



shaping the future of optics

## **Optotune ELM-25-3.7-18-C**

### **Test report**

November 2025  
Amir Saba, Application Engineer

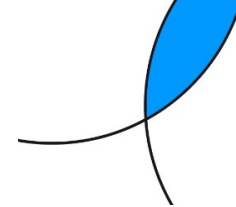
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# Summary

- **Working distance (WD) range of 200mm-Inf (Shorter WD possible)**
- **Performance close to the Nyquist rate of 2.74 $\mu$ m pixel size**
  - Resolution >170 lp/mm for center of the image across the WD tuning range
  - Resolution  $\geq$ 140 lp/mm across the field and WD tuning range
- **FP-sensitivity: 200mm-Inf WD with only 3.6dpt range**
- **Very negligible field curvature and distortion**
  - Distortion is <1%
- **Vignetting level of  $\sim$ 29%**
- **<10% resolution degradation (only corners) due to the gravity-coma for horizontal optical axis**
- **Very good polychromatic performance**
  - Performance very similar between white and blue backlights



# ELM-25-3.7-18-C Datasheet



## Lens module specifications

|  | EL-12-30-TC-VIS-16D | EL-7-20-TC-VIS-14D |             |
|--|---------------------|--------------------|-------------|
| Effective focal length                   |                     | 24.5               | mm          |
| F/# (fixed)                              | 3.2                 | 3.7                |             |
| Maximum sensor format                    |                     | 1.1                | inch        |
| Maximum image circle (Φ)                 |                     | 18                 | mm          |
| Lifecycles (10-90% sinusoidal)           |                     | >1'000'000'000     | cycles      |
| FOV for 1.1" sensor                      | Diagonal            | 40.0               | °           |
|  | Horizontal          | 28.8               | °           |
|  | Vertical            | 28.8               | °           |
| Back focal length (BFL)                  |                     | 13.53              | mm (in air) |
| Optical distortion                       |                     | <0.5               | %           |
| Pixel size (recommended)                 |                     | 2.74               | μm          |
| Wavelength range                         |                     | 420-900            | nm          |
| Relative illumination                    | >86                 | >89                | %           |
| Max chief ray angle                      | 10.2                | 9.5                | °           |
| Working distance (WD) range <sup>1</sup> |                     | 200 to inf         | mm          |
| Optimal WD                               |                     | 1000               | mm          |
| WD at 0 dpt                              |                     | inf                | mm          |
| Mount                                    |                     | C-mount            |             |
| Filter thread                            |                     | M49x0.5            |             |
| Connector type                           |                     | Hirose (6 pins)    |             |
| Total track length (TTL)                 |                     | 142.5              | mm          |
| Dimension (Φ x L)                        |                     | 60.2 x 129.0       | mm          |
| Weight                                   |                     | 555                | g           |
| Operating temperature                    |                     | -20 to +65         | °C          |
| Storage temperature                      |                     | -40 to +85         | °C          |

## Focus tunable lens specifications

|                                       | EL-12-30-TC-VIS-16D | EL-7-20-TC-VIS-14D |     |
|---------------------------------------|---------------------|--------------------|-----|
| Focal power range (@25°C)             | -6 to +10           | -6 to +8           | dpt |
| Focal power range for module WD range |                     | 0.0 to +3.6        | dpt |
| Temperature sensor and EEPROM         |                     | Yes                |     |
| Control current (typical)             |                     | -250 to +250       | mA  |
| Max. control current                  |                     | -300 to +300       | mA  |
| Motor coil resistance @ 30°C          | 15                  | 12                 | Ω   |
| Absolute maximum voltage (coil)       | 6                   | 6                  | V   |

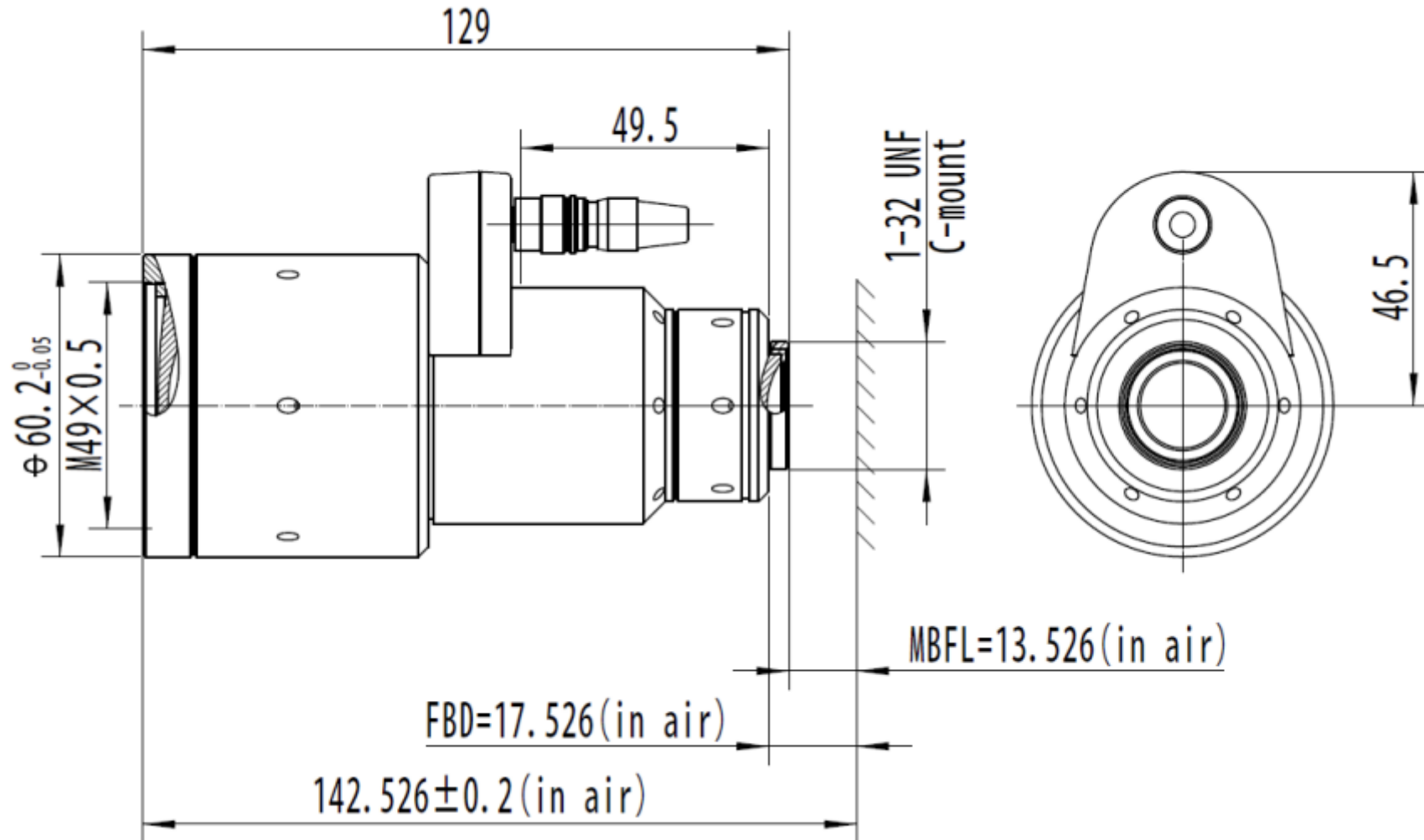
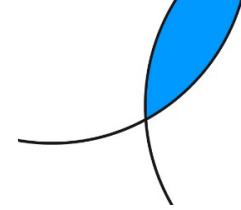
## Electrical layout

