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# Test report of **ELM-75-4.0-16-C** Integrated liquid lens Optotune **EL-16-40-GTC-VIS-5D**

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Daniele Ghedalia, Application Engineer

Optotune Switzerland AG | Bernstrasse 388 | CH-8953 Dietikon | Switzerland  
Phone +41 58 856 3011 | [www.optotune.com](http://www.optotune.com) | [info@optotune.com](mailto:info@optotune.com)

# Summary



- High resolution for 3.45 um pixel size and 1.1" Sensor:
  - Very small amount of vignetting for 1.1" Sensor
  - **Nyquist limit** (up to 145 lp/mm) with minimal drop at edges and corners
  - **No gravity coma** in horizontal configuration
  - Excellent polychromatic performance

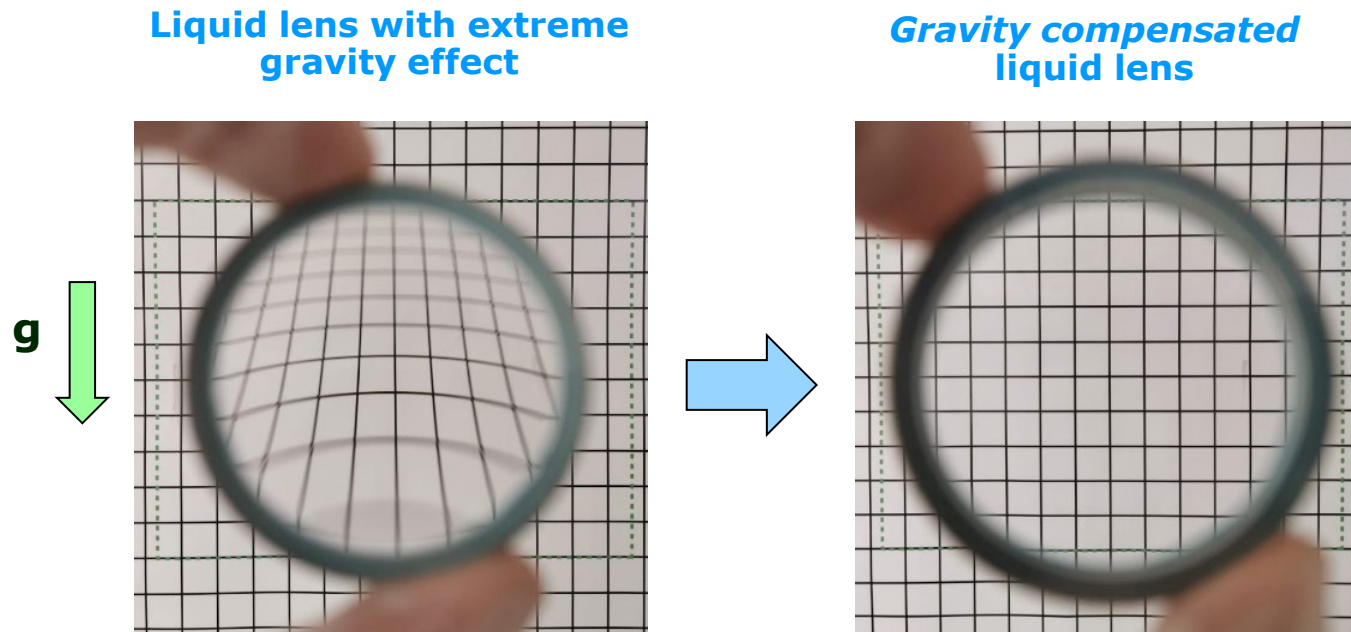
Working distance [mm]	Resolution [lp/mm on the image]			
	White light		Red light	
	Vertical	Horizontal	Vertical	Horizontal
350	140	142	140	140
420	137	138	135	135
650	141	128	141	141

- Angular Field of View [°] From 350 mm to 650 mm

AFOV Type \ WD	650 mm	420 mm	350 mm
Width	11.01	11.60	11.32
Height	8.08	8.51	8.31
Diagonal	13.63	14.35	14.01

# First ELM with gravity compensated liquid lens

- Thanks to passive gravity compensation technology, the performance of this ELM is identical for vertical vs. horizontal optical axis orientation

