COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
CHAIRMAN BRIAN BABIN

SUBCOMMITTEE ON SPACE & AERONAUTICS

HEARING CHARTER

From Detection to Deflection: Evaluating NASA's Planetary Defense Strategy

Thursday, May 15, 2025
10:00 A.M.
2318 Rayburn House Office Building

Purpose

This hearing will examine NASA's Planetary Defense strategy, including efforts to detect and characterize near-Earth objects (NEOs). It will also assess U.S. preparedness to respond to potential threats from NEOs, review current technologies under development, and identify potential gaps in our planetary defense capabilities. The hearing will also evaluate NASA's progress towards completing the survey of NEOs greater than 140 meters in diameter as statutorily required by the George E. Brown, Jr. Near-Earth Object Survey Act.

Witnesses

- **Dr. Nicola Fox,** Associate Administrator, Science Mission Directorate, National Aeronautics and Space Administration
- **Professor Amy Mainzer,** Department of Earth, Planetary, and Space Sciences, University of California, Los Angeles
- **Dr. Matthew J. Payne,** Director, Minor Planet Center, Smithsonian Astrophysical Observatory

Overarching Questions

- How much progress has NASA made towards completing the statutory requirements in the George E. Brown, Jr. NEO Survey Act?
- What are the most important priorities regarding detecting, characterizing, and developing the means to deflect NEOs?
- How is NASA implementing the recommended actions in the NASA Planetary Defense Strategy and Action Plan?

Introduction

On December 27, 2024, the Minor Planet Center (MPC) received reports of an asteroid, designated 2024 YR4, with a 1% chance of impacting Earth in 2032.[1] With an estimated diameter between 174 and 220 feet—just under the length of a Boeing 747— a collision with Earth could have serious consequences. By February 18, 2025, NASA had revised the impact probability upward to 3.1%, the highest probability recorded by NASA for an asteroid of that size.[2]

Asteroids like 2024 YR4 remind us that various sizes of asteroids and comets continually strike Earth. While many are small and burn up in the atmosphere, some are large enough to survive atmospheric reentry and impact Earth's surface. One of the most notable impacts in recent history occurred in 2013, approximately 14 miles above Chelyabinsk, Russia.[3] An approximately 65-foot diameter meteor traveling 11 miles per second smashed into Earth's atmosphere; the atmospheric entry and resulting airburst caused a blast equal to 440,000 tons of TNT.[4] The overpressure blew out windows for 200 square miles, injuring over 1600 people,[5] and caused an estimated 1 billion rubles (approximately $33 million) in damage.[6]

Estimated to be up to 220 feet in diameter, 2024 YR4 is about three times the size of the Chelyabinsk meteor (estimated to be approximately 65 feet wide).[7] Fortunately, after additional observation and analysis, NASA revised the probability of a 2024 YR4 impact from 3.1% down to just 0.0004% by the end of February 2025.[8]

The 2024 YR4 asteroid underscores the importance of detecting and tracking large NEOs and preparing a response should one threaten Earth. Public opinion surveys consistently rank planetary defense among NASA's highest priorities.[9] This hearing will investigate the effectiveness of NASA's efforts to detect, catalog, and prepare for potential NEO threats.

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[1] NASA, Planetary Defense, NASA Shares Observations of Recently-Identified Near Earth Asteroid (Jan. 29, 2025), available at: https://science.nasa.gov/blogs/planetary-defense/2025/01/29/nasa-shares-observations-of-recently-identified-near-earth-asteroid/

[2] NASA, Planetary Defense, Dark Skies Bring New Observations of Asteroid 2024 YR4, Lower Impact Probability (Feb. 19, 2025), available at: https://science.nasa.gov/blogs/planetary-defense/2025/02/19/dark-skies-bring-new-observations-of-asteroid-2024-yr4-lower-impact-probability/

[3] NASA, Planetary Defense, Remembering the Chelyabinsk Impact 10 Years Ago, and Looking Into the Future (Feb. 15, 2025), available at: https://science.nasa.gov/blogs/planetary-defense/2023/02/15/remembering-the-chelyabinsk-impact-10-years-ago-and-looking-to-the-future/

[4] *Id. Supra note 3*

[5] *Id. Supra note 3*

[6] Phil Black and Laura Smith-Spark, CNN, Russia starts cleanup after meteor strike (Feb. 19, 2013), available at: https://www.cnn.com/2013/02/16/world/europe/russia-meteor-shower/index.html.

