

Telecentric inspection with EL-16-40

Achieving large z-range without significant magnification change

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Summary

- Large z-range of over **10mm**
- **No** added vignetting
- **No** distortion
- **No** loss of resolution
- **Very small** magnification change
→ easy software compensation



Measurement setup



Cameras used

- Dalsa Genie TS M4096, 6um pixels
- iDS UI-3480CP, 2.2um pixels

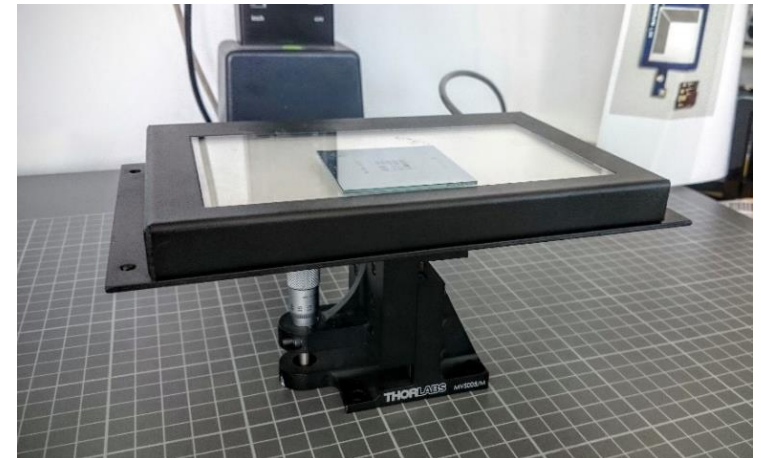
Tubes:

- M42 tube required for large format sensors
- C-mount tube ok for sensors up to 20mm in diagonal (as shown)

Optotune EL-16-40-TC

Sill Optics Correctal T/2.0

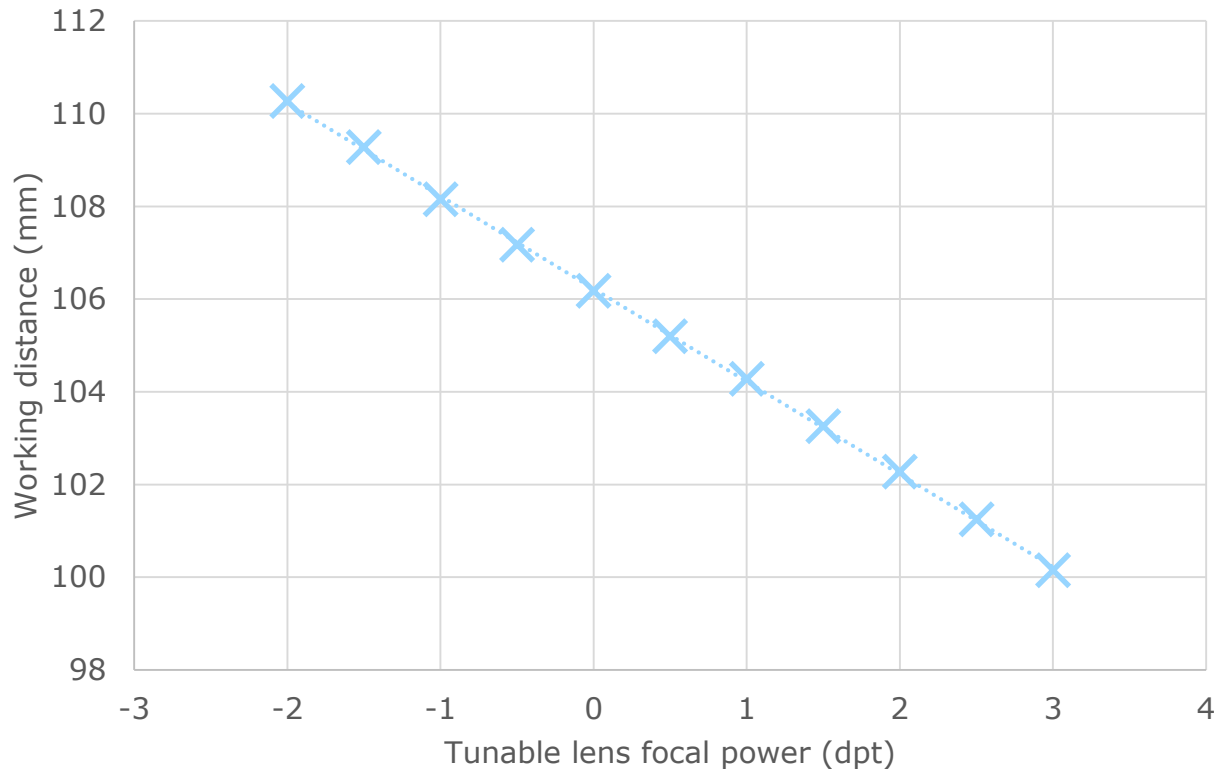
Backlight, USAF target and micrometer adjustable mount



