



shaping the future of optics



# **VS-TCH2-65-LQL1 2x Telecentric lens with EL-16-40-TC-VIS-5D integrated**

## **Test report**

Zürich, July 2021

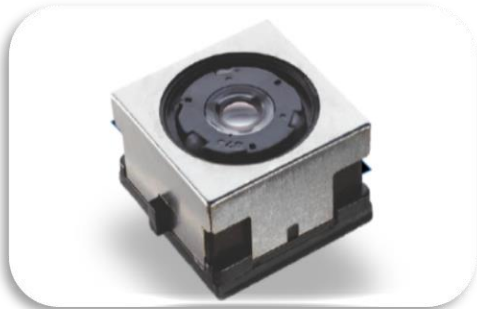
Dr. Gustavo Ciardi

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Phone +41 58 856 3011 | [www.optotune.com](http://www.optotune.com) | [info@optotune.com](mailto:info@optotune.com)

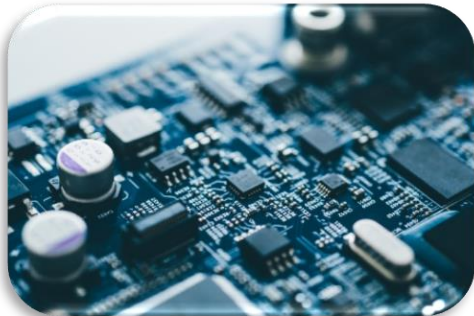
# Applications: metrology and high precision measurements



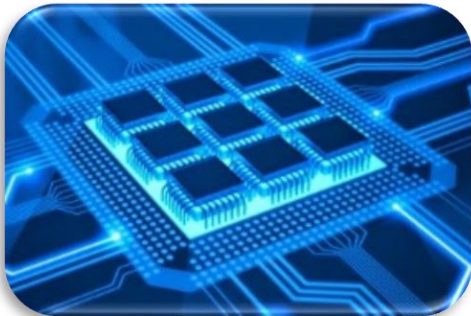
Contact lens inspection



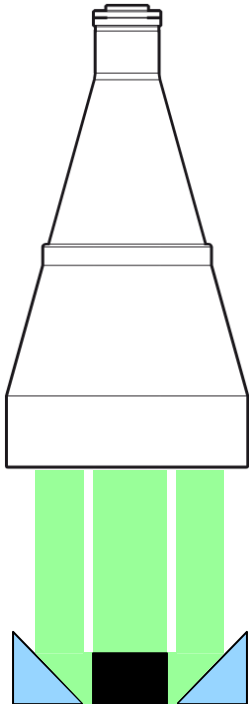
Camera phone lens inspection



Electronics inspection



IC inspection



IC inspection – image 5 sides with one camera

# Summary

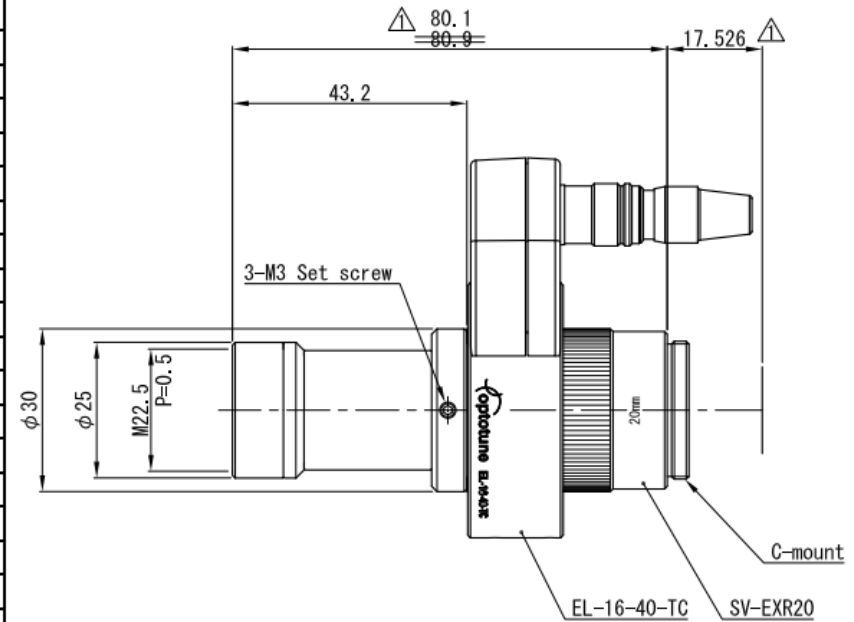
- Compact form factor
- Close to Nyquist limit resolution
- Very good polychromatic performances
- Large Z-range = 3 mm
- MAG change 2.1%/mm
  - Max MAG change = 6%
- Optical leverage = 0.5 mm/dpt



