



Calibration Protocol  
DMC01 - 0046



# Calibration Certificate

Digital Mapping Camera (DMC)

DMC Serial Number: **DMC01-0046**

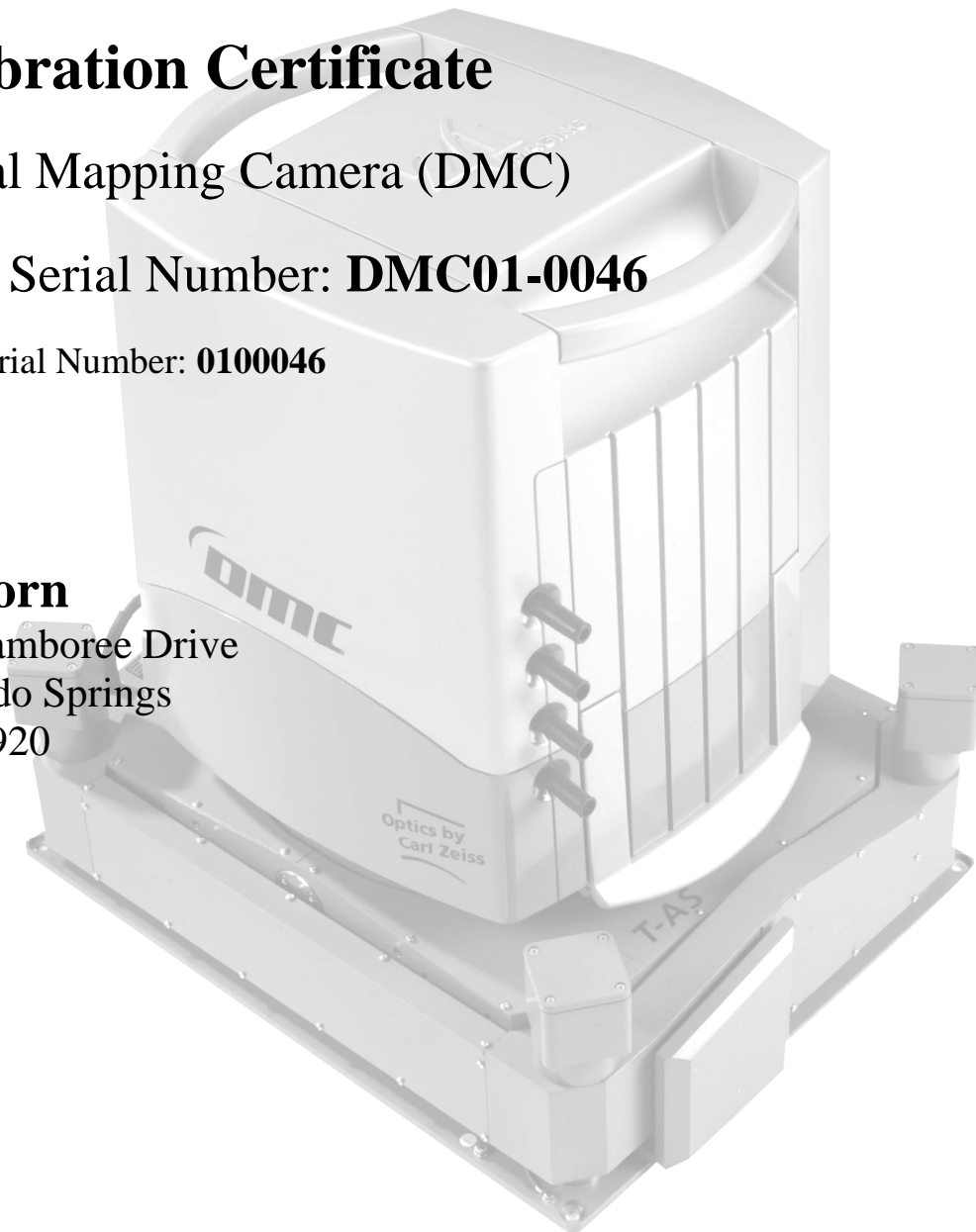
CBU Serial Number: **0100046**

For

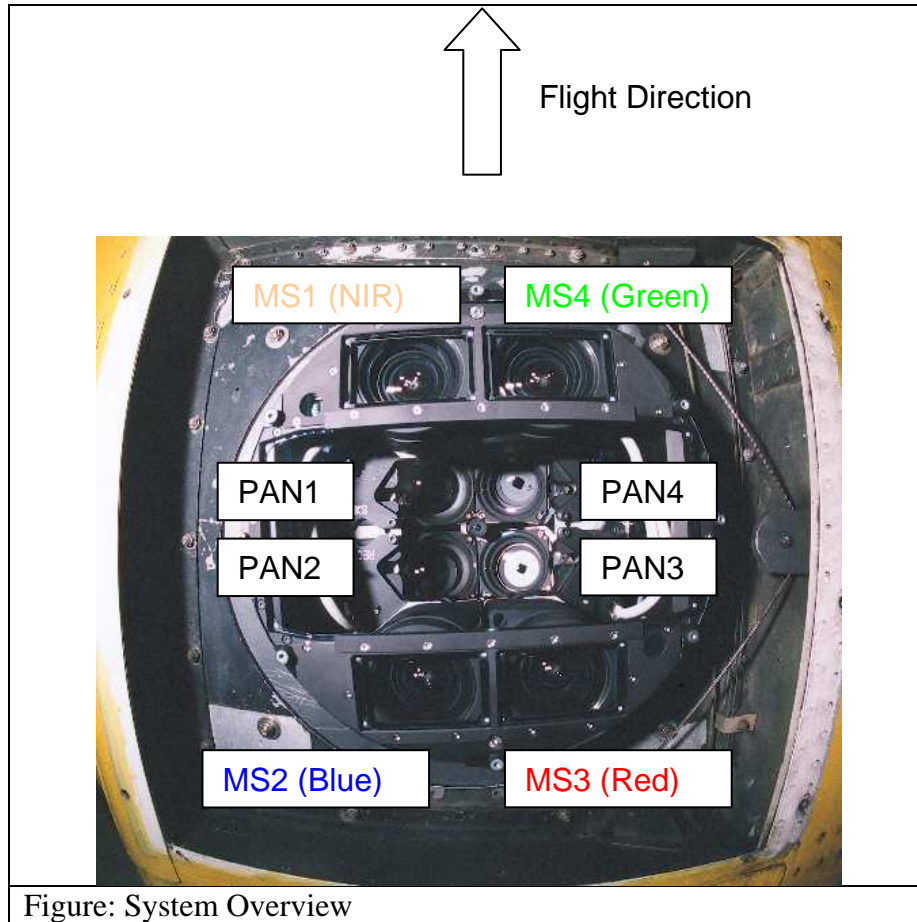
**Sanborn**

1935 Jamboree Drive  
Colorado Springs  
CO 80920

USA



## System Overview



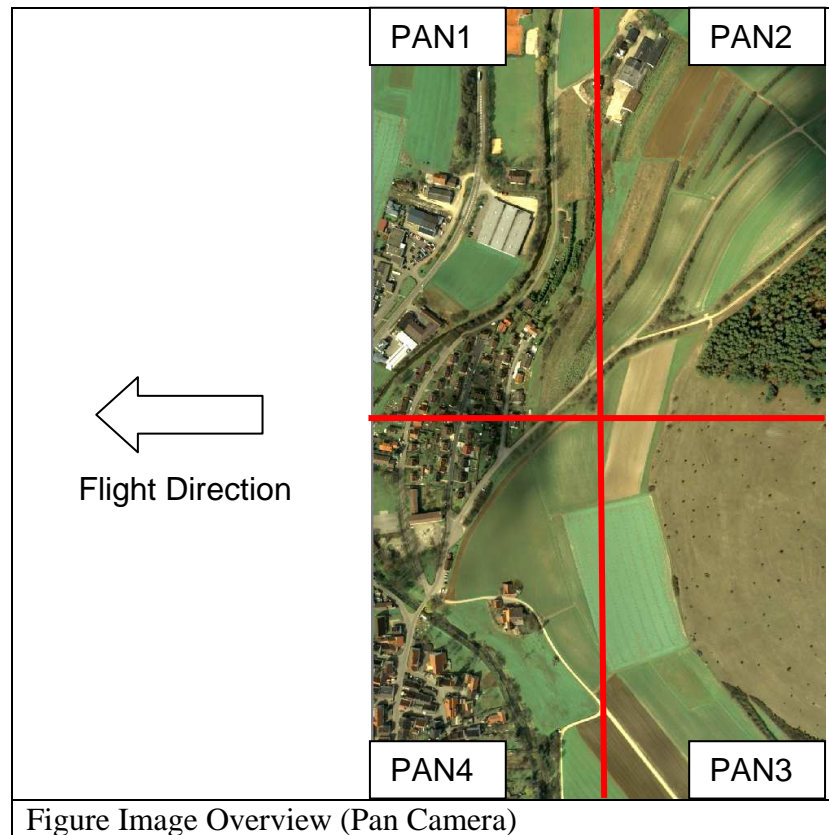


Figure Image Overview (Pan Camera)

### **Camera Parameter for Virtual Image (High Resolution)**

Virtual Focal Length [m]	0.12
Virtual Sensor Size [Pixel]	13824 x 7680
Virtual Pixel Size [ $\mu\text{m}$ ]	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 [ $\mu\text{m}$ ]	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 5.0.10.3**

Virtual Focal Length [m]	0.030
Virtual Sensor Size [Pixel]	3456x1920
Virtual Pixel Size [ $\mu\text{m}$ ]	12
Virtual Principle Point [mm]	X = 0.0 Y = 0.0
Distortion Parameter	Distortion Free



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### Camera Serial Number and Burn-In flights

	Burn In Flight: 13.12.2006					
Camera	Serial Number	Calib. Date				
PAN1	00114261	27.11.2006				
PAN2	00114262	23.11.2006				
PAN3	00114264	23.11.2006				
PAN4	00114266	20.11.2006				
MS1 (NIR)	00113908	22.11.2006				
MS2 (Blue)	00114316	27.11.2006				
MS3 (Red)	00113911	29.11.2006				
<del>MS4 (Green)</del>	<del>00113914</del>	<del>22.11.2006</del>				
MS4 (Green)	00114323	08.12.2006				

## Camera Orientation PAN-Cameras (Burn-In Flight 13.12.2006)

Camera (Serial Number)	X [m] (Accuracy)	Y [m] (Accuracy)	Z [m] (Accuracy)	Omega [Deg] (Accuracy)	Phi [Deg] (Accuracy)	Kappa [Deg] (Accuracy)
PAN1 (00111724)	0.064 (0)	-0.079 (0)	1000 (0)	18.005 (0.001)	10.011 (0.001)	86.538 (0.001)
PAN2 (0111726)	-0.064 (0)	-0.079 (0)	1000 (0)	17.888 (0.001)	-10.259 (0.001)	92.957 (0.001)
PAN3 (0211172)	-0.064 (0)	0.079 (0)	1000 (0)	-18.008 (0.001)	-10.013 (0.001)	-93.607 (0.001)
PAN4 (02111731)	0.064 (0)	0.079 (0)	1000 (0)	-17.885 (0.001)	10.262 (0.001)	-86.044 (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 5.1, from Intergraph Z/I Imaging photogrammetric product suite.

Platform calibration performed by

  
Dipl. Ing. C. Müller

15.12.2006  
Date



# Calibration Protocol DMC01 - 0046



## Additional System Components (Burn-In Flight 13.12.2006)

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)

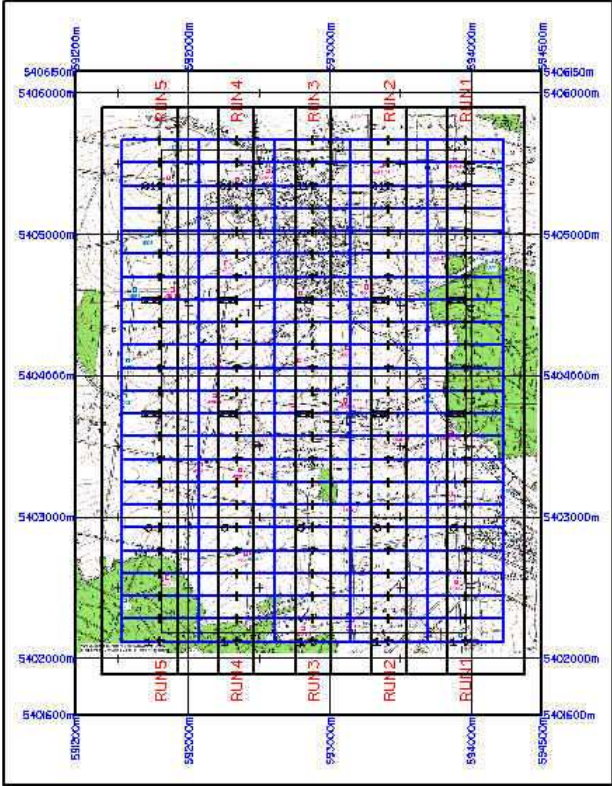
The results of the orientation of the IMU were generated with support of ImageStation Automatic Triangulation (ISAT), Version 5.1, from Intergraph Z/I Imaging photogrammetric product suite.

Calibration performed by

\_\_\_\_\_  
Dipl. Ing. C. Müller

\_\_\_\_\_  
Date

## Aerotriangulation Results (Burn-In Flight 13.12.2006)

	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	10	
Check Points Used	24		
GSD [cm]	6		

### Statistic results:

<b>Matching results: 0 Weak Areas - covered with clouds</b> <b>Whole Block</b> 115 exposures used 0 exposures not used	
<b>Whole Block</b>	<b>Sigma relativ: 1.444 um</b>
<b>Whole Block</b>	<b>Sigma absolut: 1.448 um</b>
<b>Whole Block</b> Photo-T Parameters and Results for Project EL5000_n  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	0.038	0.018	0.043	0.030
	RMS Check	0.042	0.026	0.111	0.035
	RMS Limits	0.100	0.100	0.150	
	Max Ground Residual	0.072	0.031	0.071	
	Residual Limits	0.100	0.100	0.150	
	Mean Std Dev Object	0.009	0.009	0.020	
	RMS Photo Position				
	RMS Photo Attitude				
	Mean Std Dev Photo Position	0.015	0.017	0.015	
	Mean Std Dev Photo Attitude	0.001	0.001	0.000	
Key Statistics					
	Sigma:	<b>1.4 um</b>			
	Number of iterations:	2			
	Degrees of Freedom:	29635			

The results of the Aerotriangulation were generated with ImageStation Automatic Triangulation (ISAT), Version 5.0, from Intergraph Z/I Imaging photogrammetric product suite.

Aerotriangulation performed by

  
 Dipl. Ing. C. Müller

15.12.2006  
 Date



Calibration Protocol  
DMC01 - 0046



**Calibration Certificate**

**N<sup>o</sup> 00114261**

Object                      Digital Aerial Survey Camera  
Manufacturer              Z/I Imaging D-73431 Aalen  
Type                         DMC-Panchromatic  
Serial Number              00114261

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70

Date of Calibration                      27.Nov.2006

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CertifiedDate

10.Apr.2007

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

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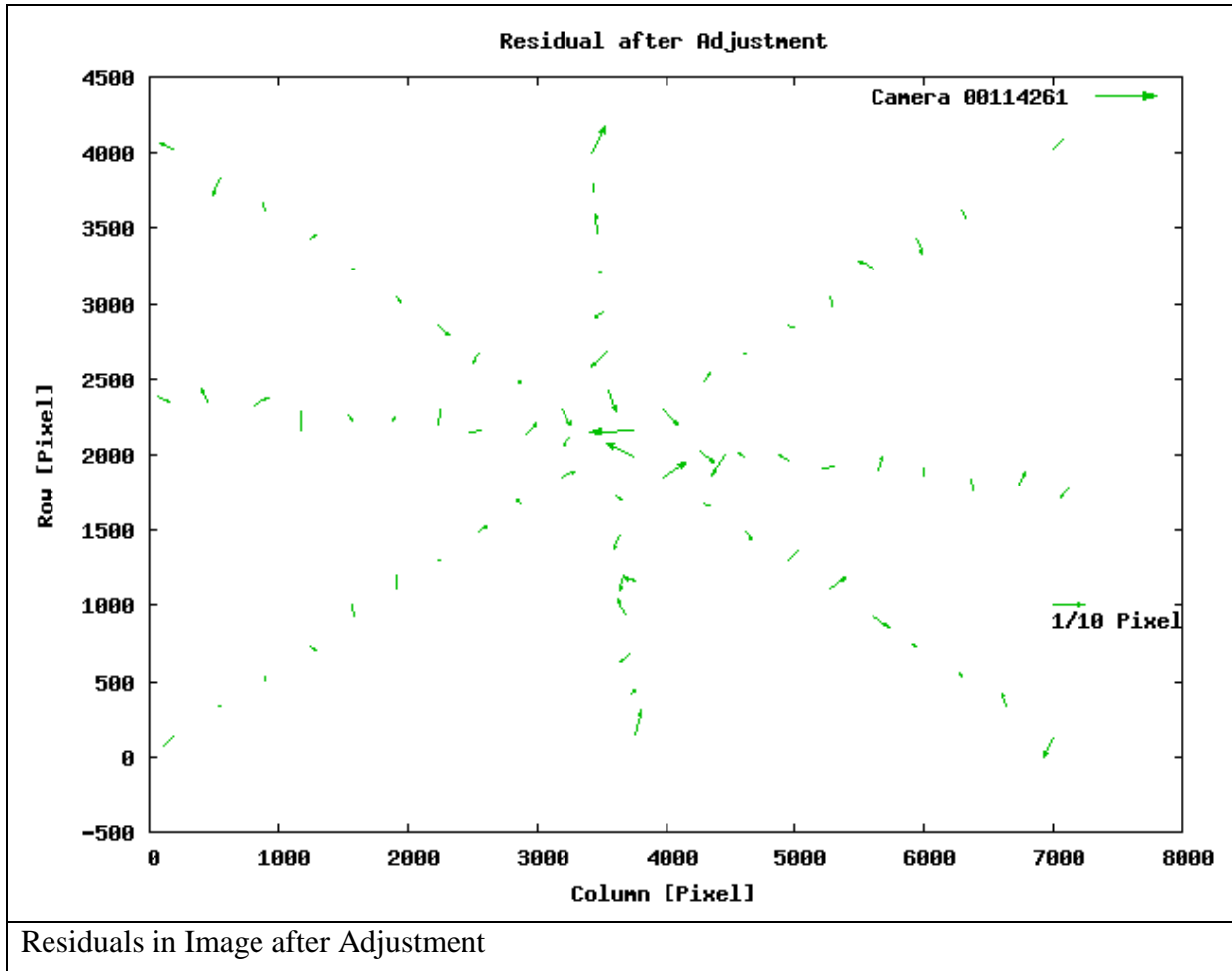
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00114261

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	8.198E-05	7.214E-06
	$y_0$	-0.0003911	4.383E-06
Focal Length [m]	$\Delta f$	-0.0004322	1.249E-06
Radial Distortion	$K_1$	0.7921	0.0327
	$K_2$	-375.4	29.7
	$K_3$	-2431	7861
Decentering distortion	$P_1$	-0.0001663	0.0001644
	$P_2$	-0.0001743	8.345E-05
In Plane Distortion	$B_1$	2.045E-05	8.642E-06
	$B_2$	2.887E-05	5.058E-06

Adjusted Focal length = 0.12+ dc =0.1195678 [m]



Max Residual [ $\mu\text{m}$ ]: 1.7

Threshold [ $\mu\text{m}$ ]: 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".

