

Calibration Report

Short version



Camera:	UltraCam D, S/N UCD-SU-1-0012
Manufacturer:	Vexcel Imaging GmbH, A-8010 Graz, Austria
Date of Calibration:	Feb-25-2015
Date of Report:	Mar-06-2015
Camera Revision:	17.0
Revision of Report:	17.0

Calibration Report

Geometric Calibration



Camera:	UltraCam D, S/N UCD-SU-1-0012
Manufacturer:	Vexcel Imaging GmbH, A-8010 Graz, Austria
Panchromatic Camera:	ck = 101.400mm
Multispectral Camera:	ck = 101.400mm
Date of Calibration:	Feb-25-2015
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Panchromatic Camera

Large Format Panchromatic Output Image

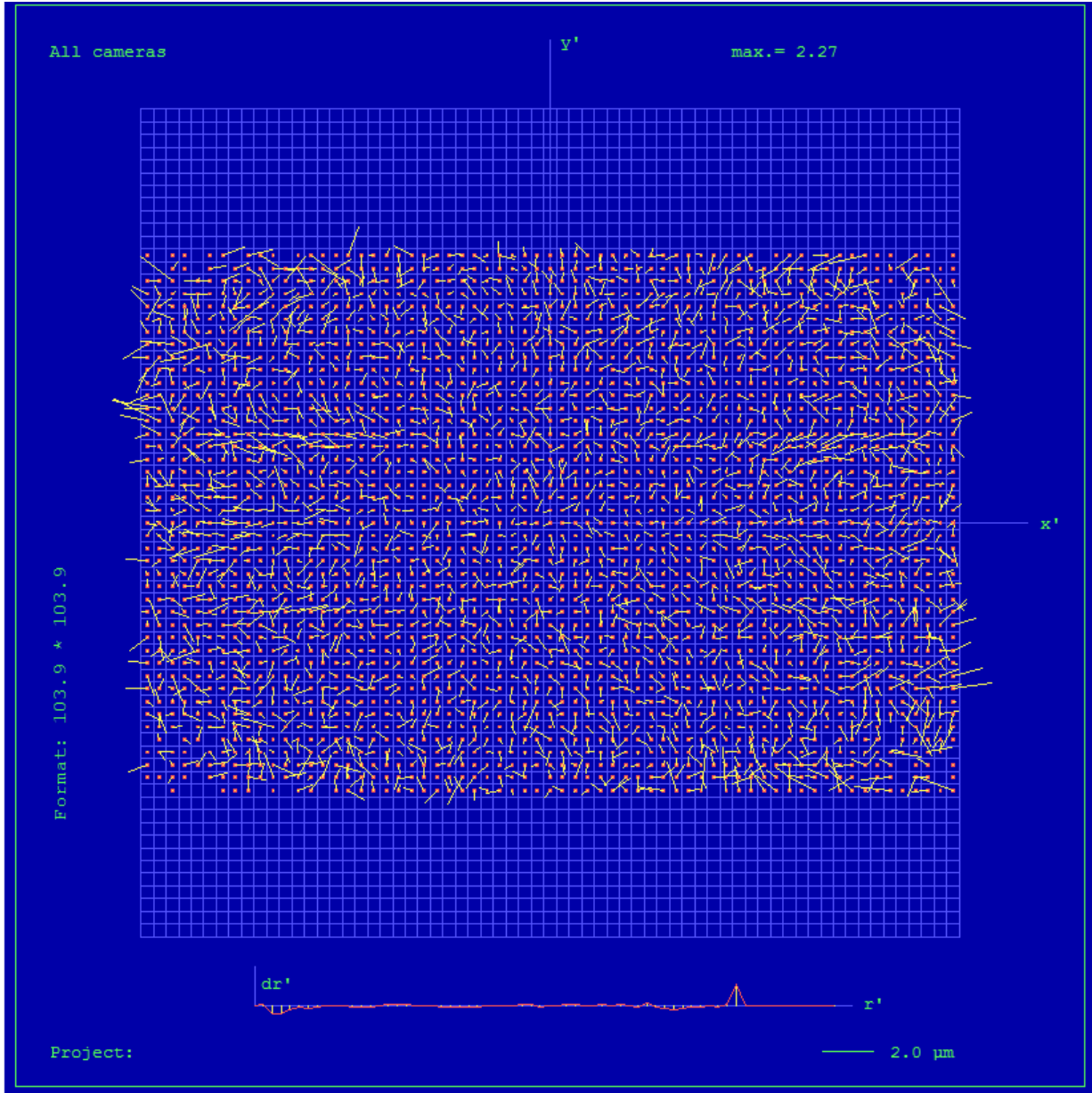
Image Format	long track	67.5mm	7500 pixel
	cross track	103.5mm	11500 pixel
Image Extent		(-33.75, -51.75)mm	(33.75, 51.75)mm
Pixel Size		9.000µm*9.000µm	
Focal Length	ck	101.400mm	± 0.002mm
Principal Point (Level 2)	X_ppa	-0.180 mm	± 0.002mm
	Y_ppa	0.270 mm	± 0.002mm
Lens Distortion	Remaining Distortion less than 0.002mm		