# Datasheet

## Telecentric Lens

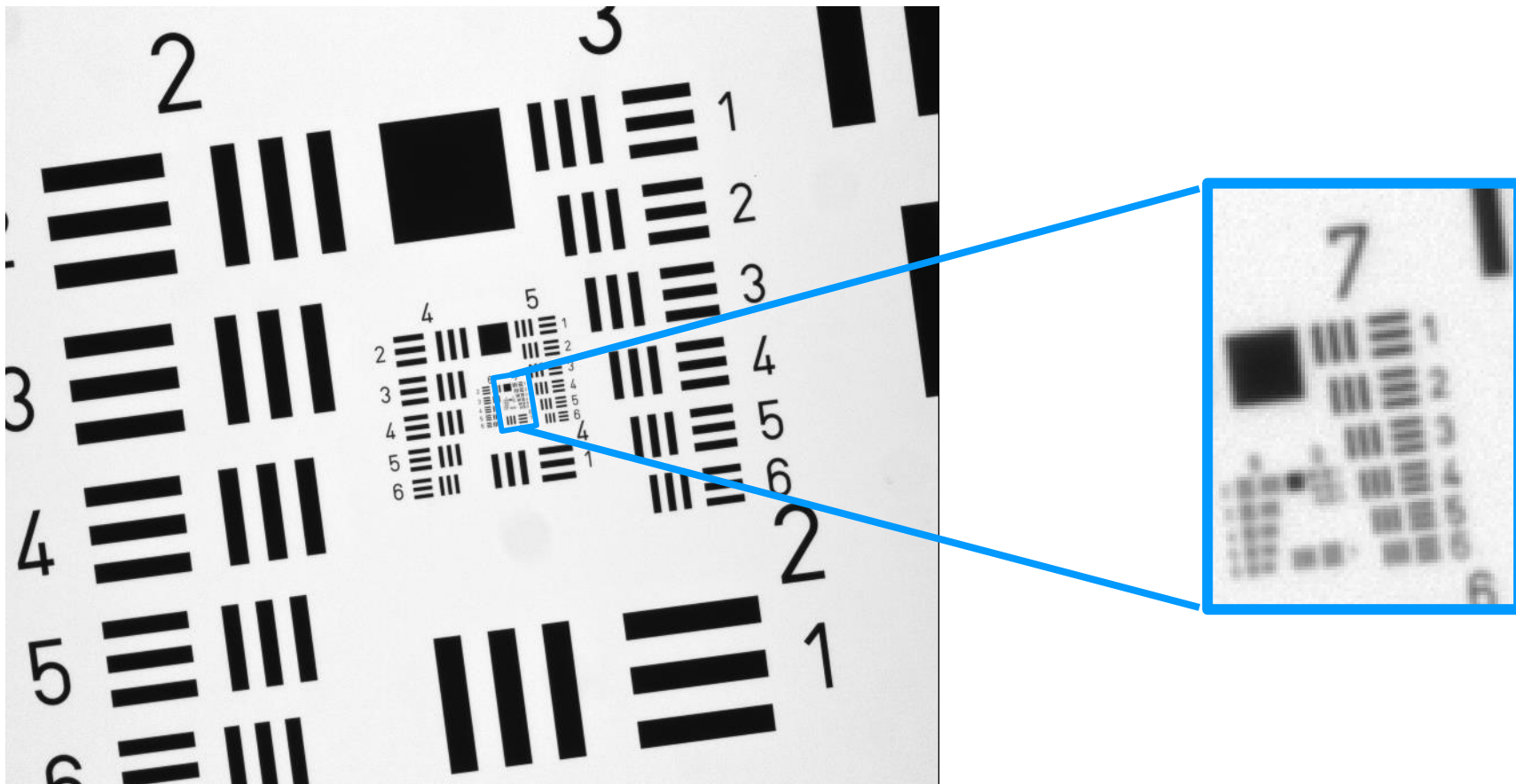
Model		VS-TCH2-65-LQL1 + Liquid Lens + SV-EXR20	
Focus tunable lens (Optotune)	Model	EL-16-40-TC-VIS-5D-C	
	Focal power	-2 dpt	+3 dpt
Extension Tube		SV-EXR20	
Optical Mag.		× 2.0	× 1.9
FOV	2/3"	3.6 × 4.2 mm	3.8 × 4.5 mm
	1/2"	2.4 × 3.2 mm	2.6 × 3.4 mm
	1/3"	1.8 × 2.4 mm	1.9 × 2.6 mm
WD		66.3 mm	63.6 mm
Optical leverage		0.54 mm/dpt	
O/I (Object & Imager Distance)		163.9 mm	161.2 mm
Working F/#		13.7	12.9
NA		0.073	0.074
DOF at PCoC $\phi$ 0.04mm		0.3 mm	0.3 mm
TV Distortion (2/3")		0.04 %	0.02 %
Relative Illuminance (Y=5.5)		98 %	98 %
Wavelength		Visible	
Mount		C-Mount	
Flange Back		17.526 mm	
Sensor Size (max.)		2/3"	
Co-Axial Prism		-	
Filter Thread		M 22.5 P= 0.5	
Weight (approx.)		- g	
Dimension		$\phi$ 30 (max.) × L = 80.1 mm	