[7] NASA, A Timeline of Meteoric Descent, available at: www.nasa.gov/wp-content/uploads/2015/05/timeline-meteor-descent.pdf?emrc=20ccd6; NASA, Marshall Center Astronomer Bill Cooke, Other NASA Researchers Among International Science Coalition Issuing Chelyabinsk Meteor Findings in New Papers (Nov. 08, 2013), available at: https://www.nasa.gov/centers-and-facilities/marshall/marshall-center-astronomer-bill-cooke-other-nasa-researchers-among-international-science-coalition-issuing-chelyabinsk-meteor-findings-in-new-papers/

[8] NASA, Planetary Defense, Latest Calculations Conclude Asteroid 2024 YR4 Now Poses NO Significant Threat to Earth in 2032 and Beyond, (Feb. 24, 2025) available at: https://science.nasa.gov/blogs/planetary-defense/2025/02/24/latest-calculations-conclude-asteroid-2024-yr4-now-poses-no-significant-threat-to-earth-in-2032-and-beyond/. NASA estimated a 3.8% probability of the asteroid hitting the Moon in 2032.

[9] Brian Kennedy and Alec Tyson, Americans' Views of Space: U.S. Role, NASA Priorities and Impact of Private Companies, Pew Research Center, (July 20, 2023), Available at: https://www.pewresearch.org/science/2023/07/20/americans-views-of-space-u-s-role-nasa-priorities-and-impact-of-private-companies/

Background

NEOs are naturally occurring objects, such as asteroids or comets, with a perihelion distance of less than 1.3 Astronomical Units from the Sun[10] (i.e., objects within about 45 million kilometers of Earth's orbit). Scientists believe millions of NEOs exist, ranging in size, shape, velocity, and composition.[11] It is precisely this diversity that makes NEO observation critical and NEO threat assessment challenging.

Depending on a NEO's size and other factors, an Earth impact could have:

- Global effects: Existence of up to 1000 NEOs over 1 kilometer in size, of which approximately 95% have been detected.
- Regional impact effects: Up to 25,000 NEOs over 140 meters in size, of which only about 42% have been detected.
- Concentrated urban area effects: NASA estimates over 230,000 NEOs over 50 meters in size, of which under 8% have been detected.
- Small scale or no effects: Tens of millions of NEOs under 50 meters, of which under 1% have been detected.[12]

