



Stennis Space Center

QuickBird Panchromatic Imagery: Spatial Resolution Evaluation

Slawomir Blonski

Lockheed Martin Space Operations – Stennis Programs
NASA Stennis Space Center, MS 39529
Telephone: 228-688-1944
e-mail: slawomir.blonski@ssc.nasa.gov

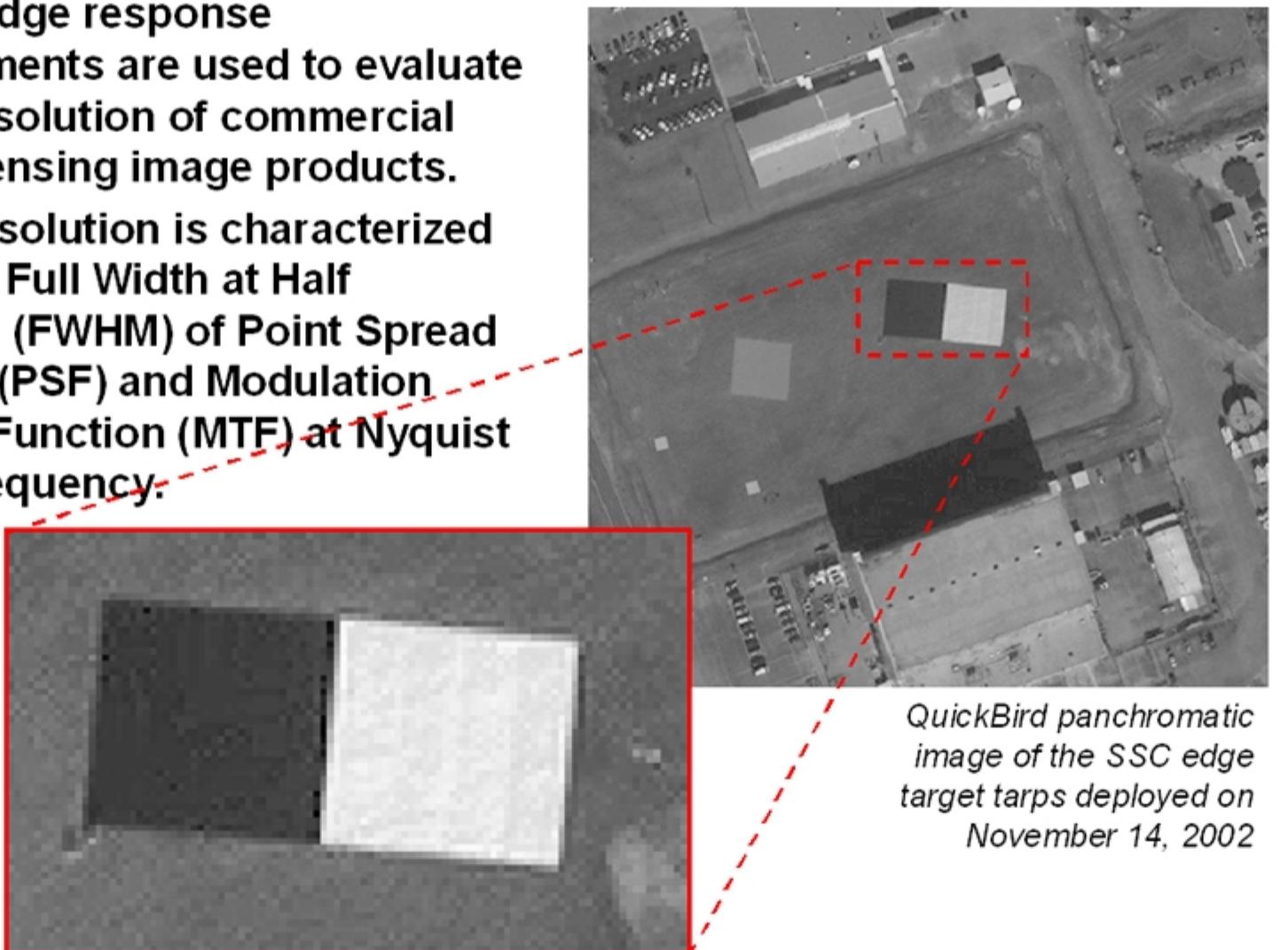
Joint Agency for Commercial Imagery Evaluation Workshop
Reston, Virginia, USA
May 20, 2003



SSC Edge Targets

Stennis Space Center

- In-flight edge response measurements are used to evaluate spatial resolution of commercial remote sensing image products.
- Spatial resolution is characterized with both Full Width at Half Maximum (FWHM) of Point Spread Function (PSF) and Modulation Transfer Function (MTF) at Nyquist spatial frequency.



