

In-orbit MTF and Straylight verification for the PROBA-V instrument

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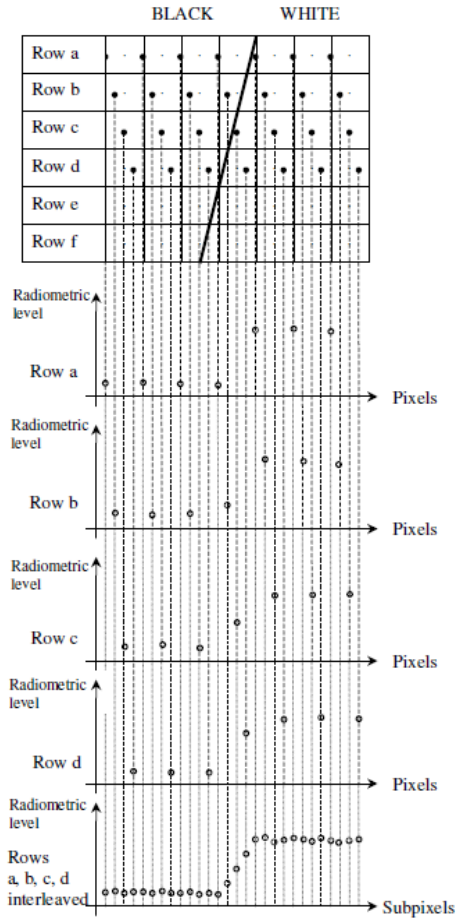
Content

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 - Edge
 - LSF reconstruction

MTF Verification

- Modulation Transfer Function determines how much contrast in the original object is maintained by the detector (or system)
- In orbit verification of MTF : combination of optics, detector, readout, compression and further processing to radiance (system MTF)

Method



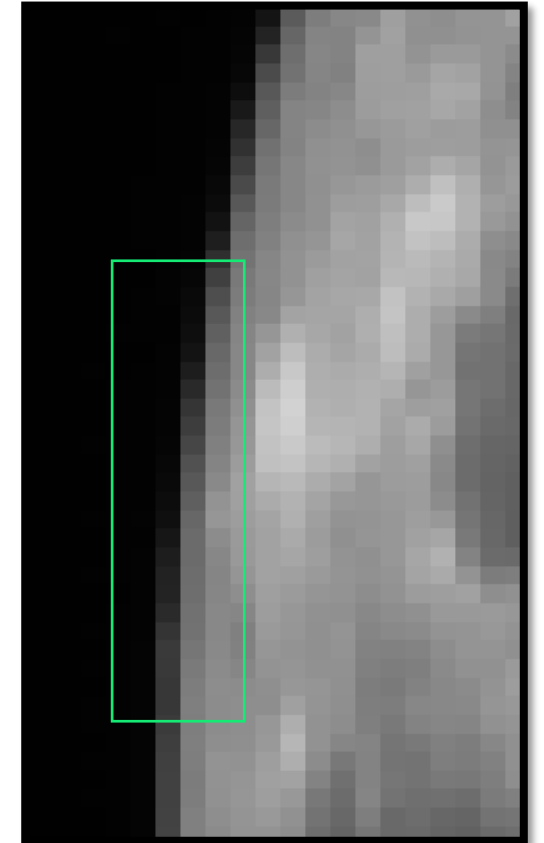
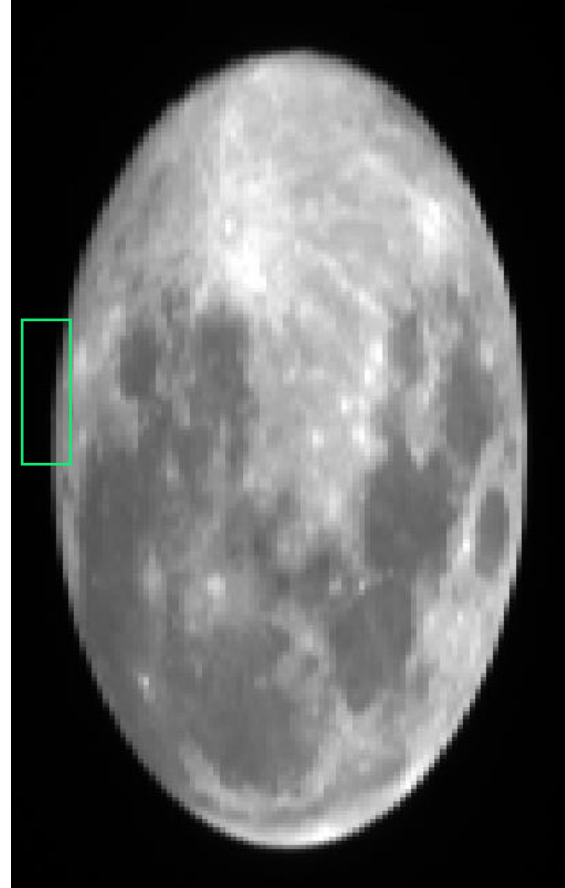
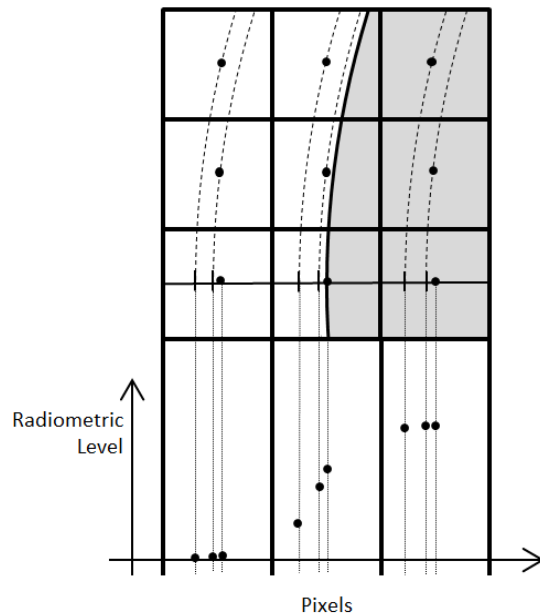
Slanted edge method :