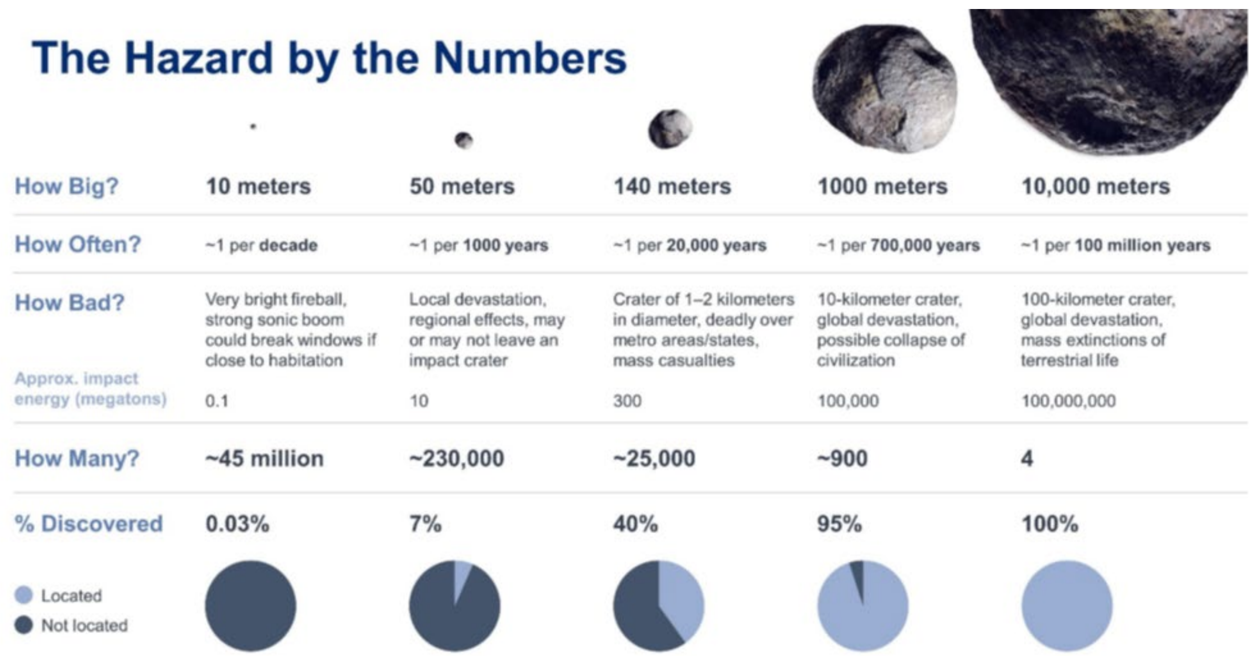

Figure 1: Estimated NEO population. [Source: Johns Hopkins University Applied Physics Lab]

As the *Planetary Science and Astrobiology Decadal Survey* notes, "Although the annual probability of Earth being struck by a larger asteroid or comet is small, the consequences of such

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[10] UN Office of Outer Space Affairs, Near-Earth Objects, available at: https://www.un-spider.org/category/disaster-type/near-earth-objects

[11] National Science and Technology Council, National Preparedness Strategy for Near-Earth Object Hazards and Planetary Defense (April 2023), available at: https://assets.science.nasa.gov/content/dam/science/psd/planetary-science-division/2025/2023-NSTC-National-Preparedness-Strategy-and-Action-Plan-for-Near-Earth-Object-Hazards-and-Planetary-Defense.pdf

[12] *Id. Supra note 11*

collision are so serious that prudence dictates that society assess the nature of the threat and be prepared to respond."[13] Over the last 30 years, the United States has developed a comprehensive framework for administering its planetary defense activities. Planetary defense refers to "all the capabilities needed to detect and warn of potential 10-meter and larger NEO impacts with Earth, and to either prevent such an event or mitigate the possible effects of an impact."[14]

History and Policy

NEO Survey Efforts

In the 1990s, NASA worked with the Department of Defense and international space agencies to identify and catalog NEOs greater than 1 kilometer in diameter.[15] In 1998, NASA established the Near-Earth Object Program Office at NASA's Jet Propulsion Laboratory (JPL) to coordinate discovery efforts and compute Earth close-approach and impact probabilities.[16] The Office also took on the NEO cataloguing effort.[17] In 2003, a NASA-chartered science definition team considered the feasibility of expanding surveying efforts to include smaller NEOs. The team recommended that NASA expand its NEO detection efforts to include objects 140 meters or larger in diameter.[18] This prompted the George E. Brown, Jr. Near-Earth Object Survey Act (Brown Act), enacted as section 321 of the National Aeronautics and Space Administration Authorization Act of 2005.[19]

The Brown Act assigned NASA responsibility for detecting and characterizing near-Earth asteroids and comets, and for providing for warning and mitigation of any potentially hazardous NEOs.[20] It also directed the NASA Administrator to "plan, develop, and implement a Near-Earth Object Survey program to detect, track, catalogue, and characterize the physical characteristics of near-Earth objects equal to or greater than 140 meters in diameter to assess the threat of such near-Earth objects to the Earth," with a goal of 90% completion of the catalogue within 15 years of enactment (a deadline of 2020).[21]

Threat Response

The National Aeronautics and Space Administration Authorization Act of 2008 directed the Office of Science and Technology Policy (OSTP) to develop an interagency policy for notification and emergency response in the event of a NEO threat, and to recommend a lead federal agency for NEO threat protection and mitigation efforts.[22] OSTP later issued a memorandum addressing NEO threat response and assigning NASA as the lead agency for

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[13] National Academies of Sciences, Engineering, and Medicine, Origins, Worlds, and Life: A Decadal Strategy for Planetary Science and Astrobiology 2023-2032, (2023), available at: https://doi.org/10.17226/26522
[14] *Id. Supra note 11*
[15] NASA, NASA Planetary Defense Strategy and Action Plan, (April 2023), available at: https://www.nasa.gov/wp-content/uploads/2023/06/nasa_-_planetary_defense_strategy_-_final-508.pdf
[16] Erik M. Conway, Donald K. Yeomans, Meg Rosenburg, A History of Near-Earth Objects Research, NASA SP-2022-4235, available at: https://www3.nasa.gov/sites/default/files/atoms/files/a_history_of_near-earth_object_research_tagged.pdf.
[17] *Id. Supra note 16*
[18] *Id. Supra note 16*
[19] National Aeronautics and Space Administration Authorization Act of 2005 (P.L. 109-155)
[20] *Id. Supra note 19*
[21] *Id. Supra note 19*
[22] National Aeronautics and Space Administration Authorization Act of 2008 (P.L 110-422)

detection, tracking, and notification activities, as well as for mitigation research.[23] To carry out these functions, NASA established the Planetary Defense Coordination Office,[24] later authorized by the National Aeronautics and Space Administration Authorization Act of 2022, which Congress passed as part of the CHIPS Act of 2022.[25]