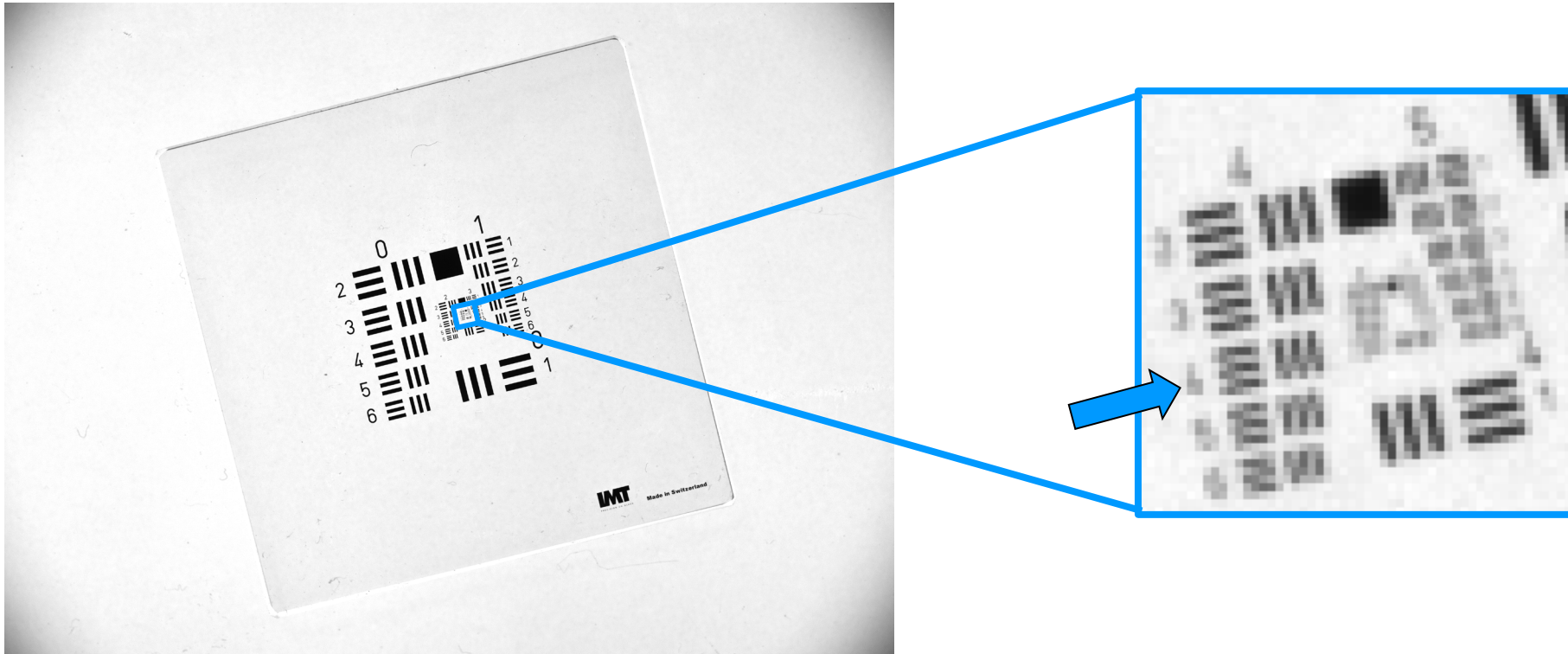


# Main specifications

Sensor	IMX255LQR 1" format 14.131mm x 7.452mm, 16.0mm
Wavelength (nm)	430nm-700nm
EFL (mm)	73mm
F-number	4.0
BFL (mm)	12.4mm (+0.7mm CG+0.3mm Filter)
TTL (mm)	95.5mm (+0.7mm CG+0.3mm Filter)
Max Image Circle (mm)	18.0mm
DFOV	12.9° @16.0mm
HFOV	11.4° @14.131mm
VFOV	6.1° @7.452mm
Working Object Distance	350mm to 650mm (with 1.00 to -1.55 dpt) Best MTF at 420mm
Distortion F-Tan(Theta)	1.0%
Relative Illumination	90% @16.0mm
Max Chief Ray Angle	4.5° @16.0mm
Lens construction	12G + EL-16-40-GTC

# Method for image evaluation

- After acquisition, images are zoomed in to show resolution limited element



Note: 1.1" image sensor used is 10% larger than the nominal image circle

# Four different tests performed

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- [Test setup 1 \(Vertical with white backlight\)](#)
- [Test setup 2 \(Horizontal with white backlight\)](#)
- [Test setup 3 \(Vertical with red backlight\)](#)
- [Test setup 4 \(Horizontal with red backlight\)](#)

# Test setup 1



Camera: 1.1", 4104 x 3004 px,  
Pixel size = 3.45  $\mu\text{m}$

Model: IDS UI-3200SE-M-GL

Lens: ELM-75 with EL-16-40-VIS-5D-GC

Orientation: **Vertical** Optical Axis

Controller: Optotune ICC-4C-500

Target: USAF chrome target, transparent

Light: **White** backlight

# WD 420 mm @ 0 dpt

## Camera

Sensor size = 4104 x 3004 px

Nyquist limit = 145 lp/mm

Pixel size = 3.45  $\mu$ m

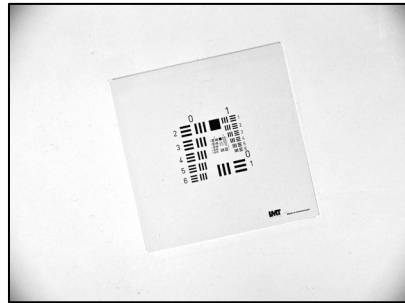
## Light

White background illumination

## Orientation

Vertical

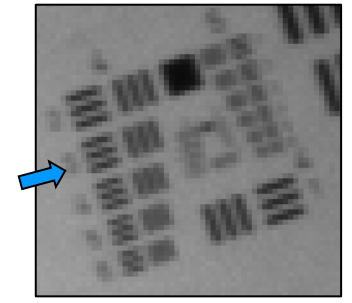
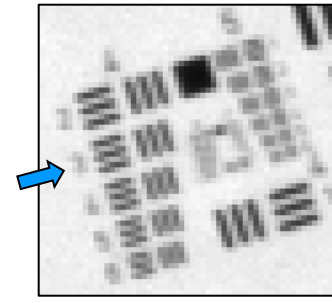
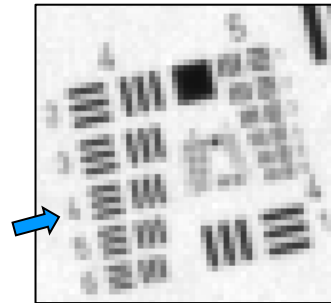
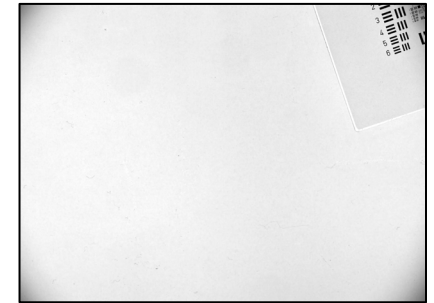
### Center



