



Test report of ELM-75-3.9-16-C

Integrated liquid lens EL-16-40-GTC-VIS-5D

Summary



- High resolution for 3.45 μm 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

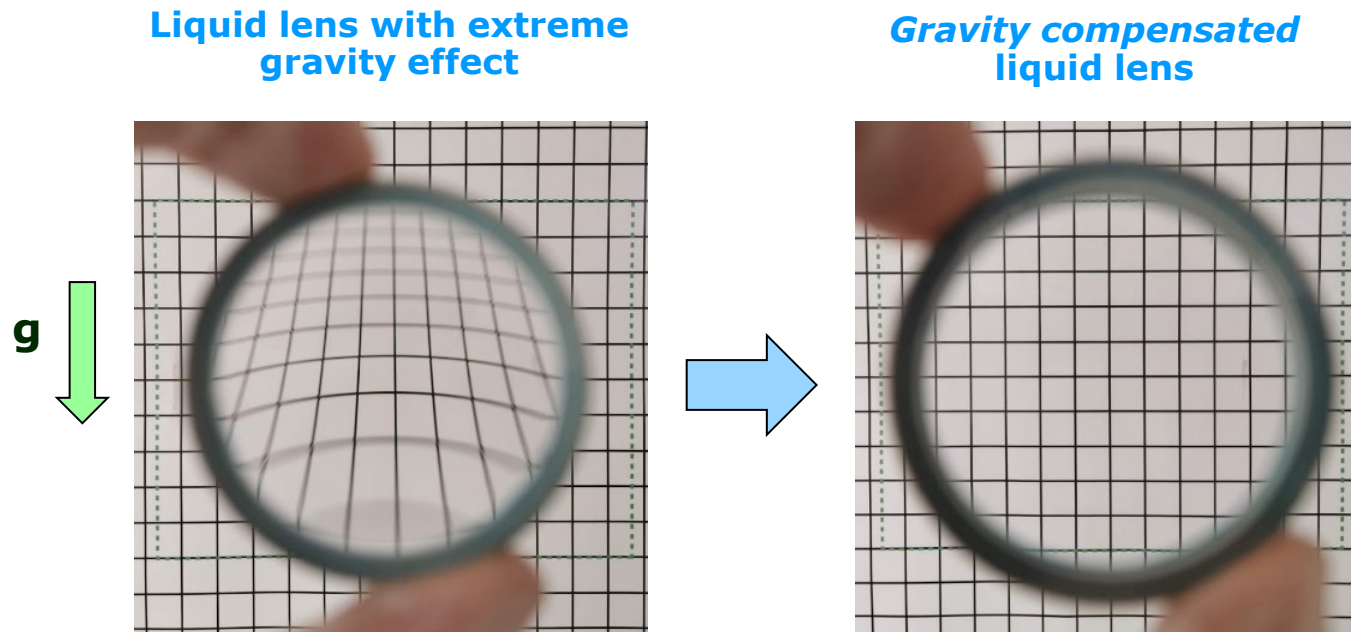
Working distance [mm]	Resolution [lp/mm on the image]			
	White light		Red light	
	Vertical	Horizontal	Vertical	Horizontal
350	140	142	140	140
420	137	138	135	135
650	141	128	141	141

- Angular Field of View [$^{\circ}$] 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