| Hirose connector (HR10G-7R-6PB) | Function             | Sensor pins |  |
|---------------------------------|----------------------|-------------|--|
| Pin 1                           | Control current +    | -           |  |
| Pin 2                           | Control current -    | -           |  |
| Pin 3                           | Ground               | 1-4         |  |
| Pin 4                           | Vcc (3.0-3.7V)       | 8           |  |
| Pin 5                           | I <sup>2</sup> C SCL | 6           |  |
| Pin 6                           | I <sup>2</sup> C SDA | 5           |  |

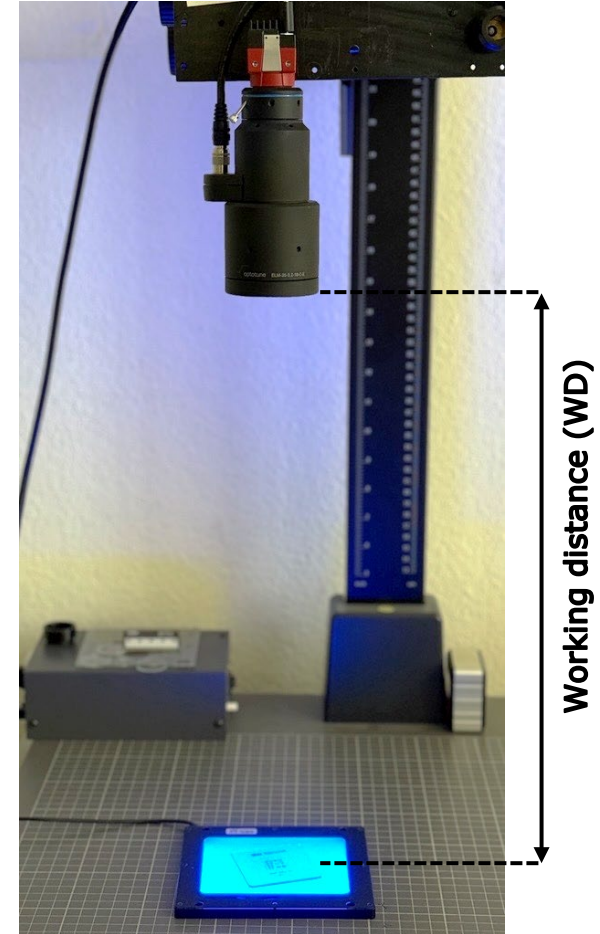
| Hirose connector (HR10G-7R-6SB) | Function                       | Value |  |
|---------------------------------|--------------------------------|-------|--|
| Pin 1                           | GPIO Trigger                   | -     |  |
| Pin 2                           | Analog In                      | 0-10V |  |
| Pin 3                           | UART Tx / I <sup>2</sup> C SCL | TTL   |  |
| Pin 4                           | UART Rx / I <sup>2</sup> C SDA | TTL   |  |
| Pin 5                           | GND                            | -     |  |
| Pin 6                           | Vcc                            | 5-24V |  |

# Mechanical drawing



# Test Setup

|                      |   |
|----------------------|---|
| <b>Camera:</b>       | Alvium 1800 C-2040<br>1.1" 4512 x 4512 px<br>Pixel size = 2.74 $\mu\text{m}$<br>Nyquist rate = 182 lp/mm<br>C-mount |
| <b>Lens:</b>         | ELM-35-3.7-18-C   |
| <b>Tunable lens:</b> | EL-7-20-TC-VIS-14D<br>SN: DHAB0149  |
| <b>Orientation:</b>  | Vertical Optical Axis   |
| <b>Driver:</b>       | ECC-1C<br>SN: CXAB1415, FW: 2.0.741648  |
| <b>Target:</b>       | USAF chrome target, positive  |
| <b>Light:</b>        | White backlight (LED1-FLS-110x110W)<br>Blue backlight   |



# Field of view with 1.1" sensor

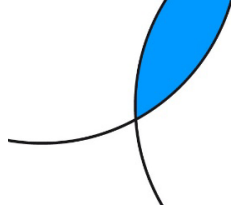
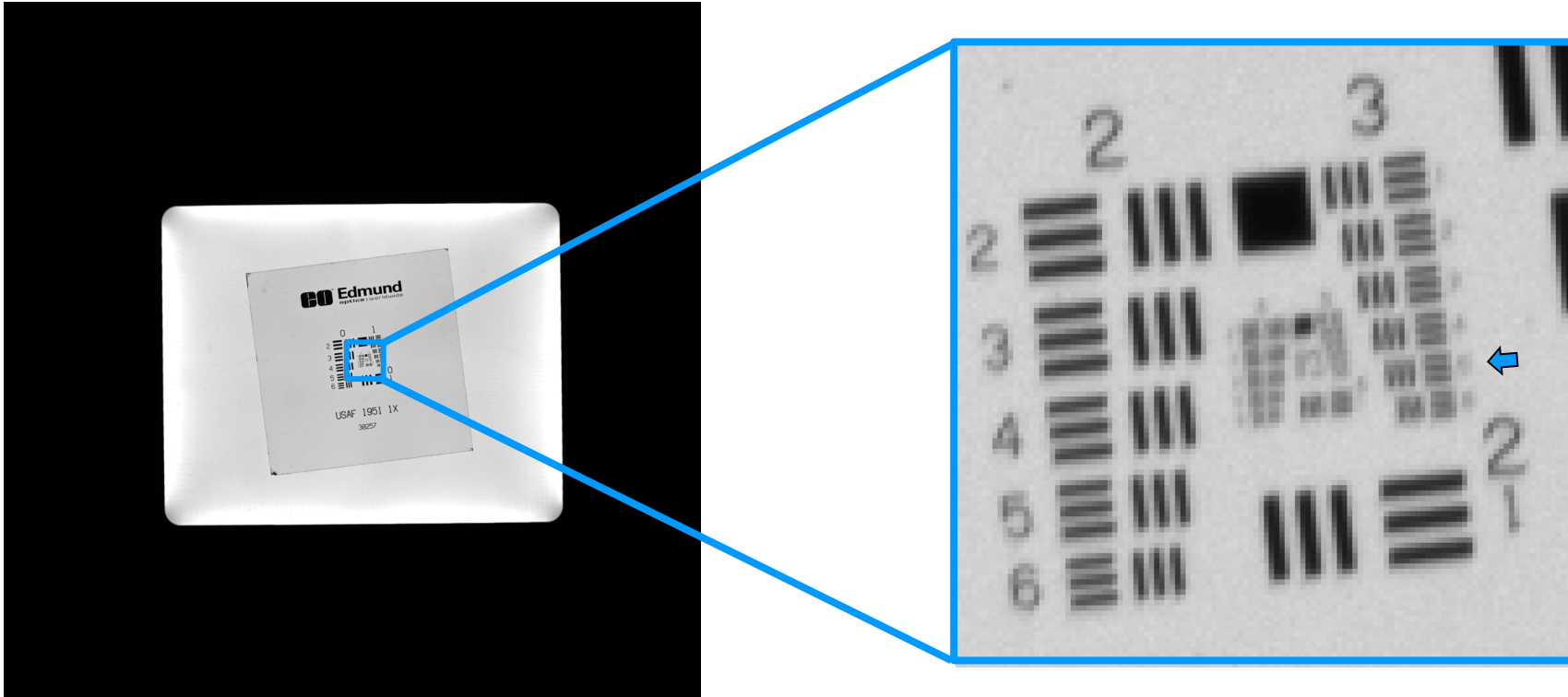