### Edge



### Corner



USAF element:	4/4
Line width ( $\mu$ m):	22.1
Lp/mm (object):	23
Magnification:	0.166
<b>Lp/mm (image):</b>	<b>137</b>

USAF element:	4/3
Line width ( $\mu$ m):	24.8
Lp/mm (object):	20
Magnification:	0.166
<b>Lp/mm (image):</b>	<b>122</b>

USAF element:	4/3
Line width ( $\mu$ m):	24.8
Lp/mm (object):	20
Magnification:	0.166
<b>Lp/mm (image):</b>	<b>122</b>

# WD 350 mm @ 1 dpt

## Camera

Sensor size = 4104 x 3004 px

Nyquist limit = 145 lp/mm

Pixel size = 3.45  $\mu$ m

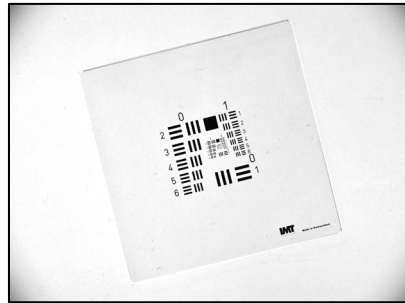
## Light

White background illumination

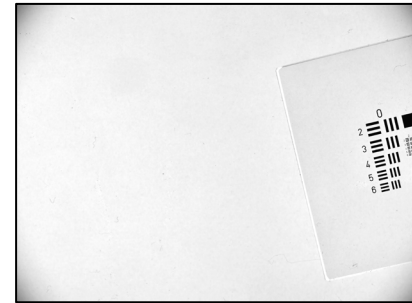
## Orientation

Vertical

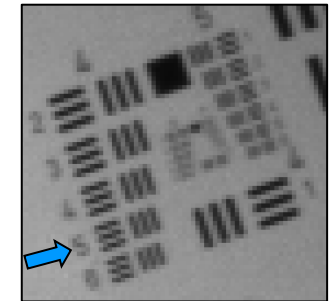
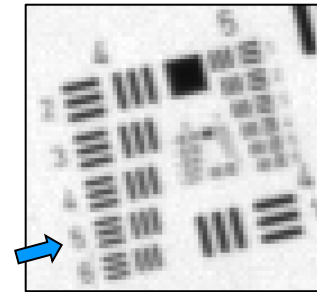
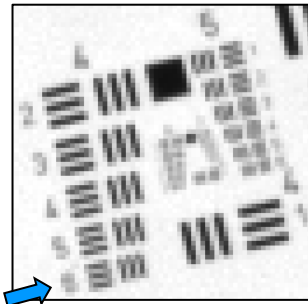
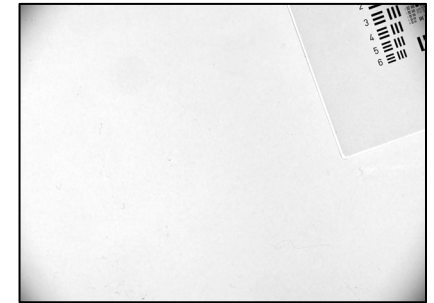
### Center



### Edge



### Corner



USAF element:	4/6
Line width ( $\mu$ m):	17.54
Lp/mm (object):	29
Magnification:	0.204
<b>Lp/mm (image):</b>	<b>140</b>

USAF element:	4/5
Line width ( $\mu$ m):	19.69
Lp/mm (object):	25
Magnification:	0.204
<b>Lp/mm (image):</b>	<b>124</b>

USAF element:	4/5
Line width ( $\mu$ m):	19.69
Lp/mm (object):	25
Magnification:	0.204
<b>Lp/mm (image):</b>	<b>124</b>

# WD 650 mm @ -1.55 dpt

## Camera

Sensor size = 4104 x 3004 px

Nyquist limit = 145 lp/mm

Pixel size = 3.45  $\mu$ m

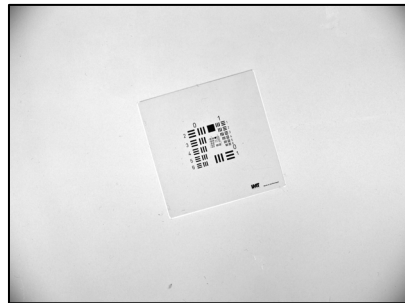
## Light

White background illumination

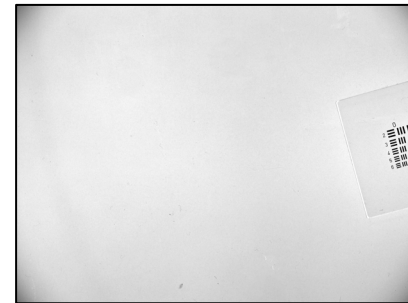
## Orientation

Vertical

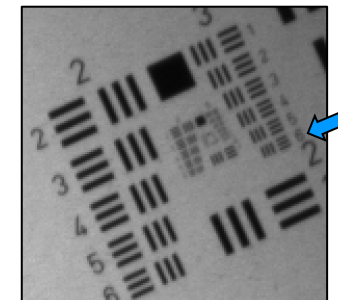
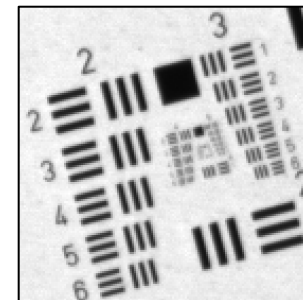
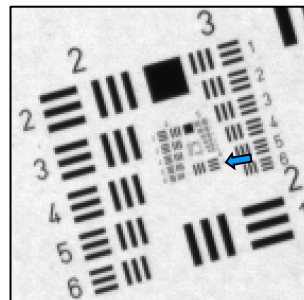
### Center