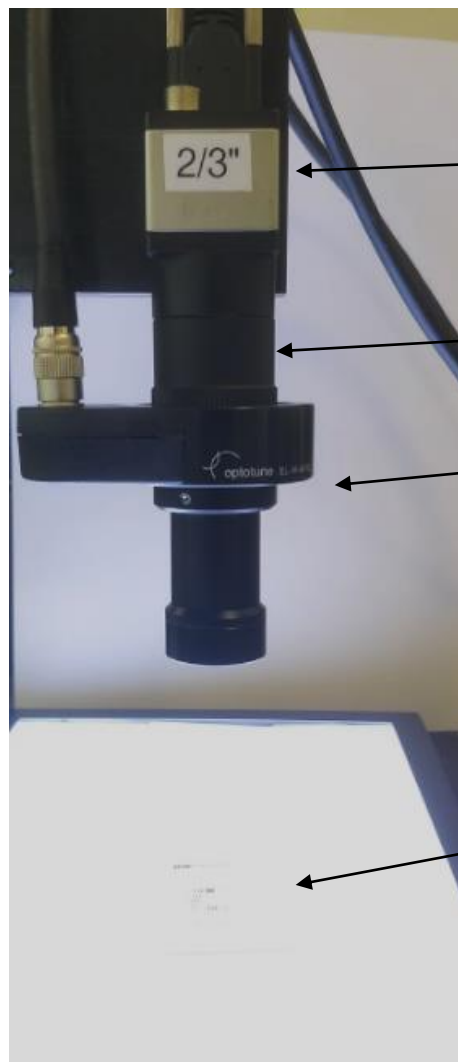
**VS TECHNOLOGY CORPORATION**

# Method for image evaluation

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



# Test setup



Camera:	2/3" (IDS UI-3280CP-M-GL) 2456x2054 pixels, 3.45 um px
Tube	20 mm
Lens:	VS-TCH2-65-LQL1 with EL-16-40-TC-VIS-5D-1-C
F/#	13.7 (fixed)
Driver:	Optotune Lens Driver 4
Target:	Transparent USAF target
Light:	White backlight
Optical axis:	Vertical