Multispectral Camera

Medium Format Multispectral Output Image (Upscaled to panchromatic image format)

Image Format	long track	67.5mm	2400 pixel
	cross track	103.5mm	3680 pixel
Image Extent		(-33.75, -51.75)mm	(33.75, 51.75)mm
Pixel Size		28.125µm*28.125µm	
Focal Length	ck	101.400mm	
Principal Point (Level 2)	X_ppa	-0.180 mm	± 0.002mm
	Y_ppa	0.270 mm	± 0.002mm
Lens Distortion	Remaining Distortion less than 0.002mm		

Full Pan Image, Residual Error Diagram



Residual Error (RMS): **1.11 μm**

Explanations:

1) Calibration Method:

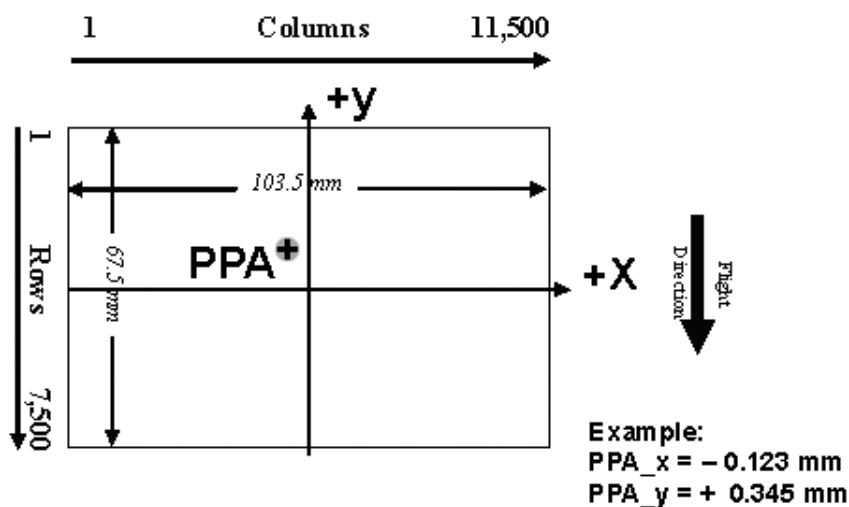
The geometric calibration is based on a set of 84 images of a defined geometry target with 240 GCPs.

Number of point measurements for the panchromatic camera : 18457
 Number of point measurements for the multispectral camera : 71929

Determination of the image parameters by Least Squares Adjustment.
 Software used for the adjustment: BINGO (GIP Eng. Aalen, Germany)

2) Level 2 Image Coordinate System: pan 11500 pixel by 7500 pixel
 MS 3680 pixel by 2400 pixel

Lvl2, Camera prop. Orientation

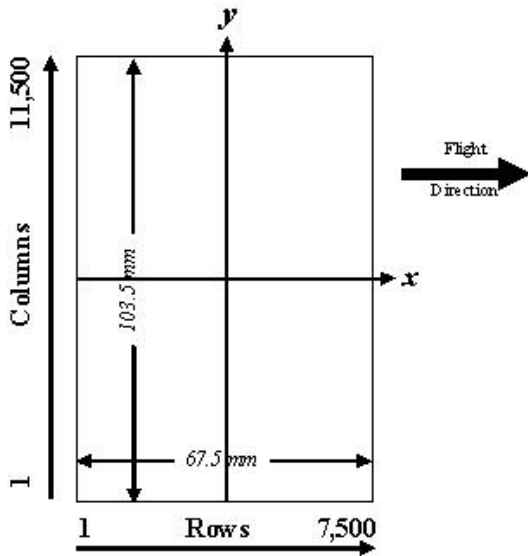


The image coordinate system of the Level 2 images is shown in the above figure. The level 2 image consists of 11500 columns and 7500 rows, which leads to a total image format of 103.5 * 67.5 mm. The coordinate of the principal point in the level 2 image is given on page 3 of this report. The above figure shows the position of an example principal point at the coordinate (-0.123 / 0.345).