- Find structures in image, large enough
- High contrast
- Sub pixel edge spread function (ESF) reconstruction
- Translate to lunar edge

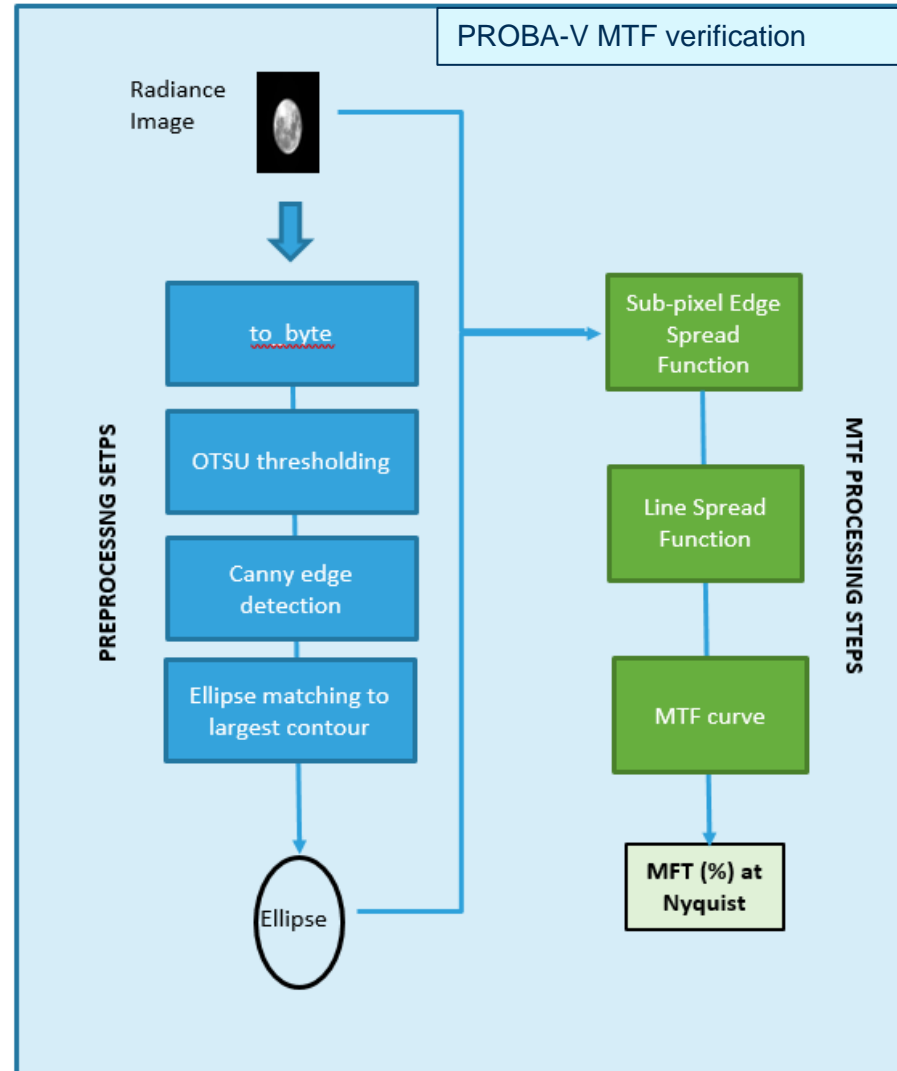
Françoise Viallefont-Robinet, Dominique Léger, "Improvement edge method for on orbit MTF measurement", Optics Express, Vol. 18, No. 4, February 2010.