Image size (2.74  $\mu\text{m}$  pixel size):

- Width = 12.4 mm
- Height = 12.4 mm
- Diagonal = 17.5 mm

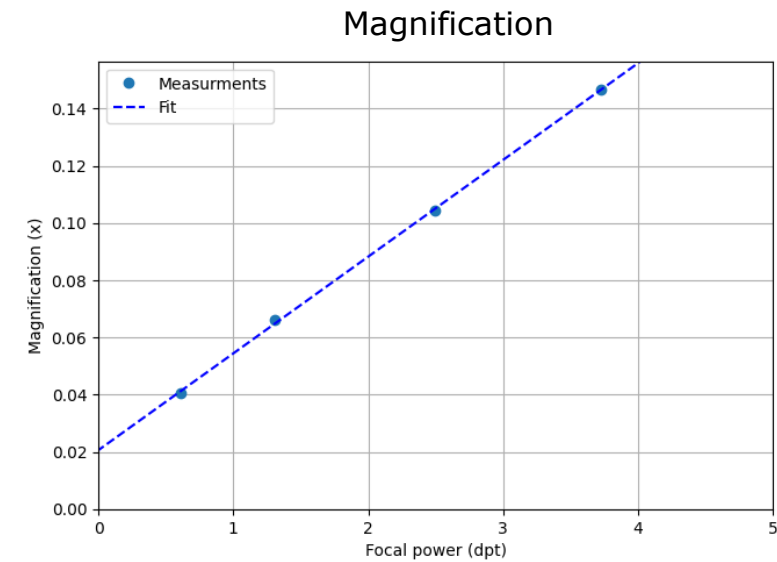
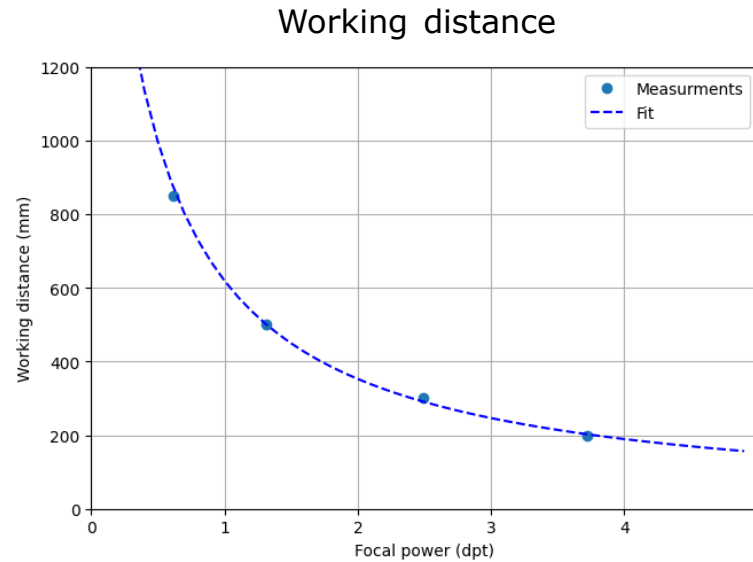
# Image evaluation

- All the images are taken at Gain 0, and without gamma correction
- The intensity of illumination is controlled to adjust the histogram of the images
- After acquisition, images are zoomed in to show the resolution-limited element



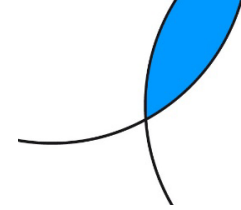
# Working distance, Magnification

- Magnification and working distance of this ELM is very well aligned with an ento-centric lens



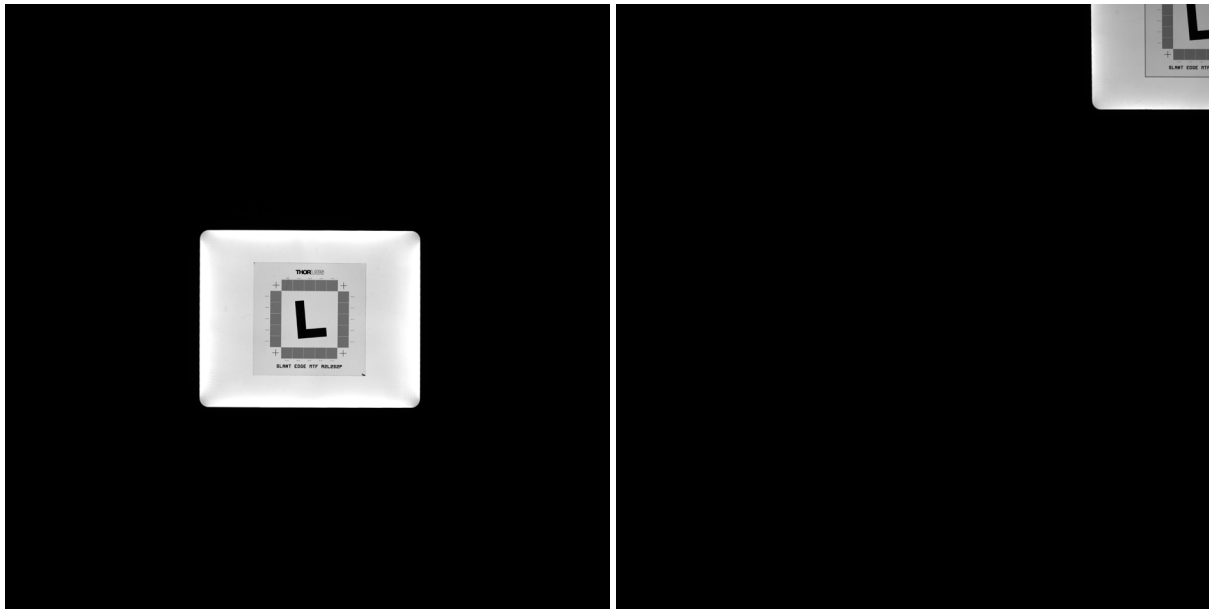
- \* Measured with blue LED backlight
- \* Magnification measured at the center of the image