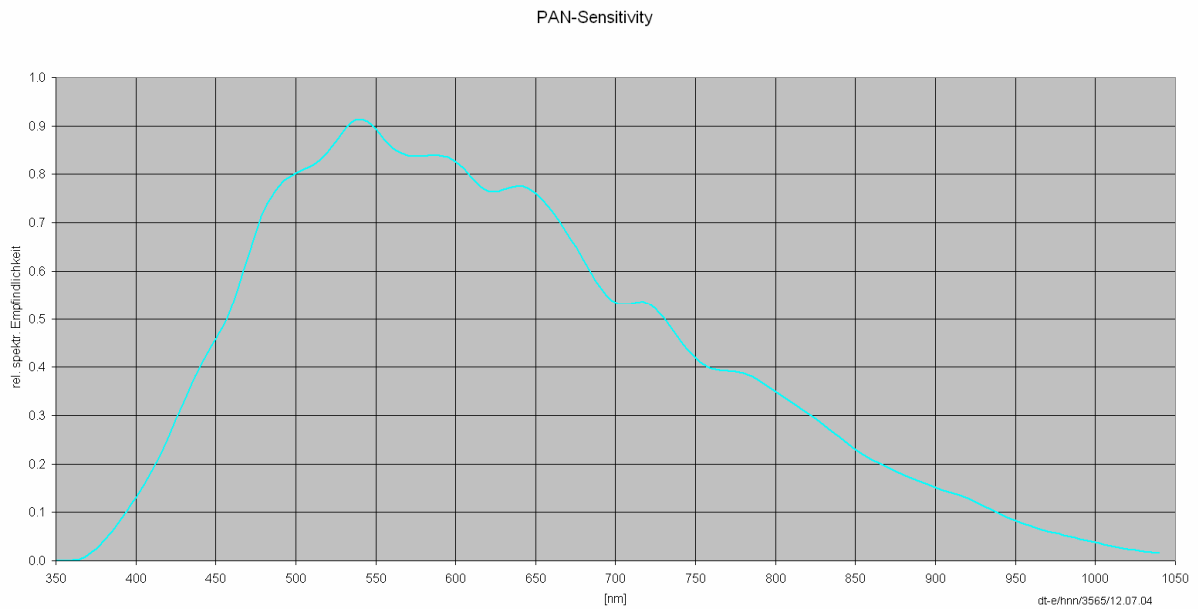
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

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

Camera ID	00114261
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

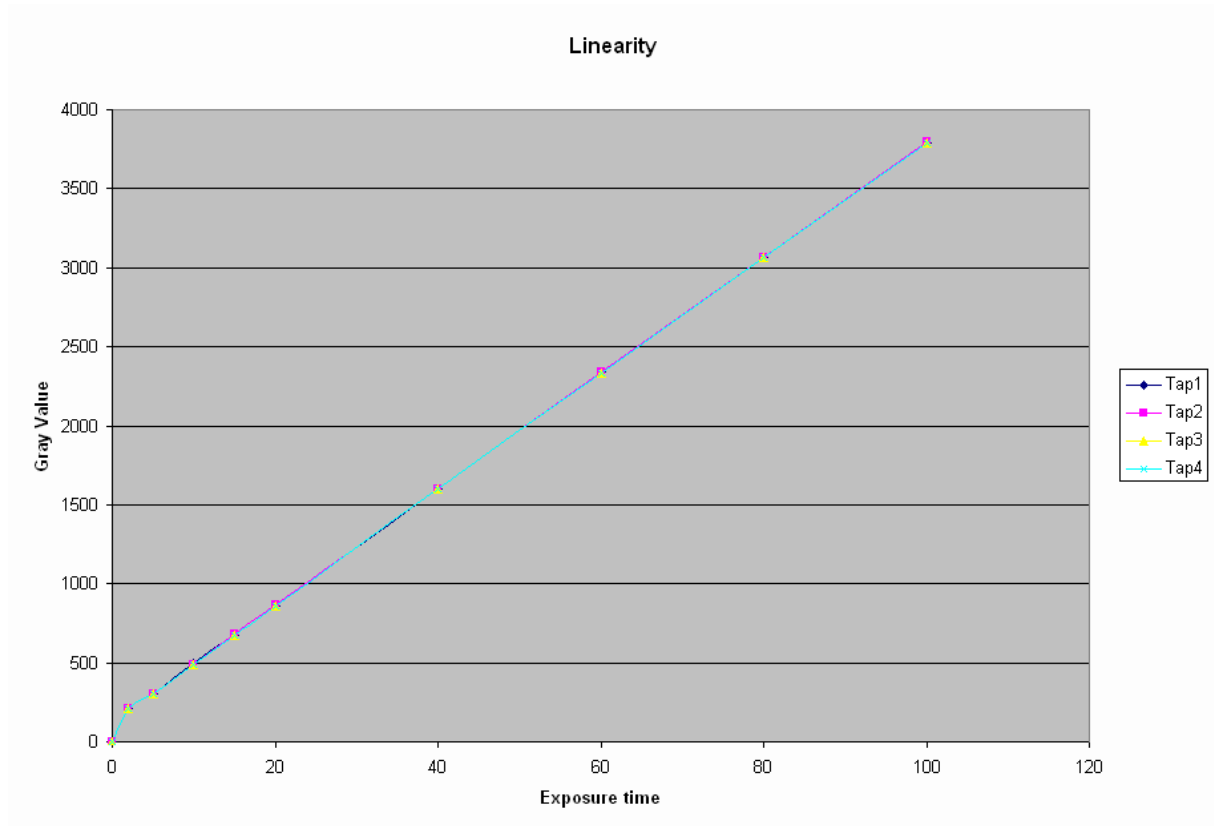
## Sensitivity of camera



**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".

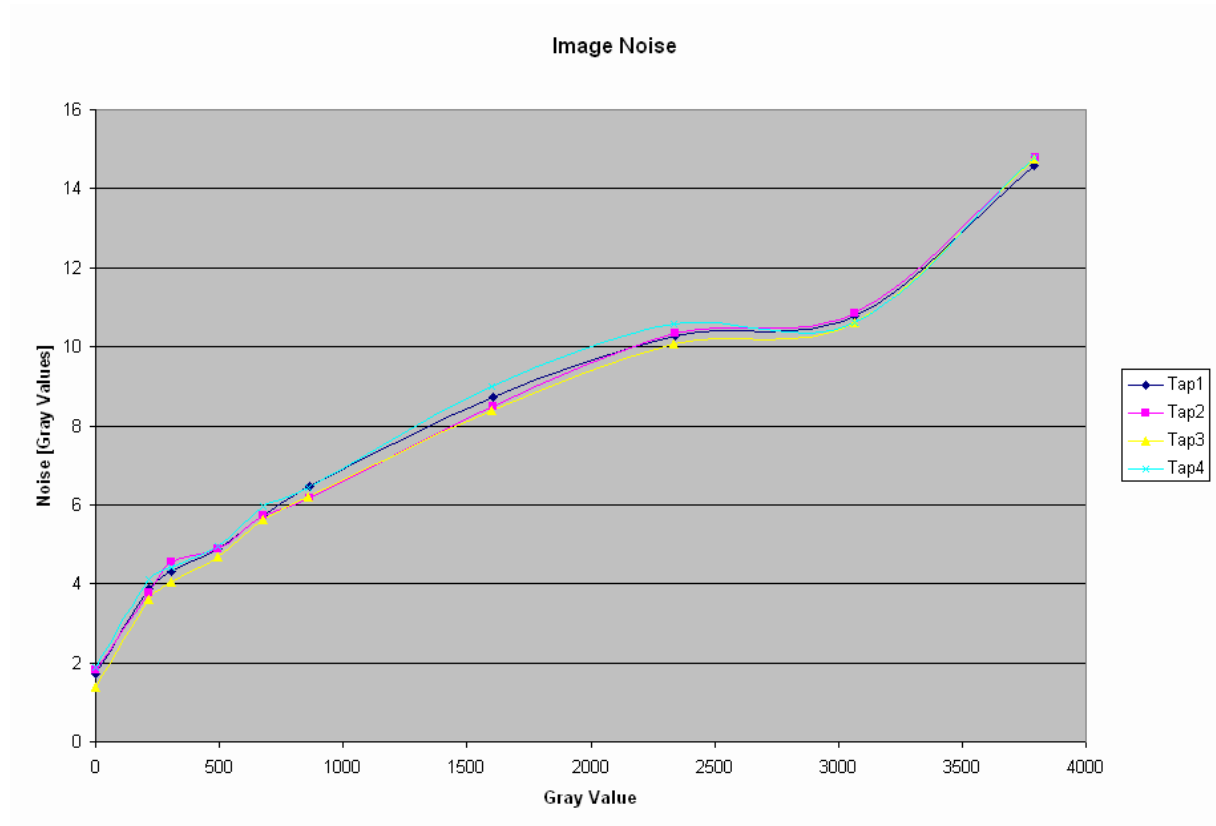
### Sensor Linearity



**Remark:**

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

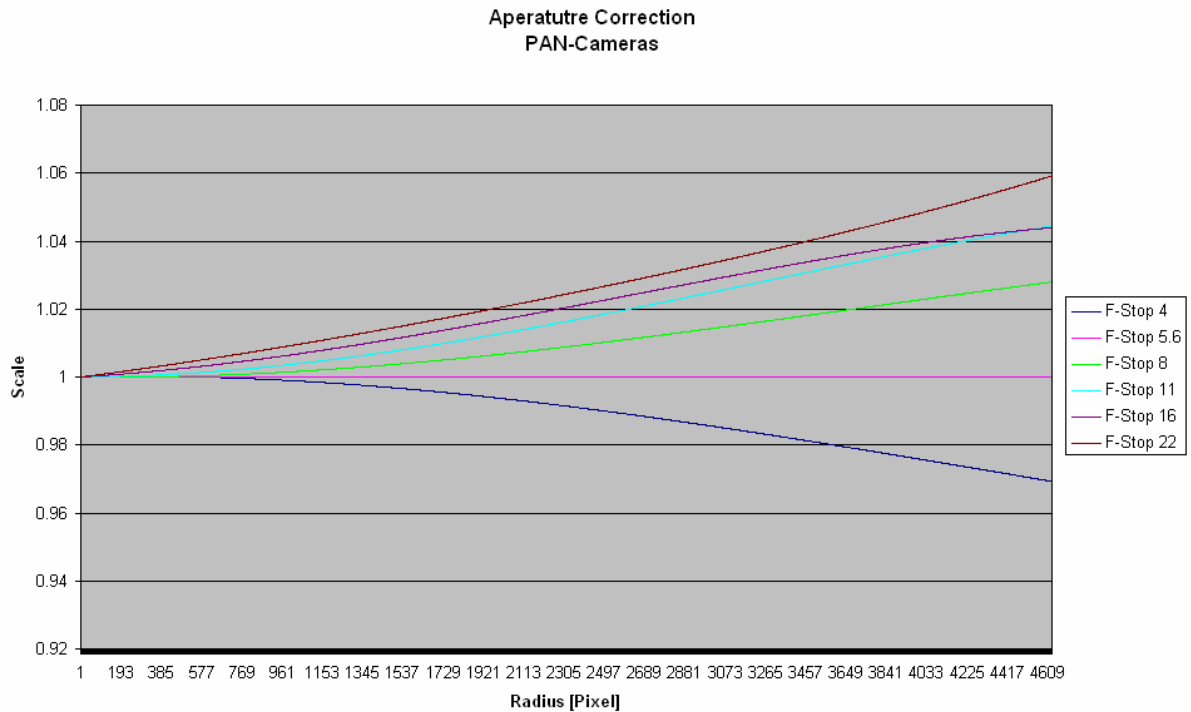
### Sensor Noise



**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 - 0046



**Calibration Certificate**

**N<sup>o</sup> 00114262**

Object                      Digital Aerial Survey Camera  
Manufacturer              Z/I Imaging D-73431 Aalen  
Type                         DMC-Panchromatic  
Serial Number              00114262

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70

Date of Calibration                      23.Nov.2006

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CertifiedDate

Division Head

Person in Charge

10.Apr.2007

(H. Sohnle)

(S. Schröder)

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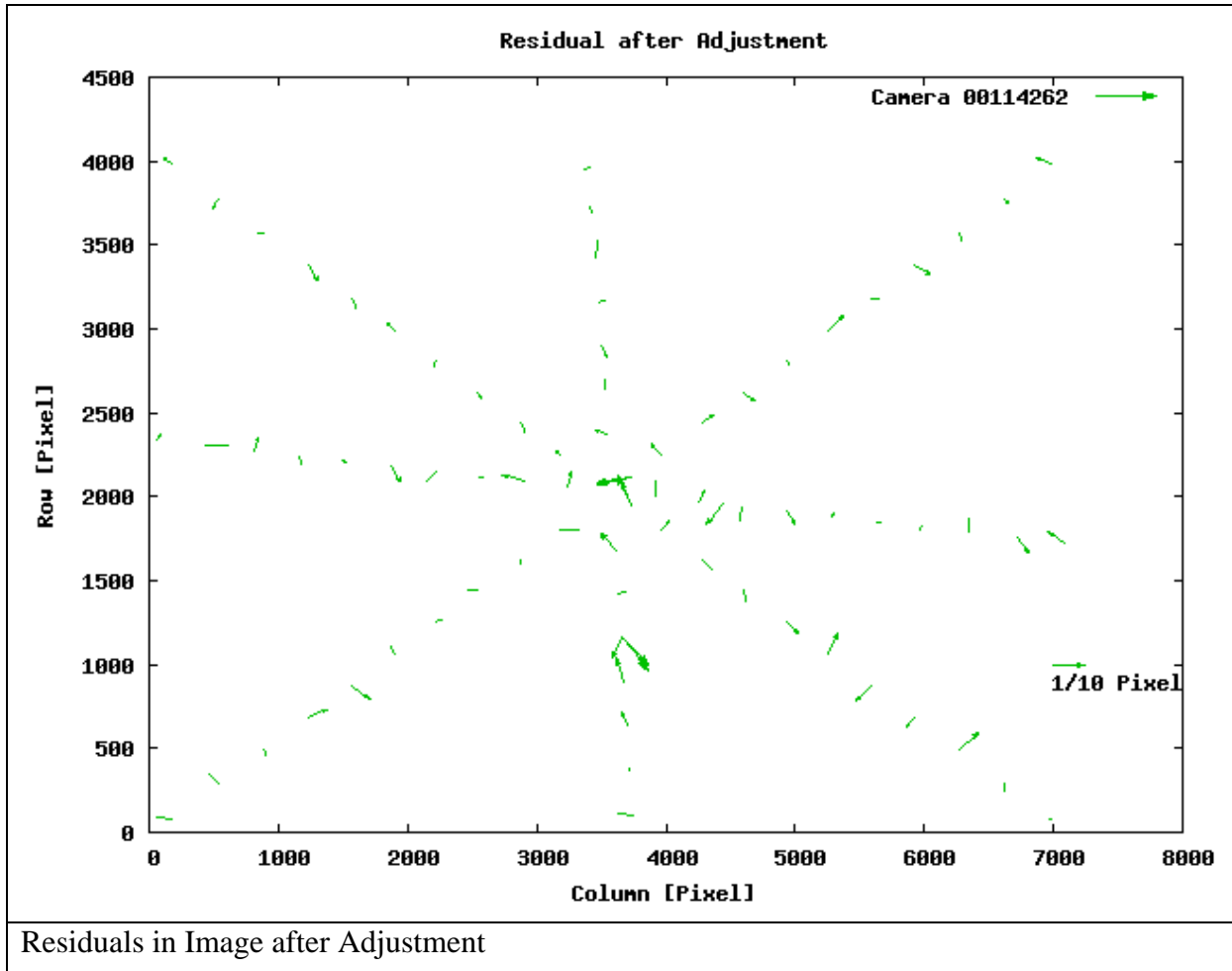
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00114262

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-6.161E-05	7.575E-06
	$y_0$	0.0001899	4.584E-06
Focal Length [m]	$\Delta f$	-0.0005027	1.327E-06
Radial Distortion	$K_1$	0.7836	0.03469
	$K_2$	-321.7	31.53
	$K_3$	-19020	8353
Decentering distortion	$P_1$	-0.0005747	0.0001727
	$P_2$	-0.0001497	8.715E-05
In Plane Distortion	$B_1$	2.838E-05	9.196E-06
	$B_2$	1.429E-05	5.387E-06

Adjusted Focal length = 0.12+ dc =0.1194973 [m]



Max Residual [ $\mu\text{m}$ ]: 1.4

Threshold [ $\mu\text{m}$ ]: 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".