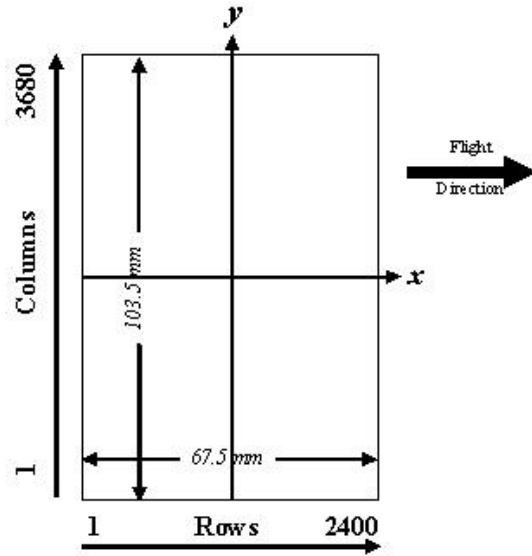
UltraCam D, Serial Number UCD-SU-1-0012

3) Level 3 Image Coordinate System:
(after rotation of 270° CW)

pan 7500 pixel by 11500 pixel
MS 2400 pixel by 3680 pixel a Microsoft company



Panchromatic Image Format



Multispectral Image Format

4) Position of Principal Point in Level 3 Image

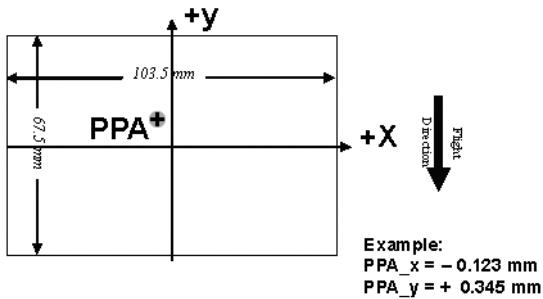
The position of the principal point in the level 3 image depends on the “rotation” setting used in the OPC during the pan-sharpening step. The exact position relative to the image center is given in the table below as a function of the rotation setting used in the OPC. The coordinates are specified for clockwise (CW) rotation in steps of 90 degrees, according to the principal point coordinate given on page 3 for high- and low resolution images.

Image Format	Clockwise Rotation (Degree)	PPA	
		X	Y
Level 2	-	-0.180	0.270
Level 3	0	-0.180	0.270
Level 3	90	0.270	0.180
Level 3	180	0.180	-0.270
Level 3	270	-0.270	-0.180

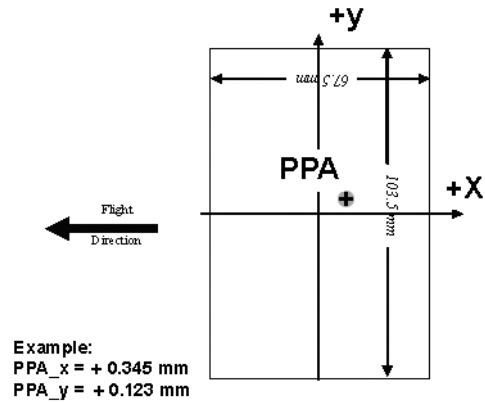
UltraCam D, Serial Number UCD-SU-1-0012

The coordinates in the figure below are only example values to illustrate the effect of image rotation on the principal point position, and do **not** correspond to the camera described in this report.

