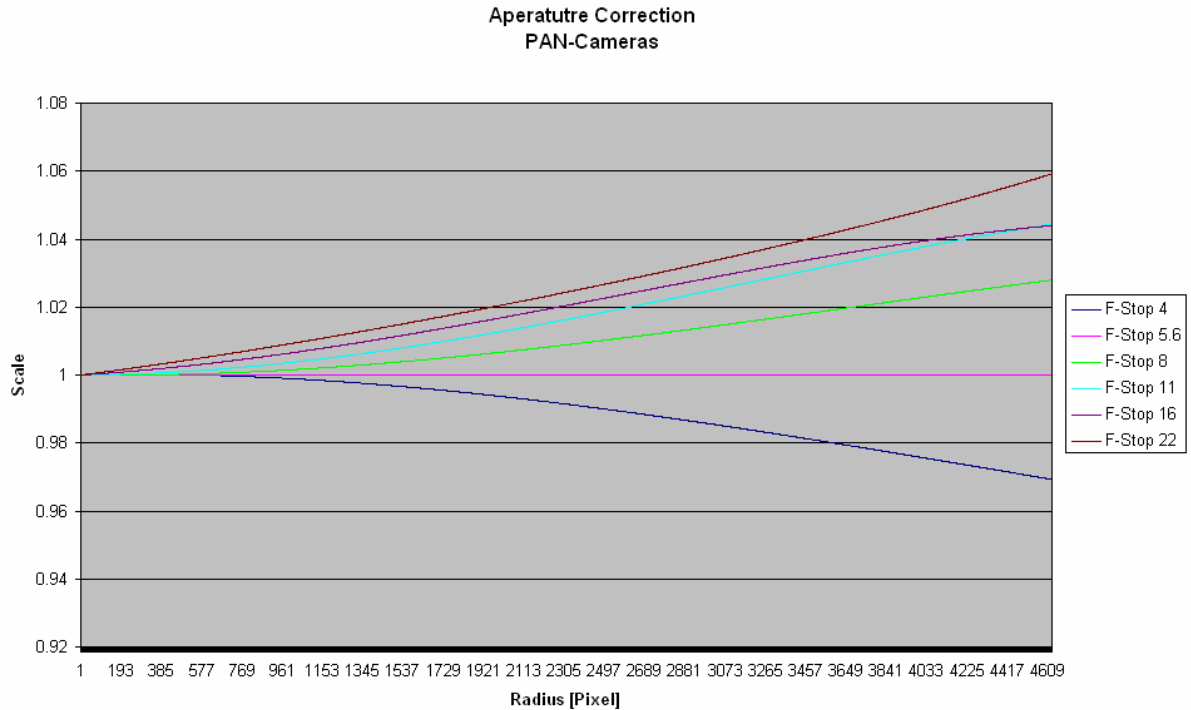
Sensor Noise



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
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Calibration Protocol DMC01 - 0053



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

02.Jul.2007

Division Head


(H. Sohnle)

Person in Charge


(S. Schröder)

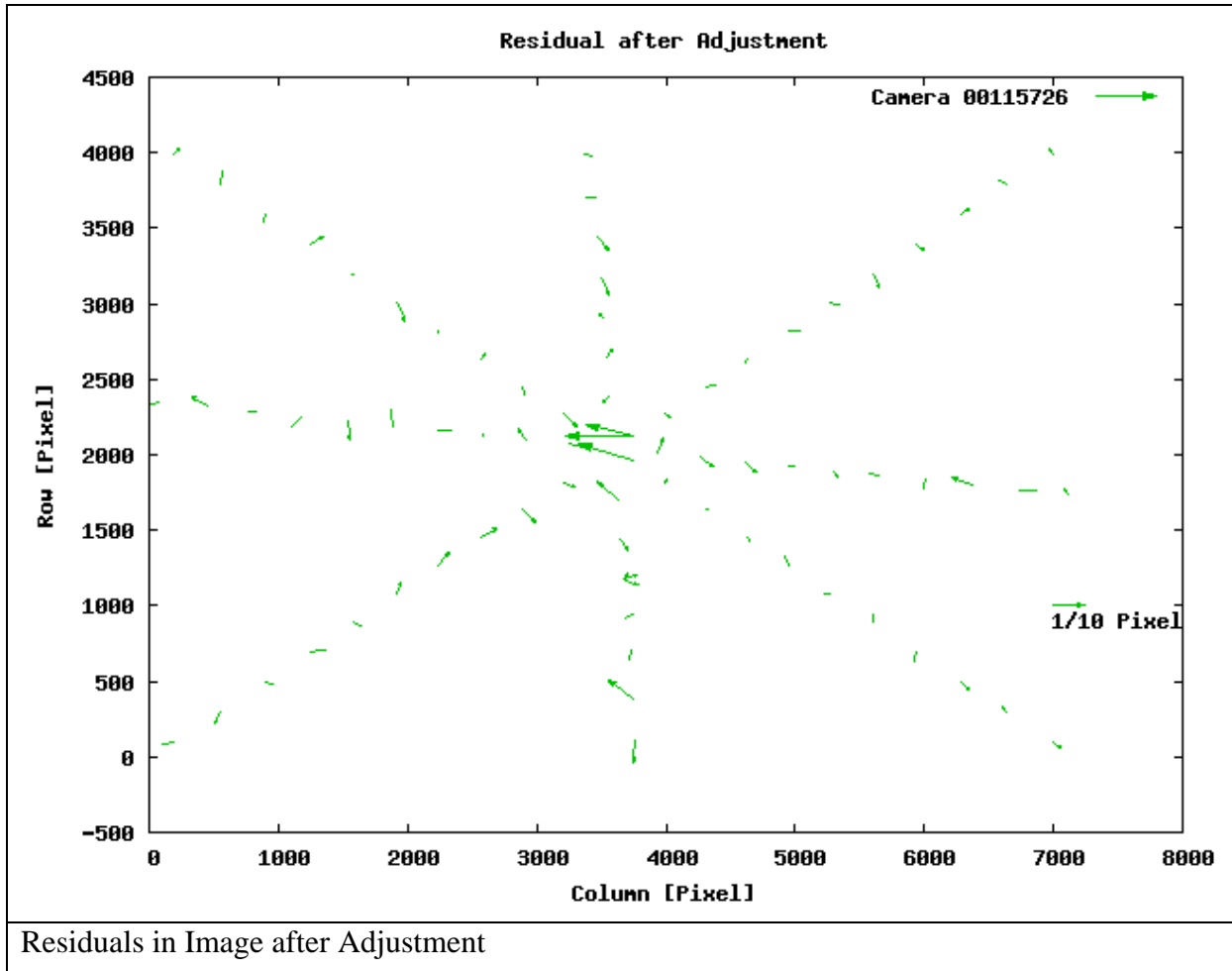
Geometric Calibration Protocol

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
Decentering 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]



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".

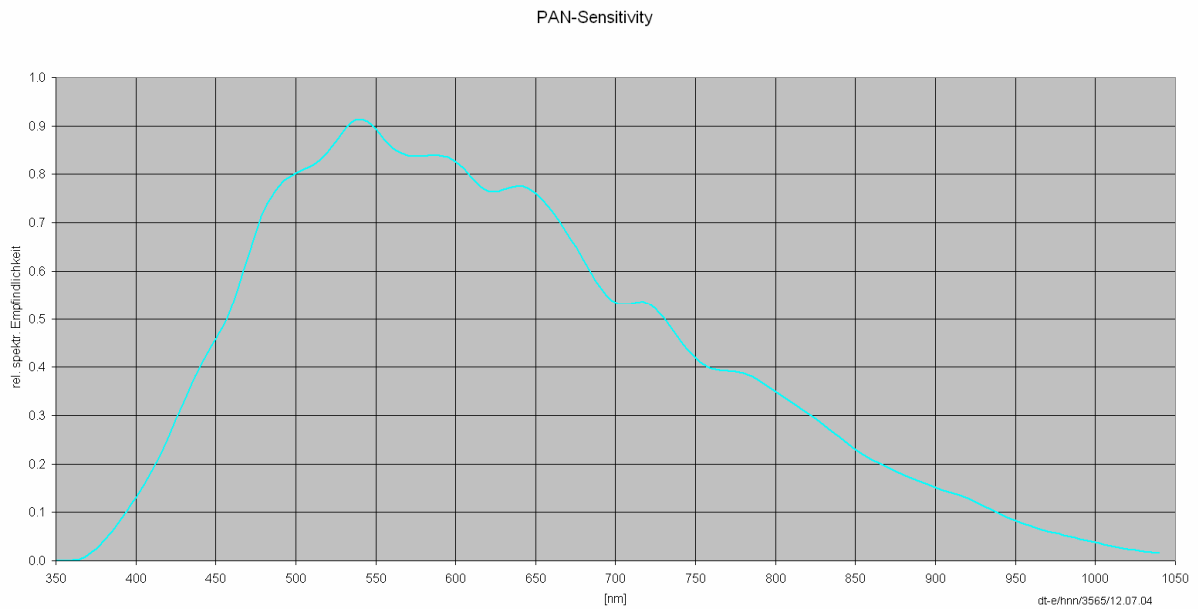
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

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

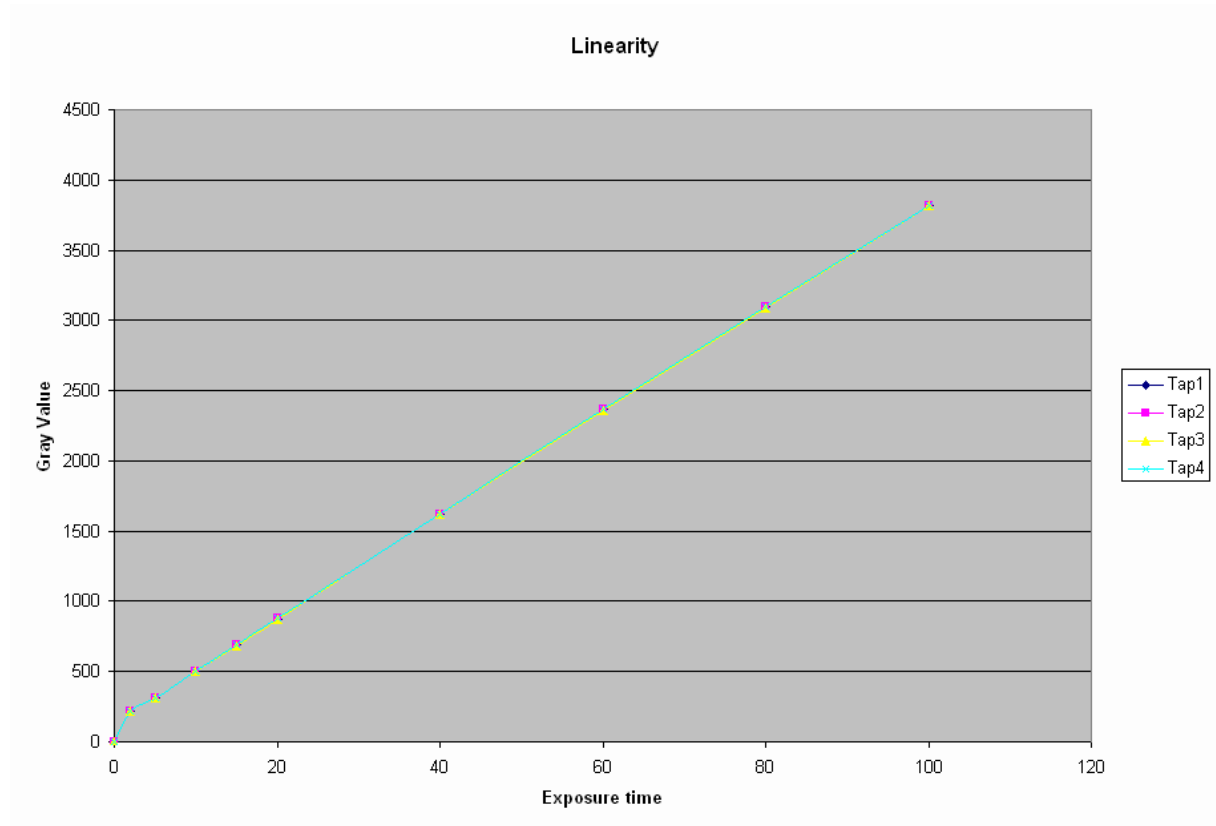
Sensitivity of camera



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".

