参考資料1

APOPHIS T-4 YEARS WORKSHOP – SUMMARY COMMUNIQUE

5 May 2025

The solar system small bodies community having a dedicated interest in the planetary defense science opportunity presented by the exceedingly rare natural event of asteroid Apophis (safely passing within 32,000 km of Earth on April 13, 2029) held a two-day Workshop at the University of Tokyo, April 9-10, 2025. This "Apophis T-4 Years" workshop was attended by more than 300 scientists and engineers (most in-person; others by virtual connection) representing 31 countries on 5 continents. The current workshop is the culmination of a series of international workshops begun as virtual meetings, starting annually in 2020 at "Apophis T-9 years."

Over the course of two days presentations included the *DESTINY+* mission (Japan), the *RAMSES* mission (ESA), and the *OSIRIS-APEX* mission (NASA). Additional spacecraft and instrument concepts were proposed and discussed.

Summarized here are the Findings and Recommendations reached collectively by the Workshop participants, drafted into final form by the Science Organizing Committee whose names appear below.

Findings

1. With the **United Nations** declaring 2029 as the **International Year of Asteroid Awareness and Planetary Defense**, and as 330 Workshop participants from 31 countries and 5 continents (representing multiple space agencies as well as private space enterprises), **we recognize that the entire world will be watching** how we collectively respond to the knowledge opportunity for planetary defense presented by the safe but very close Earth passage by the asteroid Apophis in April 2029.

2. Speaking as a collective voice of international experts in the study of asteroids and planetary defense, recognizing the breadth and complexity of the possible effects of Earth's tidal forces on Apophis during its safe passage, we find that no single telescopic or spacecraft investigation can encompass measurements taking full advantage of the Apophis 2029 knowledge opportunity. Thus, **we find that international collaborations and coordination are imperative for achieving Apophis 2029 science.**

3. Recognizing that planetary defense is an international concern, as asteroid impacts know no borders, **we collectively affirm that planetary defense is a shared international responsibility**. Therefore we dedicate ourselves to support, encourage, celebrate, and **we commit to collaborative and coordinated international efforts** to achieve a thorough scientific investigation of the Apophis 2029 safe passage through telescopic and *in situ* spacecraft measurements before, during, and after Earth flyby. **We commit to sharing openly with the world the outcomes of our Apophis scientific investigations.**

4. With a collective international voice, **we endorse as *essential Apophis science investigations* the stated mission objectives and complementarity of the flyby by *DESTINY+* and the successive rendezvous missions *RAMSES* and *OSIRIS-APEX*. These are the highest priority missions for Apophis and should be fully funded and supported to ensure successful achievement of their science objectives. We strongly encourage additional partners supporting these cornerstone investigations.**

5. **We additionally encourage support for SmallSat and CubeSat opportunities** to demonstrate new technologies further advancing the science of planetary defense while also creating new opportunities for student experiences in the field.

6. We collectively entreat and emphasize to our respective agencies, member states, funding sources, and all interested parties that ***time is of the essence*** **for moving forward decisively in funding current science investigations proposed and underway, which are essential for achieving the Apophis science outcomes being anticipated and to be watched by the entire world.** Time is particularly of the essence for **envisioning and supporting new concepts** in space science and planetary defense capabilities, whose performance can be validated by the sum of all efforts being devoted to the Apophis 2029 opportunity.

Recommendations

A. We recommend that collaborative and coordinated international efforts be devoted over the broadest possible suite of Earth-based telescopic assets, across all wavelength ranges (including radar and radio), to contribute, expand, and strengthen the science return from the Apophis 2029 encounter, as well as through extended duration post-encounter observations. We note, as a corollary recommendation, support for coordinated observations of upcoming Apophis apparitions prior to 2029, requiring access to large aperture telescopes.

B. To achieve the maximum science return from the Apophis 2029 knowledge opportunity, we recommend:

(i) Funding support for ongoing theoretical, laboratory, and collaborative investigations to determine quantitatively what measurements are achievable in yielding significant science outcomes of the Apophis encounter with Earth's tidal forces, for which Apophis physical effects may continue to evolve long after the Earth encounter.

(ii) International agency and science community coordination for achieving key science results. Time is of the essence for all agencies and entities executing flight missions to coordinate on science requirements. From this coordination, achievable data requirements and data acquisition strategies can set the framework for the broad community and interagency coordination needed to achieve successful science outcomes from the Apophis 2029 opportunity.

C. Following this community's Communique one year ago (Apophis T-5 Workshop) stating *"Janus to Apophis is our highest recommendation"* for a NASA-led pre-encounter investigation, we follow-up by urging NASA to issue a timely response to the *Apophis 2029 Innovation Using the Janus Spacecraft Request for Information.*

Apophis T-4 Workshop Science Organizing Committee

Richard Binzel, Co-Chair
Massachusetts Institute of Technology

Patrick Michel, Co-Chair
Centre National de la Recherche Scientifique

Seiji Sugita, Co-Chair
University of Tokyo

Brent Barbee
NASA Goddard Space Flight Center

Julia de Leon
Instituto de Astrofisica de Canarias

Michael Küppers
European Space Astronomy Centre

Monica Lazzarin
University of Padova

Naomi Murdoch
Institut Supérieur de l'Aéronautique et de l'Espace-SUPAERO

Mike Nolan
University of Arizona

Cristina Thomas
Northern Arizona University