NON-GOVERNMENTAL NEO DISCOVERY INTERNATIONAL PROGRAMS INCLUDING THE ASTROMETRICA SOFTWARE

Nancy C. Wolfson [(1)],
[(1)The] American Institute of Aeronautics and Astronautics, nancyplanetarydefense@gmail.com, Minnesota Ave NE, Washington DC 20019, - 202-345-1147

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Near-Earth Objects (NEOs) pose a significant threat to Earth. The Chelyabinsk meteor impact in 2013 served as a stark reminder of this danger, releasing energy equivalent to 30 times the Hiroshima atomic bomb, causing widespread infrastructure damage and injuring approximately 1600 individuals. Apophis, is an asteroid approximately 370 meters in diameter (roughly the size of three and a half football fields), This asteroid is expected to make a particularly close approach to Earth on April 13, 2029, highlighting the critical need for enhanced NEO observation. Current detection efforts have cataloged only a fraction of the estimated NEO population, with a tracking rate of less than 0.1%. This low rate is primarily attributed to factors such as time-consuming detection pipelines and software limitations in identifying faint, rapidly moving objects. This paper will explore the importance of expanding our NEO observation capabilities by:

1. Incorporating the contributions of Next-Generation Space Science (young professionals) through initiatives such as the "Developing CNN-Based Detection of Near-Earth Objects" effort.
2. Leveraging the efforts of non-governmental institutions and independent NEO detection campaigns. These campaigns utilize various technologies, including Astrometrica, a powerful tool for astrometric data reduction of CCD images. Key features of Astrometrica include: Image Processing: Facilitates automatic reference star identification, moving object detection and identification, and a "Track and Stack" function for following fast or faint objects. Data Integration and Sharing: Enables data sharing with the Minor Planet Center (MPC) and facilitates the downloading of MPCOrb data.

Furthermore, this paper will introduce our recently formed NEO Detection Program "Look Up is an Asteroid". This program aims to: a) Contribute significantly to the discovery of NEOs using Astrometrica, b) To provide comprehensive trainings to other professionals from various sectors within the space industry in order to foster their involvement in the field, and c) Unite currently fragmented international independent or non-governmental NEO Discovery efforts into a cohesive network. This unified approach will foster the growth and development of new independent NEO discovery programs worldwide. This paper will demonstrate that these independent efforts are not merely educational exercises, but genuine scientific endeavors that: Contribute significantly to our understanding of NEOs (NEO Catalog) and inspire the next generation of researchers in planetary defense. By integrating the valuable insights and data generated by these independent efforts, the global community can significantly enhance NEO discovery capabilities and strengthen our collective efforts to protect Earth from potential impacts.

Introduction

Asteroids and comets are remnants of the Solar System's formation, pose a significant but infrequent danger to life, cities, and infrastructure on Earth. These near-Earth objects (NEOs) can disrupt various societal aspects in affected areas, including business and financial dynamics. Government-led initiatives, spearheaded by major space agencies such as NASA, ESA, and JAXA, form a crucial cornerstone of planetary defense efforts, with other agencies contributing in varying capacities. However, a comprehensive understanding and robust tracking of Near-Earth Objects (NEOs) necessitates a collaborative paradigm that transcends the traditional boundaries of national space agencies. The multifaceted endeavour to characterize our solar system's NEO population demands the concerted efforts of a diverse array of actors and approaches to effectively address the complex technical and non-technical dimensions inherent in planetary defense. This manuscript offers a comprehensive and up-to-date overview of notable non-governmental initiatives in the realm of planetary defense and NEO studies. To illuminate the evolutionary trajectory and lessons gleaned within this sector, the analysis will focus on two specific, and seemingly disparate, initiatives, tracing their development and highlighting key insights gained.

1. Understanding the Basics of Near-Earth Objects (NEOs)

1.1 Early Astronomical Observations:

While the contemporary field of Planetary Defense is still considered to be in its formative stages, the systematic identification and cataloging of Near-Earth Objects (NEOs) represent a continuum of astronomical inquiry that stretches back to antiquity, albeit initially limited by the prevailing technological constraints of those eras. Early astronomers like Galileo and Johannes Kepler made observations of celestial bodies that would later be classified as NEOs.

1.2 NEO Discovery Pre-Scientific Engagement: Prior to the formalization of astronomical science, ancient civilizations engaged in systematic observation of the celestial sphere, recording anomalous phenomena that, in retrospect, provided foundational data for later astronomical investigations. The year 1801 marks a significant inflection point with Giuseppe Piazzi's discovery of Ceres, conventionally recognized as the genesis of systematic asteroid detection.