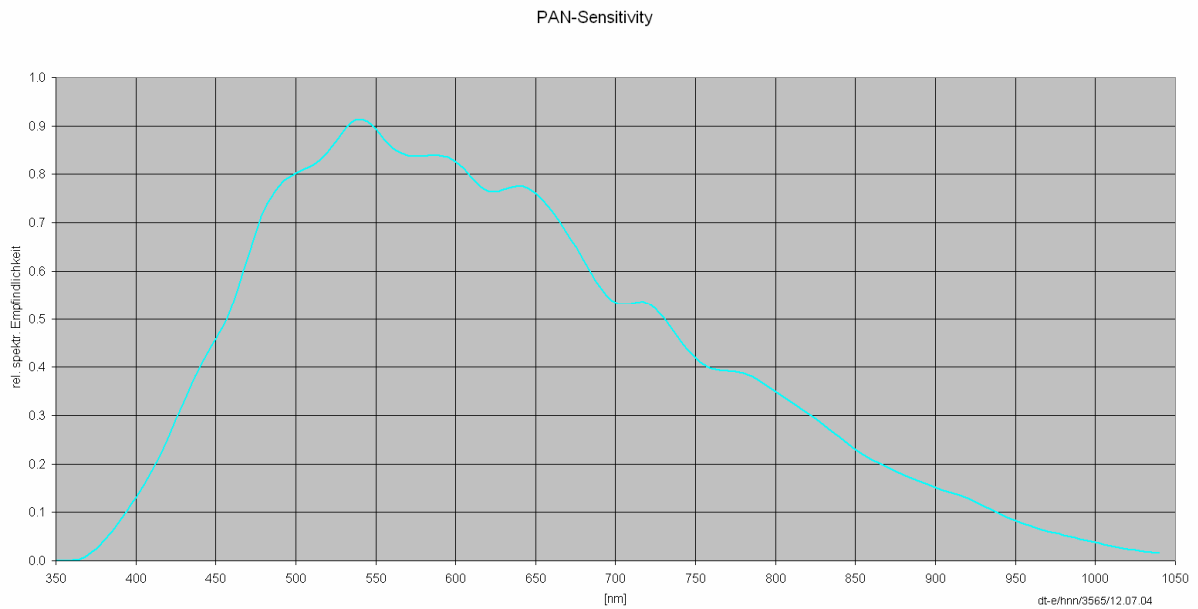
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

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

Camera ID	00114262
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

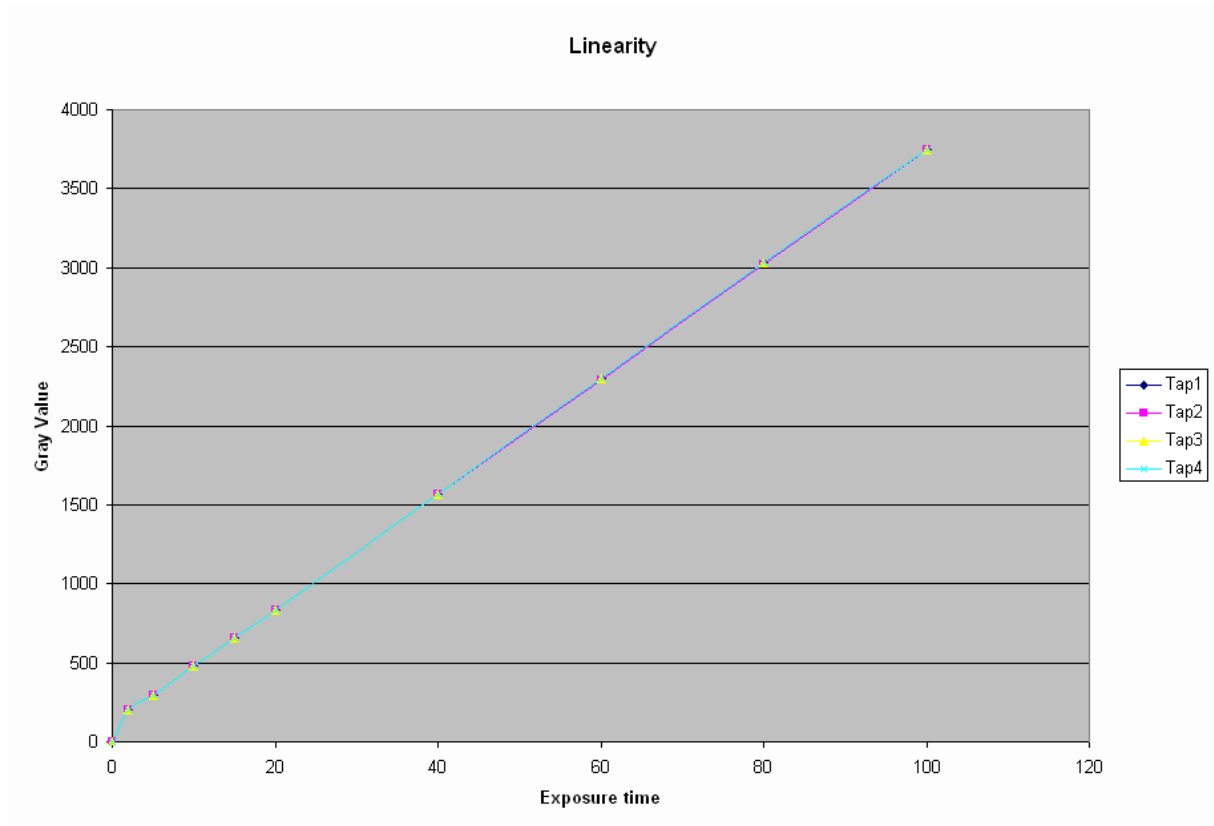
## Sensitivity of camera



**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".

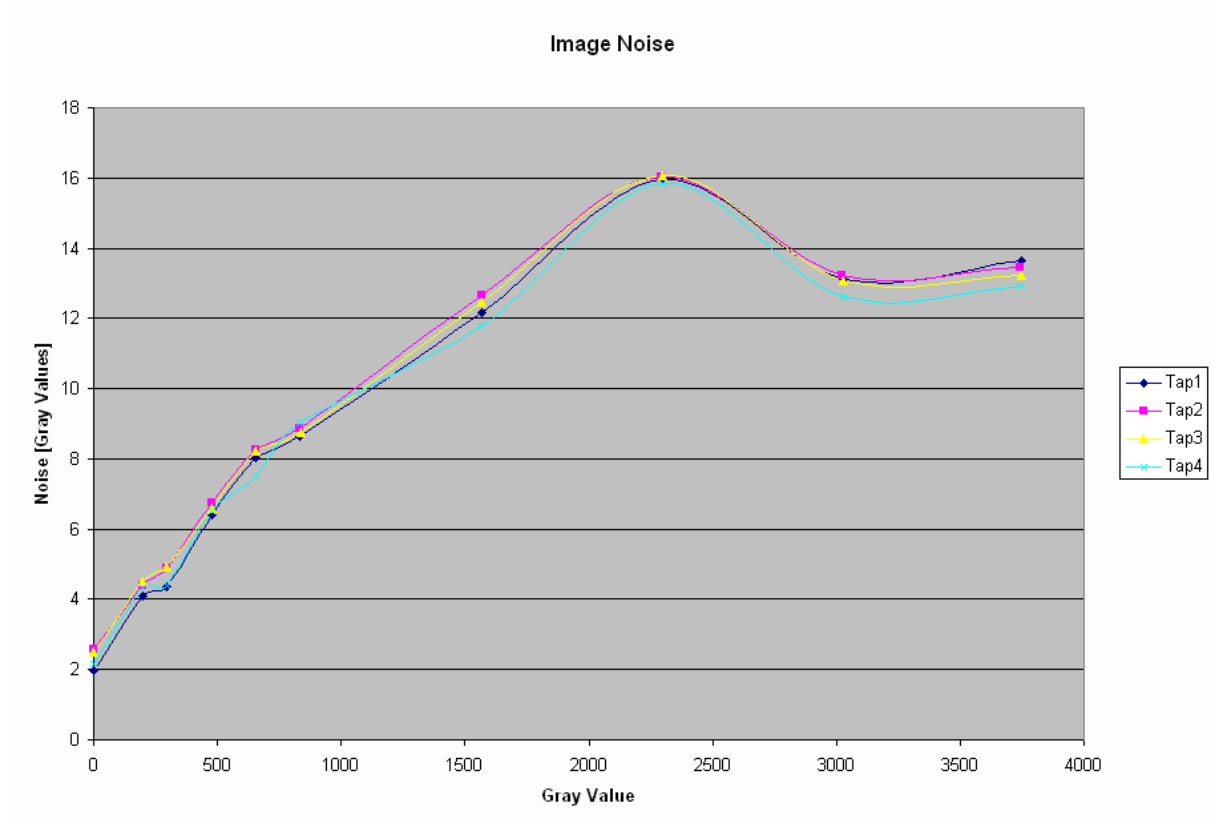
### Sensor Linearity



**Remark:**

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

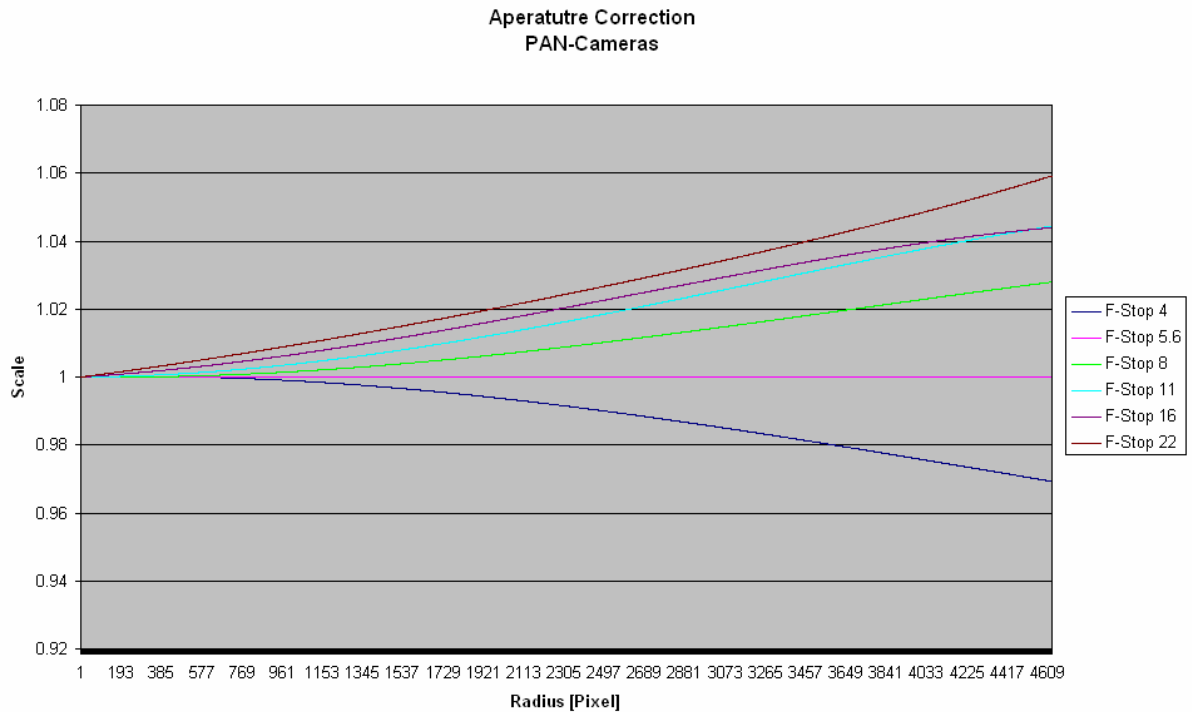
### Sensor Noise



**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	1674	1029
1	1674	1030
2	1675	1030

Defect Column	RowStart	ColumnStart	RowEnd	ColumnEnd
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# Calibration Protocol DMC01 - 0046



## Remark

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





Calibration Protocol  
DMC01 - 0046



**Calibration Certificate**

**N<sup>o</sup> 00114264**

Object                      Digital Aerial Survey Camera  
Manufacturer              Z/I Imaging D-73431 Aalen  
Type                         DMC-Panchromatic  
Serial Number              00114264

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70

Date of Calibration                      23.Nov.2006

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CertifiedDate

Division Head

Person in Charge

10.Apr.2007

(H. Sohnle)

(S. Schröder)

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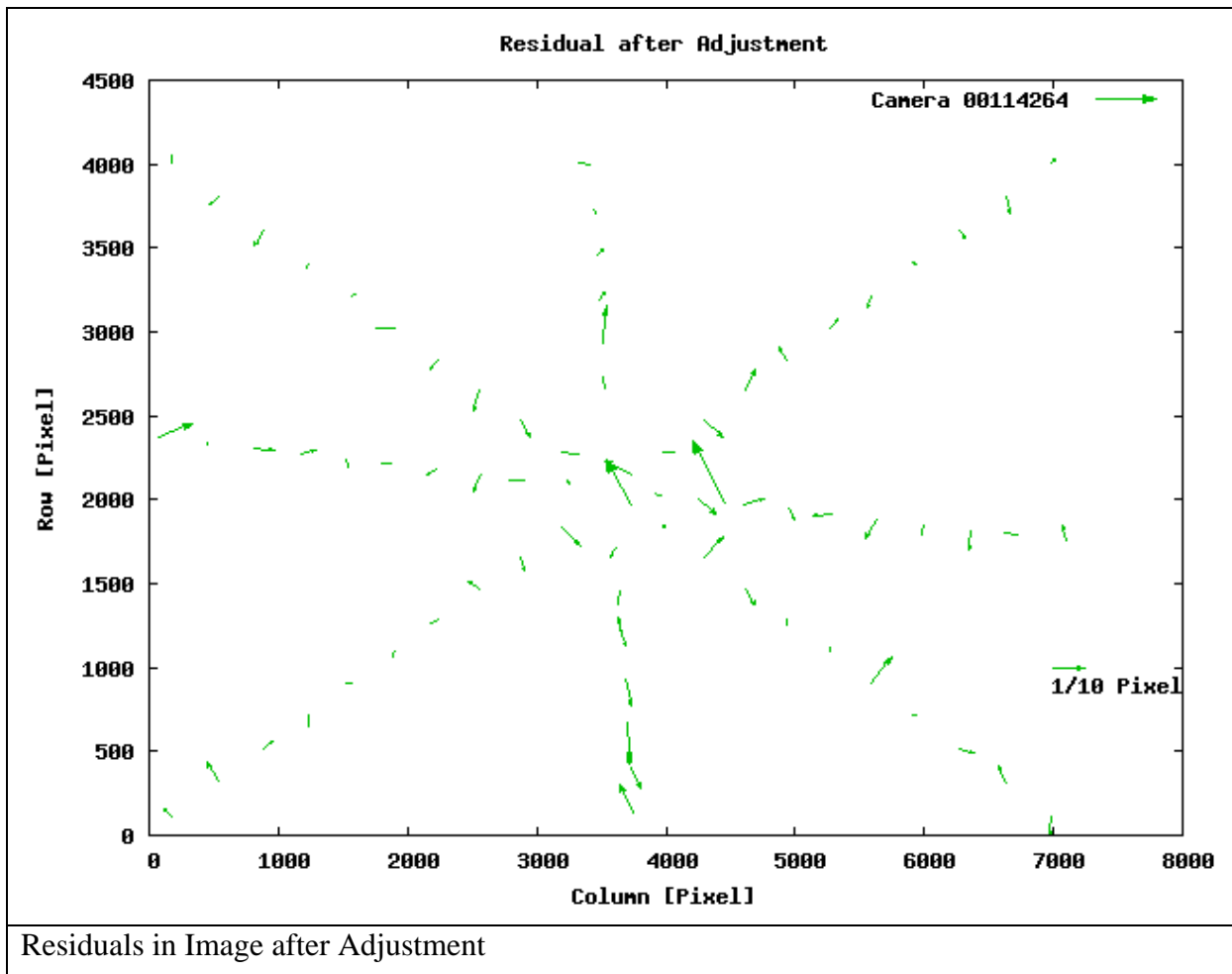
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00114264

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-5.129E-06	9.078E-06
	$y_0$	-0.0001939	5.465E-06
Focal Length [m]	$\Delta f$	-0.0005042	1.562E-06
Radial Distortion	$K_1$	0.8566	0.04066
	$K_2$	-275.3	36.93
	$K_3$	-37060	9775
Decentering distortion	$P_1$	-0.0004001	0.000207
	$P_2$	-0.0005403	0.0001035
In Plane Distortion	$B_1$	8.505E-05	1.073E-05
	$B_2$	1.943E-05	6.274E-06

Adjusted Focal length = 0.12+ dc =0.1194958 [m]



Max Residual [ $\mu\text{m}$ ]: 2.2

Threshold [ $\mu\text{m}$ ]: 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".

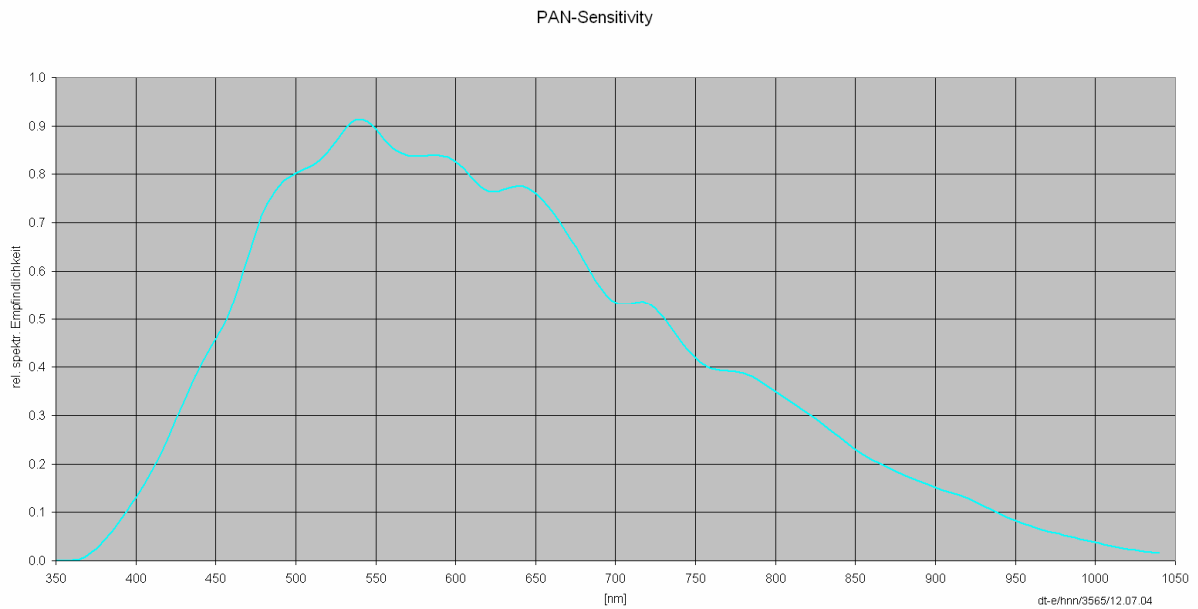
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