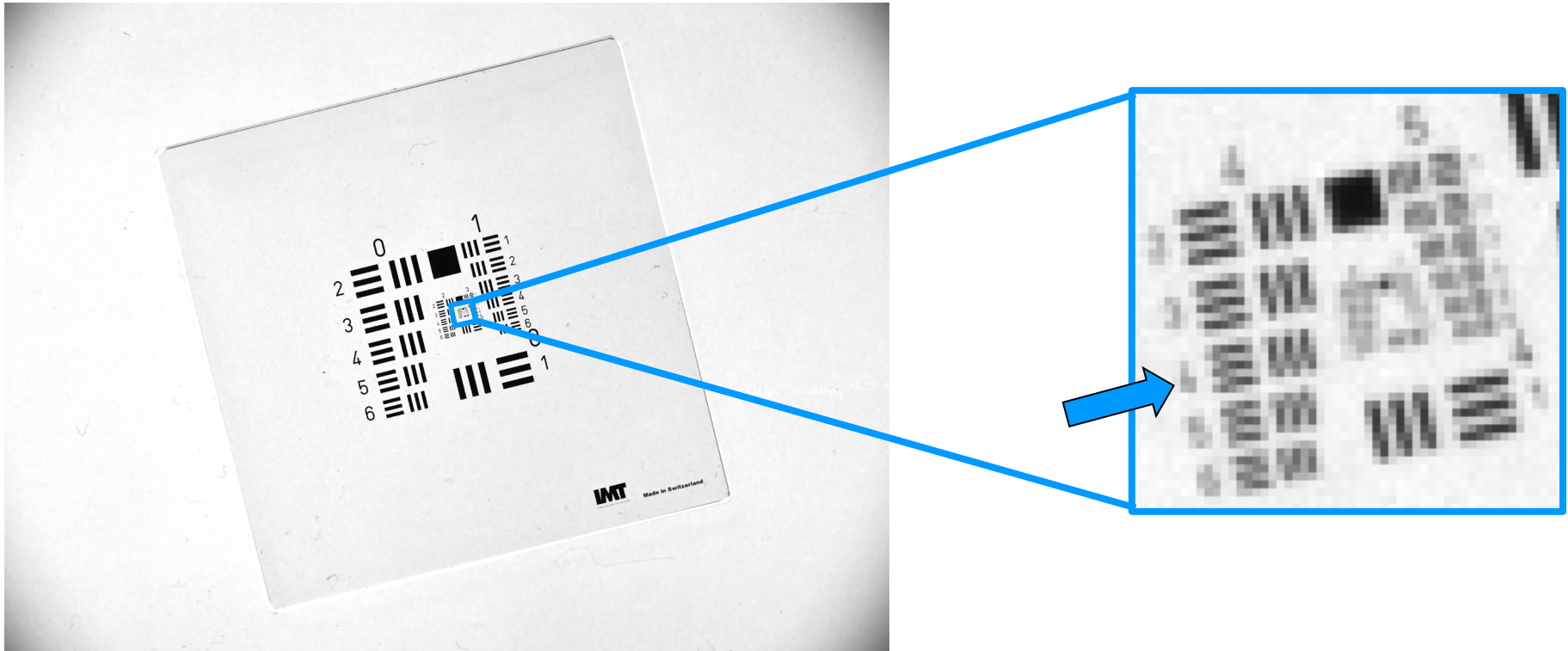


Main specifications

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

- [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 μm

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 μm

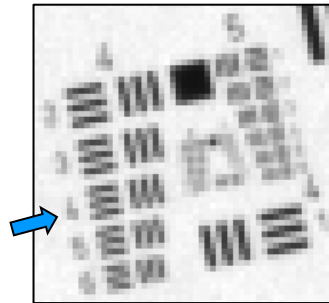
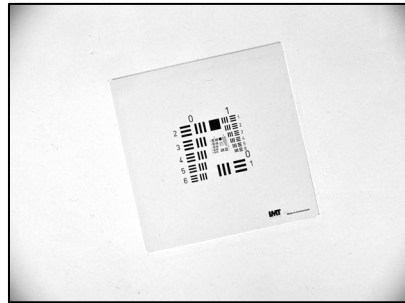
Light

White background illumination

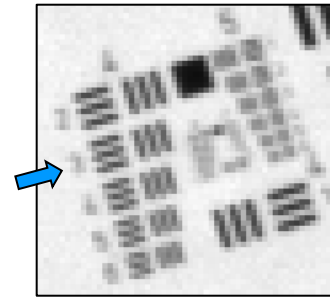
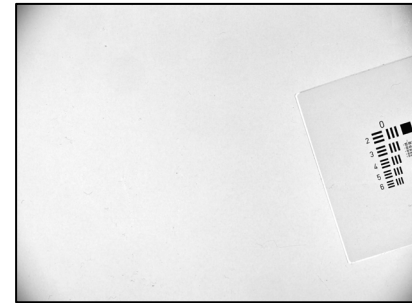
Orientation

Vertical

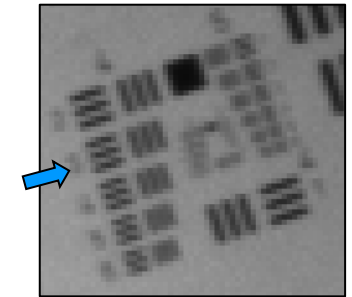
Center



Edge



Corner



USAF element:	4/4
Line width (μm):	22.1
Lp/mm (object):	23
Magnification:	0.166
Lp/mm (image):	137

USAF element:	4/3
Line width (μm):	24.8
Lp/mm (object):	20
Magnification:	0.166
Lp/mm (image):	122

