



Calibration Protocol  
DMC01 - 0044



# Calibration Certificate

Digital Mapping Camera (DMC)

DMC Serial Number: **DMC01-0044**

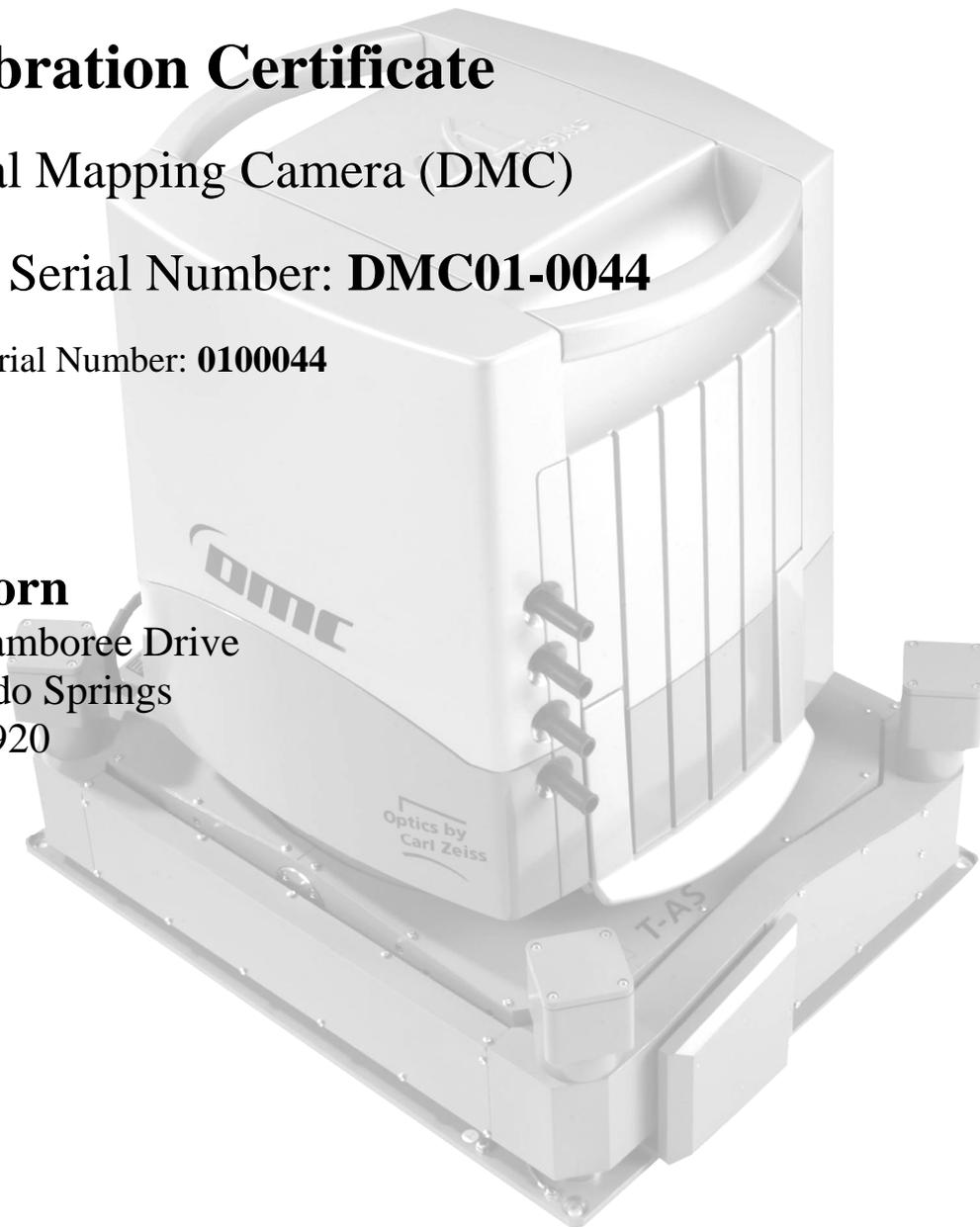
CBU Serial Number: **0100044**

For

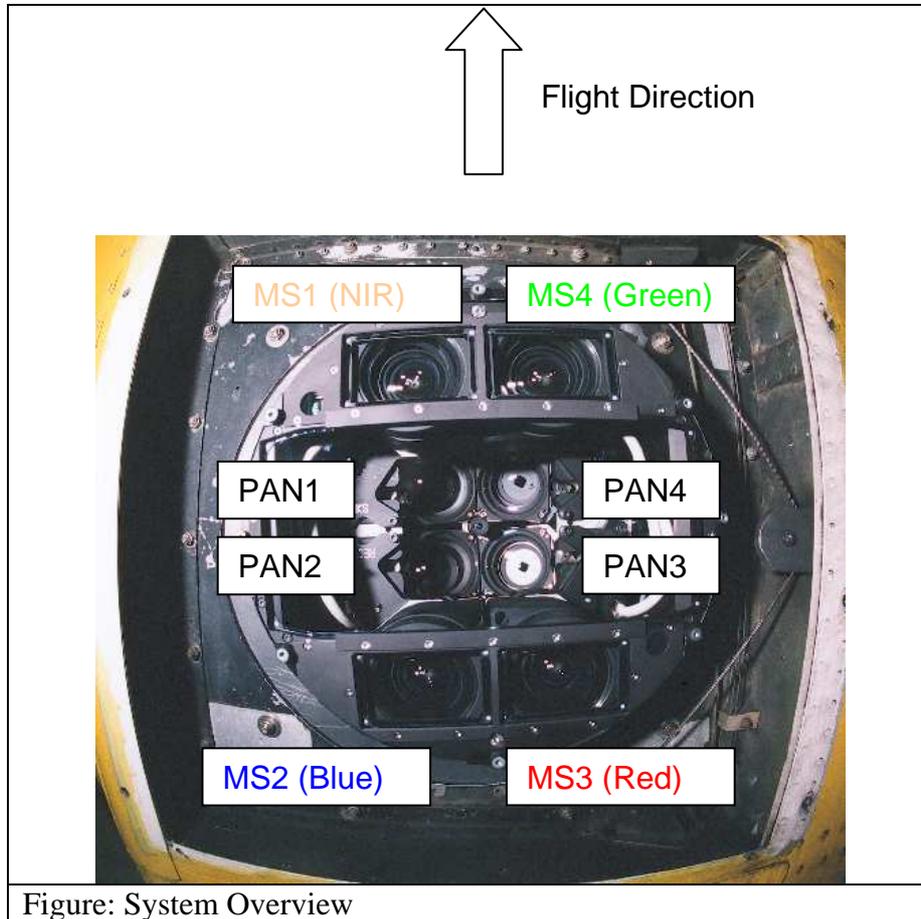
**Sanborn**

1935 Jamboree Drive  
Colorado Springs  
CO 80920

USA



## System Overview



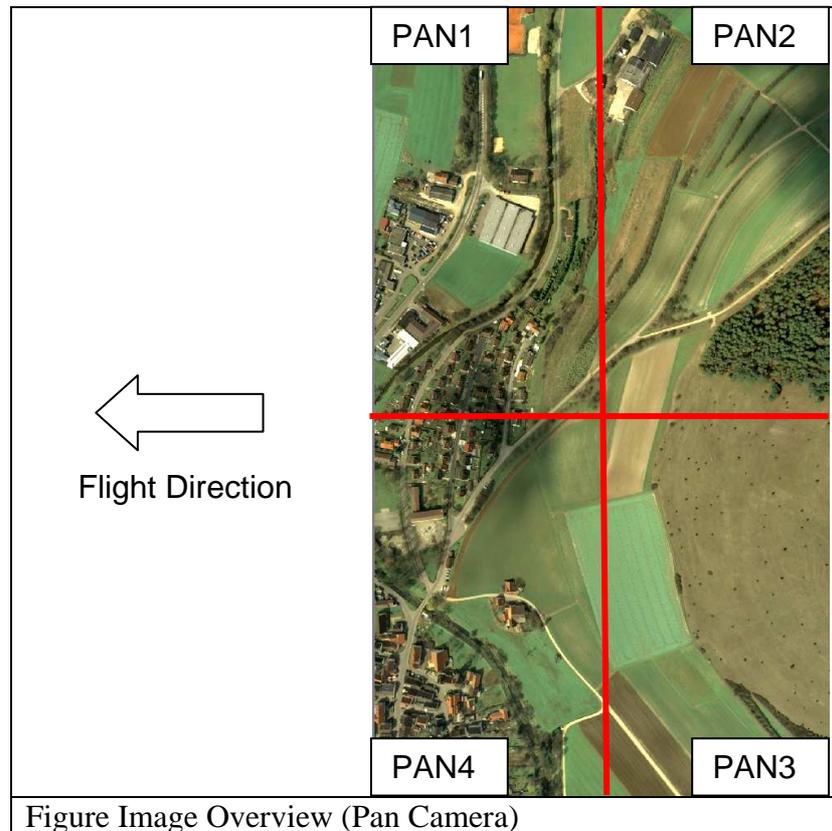


Figure Image Overview (Pan Camera)

### **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: 28.11.2006					
Camera	Serial Number	Calib. Date				
PAN1	00114276	06.11.2006				
PAN2	00114277	01.11.2006				
PAN3	00114283	13.11.2006				
PAN4	00114284	07.11.2006				
MS1 (NIR)	00113936	06.11.2006				
MS2 (Blue)	00111744	04.11.2006				
MS3 (Red)	00113913	10.11.2006				
MS4 (Green)	00113893	24.10.2006				

## Camera Orientation PAN-Cameras (Burn-In Flight 16.11.2006)

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)	17.983 (0.001)	10.088 (0.001)	87.016 (0.001)
PAN2 (0111726)	-0.064 (0)	-0.079 (0)	1000 (0)	17.927 (0.001)	-10.198 (0.001)	93.185 (0.001)
PAN3 (0211172)	-0.064 (0)	0.079 (0)	1000 (0)	-17.980 (0.001)	-10.074 (0.001)	-93.169 (0.001)
PAN4 (02111731)	0.064 (0)	0.079 (0)	1000 (0)	-17.928 (0.001)	10.183 (0.001)	-87.010 (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

29.11.2006  
Date



# Calibration Protocol DMC01 - 0044



## Additional System Components (Burn-In Flight 28.11.2006)

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)

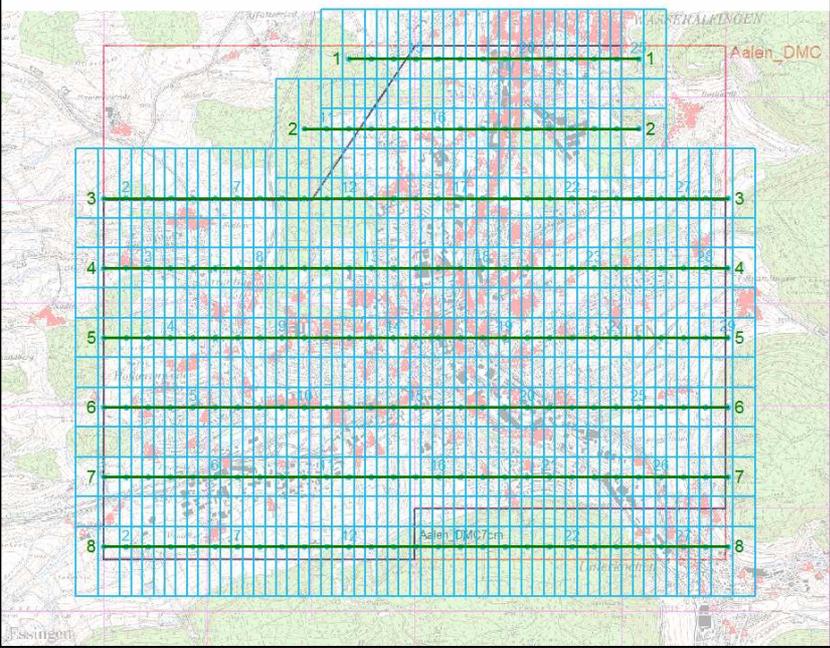
The results of the orientation of the IMU were generated with support of ImageStation Automatic Triangulation (ISAT), Version 5.1, from Intergraph Z/I Imaging photogrammetric product suite.

Calibration performed by

\_\_\_\_\_  
Dipl. Ing. C. Müller

\_\_\_\_\_  
Date

## Aerotriangulation Results (Burn-In Flight 28.11.2006)

	Photo Scale	1:5833
	Flying Height [m]	700 AGL
	Flying Altitude [m]	1130 AMSL
	Run-Spacing [m]	677.4
	Base-Length [m]	215.0
	Number of Exposures	204
	Side-lap [%]	30
	End-lap [%]	60
	Terrain Height [m]	430
	Number of strips	8
	Photos in one strip	14-29
	Photos Used	155
	Control Points Used	254
	Check Points Used	0
	GSD [cm]	7

### Statistic results:

<b>Matching results: 0 Weak Areas - covered with clouds</b>	
<b>Whole Block</b>	155 exposures used 0 exposures not used
<b>Whole Block</b>	<b>Sigma relativ: 1.661 um</b>
<b>Whole Block</b>	<b>Sigma absolut: 1.280 um</b>
<b>Whole Block</b>	
Photo-T Parameters and Results for Project Aalen_DMC_44	
PhotoT Triangulation Options	
Adjustment Mode	: Absolute
Precision Computation	: Enabled
Error Detection	: Disabled
Camera Calibration	: Disabled
Self-Calibration	: Enabled
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	0.035	0.039	0.102	0.037
	RMS Check				
	RMS Limits	0.100	0.100	0.150	
	Max Ground Residual	0.102	0.194	0.315	
	Residual Limits	0.100	0.100	0.150	
	Mean Std Dev Object	0.000	0.000	0.000	
	RMS Photo Position				
	RMS Photo Attitude				
	Mean Std Dev Photo Position	0.000	0.000	0.000	
	Mean Std Dev Photo Attitude	0.000	0.000	0.000	

Key Statistics

Sigma:           **1.3 um**

Number of iterations: 4

Degrees of Freedom: 38530

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

30.11.2006  
 Date



Calibration Protocol  
DMC01 - 0044



## Calibration Certificate

N<sup>o</sup> 00114276

Object                      Digital Aerial Survey Camera  
Manufacturer              Z/I Imaging D-73431 Aalen  
Type                         DMC-Panchromatic  
Serial Number              00114276

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70

Date of Calibration                      06.Nov.2006

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CertifiedDate

04.Dec.2006

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

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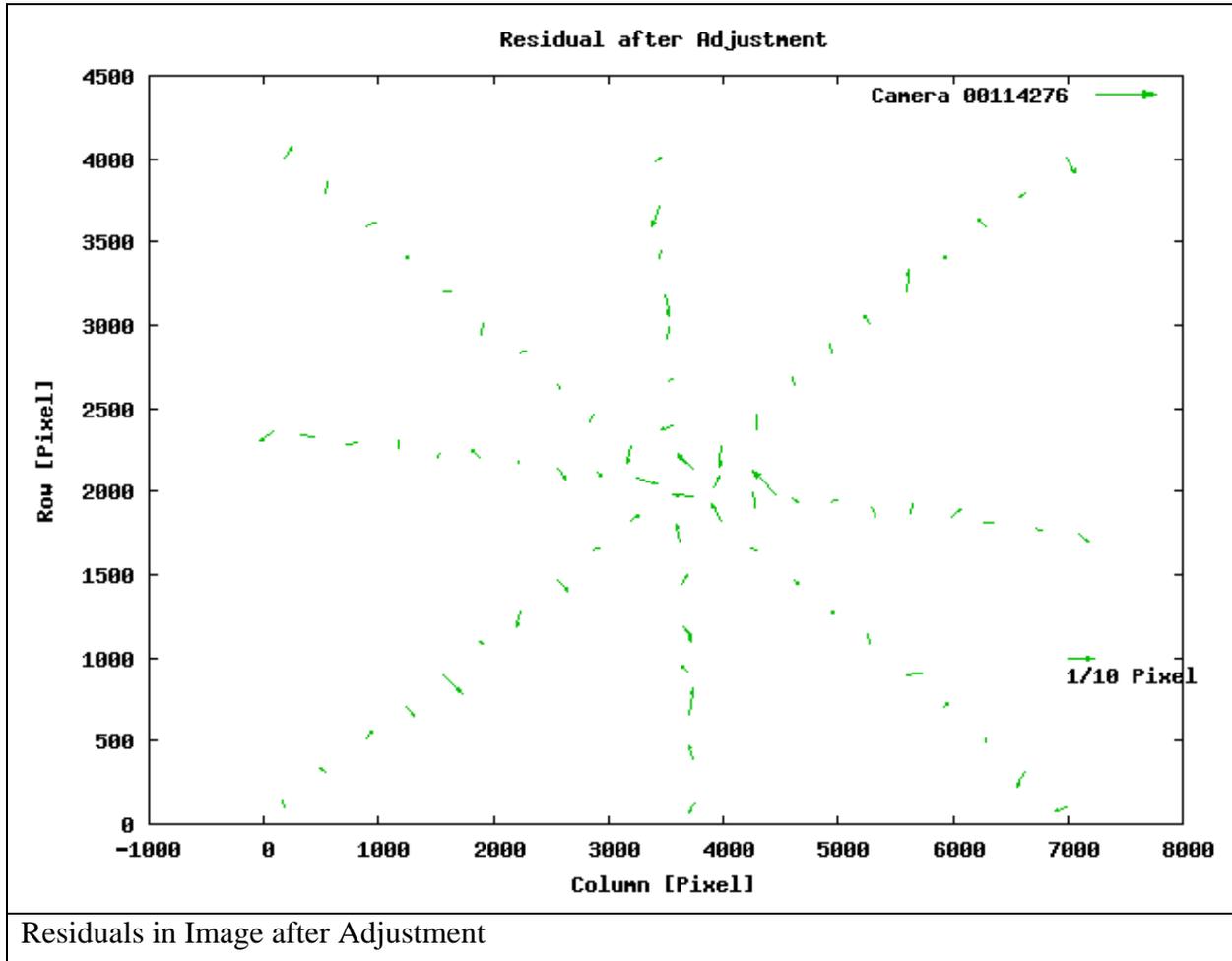
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00114276

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-1.102E-05	6.343E-06
	$y_0$	-5.824E-05	3.832E-06
Focal Length [m]	$\Delta f$	-0.000458	1.099E-06
Radial Distortion	$K_1$	0.6105	0.02874
	$K_2$	-259.9	26.12
	$K_3$	-25730	6918
Decentering distortion	$P_1$	-0.0005148	0.0001446
	$P_2$	1.983E-05	7.278E-05
In Plane Distortion	$B_1$	-8.043E-05	7.613E-06
	$B_2$	7.231E-05	4.46E-06

Adjusted Focal length = 0.12+ dc =0.119542 [m]



Max Residual [ $\mu\text{m}$ ]: 1.2

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".