# Benchmark without liquid lens (17.6 mm of spacers)

## WD = 65 mm, PMAG=1.96, FOV=4.32 mm

### Camera

Sensor size = 2456x2054 pixels

Nyquist limit = 144 lp/mm

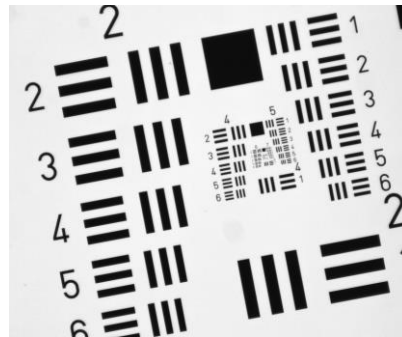
Pixel size = 3.45  $\mu$ m

### Light

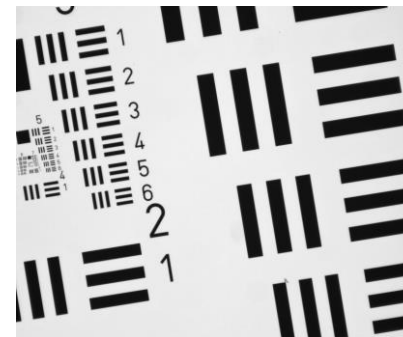
White background illumination



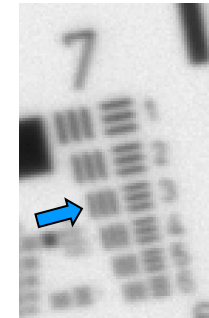
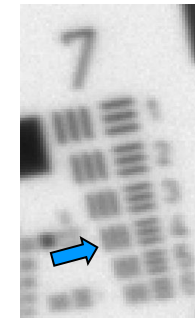
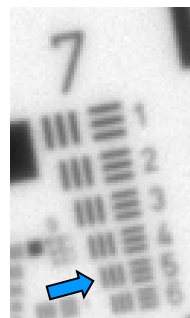
### Center



### Edge



### Corner



USAF element: 7/5  
 Line width ( $\mu$ m): 2.46  
 Lp/mm (object): 203  
 Magnification: 1.964  
**Lp/mm (image): 103**

7/4  
 2.76  
 181  
 1.964  
**92**

7/3  
 3.1  
 161  
 1.964  
**82**



# WD = 65 mm @ 0dpt, PMAG=1.96, FOV=4.32 mm

## Camera

Sensor size = 2456x2054 pixels

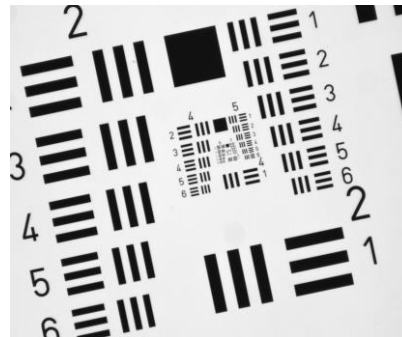
Nyquist limit = 144 lp/mm

Pixel size = 3.45  $\mu$ m

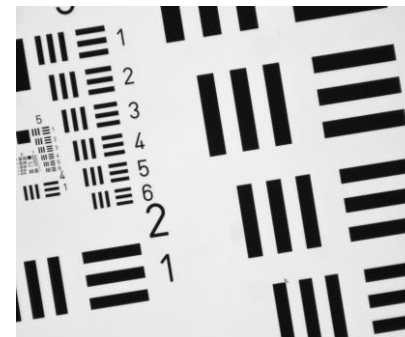
## Light

White background illumination

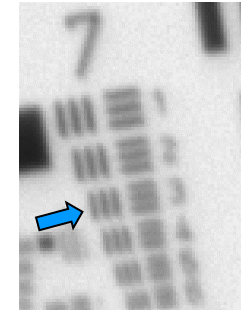
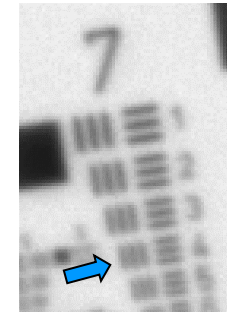
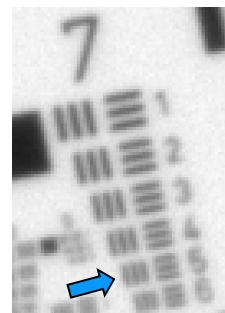
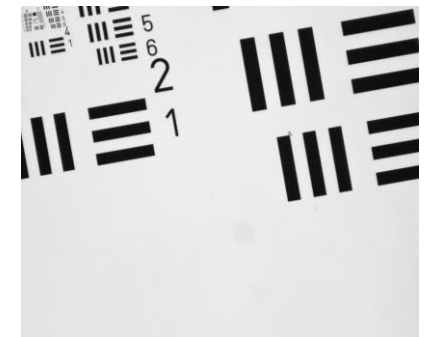
### Center



### Edge



### Corner



USAF element: 7/5  
Line width ( $\mu$ m): 2.46  
Lp/mm (object): 203  
Magnification: 1.964  
**Lp/mm (image): 103**