USAF element:	4/3
Line width (μm):	24.8
Lp/mm (object):	20
Magnification:	0.166
Lp/mm (image):	122

WD 350 mm @ 1 dpt

Camera

Sensor size = 4104 x 3004 px

Nyquist limit = 145 lp/mm

Pixel size = 3.45 μm

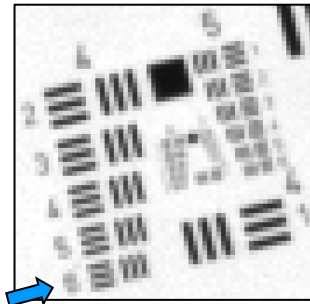
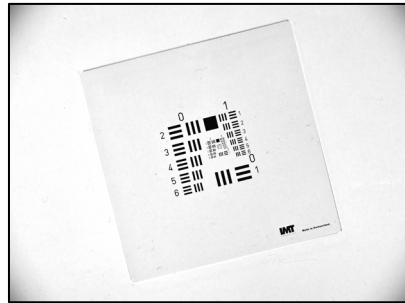
Light

White background illumination

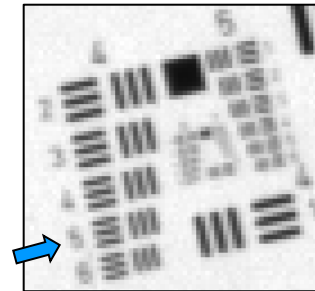
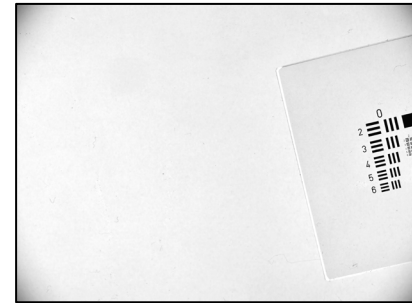
Orientation

Vertical

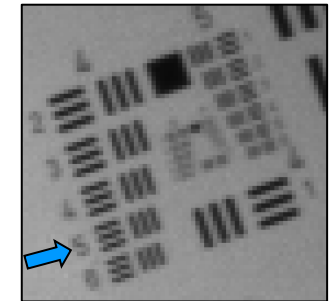
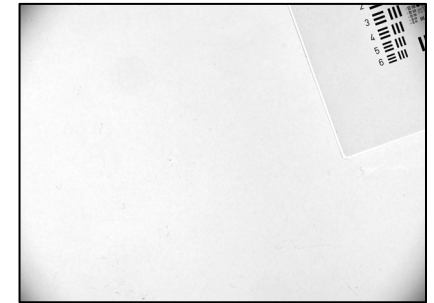
Center



Edge



Corner



USAF element: 4/6
Line width (μm): 17.54
Lp/mm (object): 29
Magnification: 0.204
Lp/mm (image): 140

4/5
19.69
25
0.204
124

4/5
19.69
25
0.204
124

WD 650 mm @ -1.55 dpt

Camera

Sensor size = 4104 x 3004 px

Nyquist limit = 145 lp/mm

Pixel size = 3.45 μm

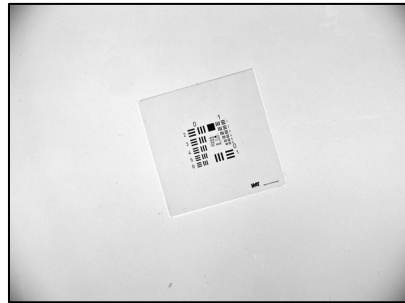
Light

White background illumination

Orientation

Vertical

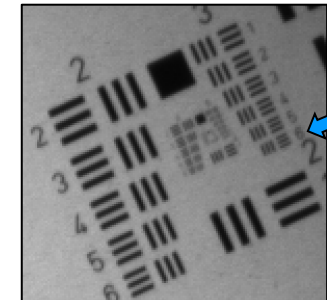
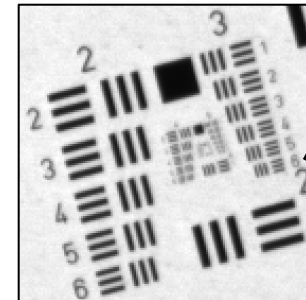
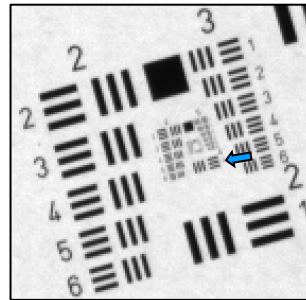
Center