Method

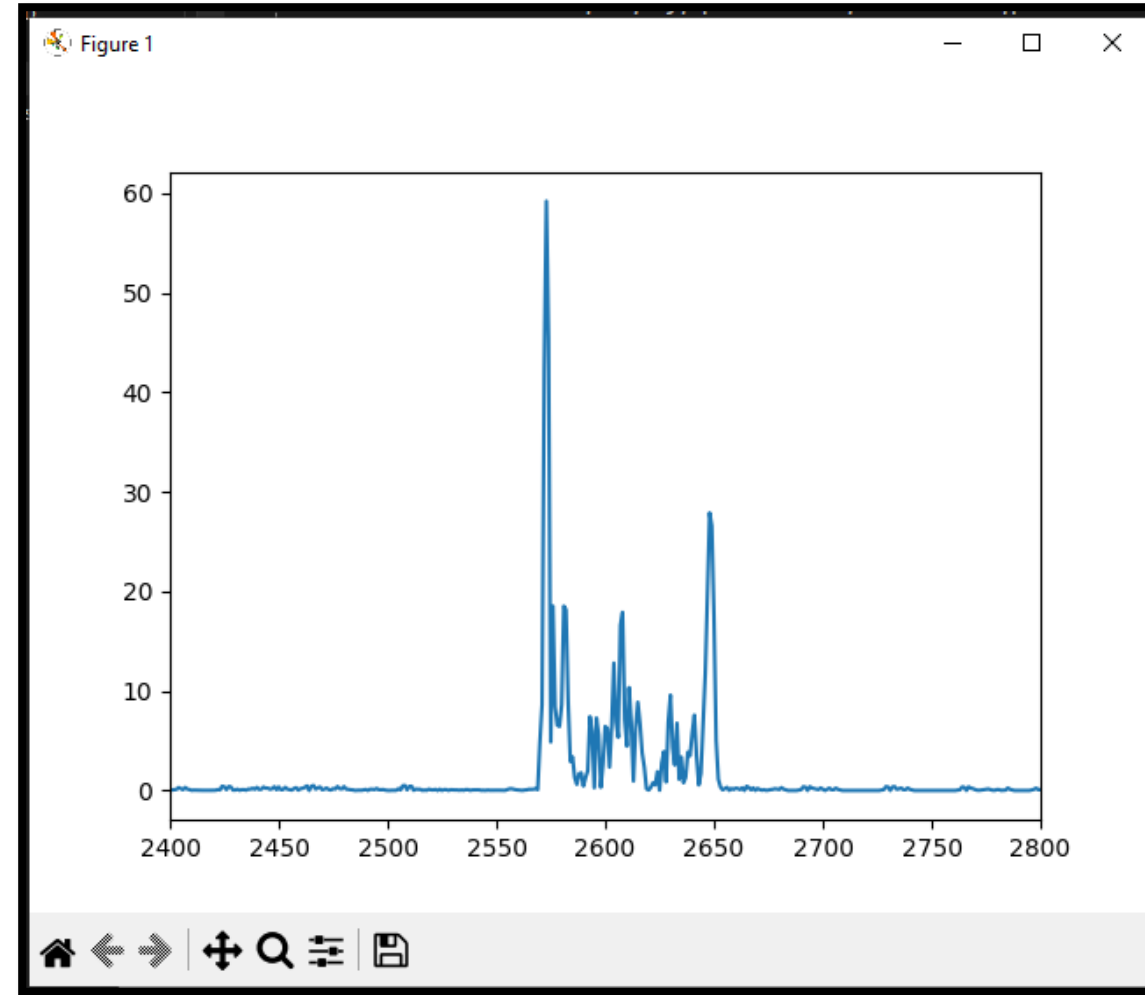
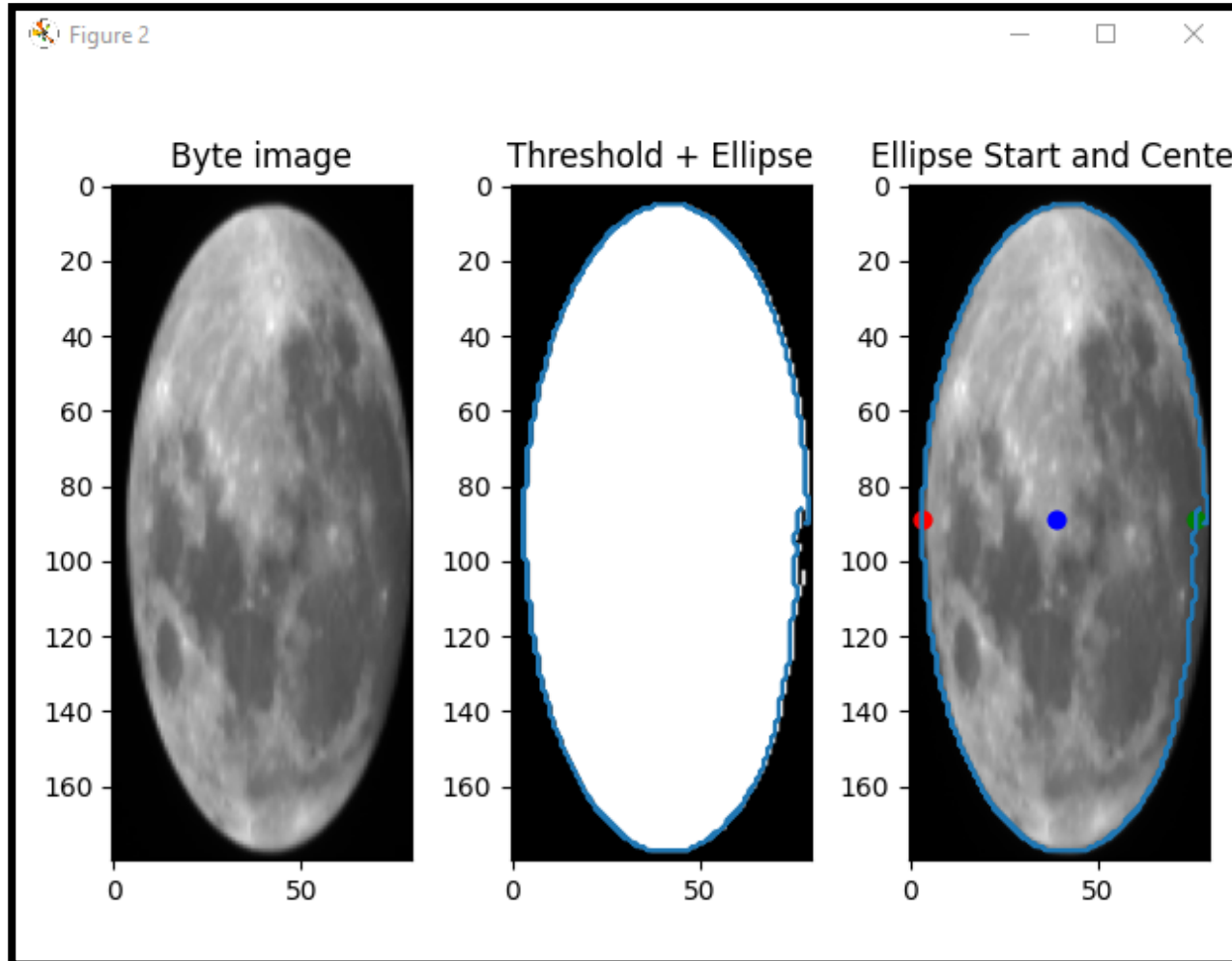
- window at the edge
- $N_x < N_y$
- Correct for ellipse (x-position)
- Normalize to maximum value, close to the edge
- Estimate ESF function