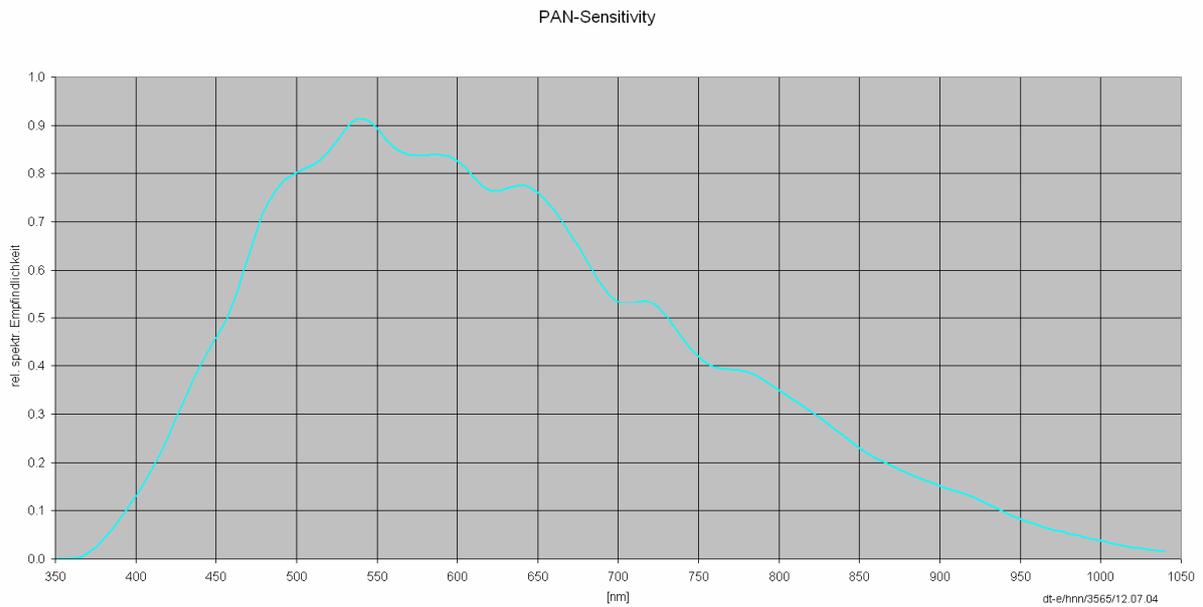
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

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

Camera ID	00114276
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

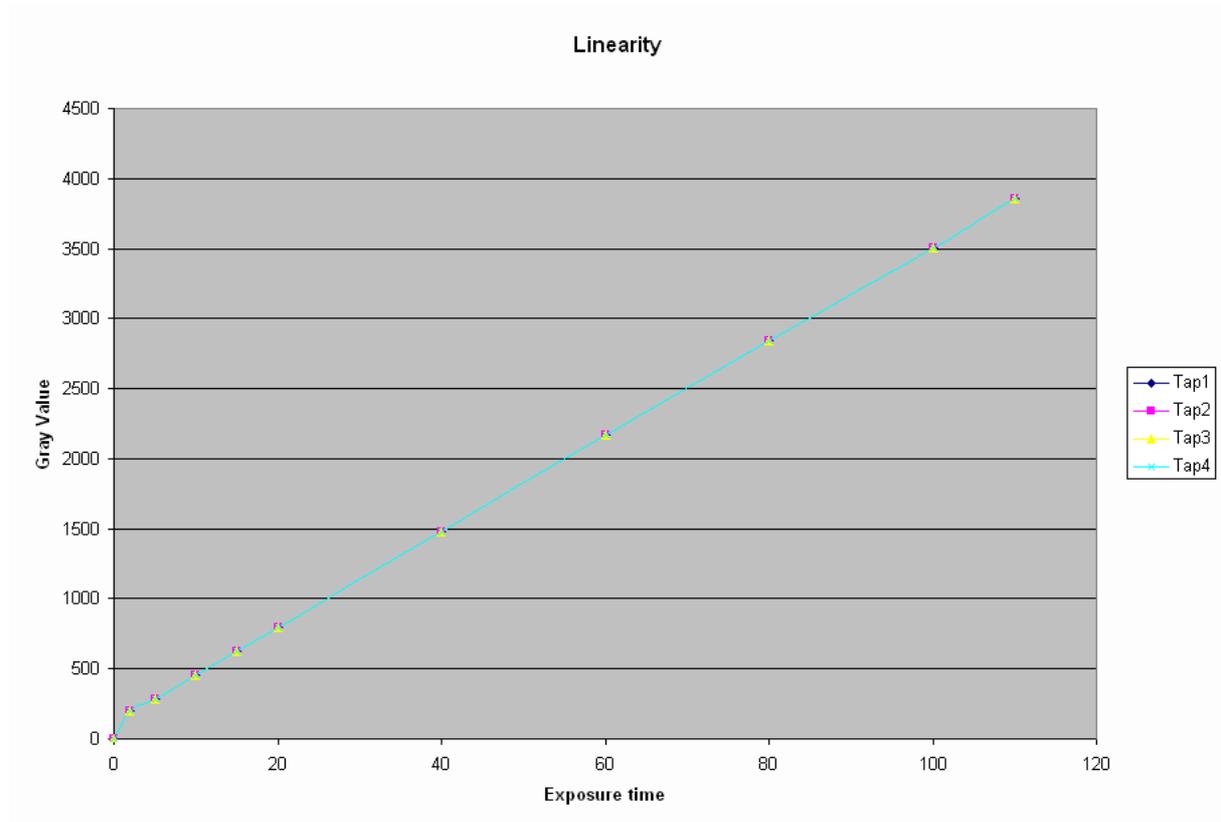
## Sensitivity of camera



**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".

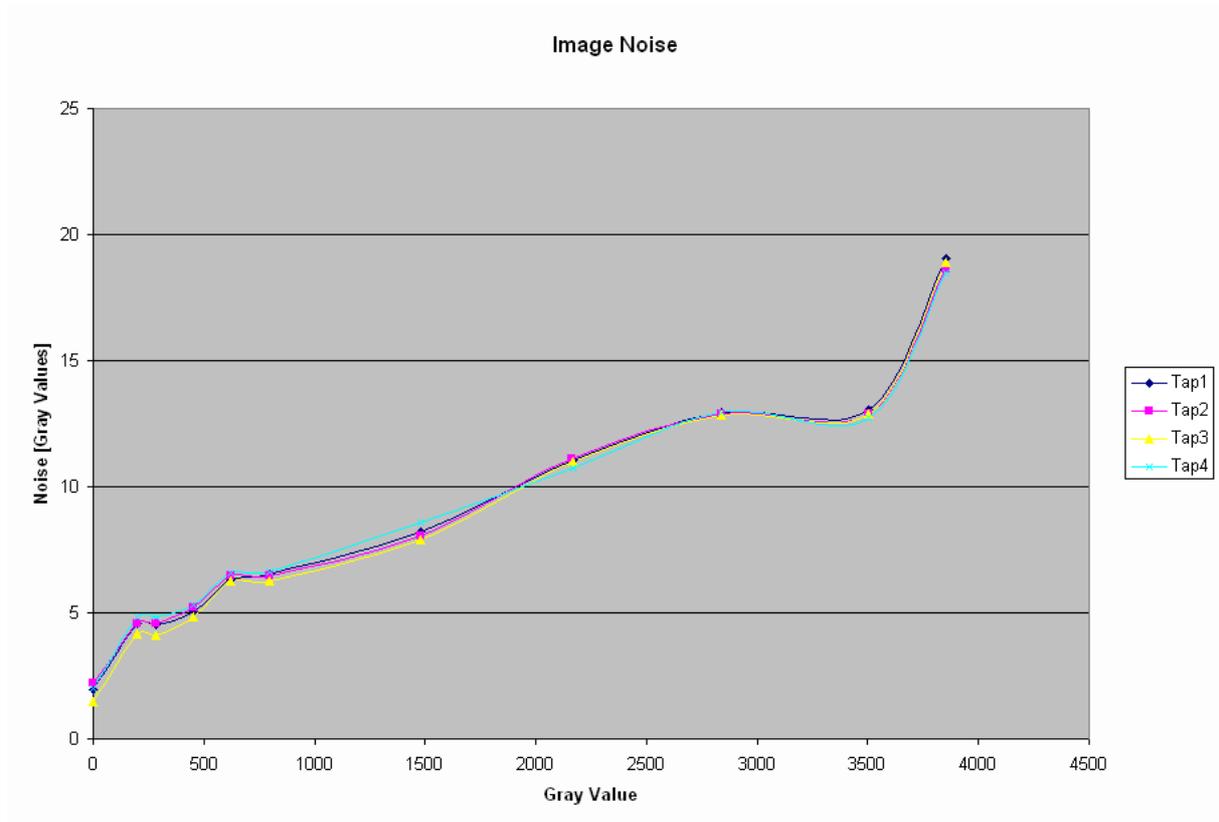
### Sensor Linearity



**Remark:**

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

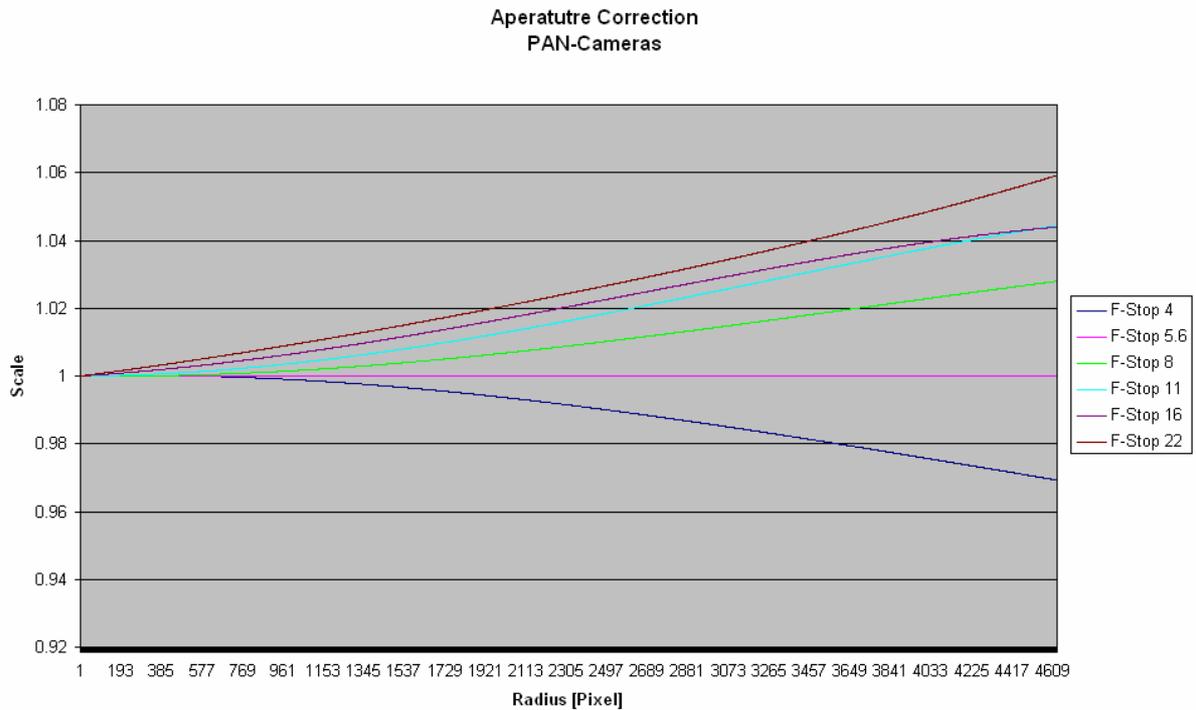
### Sensor Noise



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

Nr	Row	Column
0	325	2624

Defect Column	RowStart	ColumnStart	RowEnd	ColumnEnd

**Remark**

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



Calibration Protocol  
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## Calibration Certificate

N<sup>o</sup> 00114277

Object                      Digital Aerial Survey Camera  
Manufacturer              Z/I Imaging D-73431 Aalen  
Type                         DMC-Panchromatic  
Serial Number              00114277

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70

Date of Calibration                      01.Nov.2006

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CertifiedDate

04.Dec.2006

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

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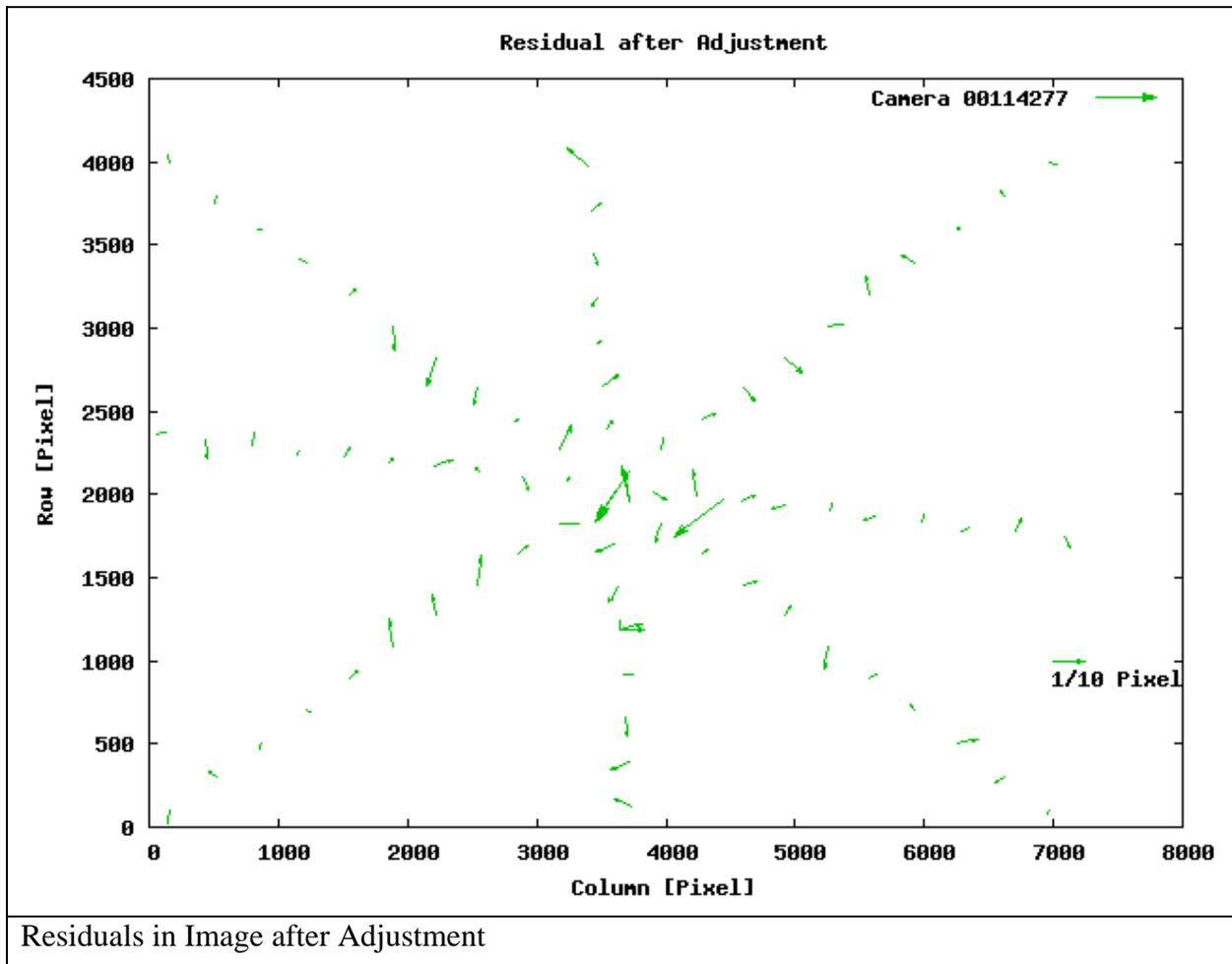
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00114277

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-0.0001811	8.813E-06
	$y_0$	-6.394E-05	5.332E-06
Focal Length [m]	$\Delta f$	-0.0004805	1.544E-06
Radial Distortion	$K_1$	0.8179	0.04035
	$K_2$	-372.4	36.68
	$K_3$	-5172	9718
Decentering distortion	$P_1$	-0.0001365	0.0002009
	$P_2$	5.697E-05	0.0001014
In Plane Distortion	$B_1$	-2.554E-05	1.07E-05
	$B_2$	2.809E-05	6.267E-06

Adjusted Focal length = 0.12+ dc =0.1195195 [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".

