

shaping the future of optics



# Sill Optics Correctal T30/2.0 and Optotune EL-16-40 for fast focusing

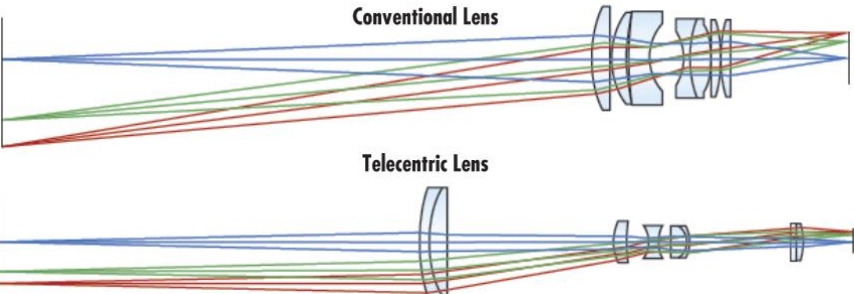
July 2022

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# About telecentric lenses

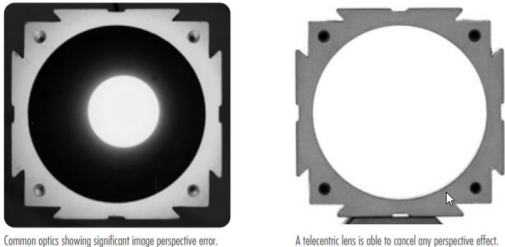
**Telecentric lenses** only accept incoming ray bundles that are parallel to the optical axis



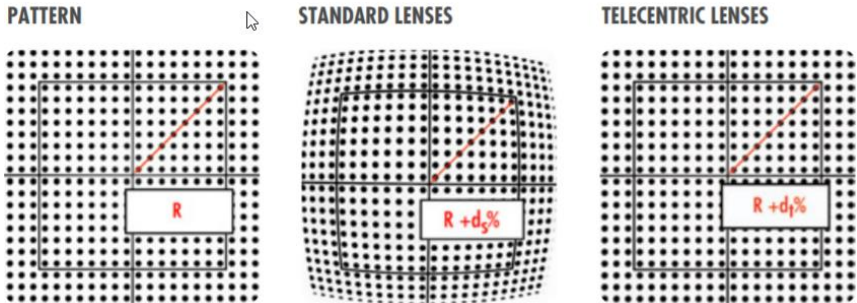
Main benefits:  
**Constant magnification**



**No perspective error**



**Nearly zero image distortion**

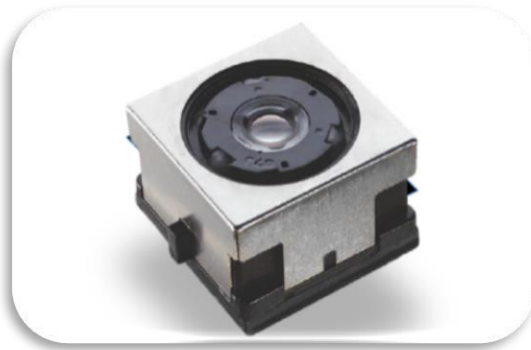


Images courtesy of Edmund Optics

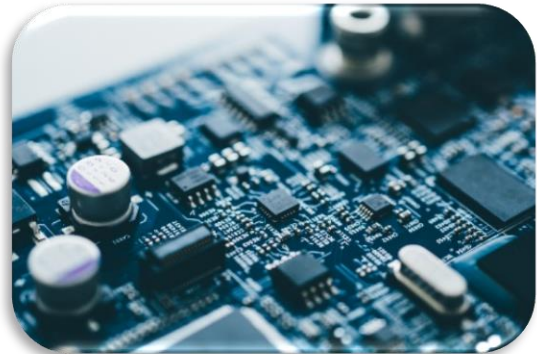
# Application examples of telecentric lens + liquid lens