QuickBird panchromatic image of the SSC edge target tarps deployed on November 14, 2002



Edge Response Selection

Stennis Space Center

- Rectangular area of the edge target image is selected for the edge response analysis.
- Effects of the adjacent surfaces (grass) must be avoided.
- Uniformity of the edge target panels is still the greatest challenge.



Acknowledgments

Stennis Space Center

Kara Holekamp *Lockheed Martin Space Operations –
Stennis Programs*
Charles Smith *Stennis Space Center, Mississippi*
Mary Pagnutti
Robert Ryan

Vicki Zanoni *NASA Earth Science Applications Directorate
Stennis Space Center, Mississippi*



QuickBird Image Acquisitions

Stennis Space Center

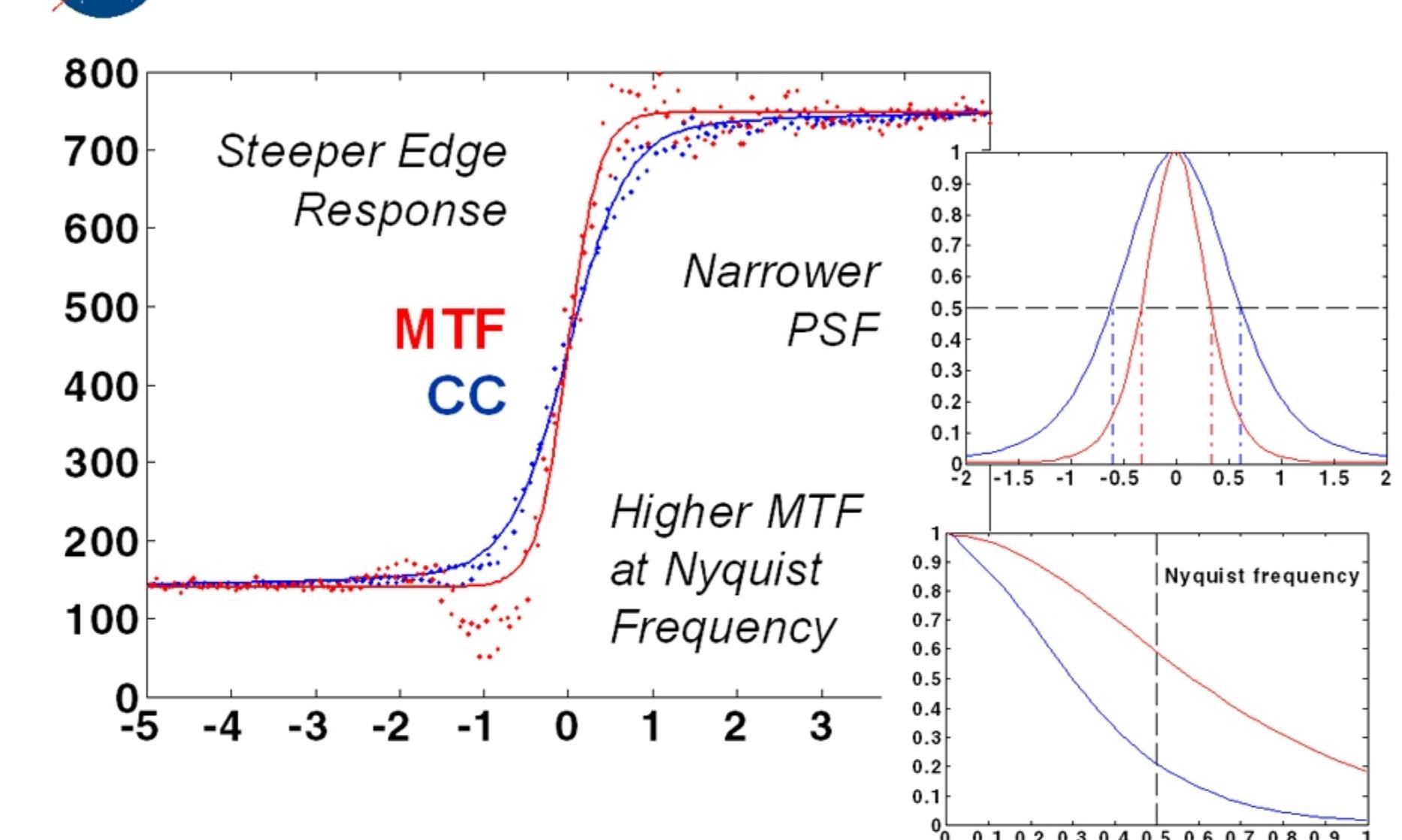
Date	Location	Product GSD (m)	Satellite Elevation Angle (°)	Satellite Azimuth Angle (°)
17-Feb-02	Stennis Space Center, MS	0.7	67.3	10.5
20-Jul-02	Brookings, SD	0.7	64.1	349.8
25-Aug-02	Brookings, SD	0.7	70.4	332.7
7-Sep-02	Brookings, SD	0.7	75.0	191.2
14-Nov-02	Stennis Space Center, MS	0.6	79.5	275.7
2-Apr-03	Stennis Space Center, MS	0.6	86.9	243.4