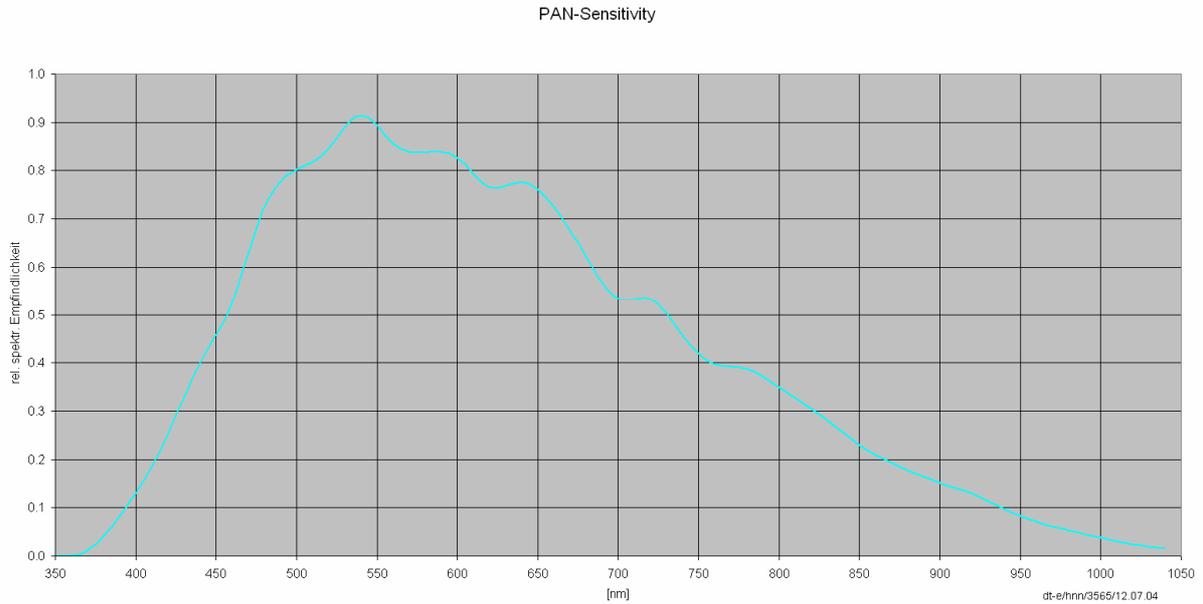
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

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

Camera ID	00114277
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

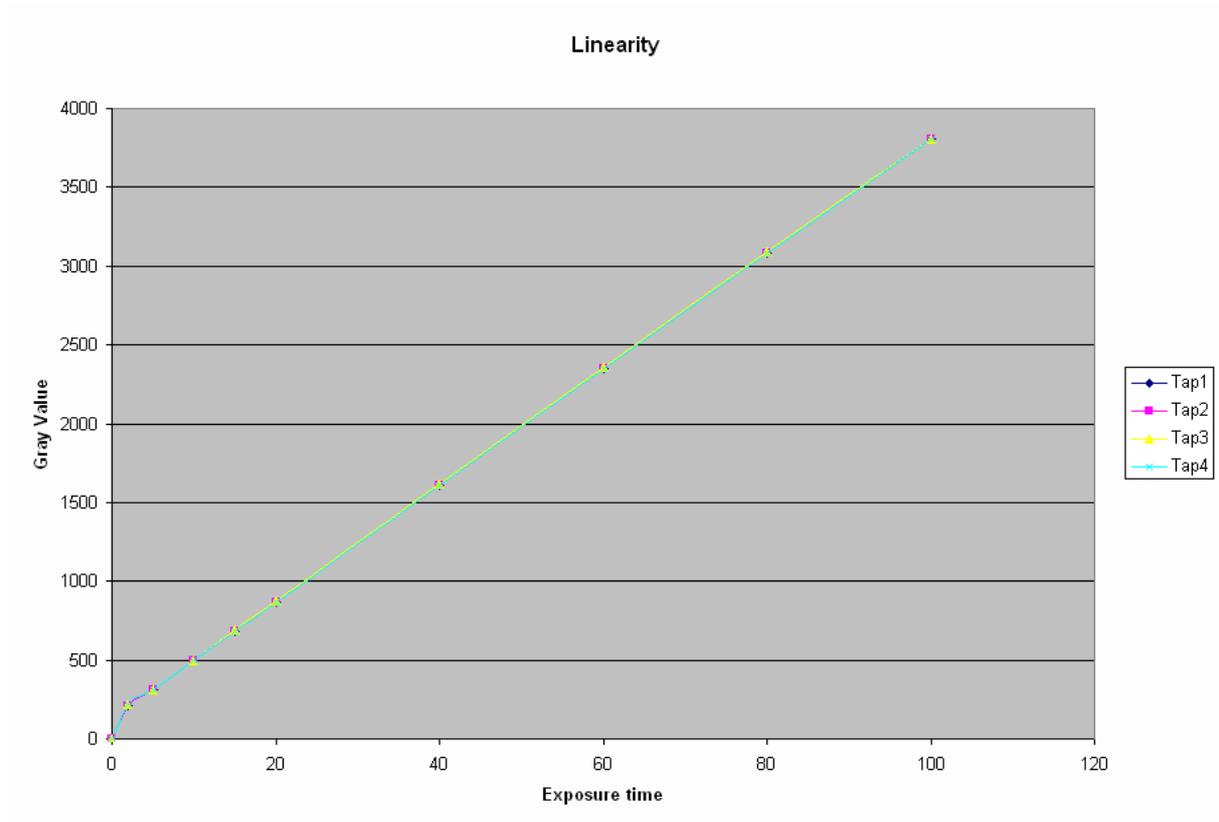
## Sensitivity of camera



**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".

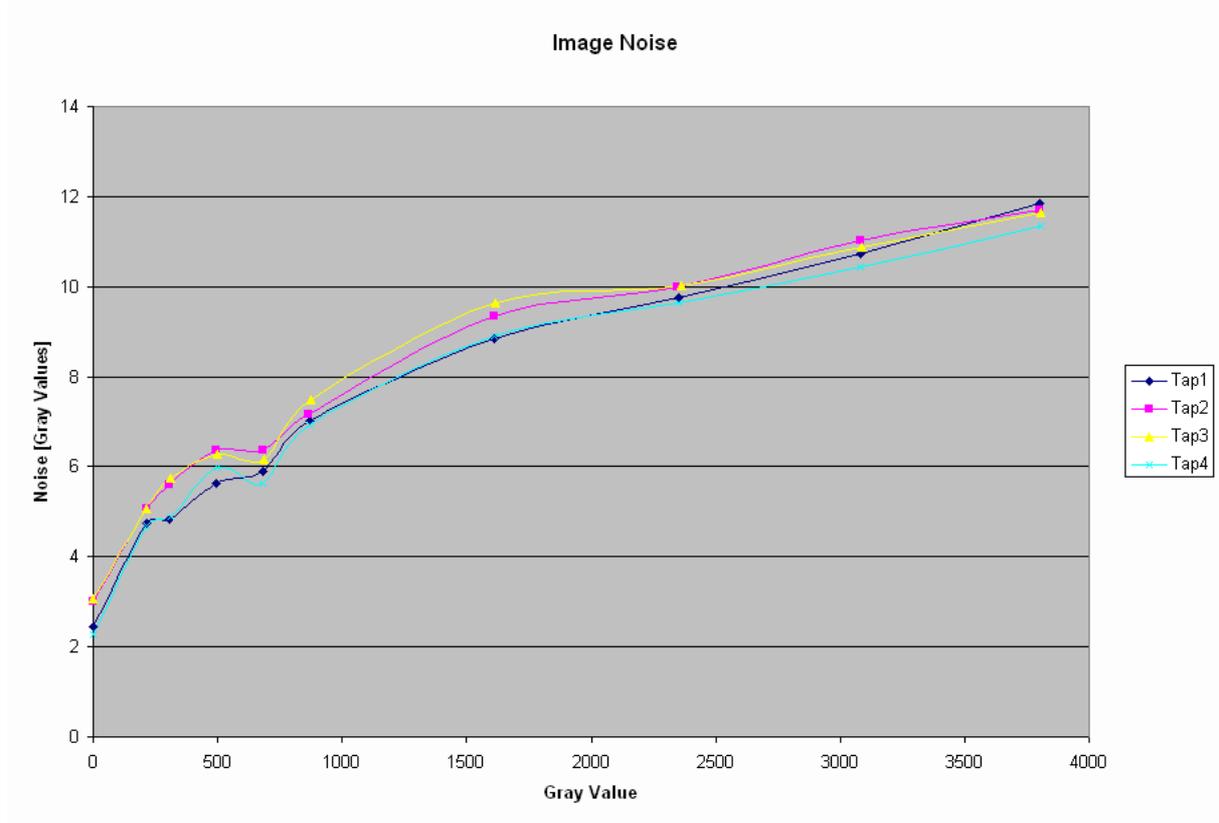
### Sensor Linearity



**Remark:**

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

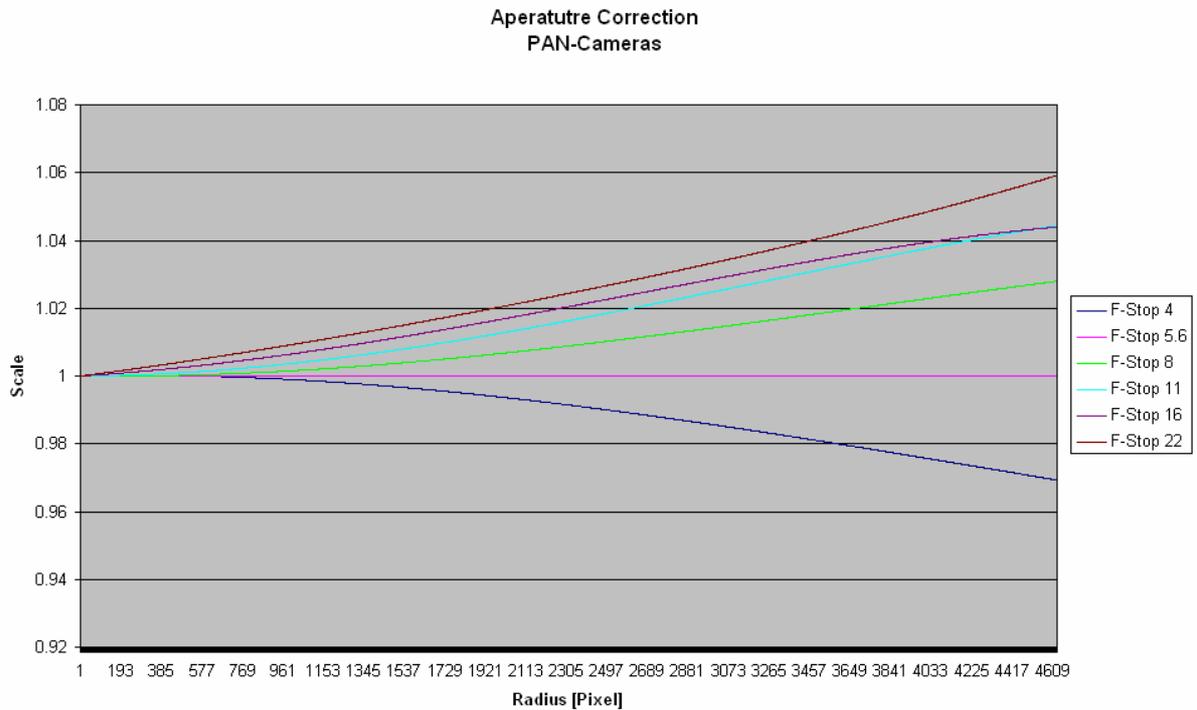
### Sensor Noise



**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 - 0044



## Calibration Certificate

N<sup>o</sup> 00114283

Object                      Digital Aerial Survey Camera  
Manufacturer              Z/I Imaging D-73431 Aalen  
Type                         DMC-Panchromatic  
Serial Number              00114283

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70

Date of Calibration                      13.Nov.2006

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CertifiedDate

04.Dec.2006

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

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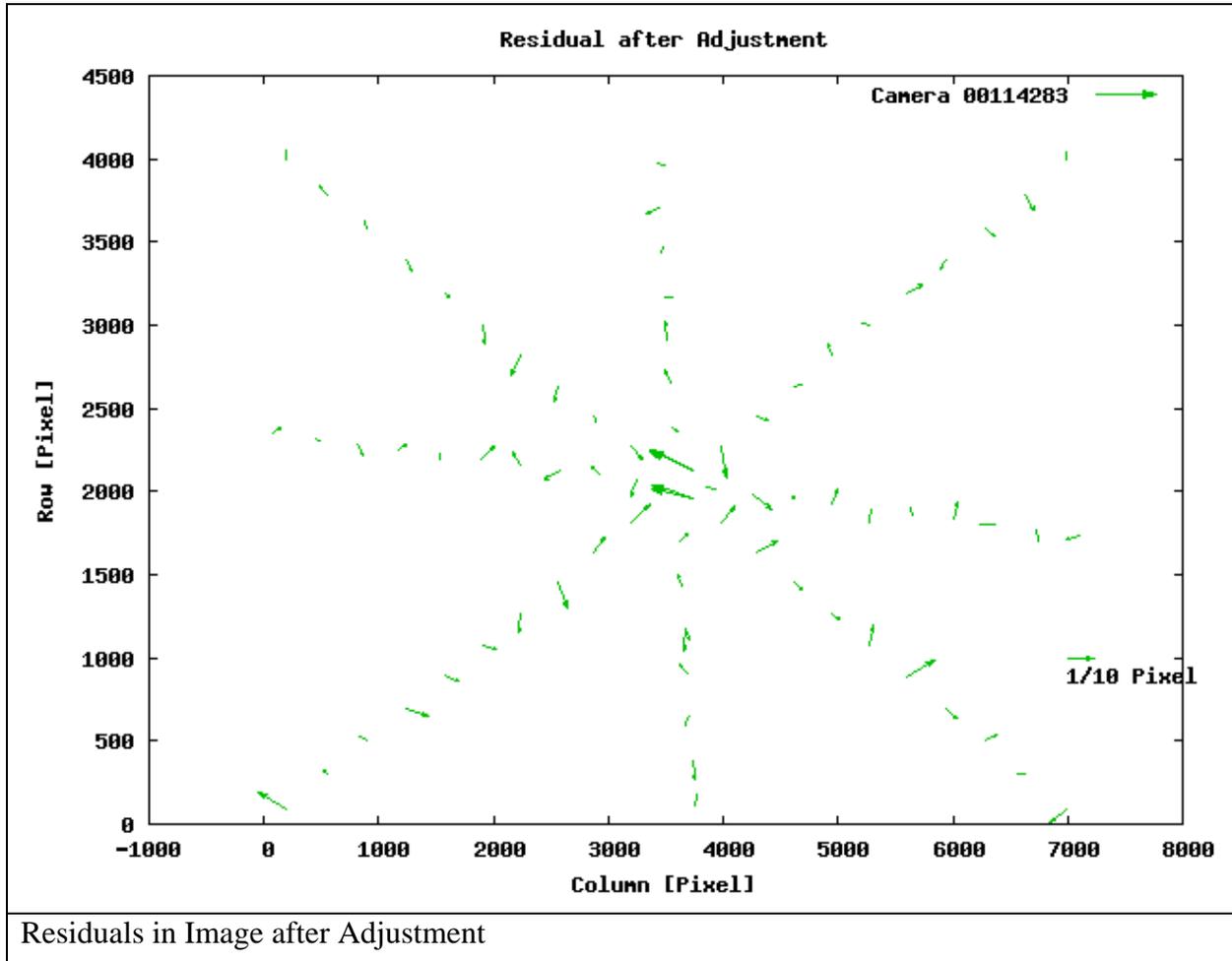
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00114283

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	6.913E-05	9.289E-06
	$y_0$	4.255E-05	5.643E-06
Focal Length [m]	$\Delta f$	-0.0004522	1.638E-06
Radial Distortion	$K_1$	0.6732	0.04304
	$K_2$	-281.2	38.96
	$K_3$	-31700	10300
Decentering distortion	$P_1$	0.0001382	0.0002117
	$P_2$	7.034E-06	0.0001075
In Plane Distortion	$B_1$	2.207E-05	1.134E-05
	$B_2$	5.785E-05	6.604E-06

Adjusted Focal length = 0.12+ dc =0.1195478 [m]



Max Residual [ $\mu\text{m}$ ]: 2.0

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”.

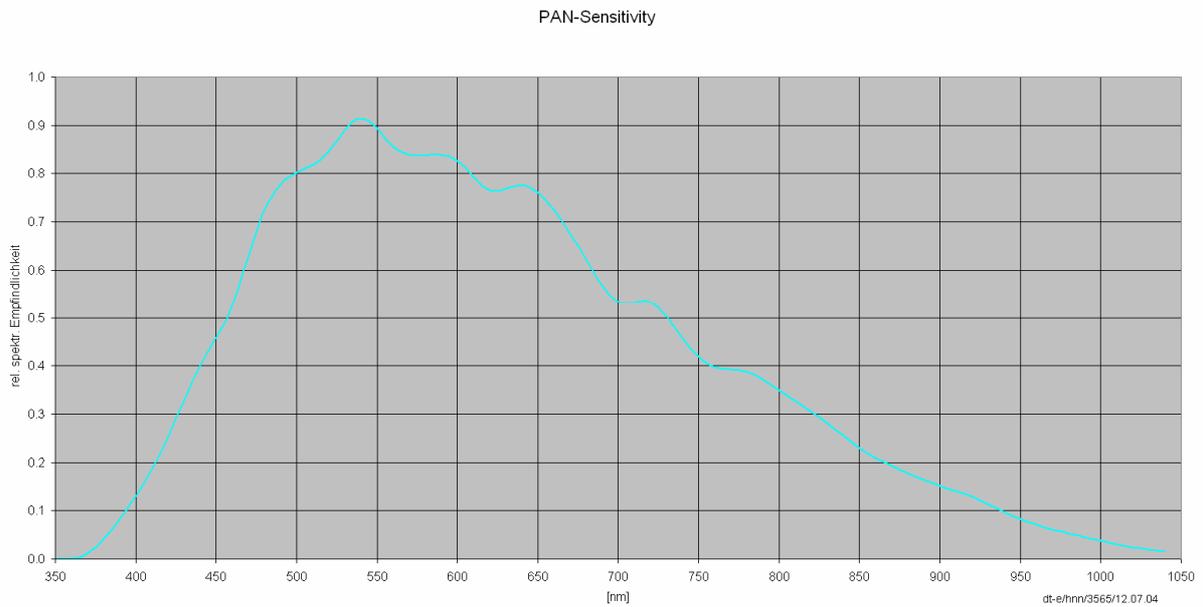
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

