OrbView-3
Spatial Characterization

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OrbView-3 Spatial Characterization

Objectives

- Assess OrbView-3 spatial performance through on-orbit MTF measurement
- Identify the on-orbit technique for robust MTF measurement

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OV-3 Orbit Characteristics

Launch Date	June 26, 2003
Orbit Type	Sun Synchronous
Inclination Angle	97.25°
Altitude	470 km
Descending Node	10:30 am
Revisit Period	3 Days (50° FOR)

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OV-3 Sensor Characteristics

Imaging Mode	Panchromatic	Multispectral
Ground Sample Distance (Nadir)	1 m	4 m
Spectral Bandwidth	450 – 900 nm	450 – 520 nm
		520 – 600 nm
		625 – 695 nm
		760 – 900 nm
Imaging Array Width	8032 detectors	4 x 2008 detectors
Swath Width (Nadir)	8 km	
Pixel Quantization	11 bits per pixel per channel	
Compressed Bit Rate (Downlink)	2 bits per pixel per channel	

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OV-3 Focal Plane

- Panchromatic detectors
  - Detector size: 6µm C/S x 5.4µm A/S
  - Co-linear array
    - Even/odd detectors offset by 24µm
  - Line rates: 5000, 2500, 1000, 500 lps
  - Integration fraction: Full, 1/2, 1/4, 1/8

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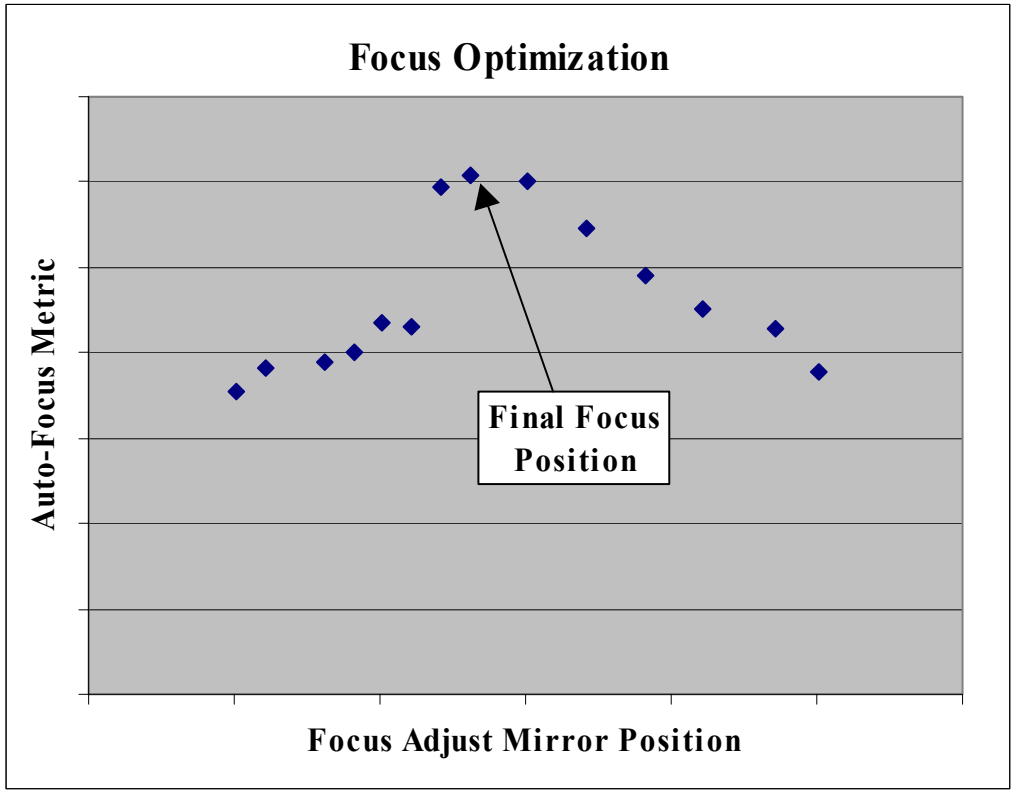
Focus Optimization

- Initial step in on-orbit calibration process
  - Pre-requisite for MTF measurement
- Systematically change focus mirror
  - Large number of urban edges
  - Consistent acquisition parameters
  - Automatically determine edge response of high contrast features
- Select best focus position based on highest edge response

Focus Optimization



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Modulation Transfer Function