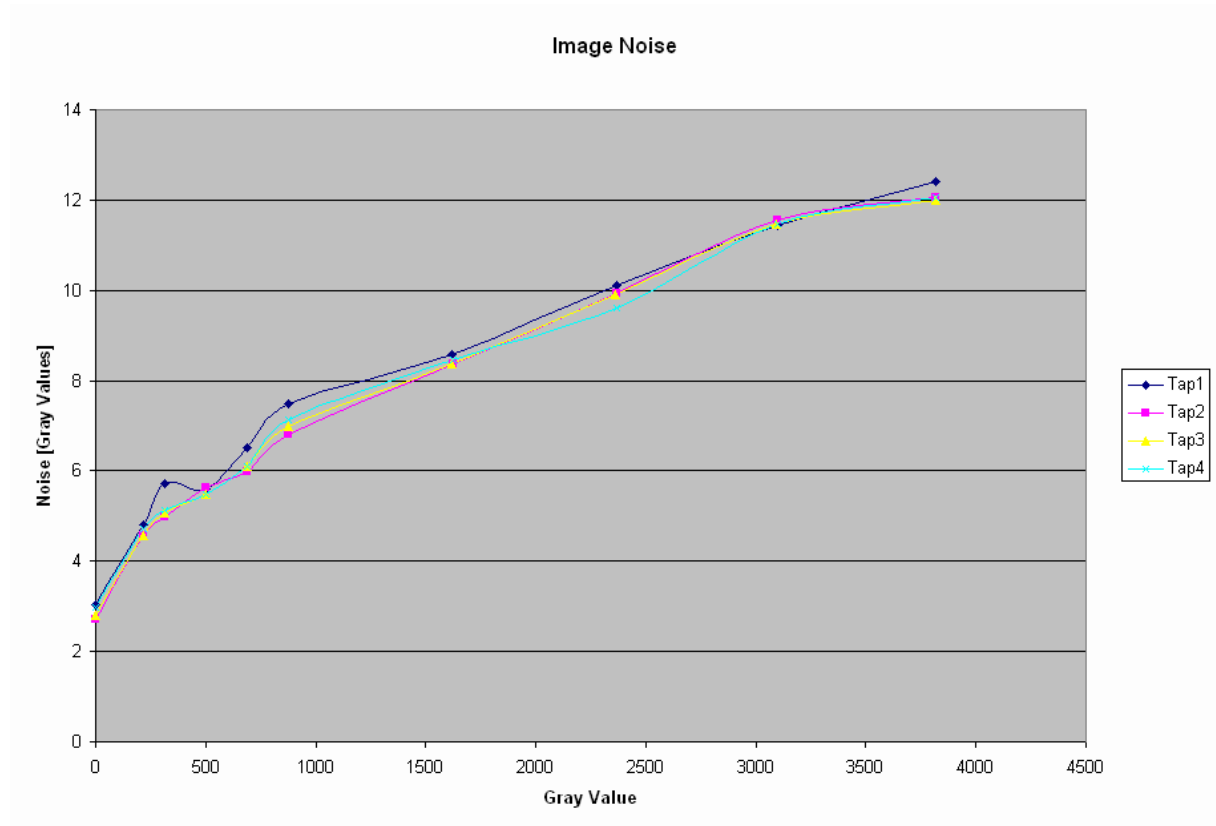
Sensor Linearity



Remark:

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

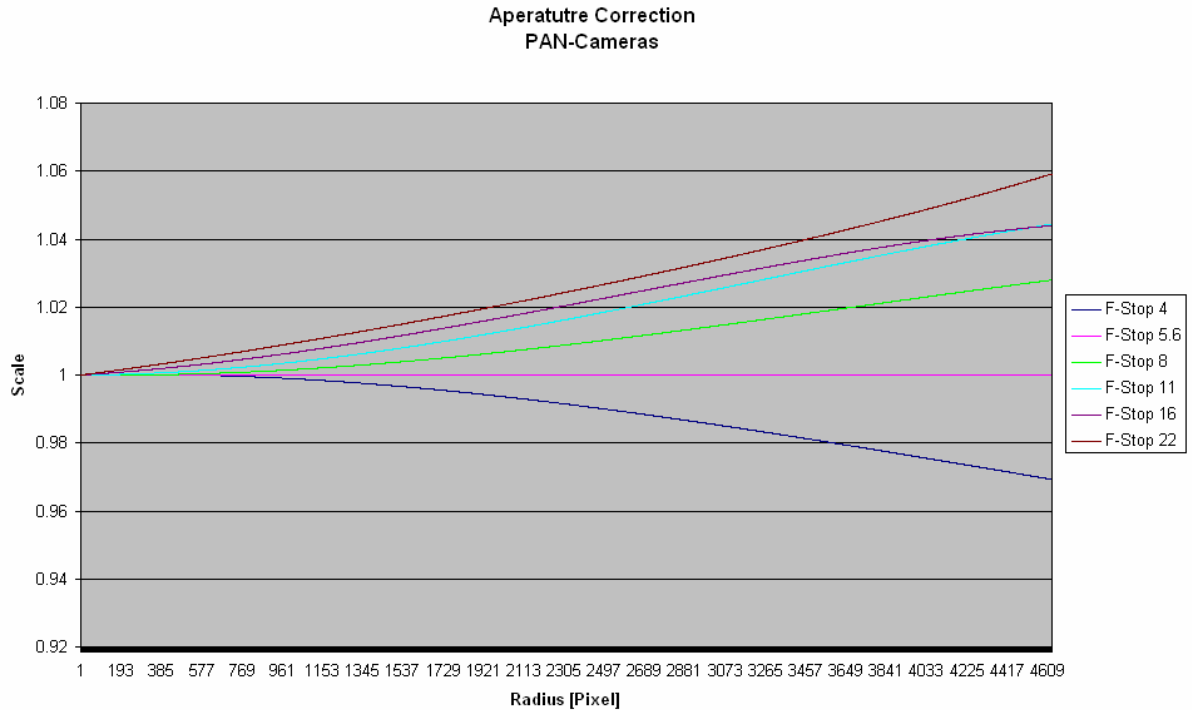
Sensor Noise



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
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Calibration Protocol DMC01 - 0053



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

02.Jul.2007

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

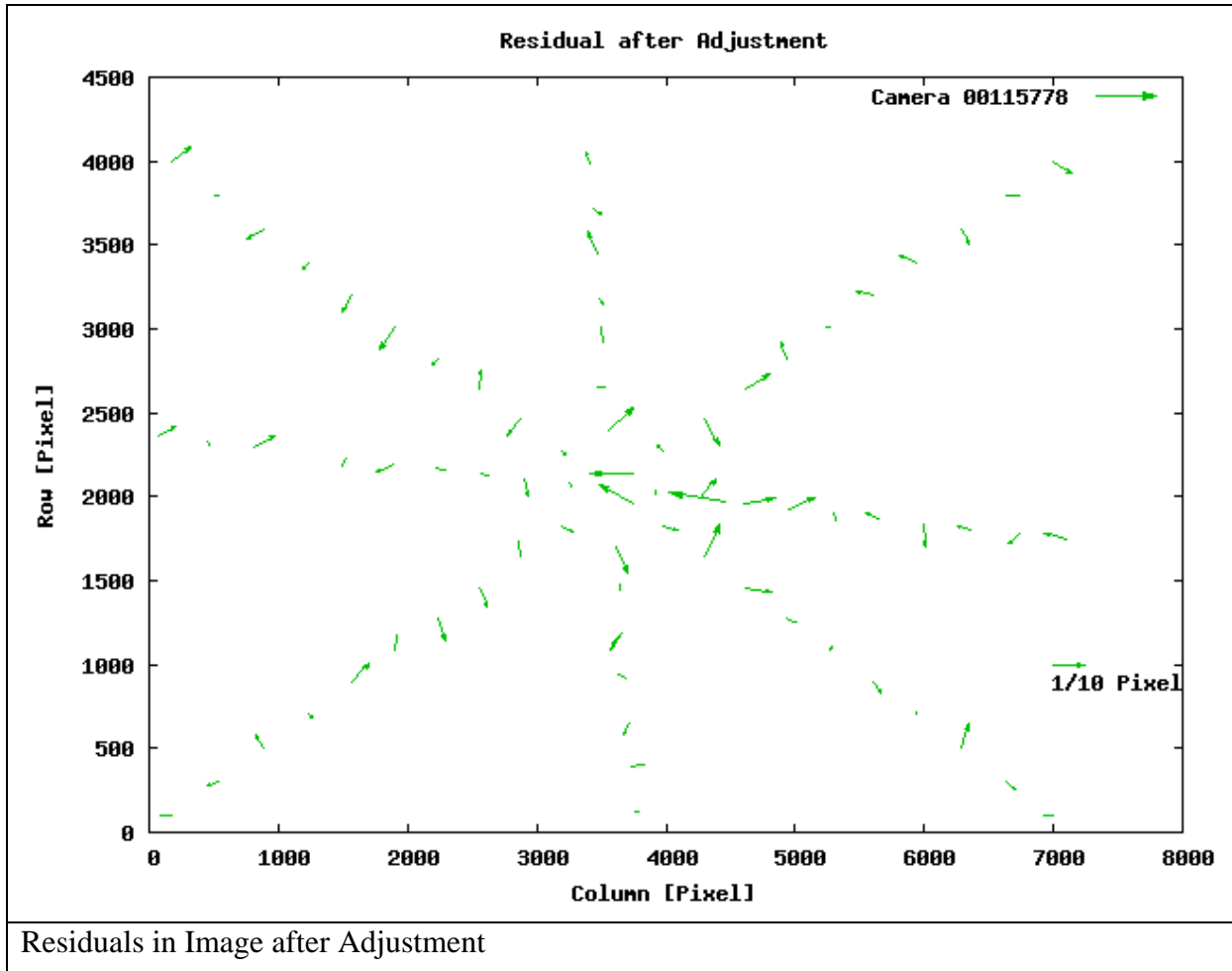
Geometric Calibration Protocol

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
Decentering 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]



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".

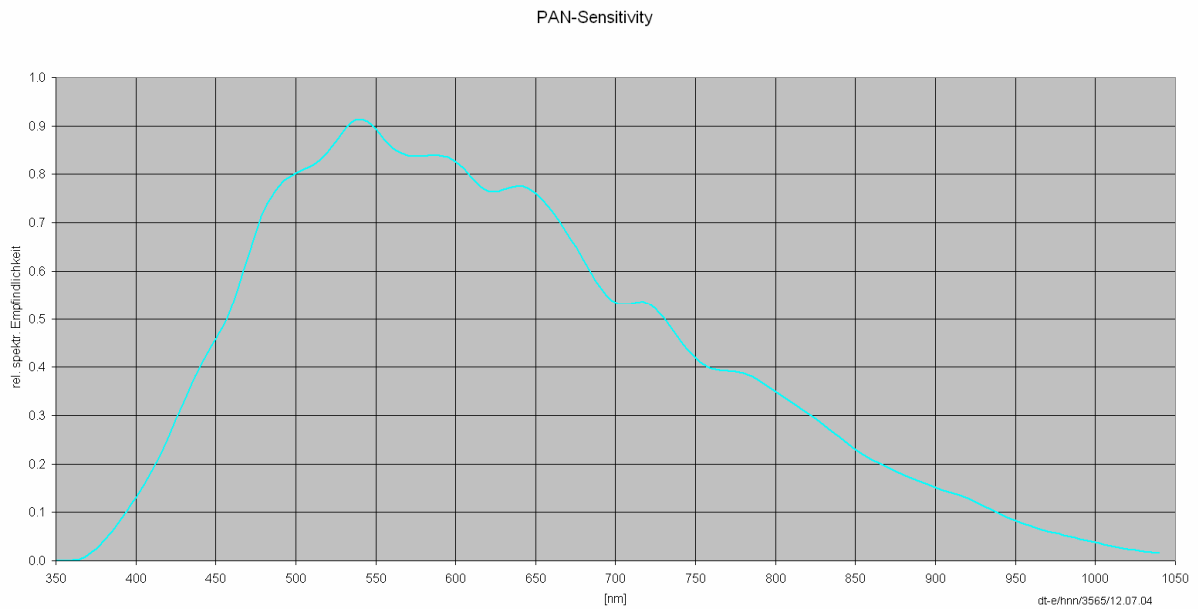
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