Standard (and one basic) image products georeferenced using Cubic Convolution (CC) and Modulation Transfer Function (MTF) resampling.



Resampling: MTF vs. CC

Stennis Space Center



5/12/2003



Edge Response Analysis

Stennis Space Center

- Selected edge area includes a set of edge responses, each with an edge position shifted by a fraction of a pixel from an adjacent response.
 - Nonlinear least-square fit of a two-dimensional function that is a linear combination of three sigmoidal functions.
- Actual intensity in the edge area

$$e_i(x) = d + \sum_{k=1}^3 \frac{a_k}{1 + \exp\left[\frac{b_1 \Delta i + b_2 - x}{c_k}\right]}$$

Best fit with the sigmoidal functions
- Optimized parameters: $a_1, a_2, a_3, b_1, b_2, c_1, c_2, c_3, d$
 - Position and orientation of the edge, described by parameters b_1 and b_2 , are found simultaneously with the parameters characterizing spatial resolution (c_1, c_2 , and c_3)
 - Measured edge tilt: $\theta = \tan^{-1}(b_1)$
 - Distance is scaled by cosine of the edge tilt angle: $x = \delta \cos \theta$

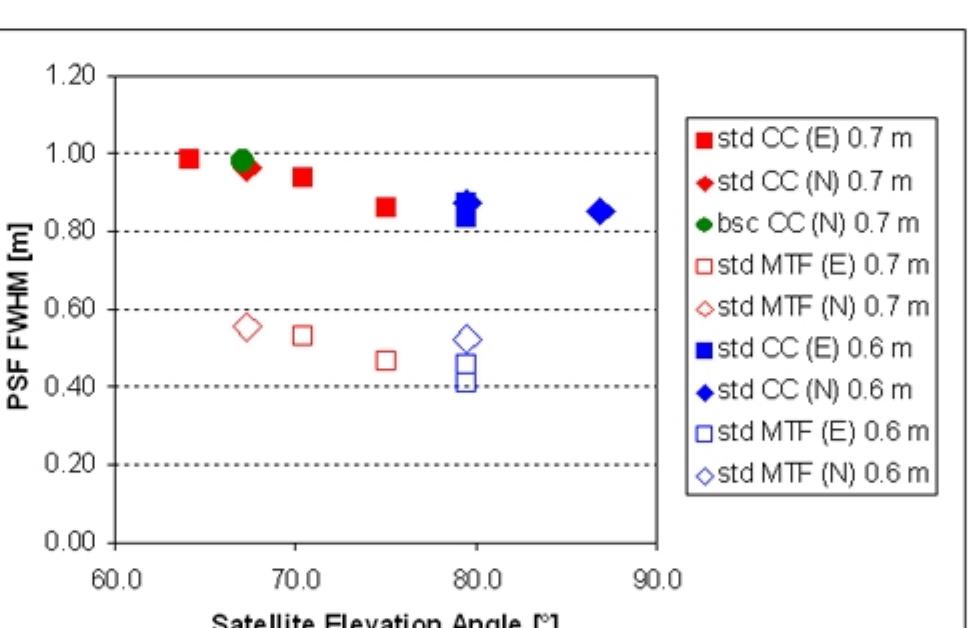
5/12/2003



Point Spread Function

Stennis Space Center

- FWHM of PSF measures extent of spatial response for single pixel.
- For QuickBird images with CC resampling, PSF FWHM is approximately equal to $1.3\text{--}1.4 \times \text{GSD}$.
- Resampling to smaller GSD only slightly improves (reduces) the extent of spatial response.
- MTF resampling improves spatial resolution by the factor of ~2, but noise and overshoots increase.



Easting (horizontal) direction: (E)
Northing (vertical) direction: (N)

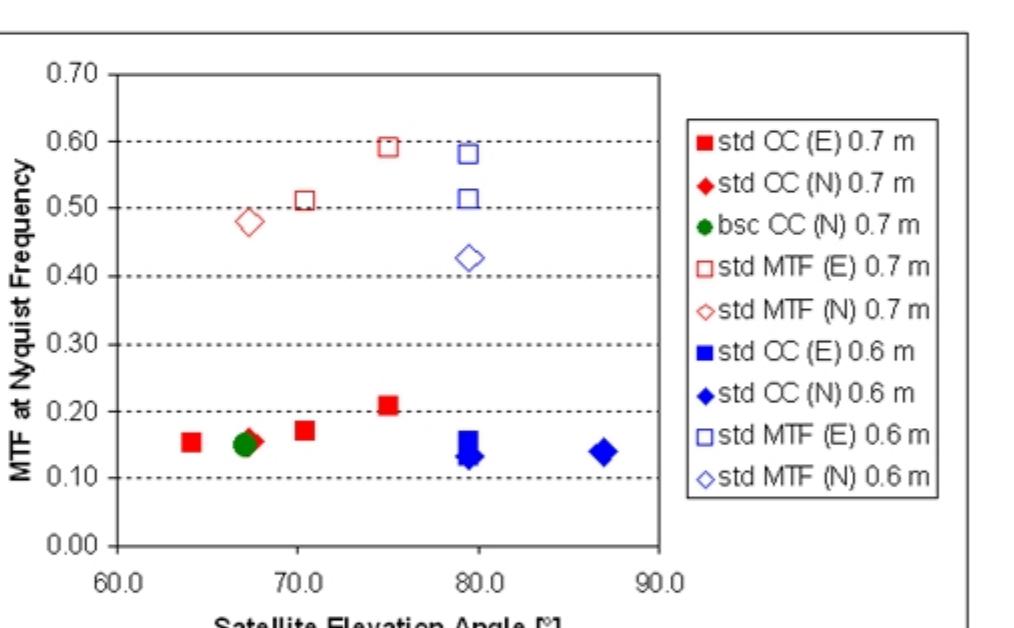
5/12/2003



Modulation Transfer Function

Stennis Space Center

- MTF values at Nyquist spatial frequency exceed NASA Scientific Data Purchase contract requirements for QuickBird image products created with CC as well as with MTF resampling.
- MTF resampling creates images with higher values of MTF at Nyquist frequency (boost).
- Resampling image products to smaller GSD (0.6 m vs. 0.7 m) reduces value of MTF at Nyquist frequency, but NASA requirements are still fulfilled.