Prototype



Prototype



Prototype

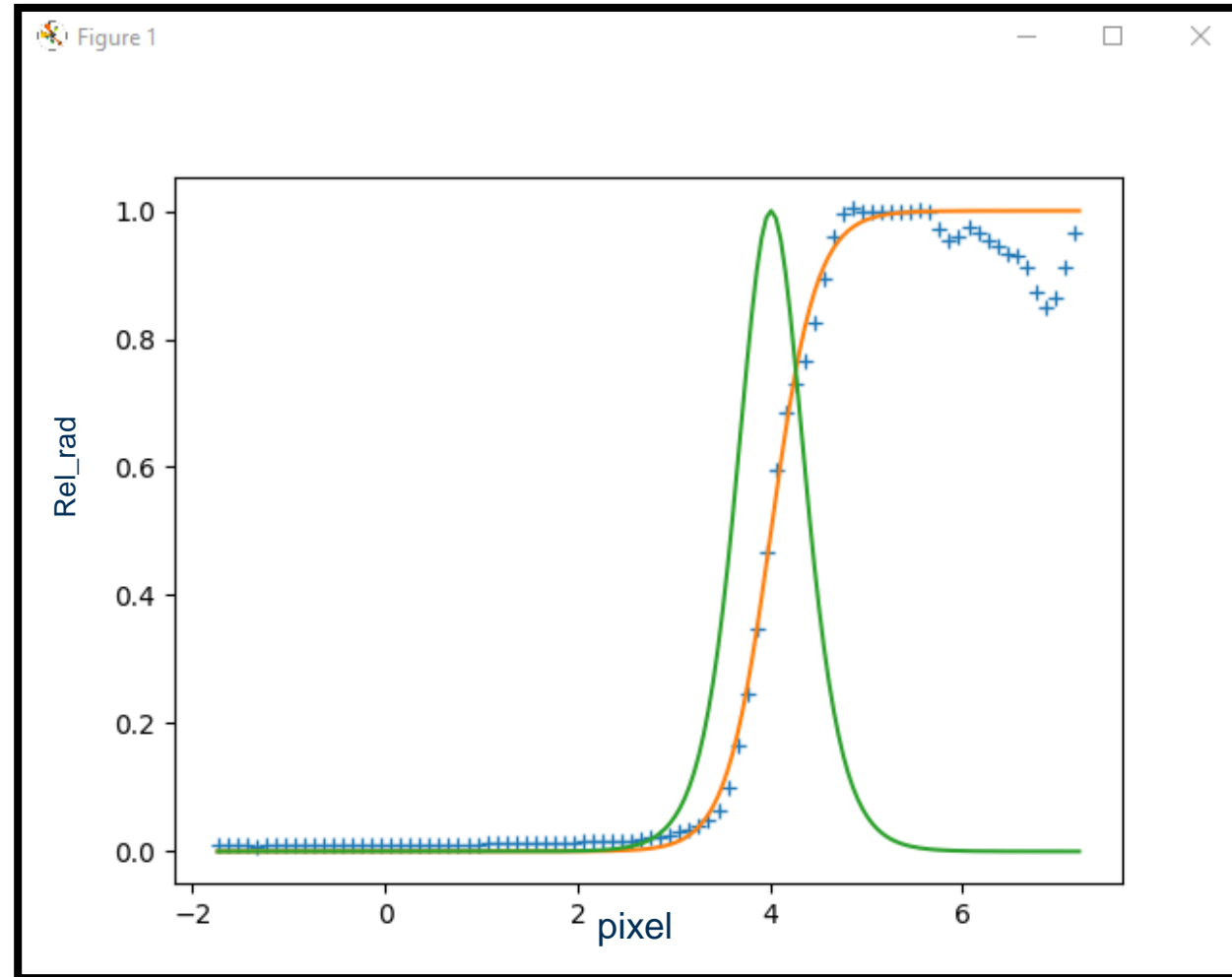
$$ESF(x) = \frac{1}{1 + e^{-s*(x-x_{slope})}}$$

Function fit

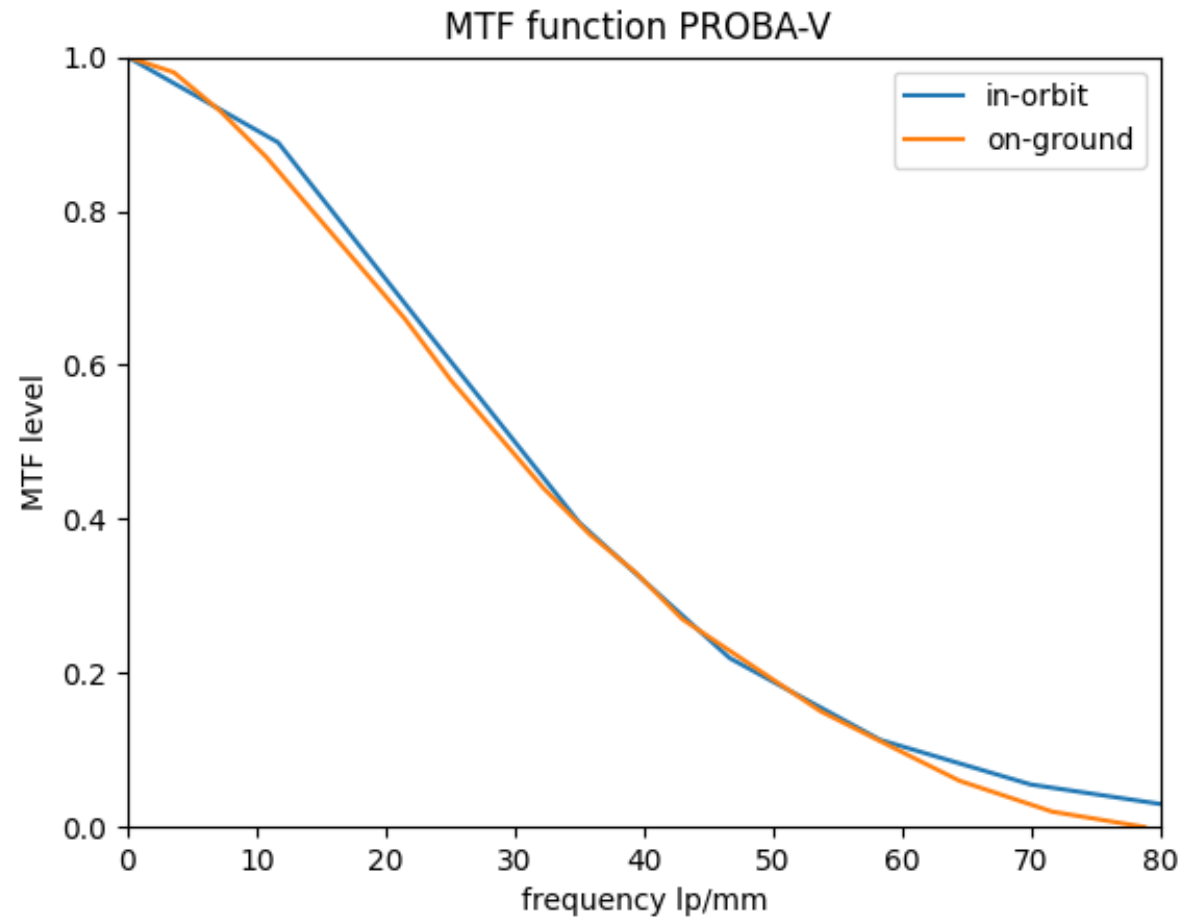
- s : slope
- x_{slope} : position offset