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

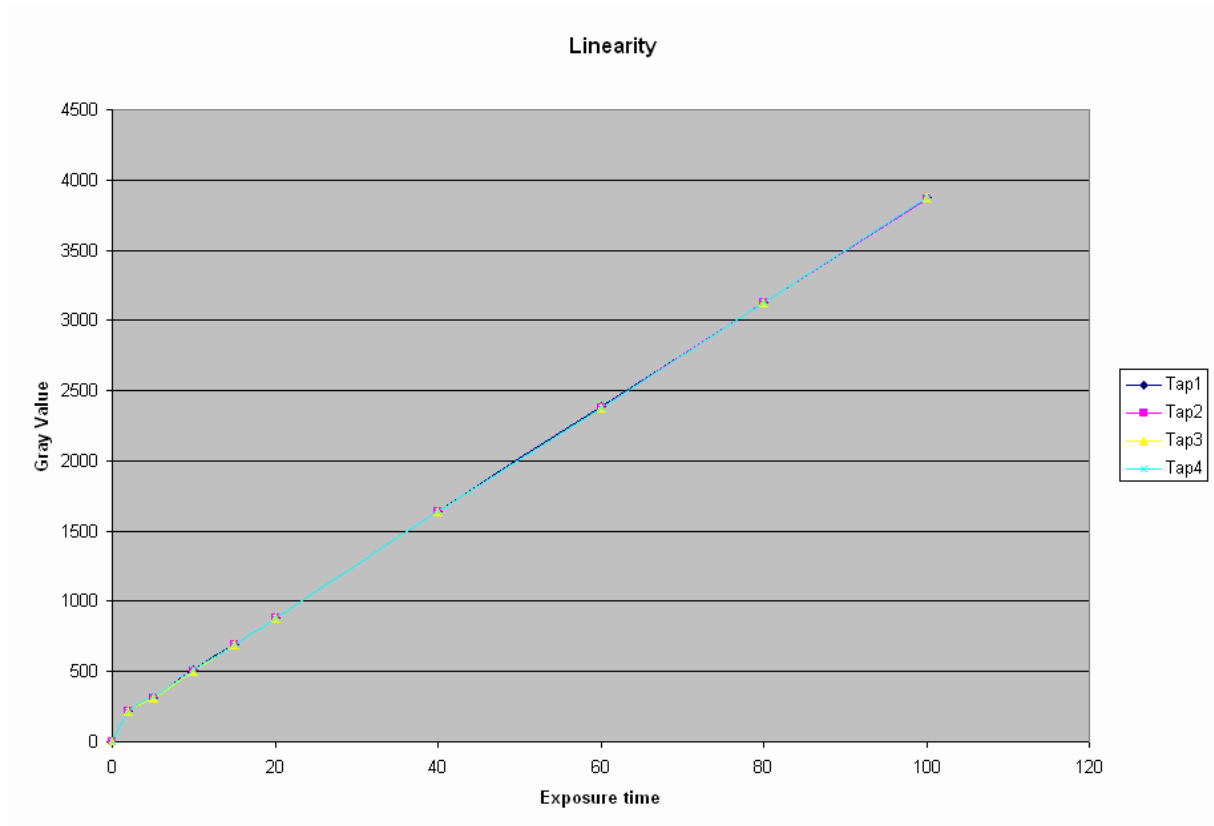
Sensitivity of camera



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".

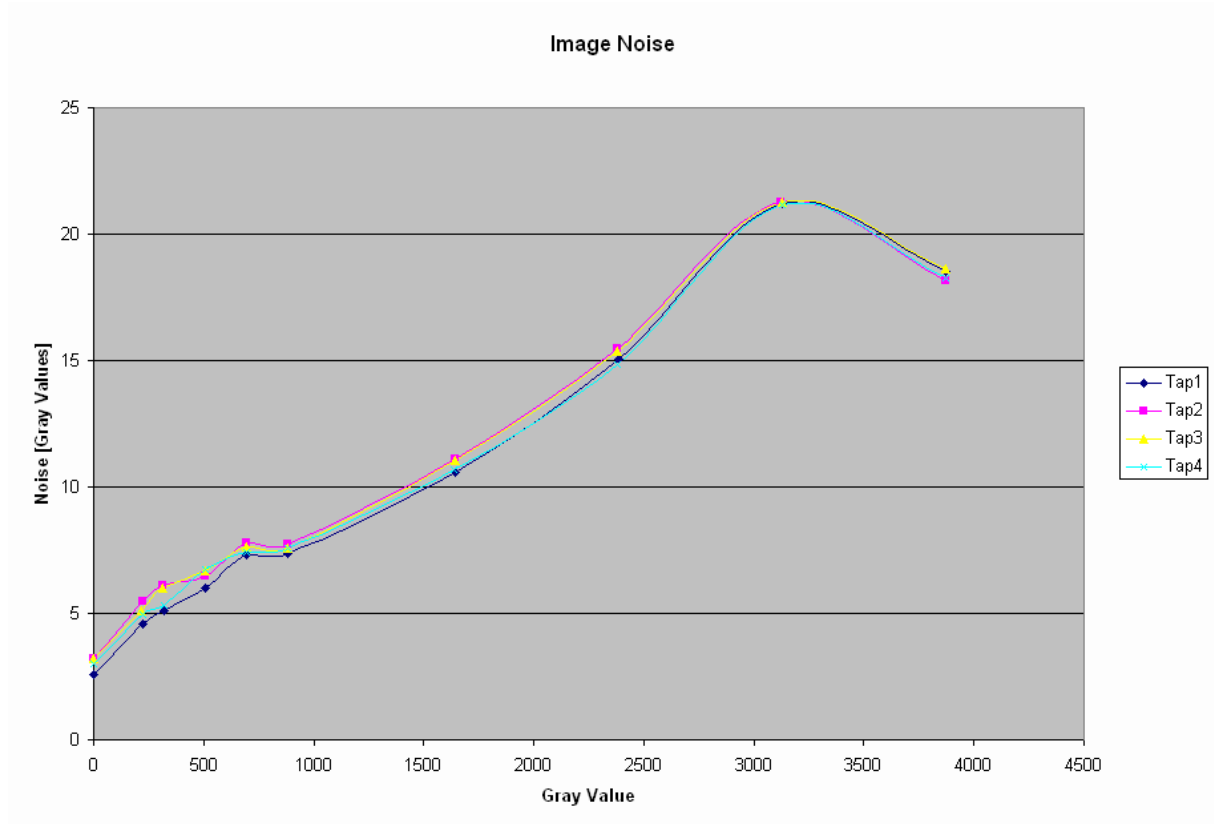
Sensor Linearity



Remark:

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

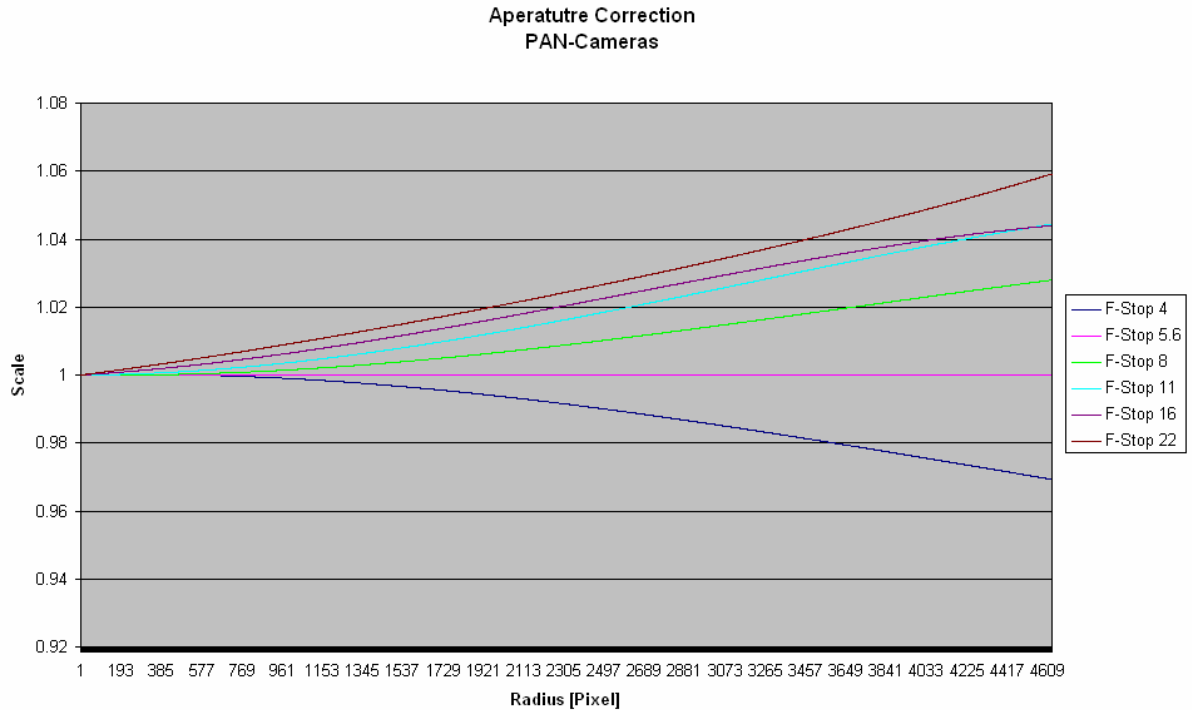
Sensor Noise



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
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Calibration Protocol DMC01 - 0053



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

02.Jul.2007

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

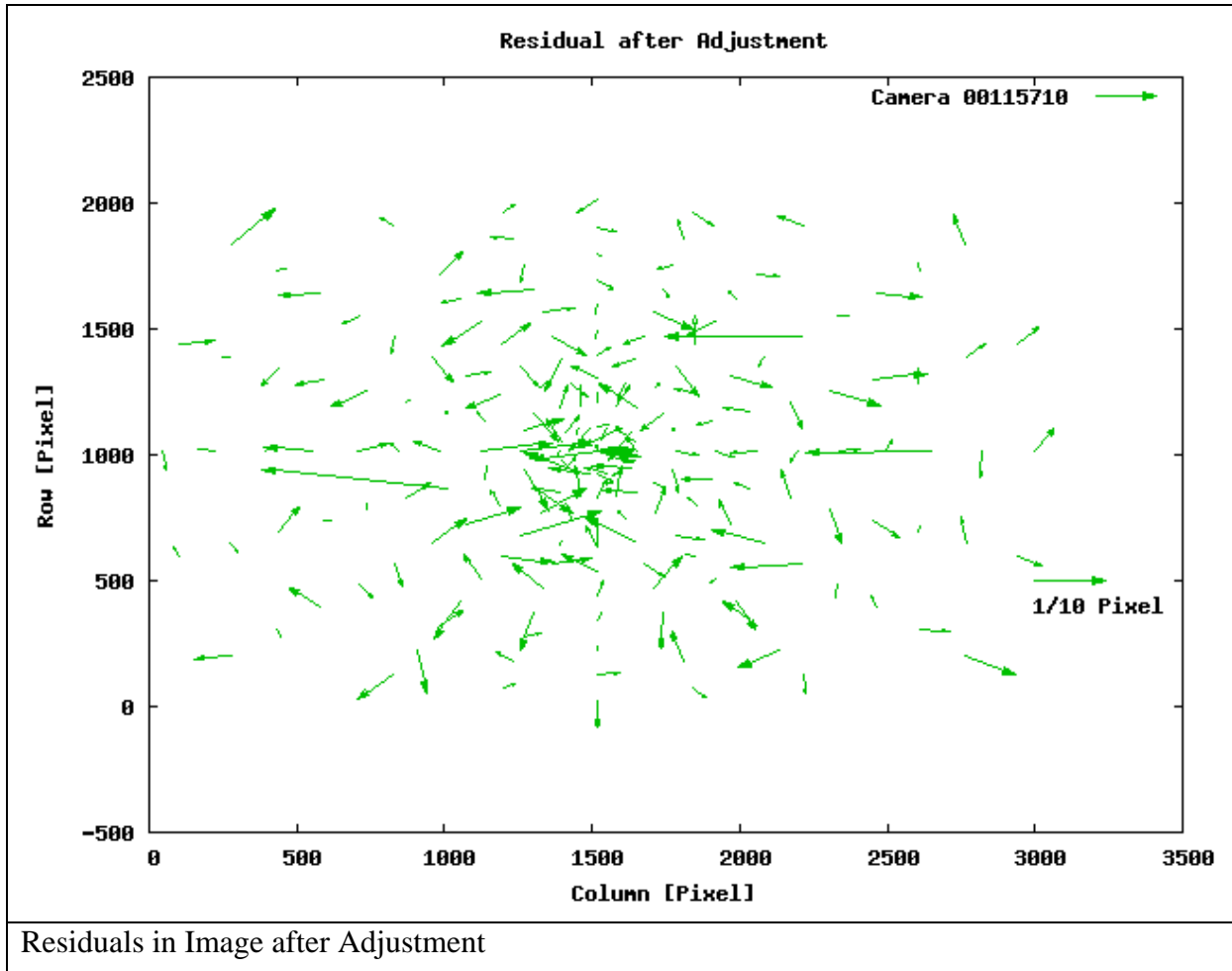
Geometric Calibration Protocol

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
Decentering 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]



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".