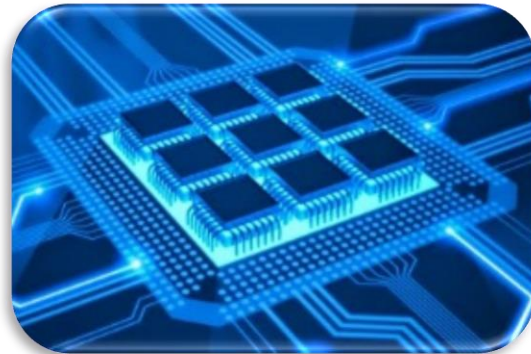
Contact lens inspection



Camera phone lens inspection



Electronics inspection



IC inspection

**And many more applications where the depth of field (DoF) of a telecentric lens is not large enough**

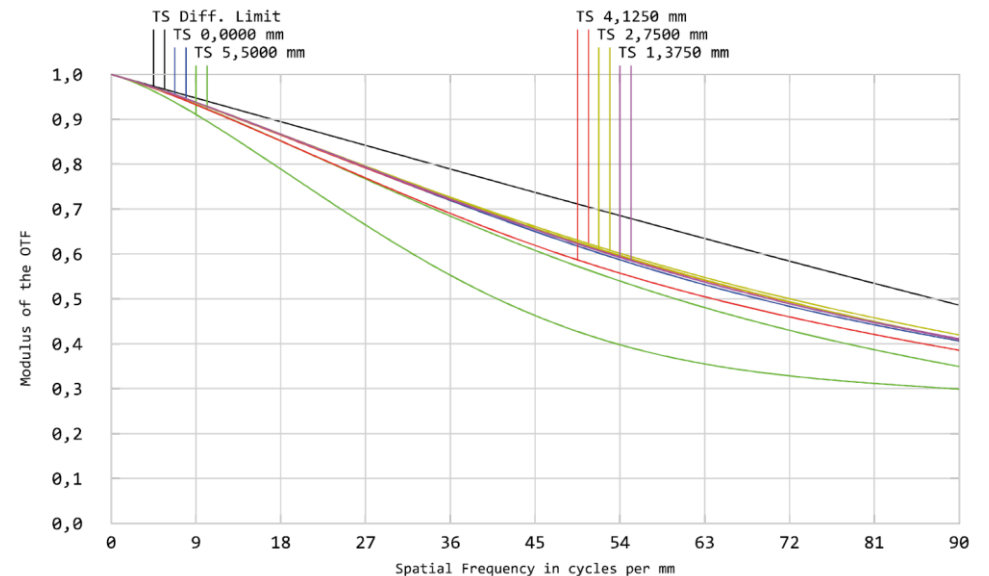
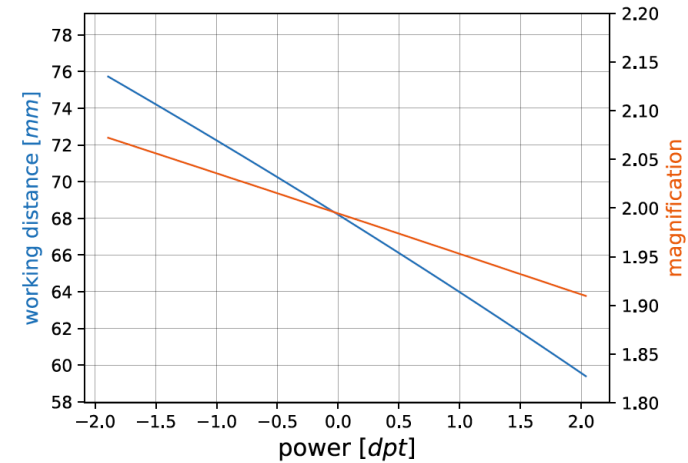
# Test report summary

- Up to 20mm working distance range
  - Recommended range is 8mm
- High resolution of up to 127 lp/mm
  - Same as without any liquid lens
  - Best performance at 66% iris setting
- Resolution stays constant across the field
- Very good polychromatic performance
  - Performance very similar between white and red backlights