### Edge



### Corner



USAF element:	4/1
Line width ( $\mu$ m):	31.25
Lp/mm (object):	16
Magnification:	0.113
<b>Lp/mm (image):</b>	<b>141</b>

USAF element:	3/6
Line width ( $\mu$ m):	35.08
Lp/mm (object):	14
Magnification:	0.113
<b>Lp/mm (image):</b>	<b>126</b>

USAF element:	3/6
Line width ( $\mu$ m):	35.08
Lp/mm (object):	14
Magnification:	0.113
<b>Lp/mm (image):</b>	<b>126</b>

# Test setup 2

---

Camera: 1.1", 4104 x 3004 px,  
Pixel size = 3.45 um  
  
Model: IDS UI-3200SE-M-GL

Lens: ELM-75 with EL-16-40-VIS-5D-GC

Orientation: **Horizontal** Optical Axis

Controller: Optotune ICC-4C-500

Target: USAF chrome target, transparent

Light: **White** backlight

# WD 420 mm @ 0 dpt

## Camera

Sensor size = 4104 x 3004 px

Nyquist limit = 145 lp/mm

Pixel size = 3.45  $\mu$ m

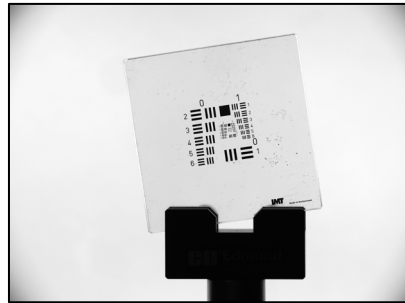
## Light

White background illumination

## Orientation

Horizontal

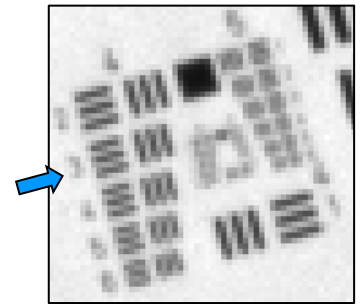
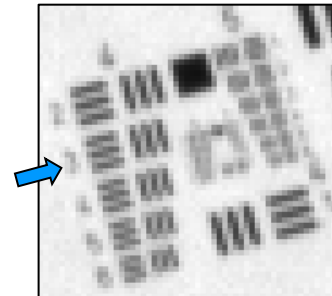
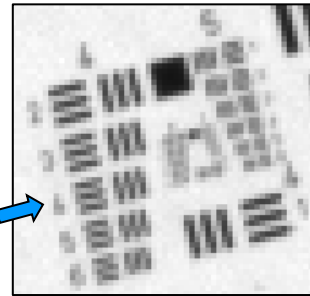
### Center



### Edge



### Corner



USAF element: 4/4  
Line width ( $\mu$ m): 22.1  
Lp/mm (object): 23  
Magnification: 0.163  
**Lp/mm (image): 138**

4/4  
22.1  
23  
0.165  
**137**

4/4  
22.1  
23  
0.167  
**135**

# WD 350 mm @ 1 dpt

## Camera

Sensor size = 4104 x 3004 px

Nyquist limit = 145 lp/mm

Pixel size = 3.45  $\mu$ m

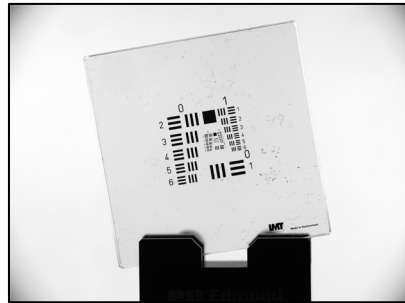
## Light

White background illumination

## Orientation

Horizontal

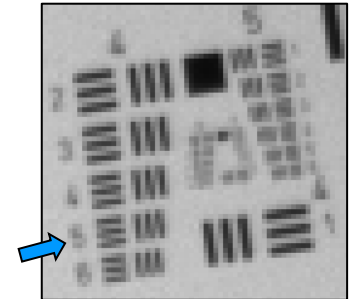
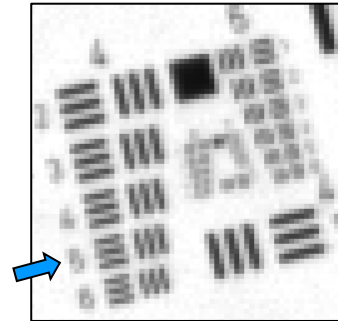
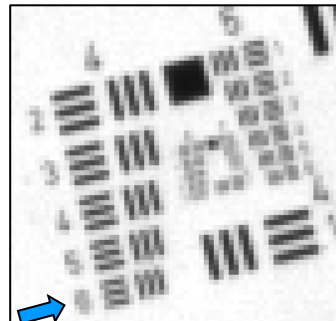
### Center



### Edge



### Corner



USAF element: 4/6  
Line width ( $\mu$ m): 17.54  
Lp/mm (object): 29  
Magnification: 0.201  
**Lp/mm (image): 142**

4/5  
19.69  
25  
0.201  
**127**

4/5  
19.69  
25  
0.201  
**127**

# WD 650 mm @ -1.55 dpt

## Camera

Sensor size = 4104 x 3004 px

Nyquist limit = 145 lp/mm

Pixel size = 3.45  $\mu$ m

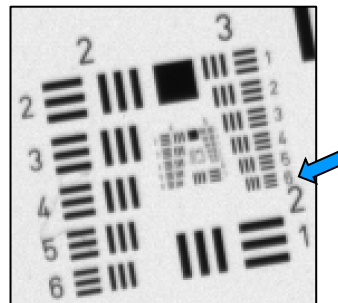
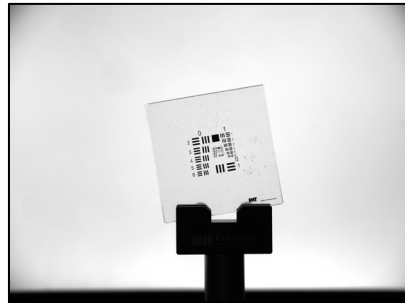
## Light