- Fundamental measure of imaging system quality (sharpness)
- Magnitude of the Fourier transform of the imaging system point spread function
  - Along/scan and cross/scan slices through 2-dimensional surface are typically analyzed

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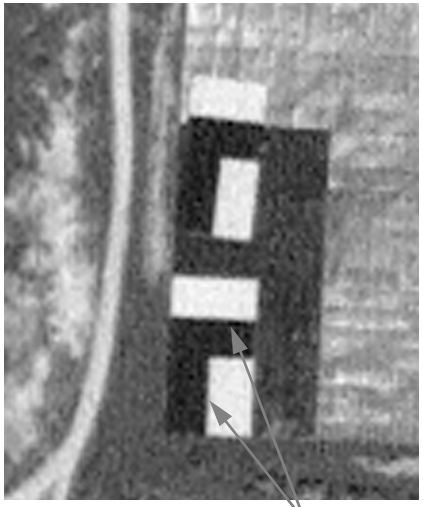
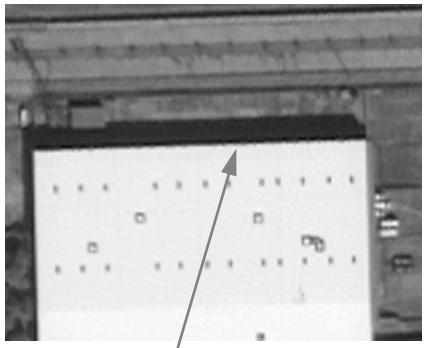
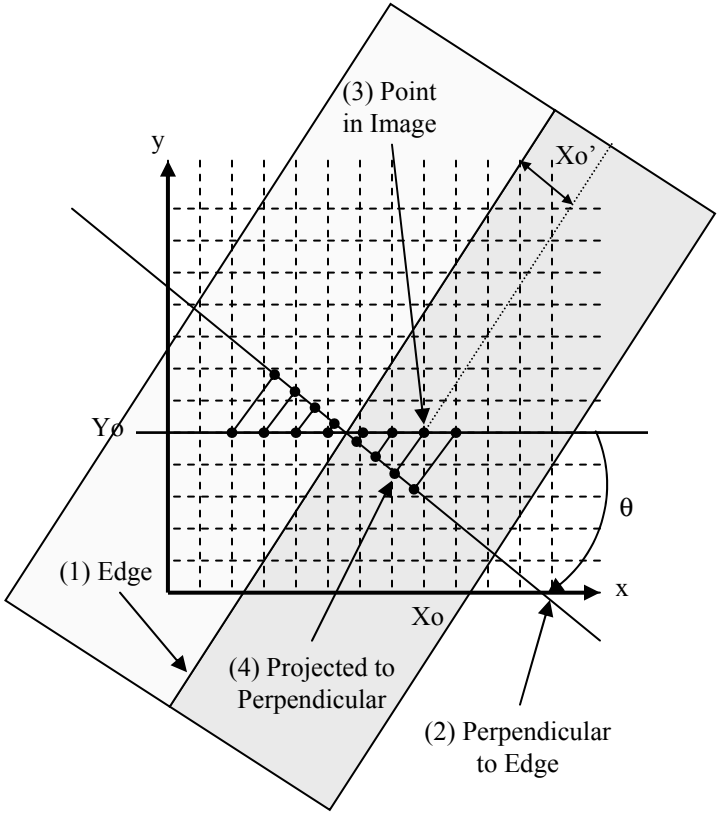
MTF: Slant-Edge Technique