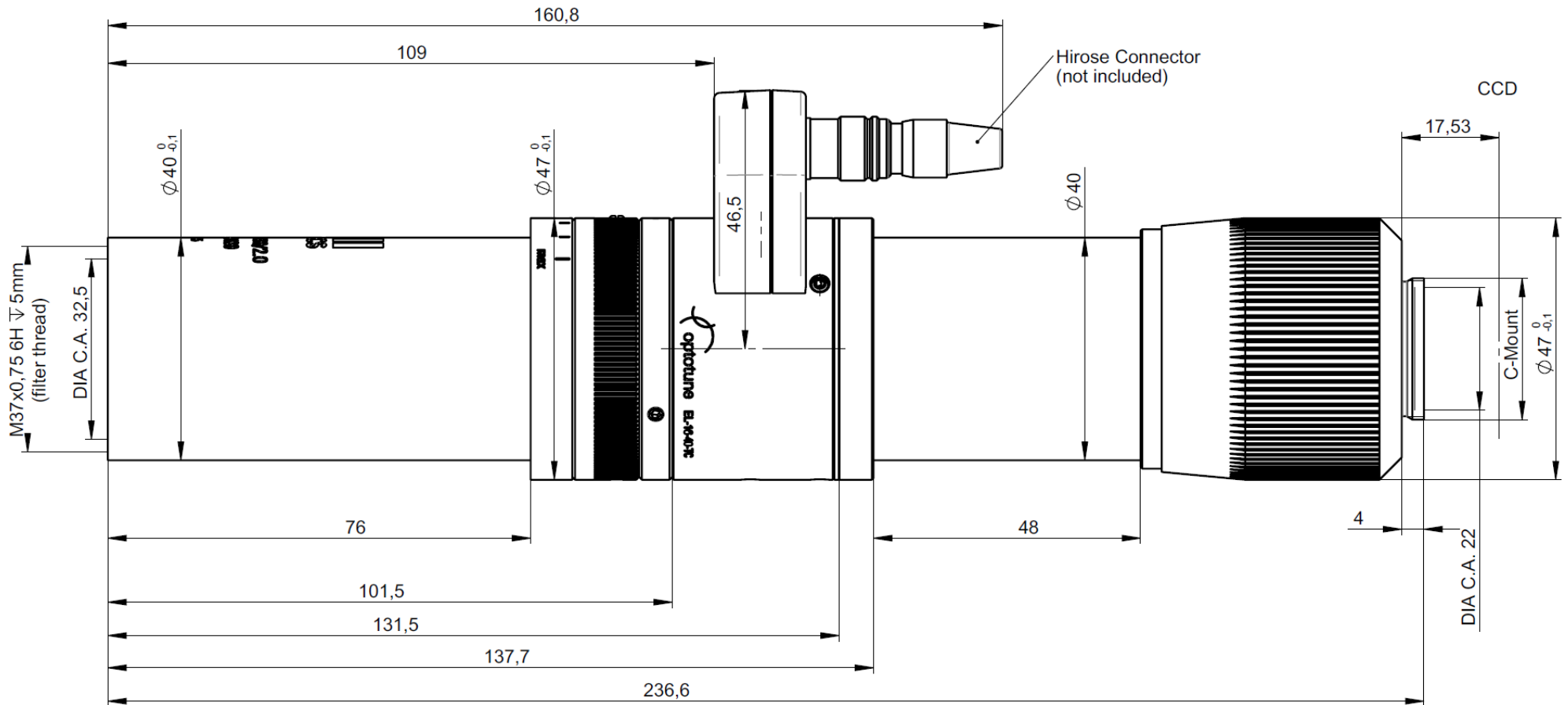


# Main specifications

specifications	
article number	S5VPJ6420
wavelength range [nm]	450-700
design wavelength [nm]	450 - 700
nominal magnification (+/-5%)	2.000
nominal working dist. [mm] (+/-2%)	68.2
object size [mm] at a chip size of [mm]	4.4 x 3.3 8.8 x 6.6 (2/3")
object size [mm] at a chip size of [mm]	6.4 x 4.8 12.8 x 9.6 (1")
object size [mm] at a chip size of [mm]	7.1 x 5.3 14.1 x 10.6 (1.1")
max. distortion [%]	0.16
max. telecentricity error [°]	0.03
recommended numerical aperture	0.120
WD at +3.0 dpt	55.4
magn. at +3.0 dpt	1.87
WD at -2.0 dpt	76.3
magn. at -2.0 dpt	2.08
weight [kg]	not yet weighed
flange back distance [mm]	17.53

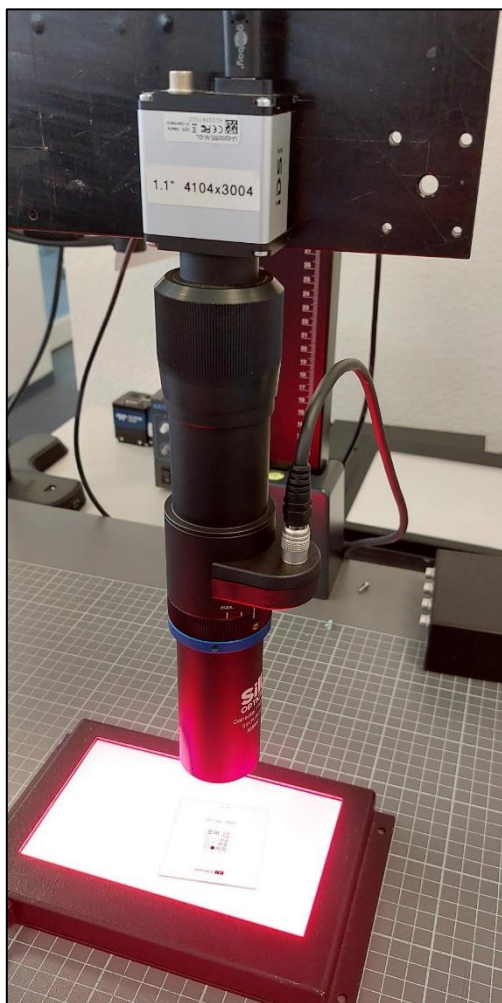


# Mechanical drawing



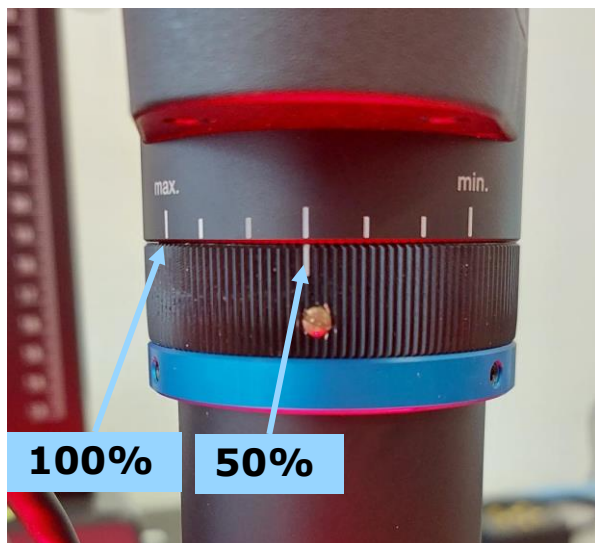
W.D. = 68,2

# Test setup

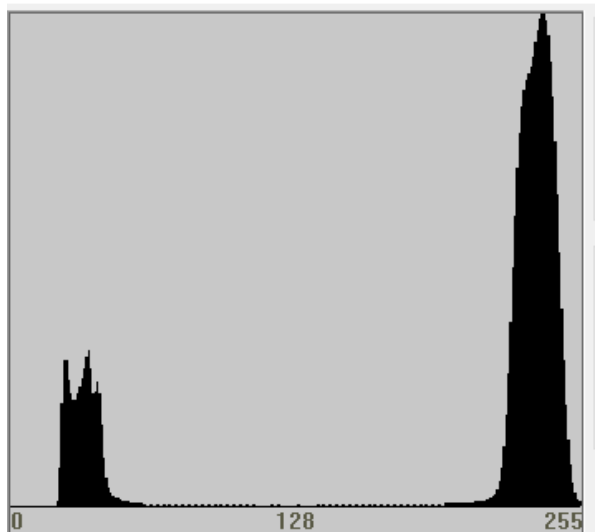


Camera:	1" IDS 4104 x 3004 pixels 3.45 um pixel size
Lens:	Sill Optics Correctal T30/2.0
Tunable lens:	EL-16-40-TC-VIS-5D-1-C (class 1) S/N: ANAA4004 WFE @ 0 mA = 0.05 $\lambda$ RMS @532 nm
Controller:	ICC-4C
Target:	Transparent USAF target
Light:	Red/white backlight
Optical axis:	Vertical