7/4  
2.76  
181  
1.964  
**92**

7/3  
3.1  
161  
1.964  
**82**



# WD = 66.3 mm @ -2 dpt, PMAG=2.01, FOV=4.21 mm

## Camera

Sensor size = 2456x2054 pixels

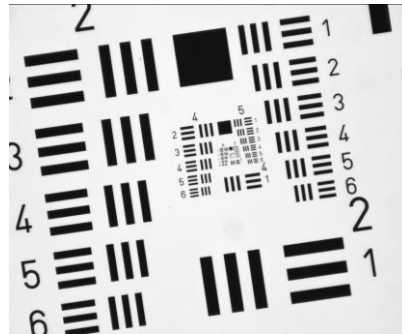
Nyquist limit = 144 lp/mm

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

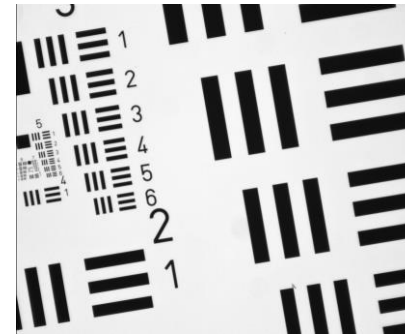
## Light

White background illumination

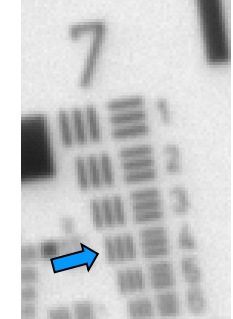
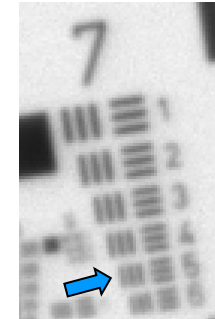
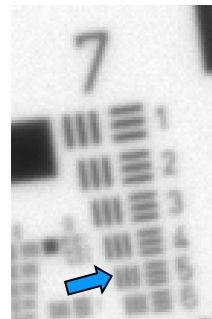
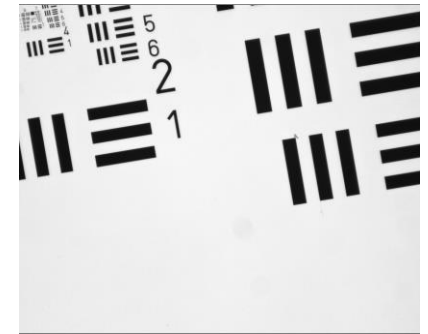
### Center



### Edge



### Corner



USAF element:	7/5
Line width ( $\mu\text{m}$ ):	2.46
Lp/mm (object):	203
Magnification:	2.014
<b>Lp/mm (image):</b>	<b>101</b>

USAF element:	7/5
Line width ( $\mu\text{m}$ ):	2.46
Lp/mm (object):	203
Magnification:	2.014
<b>Lp/mm (image):</b>	<b>101</b>

USAF element:	7/4
Line width ( $\mu\text{m}$ ):	2.76
Lp/mm (object):	181
Magnification:	2.014
<b>Lp/mm (image):</b>	<b>90</b>