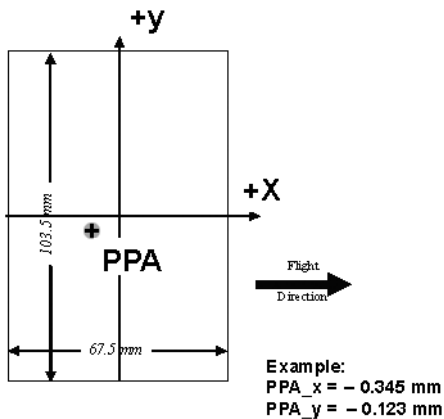
Lvl3, Rotation 0 deg clockwise



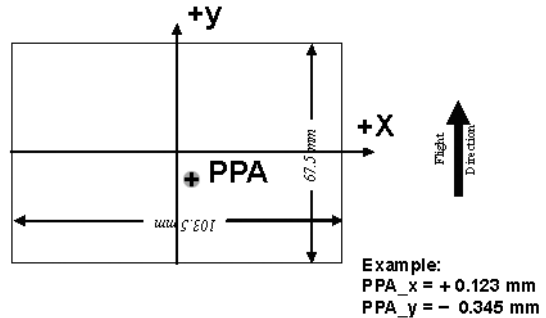
Lvl3, Rotation 90 deg clockwise



Lvl3, Rotation 270 deg clockwise



Lvl3, Rotation 180 deg clockwise

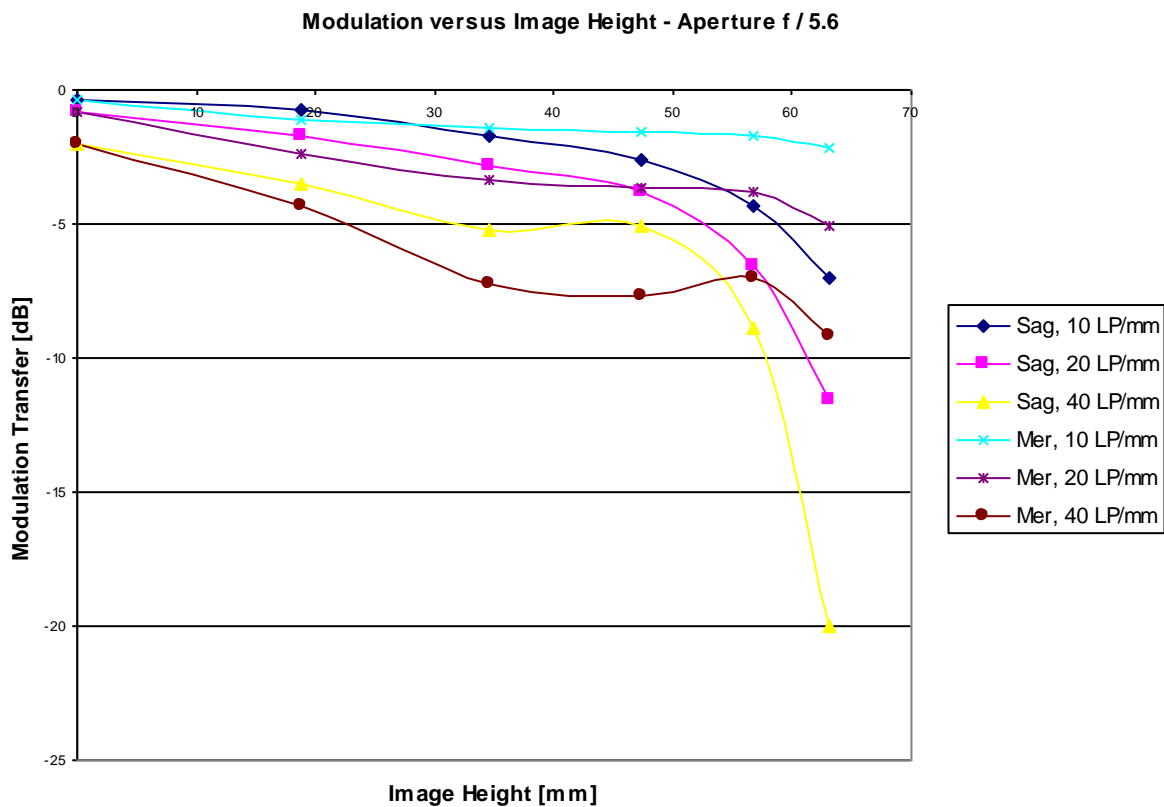


Lens Resolving Power

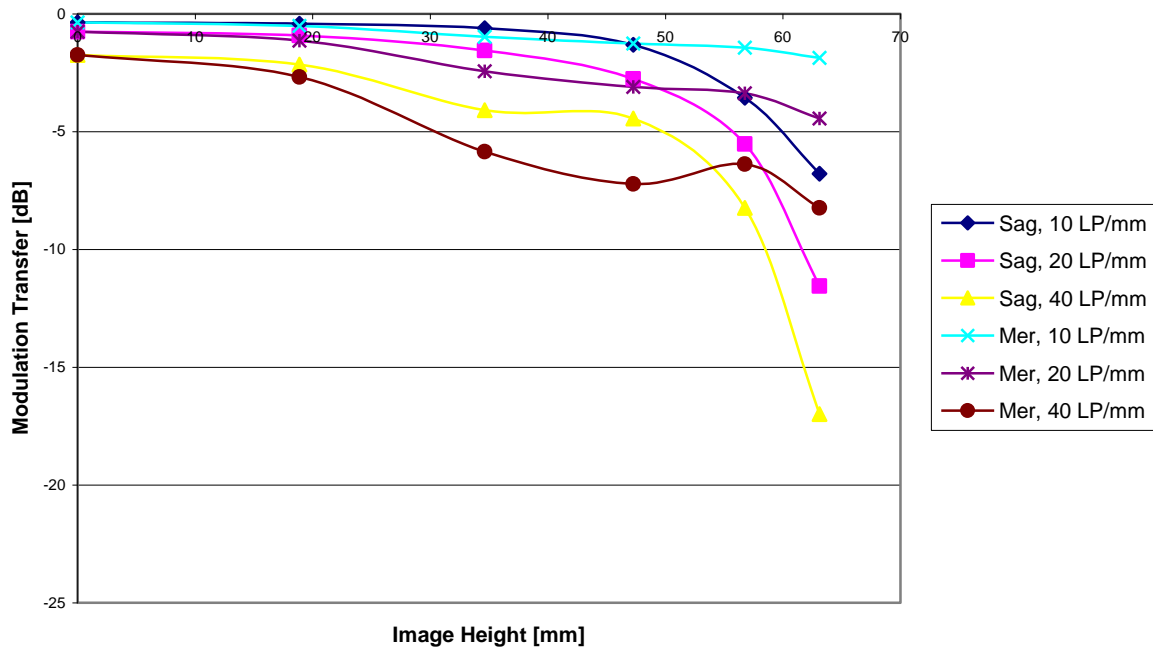
The following curves show the development of the modulation transfer function across different image heights of the panchromatic