# Slanted-Edge MTF

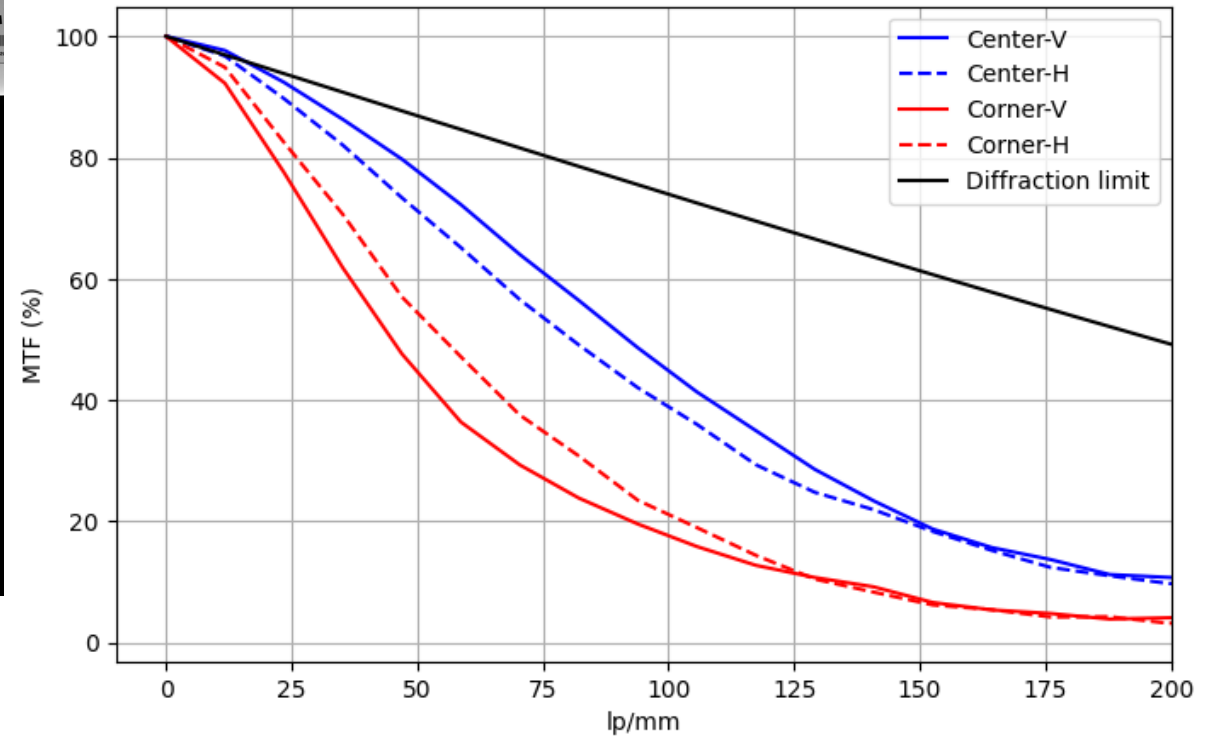


Center

Corner

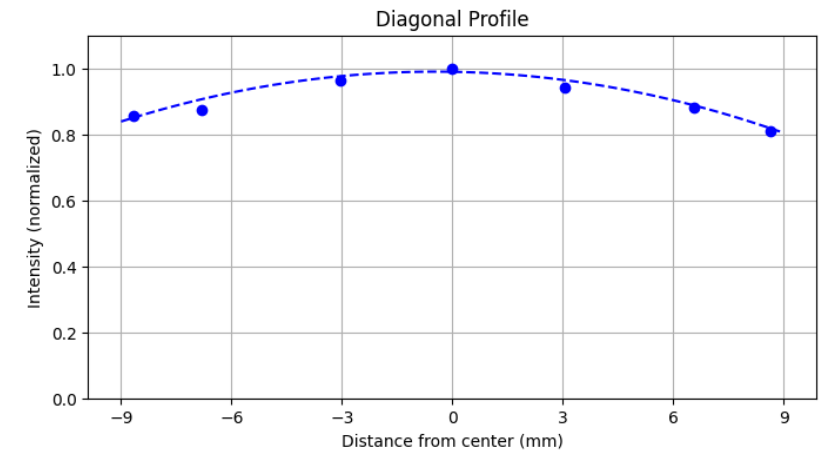
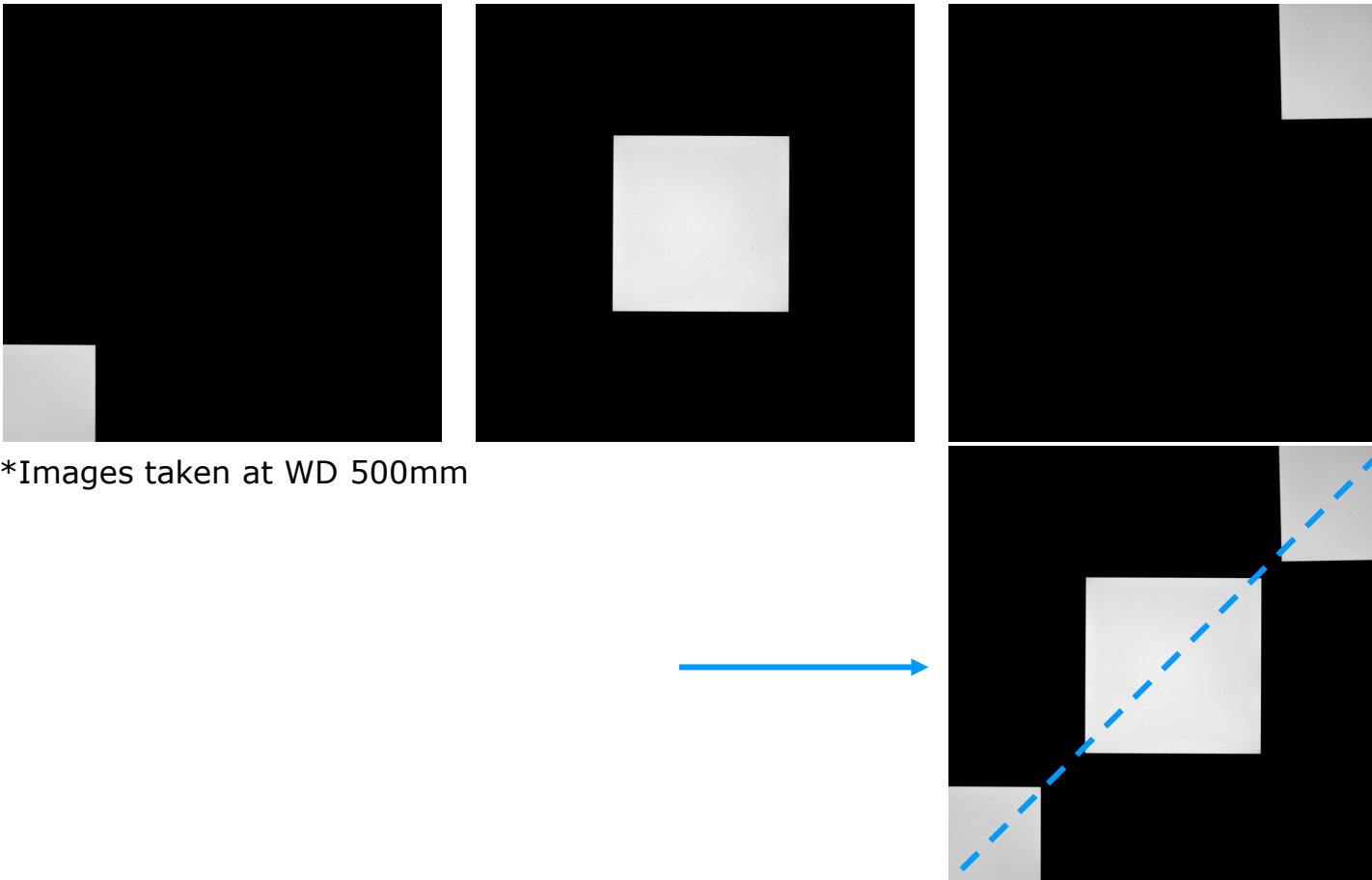