# WD = 63.6 mm @ 3 dpt, PMAG=1.9, FOV=4.46 mm

## Camera

Sensor size = 2456x2054 pixels

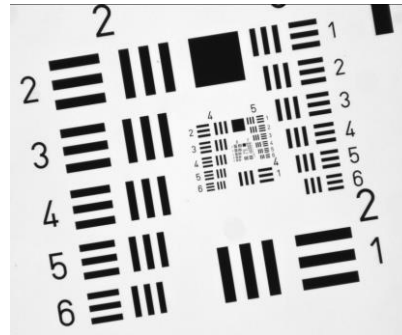
Nyquist limit = 144 lp/mm

Pixel size = 3.45  $\mu$ m

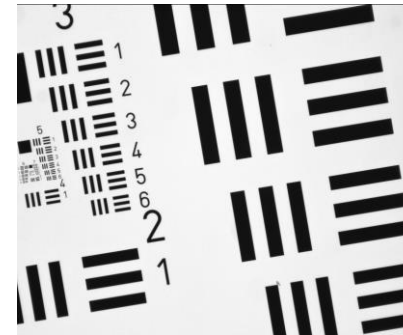
## Light

White background illumination

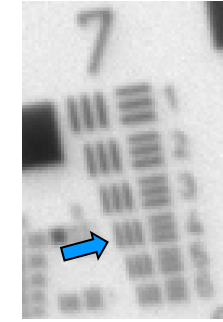
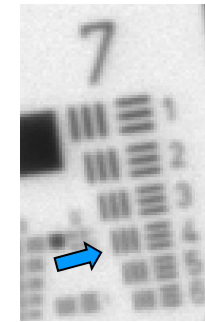
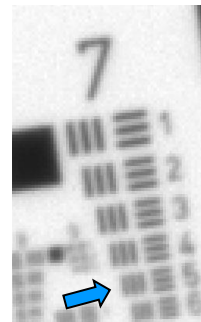
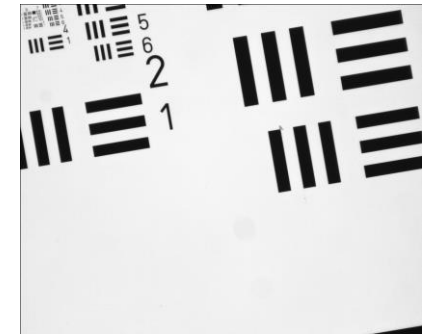
### Center



### Edge



### Corner



USAF element: 7/5  
Line width ( $\mu$ m): 2.46  
Lp/mm (object): 203  
Magnification: 1.896  
**Lp/mm (image): 107**

7/4  
2.76  
181  
1.896  
**96**

7/4  
2.76  
181  
1.896  
**96**

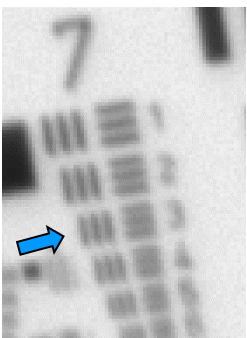
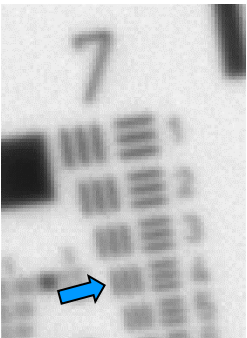
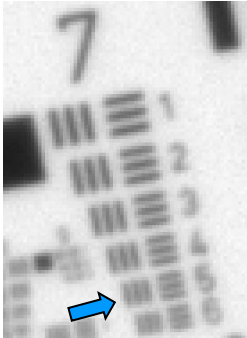
# Comparison: liquid lens vs no liquid lens

Center

Edge

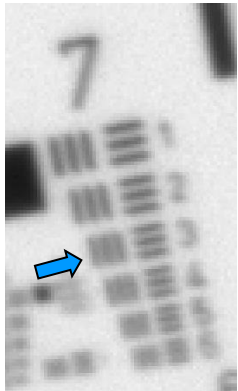
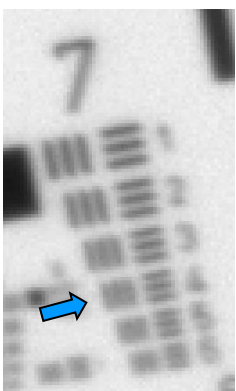
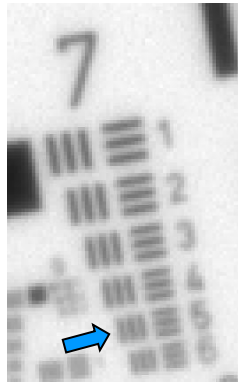
Corner

**With liquid lens**



**Without liquid lens**

Note: 17.6 mm of spacers added to compensate for EL-16-40 thickness



**No loss of image quality with the liquid lens in the assembly!**

# Test setup



Camera:	2/3" (IDS UI-3280CP-M-GL) 2456x2054 pixels, 3.45 um px
Tube	20 mm
Lens:	VS-TCH2-65-LQL1 with EL-16-40-TC-VIS-5D-1-C
F/#	13.7 (fixed)
Driver:	Optotune Lens Driver 4
Target:	Transparent USAF target
Light:	White backlight
Optical axis:	Vertical