Large z-range and high linearity



10mm WD change over specified tuning range of 5 dpt



× EL-16-40-TC (measured) Linear (EL-16-40-TC (measured))

DOF estimate:
20 lp/mm, f/3, 106mm Focus

Reach 20% contrast for
- 40um / +50um

→ DOF of 90 um

➔ **Optical leverage: 2 mm/dpt**

No vignetting visible



The EL-16-40 does *not* introduce vignetting on a 30 mm image circle

EL-16-40 @ 0dpt

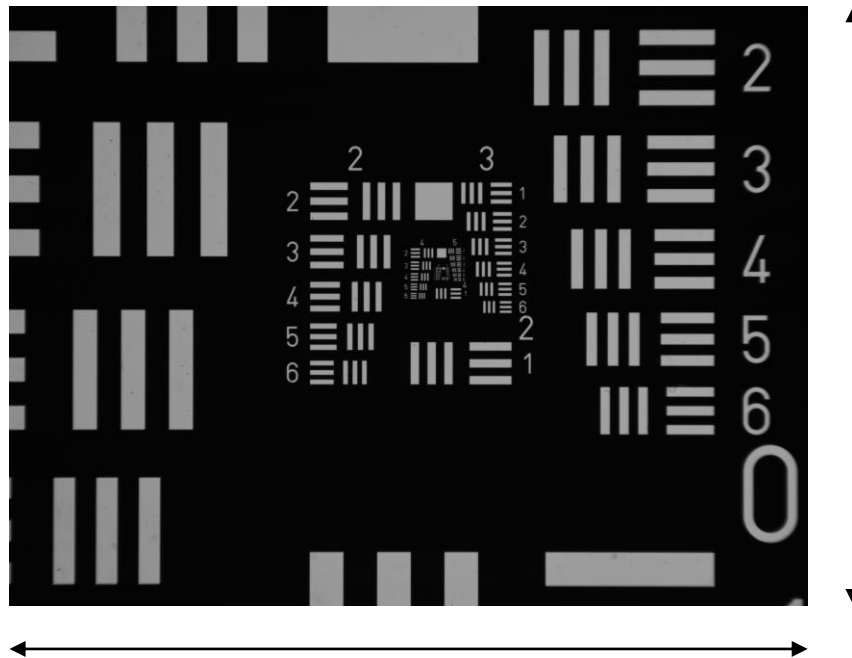


Image: 18.4 mm
Object : 9.2 mm

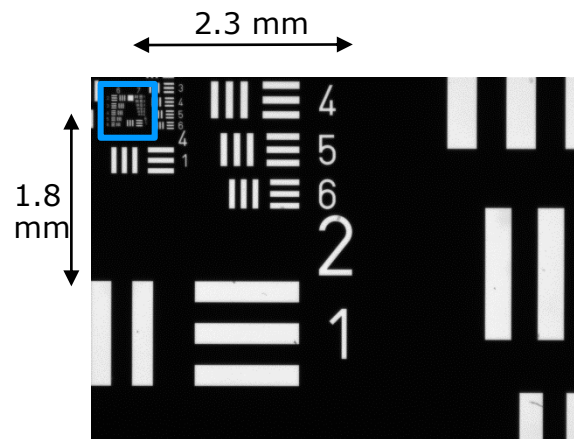
Image: 24.5 mm
Object : 12.25 mm

Resolution at full aperture (1/2): 90lp/mm observed with 2.2 um pixels



- Smallest resolved feature in the center is the 7/4 line triplet
- Lines have 2.76 um width corresponding to 181 lp/mm object resolution
- Image resolution is then 90 lp/mm.