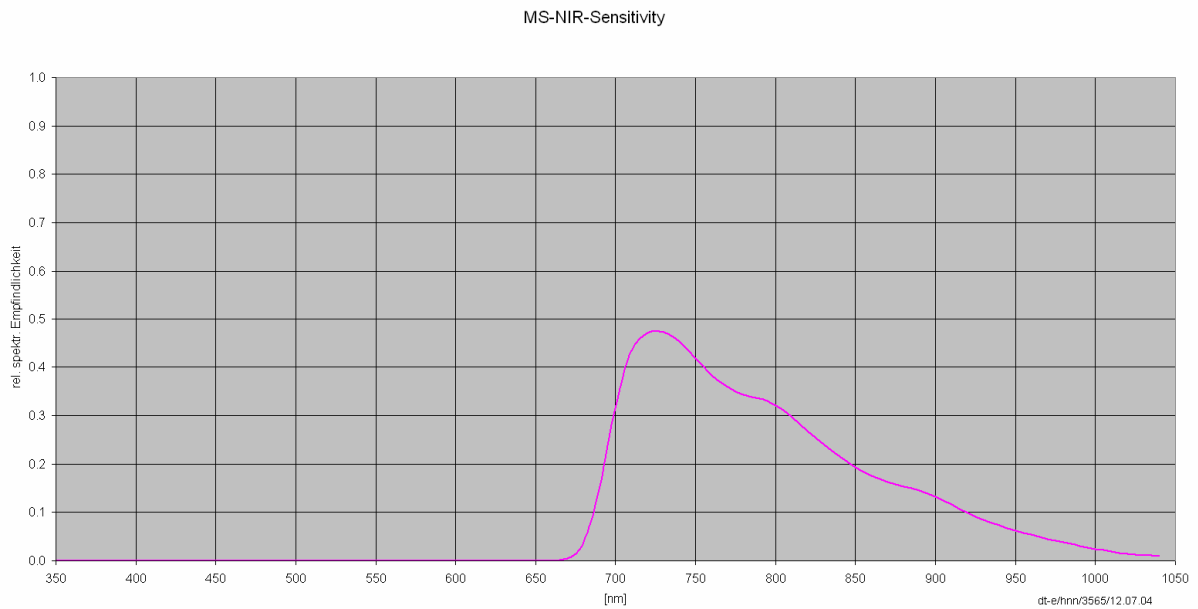
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

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

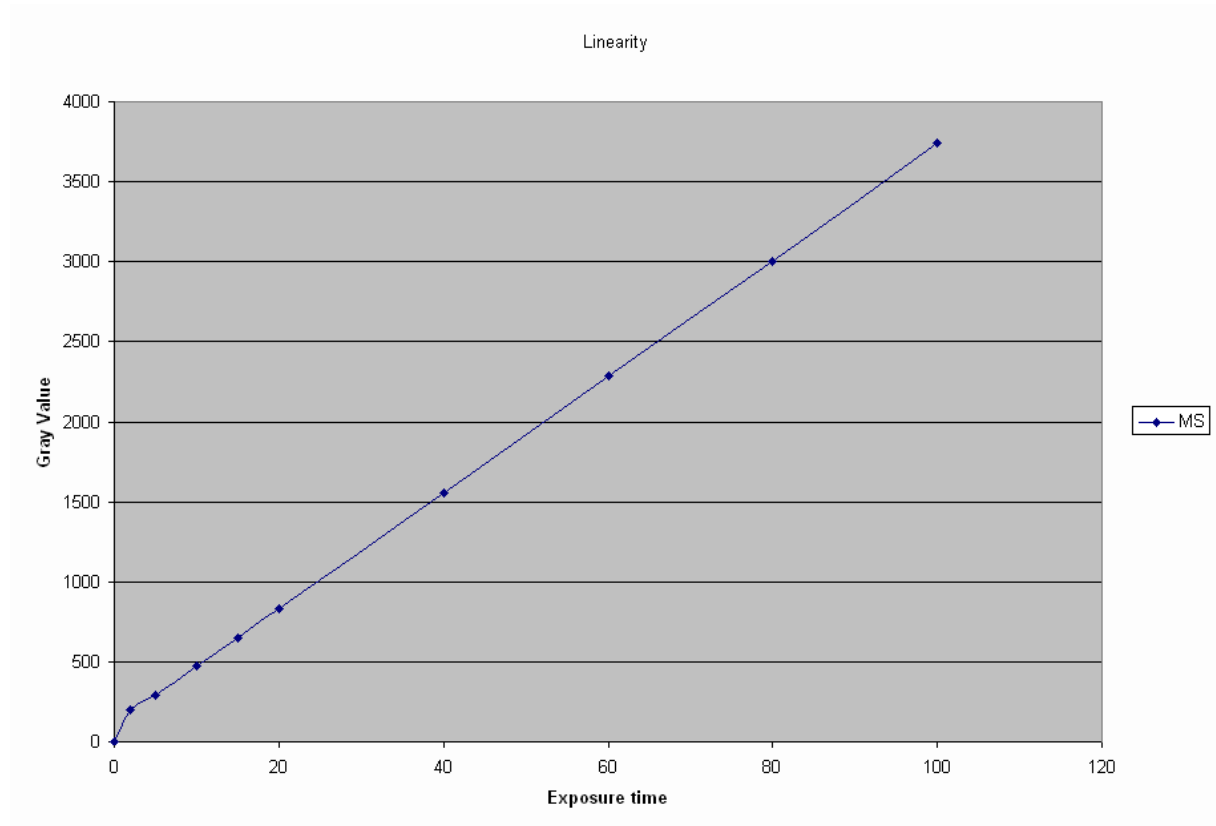
Sensitivity of camera



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".

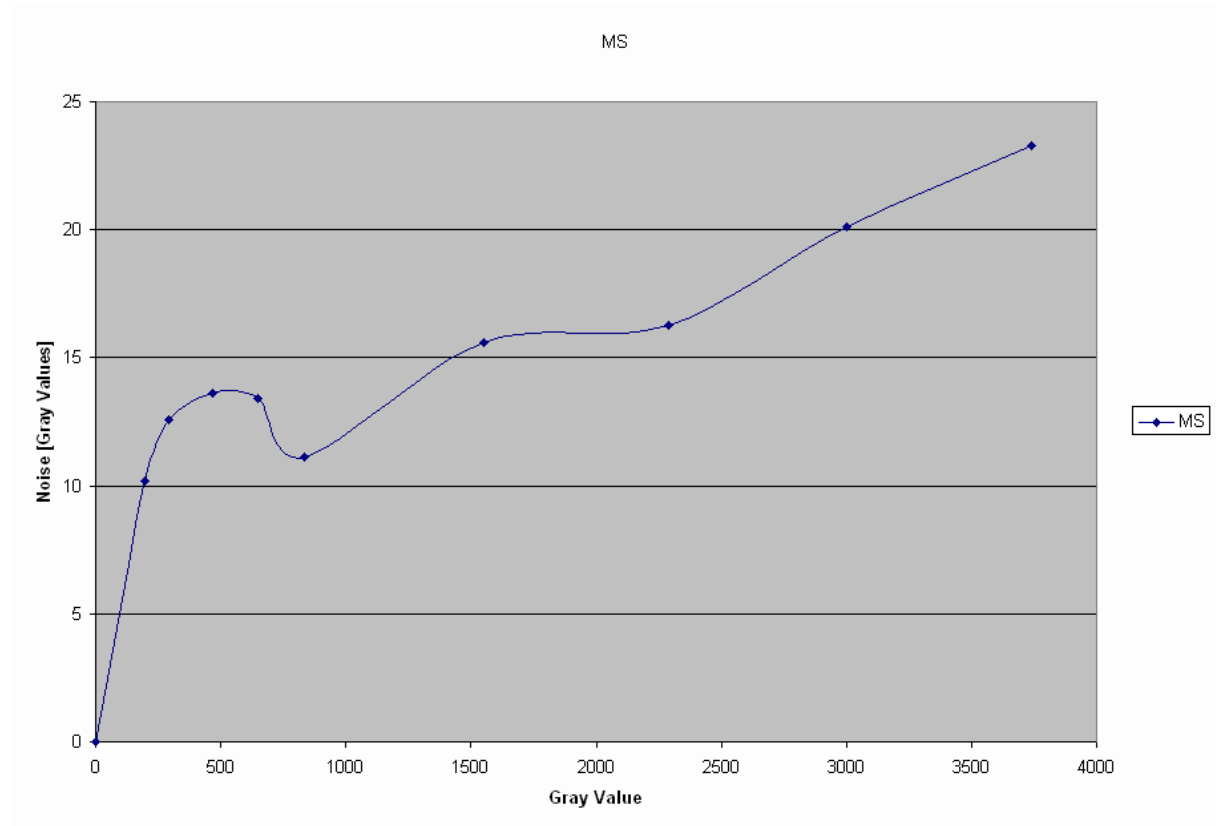
Sensor Linearity



Remark:

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

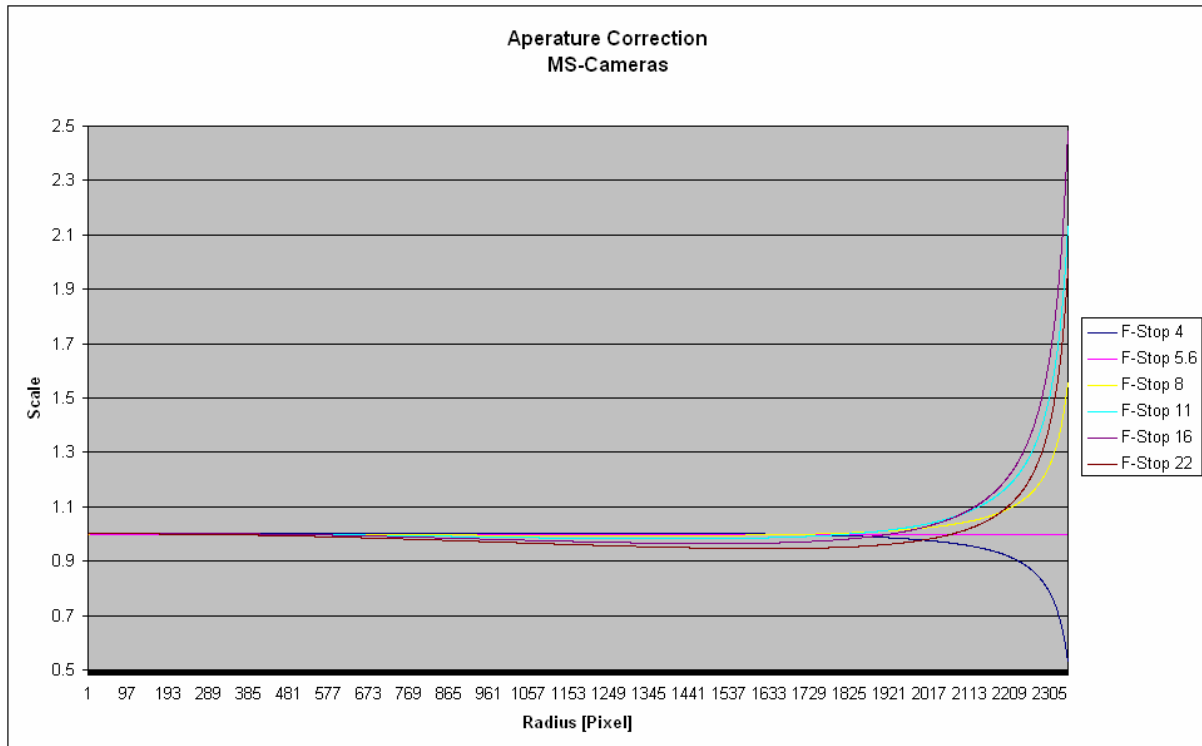
Sensor Noise



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

02.Jul.2007

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

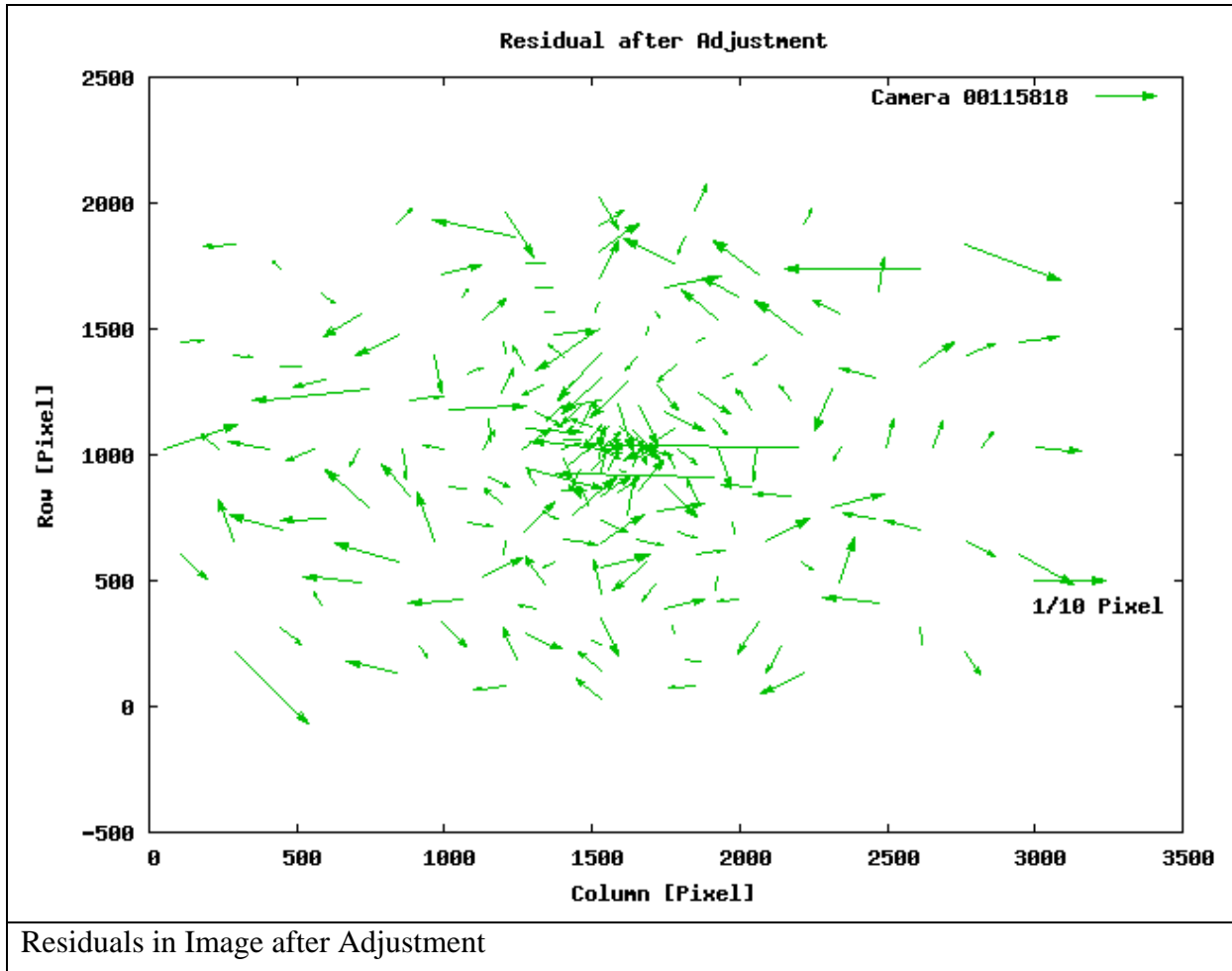
Geometric Calibration Protocol

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
Decentering 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]



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”.

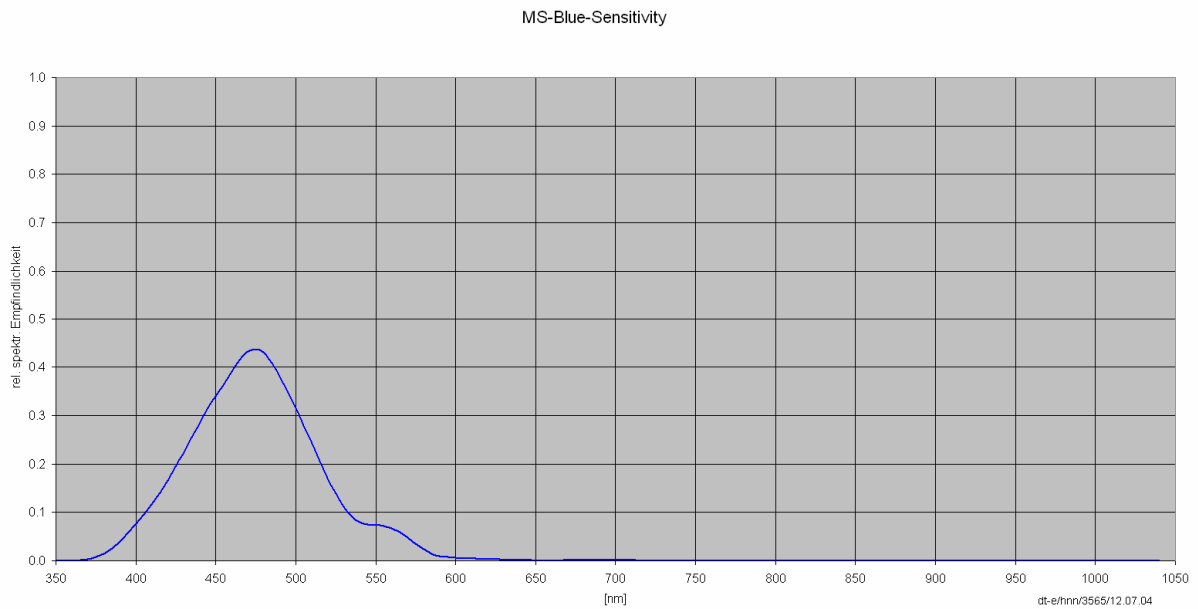
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

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

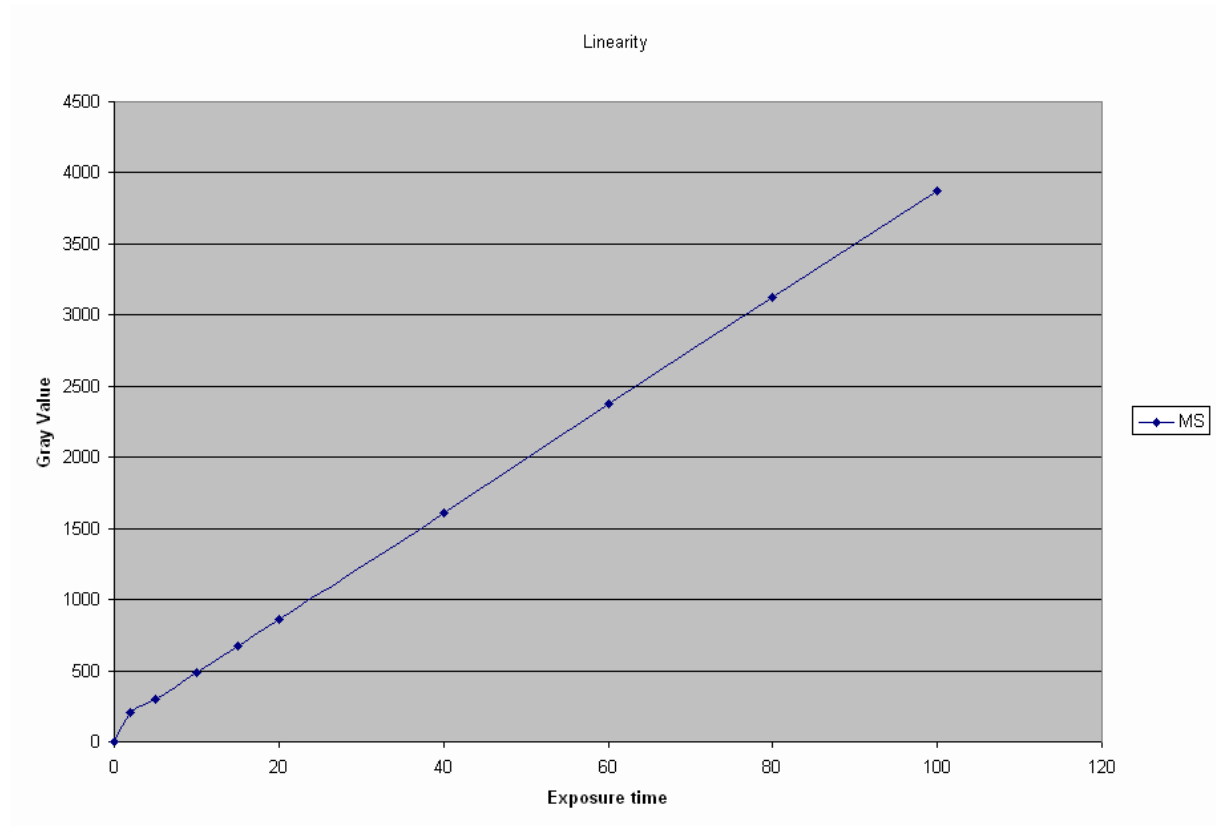
Sensitivity of camera



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".