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

Camera ID	00114264
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

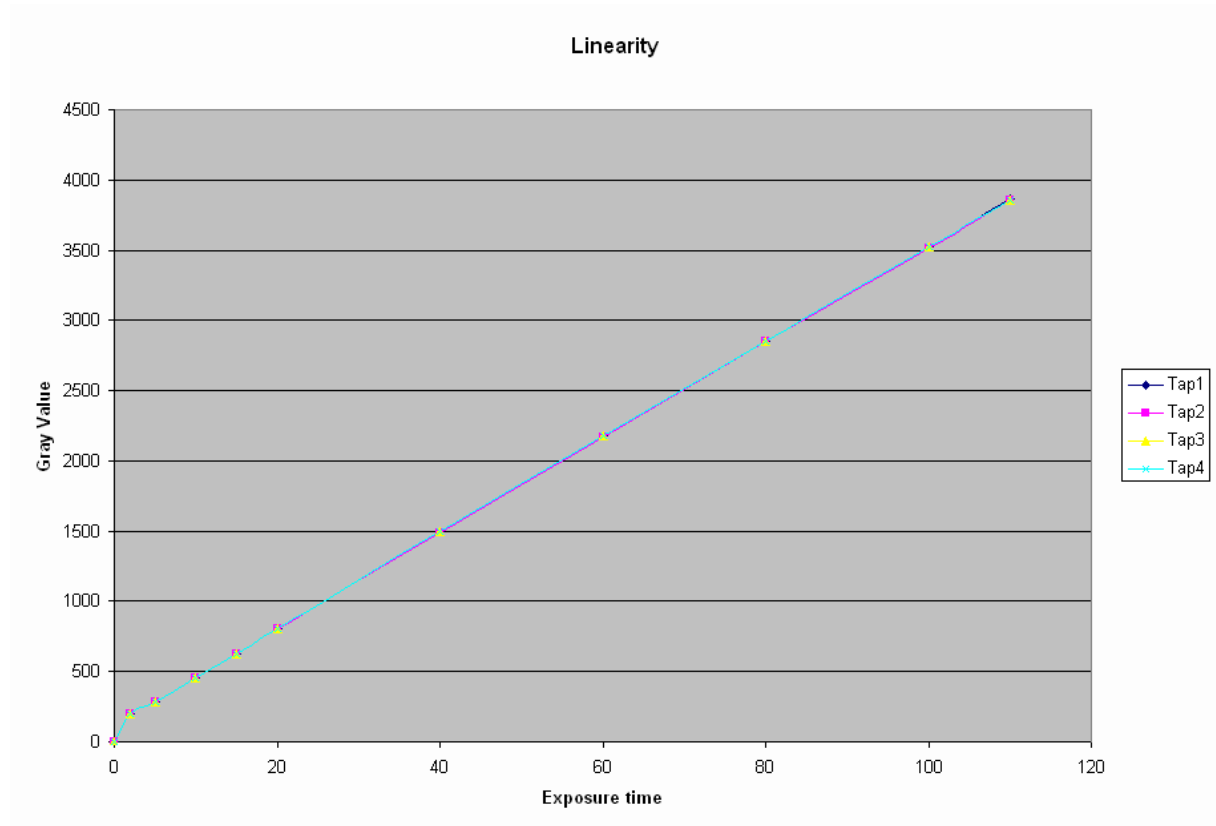
## Sensitivity of camera



**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".

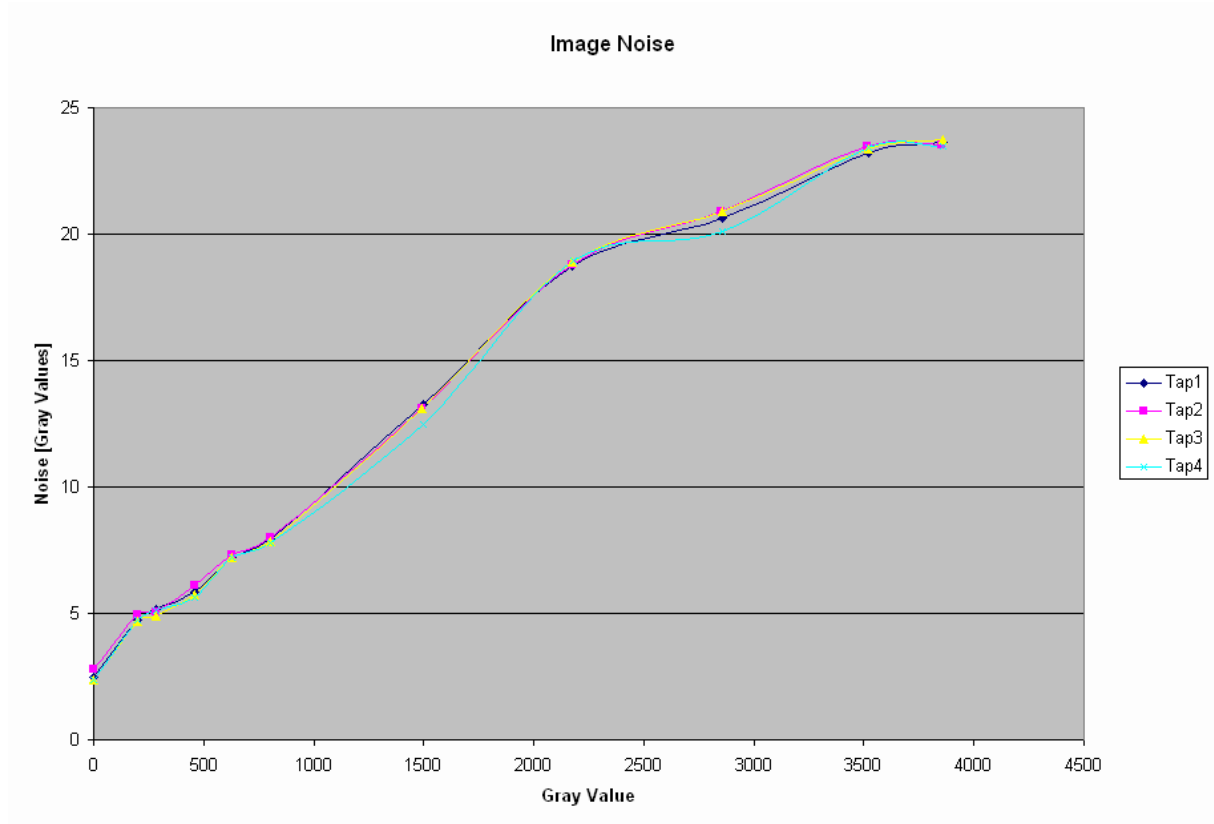
### Sensor Linearity



**Remark:**

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

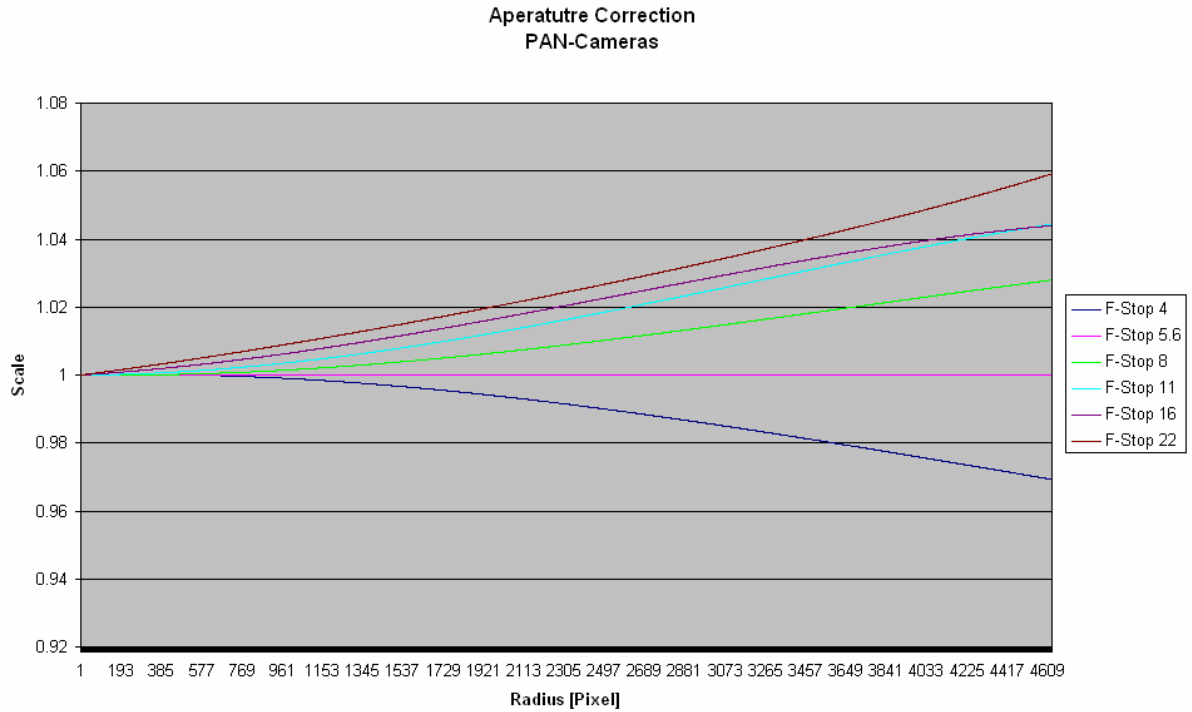
### Sensor Noise



**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: 2  
 Number of defect clusters: 0  
 Number of defect columns: 1

Nr	Row	Column
0	2544	2345
1	2545	2345

Defect Column	RowStart	ColumnStart	RowEnd	ColumnEnd
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# Calibration Protocol DMC01 - 0046



0	2048	7109	3727	7109
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## Remark

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





Calibration Protocol  
DMC01 - 0046



**Calibration Certificate**

**N<sup>o</sup> 00114266**

Object                    Digital Aerial Survey Camera  
Manufacturer            Z/I Imaging D-73431 Aalen  
Type                      DMC-Panchromatic  
Serial Number            00114266

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70

Date of Calibration                      20.Nov.2006

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CertifiedDate

10.Apr.2007

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

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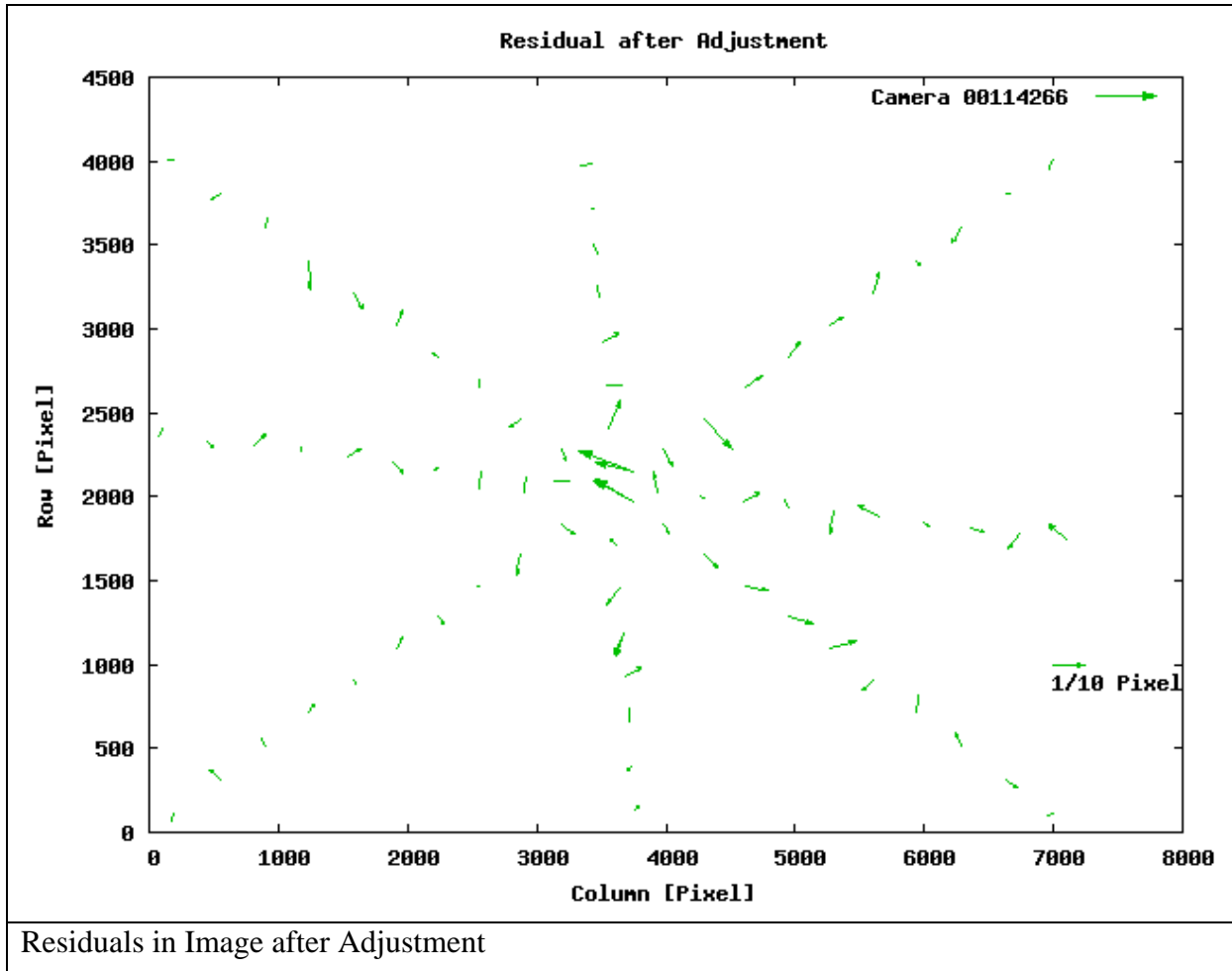
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00114266

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	4.768E-05	8.772E-06
	$y_0$	-0.0001498	5.329E-06
Focal Length [m]	$\Delta f$	-0.0004744	1.547E-06
Radial Distortion	$K_1$	0.709	0.04063
	$K_2$	-258.5	36.79
	$K_3$	-37390	9723
Decentering distortion	$P_1$	-0.0004264	0.0001999
	$P_2$	0.0002437	0.0001015
In Plane Distortion	$B_1$	3E-05	1.071E-05
	$B_2$	-3.128E-05	6.237E-06

Adjusted Focal length = 0.12+ dc =0.1195256 [m]



Max Residual [ $\mu\text{m}$ ]: 2.2

Threshold [ $\mu\text{m}$ ]: 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".

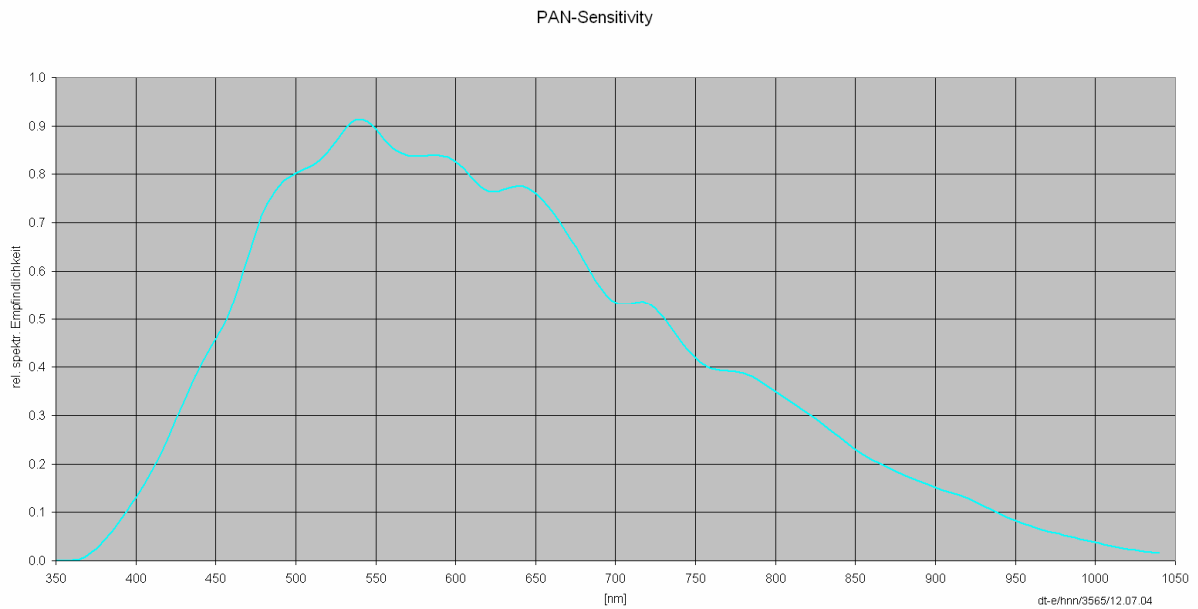
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