## Radiometric Calibration Protocol

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

Camera ID	00114283
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

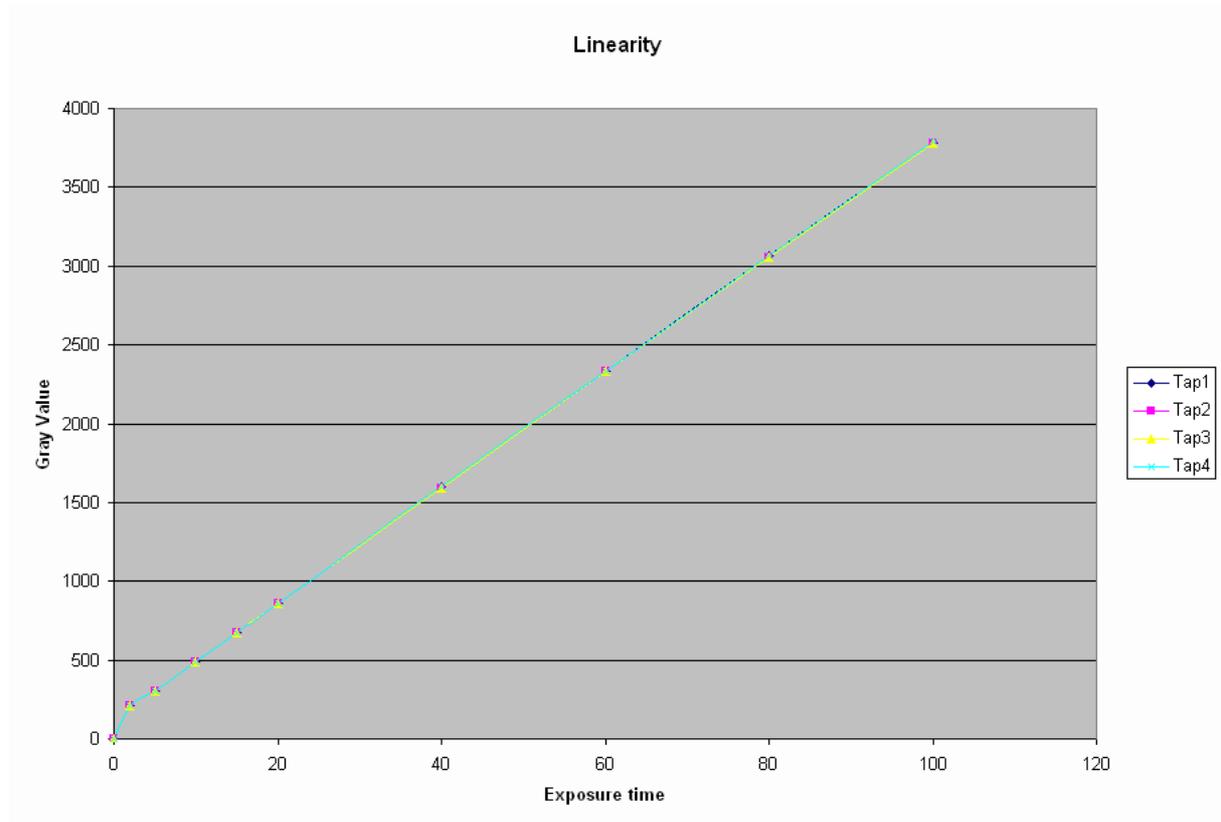
## Sensitivity of camera



**Remark:**

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

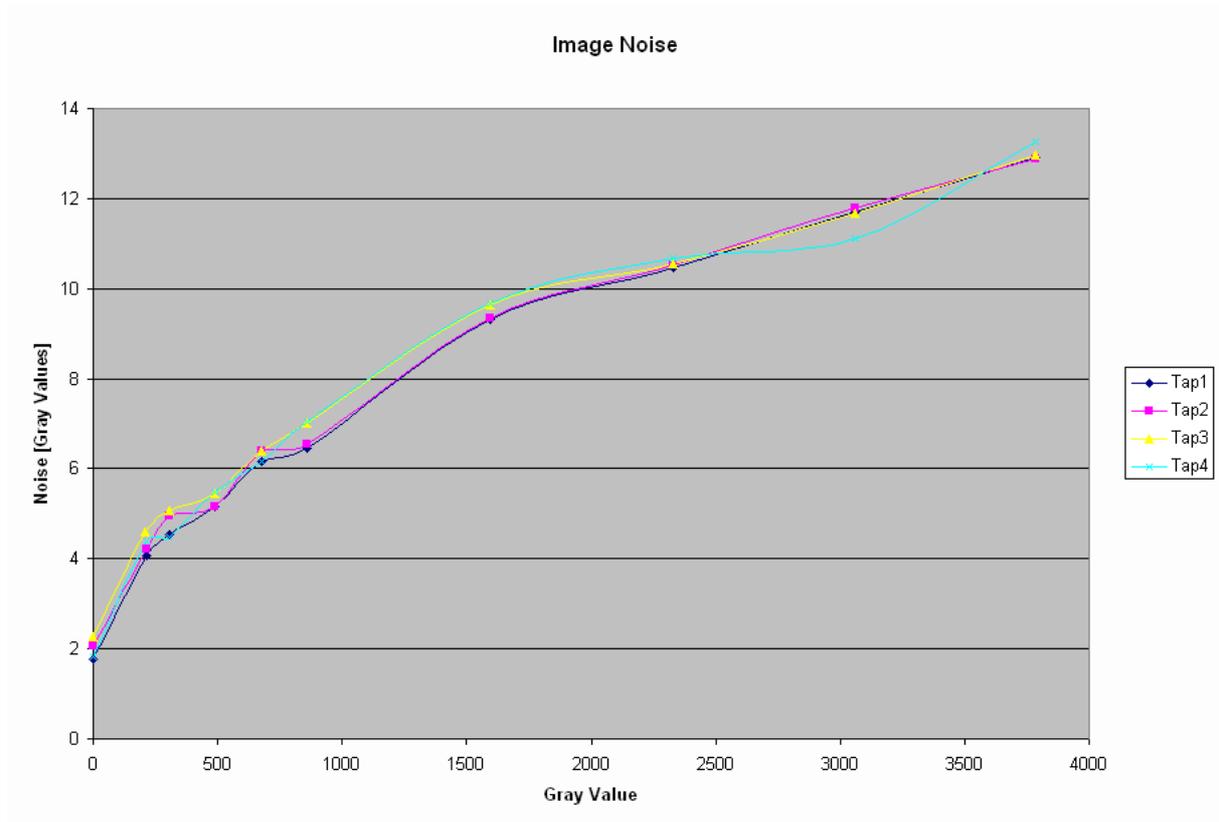
### Sensor Linearity



**Remark:**

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

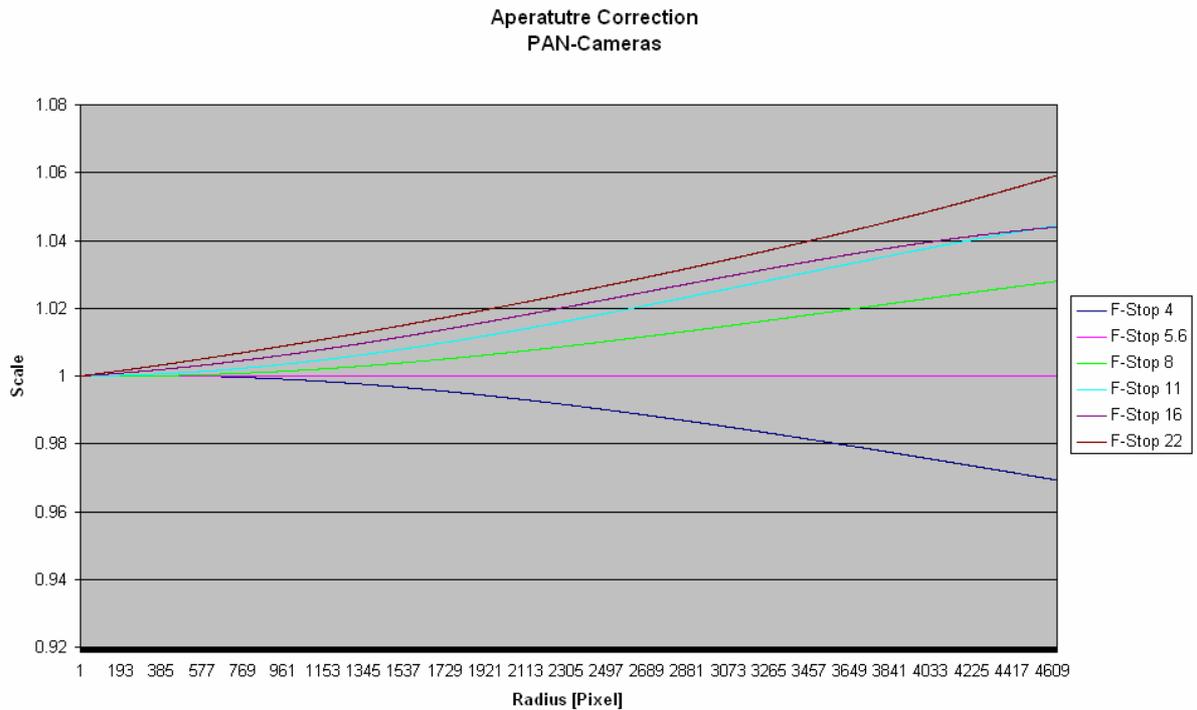
### Sensor Noise



**Remark:**

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

## Aperture Correction



**Remark:**

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

## Defect Pixel List

Number of defect pixels: 6  
 Number of defect clusters: 0  
 Number of defect columns: 0

Nr	Row	Column
0	2383	3468
1	2383	3469
2	2346	4270
3	2347	4270
4	2346	4271
5	2347	4271



# Calibration Protocol DMC01 - 0044



Defect Column	RowStart	ColumnStart	RowEnd	ColumnEnd
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Remark

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



Calibration Protocol  
DMC01 - 0044



## Calibration Certificate

N<sup>o</sup> 00114284

Object                    Digital Aerial Survey Camera  
Manufacturer            Z/I Imaging D-73431 Aalen  
Type                      DMC-Panchromatic  
Serial Number            00114284

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70

Date of Calibration                      07.Nov.2006

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CertifiedDate

04.Dec.2006

Division Head



(H. Sohnle)

Person in Charge



(S. Schröder)

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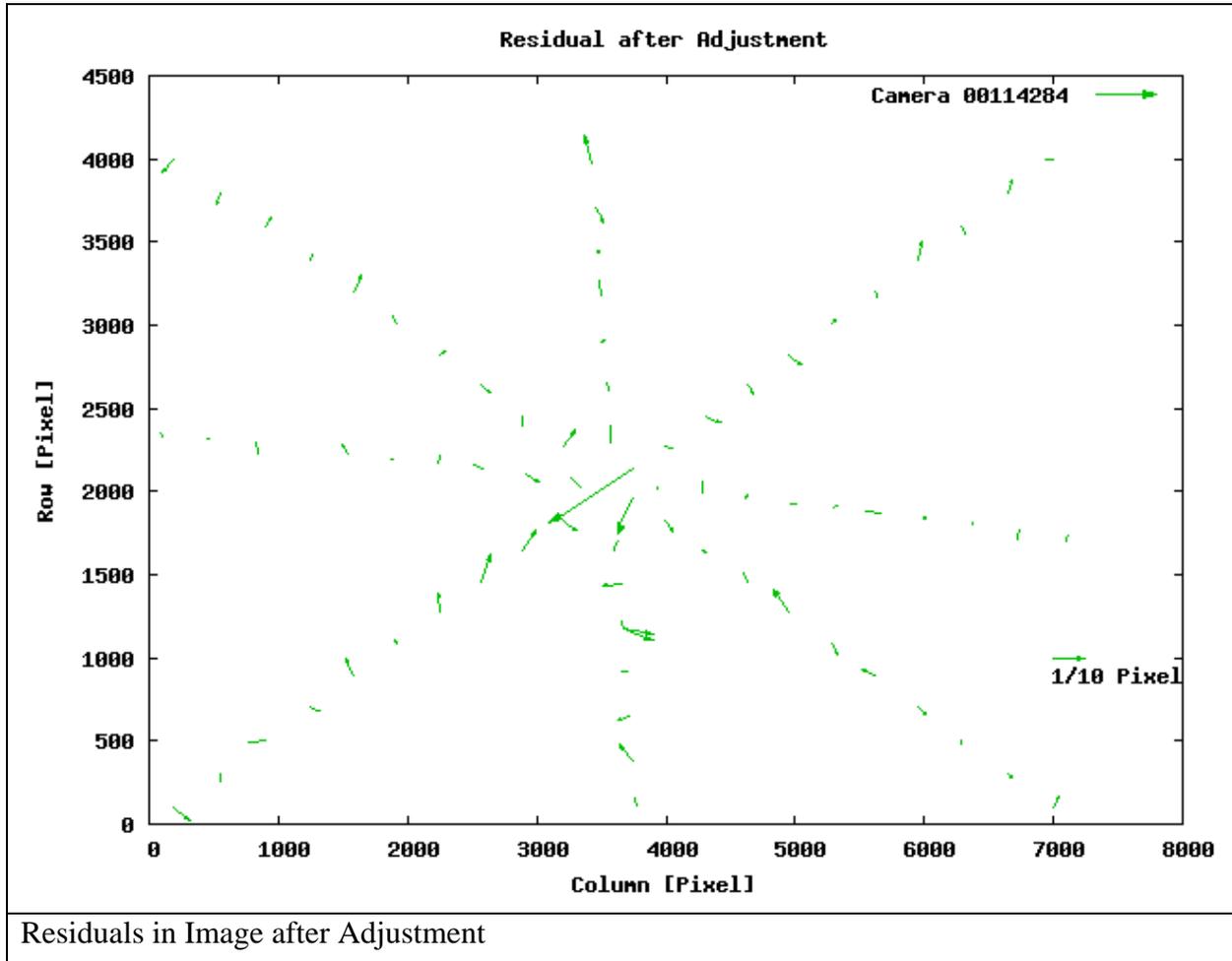
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00114284

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	0.0002087	8.775E-06
	$y_0$	2.009E-05	5.315E-06
Focal Length [m]	$\Delta f$	-0.0004461	1.512E-06
Radial Distortion	$K_1$	0.6874	0.03972
	$K_2$	-312.5	35.94
	$K_3$	-19680	9497
Decentering distortion	$P_1$	-0.0003607	0.0002
	$P_2$	0.0001161	0.000101
In Plane Distortion	$B_1$	-3.27E-05	1.045E-05
	$B_2$	-1.589E-05	6.085E-06

Adjusted Focal length = 0.12+ dc =0.1195539 [m]



Max Residual [ $\mu\text{m}$ ]: 3.7

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".

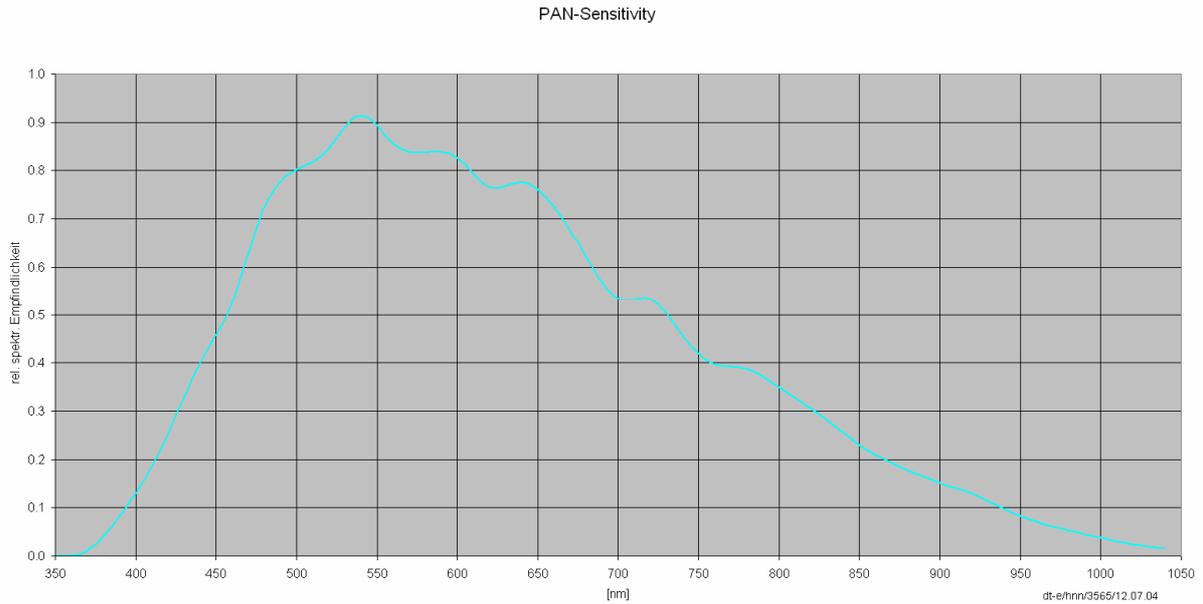
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