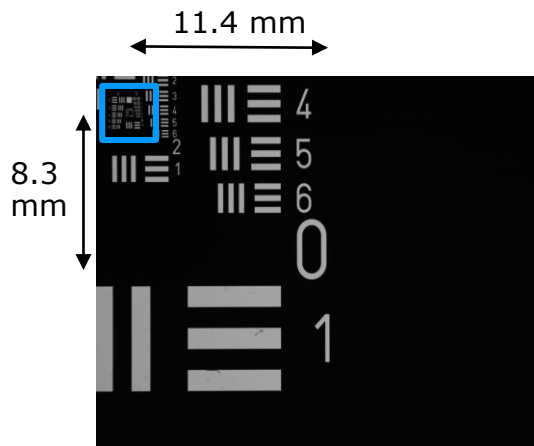
	EL-16 @ 0dpt	EL-16 @ 3dpt
Center		
Corner		



Resolution at full aperture (2/2): 50lp/mm at center (due to 6 um pixel limit)



- Smallest resolved feature in the center is the 6/5 line triplet
- Lines have 4.38 um width corresponding to 101 lp/mm object resolution
- Image resolution is then 50 lp/mm.



	EL-16 @ 0dpt	EL-16 @ 3dpt
Center		
Corner		

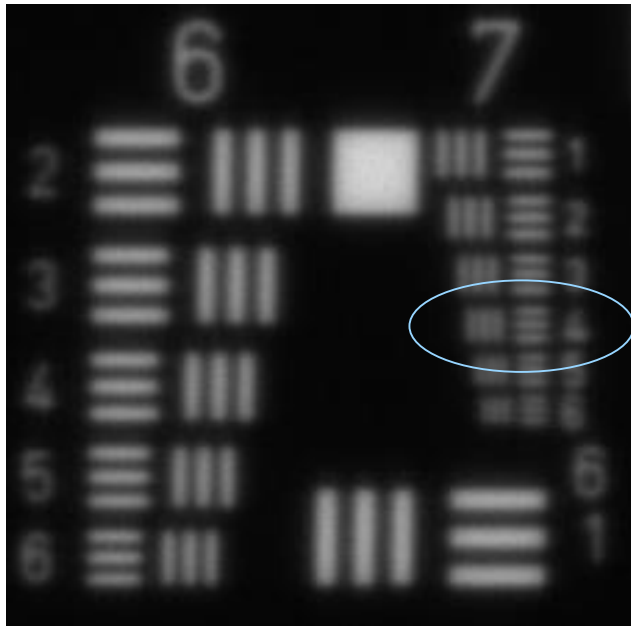
Resolution
14.7mm off
axis suffers
with fully open
aperture.