1.3 NEO Discovery Emergence of Impact Awareness: In the decades spanning the 1960s and 1970s, a discernible shift occurred within the scientific community. While not yet articulated under the rubric of "planetary defense," researchers began to investigate the potential ramifications of large-scale extraterrestrial impacts. These preliminary studies focused on the geological stratum, analyzing the imprint of historical impact events and their putative correlation with episodes of mass biotic extinction. This nascent line of inquiry laid critical groundwork for the eventual emergence of a dedicated field concerned with planetary protection strategies.

1.4 Recognizing the Threat

- **Near-Earth Object (NEO)** is any asteroid or comet whose orbit brings it within 1.3 astronomical units (AU) of the Sun. For context, 1 AU is the average distance between the Earth and the Sun. This definition means that their paths can bring them relatively close to Earth's orbit.
- **Near-Earth Asteroid (NEA)** is a *type* of NEO. As the name suggests, it is an asteroid whose orbit brings it within that same 1.3 AU of the Sun, potentially close to Earth's orbit. So, all NEAs are NEOs, but not all NEOs are NEAs (some are comets). The vast majority of NEOs are asteroids.
- The size of an NEO is an important factor in determining the potential damage it could cause if it were to impact Earth.

- **Tiny NEOs (Smaller than 40 meters / 130 feet):** These small objects are the most common. If one of these entered Earth's atmosphere, it would likely burn up completely due to friction. While they probably wouldn't cause major damage to a city, a mid-air explosion or a direct hit on a populated area could still lead to localized damage.

- **Mid-Sized NEOs (Between 40 meters and 1 kilometer / 0.6 miles):** These are considered potentially hazardous. If an NEO in this size range were to impact Earth, it could cause significant destruction. The exact level of damage would depend on how big the object is, how fast it's traveling, the angle at which it hits, and where it strikes.

- **Large NEOs (Larger than 1 kilometer / 0.6 miles):** These are rare, but they pose the biggest threat. An impact from an NEO of this size could lead to catastrophic, global damage.

2. OVERVIEW: NEAR-EARTH OBJECT (NEO) DISCOVERY ORIGINS AND DEVELOPMENT

2.1 Early Method of NEO Discovery: Before the advent of modern digital surveys, the discovery of Near-Earth Objects (NEOs) relied on two primary methods:

- **Visual Observations:**

Early NEO discoveries relied on skilled observers identifying moving point sources against the fixed stellar background through optical telescopes. While fundamental, this method was limited by the observer's field of view, sensitivity, and the transient nature of observations.

- **Photographic Surveys:**

The advent of astronomical photography marked a significant step forward. Long-exposure photographic plates allowed for the capture of fainter objects and the detection of motion by comparing images taken at different times. This introduced the concept of systematic sky surveys, albeit with limitations in terms of processing time and sensitivity compared to later digital methods. Key observatories involved in these early photographic surveys included the Palomar Observatory and the Lowell Observatory, which made significant contributions to the early census of NEOs.

2.2 Modern Era of NEO Discovery:

Automated Surveys – CCD Cameras:

The integration of Charge-Coupled Devices (CCDs) into telescope systems revolutionized NEO detection. CCDs offer significantly higher quantum efficiency (the ratio of detected photons to incident photons) and a wider dynamic range compared to photographic plates. Coupled with powerful computing infrastructure and specialized software, dedicated survey telescopes could now automatically scan large swathes of the sky, detect moving objects based on pixel-level changes between sequential exposures, and rapidly identify potential NEOs. Algorithms employing techniques like image subtraction and object tracking became crucial in processing the vast amounts of data generated. Examples of such surveys include the Lincoln Near-Earth Asteroid Research (LINEAR), the Catalina Sky Survey (CSS), and Pan-STARRS (Panoramic Survey Telescope and Rapid Response System), which have been instrumental in cataloging the majority of known NEOs. These surveys often utilize wide-field telescopes with apertures ranging from 0.5 to several meters, achieving limiting magnitudes of 20 or fainter, enabling the detection of kilometer-sized objects at significant distances. These technological and observatory advancements form the bedrock of our ability to discover, track, and characterize potential planetary threats.