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

Camera ID	00114266
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

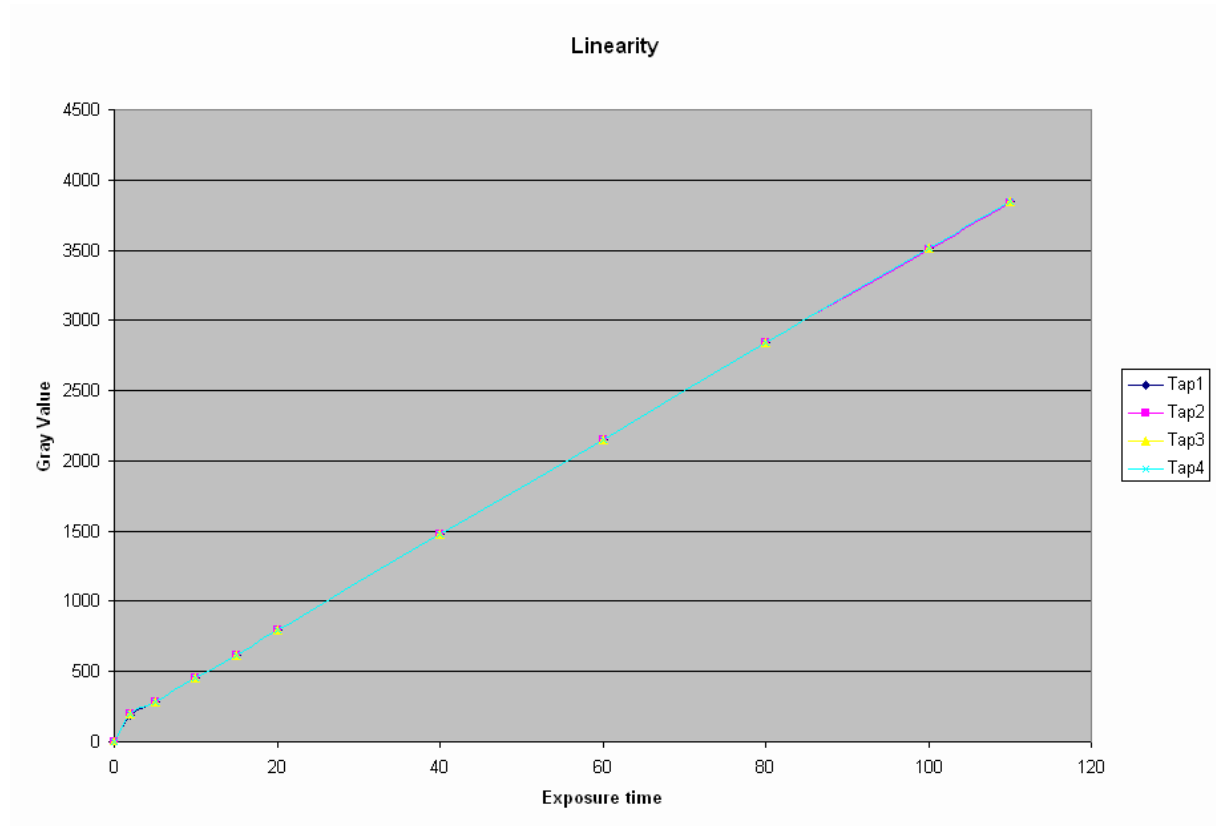
## Sensitivity of camera



**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".

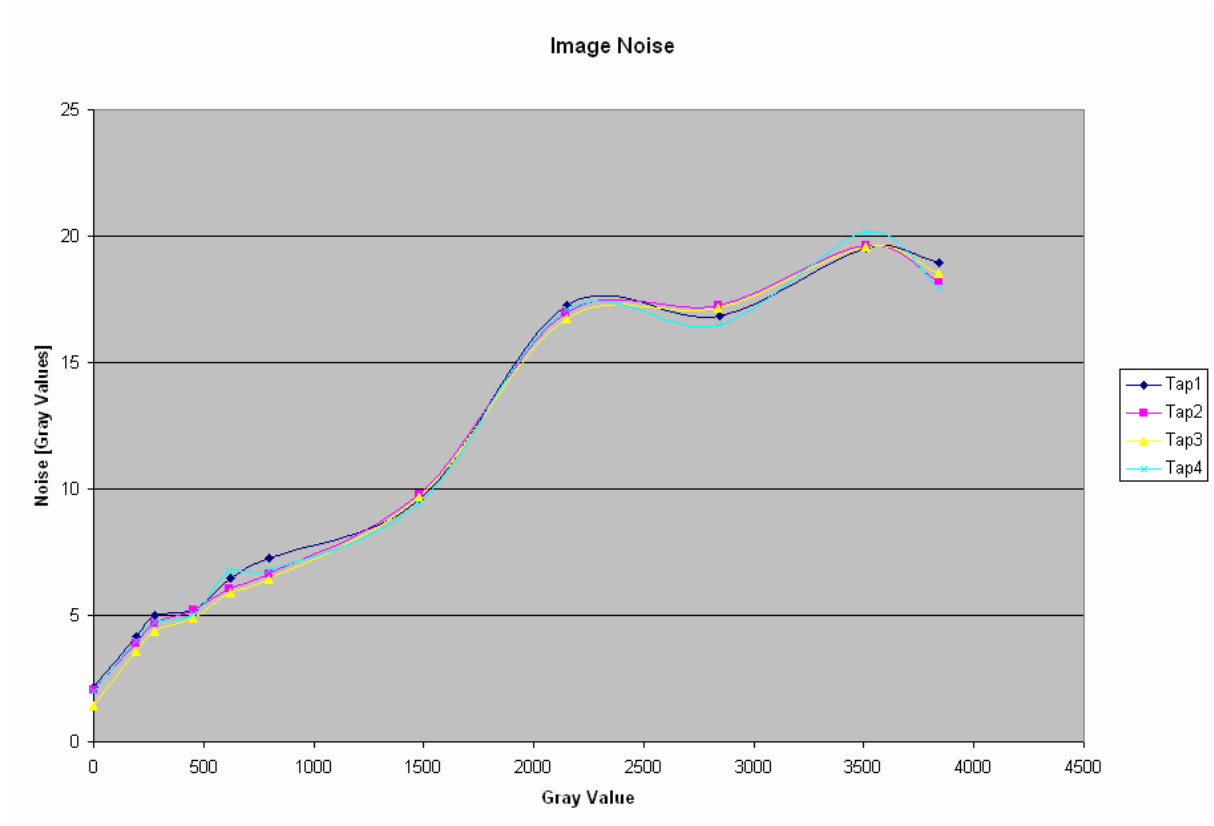
### Sensor Linearity



**Remark:**

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

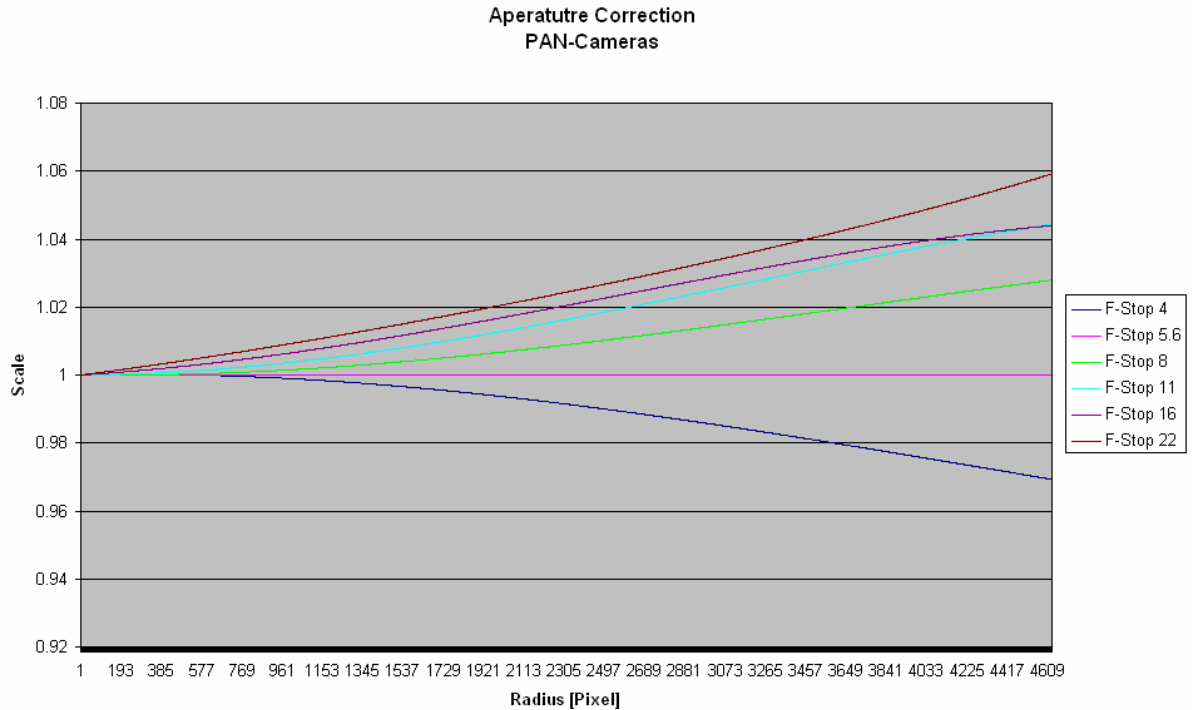
### Sensor Noise



**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 - 0046



## Calibration Certificate

N<sup>o</sup> 00113908

Object                    Digital Aerial Survey Camera  
Manufacturer            Z/I Imaging D-73431 Aalen  
Type                      DMC-MS-NIR  
Serial Number           00113908

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70

Date of Calibration                      23.Nov.2006

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CertifiedDate

10.Apr.2007

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

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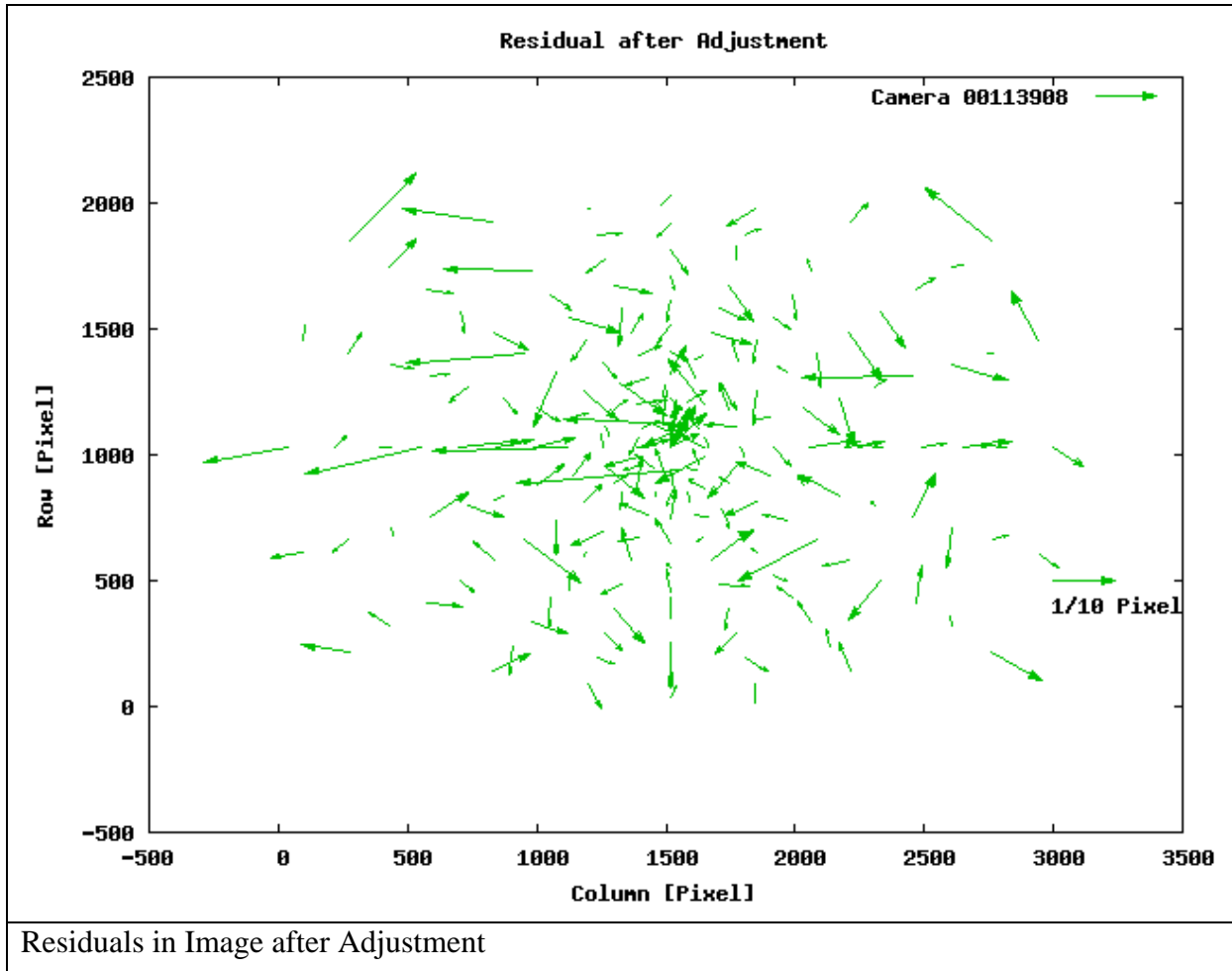
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-MS-NIR
Nominal Focal Length	0.025 m
Serial Number	00113908

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-0.0001898	1.694E-06
	$y_0$	-0.0001272	1.189E-06
Focal Length [m]	$\Delta f$	-2.789E-06	6.167E-07
Radial Distortion	$K_1$	-143.2	0.5203
	$K_2$	225400	3313
	$K_3$	-153600000	5957000
Decentering distortion	$P_1$	0.002564	0.0008809
	$P_2$	-0.0004485	0.000542
In Plane Distortion	$B_1$	0.0001358	1.529E-05
	$B_2$	-8.592E-05	1.253E-05

Adjusted Focal length = 0.025+ dc =0.024997211 [m]



Max Residual [ $\mu\text{m}$ ]: 3.2

Threshold [ $\mu\text{m}$ ]: 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".

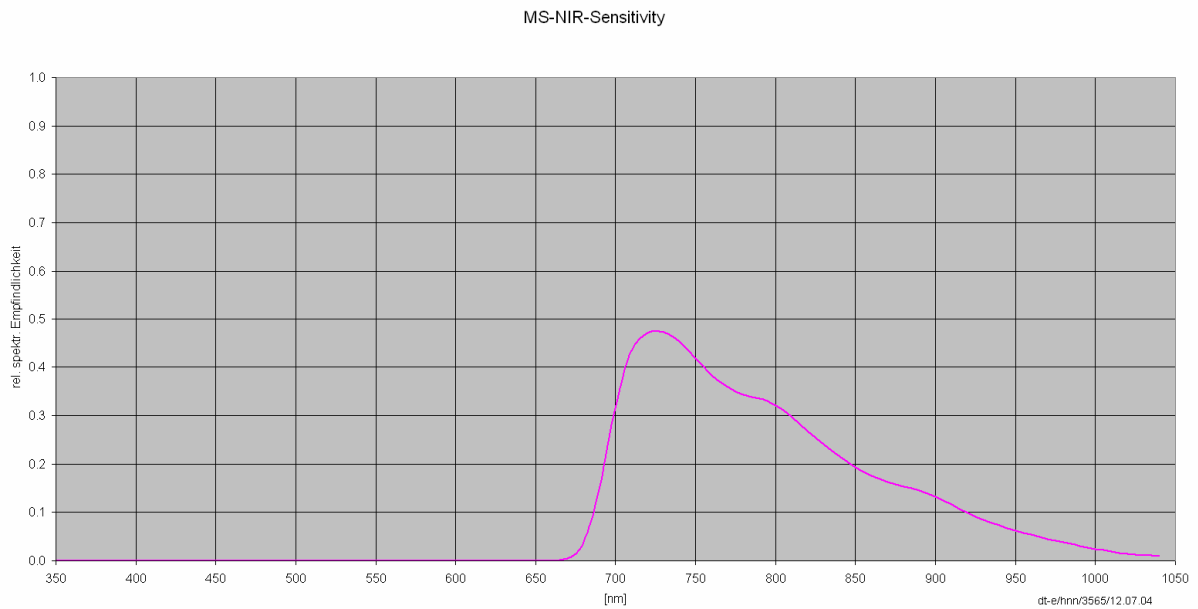
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

