



The Planetary Society Apophis Mission Design Competition

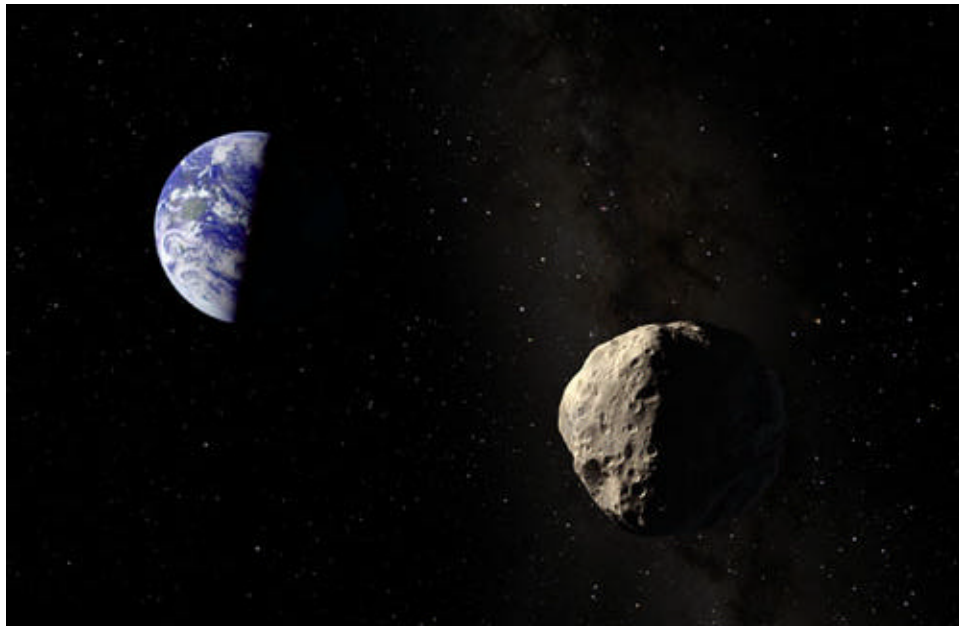


Image: Dan Durda – FIAAA

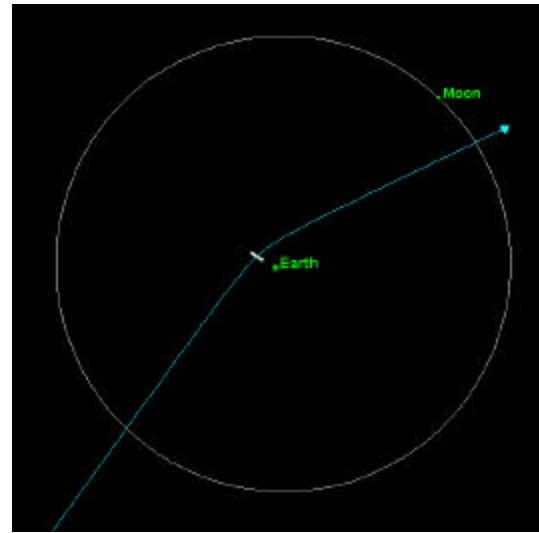
Summary

The Planetary Society is conducting a competition to design a mission to rendezvous with and “tag” a near-Earth asteroid such as Apophis. In this competition, Apophis, currently with a one in a few thousand probability of striking Earth in 2036, is treated as an example to facilitate mission design. The purpose of the competition is to gather a diverse and large suite of entries that can be a creative and useful starting point for a potential space agency project to tag any asteroid that may be coming dangerously close to Earth. \$50,000 in prize money will be offered.

The competition is being conducted in cooperation with the European Space Agency (ESA), NASA, the Association of Space Explorers (ASE), the American Institute of Aeronautics and Astronautics (AIAA), and the Universities Space Research Association (USRA). Findings of the competition will be presented at relevant conferences, and winning entries will be shared with space agencies directly, including those actively cooperating in this competition.



Asteroid Itokawa as observed by the Hayabusa spacecraft.
Credit: ISAS/JAXA



Apophis 2029 encounter with Earth relative to the orbit of the Moon. Credit: JPL/NASA

Introduction

Apophis is a near Earth object (NEO) which in 2029 will come closer to Earth than the geostationary satellite orbit, and will be gravitationally perturbed to an unknown orbit, one that could hit Earth in 2036. Very precise tracking may be required to adequately determine the probability of a 2036 impact, and it may turn out that such precise tracking will require “tagging” the asteroid with a beacon, transponder or reflector of some kind. A mission to do this has never been studied, and how an asteroid would be tagged is neither determined nor obvious.