$$LSF(x) = \frac{ESF(x)}{dx}$$

$$MTF(f) = fft(LSF(x))$$



Result

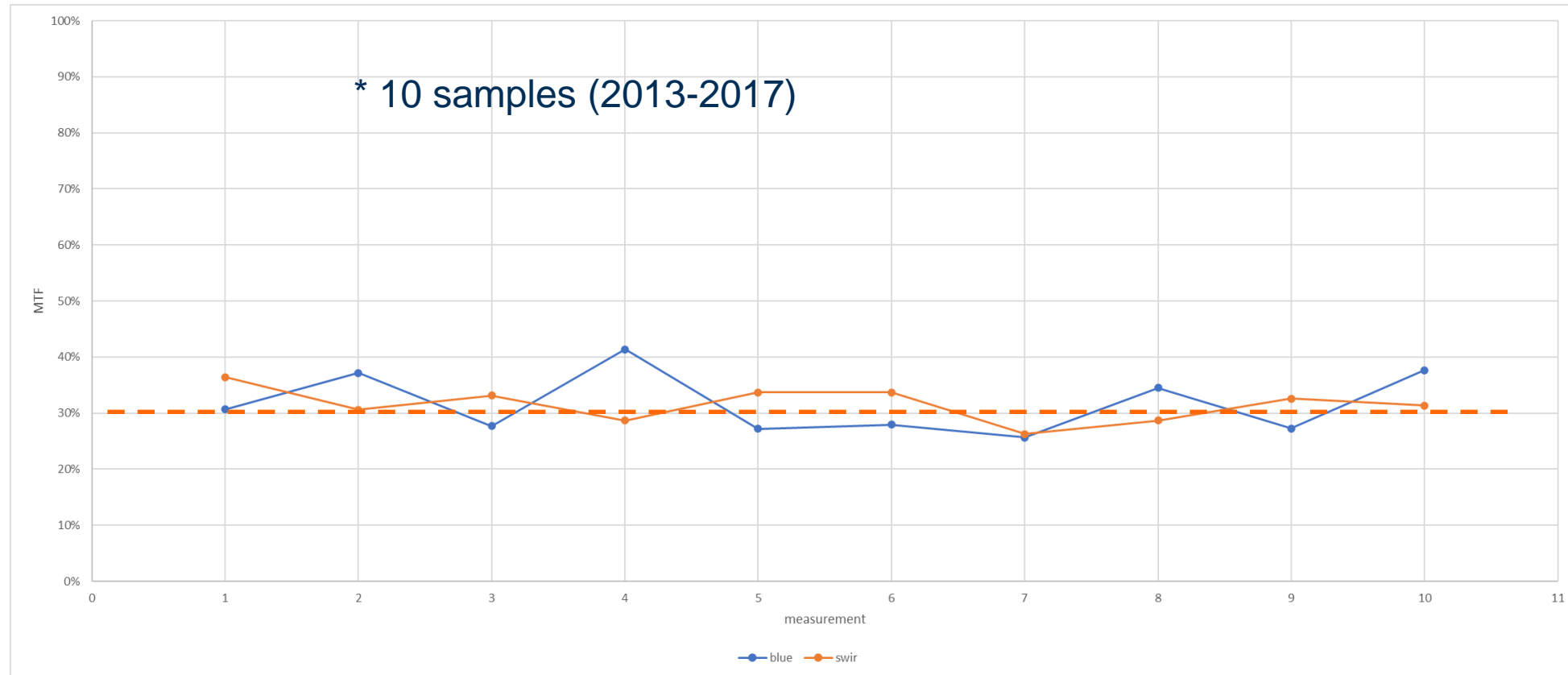


- In orbit MTF function compared to on-ground measured function (BLUE)
- Seems to match quite well
- Nyquist ($fn=38.46$)