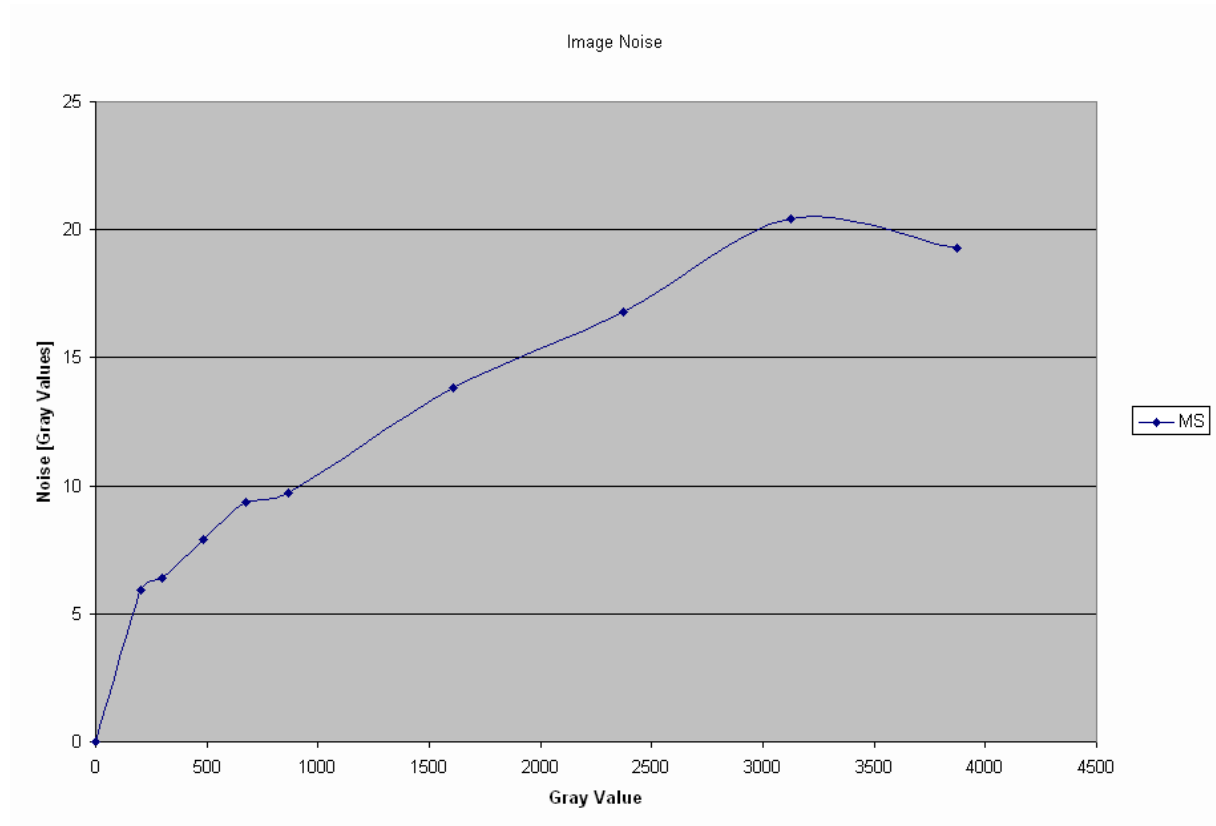
Sensor Linearity



Remark:

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

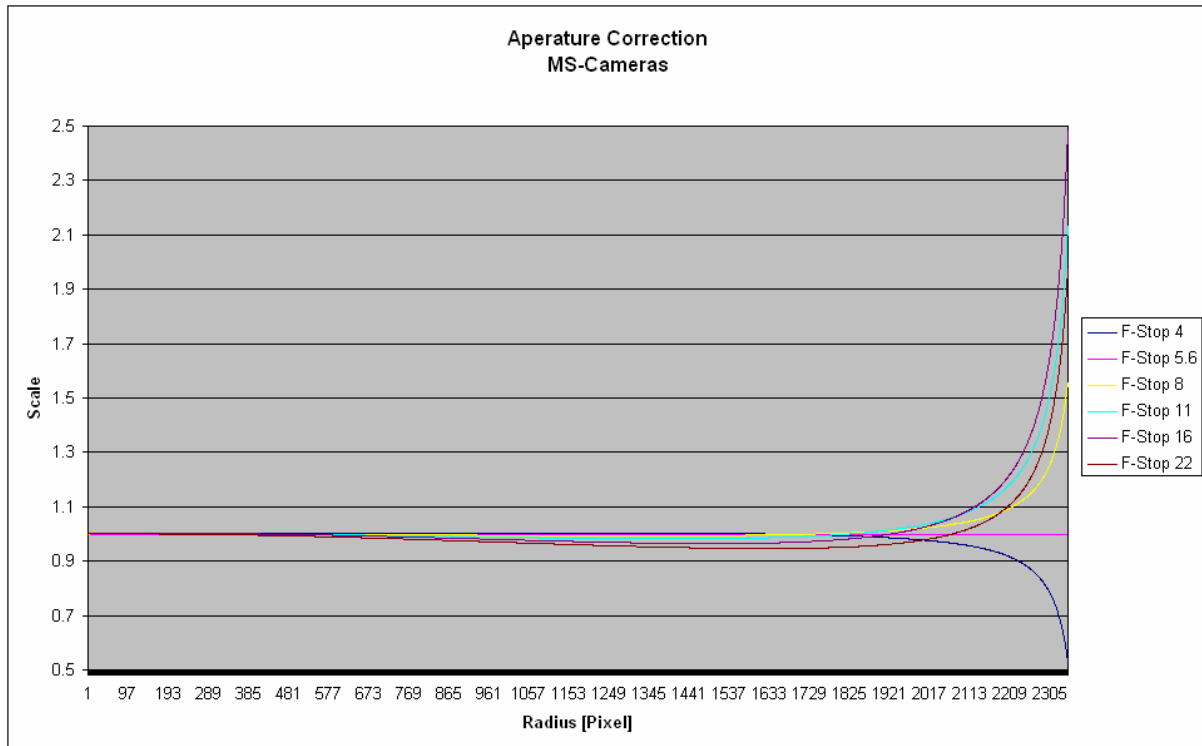
Sensor Noise



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

02.Jul.2007

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

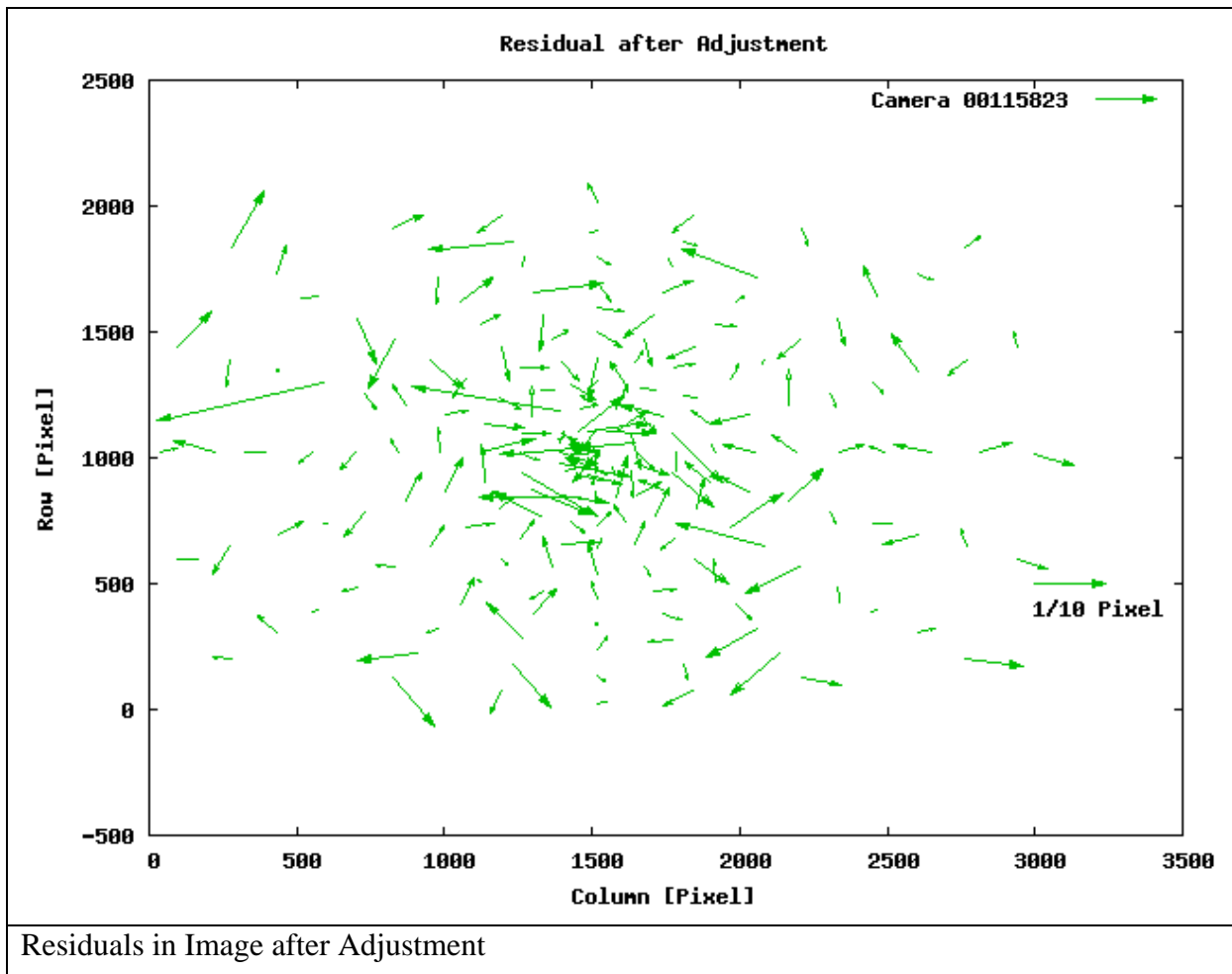
Geometric Calibration Protocol

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
Decentering 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]



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".

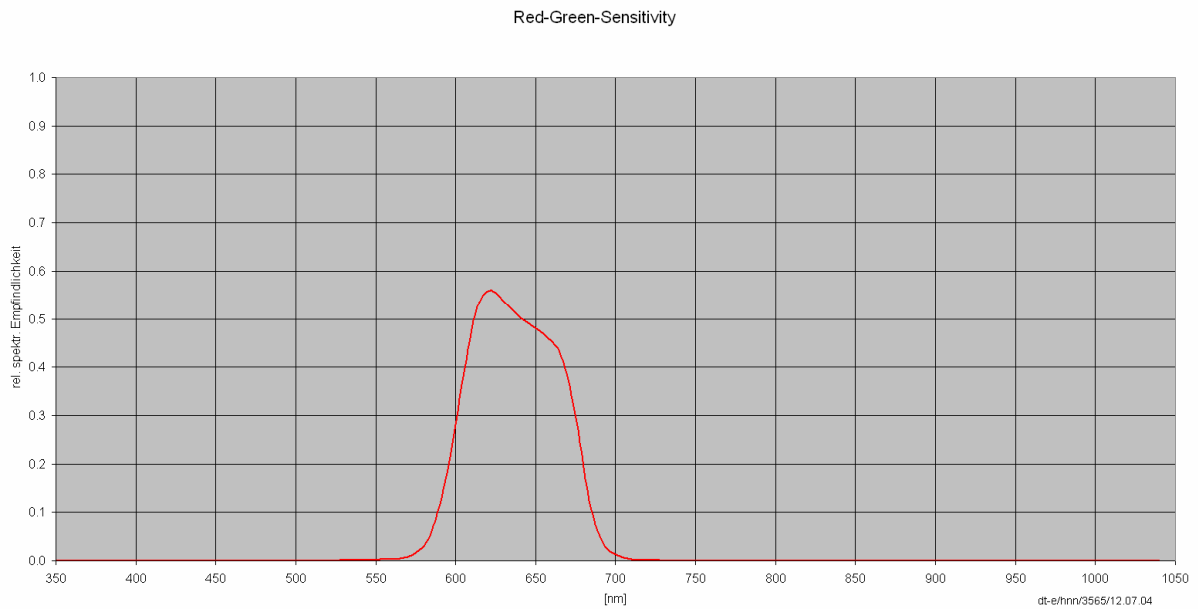
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