White background illumination

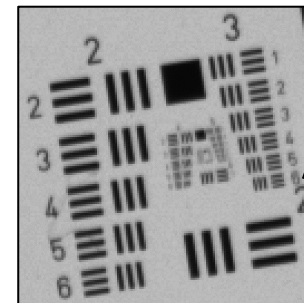
## Orientation

Horizontal

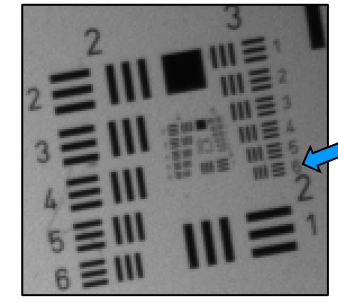
## Center



## Edge



## Corner

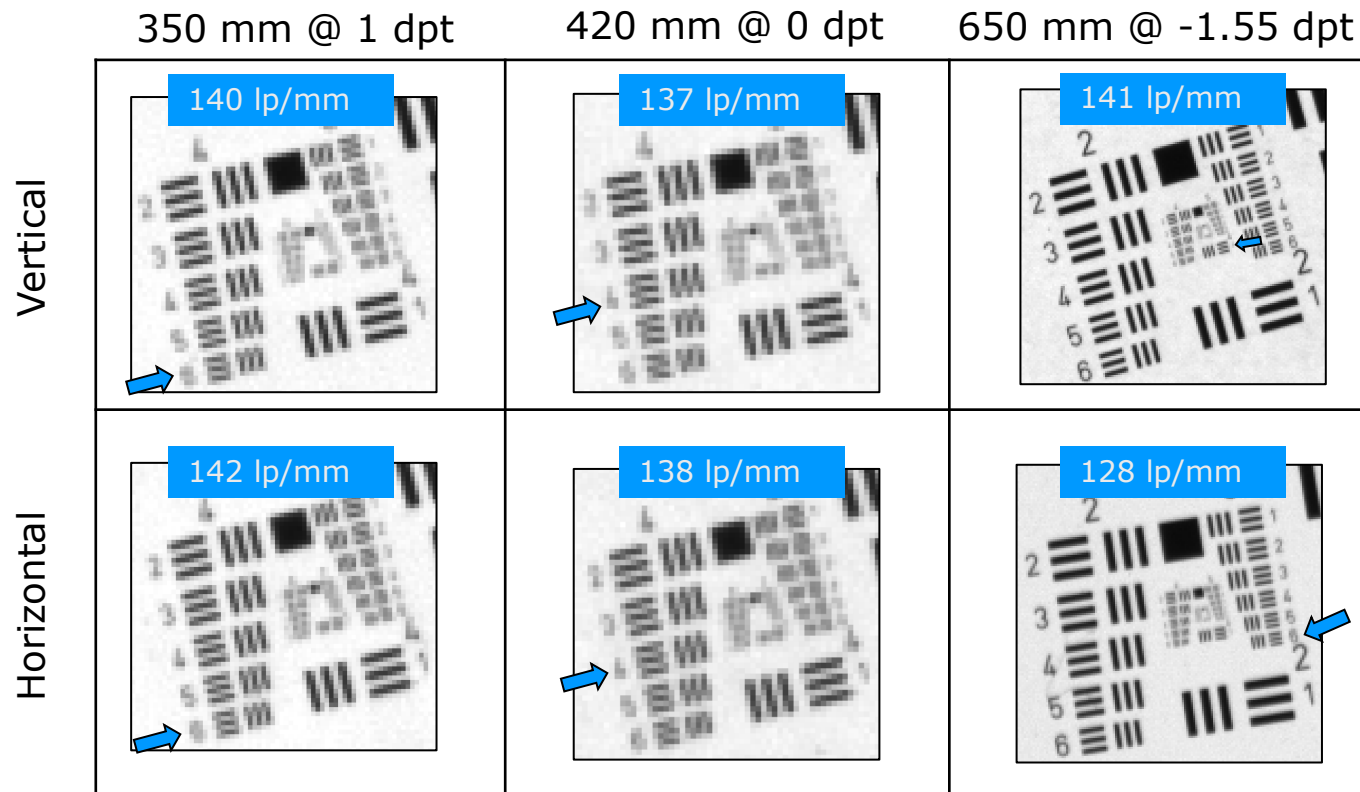


USAF element:	3/6
Line width ( $\mu$ m):	35.08
Lp/mm (object):	14
Magnification:	0.112
<b>Lp/mm (image):</b>	<b>128</b>

