

National Aeronautics and
Space Administration

Headquarters

Washington, DC 20546-0001



OCT 12 2005

Reply to Attn of:

SMD/Solar System Division

Mr. Russell L. Schweickart
Chairman, Board of Directors
B612 Foundation
125 Red Hill Circle
Tiburon, CA 94920

A handwritten signature in black ink, appearing to read "Russell L. Schweickart".

Dear Mr. Schweickart:

Thank you for your letter dated June, 6, 2005, to the Administrator bringing attention to the issue of whether it is desirable, or in fact necessary, to launch a space mission to asteroid (99942) Apophis (aka 2004 MN4) in the next 5-10 years to monitor this asteroid's future motion. Your letter has been referred to me for response.

The orbit of Apophis has been an issue of intense interest by both the professional and lay Near Earth Object (NEO) community since the discovery in late December 2004 of its close approach potential. As I'm sure you're aware, as additional astrometric data for NEOs like Apophis become available, the Jet Propulsion Laboratory's (JPL) automatic SENTRY system, in conjunction with an independent system in Pisa Italy, routinely monitors their future Earth close approaches and impact probabilities. For objects for which we cannot immediately rule out a future Earth impact, additional observations are continuously sought to refine the existing orbit.

Optical astrometric data now exist for Apophis over the period from March 2004 to early September 2005, and radar range and Doppler data were obtained over several days in late January 2005. Also, a single radar Doppler measurement was recently obtained on August 7, 2005, from the Arecibo Observatory. When used to improve the previously calculated orbit, this last Doppler measurement allowed the removal of all but the 2036 impact possibility, for which the current impact probability is now 1 in 5,500. None of the previous 2034, 2035, or 2037 impact possibilities remain as significant threats.

However, for Apophis there is still potential for passage through a small (~600 meter) gravity "keyhole" in space during the April, 13, 2029, close Earth approach that would send the object on a collision course with Earth in 2036. Our analysis agrees with your assessment that it would be far easier to accomplish a deflection mission prior to the 2029 close approach to avoid any potential 2036 collision. To determine any potential need to accomplish a mitigation mission before 2029, we would need to gain a more precise knowledge of the asteroid's orbit.

Our conclusions on how to deal with Apophis are largely based upon recent independent analyses by Steve Chesley and Jon Giorgini at JPL. A recent scientific paper by Chesley (2005) is enclosed with this letter where you will find the background and assumptions that led to these following conclusions:

1. Using the existing optical and radar data, plus simulated future data at times the object has been determined to be observable, there is a 50 percent probability that future optical and radar data through May 2006 will effectively eliminate the possibility of a 2036 impact threat. Similarly, after the projected optical and radar data through 2013 and 2021 are processed, the likelihood that this 2036 threat will be eliminated is 96 percent and 99.8 percent respectively (see Chesley, 2005; Figure 9). Thus, future ground-based observational data will more than likely completely eliminate the possibility of a 2036 impact threat by 2013.
2. If, after processing observations through 2013, the 2036 impact probability is still significant, then NASA would seek support of a characterization mission to assess the shape, surface characteristics and spin orientation and rate state. Such a mission would include the functionality of a radio transponder either in orbit about, or on the surface of, the asteroid in order to refine the asteroid's orbit. The knowledge gained from this effort would be important for precise modeling of the asteroid's trajectory, and it would be imperative for any deflection effort. Notionally, the characterization mission could be designed, built and launched from 2014-2018, with a rendezvous in 2019. Two meter accuracy in ranging to this transponder over a one year period would allow a knowledge of the asteroid's position in space to within a few hundred meters in 2029 - and hence with the use of these transponder data the 2036 impact could be definitively ruled out (or in) by 2020 (see Chesley, 2005, Figures 7&10). It is worth noting that the longer prediction intervals associated with any earlier (pre-2013 start date) tracking and characterization mission make such a mission much less effective in confirming a 2036 miss or collision than a post-2013 effort.
3. Should a characterization mission still not allow a complete removal of the 2036 impact possibility, our mission opportunity analysis shows a kinetic energy deflection mission could still be completed by the 2024-2028 timeframe assuming that the design phase of this mission took place in conjunction with the earlier characterization mission design and flight (2014-2020). Although the precise method and timeline of a deflection effort cannot be established at this early stage, the recent experience of Deep Impact, which went from initial planning to successful impact on Comet 9P/Tempel 1 in less than seven years, is relevant.
4. If we were to assume that the asteroid is actually on an Earth impacting trajectory for 2036, we can then analyze with what certainty we would know this impact probability as a function of time. From Figure 10 in Chesley (2005), we note that if the asteroid is assumed to be on an impacting trajectory in 2036, the estimated impact probability could

reach about 1 percent after 2013 and roughly 20 percent after 2021. In the unlikely event this should occur, we believe it clearly prudent to plan a deflection mission, but only after we obtain the updated data in 2013 so that it could be launched after obtaining more definitive data in 2021.

The key conclusion to be taken from this analysis is that aggressive (i.e., more expensive) action can reasonably be delayed until after the 2013 observing opportunity. For Apophis, the 16 years available after 2013 are sufficient to recognize and respond to any hazard that still exists after that time. Thus, while Apophis is an object whose motion we will continue to monitor closely in the coming years, we conclude a space mission to this object based solely on any perceived collision hazard is not warranted at this time. Even so, preliminary mission studies that lay the groundwork for a possible post-2013 characterization mission launch could be appropriate if the 2006 observing period does not completely eliminate the impact potential.

This conclusion certainly does not preclude missions to this object based on purely scientific arguments. Indeed, the asteroid's orbit is particularly attractive for spacecraft rendezvous, and the extraordinarily close encounter in April 2029 provides a unique opportunity to investigate a number of scientific NEO issues. These would best be handled through proposals to our already existing Discovery program.

We look forward to continued work with you and your organization on this fascinating and critically important issue for the security of our continued livelihood on this planet.

Sincerely,



Mary L. Cleave
Associate Administrator for
Science Mission Directorate

Enclosure

cc:

Science Mission Directorate/Dr. Hartman

- Mr. Luther
- Mr. Dantzler
- Mr. Johnson

JPL/Dr. Yeomans