The National Science and Technology Council (NSTC) National Preparedness Strategy for Near-Earth Object Hazards and Planetary Defense, issued in April 2023, sets forth the most recent iteration of a national strategy for NEO response.[26]

Planetary Defense Coordination Office

Established in 2016 within the Planetary Division of NASA's Science Mission Directorate, the PDCO succeeded the Near-Earth Object Program Office, but continues to administer the program.[27] PDCO serves as NASA's central office for planetary defense. It oversees the NEO Observations Program, which "sponsors projects that make use of telescopes around the world to search for NEOs, track them across the sky to determine their orbits, and gain information on sizes, shapes, and composition."[28] PDCO also manages interagency and international planetary defense efforts.

Surveying and Understanding Near-Earth Objects

While NASA is the lead U.S. agency for planetary defense, both NASA and the National Science Foundation (NSF) engage in the scientific exploration and characterization of NEOs. [29] NSF contributes by supporting ground-based scientific facilities used to observe and characterize NEOs.

Detection, Tracking, and Cataloguing

The Chelyabinsk meteor referenced in the introduction infamously struck without warning, partly because the meteor approached in the morning from the direction of the Sun, where ground-based telescopes have limited visibility.[30] This incident highlighted the persistent gaps in Earth's NEO monitoring capabilities. Detection is the foundation of planetary defense—knowing where NEOs are located enables tracking, risk analysis, and mitigation planning. As the Planetary Science Decadal states, "[t]he primary benefit from a comprehensive NEO survey is to

[23] *Id. Supra note 16*
[24] *Id. Supra note 16*
[25] CHIPS Act of 2022, PL 117-167 (Aug. 9, 2022), Title VII, National Aeronautics and Space Administration Authorization Act, at section 10825(b), stating that "The Administrator shall maintain an office within the Planetary Science Division of the Science Mission Directorate, to be known as the 'Planetary Defense Coordination Office'— (1) to plan, develop, and implement a program to survey threats posed by near-Earth objects equal to or greater than 140 meters in diameter… (2) identify, track, and characterize potentially hazardous near-Earth objects, issue warnings of the effects of potential impacts of such objects, and investigate strategies and technologies for mitigating the potential impacts of such objects; and (3) assist in coordinating government planning for response to a potential impact of a near-Earth object."
[26] *Id. Supra note 11*
[27] *Id. Supra note 11*
[28] NASA, Near-Earth Object Observations Program, available at: https://www.nasa.gov/solar-system/near-earth-object-observations-program/
[29] National Preparedness Strategy and Action Plan for NEOs and Planetary Defense identifies NASA as the lead agency, and directs NSF to provide support.
[30] Eddie Irizarry and Deborah Byrd, EarthSky, Asteroid 2021 SG came from the sun's direction, (September 20, 2021), available at: https://earthsky.org/space/asteroid-2021-sg-closest-to-earth-sep21-2021/

reduce the risk uncertainty associated with such high-consequence events by early identification of potentially hazardous objects—finding them before they find us."[31]

Despite being years past the deadline, NASA has not yet achieved the 90% cataloguing goal directed by the Brown Act. By late 2024, approximately 44% of the estimated NEOs over 140 meters in diameter had been discovered.[32] Continued efforts using ground- and space-based systems are underway to close the gap.

Characterization

Characterization is the process of measuring a NEO's physical and orbital properties to inform planetary defense. These properties include size, shape, mass, composition, spin rate, and trajectory—each of which influences the severity of an Earth impact and informs possible mitigation techniques, such as disruption or deflection.[33] Radar imaging allows for precise measurements that are particularly valuable for reducing NEO uncertainties, allowing NASA to predict potential Earth impacts an average of 400 years into the future.[34] Even short-duration radar observations can dramatically improve the precision of orbital models.

