IMPROVED REMEDIATION OF NEAR MSI IMAGES OF ASTEROID (433) EROS. D. R. Golish[1], D. N. DellaGiustina[1], C. A. Bennett[1], K. J. Becker[1], N. K. Shultz[1], [1]Lunar and Planetary Laboratory, University of Arizona (1415 N. 6th Ave., Tucson, AZ, 85705, dgolish@orex.lpl.arizona.edu)

Introduction: Shortly before orbit insertion around asteroid (433) Eros, the Near Earth Asteroid Rendezvous–Shoemaker (NEAR) [1] mission experienced a failed burn that ejected > 28 kg of hydrazine fuel on to the spacecraft, including the front optical surface of the Multispectral Imager (MSI). Unfortunately, this caused every surface-resolved image of Eros to have wavelength-dependent degradation of its point spread function (PSF). During the mission, the MSI team developed a preliminary remediation of the blur, utilizing post-contamination images of Canopus to model the degraded PSF [2]. This remediation was largely successful for the majority of MSI images, enabling extensive surface analysis, such as global mapping and color mapping [3,4], though images at the extreme wavelengths (450 and 1050 nm) were harder to correct. In addition, the original method necessitated cropping the images and introduced FFT edge-artifacts that reduced the usable pixel area by 21-39% [2]. We have attempted to improve this remediation by developing an alternative remediation that does not introduce cropping or FFT artifacts and adapting the PSF model to be more complex.

PSF Modeling: MSI acquired > 7000 images of Canopus after contamination, using all eight filters and in nine (3x3 grid) regions on the detector. Theoretically, imaging Canopus in multiple regions offers the possibility of developing a spatially variant PSF (and therefore correction). Unfortunately, other than the central and bottom-center region, most filters had only 16-32 images per region. Some filters (2, 7, and 0) had no images in those regions. As such, we were unable to develop a spatially variant PSF that performed better than the invariant version. Nonetheless, we utilized the nearly 6000 images in the central region to model a PSF for each filter. We model the PSF as the sum of three Gaussians: responsible for the peak, shoulder, and wings of the PSF (Figure 1). We allowed the Gaussians to be radially asymmetric, as there is a clear ~25% asymmetry in the Canopus images.

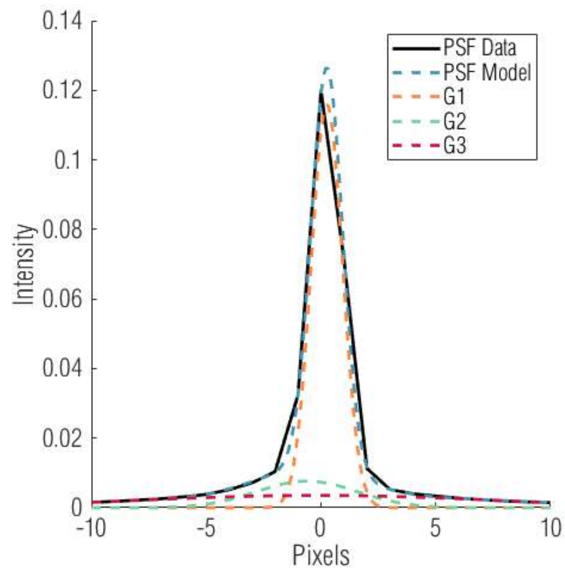

Figure 1. >500 images of Canopus acquired with the 950 nm filter are combined to produce a PSF measurement, shown as a horizontal cross-section (black solid line). We model that PSF with a sum of 3 Gaussians (dashed lines).

Improved Remediation: We corrected the blurred image data by applying a Wiener deconvolution with the modeled PSF. To avoid the edge artifacts and cropping in the original remediation, we expand the 412x537 MSI images to 512x637 with a tapered symmetric padding. That is, the image is reflected across its boundaries, to avoid discontinuities, and tapered toward zero at the new edges, to make the FFT continuous. We utilize the MATLAB function *deconvwnr* to apply the deconvolution. We have tested the MATLAB implementation against a custom version (based on the original MSI remediation) and found the noise mitigation to be superior with *deconvwnr*.

Our initial testing with this method produces significantly improved images, in addition to recovering the regions previously lost to cropping and artifacts. Examples of whole disk and limb images, taken with the 950 nm filter, are given in Figure 2. We have adapted the radiometric estimation method from the preliminary remediation to radiometrically correct the images after deblurring.

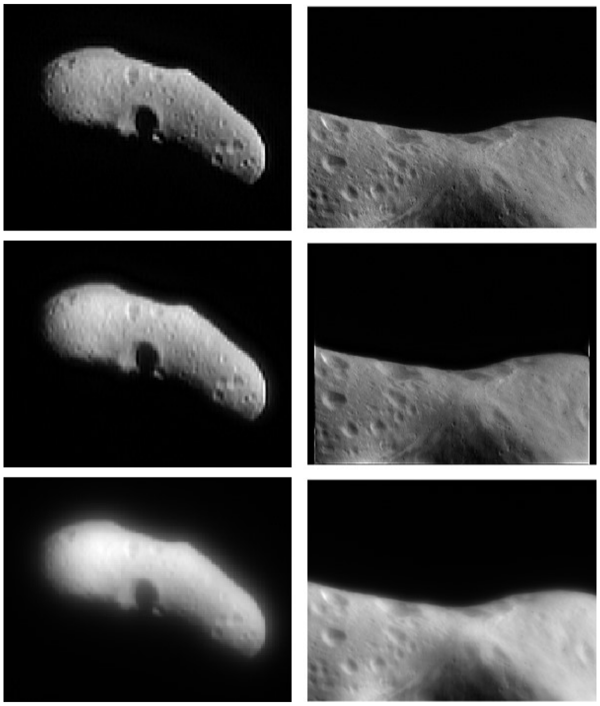

Figure 2. Initial testing with whole disk and limb images (950 nm filter) indicate that the new remediation (top row) is an improvement over both the original remediation (middle row) and the uncorrected images (bottom row).

Future Testing: The ultimate test of our improved remediation will be with scientific analysis of the deblurred images. We intend to produce new global mosaics of Eros with all filters for which we have suitable coverage, and partial high resolution mosaics where appropriate. We expect that improved color analysis of Eros's surface will be possible with the deblurred images, especially for the high and low wavelength filters that were not well corrected with the preliminary remediation. Color ratios are particularly sensitive to slight differences between images and will act as an excellent measure of the new remediation quality.

Acknowledgments: This work supported by NASA under Contract NNH18ZDA001N-PDART issued through the Planetary Data, Archiving, Restoration, and Tools program. It makes use of the USGS Integrated Software for Imagers and Spectrometers (ISIS3). The image data in this work are archived in the PDS Small Bodies Node at https://sbn.psi.edu/pds/resource/near/msiinst.html. We also thank Mark Robinson for providing code, data, and insight for the original remediation work.

References: [1] Cheng, A. F. (1997) *SSR*, 82, 3-29. [2] Li H. et al. (2002), *Icarus* 155, 244-252. [3] Bussey, D. B. J. et al. (2002) *Icarus* 155, 38-50. [4] Murchie S. et al. (2002) *Icarus* 155, 229-243. [5] Riner, M. A. et al. (2008) *Icarus* 198, 67-76.