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

Camera ID	00113908
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1

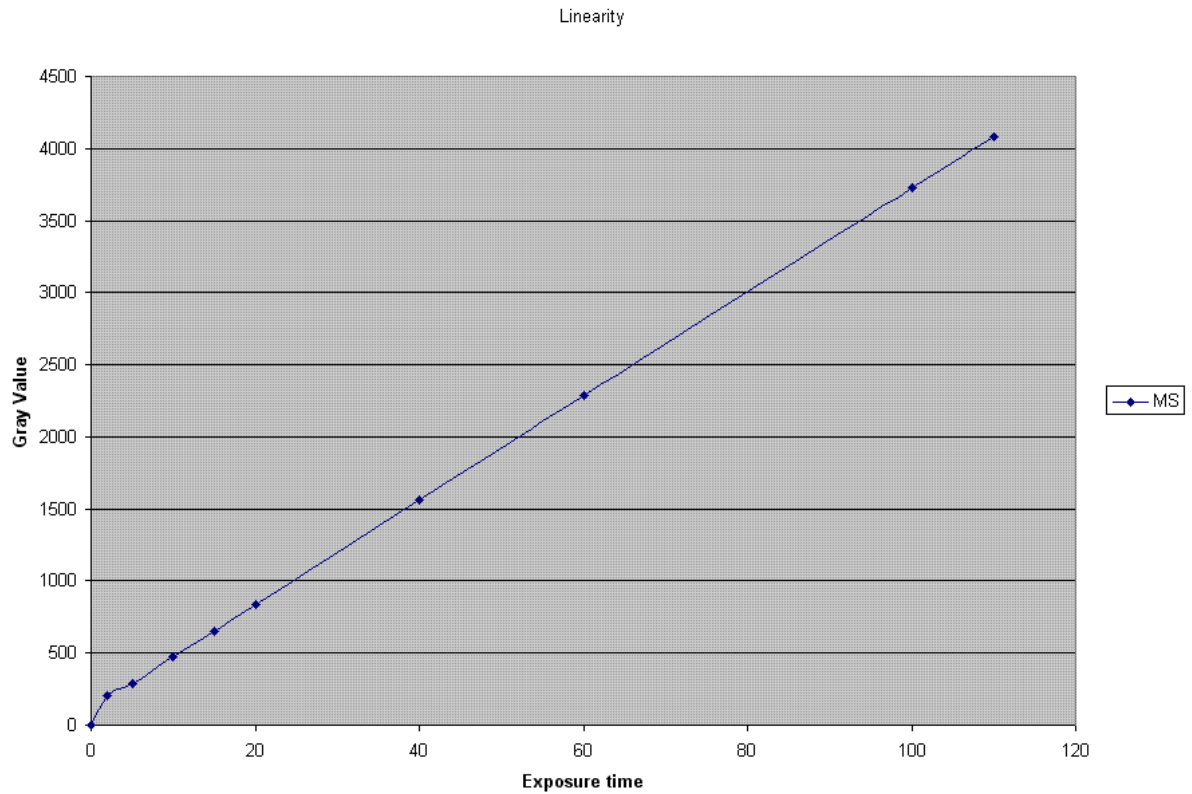
## Sensitivity of camera



**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".

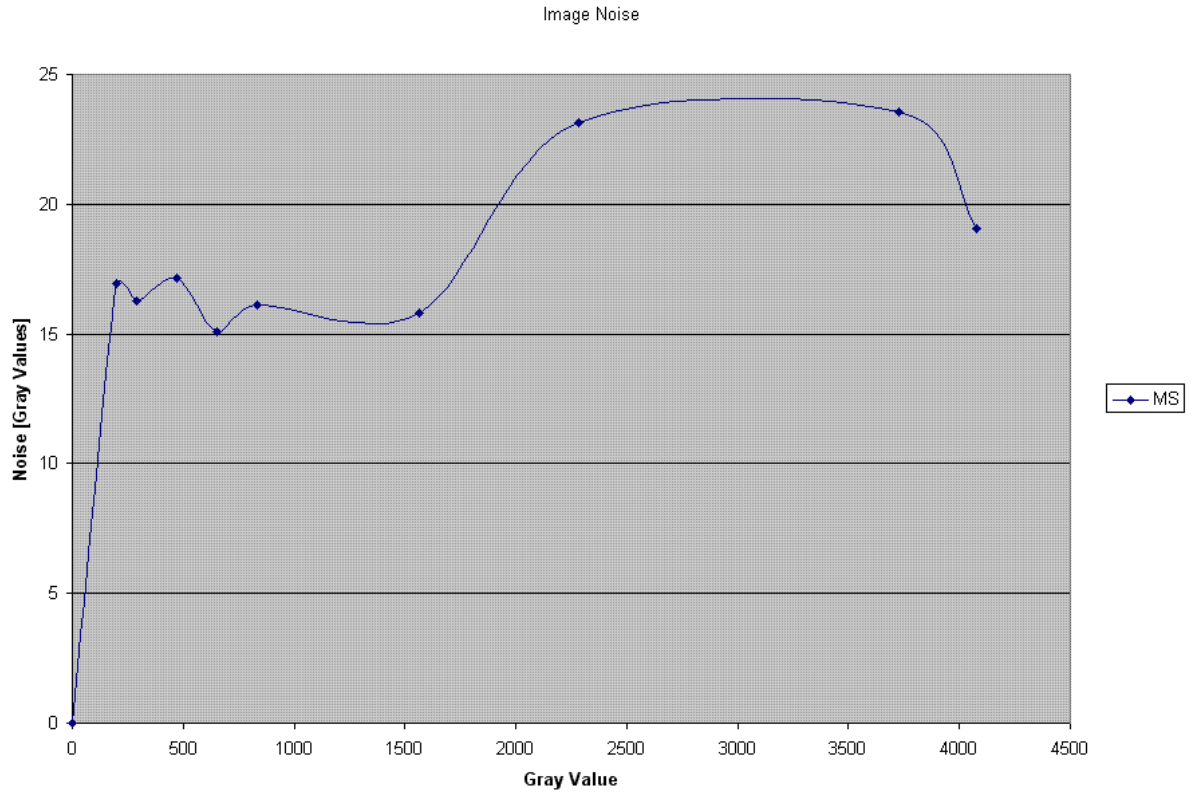
### Sensor Linearity



**Remark:**

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

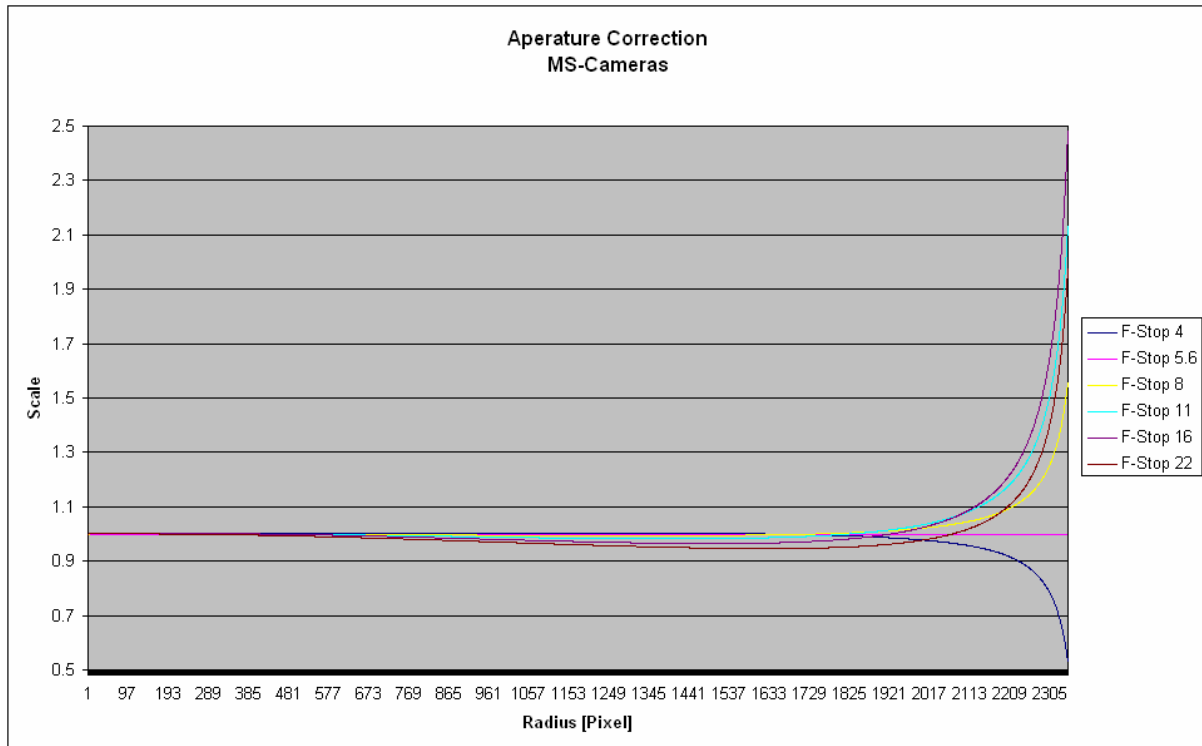
### Sensor Noise



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: 2

Nr    Row    Column

Defect Column	RowStart	ColumnStart	RowEnd	ColumnEnd
0	641	2434	1839	2434
1	1841	2434	1855	2434



# Calibration Protocol DMC01 - 0046



## Remark

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



Calibration Protocol  
DMC01 - 0046



## Calibration Certificate

N<sup>o</sup> 00114316

Object                    Digital Aerial Survey Camera  
Manufacturer            Z/I Imaging D-73431 Aalen  
Type                      DMC-MS-Blue  
Serial Number          00114316

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70

Date of Calibration                      28.Nov.2006

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CertifiedDate

10.Apr.2007

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

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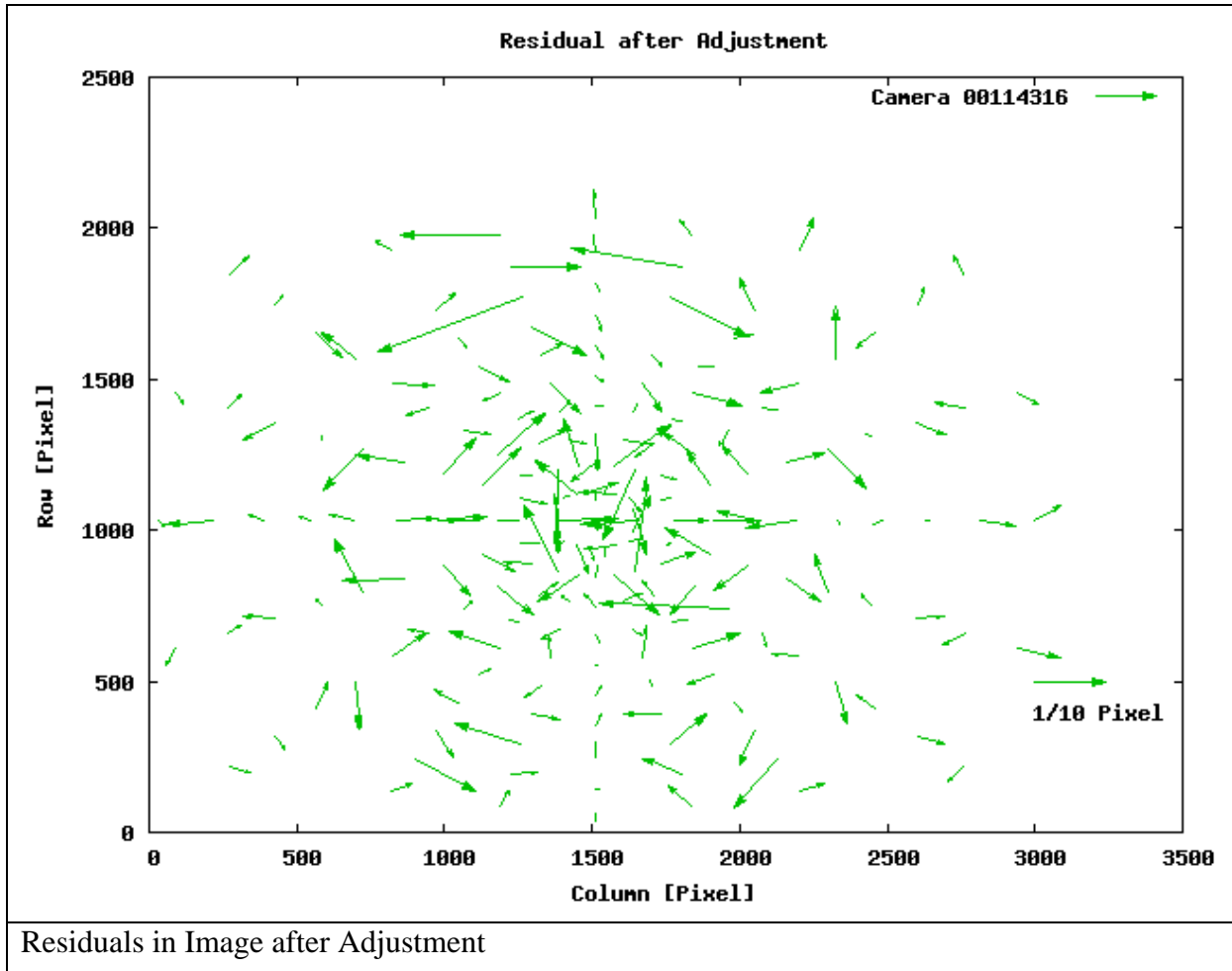
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-MS-Blue
Nominal Focal Length	0.025 m
Serial Number	00114316

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-0.0002569	1.381E-06
	$y_0$	-0.0001277	9.656E-07
Focal Length [m]	$\Delta f$	-2.126E-05	5E-07
Radial Distortion	$K_1$	-140.1	0.4218
	$K_2$	219600	2685
	$K_3$	-147600000	4829000
Decentering distortion	$P_1$	-0.0002255	0.0007182
	$P_2$	-0.0009474	0.0004395
In Plane Distortion	$B_1$	0.0001721	1.24E-05
	$B_2$	-4.073E-05	1.016E-05

Adjusted Focal length = 0.025+ dc =0.02497874 [m]



Max Residual [ $\mu\text{m}$ ]: 2.6

Threshold [ $\mu\text{m}$ ]: 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".

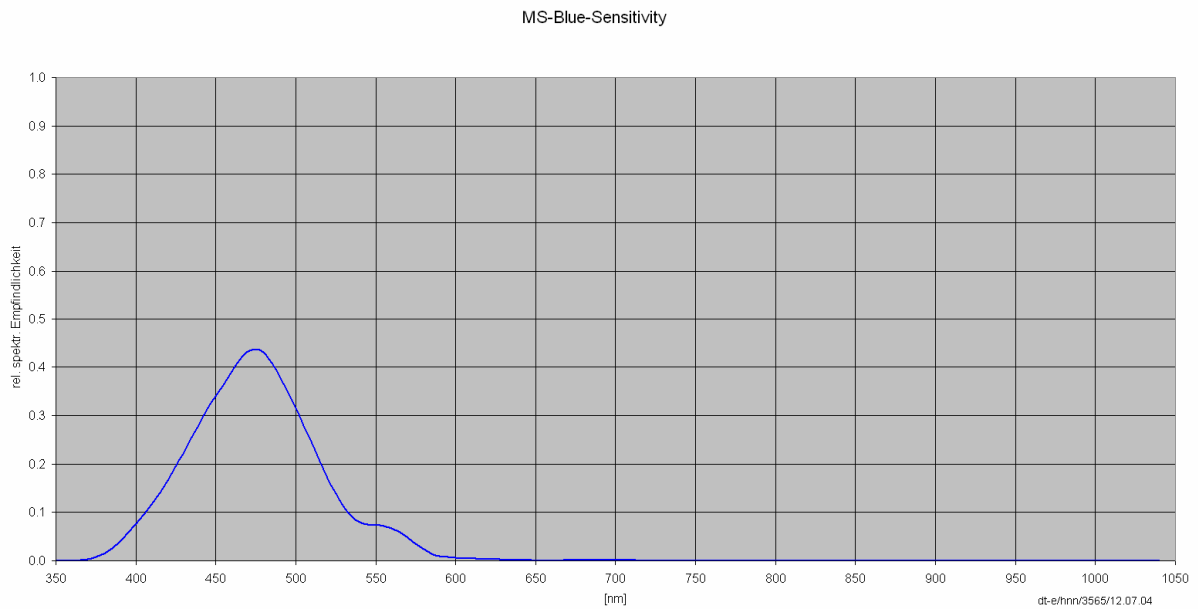
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