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

Camera ID	00114284
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

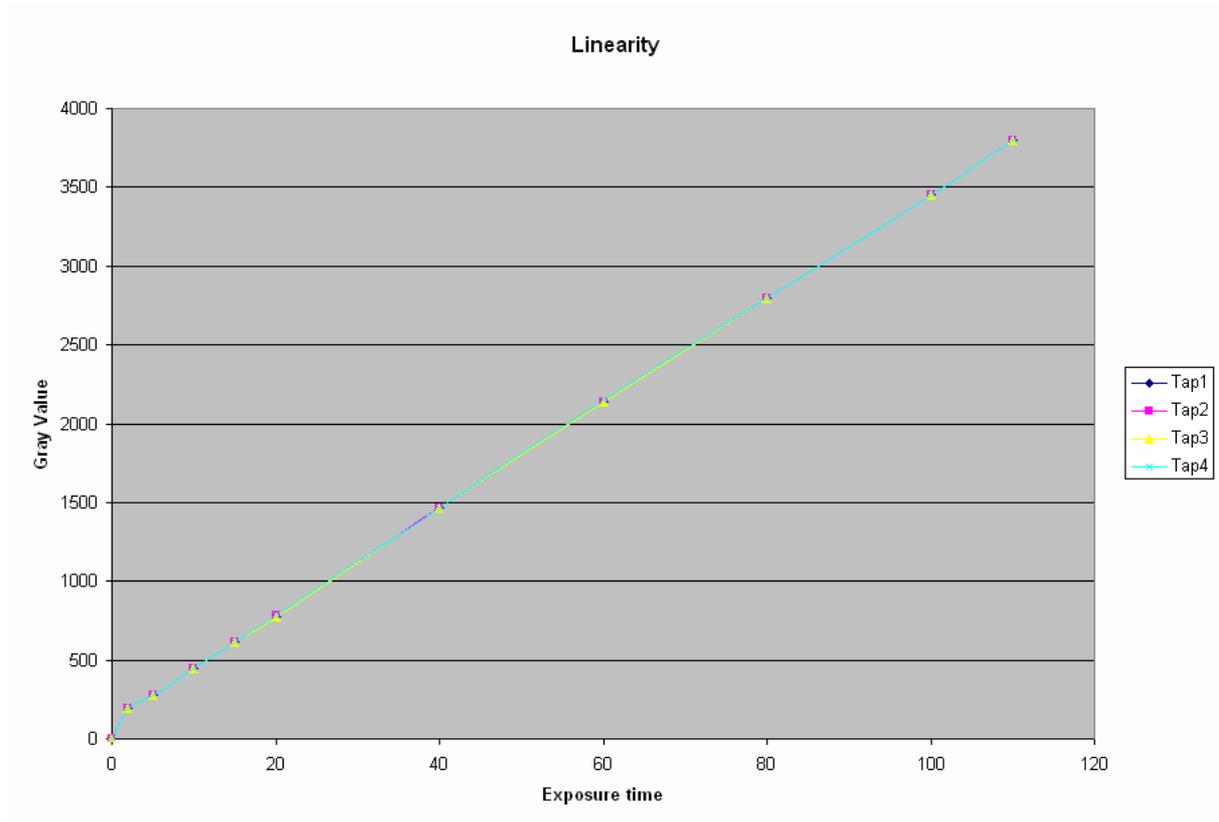
## Sensitivity of camera



**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".

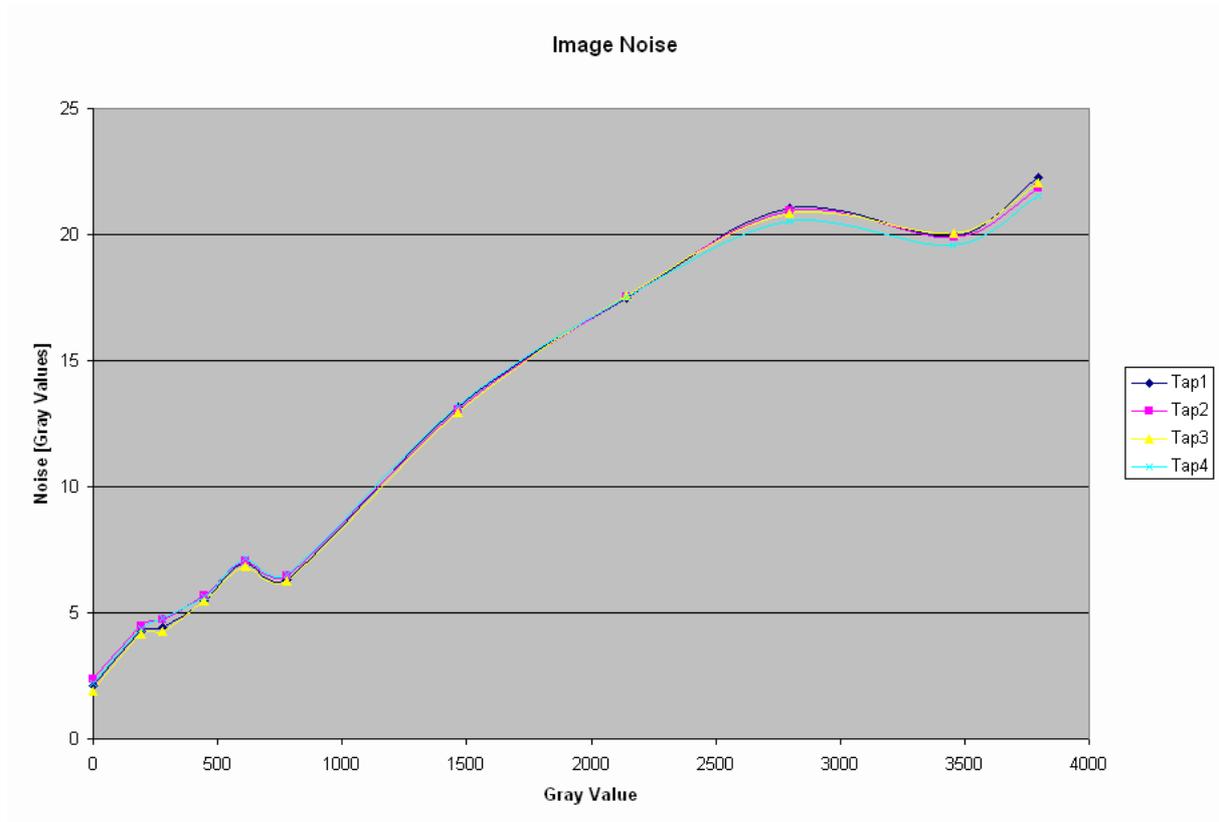
### Sensor Linearity



**Remark:**

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

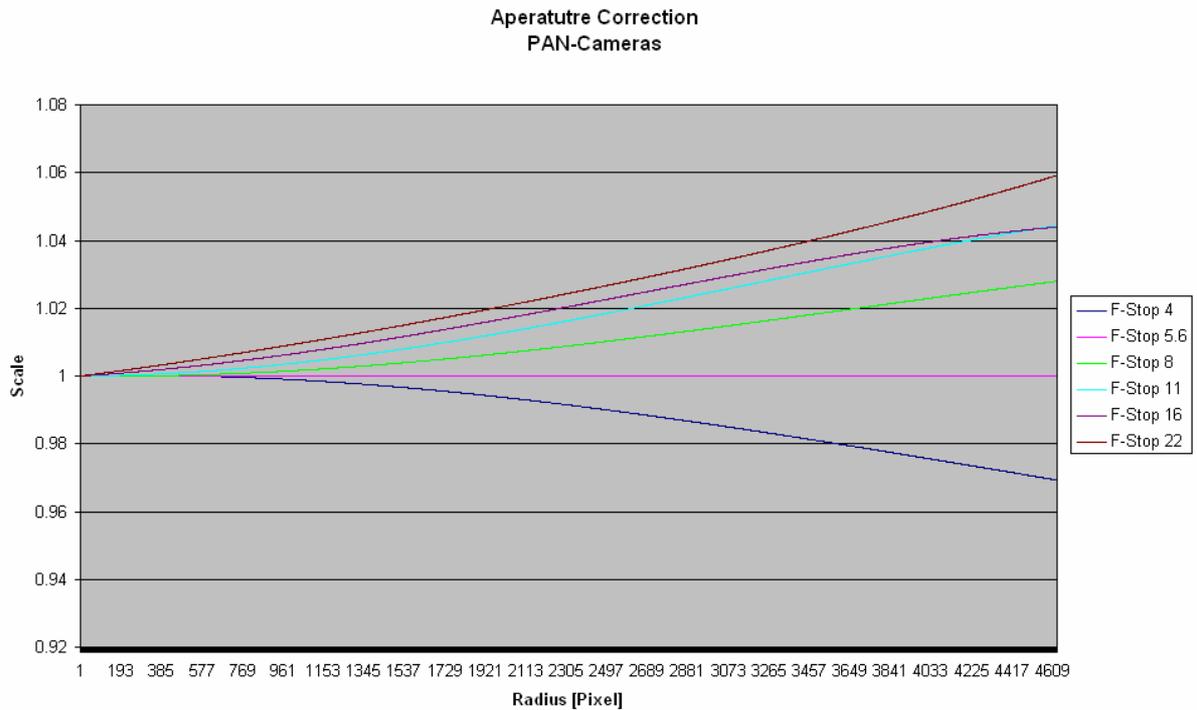
### Sensor Noise



**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 - 0044



## Calibration Certificate

N<sup>o</sup> 00113936

Object                      Digital Aerial Survey Camera  
Manufacturer              Z/I Imaging D-73431 Aalen  
Type                         DMC-MS-NIR  
Serial Number              00113936

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70

Date of Calibration                      06.Nov.2006

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CertifiedDate

04.Dec.2006

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

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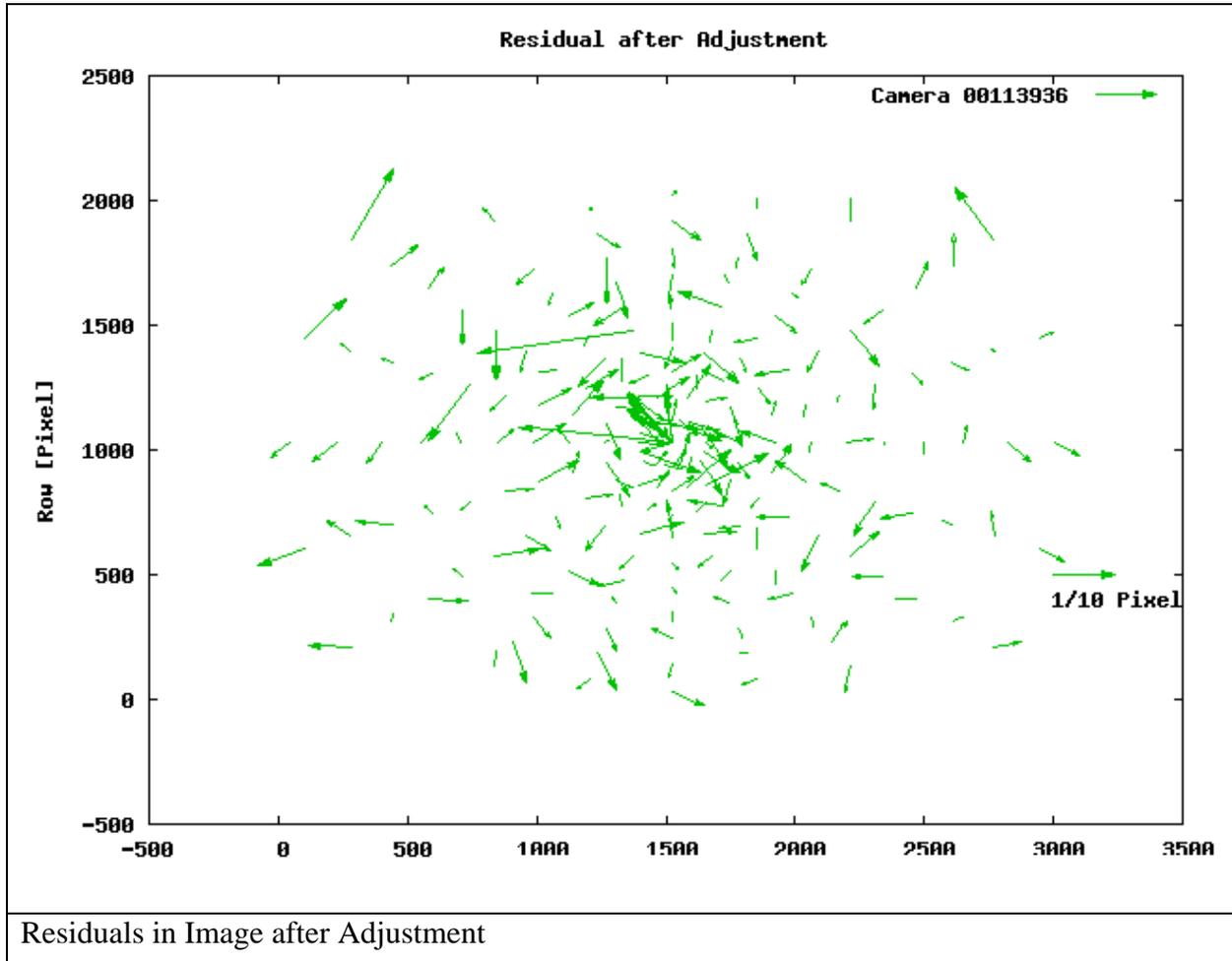
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-MS-NIR
Nominal Focal Length	0.025 m
Serial Number	00113936

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-0.0001251	1.473E-06
	$y_0$	-5.163E-05	1.033E-06
Focal Length [m]	$\Delta f$	-2.377E-05	5.364E-07
Radial Distortion	$K_1$	-144.6	0.4526
	$K_2$	221500	2883
	$K_3$	-142900000	5185000
Decentering distortion	$P_1$	-0.004993	0.0007665
	$P_2$	0.00267	0.0004712
In Plane Distortion	$B_1$	0.0001174	1.33E-05
	$B_2$	-1.109E-05	1.09E-05

Adjusted Focal length = 0.025+ dc =0.02497623 [m]



Max Residual [ $\mu\text{m}$ ]: 3.1

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".

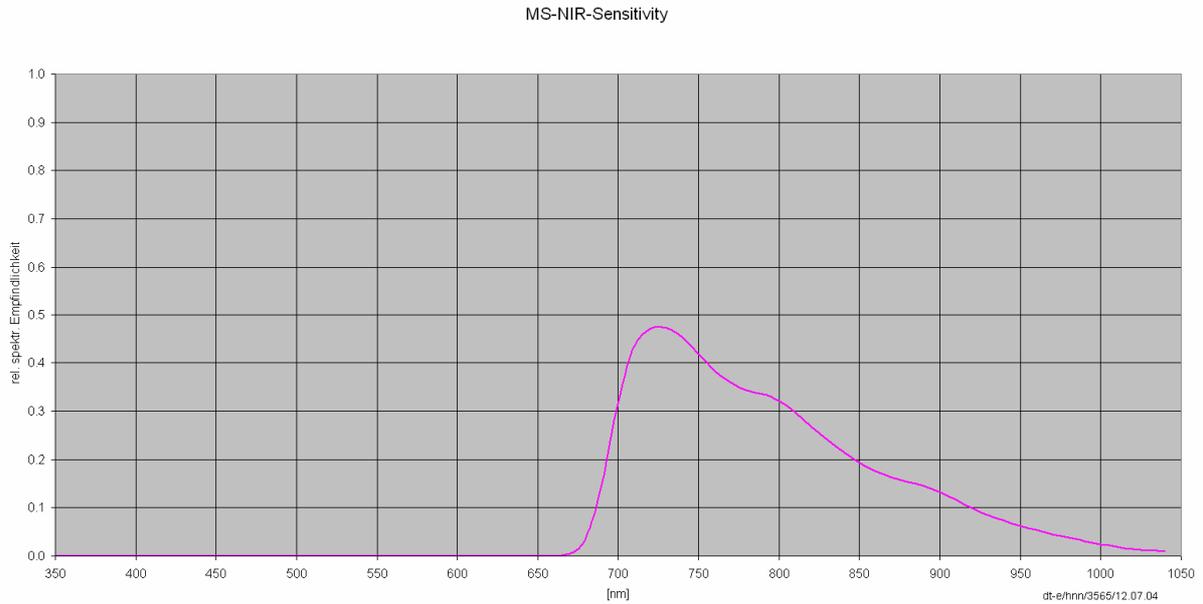
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