Follow-On Observations

Follow-on observations of initial NEO discoveries help refine estimates of orbital paths and physical characteristics. These observations help resolve an object's timing and location uncertainties, enabling a more accurate determination of a NEO's orbit. [35] Multiple observations are critical to determining a NEO's long-term trajectory (and risk to Earth) and evaluating appropriate mitigation options based on size, speed, and composition.

Minor Planet Center

The MPC serves as "the internationally agreed-to public archive of small-body orbit data submitted by observers from around the world."[36] While the MPC is a NASA-funded component of the Planetary Data System Small Bodies Node, it is hosted by the Center of Astrophysics (a collaboration between the Harvard College Observatory and the Smithsonian Astrophysical Observatory) and operates under the auspices of the International Astronomical Union.[37] The MPC is "the single worldwide location for receipt and distribution of positional measurements of minor planets, comets, and outer irregular natural satellites of the major planets."[38] The MPC is responsible for identifying and designating all received observations, maintaining a catalog of observations, and providing notifications of newly discovered objects.[39]

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[31] *Id. supra note 13*
[32] NASA, Report Regarding NASA's Progress in Tracking Near-Earth Objects Pursuant to Section 10825(d) of NASA Authorization Act of 2022 (Title VII of P.L. 117-167), (March 2025)
[33] *Id. supra note 13*
[34] *Id. supra note 13*
[35] Amy Mainzer, et al., The Future of Planetary Defense in the Era of Advanced Surveys, Bulletin of the American Astronomical Society, (November 3, 2021), available at: https://insu.hal.science/insu-03413444/
[36] NASA, Planetary Defense Coordination Office, Available at: https://www.nasa.gov/wp-content/uploads/2017/09/pdco-brochure-07262022a.pdf
[37] *Id. Supra note 15*
[38] International Astronomical Union, Minor Planet Center, available at: https://minorplanetcenter.net/.
[39] *Id. Supra note 38*

Center for Near-Earth Object Studies

The MPC transmits information to the Center for Near-Earth Object Studies (CNEOS), which is operated at NASA's Jet Propulsion Laboratory. CNEOS computes high-precision orbits for NEOs, used to predict close approaches to Earth and conduct comprehensive impact possibility analysis.[40] CNEOS uses two systems to monitor NEOs for potential impact threats. Scout is an impact hazard assessment system focusing on short-term monitoring of unconfirmed potential NEO discoveries to provide an initial assessment of impact risk. Sentry is an impact monitoring system that focuses on long-term impact monitoring by "analyz[ing] the full range of possible orbits for each NEO, searching for potential Earth close approaches over the next 100 years and calculating the probability of impact for each."[41] These systems enable rapid risk analysis and inform NASA and other agencies when and how to respond to a potential NEO threat.

<u>Capabilities</u>

Ground-Based Capabilities

Ground-based facilities are essential for the discovery and characterization of NEOs. Two programs—the Catalina Sky Survey (CSS) and the Panoramic Survey Telescope and Rapid Response System (Pan-STARRS)—have accounted for between 80% and 92% of NEOs discovered every year for the past decade.[42]

CSS, operated by the University of Arizona's Lunar and Planetary Laboratory, uses three telescopes (1.5-meter, 1-meter, and 0.7-meter instruments) located in the Santa Catalina Mountains north of Tucson, Arizona. [43] Pan-STARRS, operated by the University of Hawaii's Institute for Astronomy, consists of two 1.8-meter telescopes near the summit of Haleakala on the Island of Maui.[44]

Ground-based facilities play a crucial role in characterization. Ground-based radar observations, typically conducted at shared-use facilities, can routinely reduce orbital uncertainties by several orders of magnitude with only a few minutes of observation.[45] Following the collapse of the Arecibo Observatory in 2020, NASA has relied heavily on the Goldstone Solar System Radar in California for planetary defense radar operations. While Goldstone is a valuable asset, it is significantly less sensitive than Arecibo—approximately 15 times less so—and cannot fully replace Arecibo's capabilities for detailed NEO characterization.

NASA plans to use the Vera C. Rubin Observatory (VCRO) in part to conduct follow-up observations and assist in identifying fainter or smaller NEOs. While not yet operational, the VCRO is expected to significantly contribute to NEO survey completeness once online.

