Preliminary Plans for a Close Encounter with 253 Mathilde

by

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ABSTRACT

NASA's Near Earth Asteroid Rendezvous (NEAR) mission is planning a dose fly-by of the asteroid 253 Mathilde in June 1997. The asteroid 253 Mathilde appears to be a distinct and interesting body worthy of further investigation. Unlike the asteroids Gaspera and Ida recently explored by Galileo spacecraft fl y-bys, Mat hi lde is a C-class spect ral object and it has a larger diameter of about 60 km. Also, unlike those asteroids it has a very slow rotation period of almost a month. The plan is to navigate the NEAR spacecraft to within 1200 km of the center of Mathilde using a combination of NASA's Deep Space Network (DSN) radio metric tracking and on board optical imaging. The planned sequence of spacecraft activities will result in high resolution, multi-spect ral imager (MSI) images of Mathilde made throughout the approach and departure. In addition, the navigation tracking will be used to estimate Mathilde's mass. The mass estimate should be accurate to about ten percent.

The fly-by is not the primary goal of the mission, but instead it is a target of opportunit y on the trajectory taking the NEAR spacecraft to its ultimate goal in 1999, which is to rendezvous with and then orbit the asteroid Eros. Hence, the. planning for the Mathilde encounter assumes the trajectory and approach conditions arc constrained, to some extent, by the overall mission goals to reach Eros. This means that the encounter date and the resulting approach geometry are determi ned by optimizing the complete trajectory to Eros. Also, the planned spacecraft sequence must not endanger the spacecraft or its instruments. The result is an approach phase angle of over 120 degrees that is not ideal for first detection with optical navigation since the asteroid will appear as a thin crescent up to the last hours before closest approach.

The design parameter's for all the approach trajectory correction maneuvers (TCMs) arc the impact plane (or B-plane) conditions of the asteroid given in a target relative coordinate system. The II-plane, shown in Figure 1 for the N] EAR flyby of asteroid 253 Mathilde, is a plane passing through the. center of the. target body and perpendicular to the incoming asymptote, S, of the hyperbol ic flyby t rajectory. Coordinates in the plane arc given in the R

and 'T' directions, with 'J' being parallel to the. Earth Mean 1 'cliptic plane of 2000. The angle, theta determines the rotation of the semi-major axis of the error ellipse in the B-plane dative to the 'l'-axis and is measured positive right-handed about S.