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

Camera ID	00113936
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1

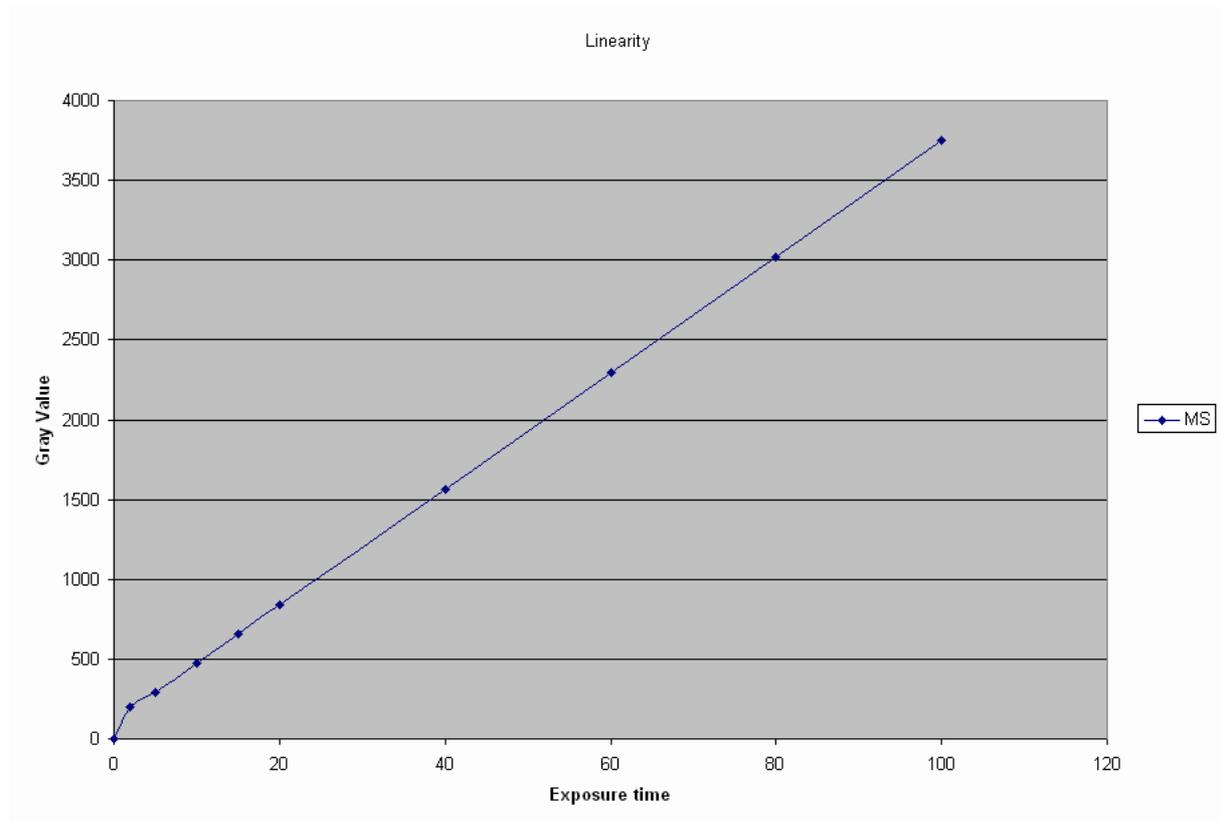
## Sensitivity of camera



**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".

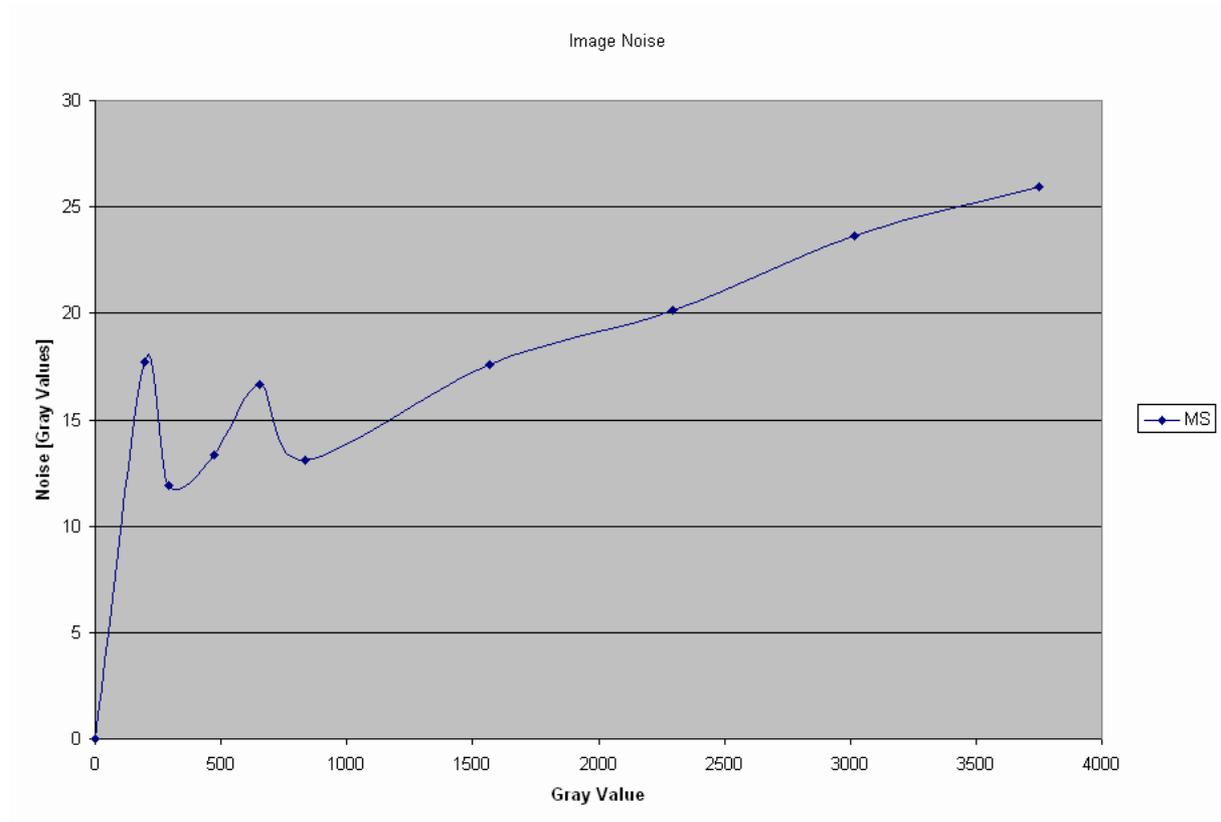
### Sensor Linearity



**Remark:**

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

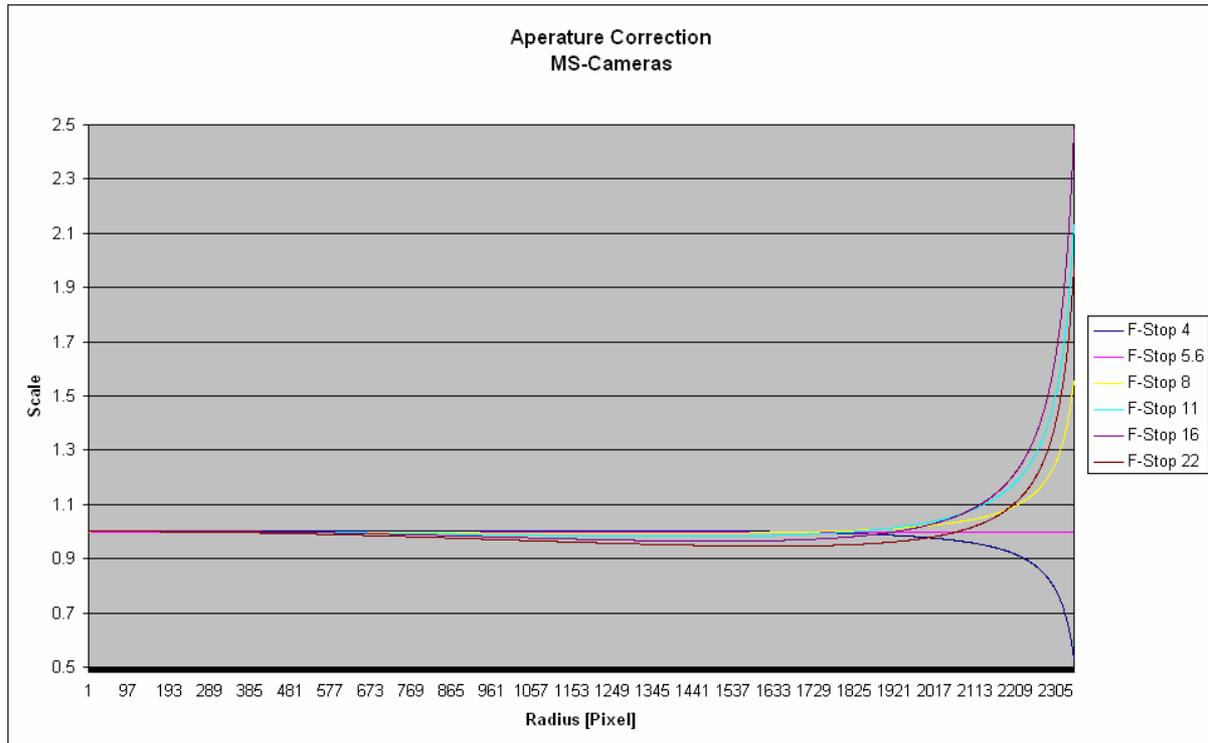
### Sensor Noise



**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 - 0044



**Calibration Certificate**

**N<sup>o</sup> 00111744**

Object                      Digital Aerial Survey Camera  
Manufacturer              Z/I Imaging D-73431 Aalen  
Type                         DMC-MS-Blue  
Serial Number              00111744

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70

Date of Calibration                      04.Nov.2006

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CertifiedDate

04.Dec.2006

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

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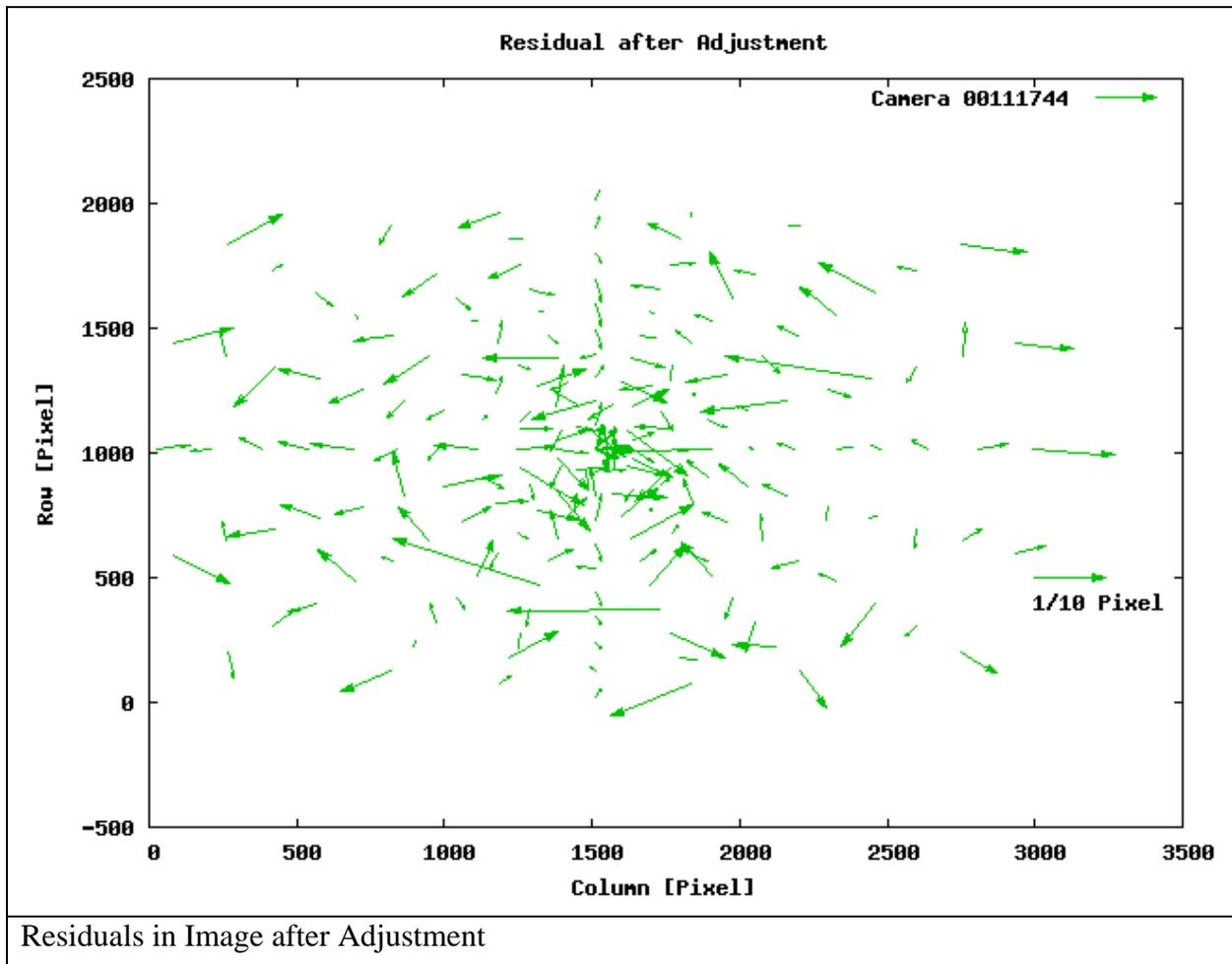
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-MS-Blue
Nominal Focal Length	0.025 m
Serial Number	00111744

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-0.0003045	1.499E-06
	$y_0$	6.278E-05	1.052E-06
Focal Length [m]	$\Delta f$	-3.351E-05	5.433E-07
Radial Distortion	$K_1$	-138.9	0.4583
	$K_2$	220600	2918
	$K_3$	-146600000	5246000
Decentering distortion	$P_1$	-0.001004	0.0007791
	$P_2$	0.003092	0.00048
In Plane Distortion	$B_1$	0.0001337	1.347E-05
	$B_2$	-8.42E-06	1.104E-05

Adjusted Focal length = 0.025+ dc =0.02496649 [m]



Max Residual [ $\mu\text{m}$ ]: 2.7

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”.

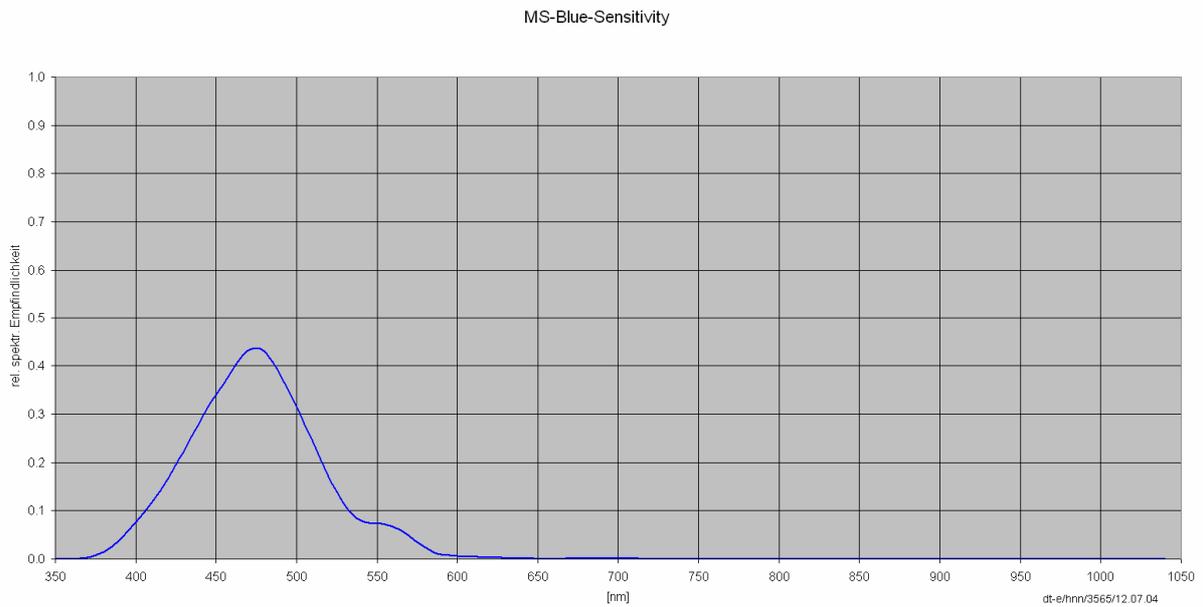
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