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[40] NASA Jet Propulsion Laboratory, Center for NEO Studies (CNEOS), available at: https://cneos.jpl.nasa.gov/about/cneos.html
[41] NASA Jet Propulsion Laboratory, Impact Risk: Introduction, available at: https://cneos.jpl.nasa.gov/risk/intro.html
[42] Tommy Grav, et al., The NEO Surveyor Near-Earth Asteroid Known Object Model, The Planetary Science Journal, (December 2023), available at: https://iopscience.iop.org/article/10.3847/PSJ/ad072e/pdf
[43] University of Arizona College of Science, About the Catalina Sky Survey, Available at: https://catalina.lpl.arizona.edu/about
[44] University of Hawaii Institute for Astronomy, Pan-STARRS, available at: https://www2.ifa.hawaii.edu/research/Pan-STARRS.shtml
[45] *Id. Supra note 13*

Space-Based Capabilities

NASA initiated the NEOWISE project, an asteroid-hunting mission that repurposed the Wide-field Infrared Survey Explorer (WISE) space telescope in 2013 to complement ground-based observations.[46] NEOWISE used infrared imaging to detect and measure precise NEO sizes, particularly dark ones that are difficult to see with visible light. It was the only space-based mission dedicated to NEO detection until its retirement in 2024 after more than a decade of service.

NASA's follow-on capability will be the Near-Earth Object Surveyor, a dedicated infrared space telescope.[47] In a 2018 study, the National Academies of Sciences, Engineering, and Medicine concluded that "a space-based thermal-infrared telescope designed for discovering NEOs is the most effective option for meeting the George E. Brown Act completeness and size requirements in a timely fashion."[48]

NEO Surveyor "is optimized for the detection, categorization, and characterization of NEOs and has no other science objectives."[49] It will carry a 50-centimeter infrared telescope capable of detecting bright and dark near-Earth objects.[50] Once launched, it will operate around the Sun-Earth L1 Lagrange point to conduct "a five-year baseline survey to find at least two-thirds of the near-Earth objects larger than 140 meters."[51] The NASA Authorization Act of 2022 directed the Administrator to continue development of NEO Surveyor,[52] and NASA now expects to launch NEO Surveyor no later than June 2028.[53]

Modeling, Prediction, and Integration

After gathering NEO data and measurements, agencies use modeling and prediction capabilities to assess risk and inform potential responses.

Consequence Assessment

Consequence assessment calculations predict various potential impact effects, including blast, ignition, seismic, cratering, fireball casualties, and longer-term effects like ejected volatiles or dust.[54] These models inform agency emergency responses and can minimize harm in scenarios where a NEO threat cannot be mitigated.[55]

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[46] California Institute of Technology, IPAC, The NEOWISE Projects, Finding, Tracking and Characterizing Asteroids, available at: https://neowise.ipac.caltech.edu/.
[47] NASA, Near-Earth Object Surveyor, available at: https://www.jpl.nasa.gov/missions/near-earth-object-surveyor/.
[48] National Academies of Sciences, Engineering, and Medicine, Finding Hazardous Asteroids Using Infrared and Visible Wavelength Telescopes, (2019), available at: https://www3.nasa.gov/sites/default/files/atoms/files/nasem_report_finding_hazardous_asteroids.pdf.
[49] Tom Hoffman, et al., Near-Earth Object Surveyor Overview, IEEE Aerospace Conference, (2022), available at: https://ntrs.nasa.gov/citations/20230006962
[50] NASA Jet Propulsion Laboratory, NEO Surveyor, available at: https://www.jpl.nasa.gov/missions/near-earth-object-surveyor/
[51] *Id. Supra note 50*
[52] *Id. supra note 25*
[53] *Id. Supra note 15*
[54] *Id. supra note 13*
[55] *Id. supra note 13*

Asteroid Threat Assessment Project

At NASA Ames Research Center, the Asteroid Threat Assessment Project (ATAP) conducts planetary defense-related analysis. Due to "[t]he amount of damage produced by such events is not easily predicted owing to uncertainties related to the object's physical properties and structure, the breakup process, and atmospheric energy deposition."[56] ATAP's Probabilistic Asteroid Impact Risk (PAIR) model simulates "the potential for any given impact scenario to survive the passage through the atmosphere and produce destructive effects at any selected points on Earth's surface."[57]

Mitigation Modeling

Mitigation modeling supports decision-making on the appropriate response to a NEO threat. These simulations can evaluate the potential effectiveness of mitigation strategies like deflection or disruption and integrate mission design options.