It is possible that radar observations and tracking in the next few years will obviate the need for a tagging mission or concern about this particular asteroid: possible, but not certain. But, even in this case, the Apophis Mission Design Competition will be useful in advancing knowledge and capability for future missions to any asteroid that may threaten an impact with Earth. We treat Apophis as an example for mission design.

The Planetary Society, the world’s largest space interest group, has long supported NEO research, both for its scientific and exploration value and to understand the potential threat of a NEO impact with Earth. The competition outlined here is designed to increase public interest, education and information about NEOs while generating useful mission design studies for possible future needs. The Society’s timely conduct of the mission design competition is a contribution of private initiative and educational outreach, in cooperation with space agency interest in stimulating broad and creative thinking about a potentially very important problem of the future.

Competition Design Scenario

If the asteroid Apophis goes through a several-hundred-meter-wide “keyhole” in 2029, it will impact Earth in 2036. Imagine that over the coming years, more Earth-based observations of Apophis are made; however, we still find that the observations are not sufficient to know whether Apophis will or will not pass through the 2029 keyhole. A better orbit determination is needed so we know whether a deflection mission is required to prevent passage through the keyhole. This can be accomplished using a mission to emplace a device on or near the asteroid that enables precise tracking of Apophis. This mission is the focus of the design competition.

The following apply to the competition:

- Tracking from this mission should decrease the size of the 2029 error ellipse sufficiently fast so that if required, a deflection mission can be accomplished before the 2029 Apophis close encounter. For the purposes of this competition, data must facilitate a deflection mission decision by 2017 (enabling 3 years development for a deflection mission and 9 years to rendezvous and deflect).
- Assume for this competition that your mission must be able to determine whether Apophis will hit the keyhole at greater than 10 percent confidence, the assumption being that such a level of confidence would be sufficient to prompt governments to launch a deflection mission.
- The focus is on the encounter or rendezvous, positioning of whatever device to assist tracking, and the conduct of asteroid tracking after the emplacement.

- Any method that will enable tracking of the asteroid at a level that will sufficiently constrain the problem is permitted. These could include surface transponders, orbiters, reflectors, beacons or other concepts. Analysis and justification must be provided and such analysis will be one of the principal judging criteria.
- Though a full mission design is required, the terminal phase of the mission is the design focus and will be given the highest weight in judging (assuming the earlier parts of the mission are determined to be realistic and feasible).
- Though there are not specific constraints, justification of all major mission parameters (e.g., mass to be delivered to vicinity of the asteroid, power required) should be provided and justified as realistic.
- Similarly, approximate end-to-end cost estimates should be provided, including operational costs and any ground assets required. Analogies with other missions or pieces of missions can be used to help generate these costs. Though no cost cap is provided here, overall cost will be a consideration in comparing proposals
- For major and significant systems or hardware (such as spacecraft, launch, or ground-based assets), proposer should demonstrate ability to use existing systems or state the requirements for new systems. If new systems are required, proposer must demonstrate the relevance and maturity of the technologies proposed and justify the steps, including costs and risks, needed to bring the technology to an acceptable level of maturity on a short enough time frame.

More details on assumptions and rules can be found in the “Proposal Details” section below.

Organizational Structure of the Competition

The Planetary Society is holding the competition. The prize money was contributed and competition made possible by Dan Geraci, a member of The Planetary Society Board of Directors, together with donations from Planetary Society members around the world. The competition will be conducted in cooperation with:

- European Space Agency (ESA)
- NASA
- American Institute of Aeronautics and Astronautics (AIAA)
- Association of Space Explorers (ASE)
- Universities Space Research Association (USRA)

The competition Advisory Committee includes:

- Daniel Durda, Southwest Research Institute, Planetary Scientist
- Louis Friedman, The Planetary Society, Executive Director
- Lewis Peach, USRA, Chief Engineer
- Russell “Rusty” Schweickart, Apollo astronaut and ASE NEO Committee Chairman
- Gen. Simon “Pete” Worden, Director, Ames Research Center

Judges will be selected at a later date.