(E) = Easting (horizontal) direction
(N) = Northing (vertical) direction

5/12/2003



PSF and MTF Derivation

Stennis Space Center

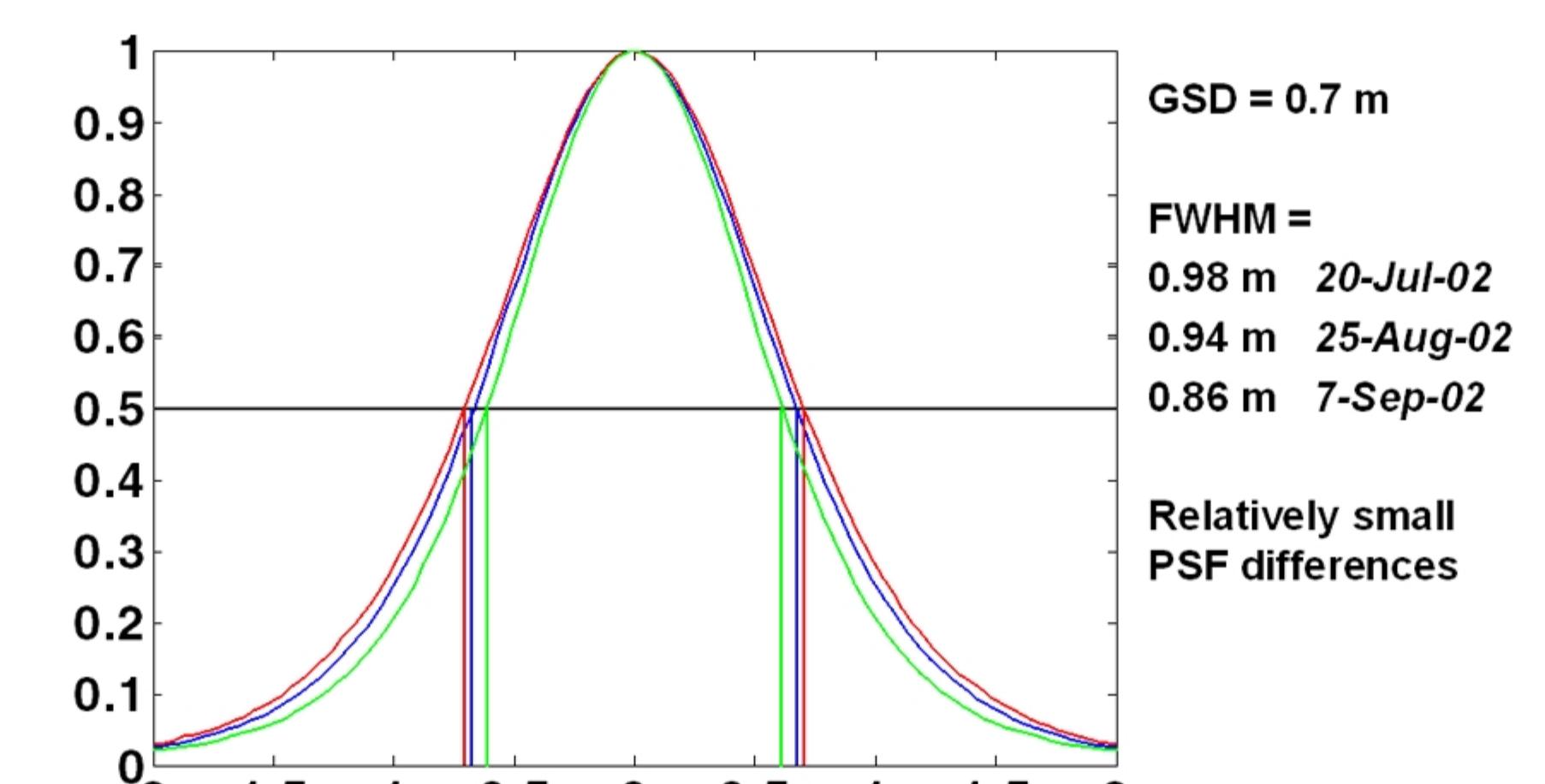
- Finding position and orientation of the edge allows for shifting of the edge responses to a single reference location so that all the edge points are aligned.
- Superimposing all the shifted edge responses creates a new edge response with a finer spatial sampling.
- Optimized edge response is generated with arbitrary spatial resolution from the best-fit parameters.