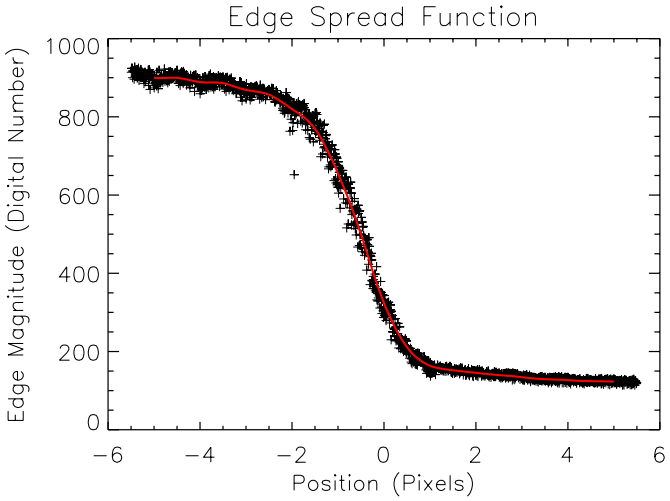


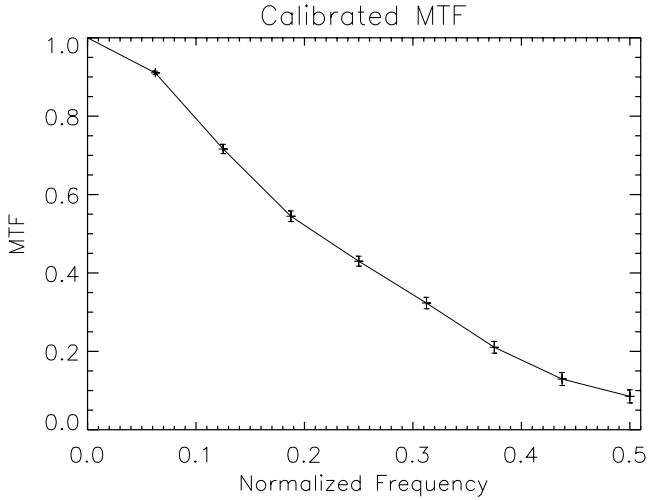
Painted Targets
(NASA/Stennis)



Building Edge







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MTF: Slant-Edge Technique

- Edge spread function
  - LOESS curve fit
  - 32 samples per pixel pitch
- Numerical differentiation to obtain line spread function
- Magnitude of Fast Fourier Transform to obtain MTF
  - Scale frequency axis to sampling rate

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MTF Measurement: Error Estimation

- Error estimate based on 32000 computer-generated edges
  - Contrast, noise, length varied
- Determine bias and precision as a function of edge parameter (contrast, noise, length)
  - During the MTF measurement process, edge parameters are determined for each edge to be measured
  - Each MTF measurement is calibrated and an error estimate assigned based on simulated edge results
- Combine independent measurements using least squares technique

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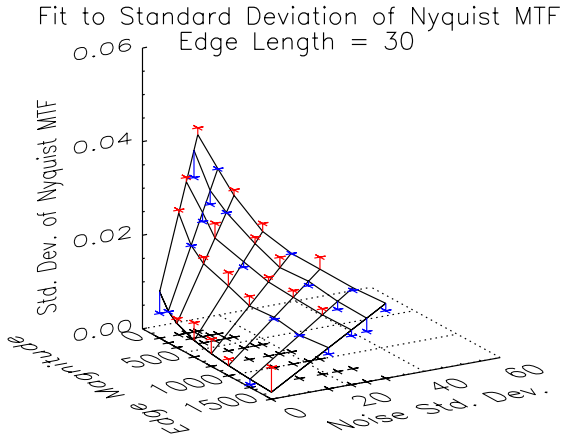
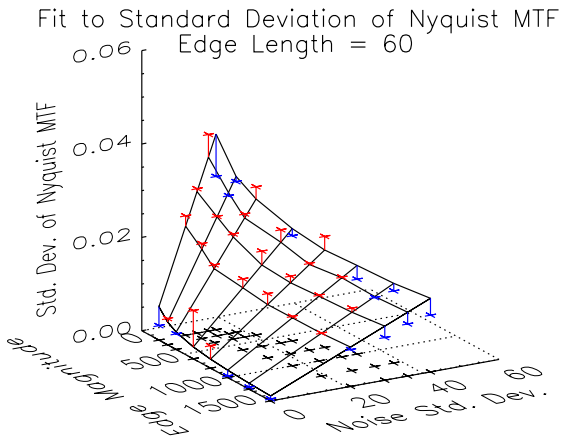
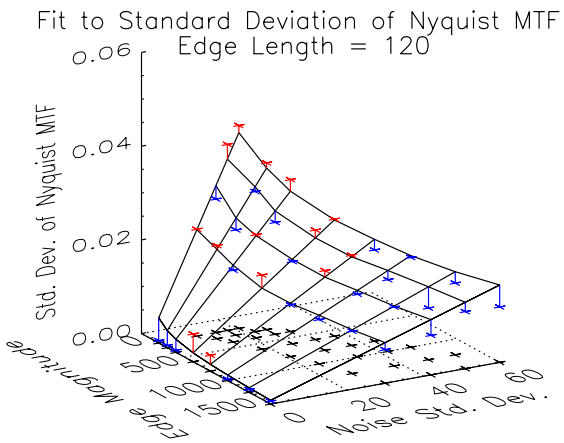
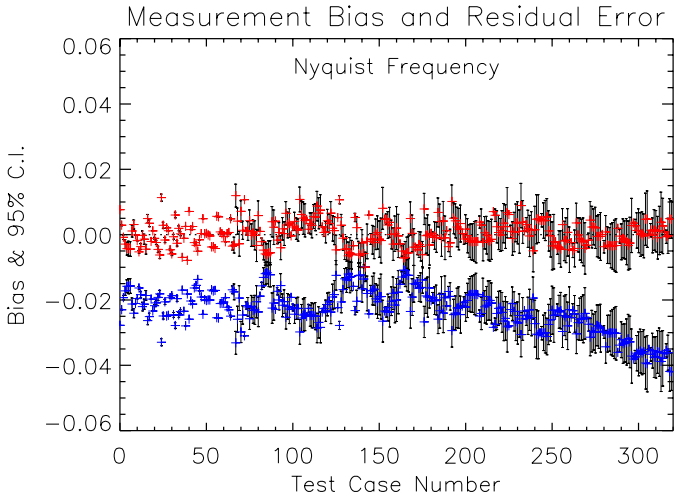
MTF Measurement: Precision and Bias Adjustment