# Test setup



Histogram - UI320xSE-M - ID: 1 - SerNo: 4103347520



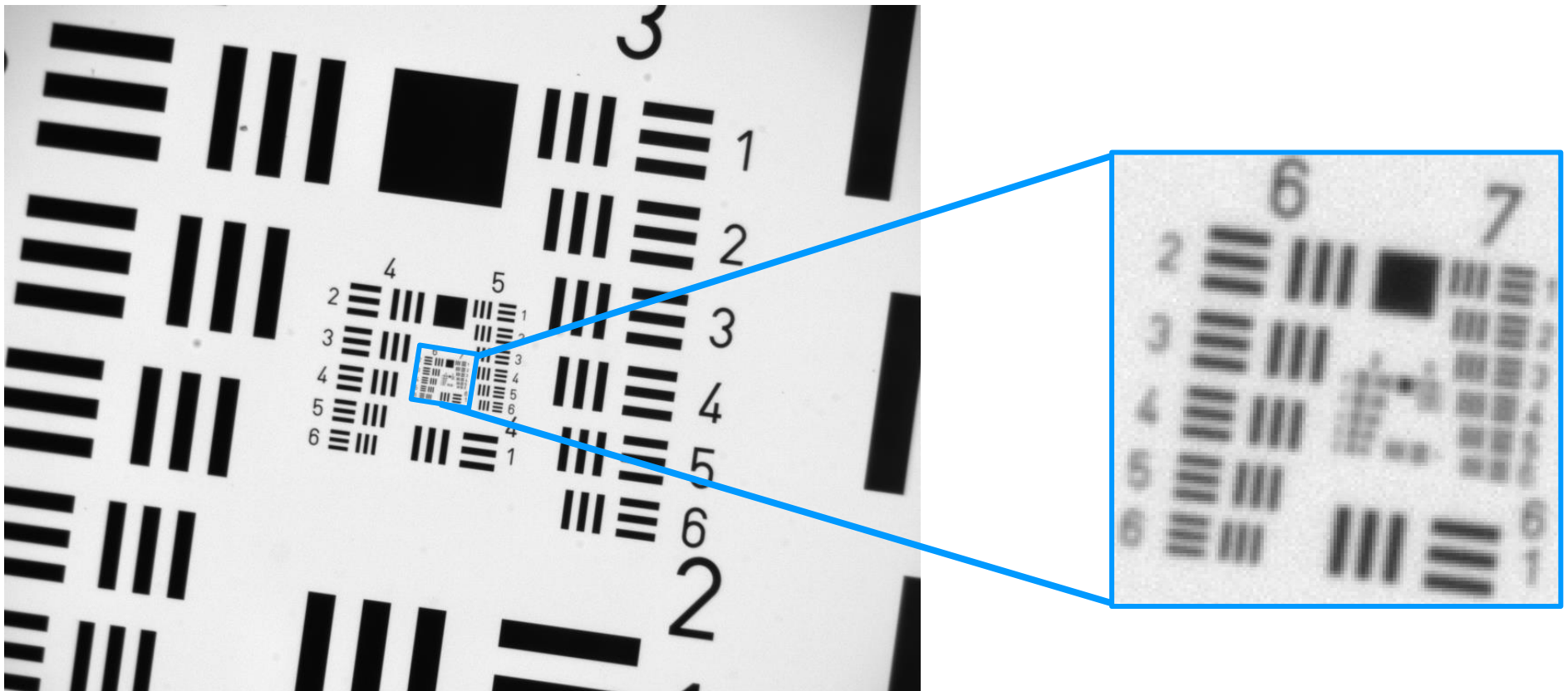
➤ The variable iris was adjusted at different aperture levels

➤ The exposure time was then adjusted accordingly in order to maximize dynamic range



# Method for image evaluation

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



# Adding the liquid lens does not change performance

## Camera

Sensor size = 4104x3004 pixels

Nyquist limit = 145 lp/mm

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

Exposure time = 10ms

## Lens

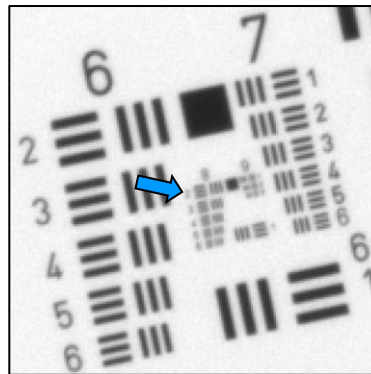
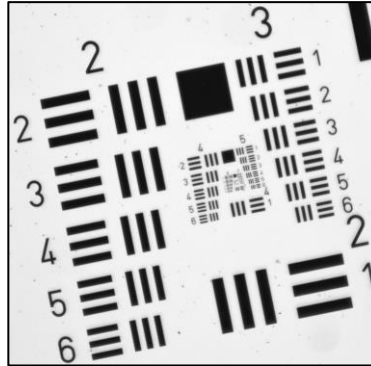
0 dpt (68mm WD)