## Radiometric Calibration Protocol

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

Camera ID	00111744
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1

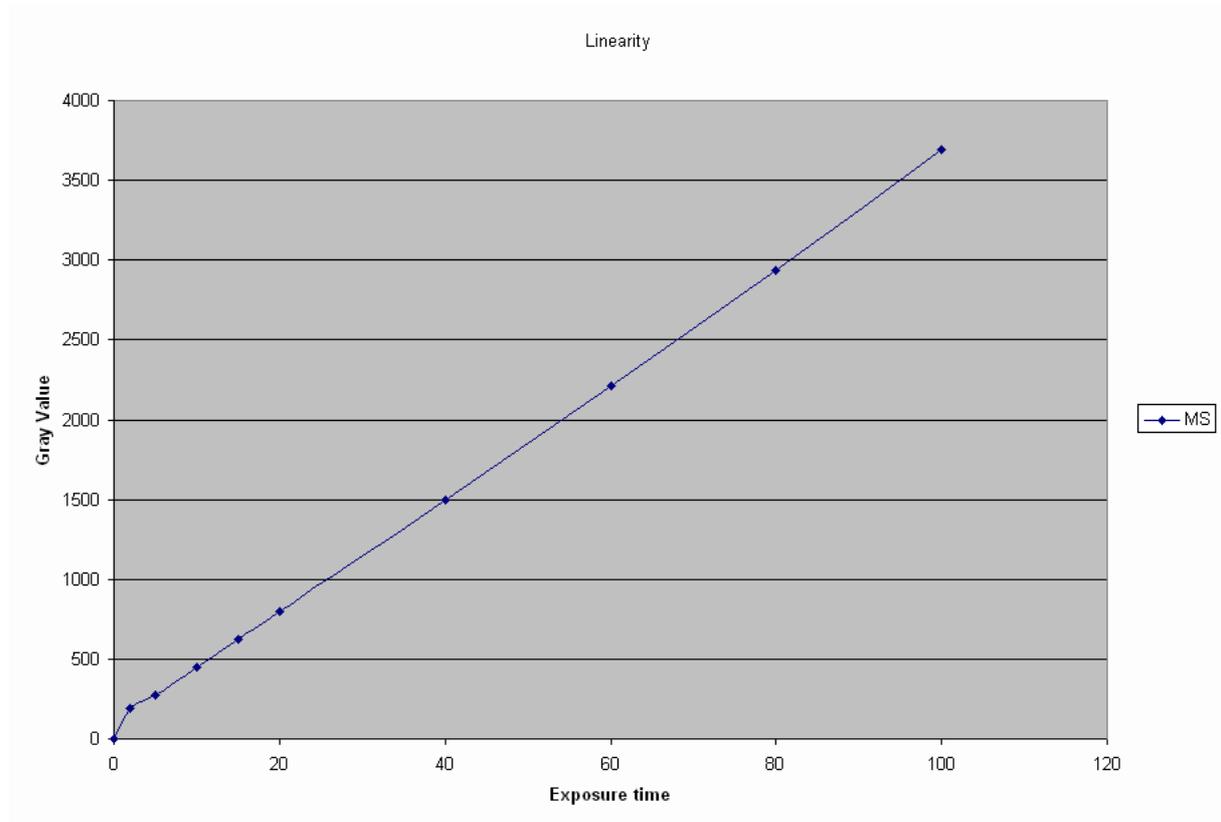
## Sensitivity of camera



**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".

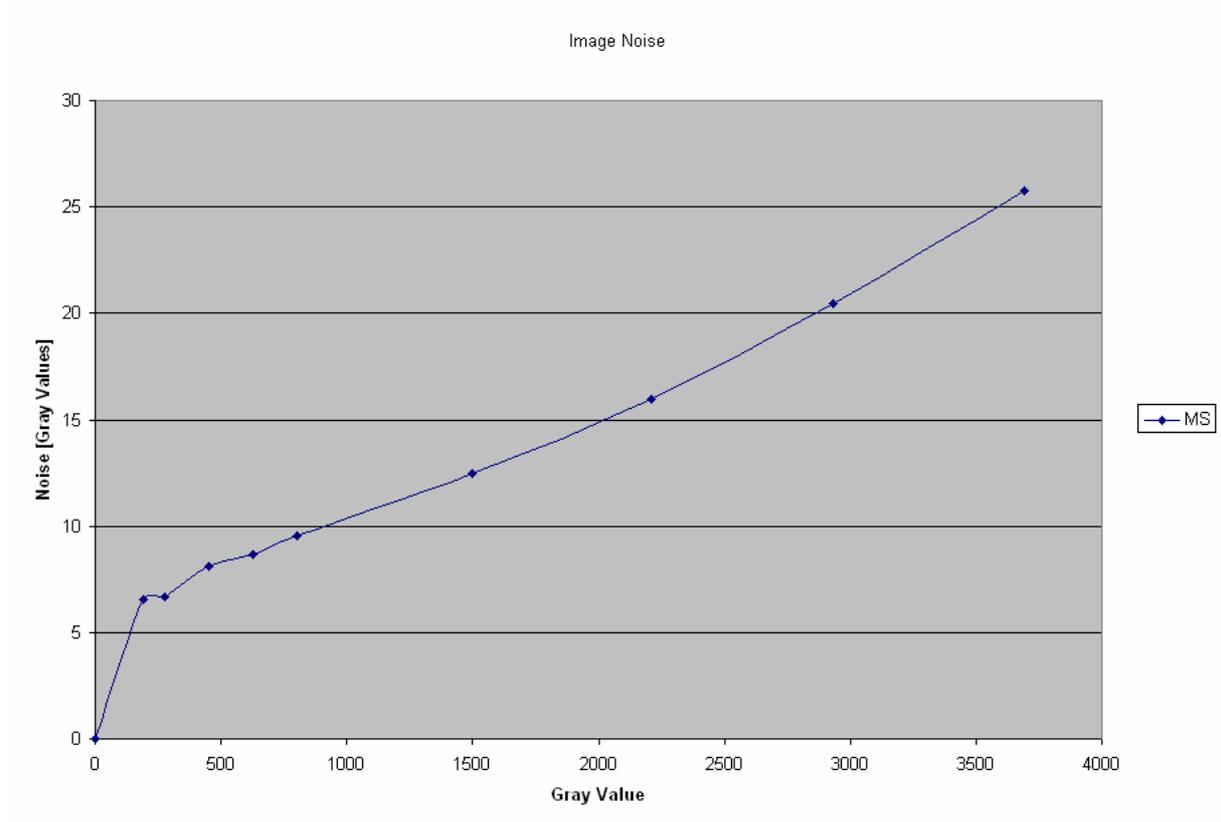
### Sensor Linearity



**Remark:**

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

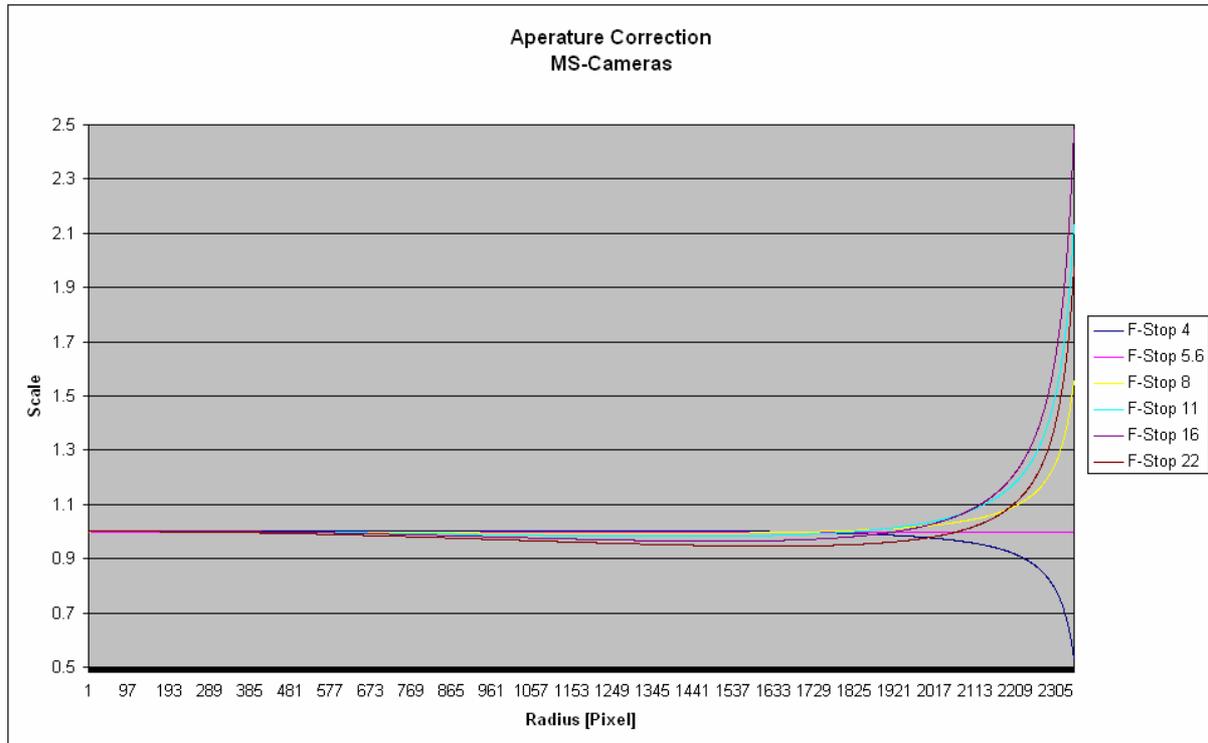
### Sensor Noise



**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: 9

Number of defect clusters: 0

Number of defect columns: 0

Nr	Row	Column
0	668	3001
1	667	3002
2	668	3002
3	669	3002
4	667	3003
5	668	3003



# Calibration Protocol DMC01 - 0044



6	669	3003
7	668	3004
8	669	3004

Defect Column	RowStart	ColumnStart	RowEnd	ColumnEnd
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## Remark

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



Calibration Protocol  
DMC01 - 0044



## Calibration Certificate

N<sup>o</sup> 00113913

Object                      Digital Aerial Survey Camera  
Manufacturer              Z/I Imaging D-73431 Aalen  
Type                         DMC-MS-Red  
Serial Number              00113913

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70

Date of Calibration                      10.Nov.2006

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CertifiedDate

04.Dec.2006

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

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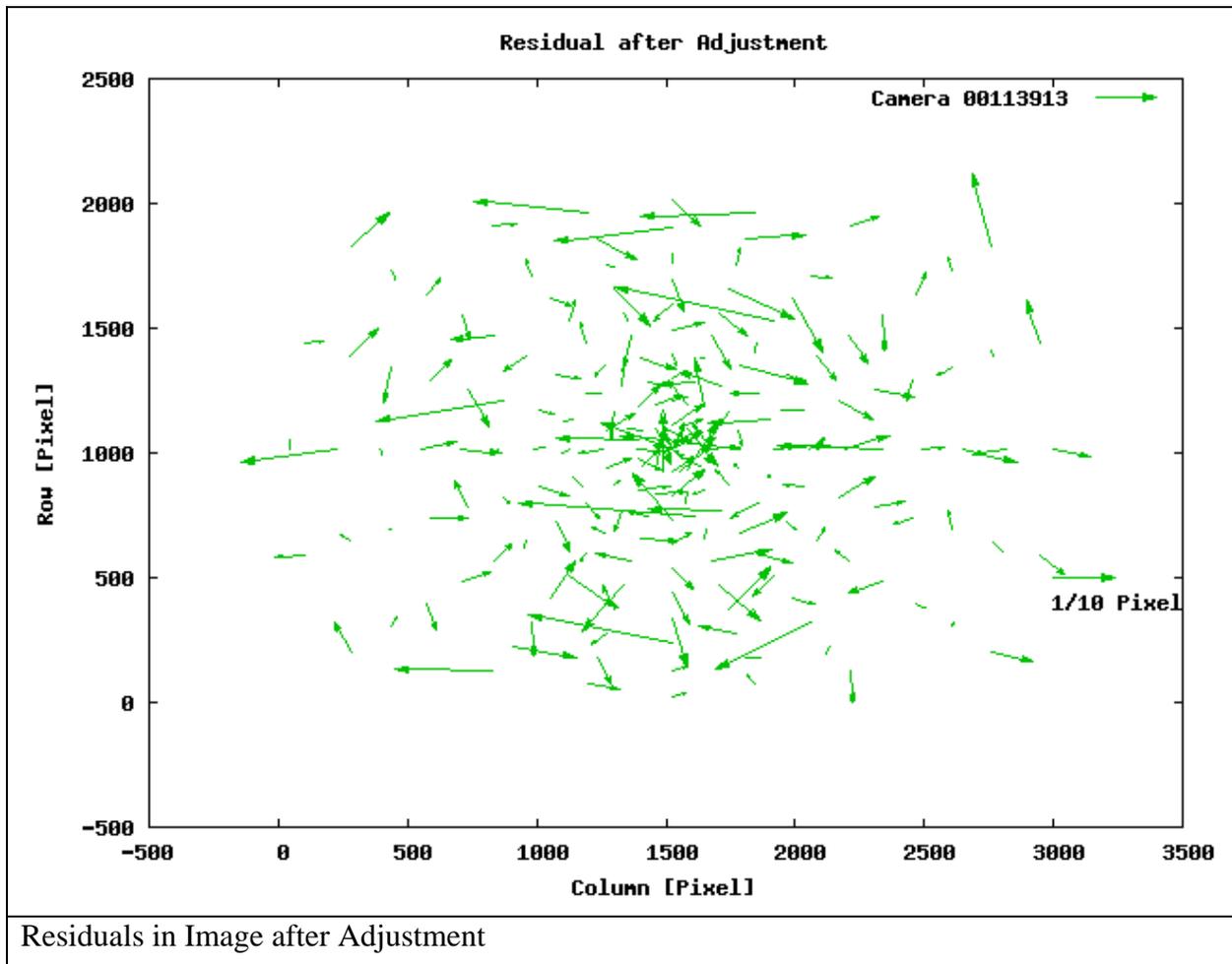
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-MS-Red
Nominal Focal Length	0.025 m
Serial Number	00113913

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-0.0001546	1.86E-06
	$y_0$	6.976E-05	1.306E-06
Focal Length [m]	$\Delta f$	-5.129E-05	6.783E-07
Radial Distortion	$K_1$	-140.6	0.5724
	$K_2$	222400	3645
	$K_3$	-152400000	6556000
Decentering distortion	$P_1$	0.0007378	0.0009675
	$P_2$	0.0007761	0.0005957
In Plane Distortion	$B_1$	0.0001497	1.682E-05
	$B_2$	-4E-05	1.379E-05

Adjusted Focal length = 0.025+ dc =0.02494871 [m]



Max Residual [ $\mu\text{m}$ ]: 3.4

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".

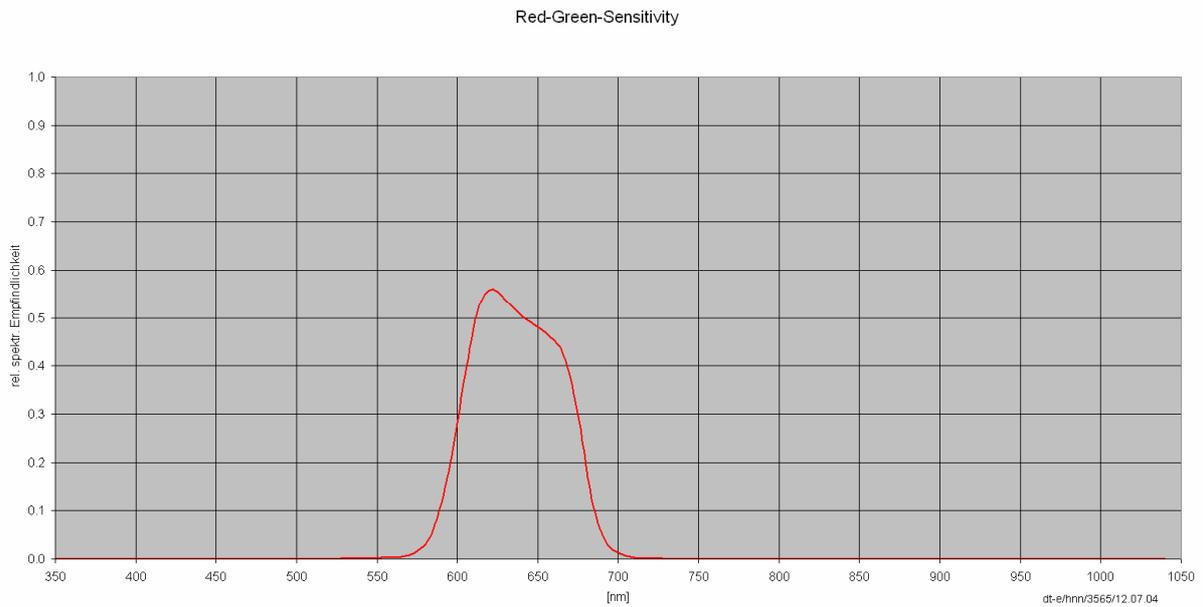
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

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

Camera ID	00113913
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1

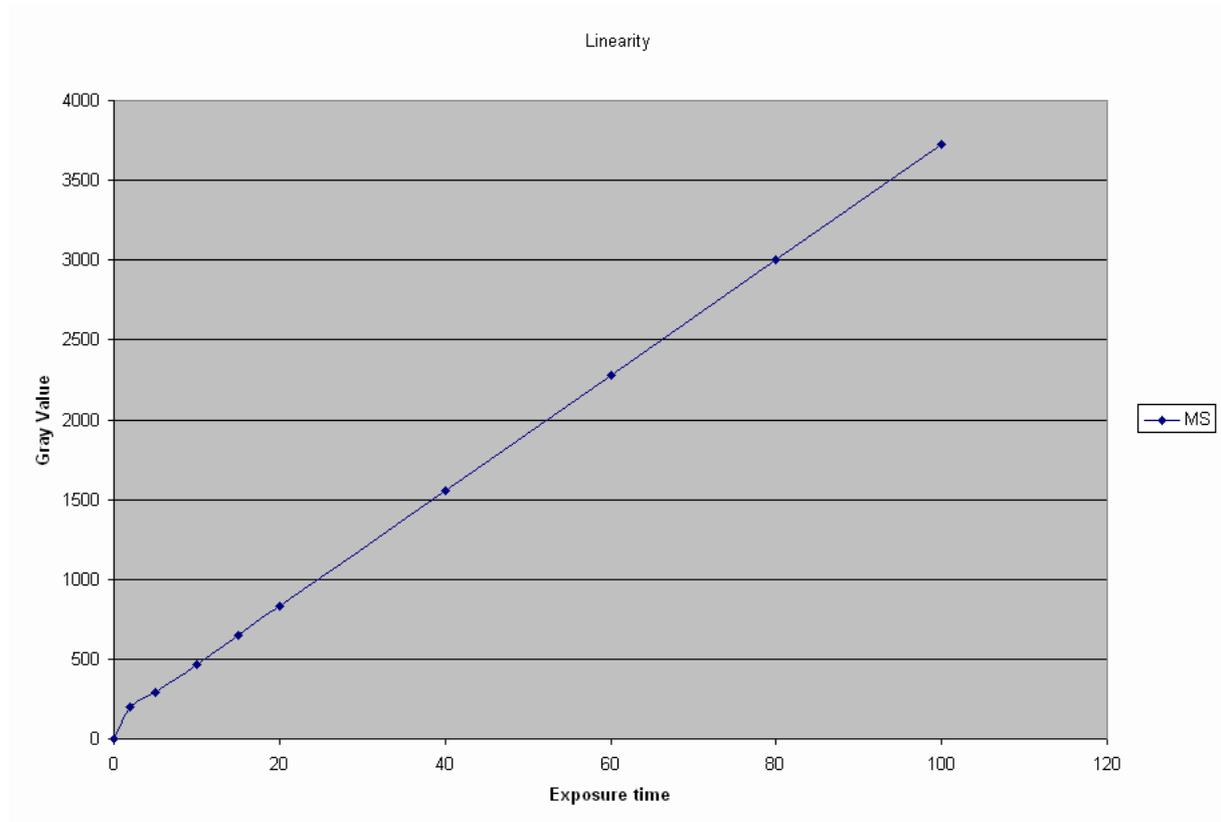
## Sensitivity of camera



**Remark:**

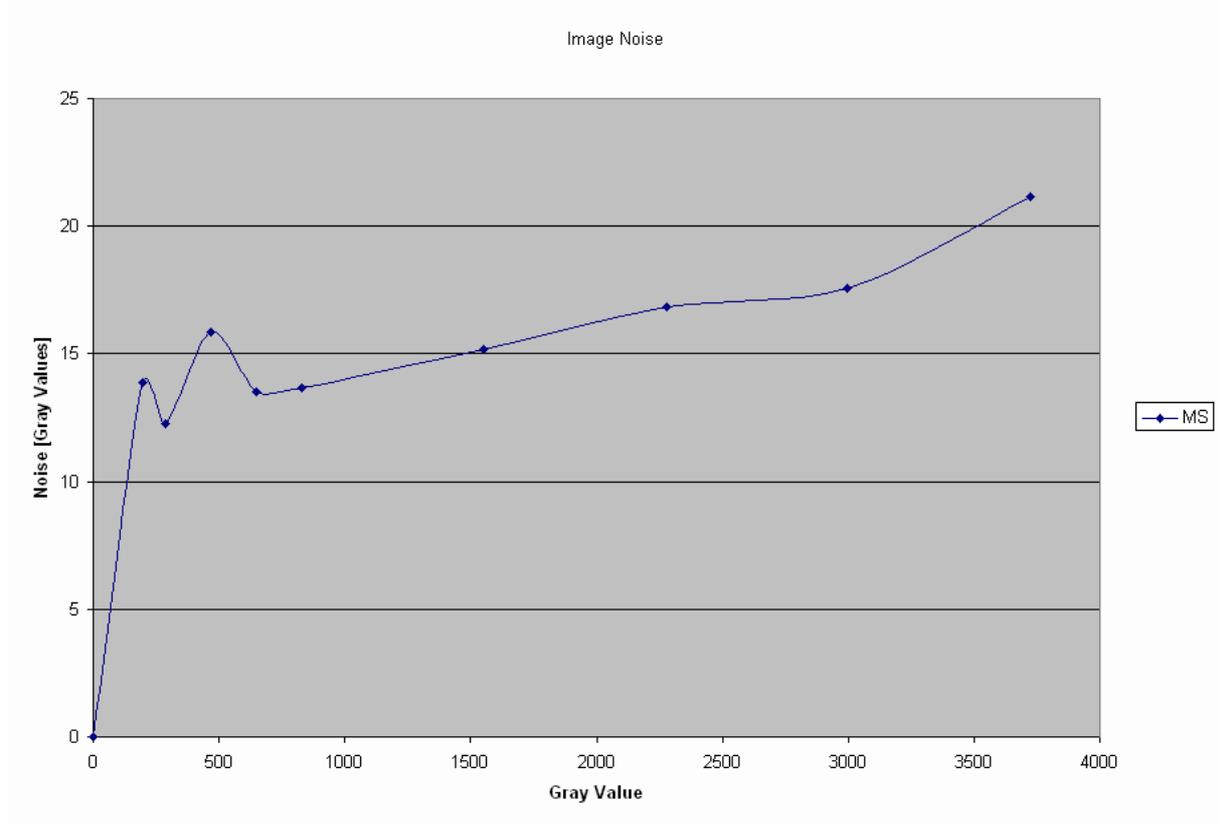
Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: "Radiometric Calibration Model".