\*Images taken with the blue LED at WD 500mm



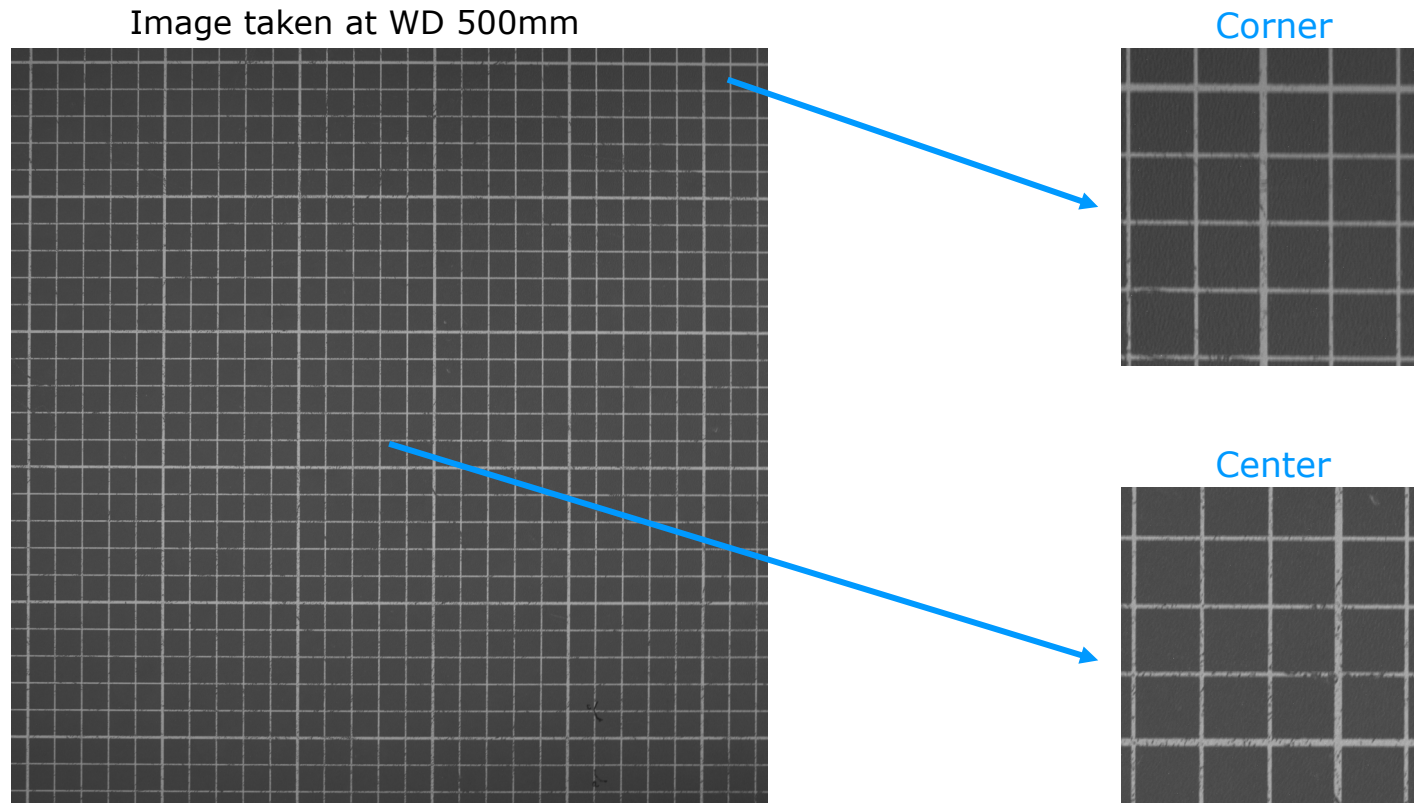
# Relative illumination

- Due to the wide-angle FOV, we did image stitching for multiple measurements with a uniform LED
- Relative illumination of this ELM is 0.29EV (18%) for 1.1" sensor
- There is a negligible dependence to the focal power/WD for the vignetting

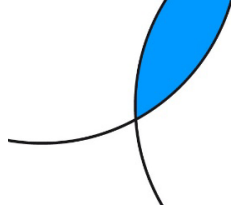


# Distortion and field curvature

- We see some distortion but no field curvature
- Geometrical distortion value:  $\leq 1\%$



# WD 850 mm: +0.49dpt, Blue light Performance is close to Nyquist limit



## Camera

Sensor size = 4512 x 4512 px

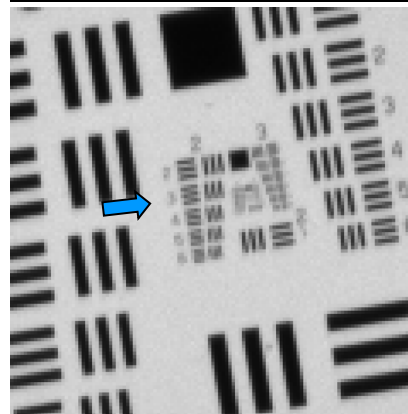
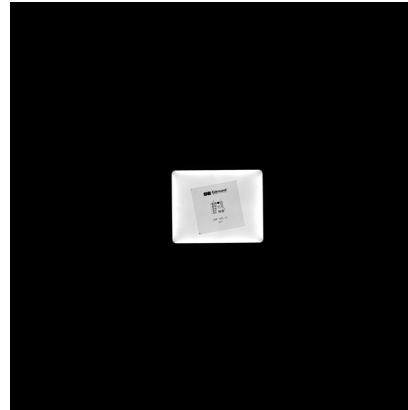
Pixel size = 2.74  $\mu\text{m}$