cones. Please note that these values have been calculated and can vary up to 10% with optics from production (especially at high LP's).

The curves are given for the meridional (tangential) and sagittal (radial) component of signals at frequencies of 10, 20 and 40 line pairs per millimeter.

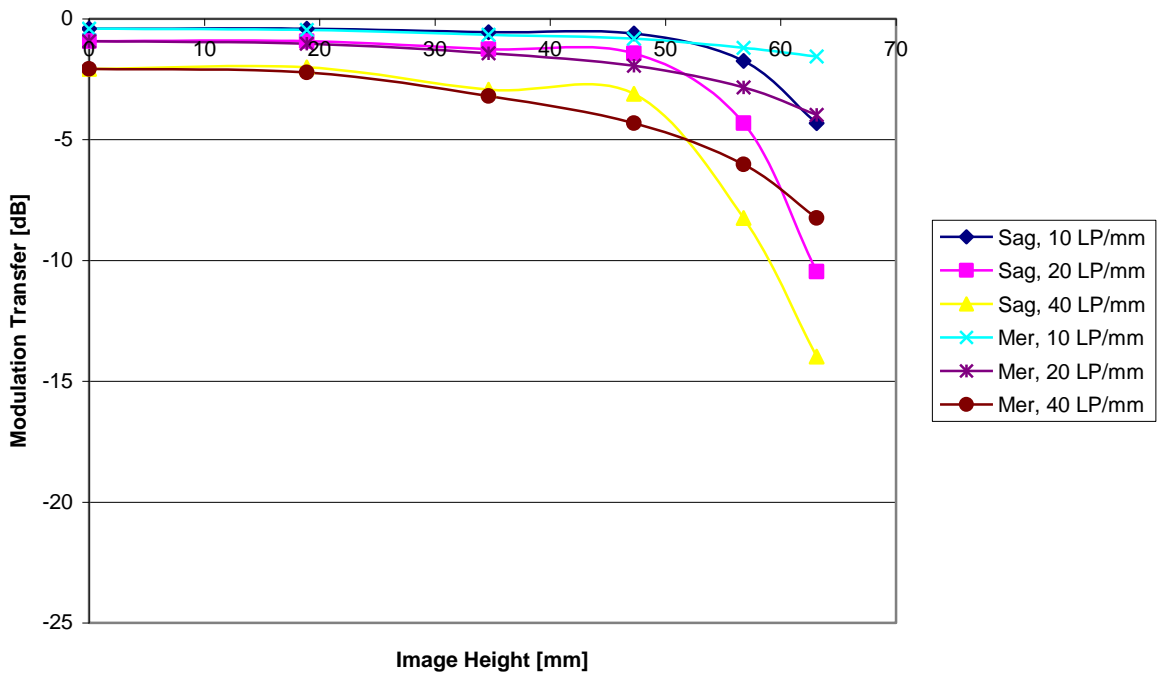
As the MTF is a function of the specific aperture size used, one set of curves is given for each aperture size.