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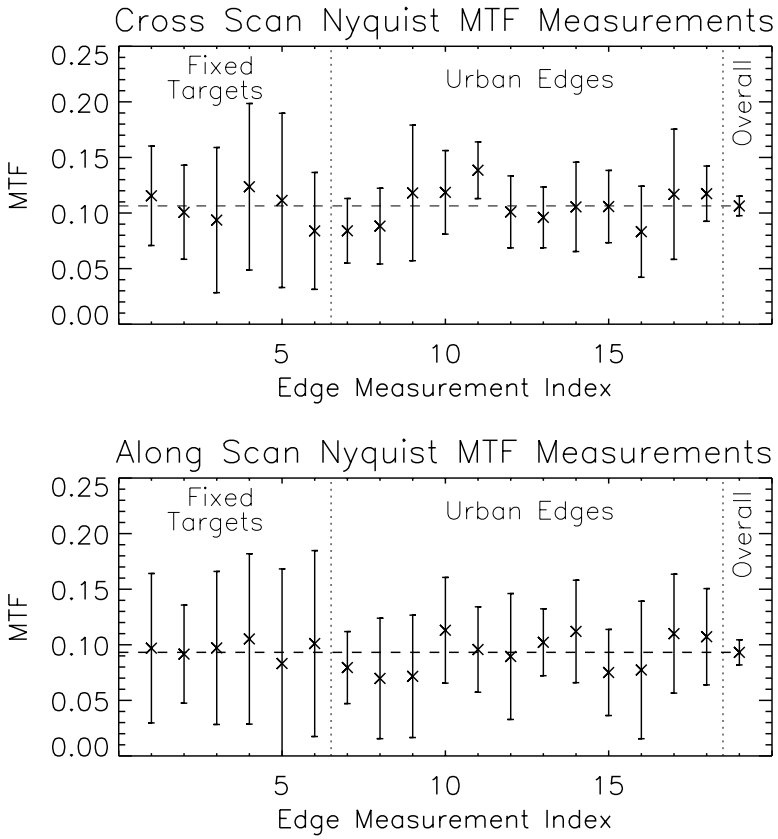
MTF Measurement: Least Squares Combination of Results



* Error estimates are 1σ values

- Error estimates of individual measurements used in weighting
- Urban edge and fixed target measurements are consistent
  - Longer urban edges increase measurement confidence
  - Urban edges are suitable for use

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MTF Measurement

- Panchromatic Basic product
  - Satellite geometry
  - Radiometric calibration
  - Interpolation to ideal linear array
  - MTF measured with and without sharpening
    - No sharpening representative of camera / system performance
    - Sharpening representative of products