Better results
with smaller
aperture

Observed resolution in line with simulated MTF

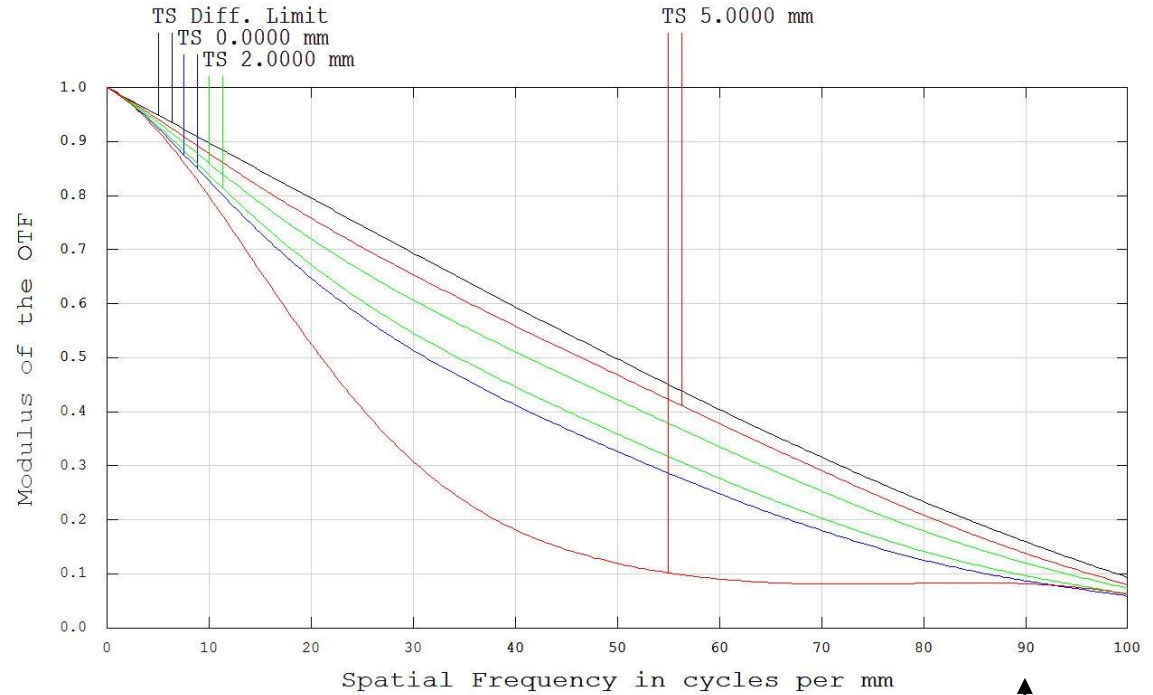


2.2 um pixel size



USAF group element: 7/4
Lp/mm (object): 181
Lp/mm (image): 90

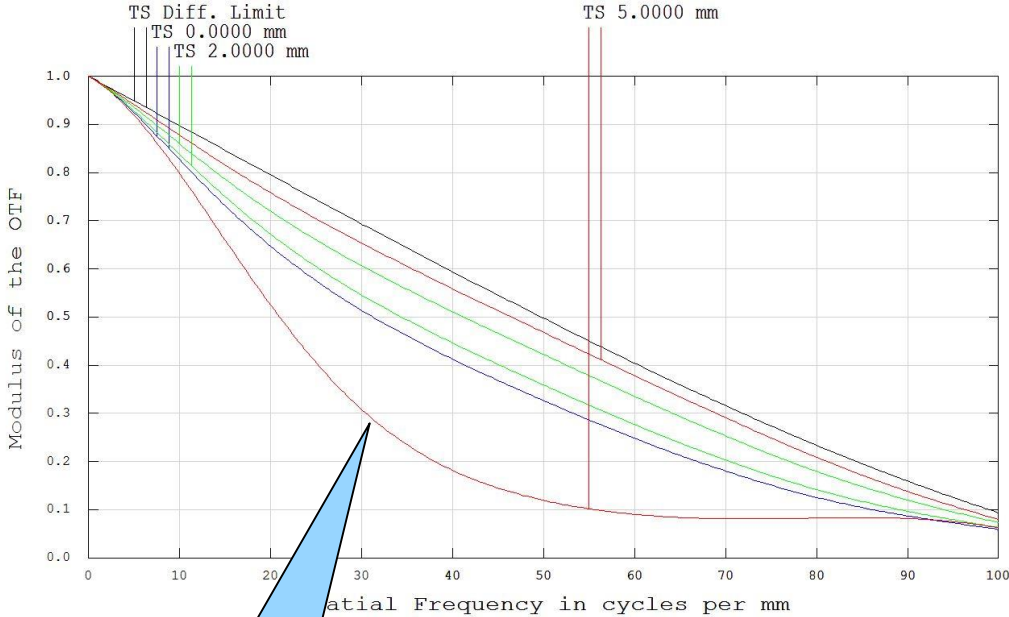
Simulated MTF (at full aperture)