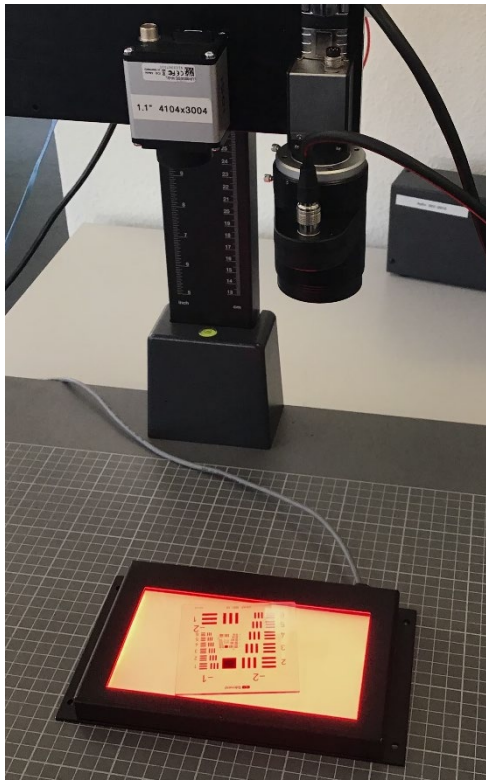
USAF element:	3/6
Line width ( $\mu$ m):	35.08
Lp/mm (object):	14
Magnification:	0.112
<b>Lp/mm (image):</b>	<b>128</b>

USAF element:	3/6
Line width ( $\mu$ m):	35.08
Lp/mm (object):	14
Magnification:	0.112
<b>Lp/mm (image):</b>	<b>128</b>

# White light @ Center: No resolution drop thanks to gravity compensation



# Test setup 3



Camera: 1.1", 4104 x 3004 px,  
Pixel size = 3.45  $\mu\text{m}$

Model: IDS UI-3200SE-M-GL

Lens: ELM-75 with EL-16-40-VIS-5D-GC

Orientation: **Vertical** Optical Axis

Controller: Optotune ICC-4C-500

Target: USAF chrome target, transparent

Light: **Red** backlight

# WD 420 mm @ 0 dpt

## Camera

Sensor size = 4104 x 3004 px

Nyquist limit = 145 lp/mm

Pixel size = 3.45  $\mu\text{m}$

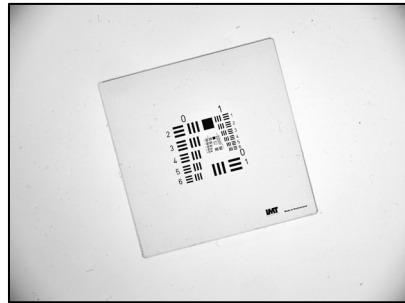
## Light

Red background illumination

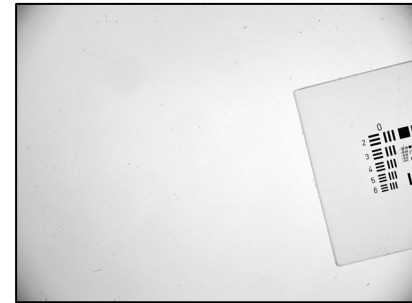
## Orientation

Vertical

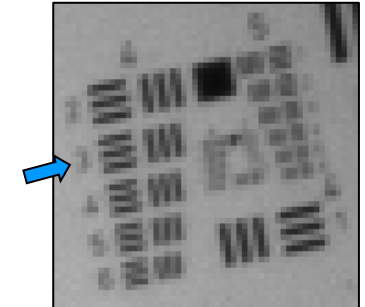
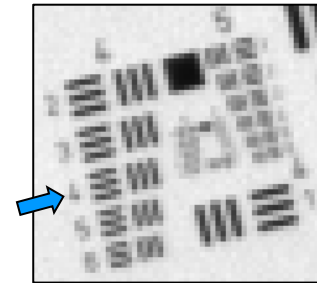
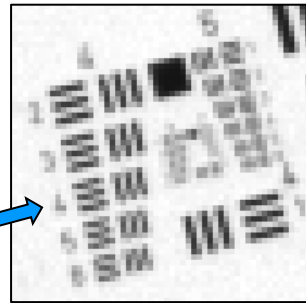
### Center



### Edge



### Corner



USAF element:	4/4	4/4	4/3
Line width ( $\mu\text{m}$ ):	22.1	22.1	24.8
Lp/mm (object):	23	23	20
Magnification:	0.167	0.167	0.167
<b>Lp/mm (image):</b>	<b>135</b>	<b>135</b>	<b>121</b>

# WD 350 mm @ 1 dpt

## Camera

Sensor size = 4104 x 3004 px

Nyquist limit = 145 lp/mm

Pixel size = 3.45  $\mu\text{m}$

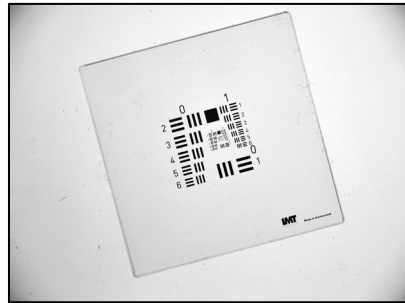
## Light

Red background illumination

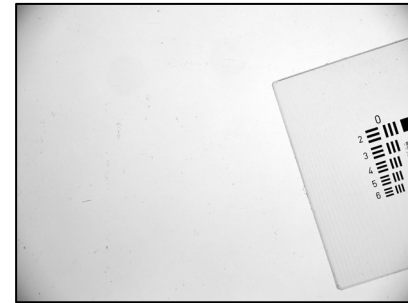
## Orientation

Vertical

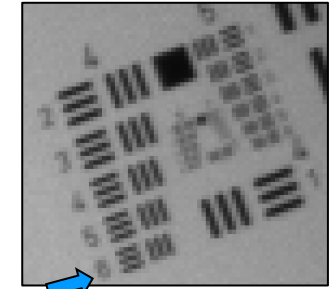
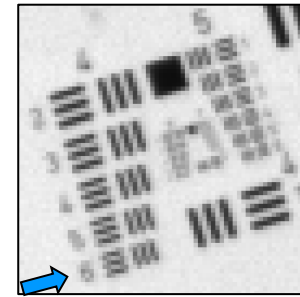
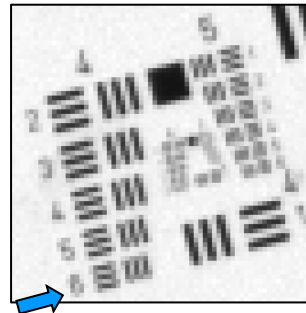
### Center