Advancements in Detection and Characterization

a) **Discovery:** Observatories scan the sky, helping scientists identify potentially hazardous objects such as asteroids and comets. By detecting these objects early on, we can assess their trajectory and potential threat to Earth.

b) **Tracking:** Once a potentially hazardous object is discovered, observatories continue to track its path accurately. This data allows scientists to predict its future trajectory, helping us assess the possibility of an impact with Earth.

c) **Characterization:** Observatories provide valuable data about the size, composition, and physical properties of hazardous objects. This information helps scientists determine the most effective ways to mitigate a potential impact if it becomes necessary.

d) **Alert Systems**: Observatories work in conjunction with global alert systems, notifying relevant organizations and authorities when a potentially hazardous object is predicted to have a high chance of impacting Earth. This allows for timely response and planning for planetary defense measures.

2.3 Modern Era of NEO Discovery:

Introducing the Astrometrica Software (amateur astronomer and citizen science)

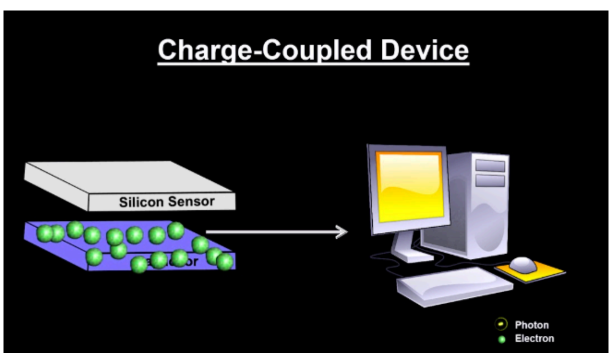
Astrometrica is an interactive software tool for scientific grade astrometric data reduction of CCD images, focusing on measurements of the minor bodies of the solar system (asteroids, comets and dwarf planets). **Is the Astrometrica Software a Stepping Stone or the Ultimate End Goal in NEO Discovery?**

Understanding the Astrometrica Technical Capabilities: Astrometrica was created by Herbert Raab, is a crucial tool for both professional and amateur astronomers involved in discovering, tracking, and characterizing minor bodies such us Near-Earth Objects (NEOS) in our solar system

The Astrometrica current version for the Windows 32bit operating system family is the successor of a DOS based software that was used for astrometric data reduction of photographic films (1990), and later CCDs (1993). Features of the current version include:

- Reads FITS (8, 16 and 32 bit integer files) and SBIG image files. The size of the images is only limited by the available memory.
- Automatic image calibration (Dark Frame and Flat Field correction).
- Blinking with automatic image alignment.
- Zoom and 'Magnifying Glass' for closeup image inspection.
- Automatic reference star identification.
- Automatic moving object detection and identification.
- 'Track and Stack' function to follow fast or very faint moving objects.
- Access to the complete MPC database of orbital elements (MPCOrb).
- Access to new-generation star catalogs (Gaia DR3, ATLAS REFCAT, PPMXL, UCAC 4, and CMC-15).
- Includes Internet access (Send e-mail to the MPC, download the MPCOrb databse or query reference star catalogs at VizieR).

Image: *Astrometrica* is a interactive software tool for scientific grade astrometric data reduction of CCD images, focusing on measurements of the minor bodies of the solar system (asteroids, comets and dwarf planets).



Astrometrica Software: What it's used for:

- Precise Position Measurement: Astrometrica allows users to accurately determine the Right Ascension (RA) and Declination (Dec) of celestial objects in astronomical images. This is crucial for tracking their movement and predicting their orbits.
- Moving Object Detection: The software has features to blink through a series of images, making it easier to identify objects that have moved relative to the background stars, which is a key technique for discovering new asteroids and comets.
- Reference Star Matching: It automatically identifies and matches stars in the image with entries in various star catalogs (e.g., Gaia DR3, ATLAS REFCAT, PPMXL, UCAC 4, CMC-15), which is essential for calibrating the image and establishing an accurate coordinate system.
- Image Calibration: Astrometrica supports basic image calibration steps like dark frame and flat field correction to improve the quality of the scientific data.
- Data Reporting: It can generate reports in the format required by the Minor Planet Center (MPC) for submitting astrometric measurements of minor planets.
- "Track and Stack": This function allows users to combine multiple images while compensating for the motion of a fast or faint moving object, increasing the signal-to-noise ratio and making it easier to measure the object's position.
- Access to Databases: It provides direct access to the complete MPC database of orbital elements (MPCOrb) and allows querying reference star catalogs online via VizieR.