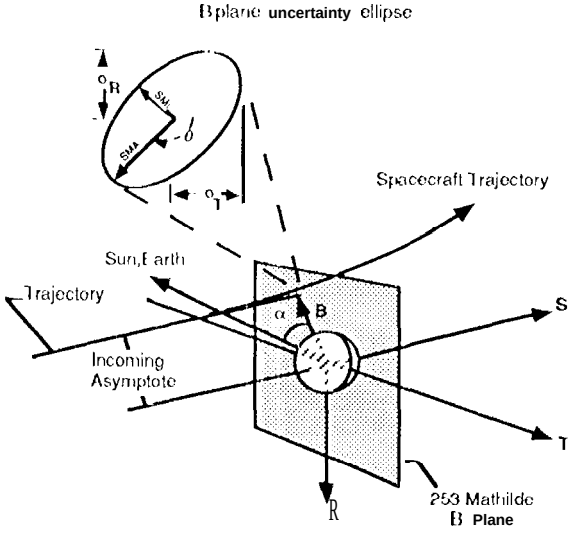
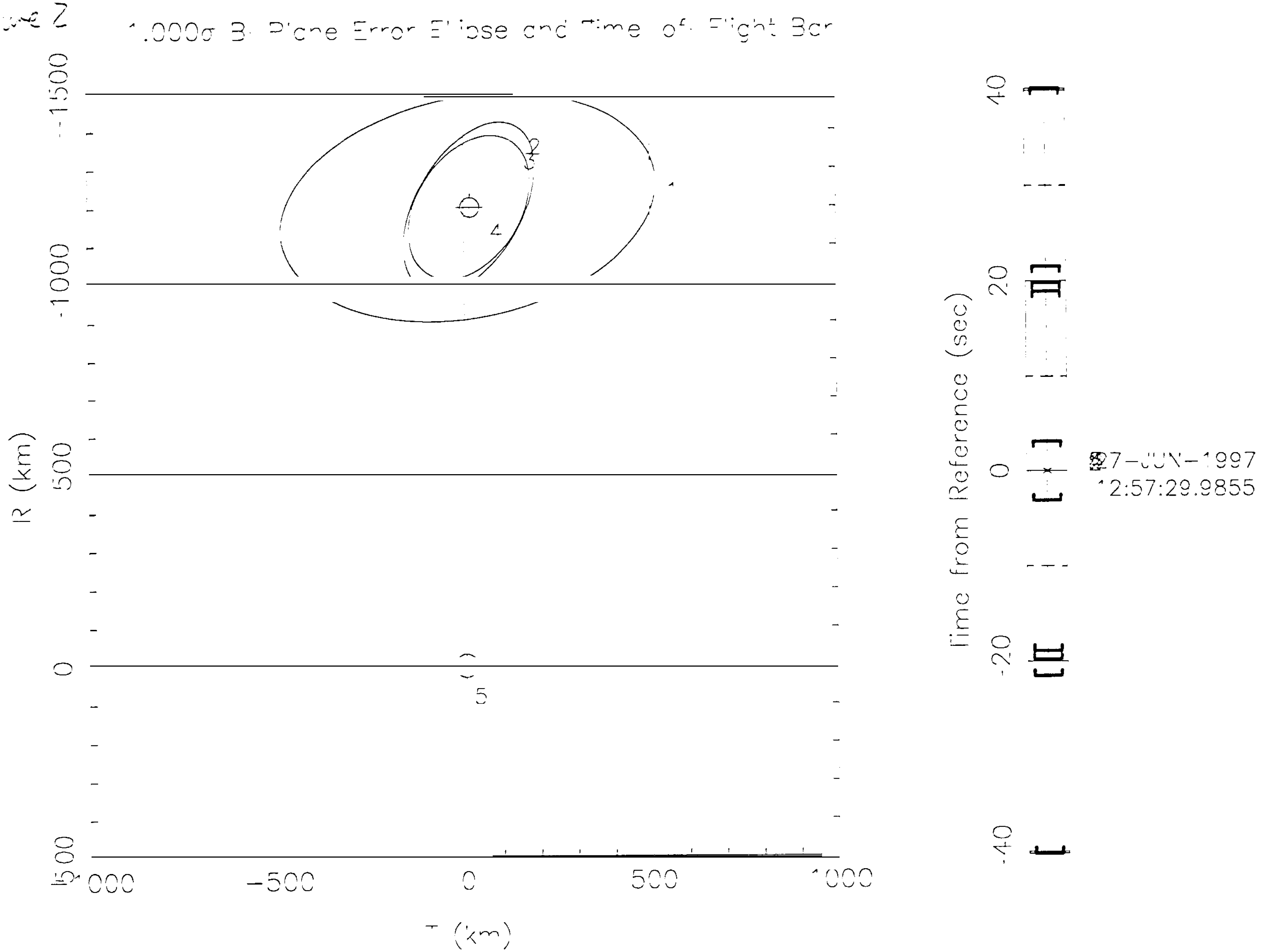


Figure 1. Definition of the B-plane

This paper gives results of the mission design and navigation trade studies undertaken to plan a navigation scenario of targeting mane.uwxs and optical navigation images during the last few days before closest approach that will dc.live.r the spacecraft to a point in the B-plane to sufficient accuracy so that the MS] pointing, sequence during the closest approach will image Mathilde and not empty space. Additional information about the. sequence of spacecraft pointing and MS] operation planned as a result of the navigation timeline and its dated delivery uncertainties will be provided.

Using measured MS] performance and predicted visibility of Mathilde, the first detection may not occur until less than two days before the closest approach. Before this first detection, the spacecraft trajectory is targeted by a Impulsive, maneuver to fly by the location of Mathilde predicted by its gmund-based ephemeris. Preliminary analysis indicates the B-plane target uncertainty cl lipse for a m aneuver performed 15 days before closest approach has semi-major axis of 205 km (1 sigma) and semi-minor axis of 137 km (1 sigma) with a linearized time of flight (1 .TF) uncertainty of 18.9 seconds. After optical navigation images have been obtained and processed, a maneuver at twelve hours before closest approach should result in an error ellipse of 26 km by 26.3 km (1 sigma) with LTF of 21.5 s. These B-plane error ellipses and 1.'1'1 'error bars are shown in 1 'igure ?.

Figure 2



1 TCV-3 Solution: December 1, 1996
2 TCV-4 Solution: May 15, 1997
3 TCV-5 Solution: June 12, 1997
4 TCV-6 Solution: June 26, 1997 (solution at -18 hours)
5 Mathilde