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

Camera ID	00114316
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1

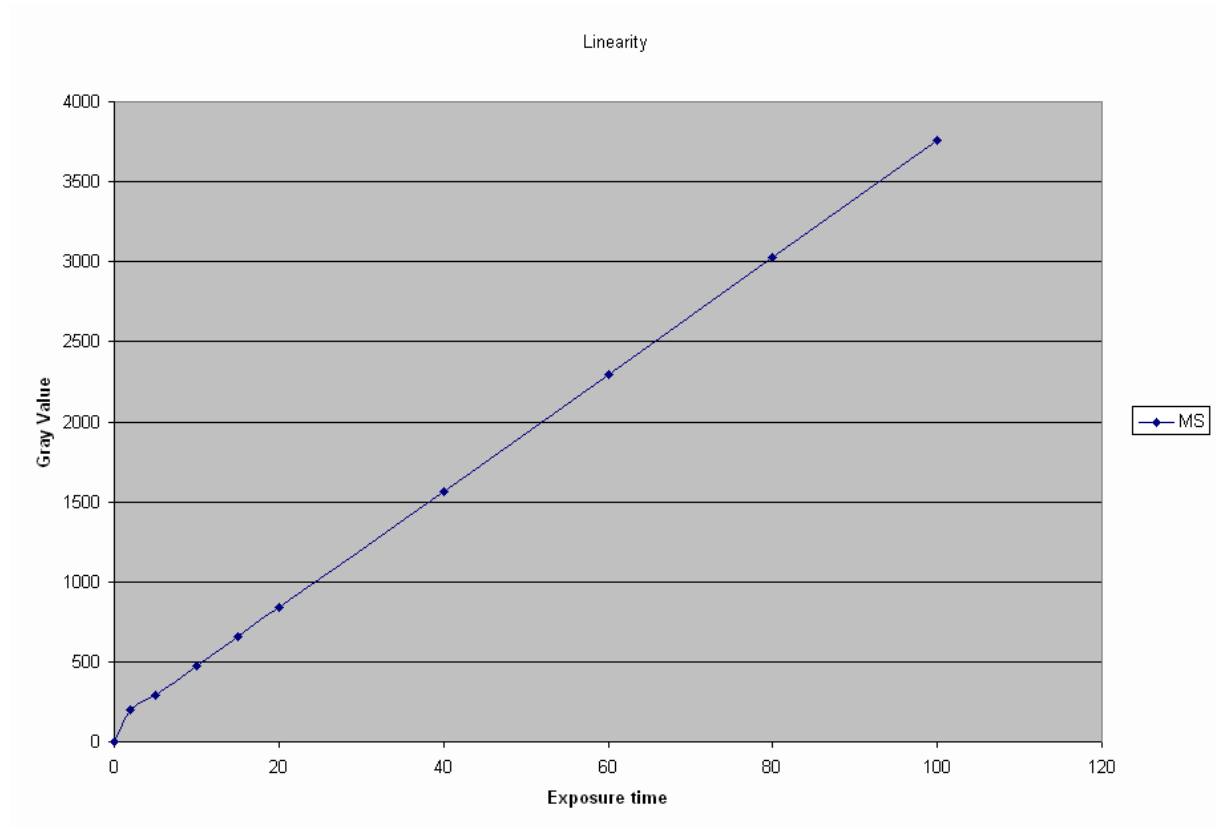
## Sensitivity of camera



**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".

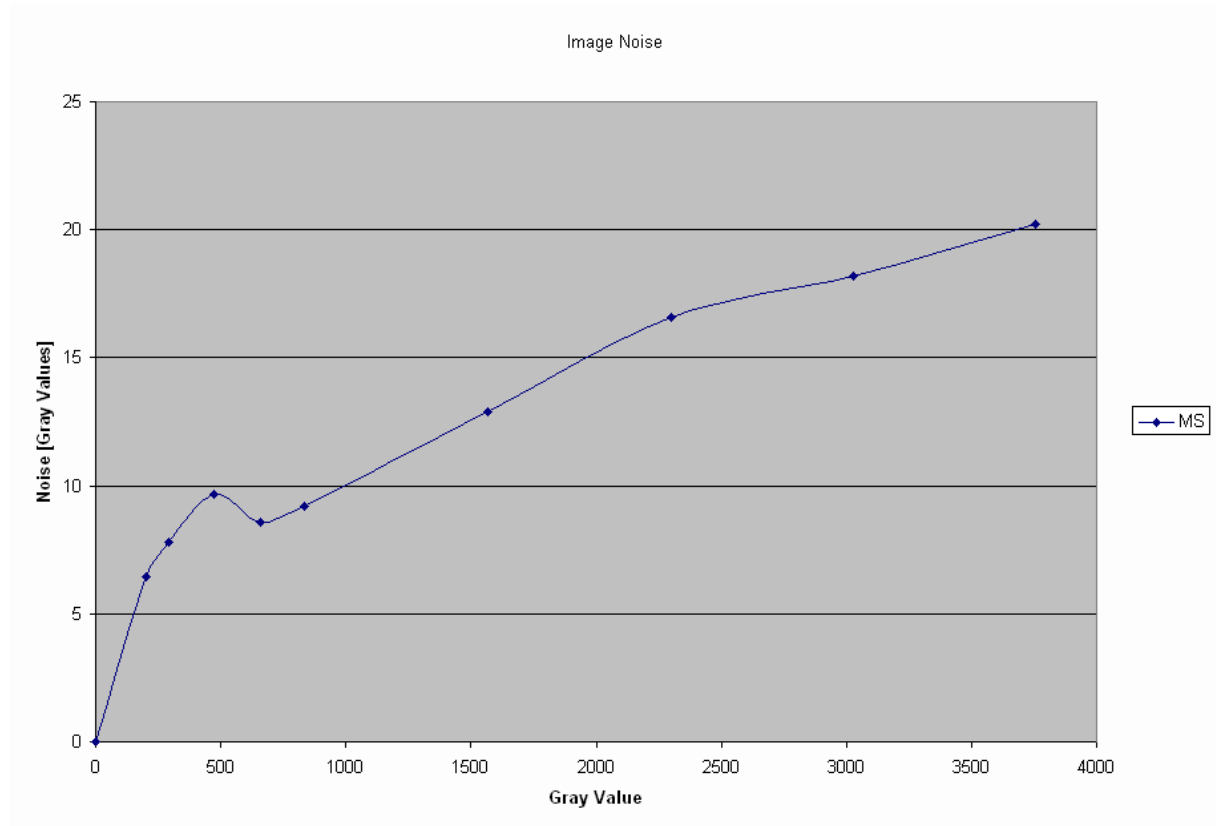
### Sensor Linearity



**Remark:**

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

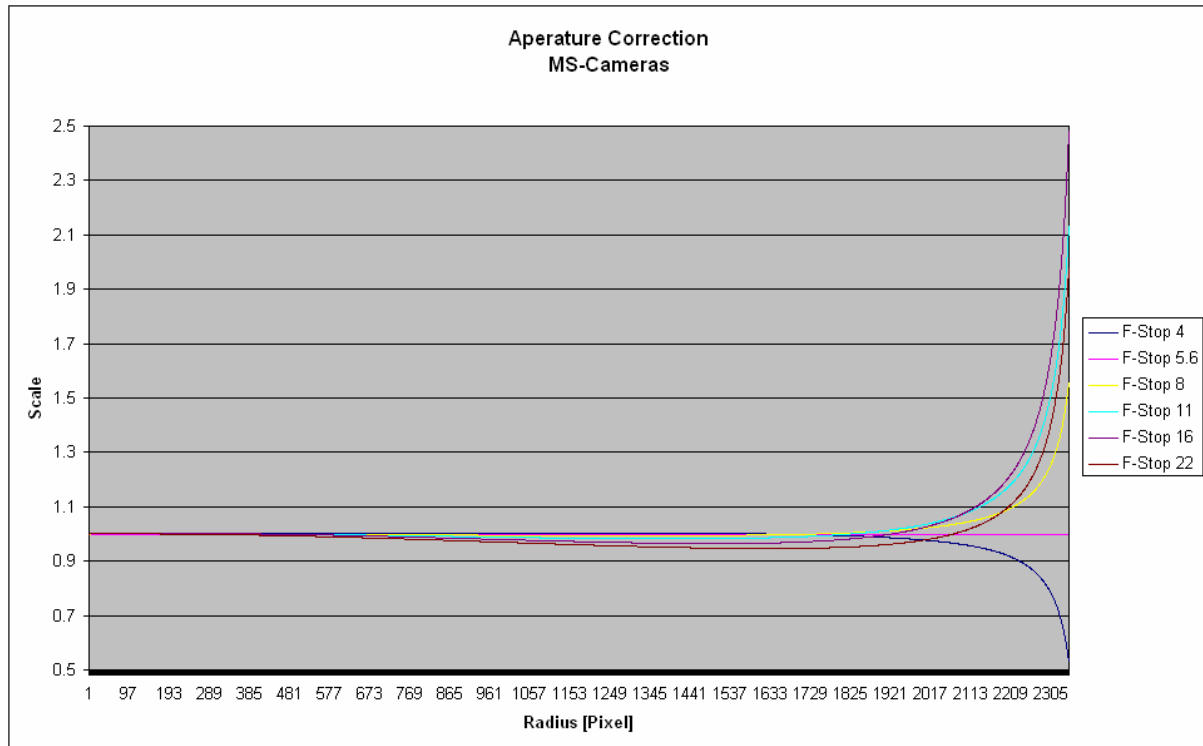
### Sensor Noise



**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 - 0046



**Calibration Certificate**

**N<sup>o</sup> 00113911**

Object                    Digital Aerial Survey Camera  
Manufacturer            Z/I Imaging D-73431 Aalen  
Type                     DMC-MS-Red  
Serial Number           00113911

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70

Date of Calibration                      29.Nov.2006

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CertifiedDate

10.Apr.2007

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

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## Geometric Calibration Protocol

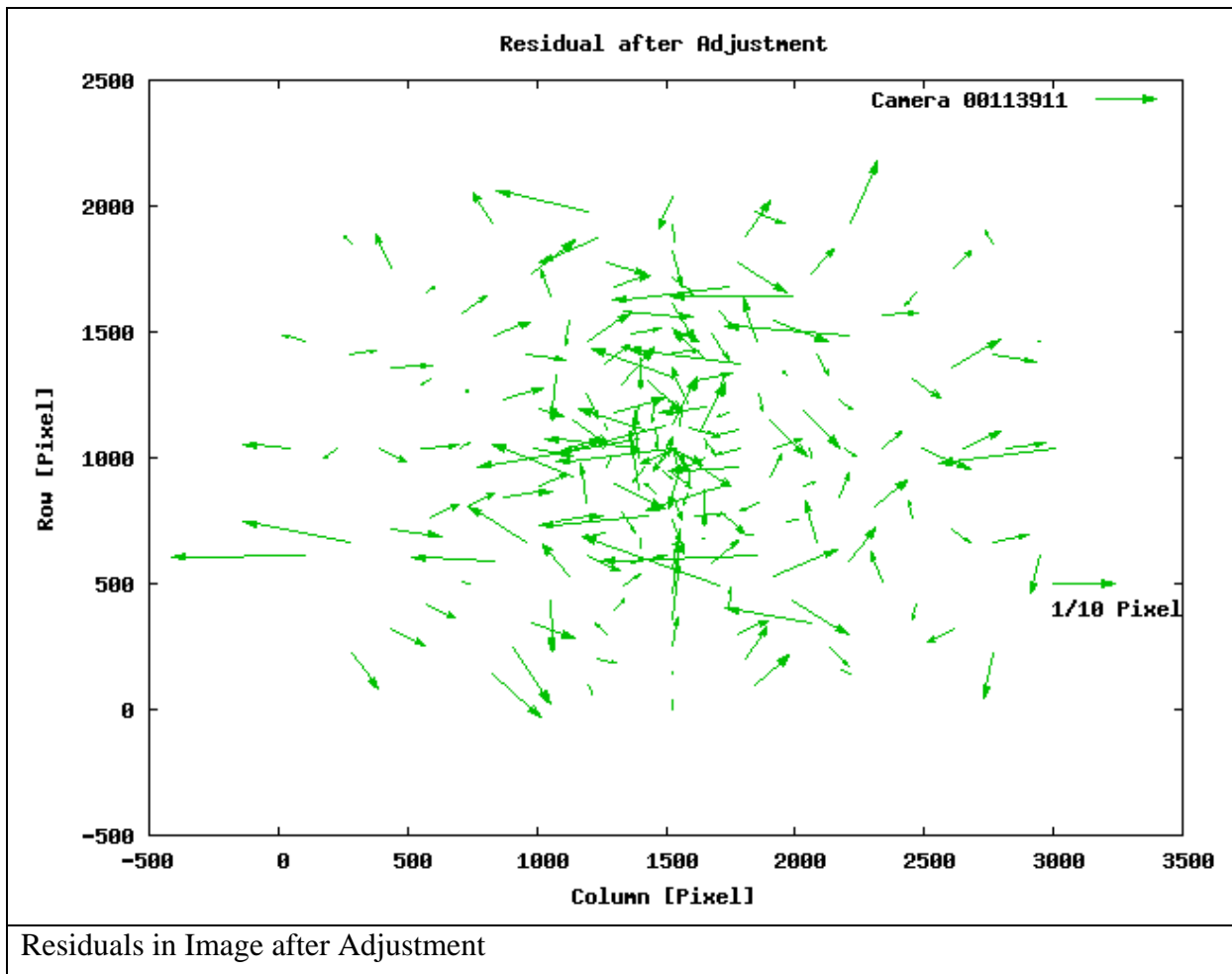
### Calibration Parameters for single camera head

Camera Type	DMC-MS-Red
Nominal Focal Length	0.025 m
Serial Number	00113911

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-0.0001549	2.072E-06
	$y_0$	-0.0001684	1.455E-06
Focal Length [m]	$\Delta f$	-5.766E-05	7.51E-07
Radial Distortion	$K_1$	-139.5	0.6336
	$K_2$	225200	4035
	$K_3$	-154200000	7256000
Decentering distortion	$P_1$	-0.0003369	0.001077
	$P_2$	0.001288	0.0006633
In Plane Distortion	$B_1$	0.0001435	1.862E-05
	$B_2$	-2.535E-05	1.526E-05

Adjusted Focal length = 0.025+ dc =0.02494234 [m]





Max Residual [ $\mu\text{m}$ ]: 3.2

Threshold [ $\mu\text{m}$ ]: 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".

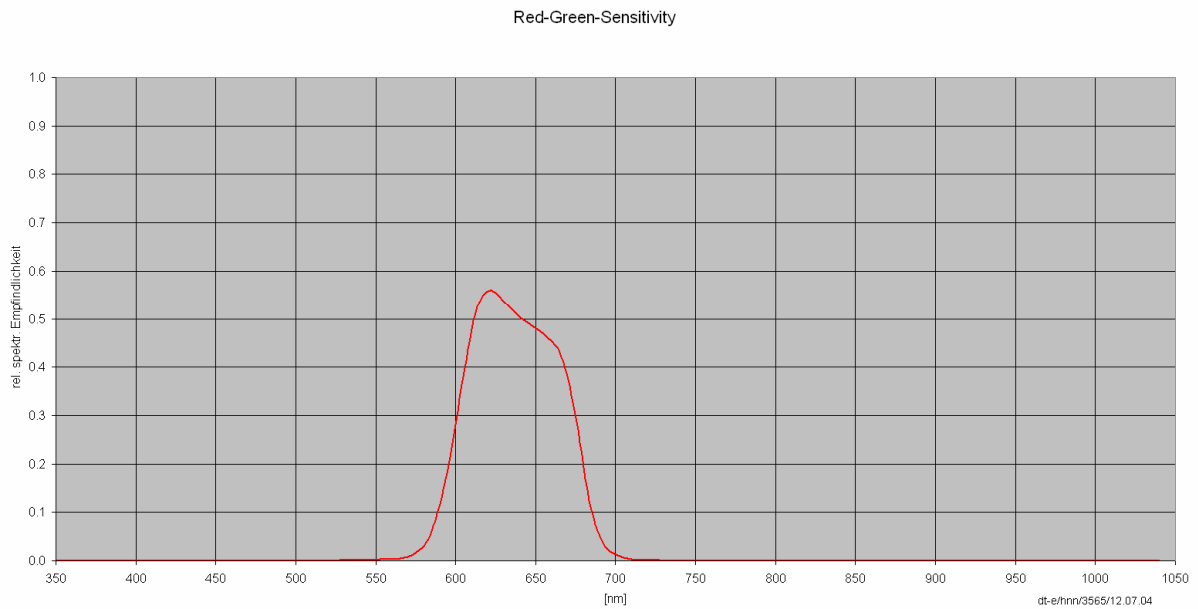
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

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

Camera ID	00113911
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1

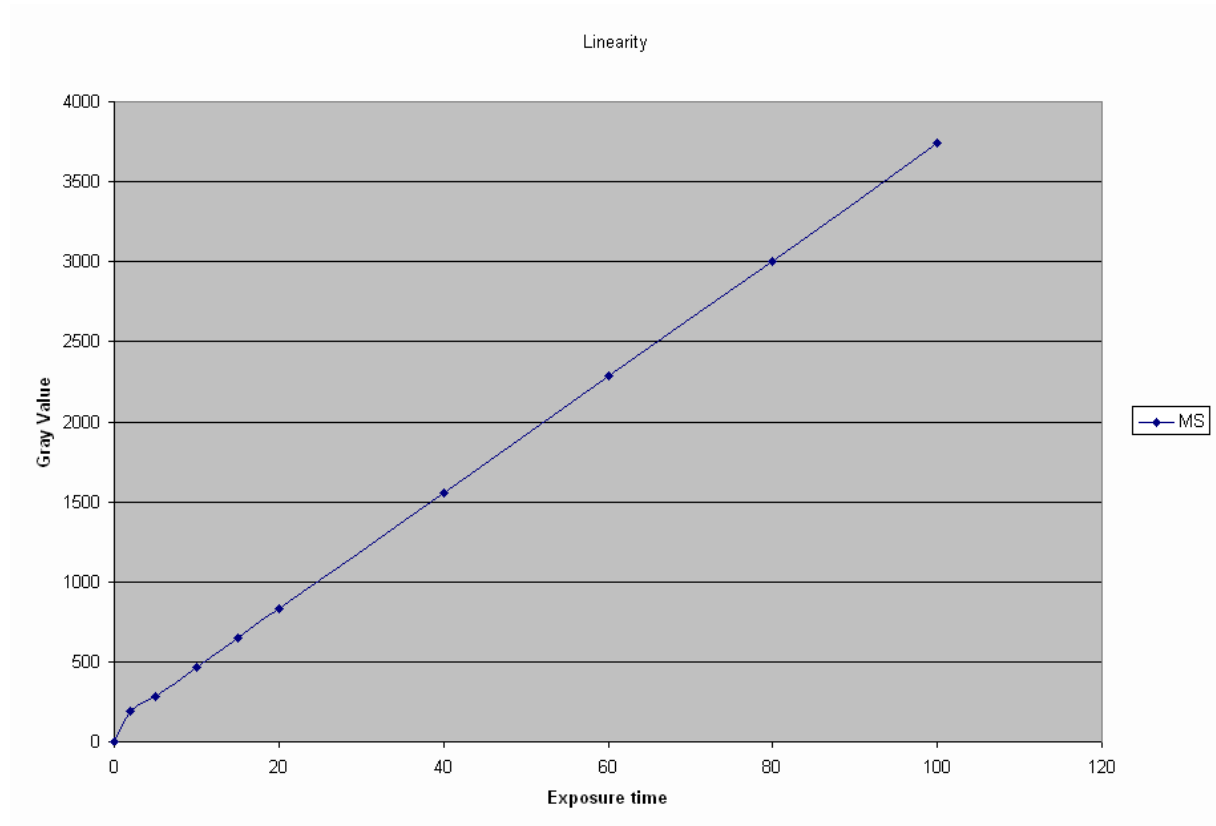
## Sensitivity of camera



**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".

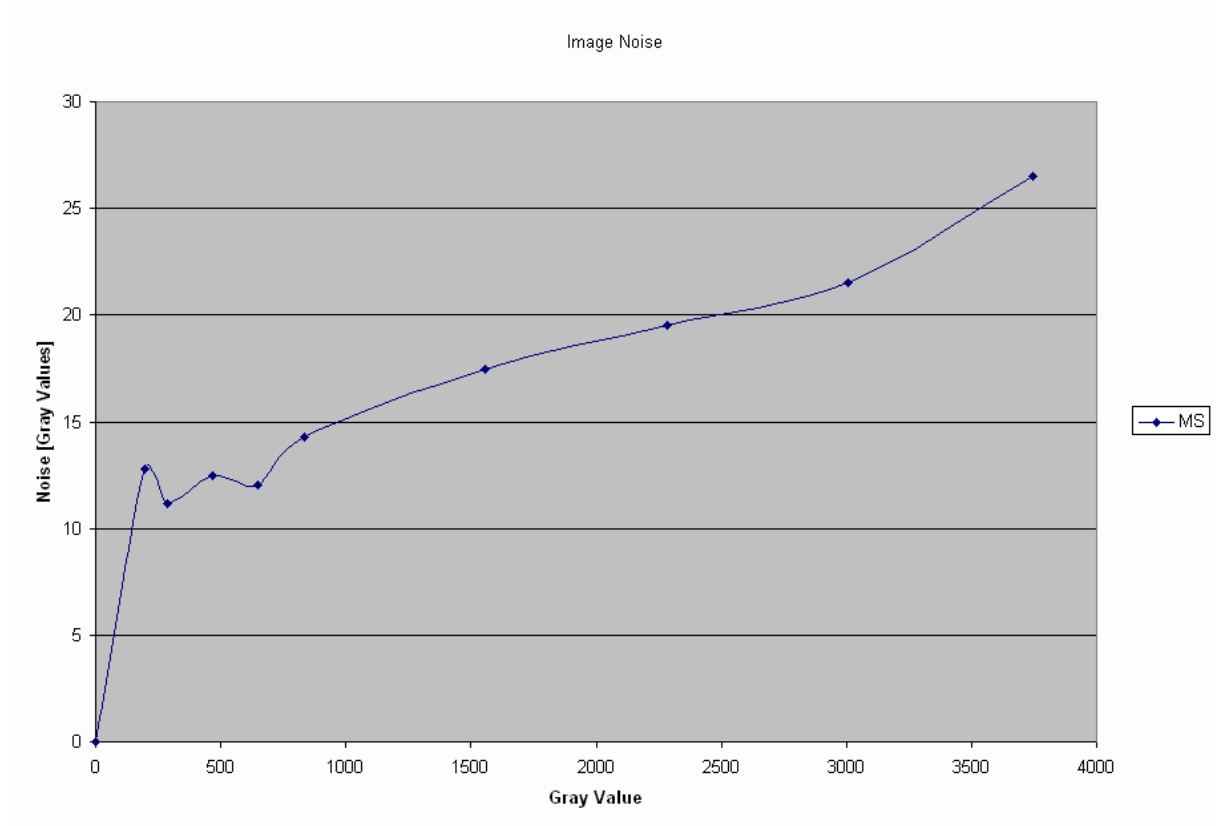
### Sensor Linearity



**Remark:**

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

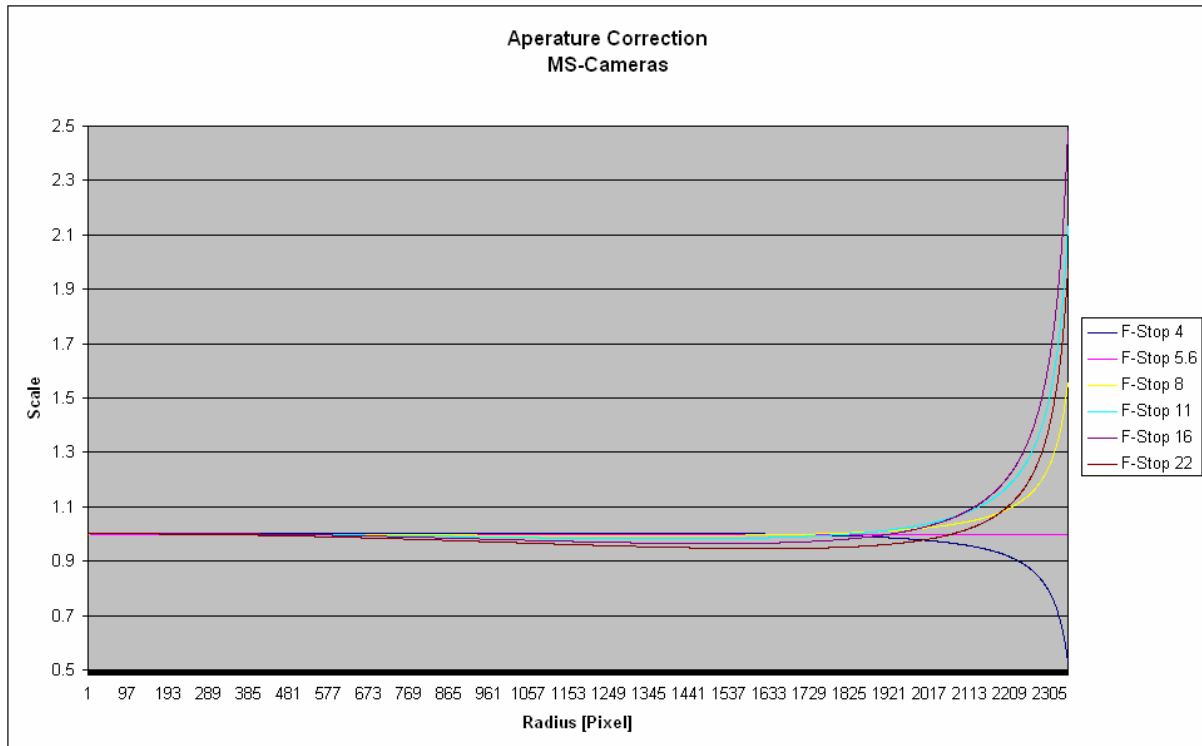
### Sensor Noise



**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	1931	2135	2047	2135

**Remark**

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



Calibration Protocol  
DMC01 - 0046



## Calibration Certificate

N<sup>o</sup> 00114323

Object                    Digital Aerial Survey Camera  
Manufacturer            Z/I Imaging D-73431 Aalen  
Type                      DMC-MS-Green  
Serial Number            00114323