### Edge



### Corner



USAF element:	4/6
Line width ( $\mu\text{m}$ ):	17.54
Lp/mm (object):	29
Magnification:	0.204
<b>Lp/mm (image):</b>	<b>140</b>

USAF element:	4/6
Line width ( $\mu\text{m}$ ):	17.54
Lp/mm (object):	29
Magnification:	0.204
<b>Lp/mm (image):</b>	<b>140</b>

USAF element:	4/6
Line width ( $\mu\text{m}$ ):	17.54
Lp/mm (object):	29
Magnification:	0.204
<b>Lp/mm (image):</b>	<b>140</b>

# WD 650 mm @ -1.55 dpt

## Camera

Sensor size = 4104 x 3004 px

Nyquist limit = 145 lp/mm

Pixel size = 3.45  $\mu$ m

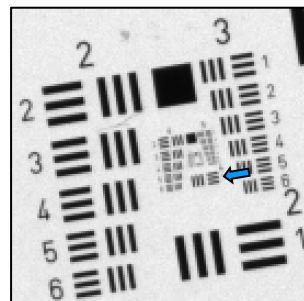
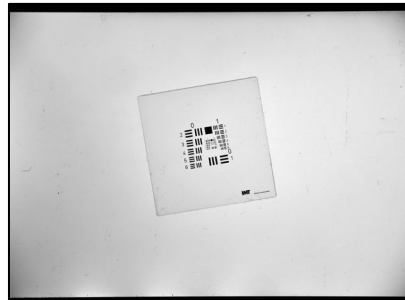
## Light

Red background illumination

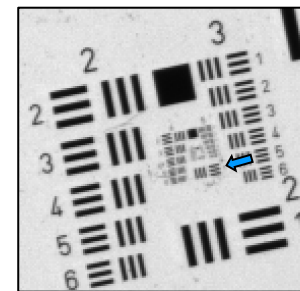
## Orientation

Vertical

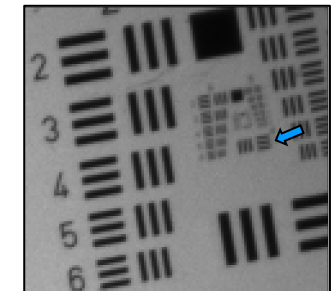
### Center



### Edge



### Corner



USAF element:	4/1
Line width ( $\mu$ m):	31.25
Lp/mm (object):	16
Magnification:	0.113
<b>Lp/mm (image):</b>	<b>141</b>

USAF element:	4/1
Line width ( $\mu$ m):	31.25
Lp/mm (object):	16
Magnification:	0.113
<b>Lp/mm (image):</b>	<b>141</b>

USAF element:	4/1
Line width ( $\mu$ m):	31.25
Lp/mm (object):	16
Magnification:	0.113
<b>Lp/mm (image):</b>	<b>141</b>

# Test setup 4

---

Camera: 1.1", 4104 x 3004 px,  
Pixel size = 3.45 um  
  
Model: IDS UI-3200SE-M-GL

Lens: ELM-75 with EL-16-40-VIS-5D-GC

Orientation: **Horizontal** Optical Axis

Controller: Optotune ICC-4C-500

Target: USAF chrome target, transparent

Light: **Red** backlight

# WD 420 mm @ 0 dpt

## Camera

Sensor size = 4104 x 3004 px

Nyquist limit = 145 lp/mm

Pixel size = 3.45  $\mu\text{m}$

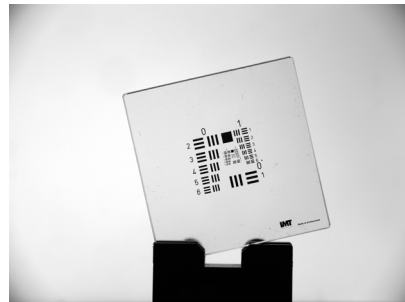
## Light

Red background illumination

## Orientation

Horizontal

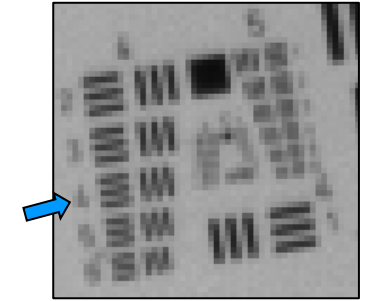
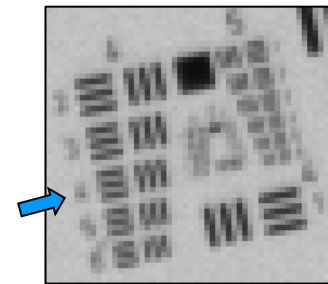
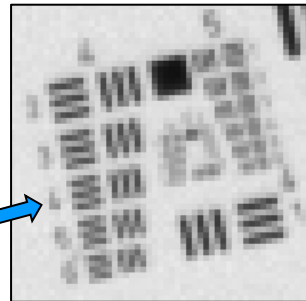
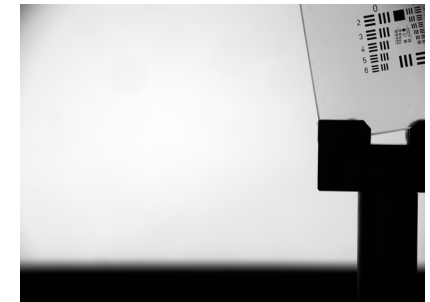
### Center