5/12/2003



PSF Comparison

Stennis Space Center

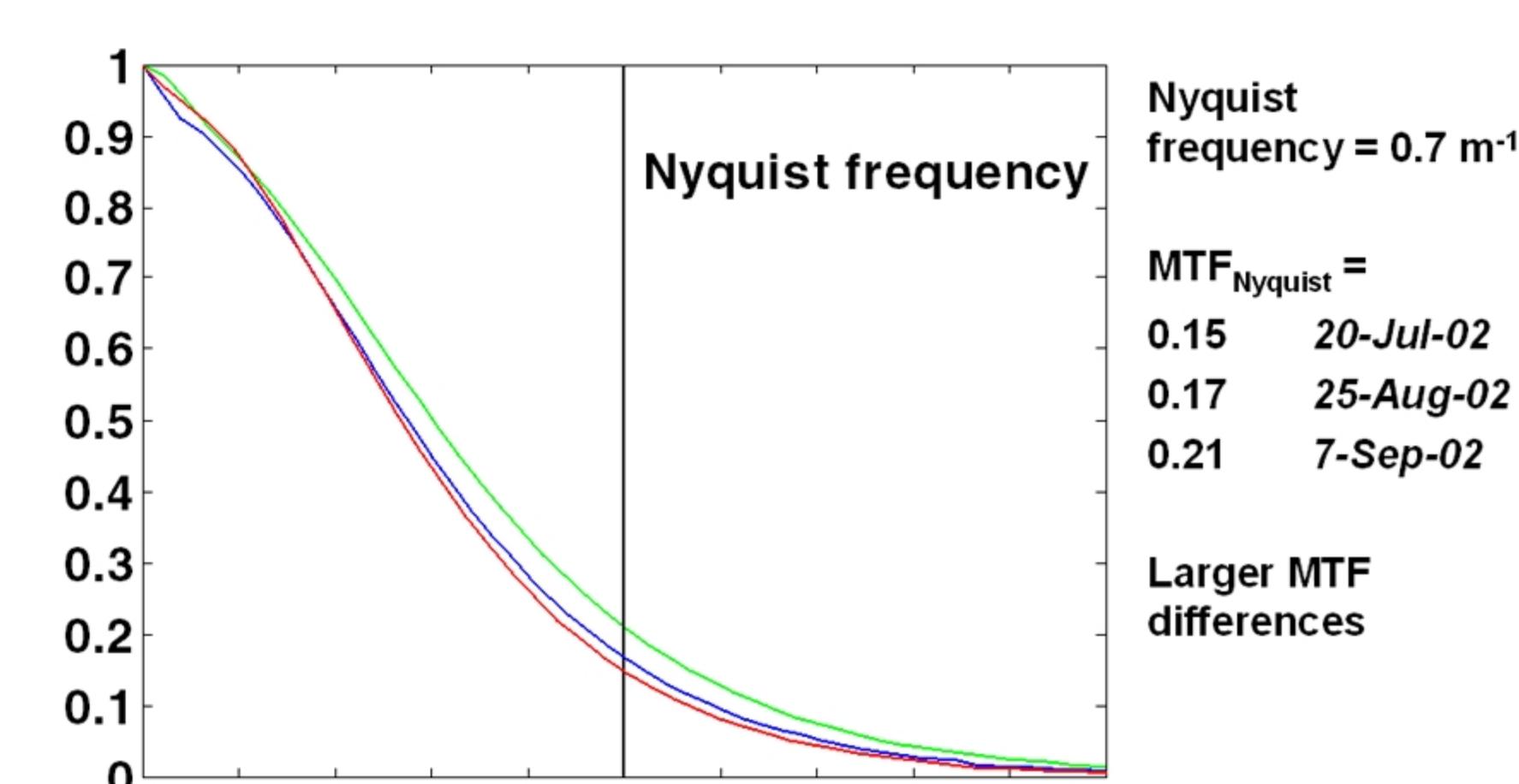


5/12/2003



MTF Comparison

Stennis Space Center



5/12/2003

0