Near-Earth Object Threat Response

Mitigation Techniques

The National Science and Technology Council (NSTC) identified NASA as the agency "best suited to lead the development, testing, and flight of technology demonstration missions aimed at providing NEO mitigation techniques." An evaluation of Rapid Mission Architectures found that the most feasible techniques for NEO mitigation included kinetic impact, nuclear, ion beam deflection, and gravity tractors.[58]

Double Asteroid Redirect Test

NASA launched the Double Asteroid Redirect Test (DART) mission in 2021, the first test of asteroid deflection technology using a kinetic impactor. In 2022, DART successfully impacted Dimorphos, altering its orbit and demonstrating the feasibility of deflection as a planetary defense method.[59]

Planetary Defense Strategy

In 2018, the NSTC released its first "National Near-Earth Object Preparedness Strategy and Action Plan"[60] to facilitate the organization and coordination of planetary defense activities among Federal agencies. In April of 2023, NSTC released an updated "National Preparedness Strategy and Action Plan for Near-Earth Object Hazards and Planetary Defense."[61] The updated strategy builds off the principles in the 2018 report, evaluates progress over the last five years, and identifies areas of focus for future government planetary defense efforts.

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[56] *Id. supra note 13*
[57] *Id. Supra note 15*
[58] *Id. supra note 13*
[59] NASA, Double Asteroid Redirection Test, Available at: https://science.nasa.gov/planetary-defense-dart/
[60] National Science and Technology Council, National Near-Earth Object Preparedness Strategy and Action Plan, (June 2018), available at: https://www.nasa.gov/wp-content/uploads/2022/03/ostp-neo-strategy-action-plan-jun18.pdf
[61] *Id. Supra note 11*

In particular, the 2023 strategy highlights two key areas of focus. First, it calls for improving planetary defense technical capabilities to enhance rapid detection, tracking, and characterization of NEOS and assess their potential threats of impact. NSTC affirms that "acquisition of improved deep space radars with planetary range for PHO observation and imaging" would strengthen technical capabilities.[62] The second focus area is increased international cooperation, particularly via multilateral initiatives and engaging with new global partners.

The strategy establishes six goals for planetary defense over the next decade and sets forth strategic actions to support each goal:

- Goal 1: Enhance NEO detection, tracking, and characterization capabilities.
- Goal 2: Improve NEO modeling, prediction, and information integration.
- Goal 3: Develop technologies for NEO deflection and disruption missions.
- Goal 4: Increase international cooperation on NEO preparedness.
- Goal 5: Strengthen and routinely exercise NEO impact emergency procedures and action protocols.
- Goal 6: Improve U.S. management of planetary defense through enhanced interagency collaboration.

To complement the NSTC plan, NASA also released its "NASA Planetary Defense Strategy and Action Plan."[63] NASA's strategy focuses on planetary defense activities at the agency level and makes recommendations for improvement. The NASA strategy mirrored the NTSC's first six goals, and described applications specific to NASA, and also added two additional goals:

- Goal 7: Improve organization of NASA's planetary defense activities.
- Goal 8: Enhance NASA's strategic communications related to planetary defense.

The NASA strategy also directly addresses agency-specific challenges, including:

- Limitations to risk assessment caused insufficient NEO observation, modeling, and prediction capabilities;
- Lack of technological preparedness for hazardous NEO mitigation (with only one mission completed to date);
- Insufficient federal planetary defense coordination; and
- Competition for Planetary Science funding for planetary defense.

International Cooperation

Given the potentially existential threat posed by NEOs, planetary defense is an inherently global effort. NASA has multiple forums for international engagement, including two United Nations-endorsed groups for planetary defense.

NASA coordinates the International Asteroid Warning Network (IAWN), which facilitates the sharing of NEO observations and analysis and coordinates NEO observation campaigns between

[62] *Id. Supra note 11*
[63] *Id. Supra note 15*

member states.[64] The Space Mission Planning Advisory Group (SMPAG) focuses on hazardous NEO mitigation and facilitates international mitigation and response efforts for NEO threats.[65] SMPAG also allows members to initiate joint NEO technology development efforts.[66] PDCO manages NASA's involvement in both organizations.

Considerations

Organization

Planetary Defense Coordination Office

The *Planetary Science Decadal* recommends that NASA's Planetary Defense Coordination Office be "robustly supported and sustained as the critical organization to advance U.S. planetary defense capabilities and initiatives in the next decade and beyond." It advises sustained funding for regular planetary defense activities, technologies, and demonstration missions.