### Edge



### Corner



USAF element:	4/4
Line width ( $\mu\text{m}$ ):	22.1
Lp/mm (object):	23
Magnification:	0.167
<b>Lp/mm (image):</b>	<b>135</b>

USAF element:	4/4
Line width ( $\mu\text{m}$ ):	22.1
Lp/mm (object):	23
Magnification:	0.167
<b>Lp/mm (image):</b>	<b>135</b>

USAF element:	4/4
Line width ( $\mu\text{m}$ ):	22.1
Lp/mm (object):	23
Magnification:	0.167
<b>Lp/mm (image):</b>	<b>135</b>

# WD 350 mm @ 1 dpt

## Camera

Sensor size = 4104 x 3004 px

Nyquist limit = 145 lp/mm

Pixel size = 3.45  $\mu\text{m}$

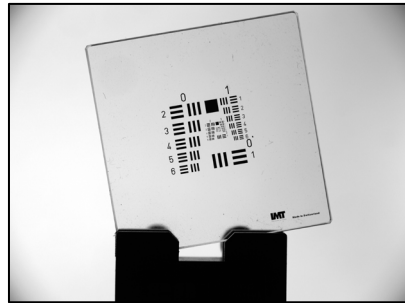
## Light

Red background illumination

## Orientation

Horizontal

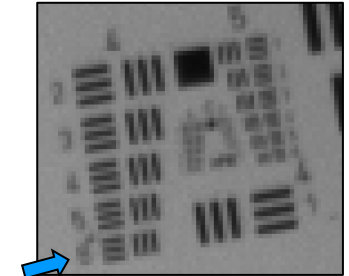
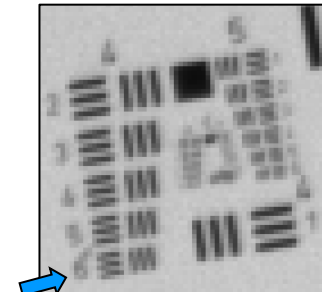
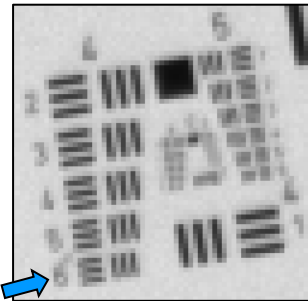
### Center



### Edge



### Corner



USAF element:	4/6
Line width ( $\mu\text{m}$ ):	17.54
Lp/mm (object):	29
Magnification:	0.204
<b>Lp/mm (image):</b>	<b>140</b>

USAF element:	4/6
Line width ( $\mu\text{m}$ ):	17.54
Lp/mm (object):	29
Magnification:	0.204
<b>Lp/mm (image):</b>	<b>140</b>

USAF element:	4/6
Line width ( $\mu\text{m}$ ):	17.54
Lp/mm (object):	29
Magnification:	0.204
<b>Lp/mm (image):</b>	<b>140</b>

# WD 650 mm @ -1.55 dpt

## Camera

Sensor size = 4104 x 3004 px

Nyquist limit = 145 lp/mm

Pixel size = 3.45  $\mu\text{m}$

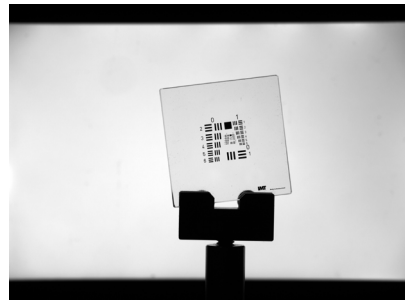
## Light

Red background illumination

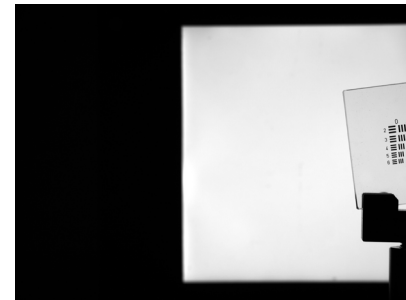
## Orientation

Horizontal

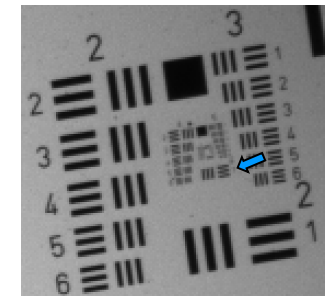
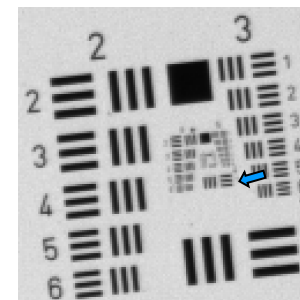
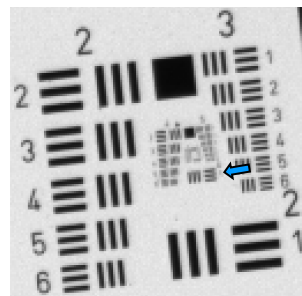
### Center



### Edge



### Corner



USAF element:	4/1
Line width ( $\mu\text{m}$ ):	31.25
Lp/mm (object):	16
Magnification:	0.113
<b>Lp/mm (image):</b>	<b>141</b>

USAF element:	4/1
Line width ( $\mu\text{m}$ ):	31.25
Lp/mm (object):	16
Magnification:	0.113
<b>Lp/mm (image):</b>	<b>141</b>

USAF element:	4/1
Line width ( $\mu\text{m}$ ):	31.25
Lp/mm (object):	16
Magnification:	0.113
<b>Lp/mm (image):</b>	<b>141</b>

# Red light @ Center: No resolution drop due to Gravity Coma