# WD = 65 mm @ 0dpt, PMAG=1.96, FOV=4.32 mm

## Camera

Sensor size = 2456x2054 pixels

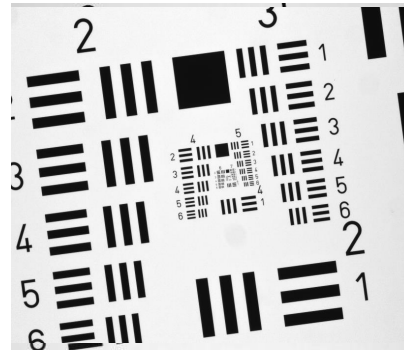
Nyquist limit = 144 lp/mm

Pixel size = 3.45  $\mu$ m

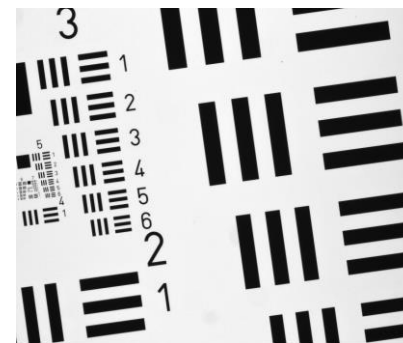
## Light

Red background illumination

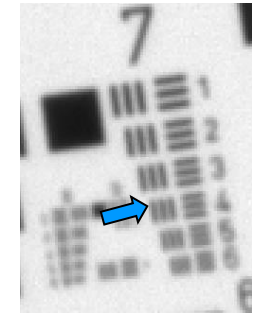
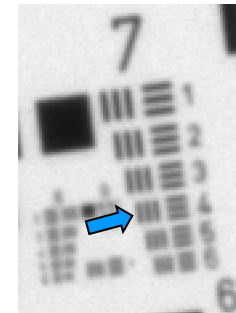
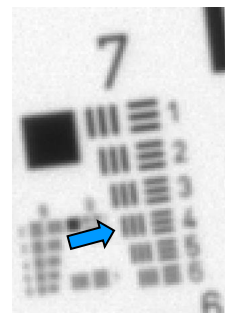
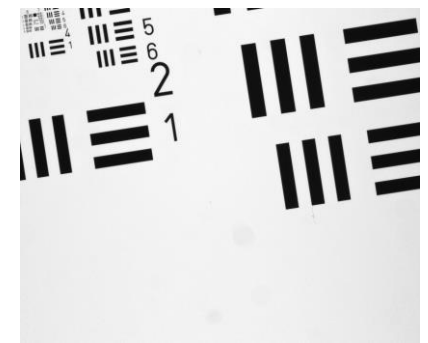
### Center



### Edge



### Corner



USAF element: 7/4  
Line width ( $\mu$ m): 2.76  
Lp/mm (object): 181  
Magnification: 1.964  
**Lp/mm (image): 92**