NEO Modeling Working Group

The NEO MWG integrates observation, modeling, and risk communication to support decision-making and public awareness in the event of a credible threat. It operates without dedicated agency funding, yet plays a key role in consequence assessment, mitigation modeling, and information integration. Reliable funding would enhance preparedness and enable timely responses.

NEO Survey

The 140-meter size threshold established by the George E. Brown Act remains a reasonable target for NEO detection, but smaller NEOs can still pose regional threats and should not be ignored.[67] Progress toward the 90% goal of the George E. Brown Act remains incomplete (as of 2021, only one-third of all NEOs over 140 meters have been discovered), reinforcing the urgency of launching the NEO Surveyor mission.[68]

Capabilities

Ground-Based Capabilities

The loss of the Arecibo Observatory eliminated one of the world's most sensitive planetary radar facilities. Additional investments in radar infrastructure and observation time at existing facilities are needed to fill this gap. The upcoming Vera C. Rubin Observatory (VCRO), funded by NSF, is expected to play a major role in identifying faint or fast-moving NEOs once operational.

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[64] International Asteroid Warning Network, About IAWM, Available at: https://iawn.net/about.shtml
[65] Space Mission Planning Advisory Group, Terms Of Reference For The Near-earth Object Threat Mitigation Space Mission Planning Advisory Group, (September 2019), Available at: https://www.cosmos.esa.int/web/smpag/terms_of_reference_v2
[66] *Id. Supra note 13*
[67] A finding of the Planetary Decadal states that "The Brown Act survey goals still provide a reasonable size threshold (≥140 m), completion level (>90%), and timetable (survey completion in <10 years from now). However, the most likely impactors are NEOs less than 140 m in diameter and these can pose a significant threat of local damage. It is therefore important to detect, track, and characterize as much of this smaller population as possible in addition to meeting the act's goals."
[68] *Id. Supra note 13*

However, dedicated research programs must focus on NEO characterization using ground-based radar. Furthermore, stronger and more formalized interagency coordination between NASA and the NSF may be needed to ensure the use of the scientific and observational assets for planetary defense.[69]

Space-Based Capabilities

While the NEOWISE mission was the only dedicated space-based asset for asteroid detection, other observatories such as the James Webb Space Telescope have occasionally been used for NEO science. Nevertheless, they are not optimized for survey or rapid detection. The NEO Surveyor mission is critical to achieving the detection goals in the Brown Act and ensuring a comprehensive, long-term planetary defense strategy.

Data Processing

Once the NEO Surveyor and the Vera C. Rubin Observatory are operational, NASA expects a tenfold increase in NEO detection rates. This surge in data will require enhanced processing infrastructure, coordination, and storage to ensure that observations are converted into timely and actionable information.

Threat Response

Mitigation strategies depend heavily on accurate characterization data. As the Planetary Defense Decadal has noted, "uncertainty in the size of detected NEOs translates into uncertainty concerning potential impact energy." This underscores the need for ongoing detection, tracking, and modeling improvements to reduce risk and ensure that any mitigation response is appropriately tailored to the threat.

Apophis

The asteroid Apophis, which is approximately 1,100 feet in diameter, will make a close pass by Earth in April 2029, coming within about 20,000 miles of Earth's surface.[70] While NASA has determined that Apophis poses virtually no risk of hitting Earth, its close approach provides an opportunity to study the asteroid in detail. NASA is planning a ground observation campaign for the close approach and will also repurpose the OSIRIS-REx spacecraft, which collected samples of a different asteroid, to conduct a post-flyby rendezvous with Apophis and make additional observations from space.[71] However, there is interest in conducting additional missions to take advantage of the Apophis pass by, including Blue Origin's proposal to land a spacecraft with scientific instruments on the asteroids surface and a proposed mission to perform a "CAT scan" of the interior of Apophis.[72]

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[69] *Id. Supra note 13*
[70] NASA, Apophis Facts, Available at: https://science.nasa.gov/solar-system/asteroids/apophis-facts/
[71] NASA, OSIRIS-APEX, Available at: https://science.nasa.gov/mission/osiris-apex/
[72] Jeff Foust, Companies offer proposals for Apophis asteroid missions, SpaceNews, (April 23, 2024), Available at: https://spacenews.com/companies-offer-proposals-for-apophis-asteroid-missions/#:~:text=That%20includes%20a%20proposal%20by,remaining%20there%20through%20the%20flyby.