Iris fully open

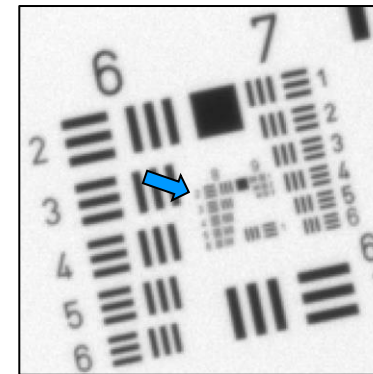
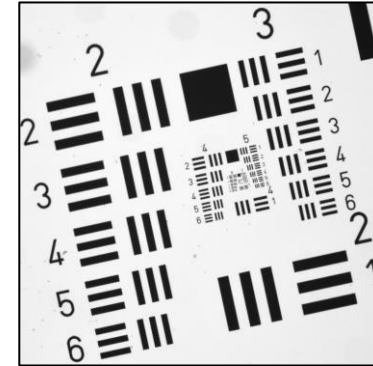
## Light

**Red** background illumination

## No Liquid Lens



## Liquid Lens



USAF element:

8/1

8/1

Line width ( $\mu\text{m}$ ):

1.95

1.95

Lp/mm (object):

256

256

Magnification:

2.026

2.026

**Lp/mm (image):**

**127**

**127**

# Center only @ 0 dpt, white light, 68 mm WD

## Camera

Sensor size = 4104x3004 pixels

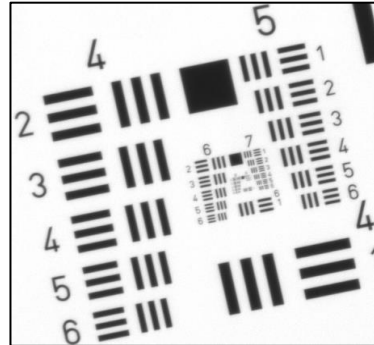
Nyquist limit = 145 lp/mm

Pixel size = 3.45  $\mu$ m

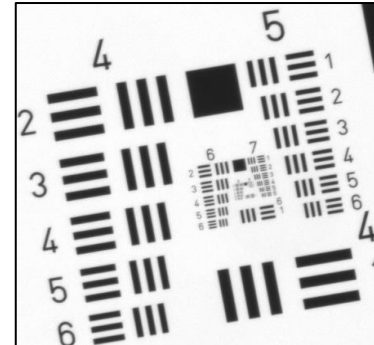
## Light

White background illumination

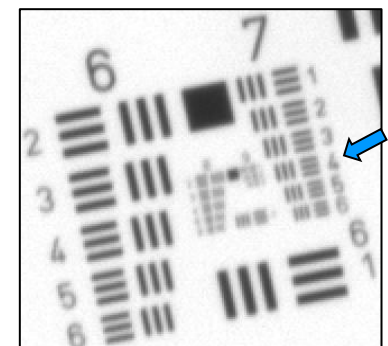
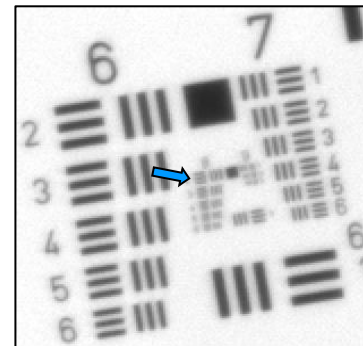
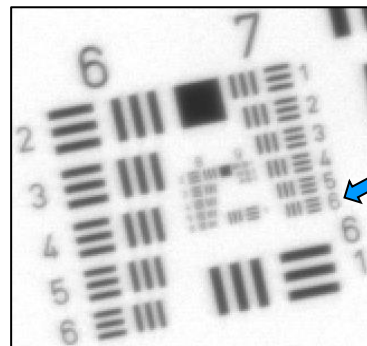
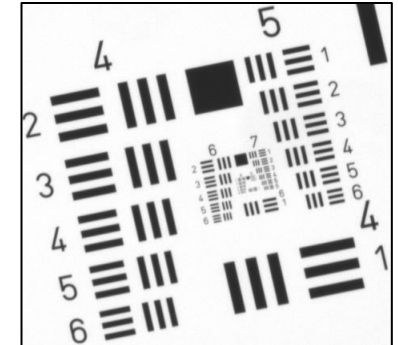
**Max aperture**  
**11.00 ms**



**66% Iris**  
**12.00 ms**



**50% Iris**  
**20.00 ms**



USAF element:	7/6	8/1	7/4
Line width ( $\mu$ m):	2.19	1.95	2.76
Lp/mm (object):	228	256	181
Magnification:	2.026	2.026	2.026
<b>Lp/mm (image):</b>	<b>113</b>	<b>127</b>	<b>89</b>