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70

Date of Calibration                      08.Dec.2006

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CertifiedDate

10.Apr.2007

Division Head

  
(H. Sohnle)

Person in Charge

  
(S. Schröder)

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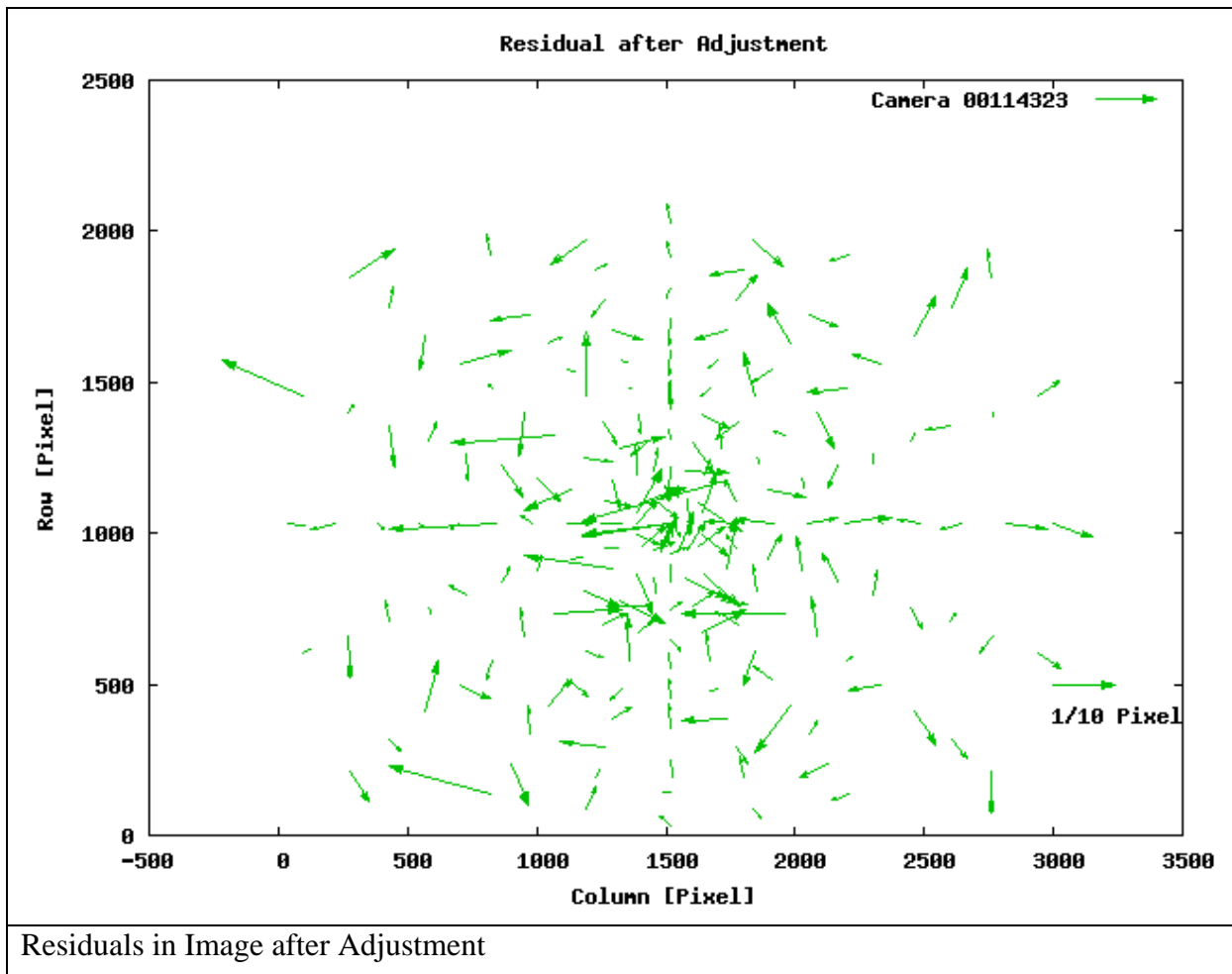
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-MS-Green
Nominal Focal Length	0.025 m
Serial Number	00114323

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-0.0002431	1.436E-06
	$y_0$	-8.58E-05	1.009E-06
Focal Length [m]	$\Delta f$	-4.13E-05	5.24E-07
Radial Distortion	$K_1$	-137.7	0.4421
	$K_2$	215800	2815
	$K_3$	-143400000	5062000
Decentering distortion	$P_1$	-0.0008696	0.0007466
	$P_2$	2.043E-05	0.0004603
In Plane Distortion	$B_1$	0.0001475	1.299E-05
	$B_2$	-7.172E-05	1.065E-05

Adjusted Focal length = 0.025+ dc =0.0249587 [m]



Max Residual [ $\mu\text{m}$ ]: 2.9

Threshold [ $\mu\text{m}$ ]: 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.

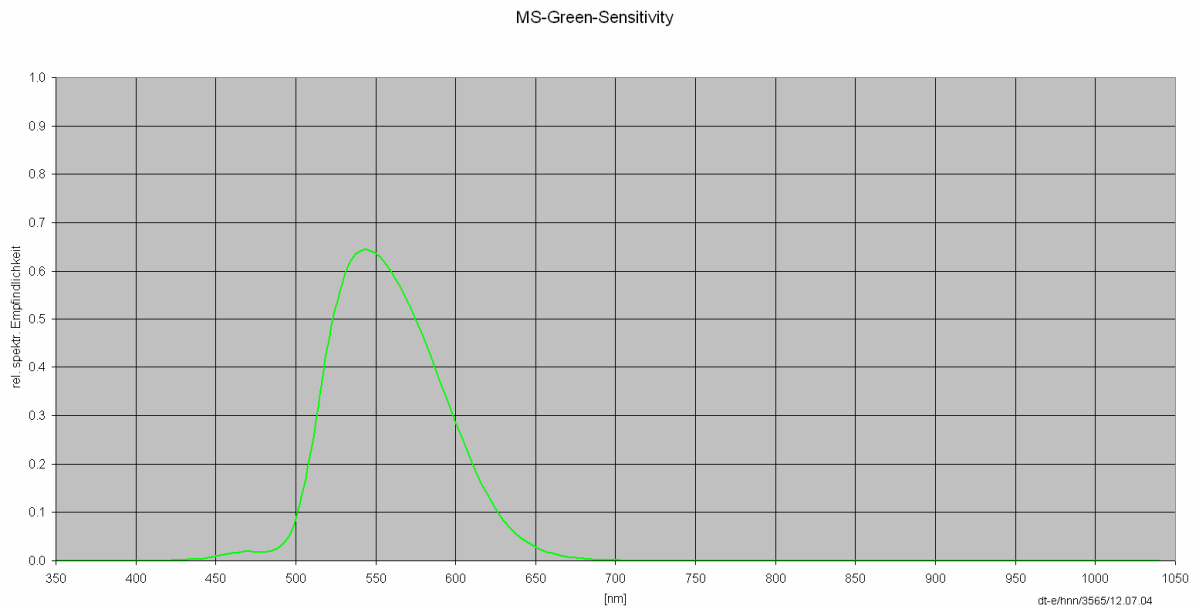
## Radiometric Calibration Protocol

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

Camera ID	00114323
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1



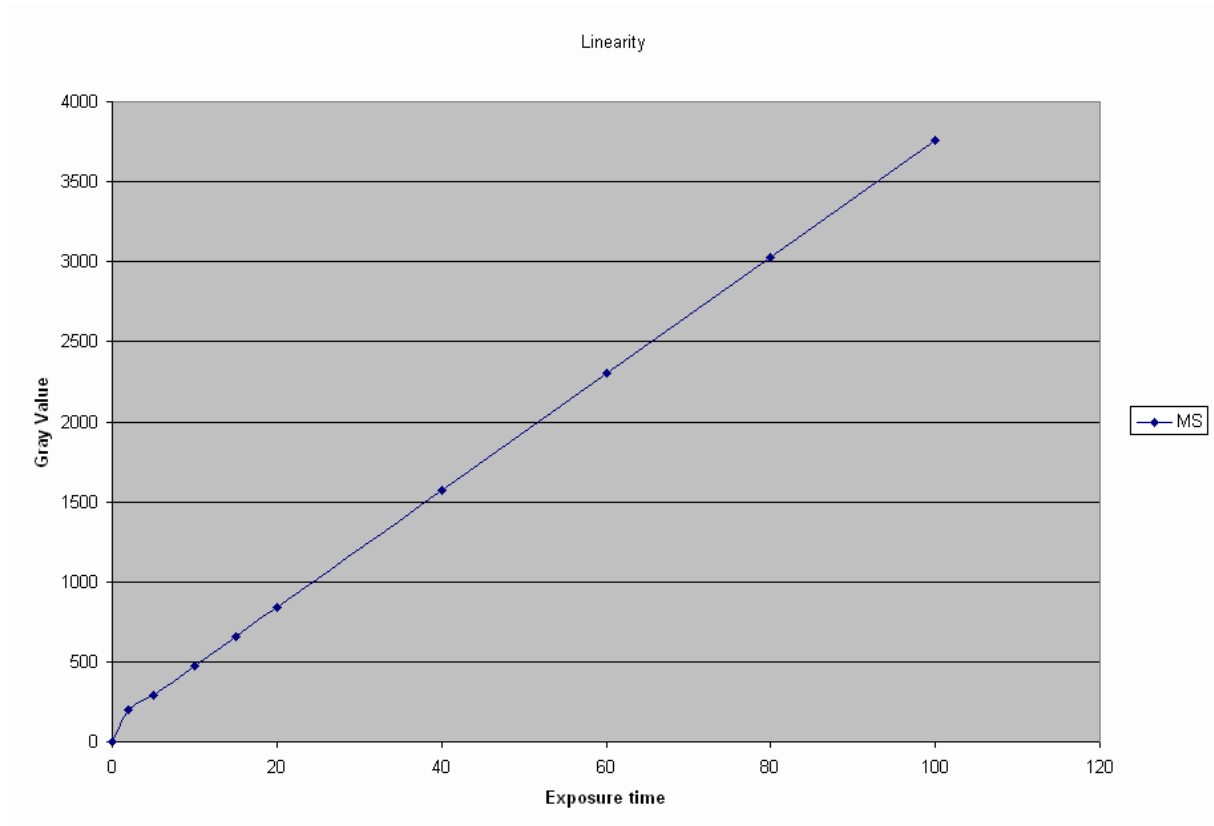
## Sensitivity of camera



**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".

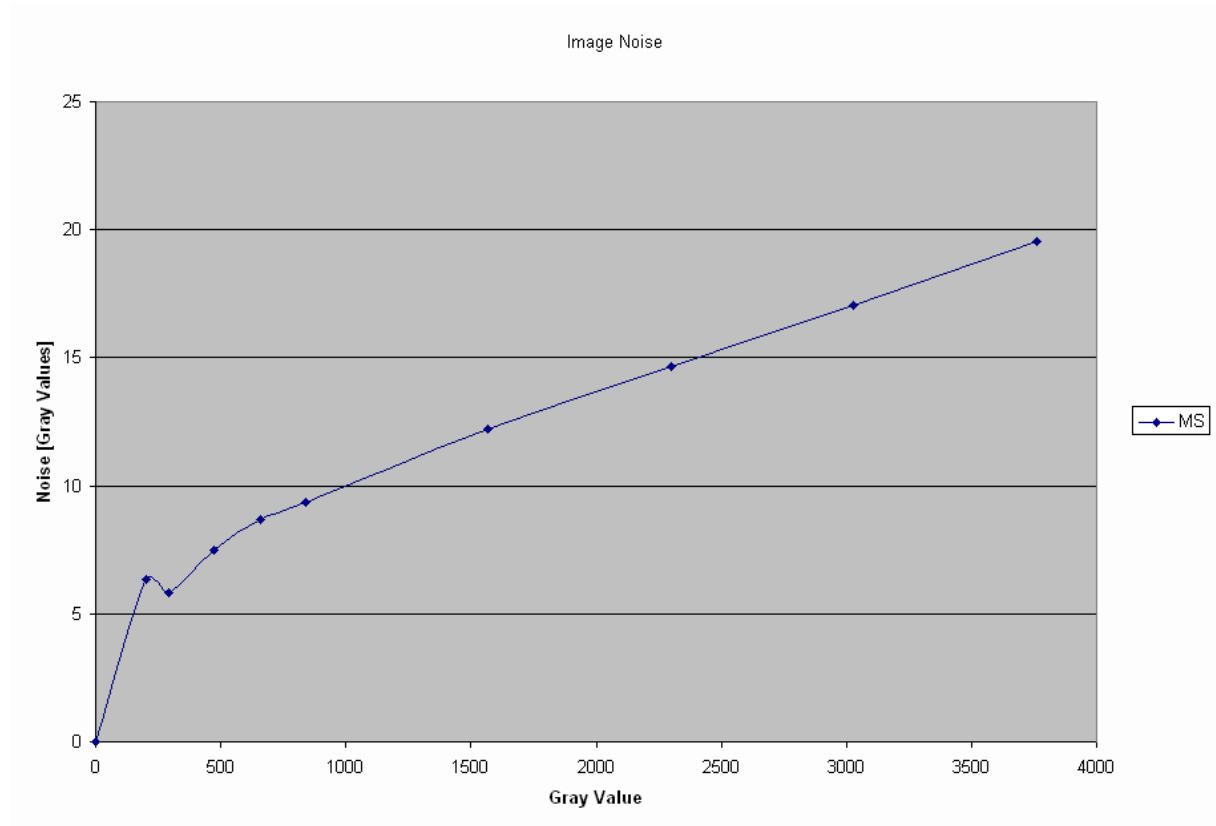
### Sensor Linearity



**Remark:**

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

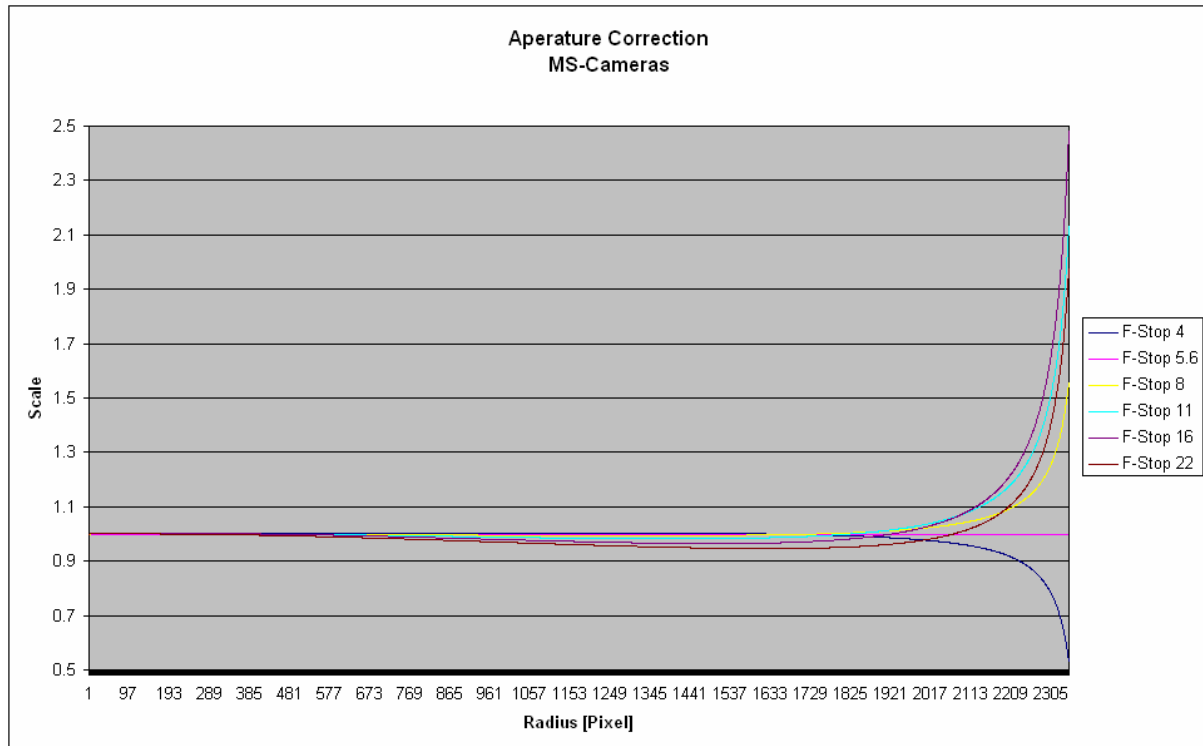
### Sensor Noise



**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: 16

Number of defect clusters: 0

Number of defect columns: 0

Nr	Row	Column
----	-----	--------

0	27	383
---	----	-----

1	27	384
---	----	-----

2	664	664
---	-----	-----

3	664	665
---	-----	-----

4	503	944
---	-----	-----

5	503	945
---	-----	-----



# Calibration Protocol DMC01 - 0046



6	504	945
7	504	946
8	505	946
9	1919	1468
10	1920	1468
11	1314	2431
12	209	2541
13	210	2541
14	210	2542
15	1567	2670

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 $\leq 50$ MS $\leq 1$	
	Max double Column	PAN $\leq 4$ MS $\leq 0$	

## Bibliography

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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.