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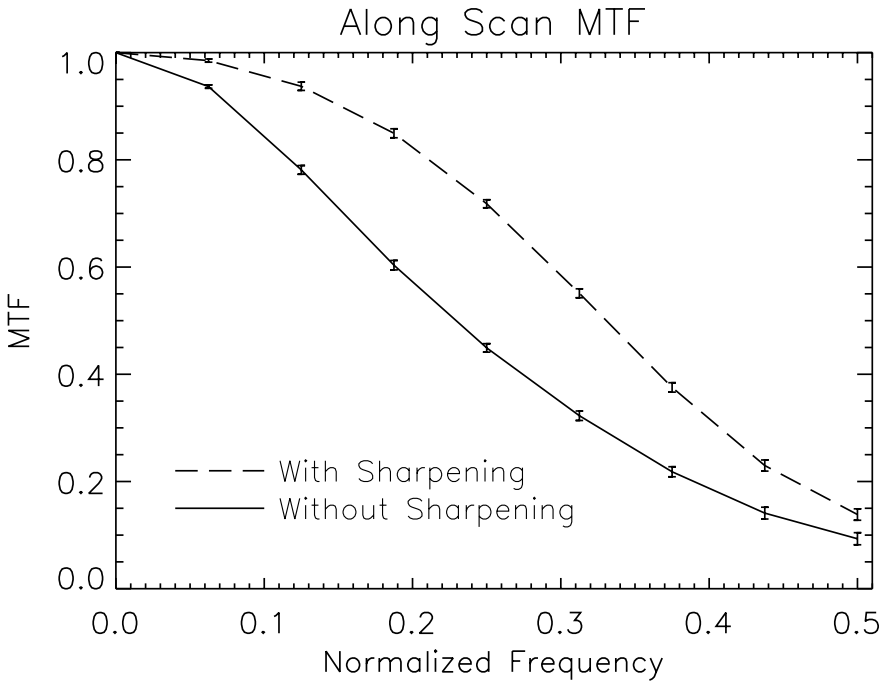
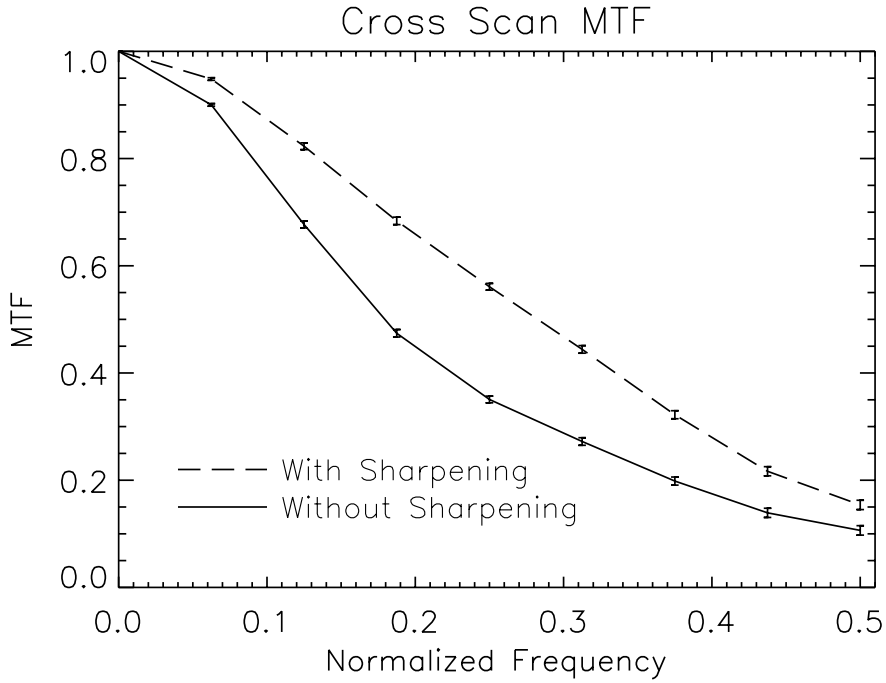
OV-3 Panchromatic MTF Results





Avg. A/S & C/S Nyquist MTF without sharpening: 0.10 ± 0.01 (1σ)

Avg. A/S & C/S Nyquist MTF with sharpening: 0.15 ± 0.01 (1σ)

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Future Work

- Periodic measurement to confirm system performance
- Measurement at discrete locations across full array

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Conclusions

- Robust on-orbit MTF measurement technique
  - Fixed targets
  - Urban edges
  - Error estimate for each measurement
- OrbView-3 MTF is characterized
  - Average of A/S & C/S Nyquist MTF
    - Without sharpening: 0.10 ± 0.01 (1σ)
    - With sharpening: 0.15 ± 0.01 (1σ)