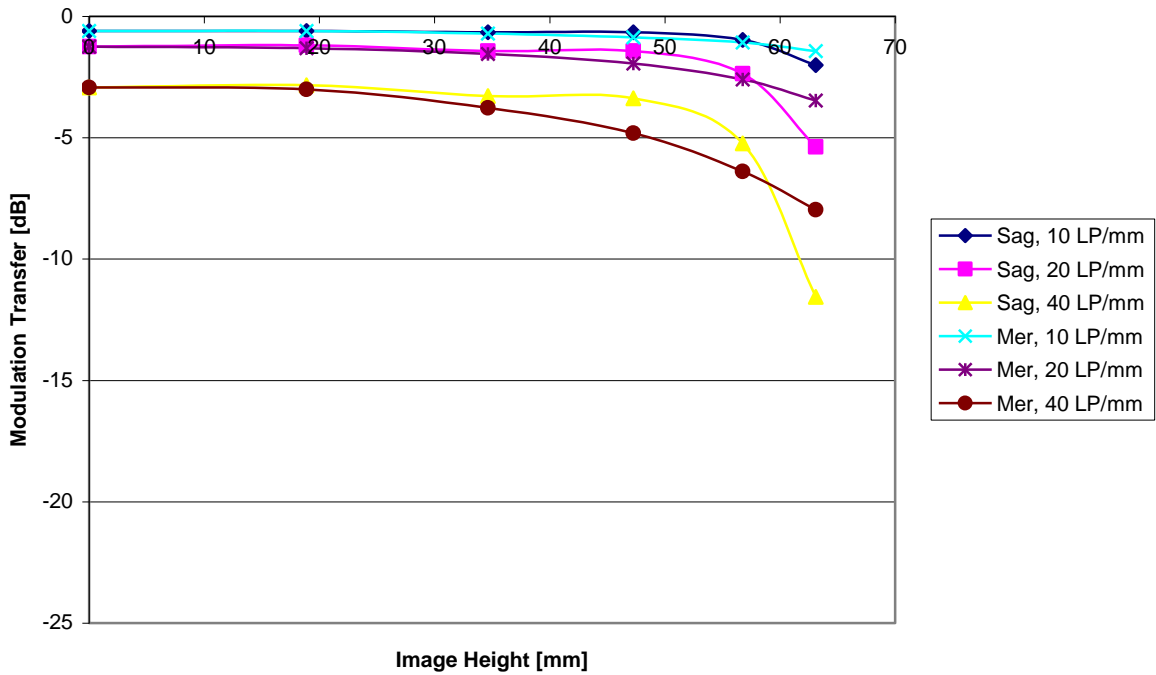
Modulation versus Image Height - Aperture f / 8