Edge



Corner



USAF element: 4/1
Line width (μm): 31.25
Lp/mm (object): 16
Magnification: 0.113
Lp/mm (image): 141

3/6
35.08
14
0.113
126

3/6
35.08
14
0.113
126

Test setup 2

Camera: 1.1", 4104 x 3004 px,
Pixel size = 3.45 μm

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 μm

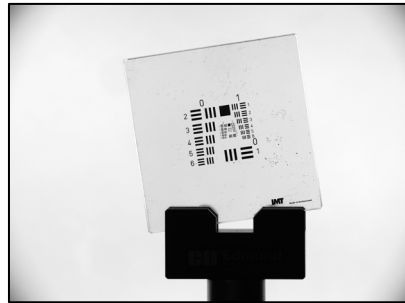
Light

White background illumination

Orientation

Horizontal

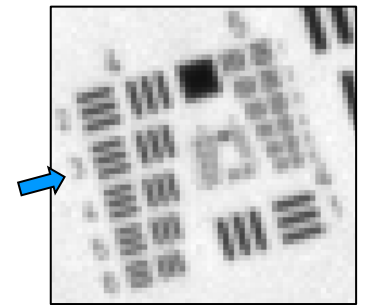
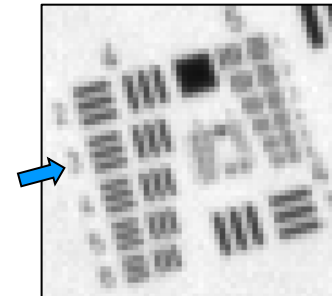
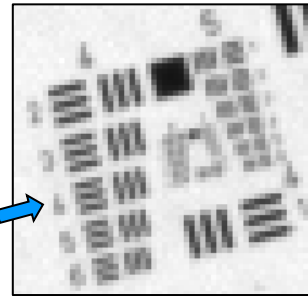
Center



Edge



Corner



USAF element: 4/4
Line width (μm): 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 μm

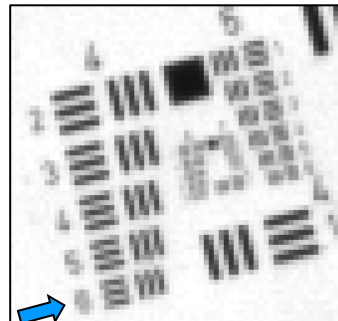
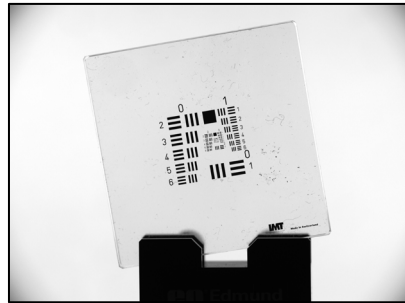
Light

White background illumination

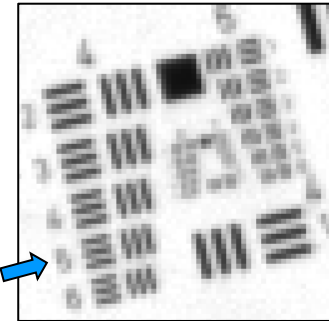
Orientation

Horizontal

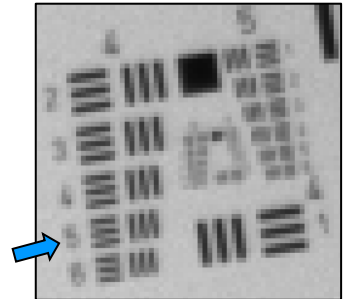
Center



Edge



Corner



USAF element: 4/6
Line width (μm): 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 μm

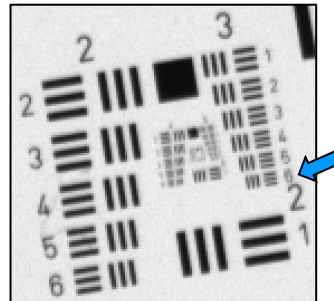
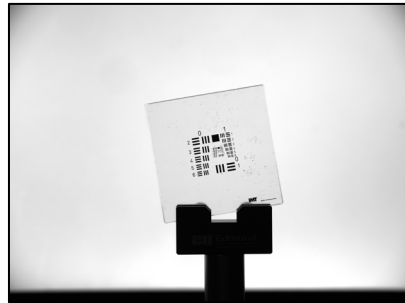
Light