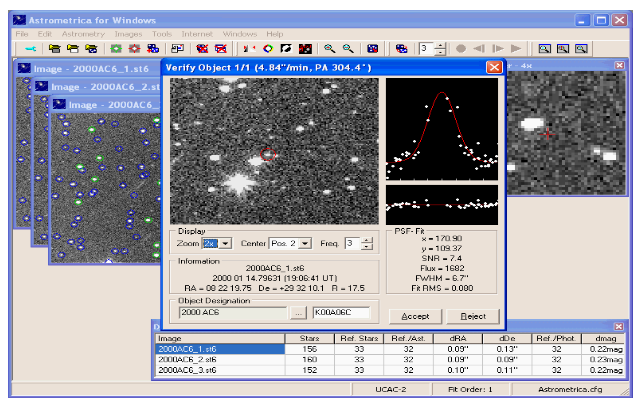


Image: Immediately following automated measurement, three images display a detected minor planet (circled in red). The software identified suitable reference stars (green circles) and rejected unsuitable ones (yellow circles). A central dialog box prompts object verification. Below the zoomed image, the object's calculated coordinates and magnitude are shown. Two graphs and supplementary data visualize the fitted Point Spread Function. The software has identified this object as minor planet 2000 AC6.

Other Technical Properties:

- Operating System: Primarily designed for the Windows (32-bit and 64-bit) operating system family. A legacy DOS version also exists but is no longer supported.
- Image Format Support: Reads FITS (8, 16, and 32-bit integer, and 32-bit float) and SBIG image files. The image size is limited only by the available computer memory.
- Star Catalog Support: Compatible with several major star catalogs for accurate astrometric reduction.
- Automatic Processing: Includes features for automatic image calibration, reference star identification, and moving object detection.
- Interactive Tools: Offers interactive tools like blinking with automatic alignment, zoom, and a magnifying glass for detailed image inspection.
- Connectivity: Provides internet access for downloading the MPCOrb database and querying star catalogs.
- Output Formats: Can export images to JPEG or BMP format and save loaded images as FITS files.
- Hardware Requirements: Recommended specifications include a PC with a 2 GHz CPU, 4 GB of RAM, and a compatible Windows operating system. Larger images may require more memory and a faster CPU.

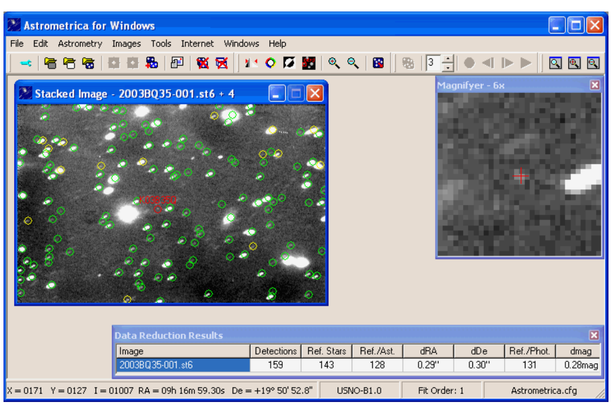


Image: This image is the result of automatically stacking five frames using Astrometrica software, a technique employed to enhance the visibility of a faint, fast-moving object. The motion compensation applied during the stacking process, crucial for a clear view of the object, causes the stars to appear as streaks. Look slightly to the right of the bright star near the center, and you'll find the 21st magnitude asteroid 2003 BQ35, moving at about 1 arc second per minute, appearing as a tiny dot.

Astrometrica Campaigns Partners:

International Astronomical Union (IAU): Governing body for astronomy, including NEO-related activities.

Minor Planet Center (MPC): Is an organization dedicated to the tracking and observation of small bodies in the solar system, including asteroids and comets. It is part of the International Astronomical Union (IAU) and has been a key institution in cataloging and disseminating data about these objects. The Minor Planet Center (MPC) was founded in 1947 by astronomer Paul W. H. Chodas It was established to provide a centralized location for the collection and dissemination of observations of minor planets (which were then often referred to as asteroids), maintain a comprehensive catalog, and provide information to the astronomical community and the public. This includes tracking their orbits, predicting their positions, and issuing alerts about potential close approaches to Earth.

3. WHAT IS PLANETARY DEFENSE?

Asteroids and comets, remnants of the Solar System's formation, pose a significant but infrequent danger to life, cities, and infrastructure on Earth. These near-Earth objects (NEOs) can disrupt various societal aspects in affected areas, including business and financial dynamics.