Nyquist limit = 182 lp/mm

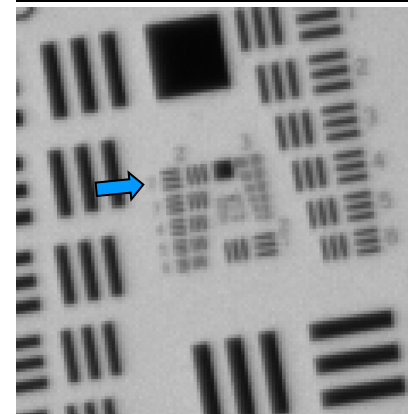
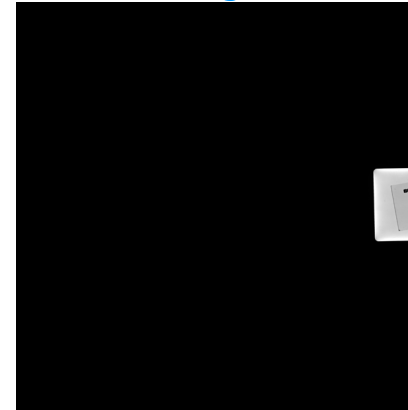
## Light

Blue background illumination

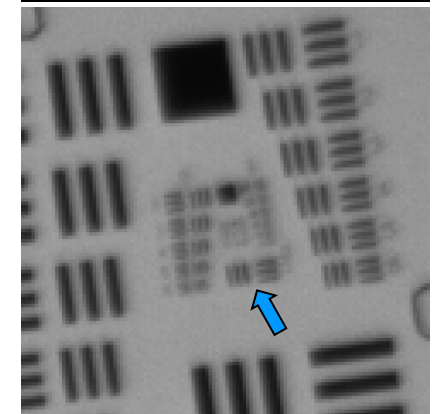
Center



Edge



Corner

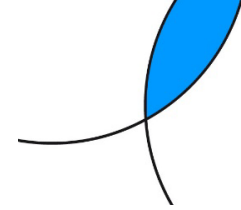


|                               |            |
|-------------------------------|------------|
| USAF element:                 | 2/3        |
| Line width ( $\mu\text{m}$ ): | 99.21      |
| Lp/mm (object):               | 5          |
| Magnification:                | 0.028      |
| <b>Lp/mm (image):</b>         | <b>180</b> |

|                               |            |
|-------------------------------|------------|
| USAF element:                 | 2/2        |
| Line width ( $\mu\text{m}$ ): | 111.36     |
| Lp/mm (object):               | 4          |
| Magnification:                | 0.028      |
| <b>Lp/mm (image):</b>         | <b>160</b> |

|                               |            |
|-------------------------------|------------|
| USAF element:                 | 2/1        |
| Line width ( $\mu\text{m}$ ): | 125        |
| Lp/mm (object):               | 4          |
| Magnification:                | 0.028      |
| <b>Lp/mm (image):</b>         | <b>143</b> |

# WD 500 mm: +1.12dpt, Blue light Performance is close to Nyquist limit



## Camera

Sensor size = 4512 x 4512 px

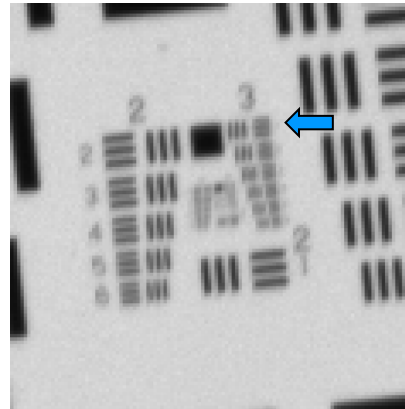
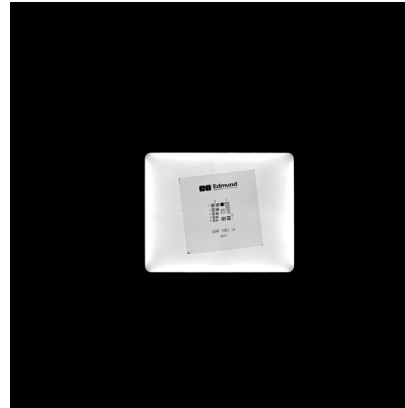
Pixel size = 2.74  $\mu\text{m}$

Nyquist limit = 182 lp/mm

## Light

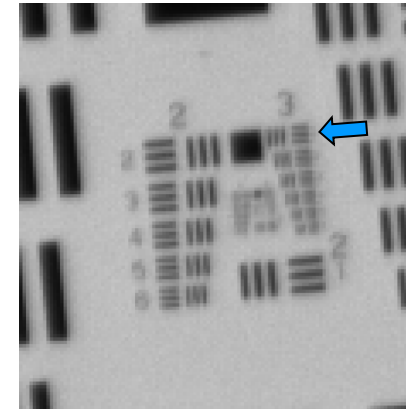
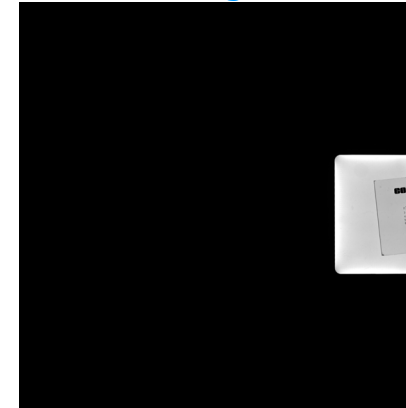
Blue background illumination

Center



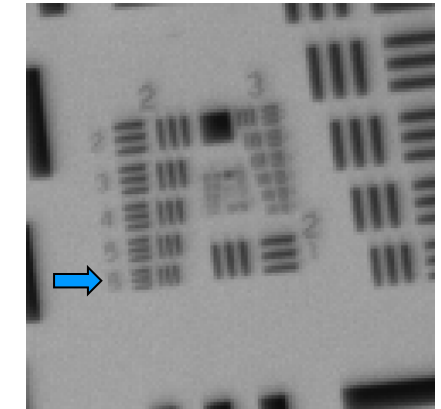
|                               |            |
|-------------------------------|------------|
| USAF element:                 | 3/1        |
| Line width ( $\mu\text{m}$ ): | 62.5       |
| Lp/mm (object):               | 8          |
| Magnification:                | 0.049      |
| <b>Lp/mm (image):</b>         | <b>163</b> |