### Sensor Linearity



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

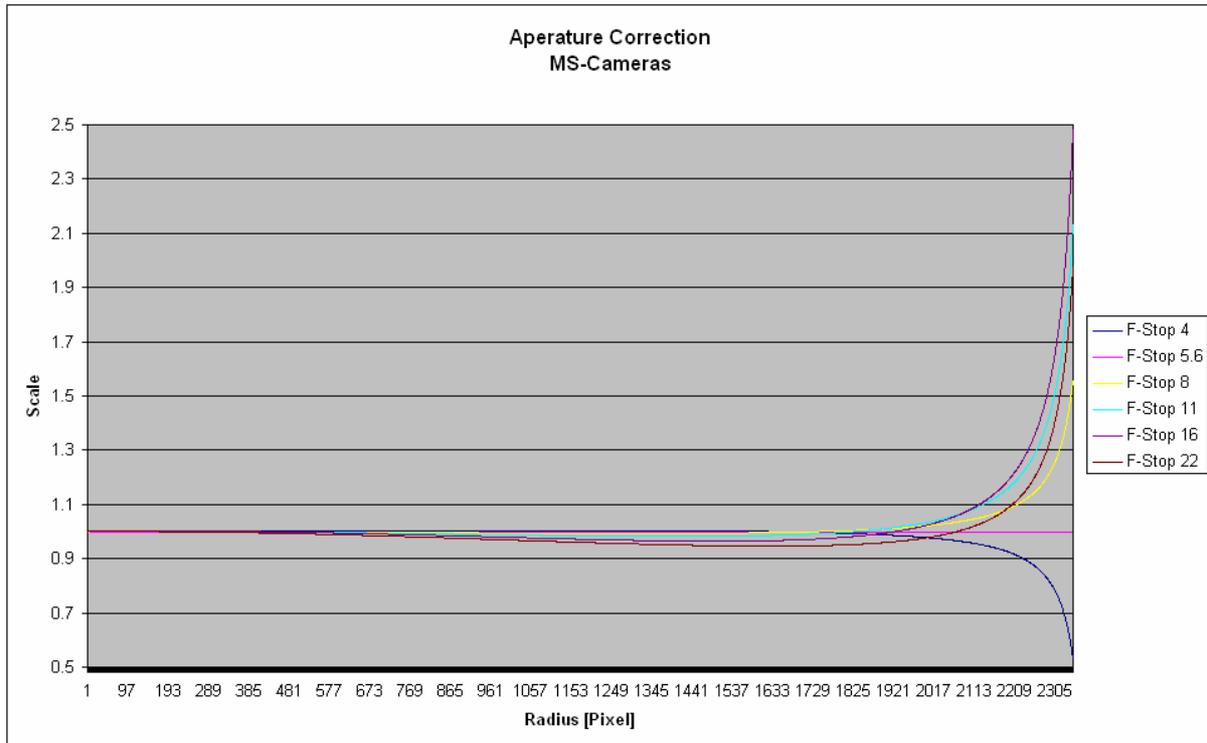
### Sensor Noise



**Remark:**

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

### Aperture Correction



**Remark:**

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

### Defect Pixel List

Number of defect pixels: 2  
 Number of defect clusters: 0  
 Number of defect columns: 0

Nr	Row	Column
0	1006	1195
1	1006	1196

Defect Column	RowStart	ColumnStart	RowEnd	ColumnEnd
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# Calibration Protocol DMC01 - 0044



## Remark

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



Calibration Protocol  
DMC01 - 0044



## Calibration Certificate

N<sup>o</sup> 00113893

Object                    Digital Aerial Survey Camera  
Manufacturer            Z/I Imaging D-73431 Aalen  
Type                      DMC-MS-Green  
Serial Number            00113893

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70

Date of Calibration                      24.Oct.2006

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CertifiedDate

04.Dec.2006

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

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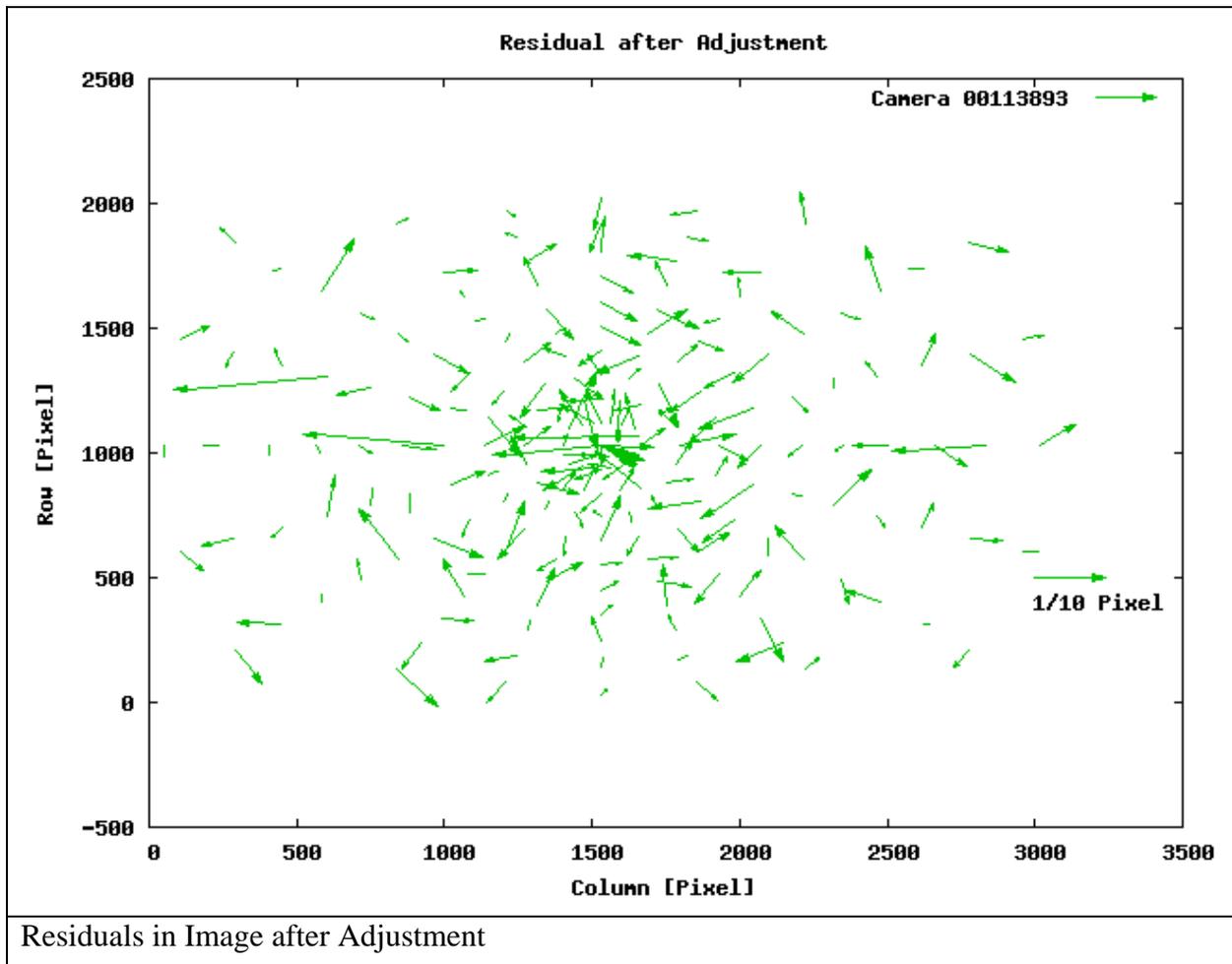
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-MS-Green
Nominal Focal Length	0.025 m
Serial Number	00113893

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-2.741E-05	1.463E-06
	$y_0$	-4.951E-05	1.029E-06
Focal Length [m]	$\Delta f$	-4.42E-05	5.317E-07
Radial Distortion	$K_1$	-138.8	0.4486
	$K_2$	228100	2856
	$K_3$	-162000000	5135000
Decentering distortion	$P_1$	-0.001139	0.0007604
	$P_2$	0.0009065	0.0004696
In Plane Distortion	$B_1$	0.0001532	1.318E-05
	$B_2$	-3.593E-05	1.081E-05

Adjusted Focal length = 0.025+ dc =0.0249558 [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".

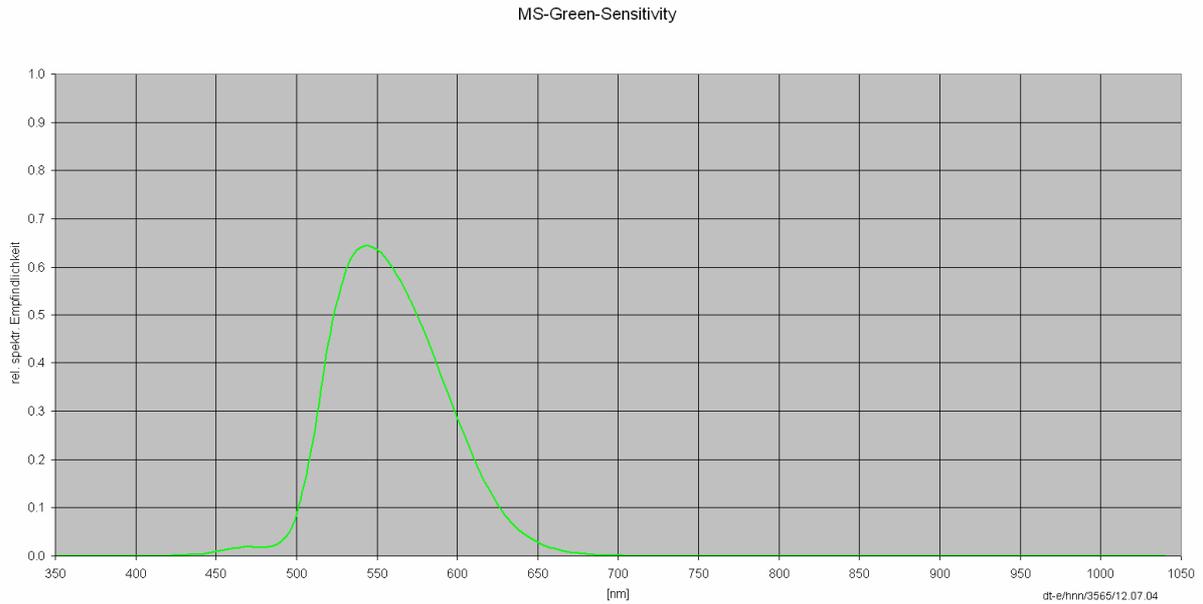
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

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

Camera ID	00113893
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1

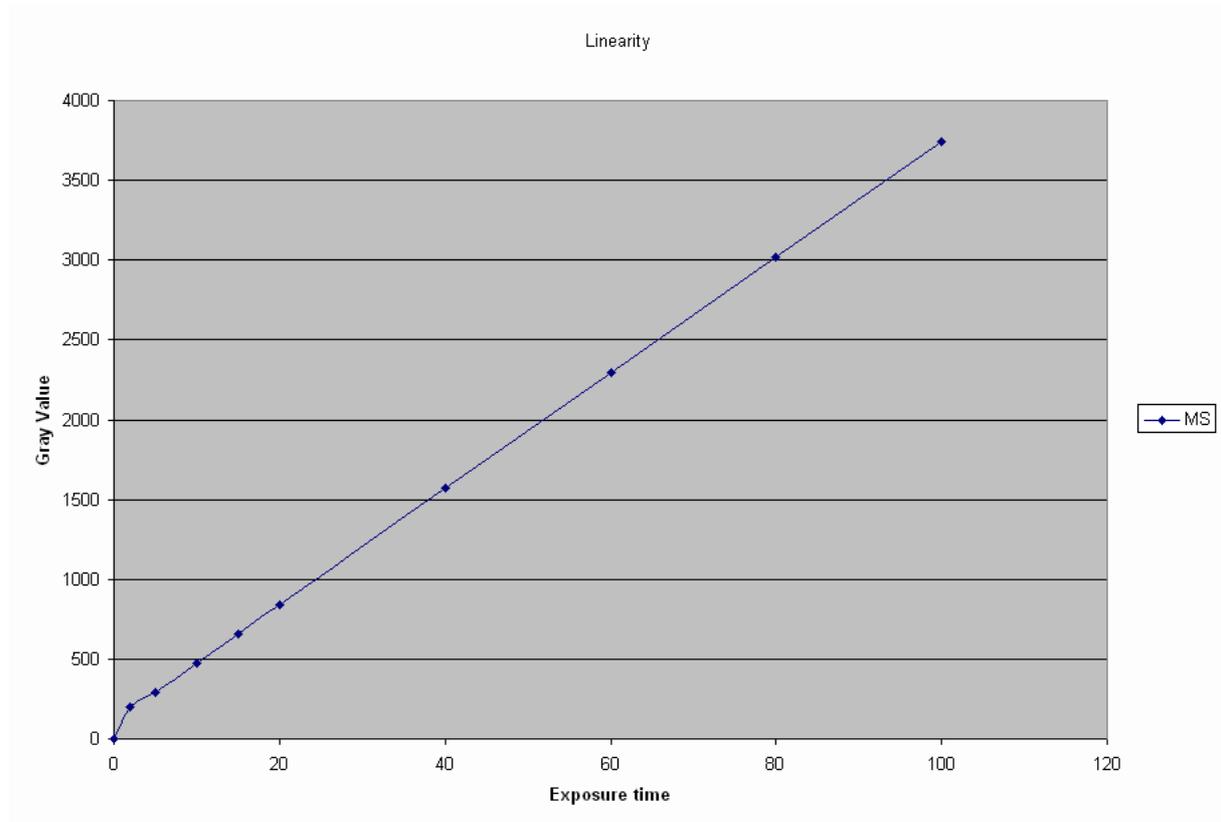
## Sensitivity of camera



**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".

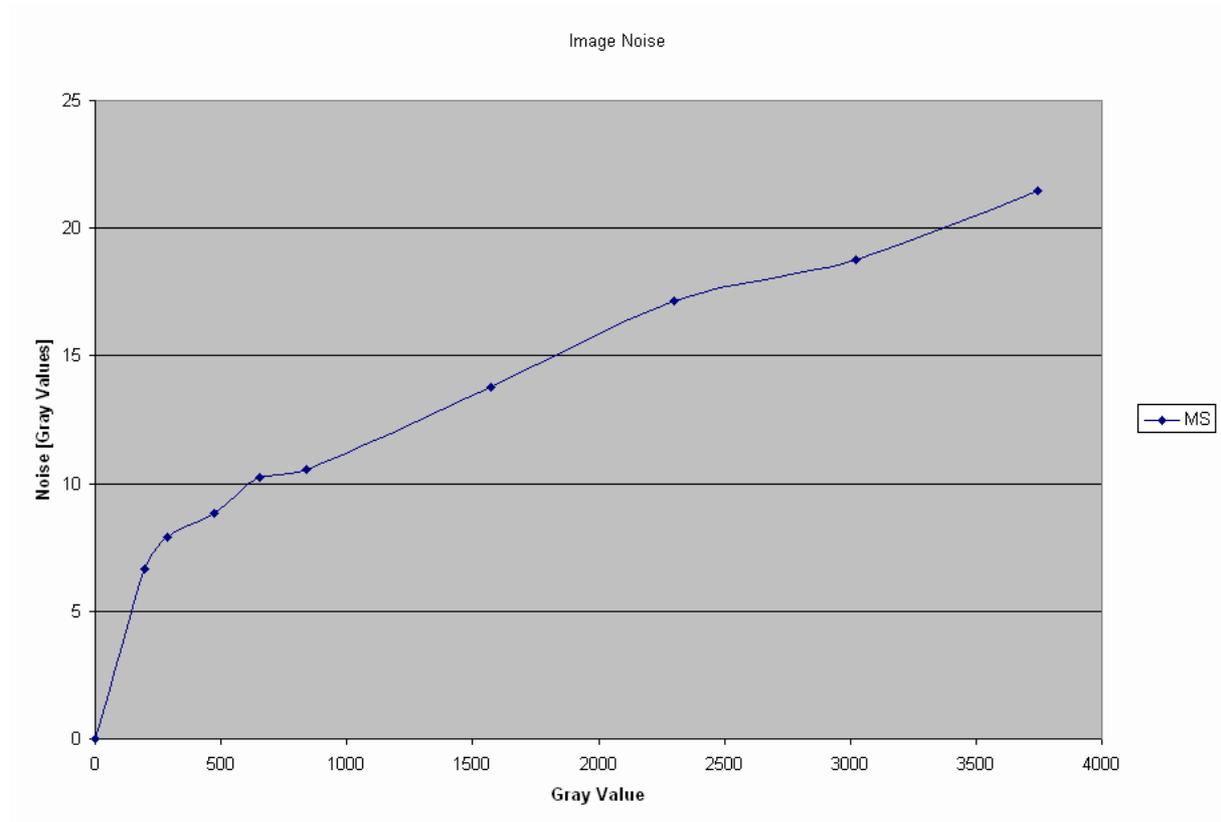
### Sensor Linearity



**Remark:**

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

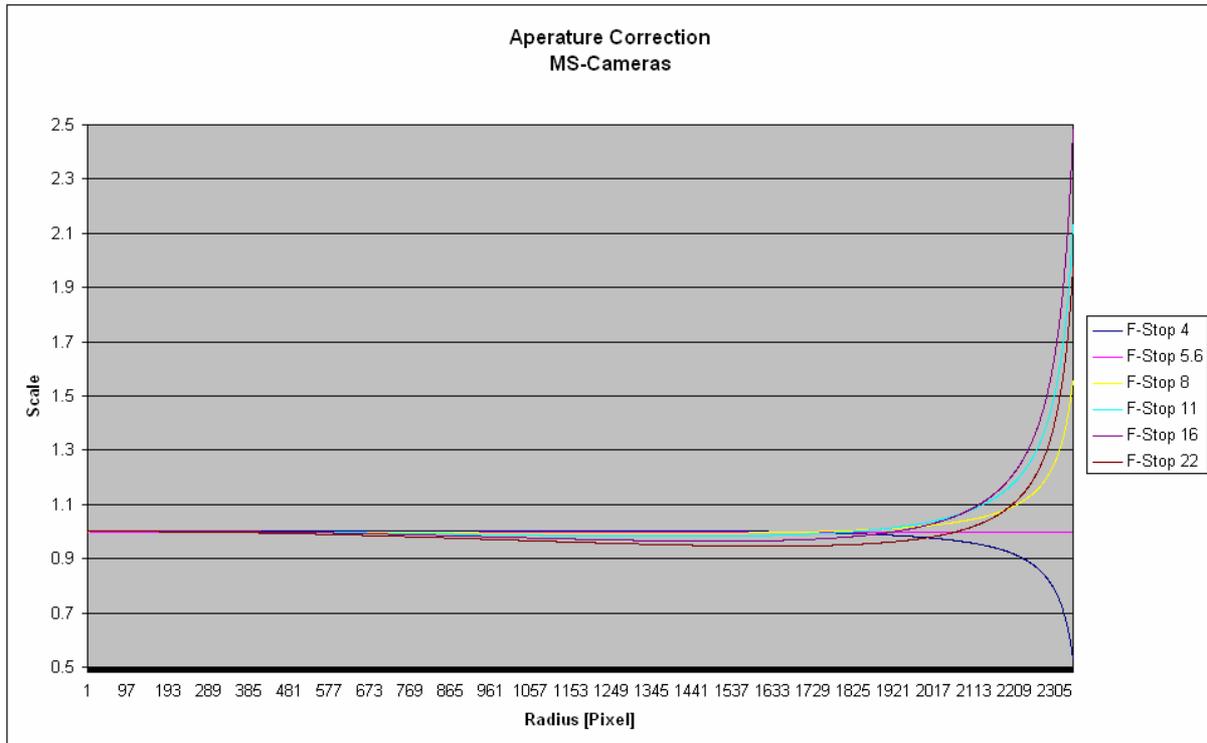
### Sensor Noise



**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: 5  
 Number of defect clusters: 0  
 Number of defect columns: 0

Nr	Row	Column
0	1044	2810
1	1043	2811
2	1044	2811
3	1045	2811
4	1046	2811



# Calibration Protocol DMC01 - 0044



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 $\pm 30\%$ 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.