White background illumination

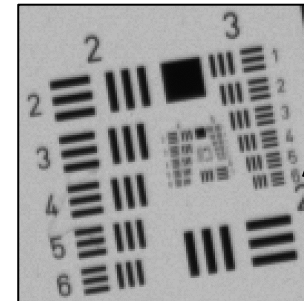
Orientation

Horizontal

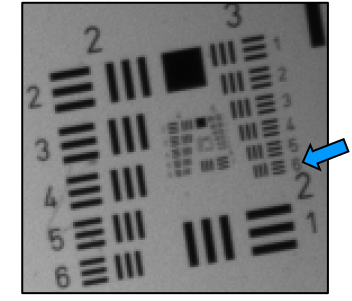
Center



Edge



Corner

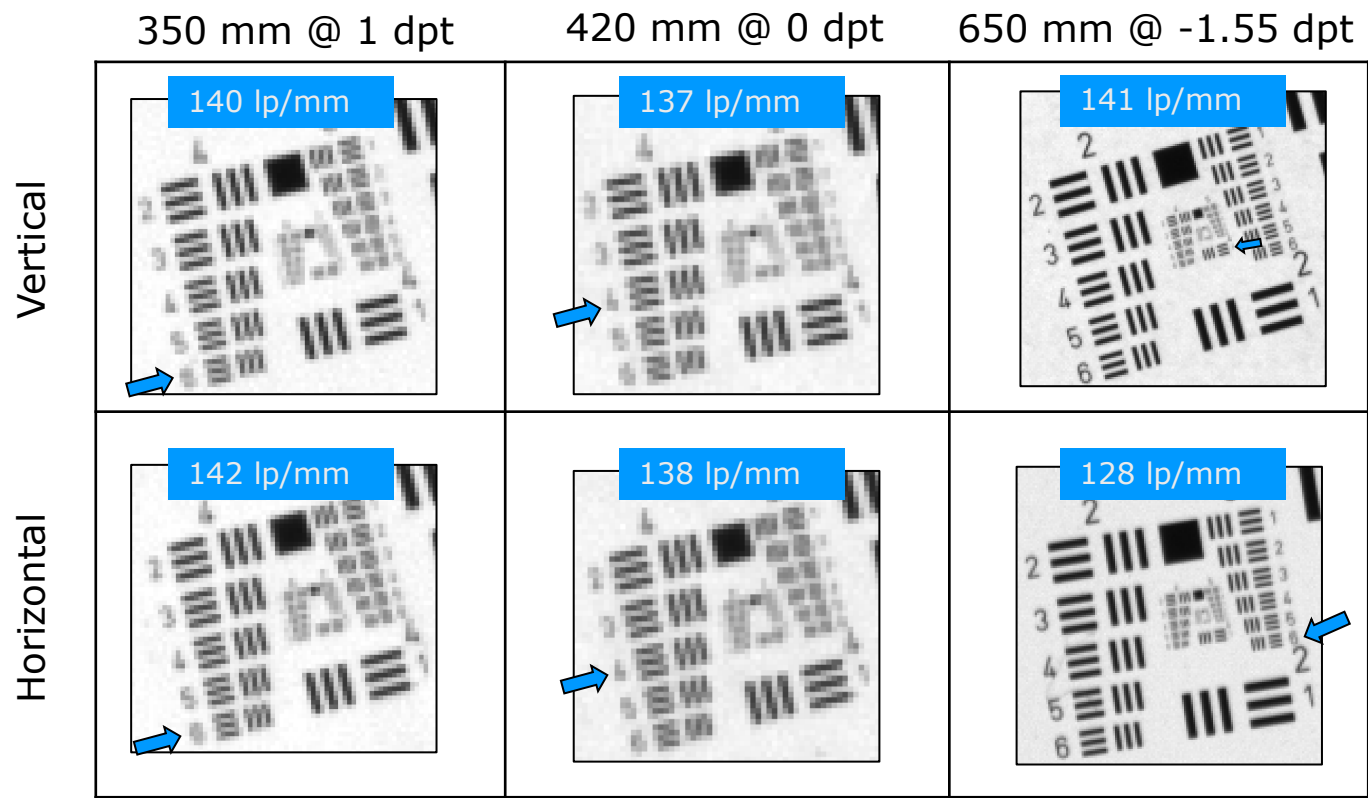


USAF element: 3/6
Line width (μm): 35.08
Lp/mm (object): 14
Magnification: 0.112
Lp/mm (image): 128

