The Design and Navigation of the NEAR Shoemaker Landing on Eros

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After a 4.5 hour controlled descent using five open-loop maneuvers on February 12, 2001, the Discovery-class NEAR-Shoemaker spacecraft successfully landed on the surface of Eros becoming the first spacecraft ever to touchdown on an asteroid. This landing was made extraordinary by the fact that the spacecraft was not designed for landing and it remained in telecommunications with NASA's Deep Space Network afterwards. The descent trajectory was designed primarily to acquire as many close range high-resolution images (< 1 km) as possible while providing optimal viewing geometries and secondarily to ensure the safety of the spacecraft by minimizing its impact velocity. Since the spherical harmonic representation of Eros' gravity diverges below the sphere circumscribing the asteroid (< 18 km), a polyhedral gravity field based on our Eros shape determination was used for integrating the trajectory below this limit. This paper discusses the design, navigation and the Monte Carlo error analyses that were critical to the design of this landing scenario. Also described is the reconstruction of the landing trajectory using radio metric, optical landmark and laser ranging tracking data, which determined the characteristics of the landing to be well within the error analyses.

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