# Center only @ 0 dpt, Red light, 68 mm WD

## Vertical Optical Axis

### Camera

Sensor size = 4104x3004 pixels

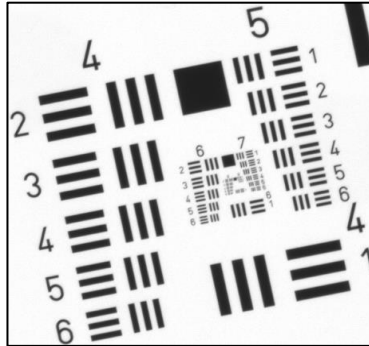
Nyquist limit = 145 lp/mm

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

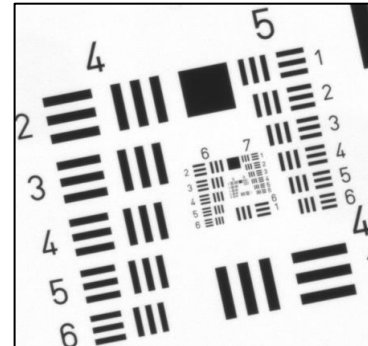
### Light

Red background illumination

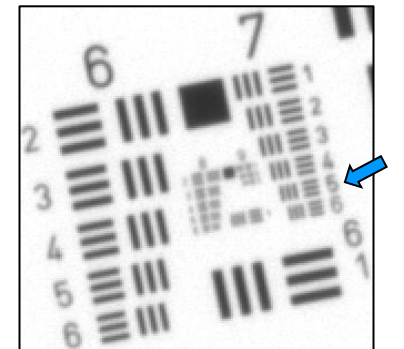
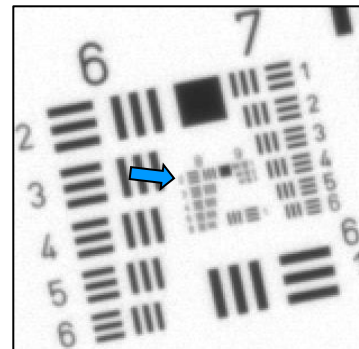
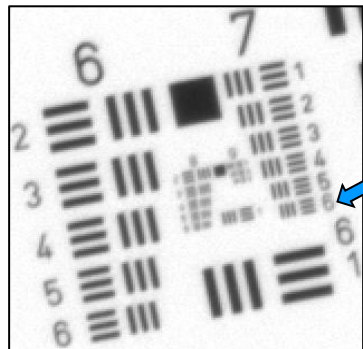
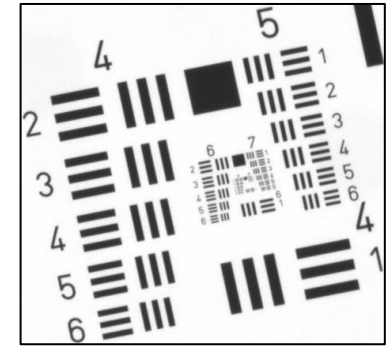
Max aperture  
8.90 ms