3/6
35.08
14
0.112
128

3/6
35.08
14
0.112
128

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



Test setup 3



Camera: 1.1", 4104 x 3004 px,
Pixel size = 3.45 μm

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 μm

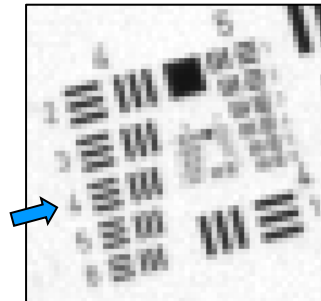
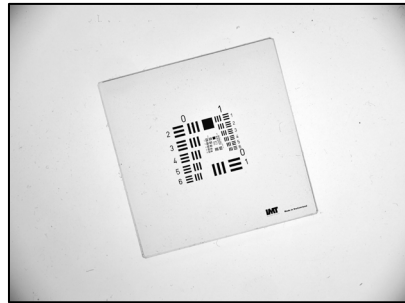
Light

Red background illumination

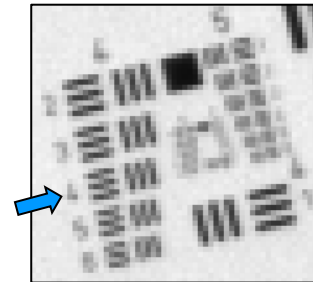
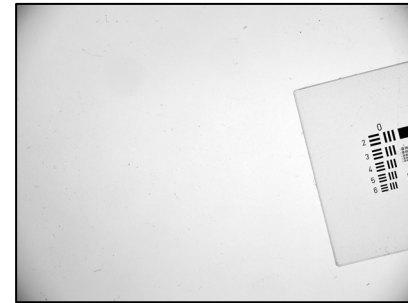
Orientation

Vertical

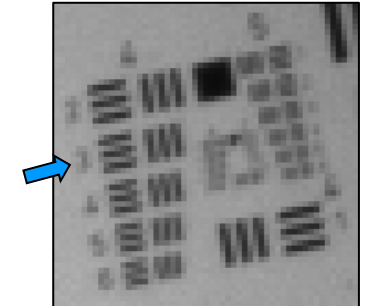
Center



Edge



Corner



USAF element: 4/4
Line width (μm): 22.1
Lp/mm (object): 23
Magnification: 0.167
Lp/mm (image): 135

4/4
22.1
23
0.167
135

4/3
24.8
20
0.167
121

WD 350 mm @ 1 dpt

Camera

Sensor size = 4104 x 3004 px

Nyquist limit = 145 lp/mm

Pixel size = 3.45 μm

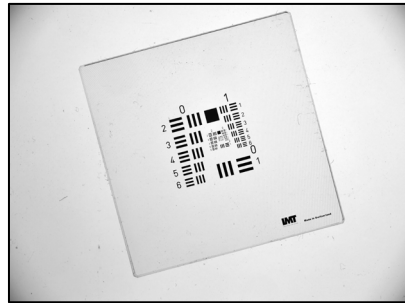
Light

Red background illumination

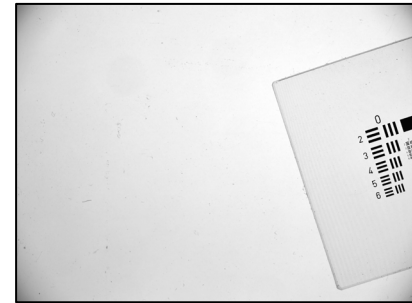
Orientation

Vertical

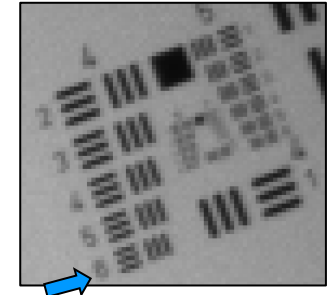
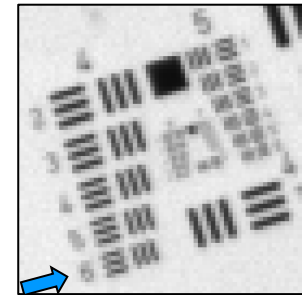
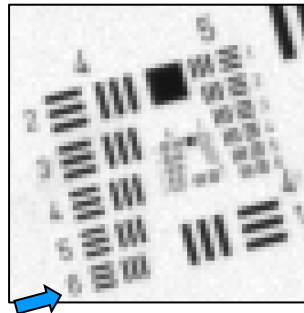
Center