Edge



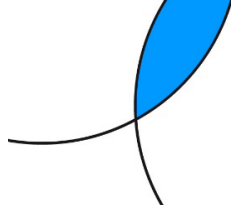
|                               |            |
|-------------------------------|------------|
| USAF element:                 | 3/1        |
| Line width ( $\mu\text{m}$ ): | 62.5       |
| Lp/mm (object):               | 8          |
| Magnification:                | 0.049      |
| <b>Lp/mm (image):</b>         | <b>163</b> |

Corner



|                               |            |
|-------------------------------|------------|
| USAF element:                 | 2/6        |
| Line width ( $\mu\text{m}$ ): | 70.15      |
| Lp/mm (object):               | 7          |
| Magnification:                | 0.049      |
| <b>Lp/mm (image):</b>         | <b>145</b> |

# WD 300 mm: +2.07dpt, Blue light Performance is close to Nyquist limit



## Camera

Sensor size = 4512 x 4512 px

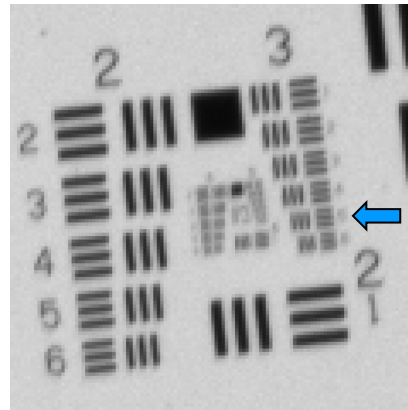
Pixel size = 2.74  $\mu\text{m}$

Nyquist limit = 182 lp/mm

## Light

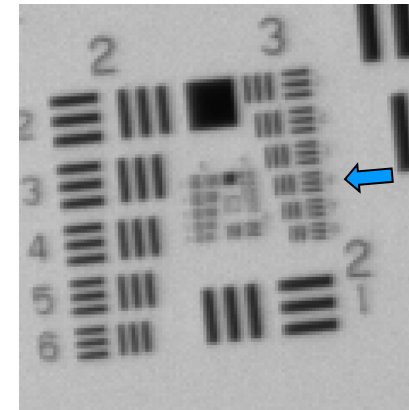
Blue background illumination

Center



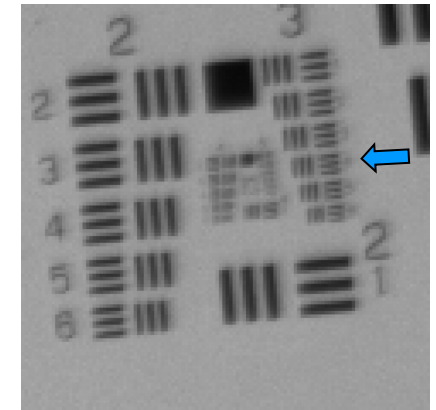
|                               |            |
|-------------------------------|------------|
| USAF element:                 | 3/5        |
| Line width ( $\mu\text{m}$ ): | 39.37      |
| Lp/mm (object):               | 13         |
| Magnification:                | 0.072      |
| <b>Lp/mm (image):</b>         | <b>176</b> |

Edge



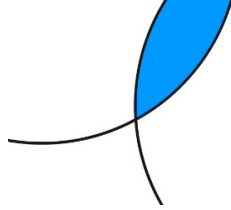
|                               |            |
|-------------------------------|------------|
| USAF element:                 | 3/4        |
| Line width ( $\mu\text{m}$ ): | 44.19      |
| Lp/mm (object):               | 11         |
| Magnification:                | 0.072      |
| <b>Lp/mm (image):</b>         | <b>157</b> |

Corner



|                               |            |
|-------------------------------|------------|
| USAF element:                 | 3/4        |
| Line width ( $\mu\text{m}$ ): | 44.19      |
| Lp/mm (object):               | 11         |
| Magnification:                | 0.072      |
| <b>Lp/mm (image):</b>         | <b>157</b> |

# WD 200 mm: +3.06dpt, Blue light Performance is close to Nyquist limit



## Camera

Sensor size = 4512 x 4512 px

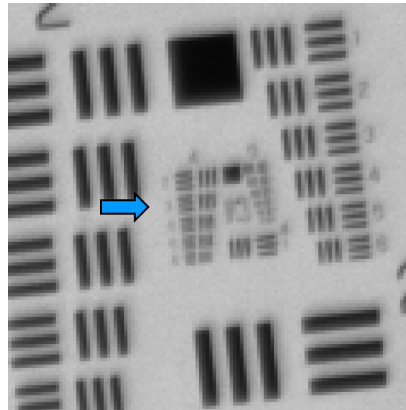
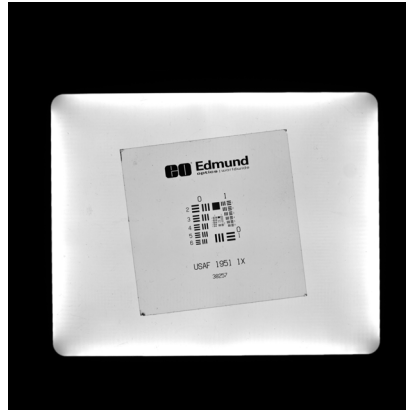
Pixel size = 2.74  $\mu\text{m}$

Nyquist limit = 182 lp/mm

## Light

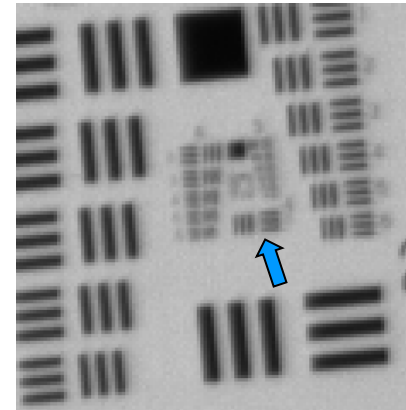
Blue background illumination

Center



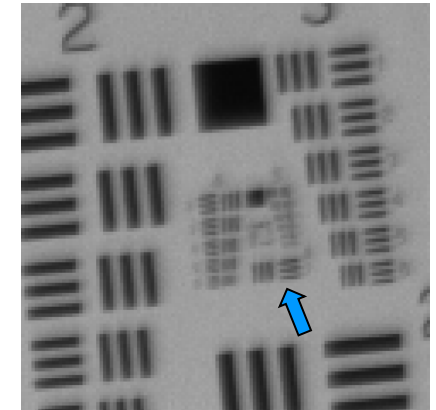
USAF element: 4/2  
 Line width ( $\mu\text{m}$ ): 27.84  
 Lp/mm (object): 18  
 Magnification: 0.101  
**Lp/mm (image): 178**