66% aperture  
10.00 ms

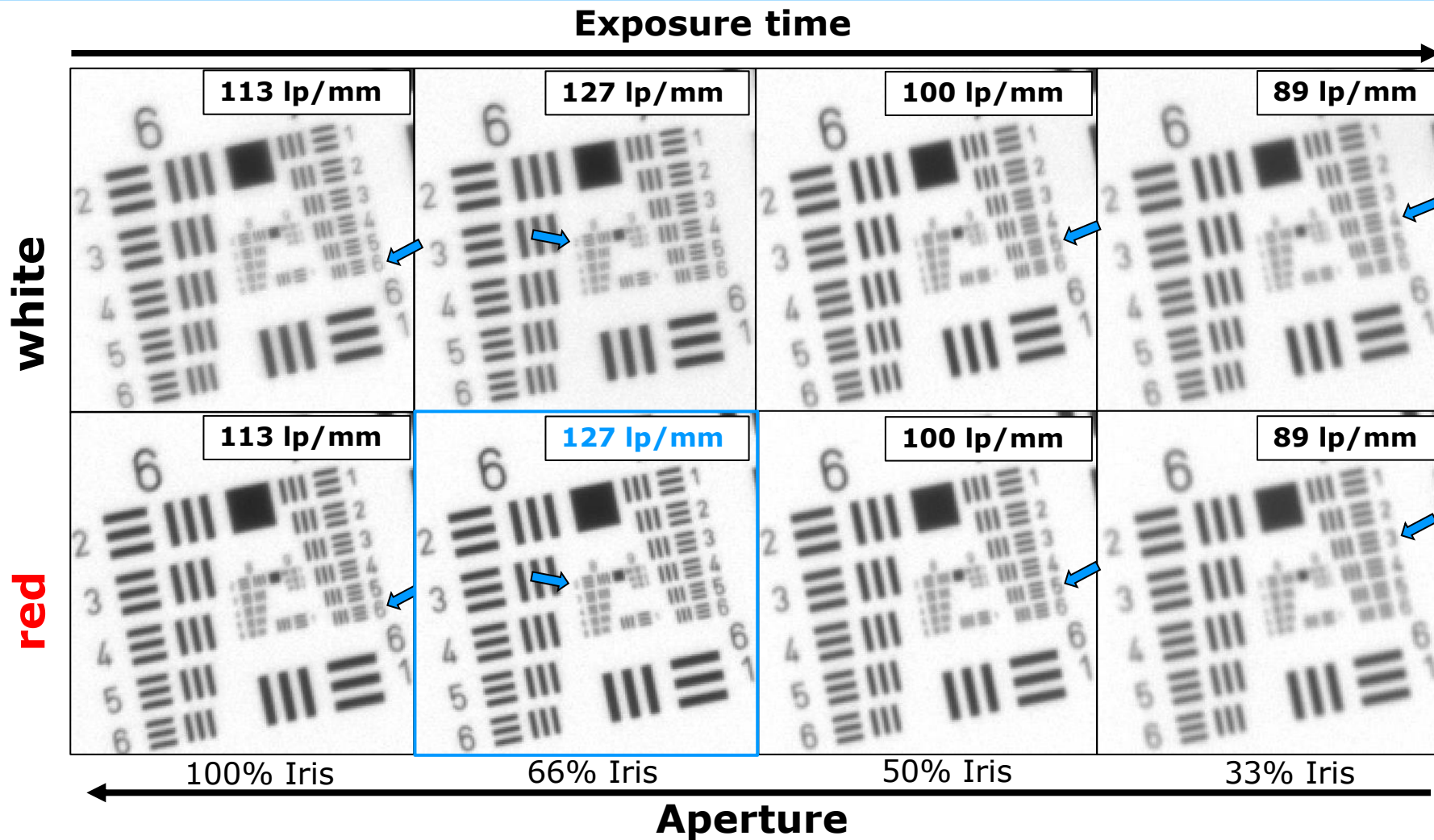


50% Iris  
16.00 ms



USAF element:	7/6	8/1	7/5
Line width ( $\mu\text{m}$ ):	2.19	1.95	2.46
Lp/mm (object):	228	256	203
Magnification:	2.026	2.026	2.026
<b>Lp/mm (image):</b>	<b>113</b>	<b>127</b>	<b>100</b>

# Best performance with red backlight and 66% open iris



# 0 dpt, Red light, 68 mm WD

## Camera

Sensor size = 4104x3004 pixels

Nyquist limit = 145 lp/mm

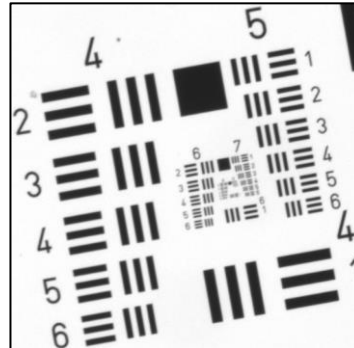
Pixel size = 3.45  $\mu\text{m}$

Exposure time = 10ms

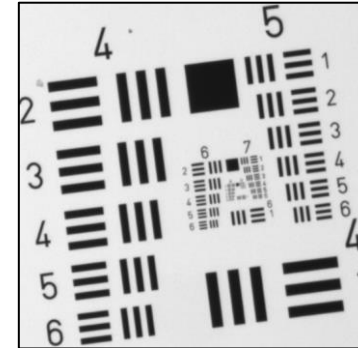
## Light

**Red** background illumination

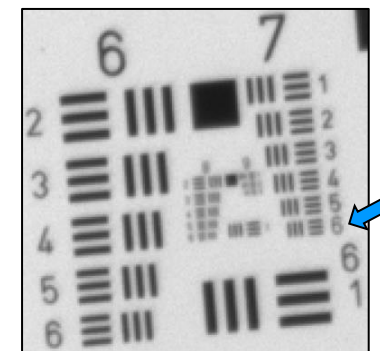
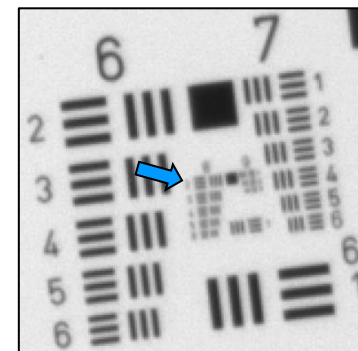
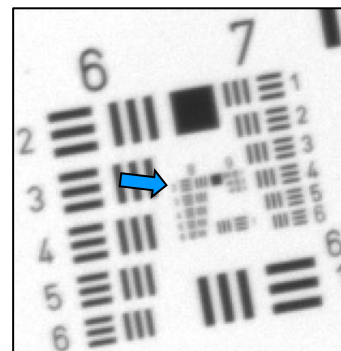
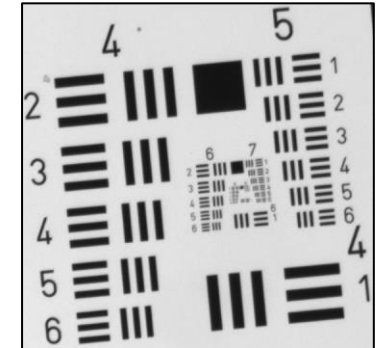
Center



Edge



Corner



USAF element:

8/1

8/1

7/6

Line width ( $\mu\text{m}$ ):

1.95

1.95

2.19

Lp/mm (object):

256

256

228

Magnification:

2.026

2.026

2.026

**Lp/mm (image):**

**127**

**127**

**113**

# -1 dpt, Red light, 72 mm WD

## Camera

Sensor size = 4104x3004 pixels

Nyquist limit = 145 lp/mm

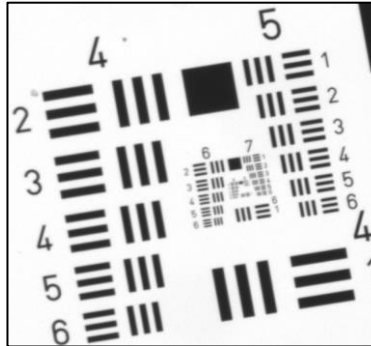
Pixel size = 3.45  $\mu\text{m}$

Exposure time = 10ms

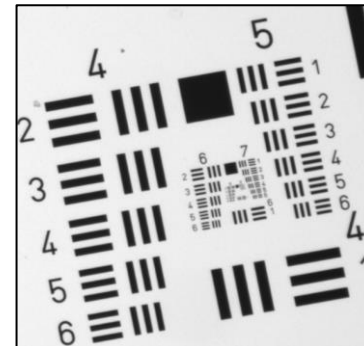
## Light

Red background illumination

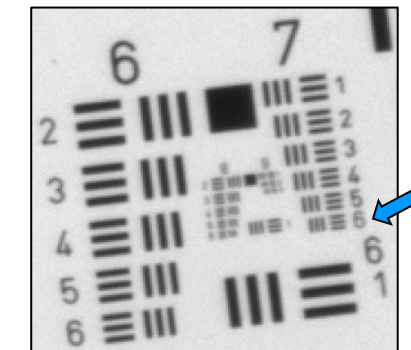
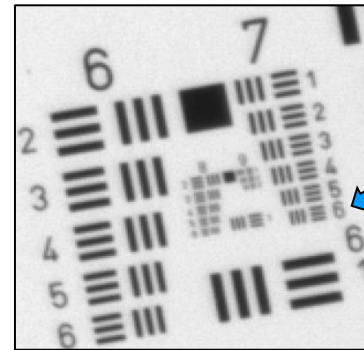
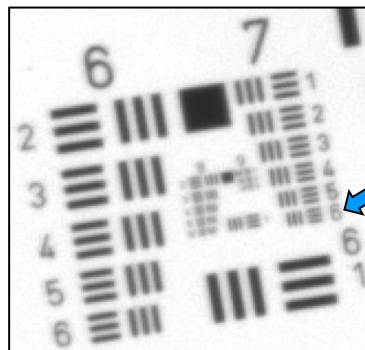
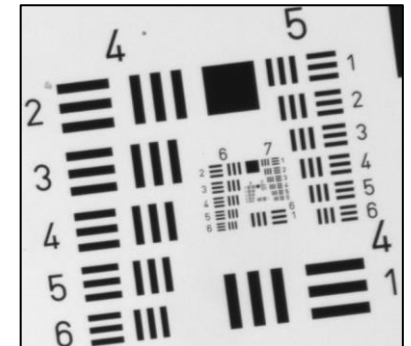
Center



Edge



Corner



USAF element:	7/6	7/6	7/6
Line width ( $\mu\text{m}$ ):	2.19	2.19	2.19
Lp/mm (object):	228	228	228
Magnification:	2.026	2.026	2.026
<b>Lp/mm (image):</b>	<b>113</b>	<b>113</b>	<b>113</b>

# +1 dpt, Red light, 64 mm WD

## Camera

Sensor size = 4104x3004 pixels

Nyquist limit = 145 lp/mm

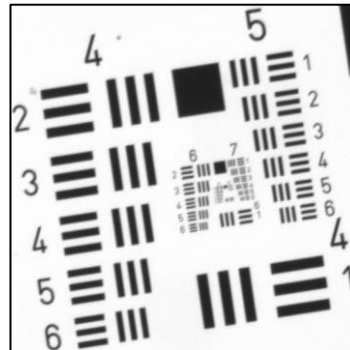
Pixel size = 3.45  $\mu\text{m}$

Exposure time = 10ms

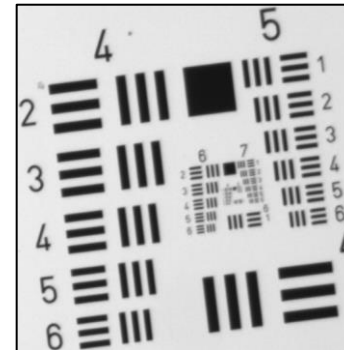
## Light

**Red** background illumination

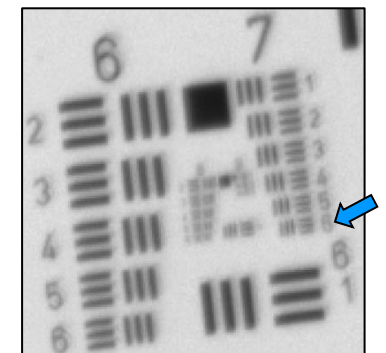
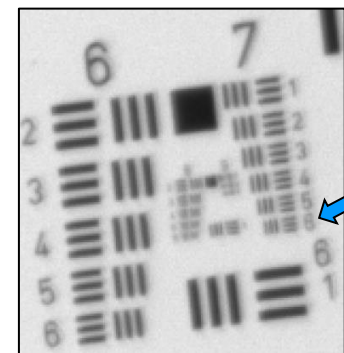
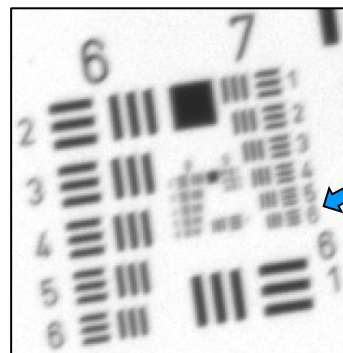
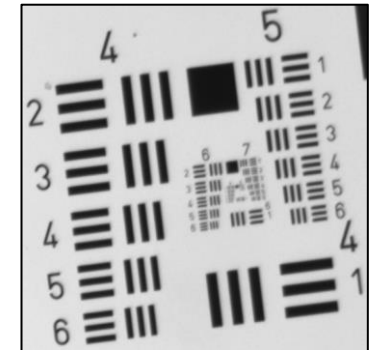
Center



Edge



Corner



USAF element:	7/6	7/6	7/6
Line width ( $\mu\text{m}$ ):	2.19	2.19	2.19
Lp/mm (object):	228	228	228
Magnification:	2.026	2.026	2.026
<b>Lp/mm (image):</b>	<b>113</b>	<b>113</b>	<b>113</b>



# Performance remains good across the field and working distance range

Red backlight,  
10 ms exposure time