Off-axis resolution is better with smaller aperture

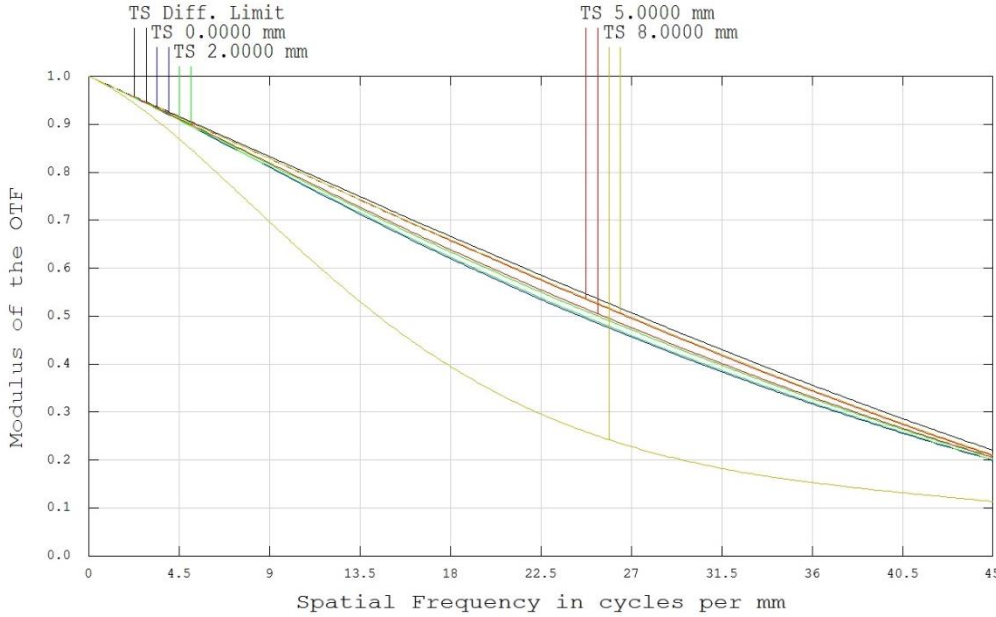


Simulated MTF (at full aperture)



5mm off-axis drops due to fully open aperture

Simulated MTF (at medium aperture)

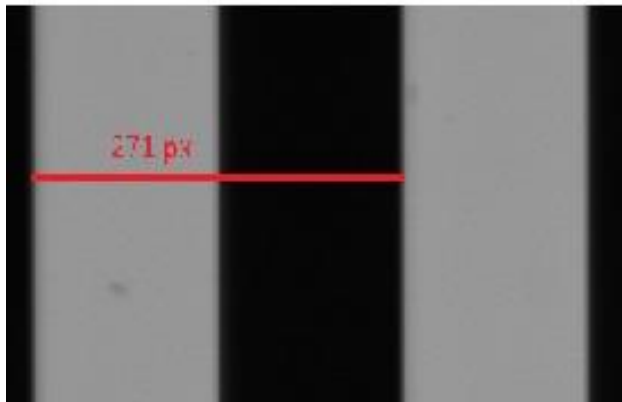


Small magnification change can be compensated in software



- The magnification change is small, reproducible and linear
- It can easily be compensated via software

EL-16 @ -2 dpt
110 mm WD

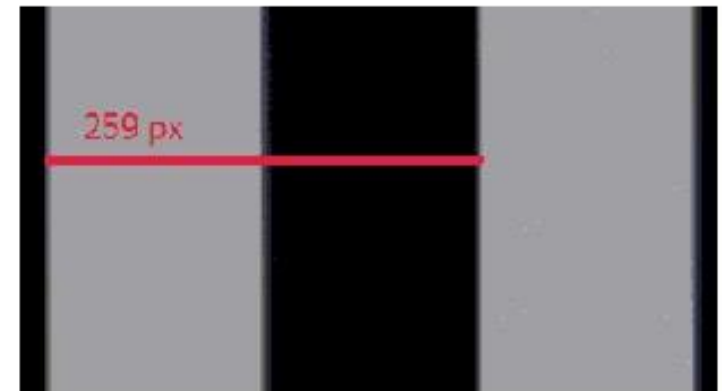


Mag: 2.04X

4.5% magnification
change over complete
z-range of 10 mm



EL-16 @ +3 dpt
100 mm WD



Mag: 1.95X

Equally good resolution also when optical axis is horizontal



- Center resolution 7/3 with
 - 3.10 μ m width and 161.3lp/mm in object space
 - 6.2 μ m width and 80lp/mm in image space.