29/08/2015	%
on-ground	34.27
in-orbid	34.50

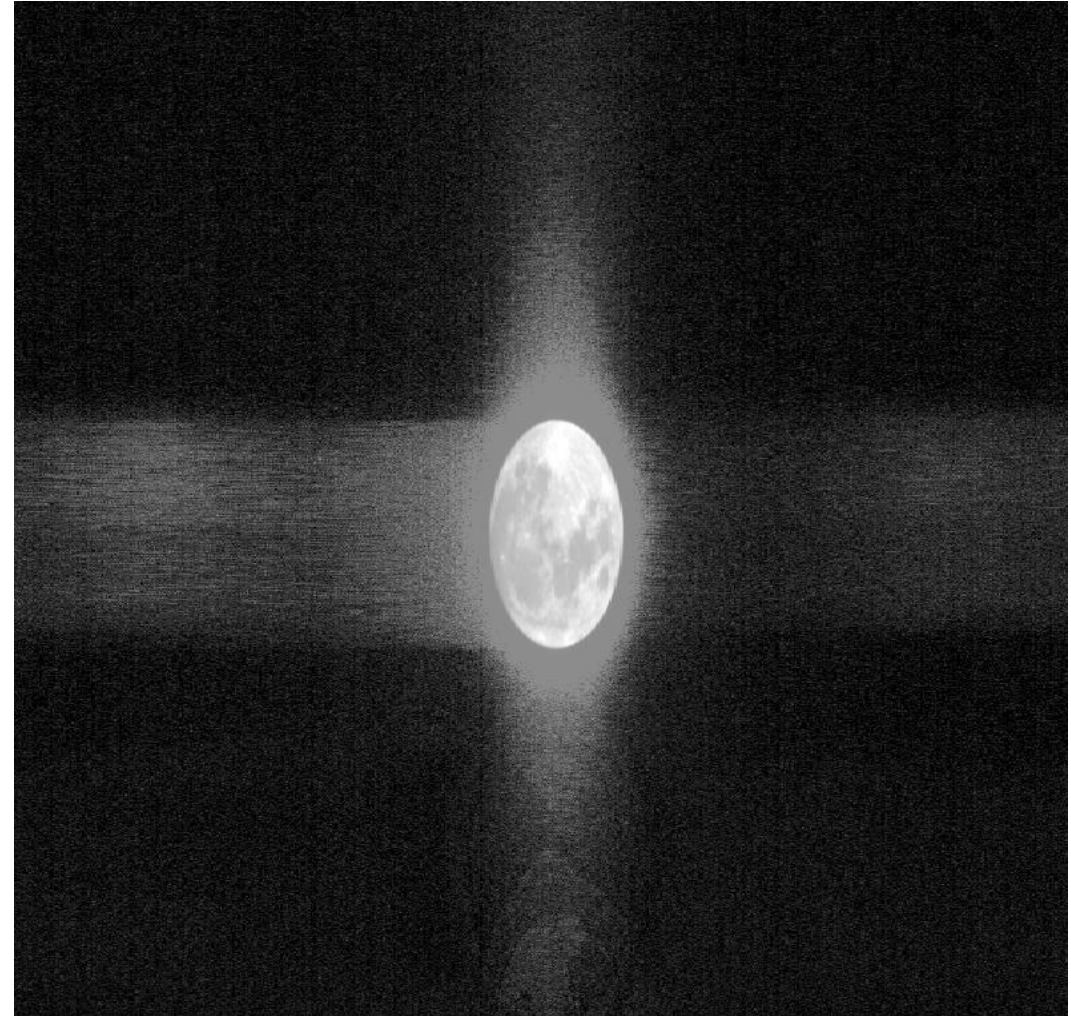
Result

The System MTF shall be better than 0.3 for the whole spectral range and over the whole field of view at the Nyquist Frequency