Edge



Corner



USAF element: 4/6
Line width (μm): 17.54
Lp/mm (object): 29
Magnification: 0.204
Lp/mm (image): 140

4/6
17.54
29
0.204
140

4/6
17.54
29
0.204
140

WD 650 mm @ -1.55 dpt

Camera

Sensor size = 4104 x 3004 px

Nyquist limit = 145 lp/mm

Pixel size = 3.45 μm

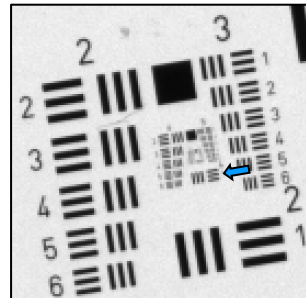
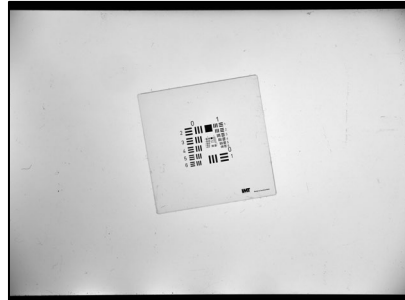
Light

Red background illumination

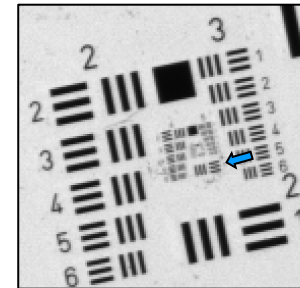
Orientation

Vertical

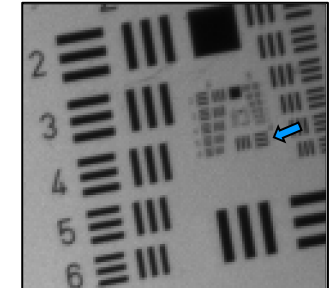
Center



Edge



Corner



USAF element: 4/1
Line width (μm): 31.25
Lp/mm (object): 16
Magnification: 0.113
Lp/mm (image): 141

4/1
31.25
16
0.113
141

4/1
31.25
16
0.113
141

Test setup 4

Camera: 1.1", 4104 x 3004 px,
Pixel size = 3.45 μm

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 μm

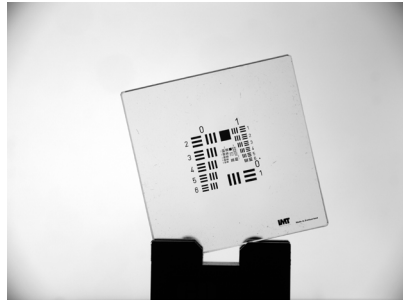
Light

Red background illumination

Orientation

Horizontal

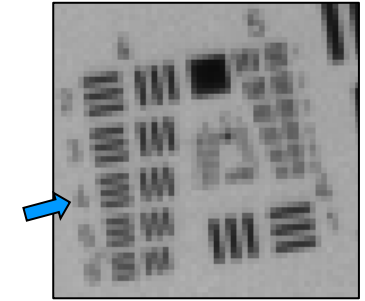
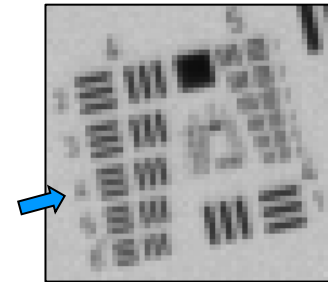
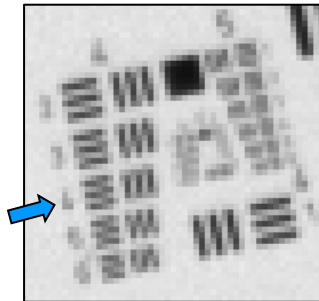
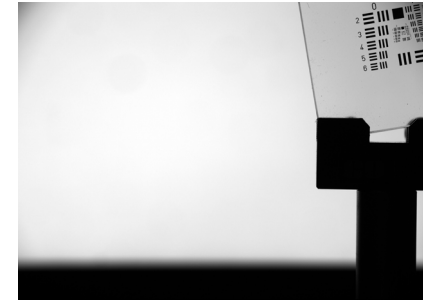
Center



Edge



Corner



USAF element: 4/4
Line width (μm): 22.1
Lp/mm (object): 23
Magnification: 0.167
Lp/mm (image): 135