Planetary Defense constitutes a multidisciplinary and increasingly critical field of scientific and technological endeavor focused on the proactive identification, comprehensive characterization, and strategic mitigation of the impact risk posed by the population of Near-Earth Objects (NEOs), encompassing both asteroidal and cometary bodies, that exhibit the potential for a collision trajectory with Earth. This domain transcends purely astronomical observation, integrating principles from celestial mechanics, planetary science, aerospace engineering, materials science, nuclear physics (in the context of specific mitigation scenarios), and international policy.

3.1 Planetary Defense Encompasses:

a) NEO Detection and Cataloging: This involves the systematic and continuous surveying of the near-Earth space environment utilizing both ground-based and space-based telescopic facilities, employing various spectral ranges (visible, infrared, radar) to discover, track, and precisely determine the orbital parameters of

NEOs. Advanced astrometric and photometric techniques are employed to refine orbital predictions and assess potential future Earth close approaches.

b) NEO Characterization: Beyond mere detection, a critical aspect involves the physical and compositional characterization of identified NEOs. This encompasses determining their size, shape, mass, rotational properties, and surface composition through spectroscopic analysis, radar imaging, and potentially future in-situ reconnaissance missions. This data is crucial for accurately modeling potential impact consequences and for devising effective mitigation strategies.

c) Impact Risk Assessment and Modeling: Sophisticated computational models are developed and continuously refined to predict the probability of Earth impact for individual NEOs over various timescales. These models incorporate orbital uncertainties, gravitational perturbations from solar system bodies, and non-gravitational forces.. Risk assessment frameworks integrate impact probability with potential consequences, considering factors such as object size, impact velocity, and potential impact location.

d) Mitigation Strategy Development: A significant area of research focuses on developing and validating technologies and strategies to alter the trajectory of a hazardous NEO. These strategies can be broadly categorized as: **a) Deflection:** Gradually altering the object's orbit over time using methods such as kinetic impactors (high-velocity non-explosive collision), gravity tractors (utilizing the gravitational pull of a spacecraft), ion beam deflectors, and potentially directed energy systems (e.g., lasers, microwave beams). **b) Disruption** (as a last resort for larger, imminent threats): Fragmenting the object into smaller, less hazardous pieces, potentially through nuclear or non-nuclear explosive devices. This strategy carries significant risks and requires careful consideration of fragment dispersion and long-term consequences. Here are four examples that have been discussed within the PD-NEO community in recent years.

- **Kinetic Impactors:** This method involves sending a spacecraft to collide with an asteroid to alter its trajectory. NASA's DART mission was a successful demonstration of this technique.
- **Gravity Tractors:** This concept involves using the gravitational pull of a spacecraft to gradually change an asteroid's orbit over time.
- **Laser Ablation:** Directing powerful lasers at an asteroid could vaporize its surface material, creating a thrust that alters its trajectory.
- **Ion Beam Deflection:** Using ion beams to gradually push an asteroid off its collision course is another potential method.

e) International Coordination and Policy: Recognizing the global implications of an asteroid impact, a crucial element of planetary defense involves fostering international collaboration among space agencies, research institutions, governments, and the United Nations. This includes establishing communication protocols, coordinating observation efforts, sharing data, developing international legal frameworks for mitigation actions, and planning for potential impact scenarios and disaster response. Organizations like the IAWN and SMPAG play pivotal roles in this international coordination. Despite significant advancements in identifying and tracking near-Earth objects (NEOs), planetary defense remains an ongoing challenge. The vastness and diversity of the NEO population, coupled with technological limitations and international coordination challenges, continue to present hurdles that require our attention.

f) Public Awareness and Support: International cooperation helps generate public awareness about the importance of planetary defense. By working together, nations can educate their citizens and raise awareness about the potential threats we face from space, fostering support for funding, research, and policy initiatives. Public engagement is vital for sustaining long-term efforts and securing public support for planetary defense.

3.2. A Wake Up call – Asteroid impact is a real threat

Key Historical Records of Catastrophic Asteroid Events for Context

While Earth has experienced countless asteroid impacts throughout its history, with smaller impacts being relatively frequent, only a fraction of the resulting craters have been identified across various countries. Scientists continuously monitor near-Earth objects to assess any potential future impact risks. Here are three key historical records of catastrophic asteroid events for context:

- **Impact and Extinction: The Asteroid That Changed Life on Earth:**

The Chicxulub impact event, which occurred approximately 66 million years ago created a massive crater in what is now the Yucatán Peninsula of Mexico. This impact, likely caused by a bolide estimated to be about 10 to 15 kilometers in diameter striking at a velocity of tens of kilometers per second, released an immense amount of energy, leading to global cataclysms such as widespread wildfires, megatsunamis, and a prolonged impact winter caused by the injection of massive quantities of dust and sulfate aerosols into the stratosphere. These environmental changes are believed to have been the primary drivers of the extinction of non-avian dinosaurs and many other life forms.