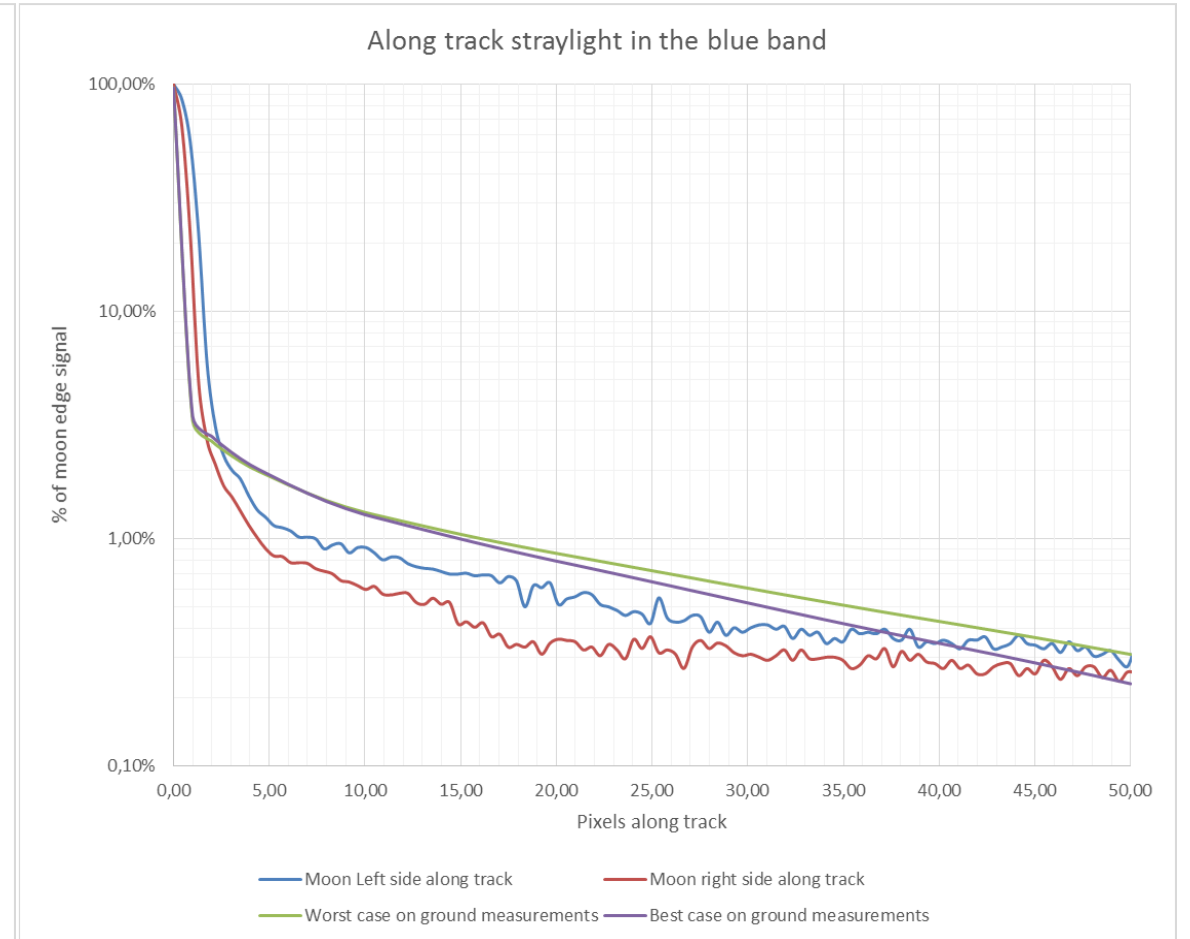
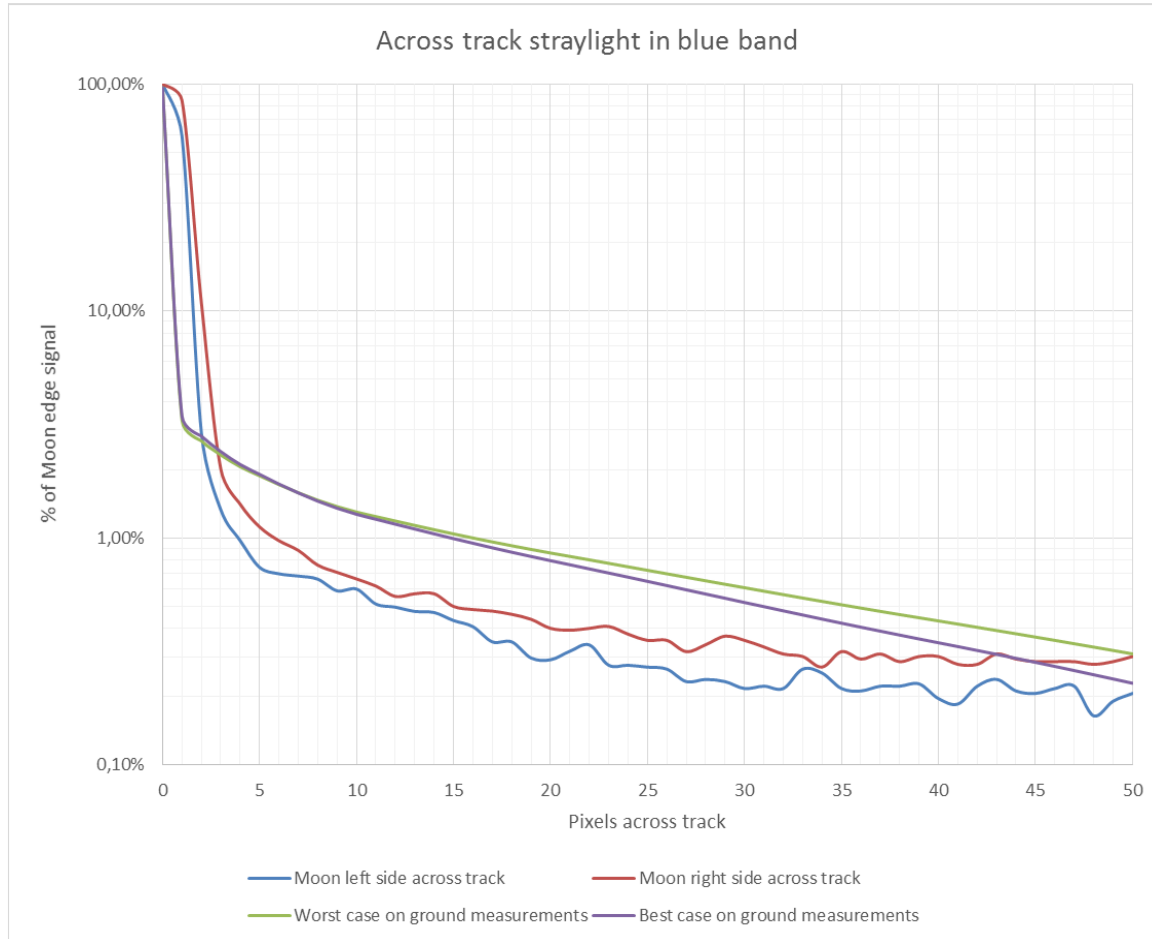


Straylight Verification

- Extremely enhanced image of the moon (moon plotted inside)
- in-field straylight
- *averaging over a few lines in center of the moon*
- along and across track