Schedule

- **March 1, 2007:** Notice of Intent due
- **August 31, 2007, 5:00 p.m. Pacific time :** Proposals due
- **Mid-December, 2007:** Winners announced

Notice of Intent

Teams intending to submit a proposal should submit a Notice of Intent to Propose, with a maximum length of 300 words, to Bruce Betts (bruce.betts@planetary.org). It should outline organization(s) involved, as well as key individuals involved, though details can change in the final proposal.

Proposal Details

Proposals must be written in English and submitted electronically in Microsoft Word *or* Adobe PDF format. Proposals are limited to 10,000 words, and no more than 40 pages total, including diagrams, figures, attachments, etc.

Proposals shall include:

- A list of team members including phone numbers, email addresses, affiliations, and job titles (C.V.s for team members are welcome but not required). One team member should be designated as the primary point of contact.
- An Executive Summary of the proposal, limited to 500 words.
- A mission scenario including:
 - A technical description of the tagging device, the method of emplacement, and conduct of tracking; and
 - Analysis of the expected precision and accuracy of the proposed tracking method.

- Sources of information used in the proposal (e.g., cost analogies, technical readiness of certain technologies, etc.) should be referenced.
- Proposals should explicitly state to whom any awarded prize money should be sent (naming individual, individuals, or organization)
- See the section above titled "Competition Design Scenario" for more design requirements and constraints.

Proposals may be submitted by email to Bruce Betts (bruce.betts@planetary.org) or by mailing a CD or DVD to the address at the bottom of this page.

Judging

A judging panel put together by The Planetary Society shall make recommendations on winner(s) and awards. Proposals will be judged upon the following (approximate relative weights shown in parentheses) technical content and detail (40%); realism of assumptions (10%, but if judged to be totally unrealistic, will be weighted much higher); perceived feasibility (technical, cost, schedule, etc.) (20%); estimated probability of success, including reliability(20%); and originality (10%). Based upon recommendations of the judging panel, final decisions will be made by The Planetary Society Board of Directors.

Eligibility

The mission design competition is open to anyone from any country. Individuals or teams may submit proposals. The competition is open to teams from academia and industry as well as student groups and private groups. Though government employees and those often funded by government monies may participate, government funding may not be used to support any of the proposing team in terms of salary or other direct costs, although facilities and equipment previously paid for by government funding may be used to support the effort. The one exception to this restriction is salaries paid at government-supported education facilities (e.g., a public university) that are not from research grants (e.g., teaching salaries so a teacher could work with students on this) are allowed.

Copyright

Copyright of the submitted proposals shall remain with the proposers. However, by submitting an entry to the Apophis Mission Design Competition, all proposers agree that The Planetary Society and other participating organizations are granted non-exclusive reproduction rights to all content contained within the proposals,

unless specifically called out as proprietary. Even if there are proprietary materials, proposers agree that at least the executive summary of their proposal shall not be proprietary and can be made public, and that the entire proposal can be shared with government space agencies as well as judges in the competition and employees and board members of The Planetary Society. Proposers also agree to permit The Planetary Society and other participating organizations to mention their names and/or affiliations in connection with the competition. The Planetary Society may also present ideas and findings generated by this competition at relevant conferences. Winning entries will be shared with space agencies directly, including those actively cooperating in this competition.

Awards

Prize Money. \$50,000 in prize money will be awarded. Based upon the quality of the entries, the judges will determine how to distribute the award money among one or more prizewinners. Of this, at least \$25,000 will be awarded to the first prizewinner. Based upon the quality of the entry pool, any remaining prize money may be distributed as honorable mention awards. A prize of \$5,000 is reserved for the best submission received from a student team (who is also not precluded from winning the first prize), in which all substantive work was performed by current students (high school, undergraduate, or graduate), with no more than two faculty advisors. To be eligible for the student award, proposers must state their eligibility as well as list all team members and their student or faculty status.

Travel. Additionally, one member of the first prize winning team will receive award travel, including transportation, food, and lodging, to attend three days of a future major science or engineering conference to present their results. The Planetary Society shall determine which conference in consultation with the winner. The Planetary Society shall not be responsible in the event that the prizewinner fails to obtain any necessary travel documents; if they are required but not obtained, the award travel offer shall become void.

Changes

Competition rules, schedule, and prizes are subject to change without prior notice. Changes will be posted on the competition website <http://planetary.org/apophis>

Contact for More Information:

Dr. Bruce Betts, Director of Projects
The Planetary Society
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