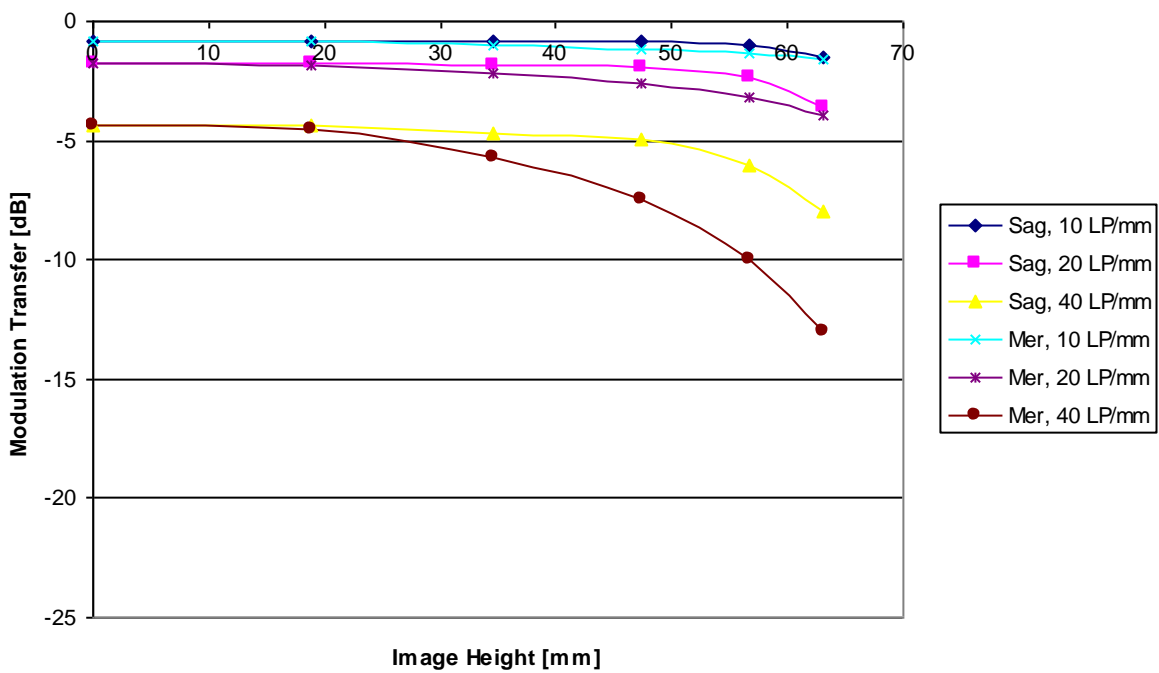
Modulation versus Image Height - Aperture f / 11