Edge



4/1  
 31.25  
 16  
 0.101  
**158**

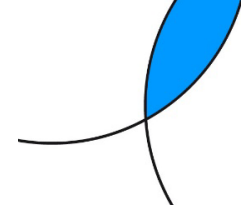
Corner



4/1  
 31.25  
 16  
 0.101  
**158**

# Polychromatic performance: White LED vs. Blue LED

## WD 500mm, +1.12dpt



### Camera

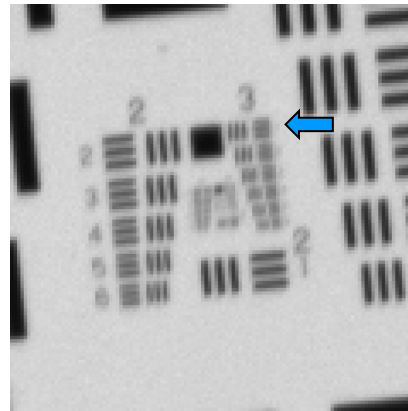
Sensor size = 4512 x 4512 px

Pixel size = 2.74  $\mu\text{m}$

Nyquist limit = 182 lp/mm

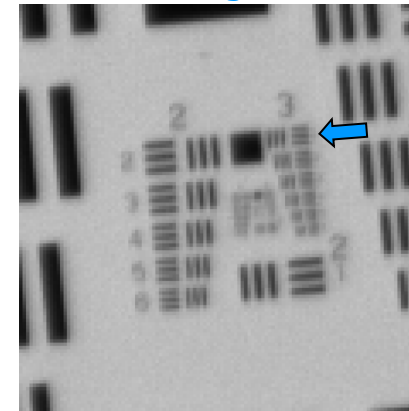
Blue

Center



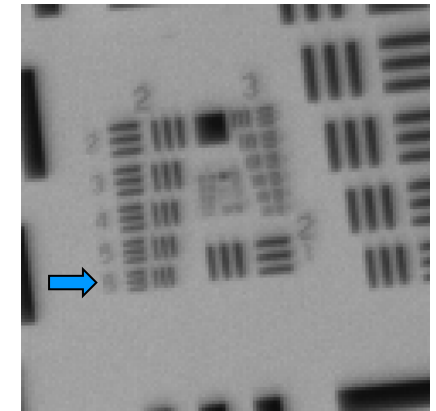
163 LP/mm

Edge



163 LP/mm

Corner



145 LP/mm

White

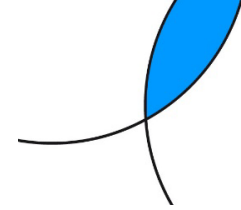
163 LP/mm

163 LP/mm

145 LP/mm

# Vertical vs. Horizontal optical axis

## WD 500mm, +1.12/0.94dpt, White LED



### Camera

Sensor size = 4512 x 4512 px

Pixel size = 2.74  $\mu\text{m}$

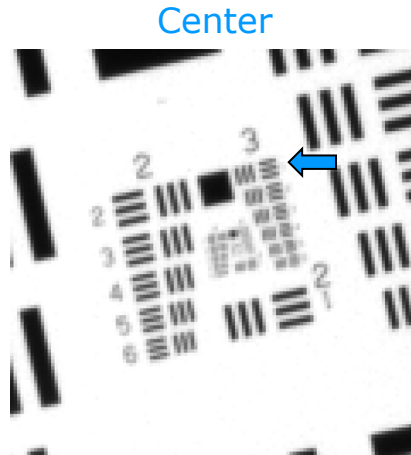
Nyquist limit = 182 lp/mm

### Light

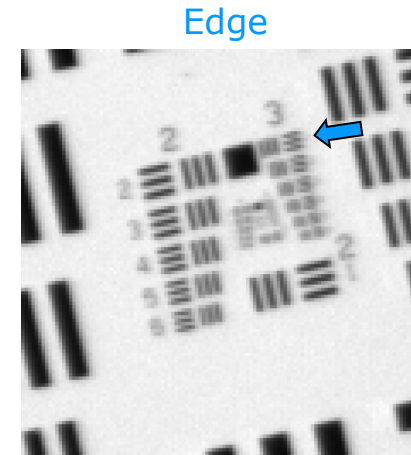
White background illumination

EL-7-20 Gravity coma:  $0.05\lambda$

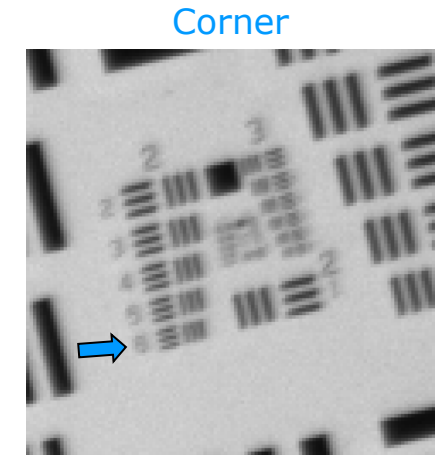
Vertical OA



163 LP/mm

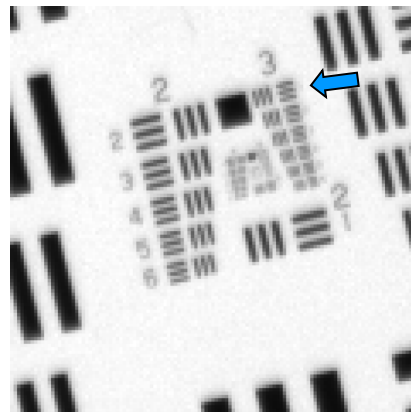


163 LP/mm

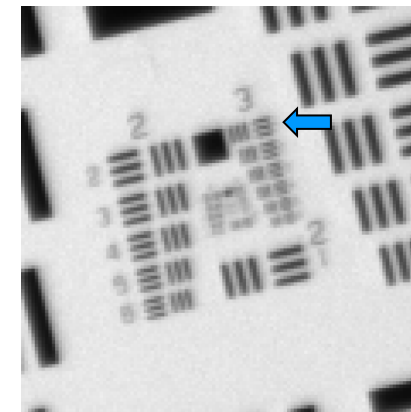


145 LP/mm

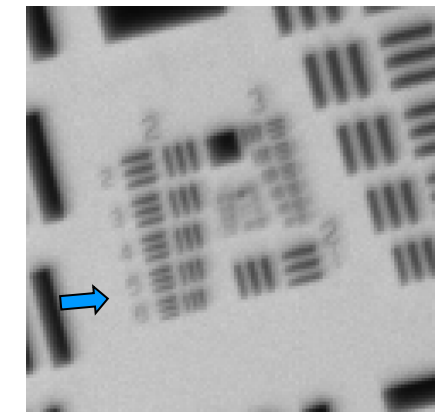
Horizontal OA



163 LP/mm



163 LP/mm



130 LP/mm