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

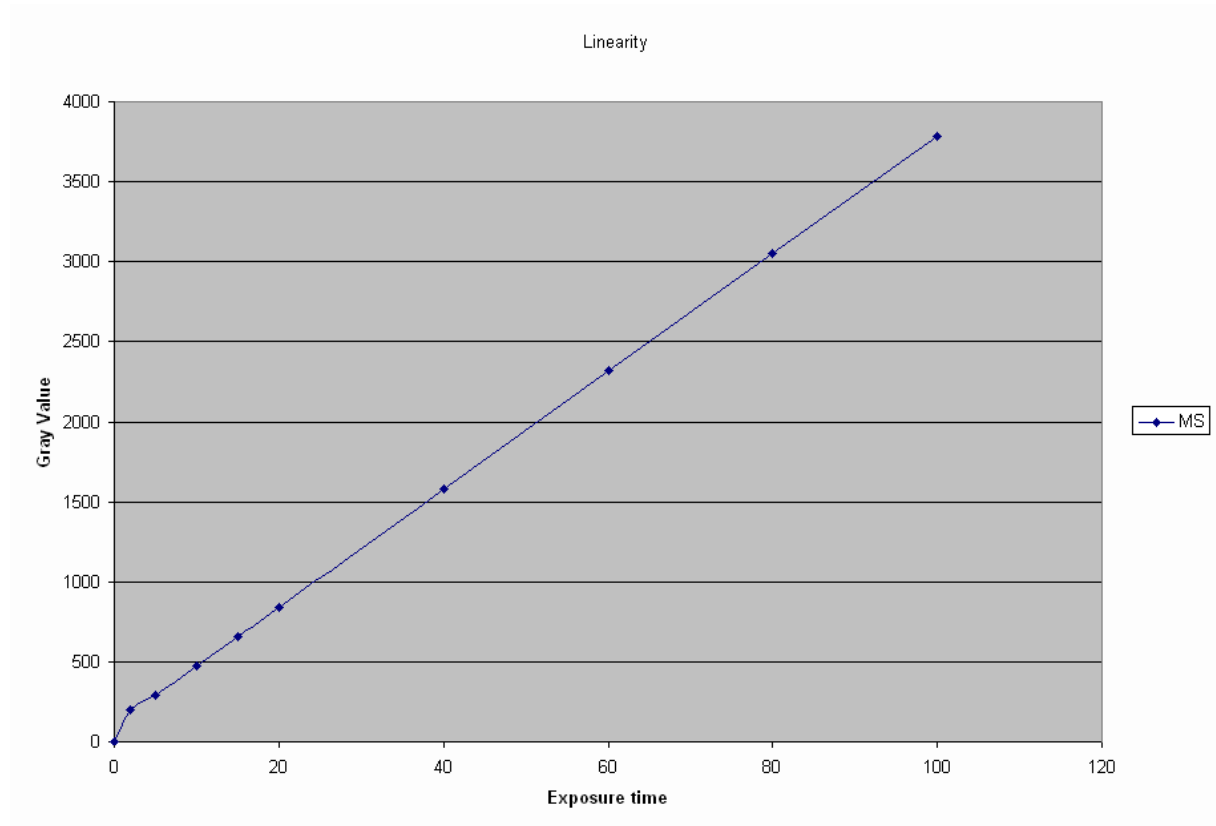
Sensitivity of camera



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".

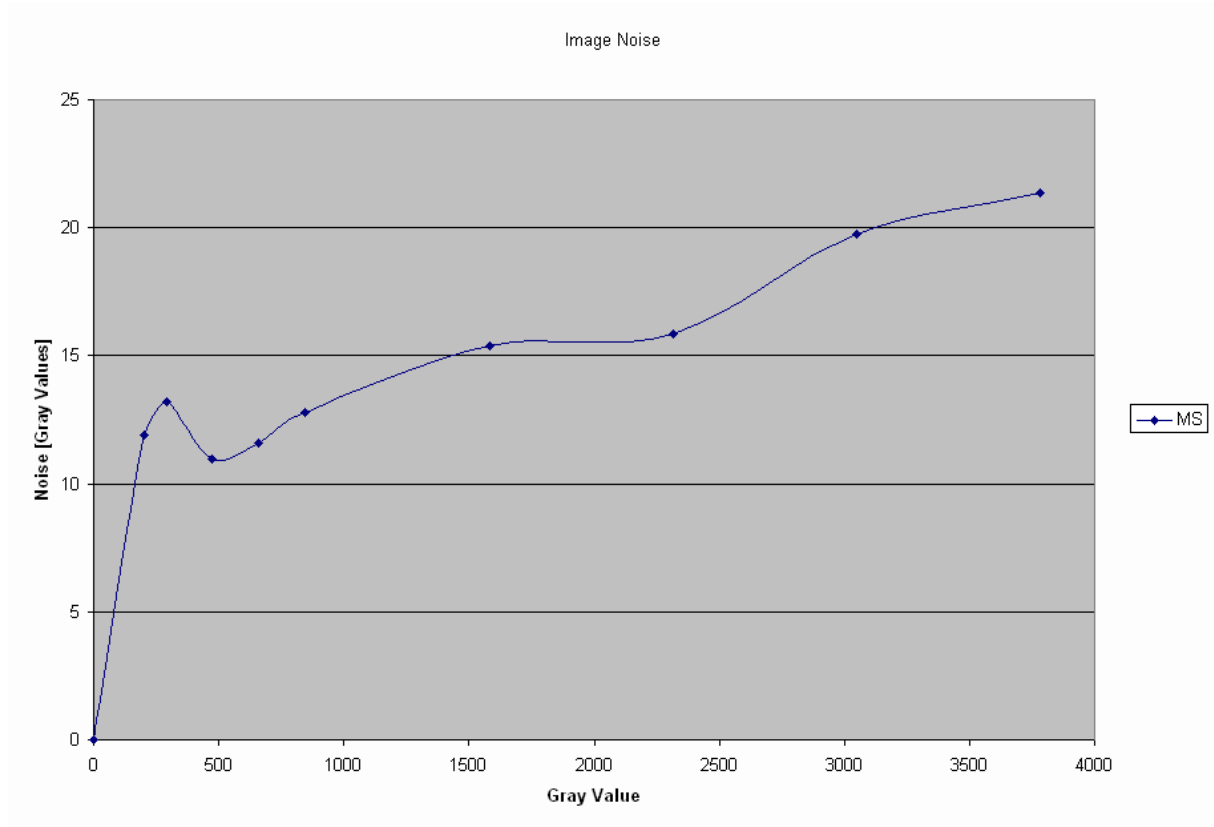
Sensor Linearity



Remark:

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

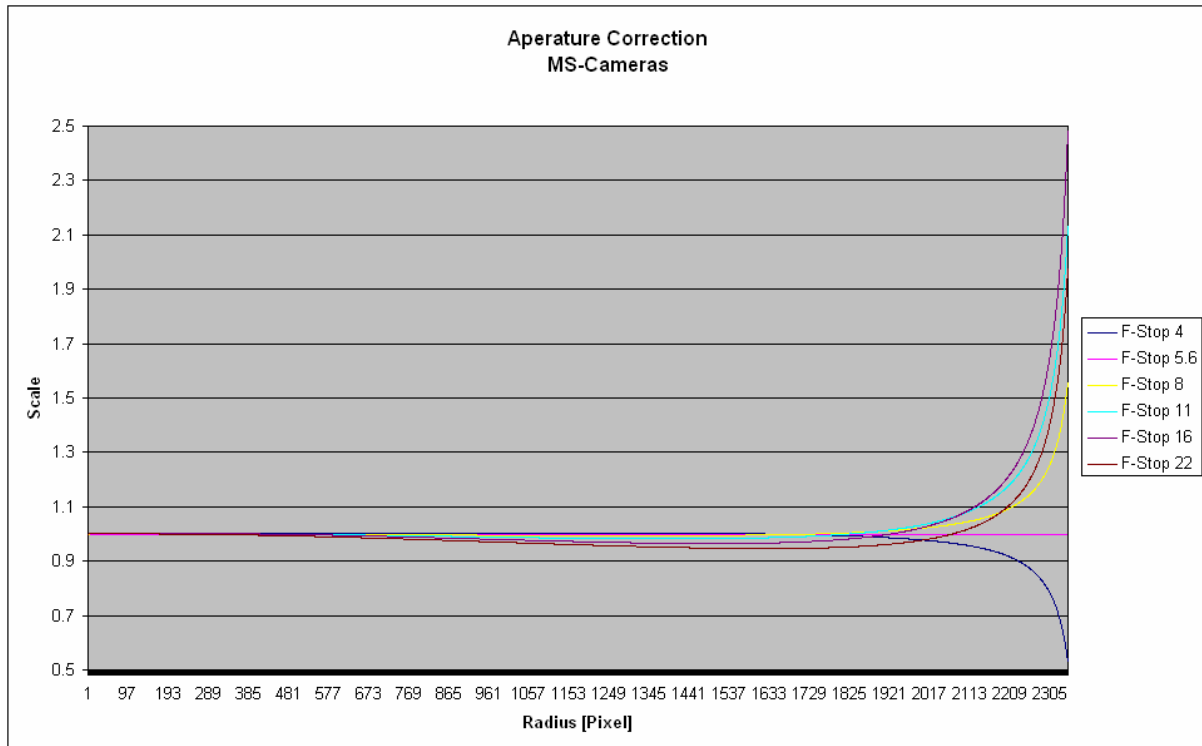
Sensor Noise



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

02.Jul.2007

Division Head


(H. Sohnle)

Person in Charge


(S. Schröder)

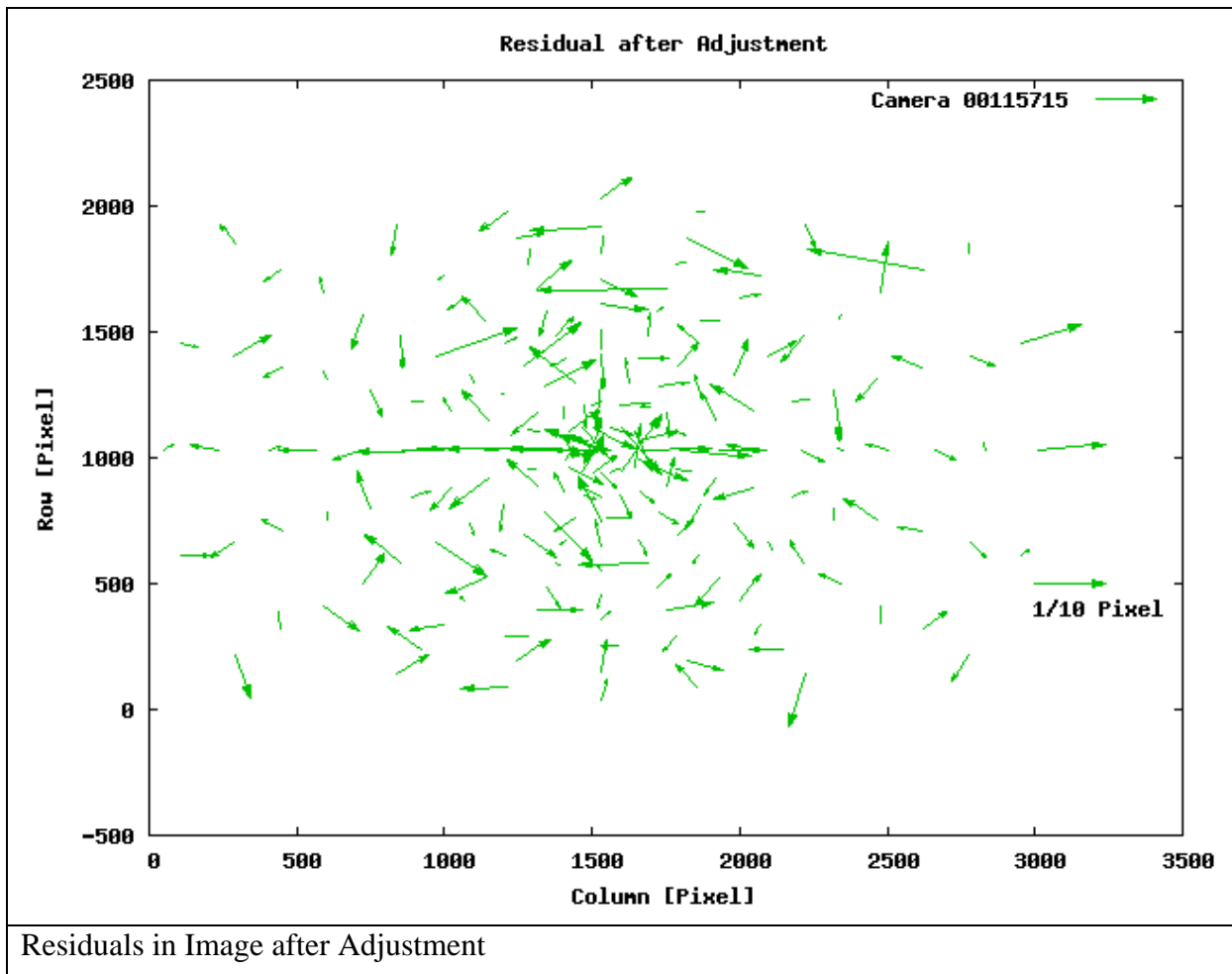
Geometric Calibration Protocol

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
Decentering 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]



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”.