7/4  
2.76  
181  
1.964  
**92**

7/4  
2.76  
181  
1.964  
**92**

# WD = 66.3 mm @ -2 dpt, PMAG=2.01, FOV=4.21 mm

## Camera

Sensor size = 2456x2054 pixels

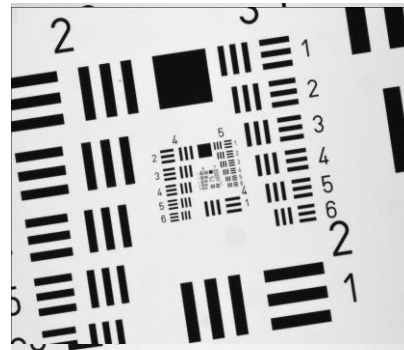
Nyquist limit = 144 lp/mm

Pixel size = 3.45  $\mu$ m

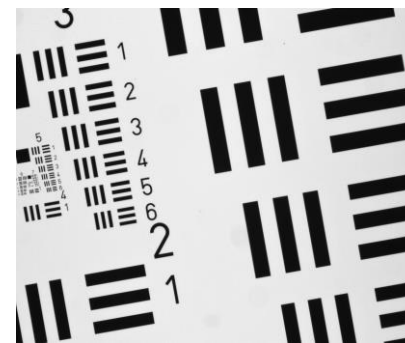
## Light

Red background illumination

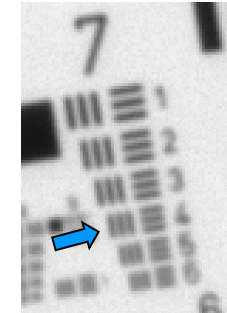
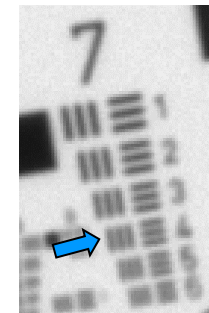
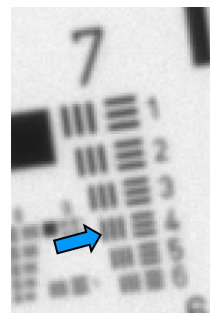
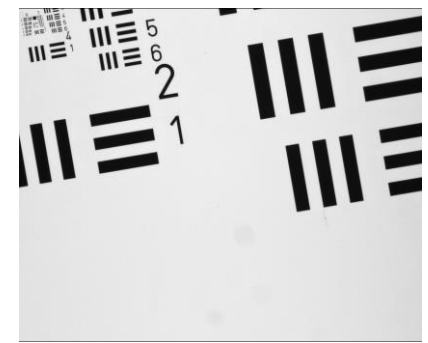
### Center



### Edge



### Corner



USAF element: 7/4  
Line width ( $\mu$ m): 2.76  
Lp/mm (object): 181  
Magnification: 2.014  
**Lp/mm (image): 90**

7/4  
2.76  
181  
2.014  
**90**

7/4  
2.76  
181  
2.014  
**90**



# WD = 63.6 mm @ 3 dpt, PMAG=1.9, FOV=4.46 mm

## Camera

Sensor size = 2456x2054 pixels

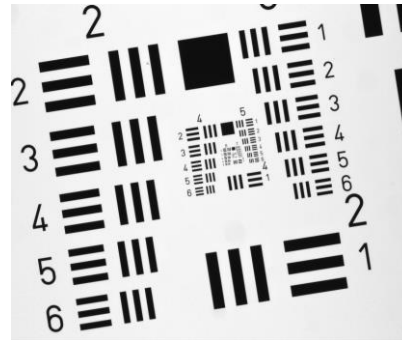
Nyquist limit = 144 lp/mm

Pixel size = 3.45  $\mu$ m

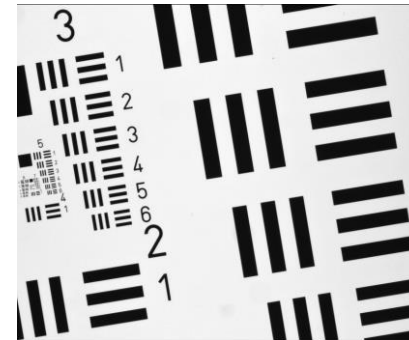
## Light

Red background illumination

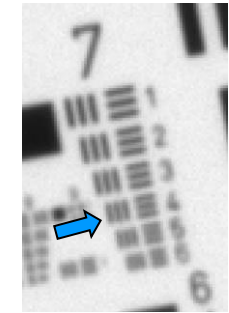
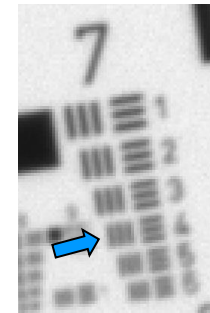
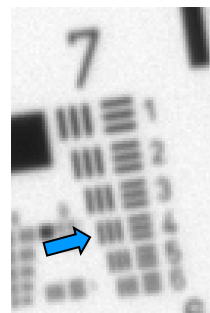
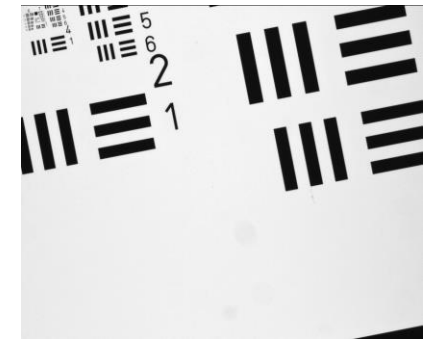
### Center



### Edge



### Corner



USAF element: 7/4  
Line width ( $\mu$ m): 2.76  
Lp/mm (object): 181  
Magnification: 1.896  
**Lp/mm (image): 96**

7/4  
2.76  
181  
1.896  
**96**

7/4  
2.76  
181  
1.896  
**96**



# Magnification change: 2.1% per mm of WD

