ORBIT DETERMINATION OF THE NEAR SPACECRAFT USING RADIOMETRIC TRACKING, ALTIMETRIC CROSSOVERS AND IMAGE-DERIVED FEATURES. E. Mazarico[1,2], G. A. Neumann[2], O. S. Barnouin[3], and R. W. Gaskell[4] [1] Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA (mazarico@mit.edu); [2] Planetary Geodynamics Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD; [3] Applied Physics Laboratory, John Hopkins University, Laurel, MD; [4] Planetary Science Institute, Altadena, CA.

Introduction: The NEAR mission was the first to study in detail a near-Earth asteroid, with a year-long observation of 433 Eros. Shape models were first derived from the NEAR Laser Rangefinder (NLR) during the orbital phase **[1]**. Together with the gravitational inferences from the radiometric tracking, it was used to study the interior structure **[2]**. The numerous images taken of the asteroid were also used to produce topographic products **[3]**. Discrepancies are generally small, but the shorter-wavelength features in the altimetric profiles are difficult to merge with the image-based shape. Better orbit reconstruction can benefit the development of precise shape models of Eros, and update solutions of its gravity field. Integration of all tracking types will also be important for future missions, such as Osiris-Rex.

Data: In addition to the near-continuous tracking by the DSN ground stations at radio wavelength, numerous images were acquired by the MSI instrument (REF) throughout the orbital phase of the NEAR mission. In total, 29,960 images were available, in which 10,284 landmarks were identified and used to produce detailed shape models **[2]**. The NLR laser altimeter collected ~16 million valid returns **[1]**.

Image Constraints: We analyzed the data from the first month of operation in orbit around 433 Eros (from March 3rd, 2000 to April 2nd, 2000) during which the spacecraft altitude was ~200km. At this distance, the gravitational force from Eros is marginal, and even the low-degree terms of the gravity field spherical harmonics expansion have little impact on the orbit. Considering only the image pairs with temporal separation greater than 10 minutes we find 858,272 unique image-image-landmark triplets, which can be used as constraints on the NEAR trajectory. We chose a representative sample of 100,000 constraints (**Figure 1**). The comparison with the JPL orbit solutions which used radiometric and landmark data shows that the image data are critical to the orbit reconstruction (**Table 1**).

Altimetric Constraints: Altimetric constraints as described by **[4]** can be constructed from individual short NLR track segments, once those have been adjusted to a common reference. Here, we use a high-resolution shape model from **[3]**. Adjustments of the spacecraft trajectory can be as large as several hundreds of meters, but significantly reduce the misfit to that shape model.

Outlook: We are modifying our orbit determination program (GEODYN) to enable the processing of both types of constraints together with the radiometric data. We anticipate improved orbits from this first use of the three datasets combined.

References: [1] Zuber et al. (2000), *Science*, 289, 2097-2100. [2] Miller et al. (2002), *Icarus*, 155, 3-17. [3] Gaskell et al. (2008), *Met.Pl.Sc.*, 43, 1049-1061. [4] Mazarico et al. (2010), *J.Geod.*, 84, 343-354.

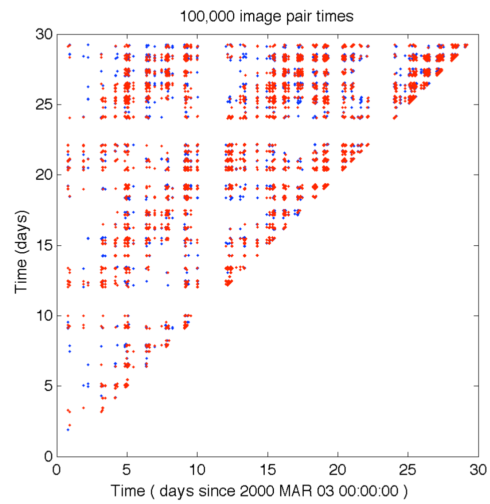

Figure 1. Acquisition times of the 100,000 pairs of images used as constraints in the orbit determination process, in red, over all the available pairs, in blue.

Observations used	RMS of total position differences with the JPL orbit solution (m)		
	arc #1 03/03-03/13	arc #2 03/14-03/25	arc #3 03/26-04/02
radio only	1769.78	1715.13	4580.55
no radio; 20,000 images	341.28	274.52	186.95
radio + 20,000 images	176.55	122.69	147.08
radio + 100,000 images	185.85	131.18	157.14
radio (deweighted) + 100,000 images	318.36	256.35	276.32

Table 1. Comparison of the orbits obtained with various datasets with the JPL solution archived on NAIF.