4/4
22.1
23
0.167
135

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 μm

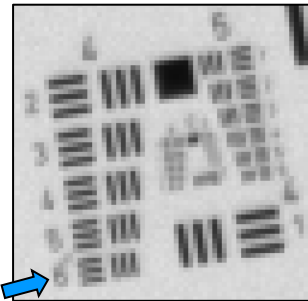
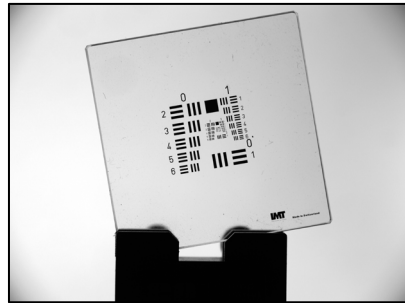
Light

Red background illumination

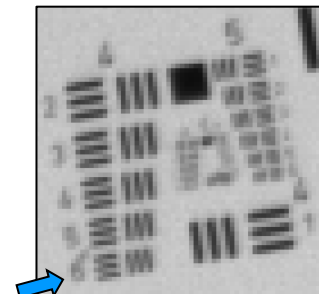
Orientation

Horizontal

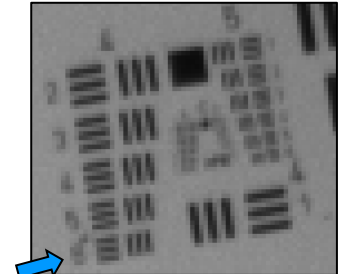
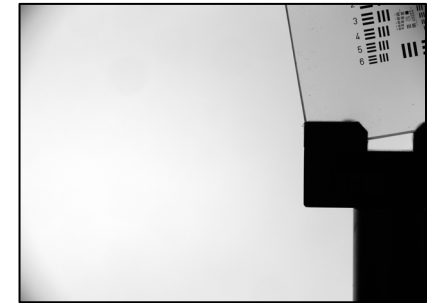
Center



Edge



Corner



USAF element: 4/6
Line width (μm): 17.54
Lp/mm (object): 29
Magnification: 0.204
Lp/mm (image): 140

4/6
17.54
29
0.204
140

4/6
17.54
29
0.204
140

WD 650 mm @ -1.55 dpt

Camera

Sensor size = 4104 x 3004 px

Nyquist limit = 145 lp/mm

Pixel size = 3.45 μm

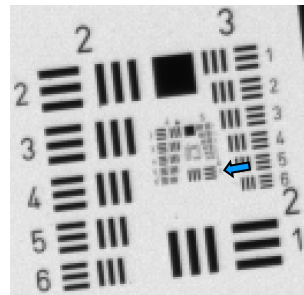
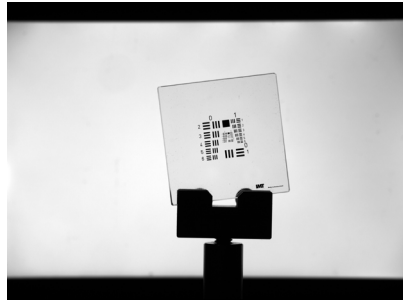
Light

Red background illumination

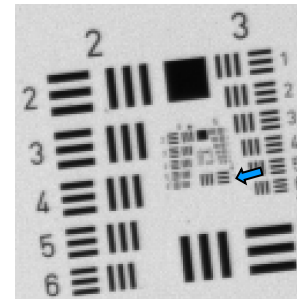
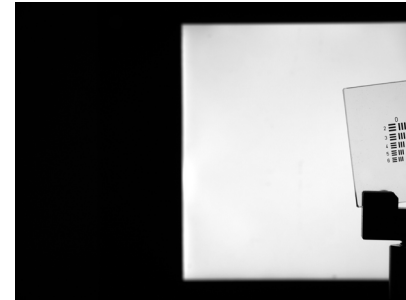
Orientation

Horizontal

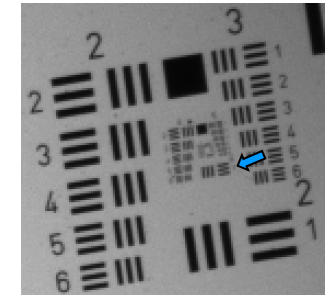
Center



Edge



Corner



USAF element: 4/1
Line width (μm): 31.25
Lp/mm (object): 16
Magnification: 0.113
Lp/mm (image): 141

4/1
31.25
16
0.113
141

4/1
31.25
16
0.113
141

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