Modulation versus Image Height - Aperture f / 16

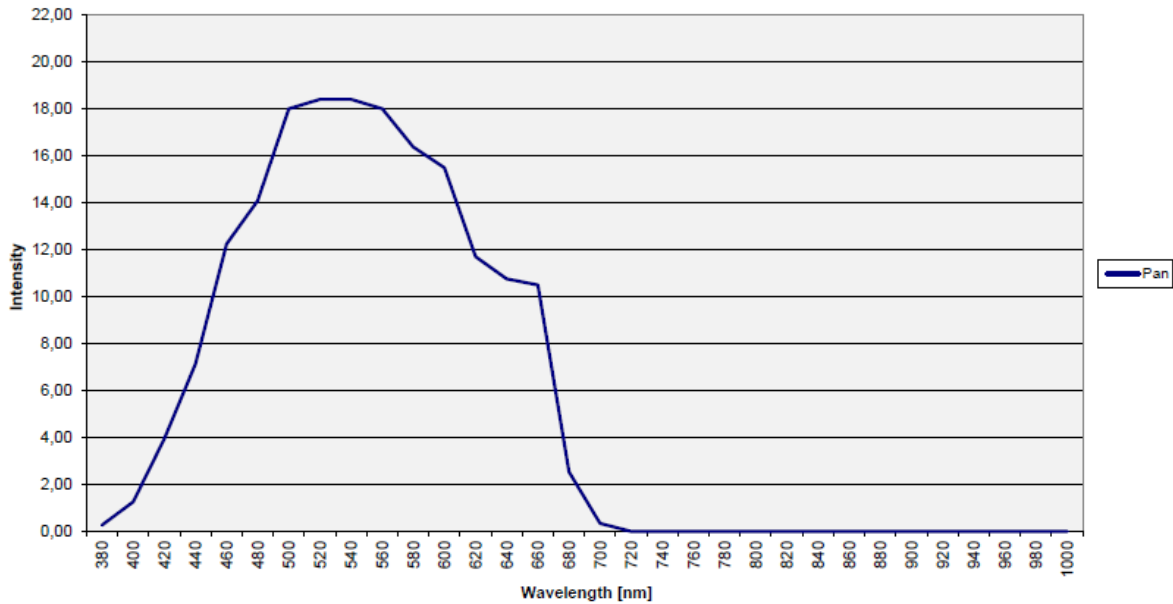


Modulation versus Image Height - Aperture f / 22

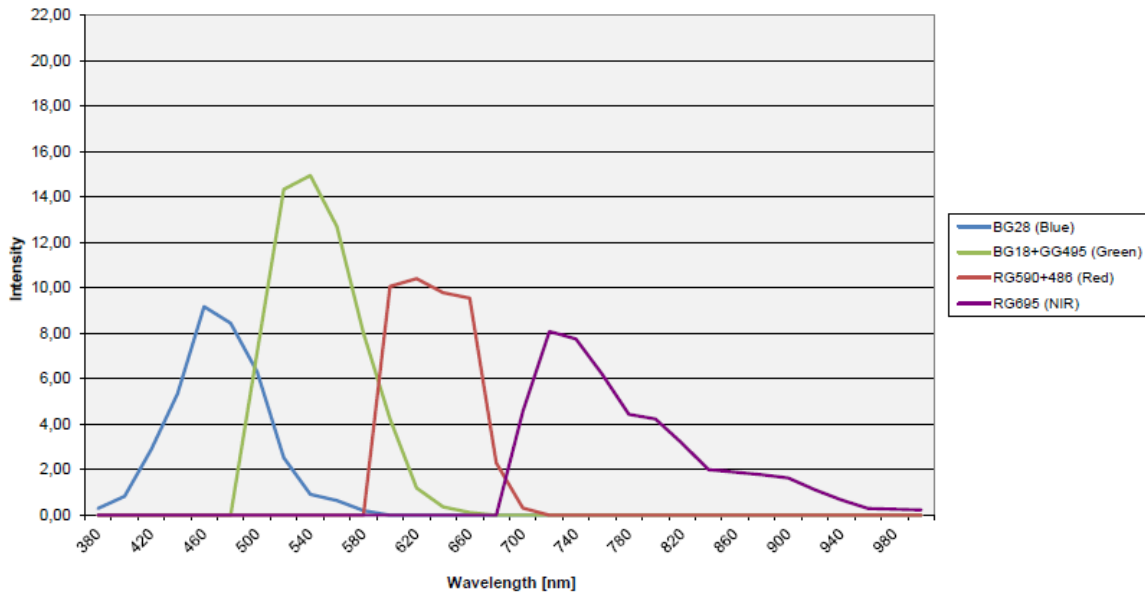


Spectral Sensitivity

Spectral Sensitivity Vexcel UCD - Panchromatic
(Schneider Lenses)



Spektral Sensitivity Vexcel UCD - Multispectral
(Schneider Lenses)



Calibration Report

Radiometric Calibration



Camera:	UltraCam D, S/N UCD-SU-1-0012
Manufacturer:	Vexcel Imaging GmbH, A-8010 Graz, Austria
Panchromatic Camera:	Apertures: f/5.6, f/8, f/11, f/16, f/22 (All Pan)
Multispectral Camera:	Apertures: f/4, f/5.6, f/8, f/11, f/16 (Red, Green) f/2.8, f/4, f/5.6, f/8, f/11 (Blue, NIR)
Date of Calibration:	Feb-25-2015
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Explanations:

Calibration Method:

The radiometric calibration is based on a series of 60 flat field images for each aperture size and sensor. The flat field is illuminated by two normal light lamps with known spectral illumination curves.

These images are used to calculate the specific sensitivity of each pixel to compensate local as well as global variations in sensitivity. Sensitivity tables are calculated for each sensor and aperture setting, and applied during post processing from level 0 to level 1.

Outlier Pixels that do not have a linear behavior as described in the CCD specifications are marked as defective during the calibration procedure. These pixels are not used or only partially used during post processing and the information is restored by interpolation between the neighborhood pixels surrounding the defective pixels.

Certain pixels that are named Qmax pixels due to the fact that they can only store and transfer charge up to a certain maximum amount are detected in an additional calibration step. These pixels are treated differently during post processing, since their behavior can affect not only single pixel values but whole columns.

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Summary



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The following calibrations have been performed for the above mentioned digital aerial mapping camera:

- Geometric Calibration
- Verification of Lens Quality and Sensor Adjustment
- Radiometric Calibration
- Calibration of Defective Pixel Elements
- Shutter Calibration
- Sensor and Electronics Calibration

This equipment is operating fully within specification as defined by Vexcel Imaging GmbH.


Dr. Michael Gruber
Chief Scientist, Photogrammetry
Vexcel Imaging GmbH


Ing. Peter Prassl
Senior Calibration Engineer
Vexcel Imaging GmbH