Straylight Verification



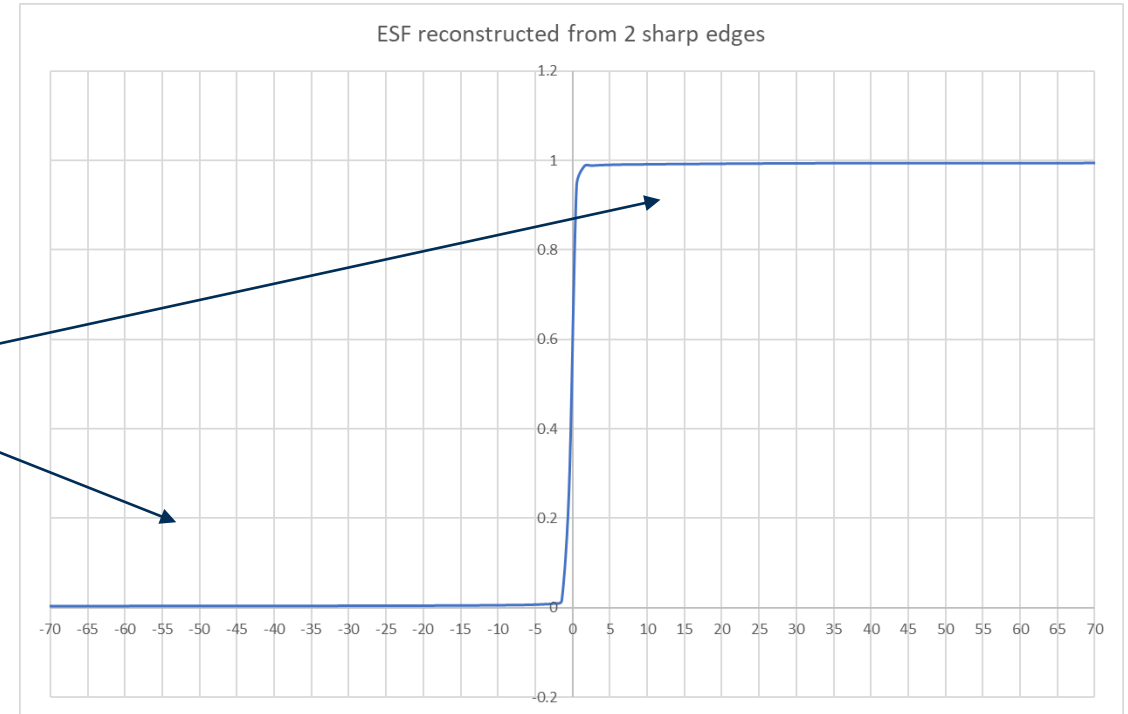
LSF reconstruction



-7 DEG



7 DEG

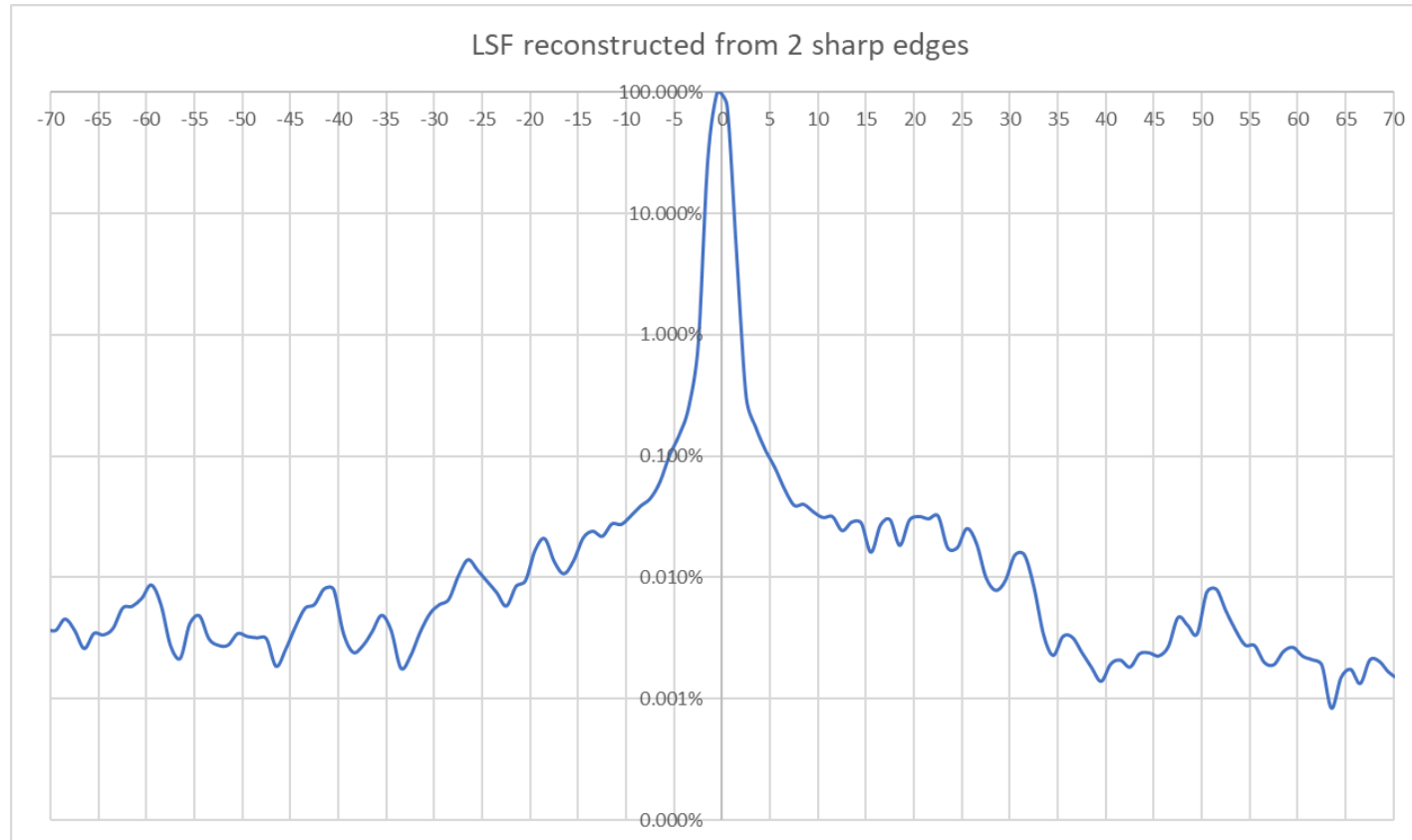


Exploit the acquired waxing and waning images, to reconstruct LSF (and potentially PSF)

$$ESF(x) = 0.5 * ESF_-(x) + 0.5 * ESF_+(x)$$

Shigemasa ANDO* and Kazuhiro TANAKA*, 2019

LSF reconstruction



Conclusion

- In-orbit MTF verification
 - MTF function reconstruction
 - Applied to several images
 - No obvious degradation (limited test)
 - Scatter in the results needs to be looked at
- Straylight verification
 - Direct verification
 - LSF reconstruction
- Commissioning

Thank you !