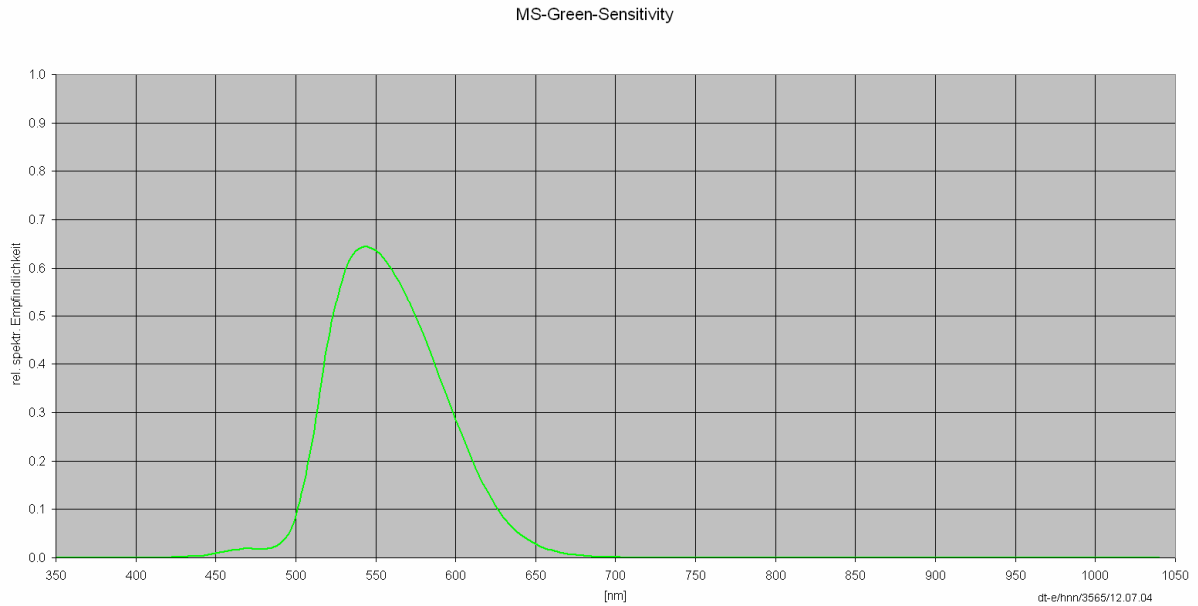
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

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

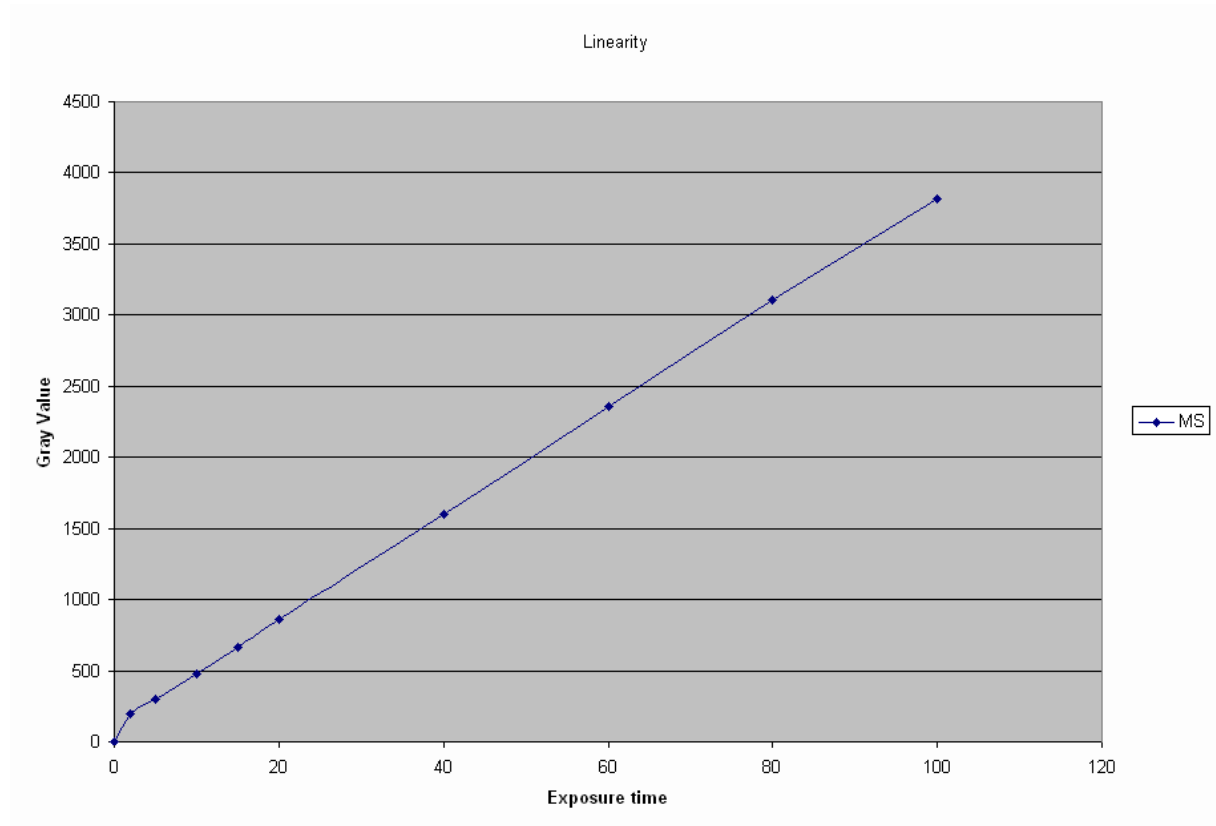
Sensitivity of camera



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".

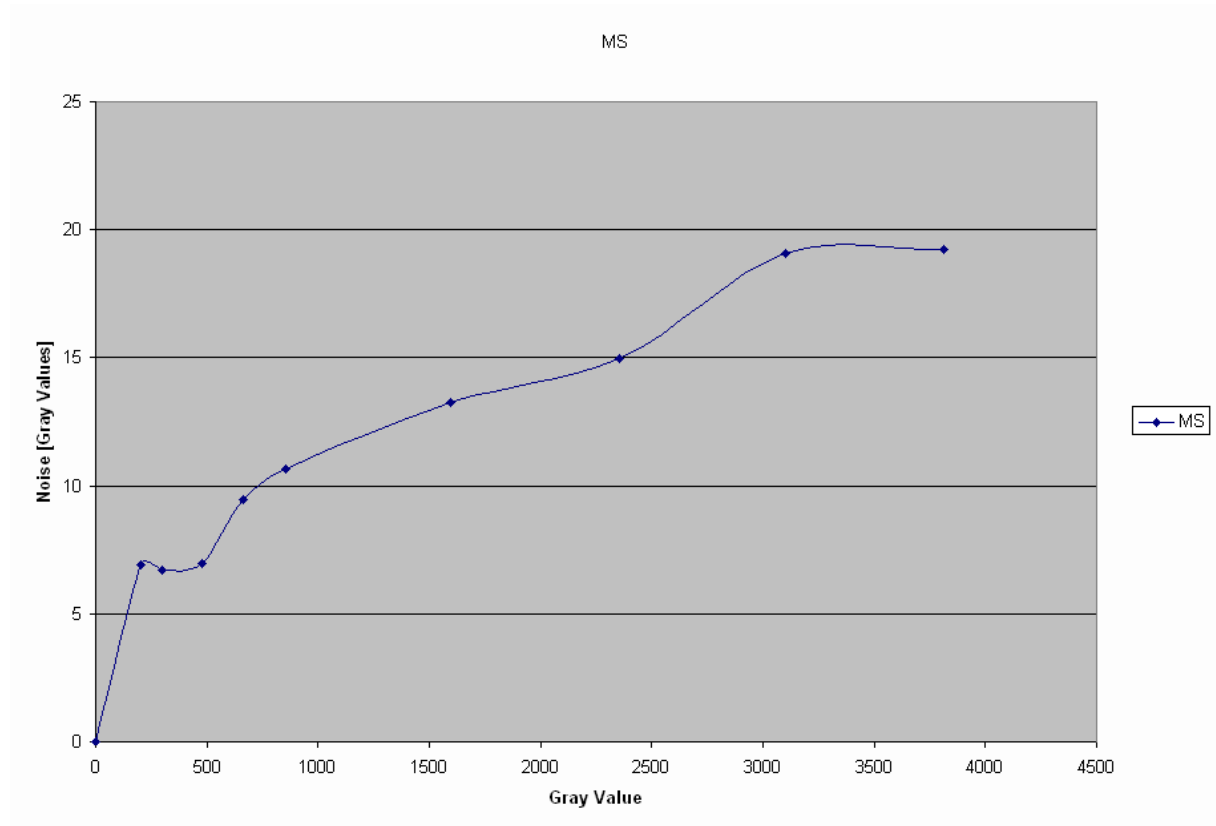
Sensor Linearity



Remark:

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

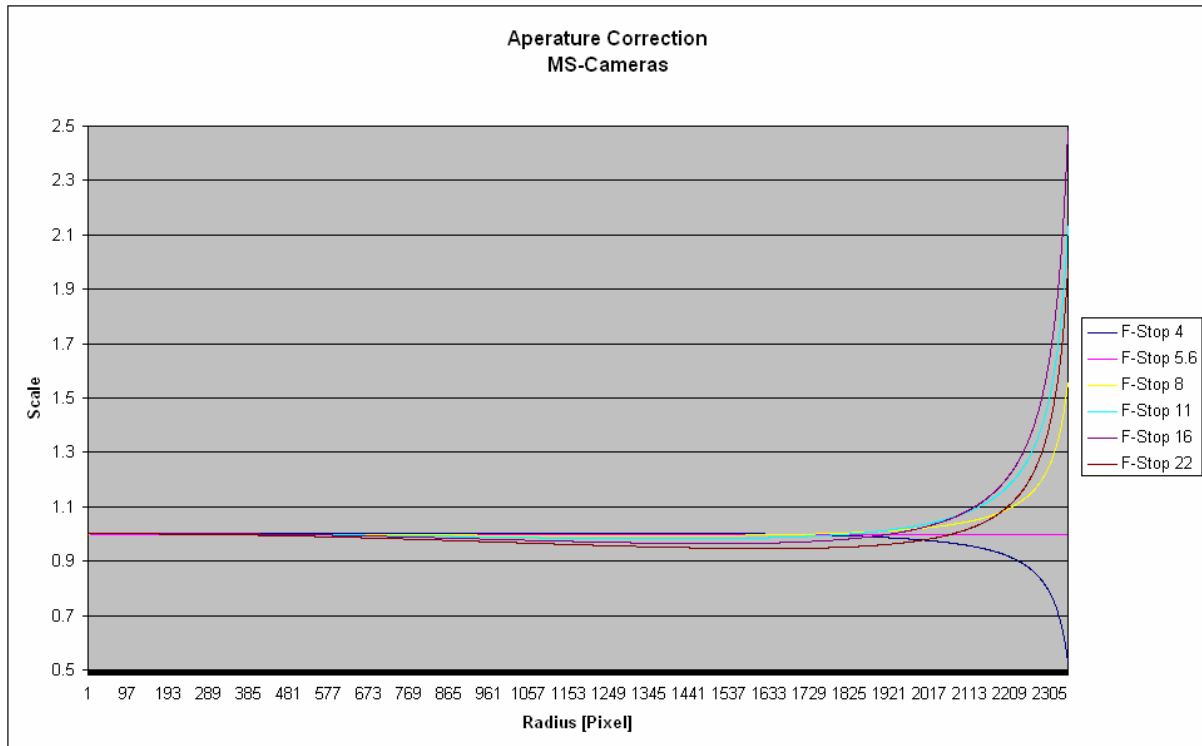
Sensor Noise



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
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0	2047	801
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Defect Column	RowStart	ColumnStart	RowEnd	ColumnEnd
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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 $\pm 30\%$ 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

Brown D. C. Close-Range Camera Calibration, Photogrammetric Engineering 37(8) 1971

Dörstel C., Jacobsen K., Stallmann D. (2003): DMC – Photogrammetric accuracy – Calibration aspects and Generation of synthetic DMC images, Eds. M. Baltsavias / A.Grün, Optical 3D Sensor Workshop, Zürich

Fraser C., Digital Camera self calibration. ISPRS Journal of Photogrammetry and Remote Sensing, (1997, 5284): 149-159

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