- **The Tunguska Event**:

It occurred on the morning of **June 30, 1908**, remains one of the most significant and perplexing impact events in recorded history. Over the remote Podkamennaya Tunguska River region of Siberia, Russia, a massive aerial explosion with an estimated energy yield equivalent to **10-15 megatons of TNT** (comparable to the early atomic bombs) flattened an estimated **830 square miles (2,150 square kilometers)** of boreal forest. This is an area roughly the size of a major metropolitan city.

- **The Chelyabinsk Meteor Impact in 2013:**

Served as a stark reminder of this danger, releasing energy equivalent to 30 times the Hiroshima atomic bomb, causing widespread infrastructure damage and injuring approximately 1600 individuals.

Image: Fireball and Bolide Data by NASA Jet propulsion Laboratory (JPL) Center for Near Earth Objects Study (CNEOS) April, 2025.

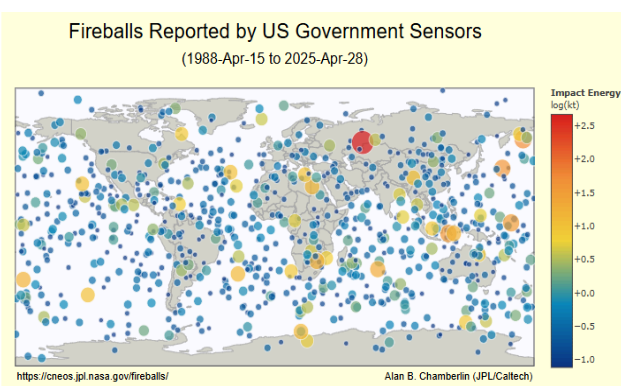


Image: April 2025 Map: The accompanying table provides information on the date and time of each reported fireball event with its approximate total optical radiated energy and its calculated total impact energy. When reported, the event's geographic location, altitude and velocity at peak brightness are also provided. Note that data are not provided in real-time and not all fireballs are reported. A blank (empty) field in the table indicates the associated value was not reported.

Showing 1 to 10 of 1,022 entries

Peak Brightness Date/Time (UT)	Latitude (deg.)	Longitude (deg.)	Altitude (km)	Velocity (km/s)	Velocity Components (km/s)			Total Radiated Energy (J)	Calculated Total Impact Energy (kt)
					vx	vy	vz		
2025-04-28 15:01:15	45.1S	67.3E	31.4					3.4e10	0.12
2025-04-21 09:27:34	29.1S	151.6E	41.0					2.3e10	0.082
2025-04-08 14:16:48	32.2S	10.4E	44.9	22.6	-20.4	9.7	-0.4	2.1e10	0.076
2025-03-29 08:12:43	49.3S	14.3E	21.6	12.3	-8.9	-5.2	6.8	5.9e10	0.19
2025-03-27 16:05:23	14.3N	111.5W	38.1	21.3	-7.3	19.8	-2.8	104.5e10	2.4
2025-03-24 05:51:43	70.4S	114.2E	21.5	28.2	-0.9	-24.8	13.4	4.9e10	0.16
2025-03-21 05:06:26	22.8S	123.5E	54.2					3.9e10	0.13
2025-03-18 17:48:32	1.5S	30.4W	27.0	20.1	-6.6	18.7	-3.1	11.0e10	0.33
2025-03-13 09:46:51	7.1S	75.9E	38.0	28.1	-28.1	0.1	-0.5	75e10	1.8
2025-02-22 10:26:08	28.1N	120.0E	46.7	15.0	-5.0	-11.1	-8.8	5.5e10	0.18

4. FORMALIZATION OF PLANETARY DEFENSE SPEARHEADED BY GOVERNMENTAL AGENCIES (ESA, NASA and JAXA)

4.1 ESA (The European space Agency)

The Dinosaurs Didn't have a Space Agency, But We Do. The 1990s marked a crucial period where the scientific space community initiated actions that can be recognized as the early formal groundwork for what we now understand as planetary defense.

The Birth of ESA (May 30, 1975):

Official Formation: The European Space Agency (ESA) is formally established with the signing of the ESA Convention by ten founding nations. In Europe, a foundational element in the nascent stages of planetary defense was the establishment of the European Space Agency (ESA) in 1975. This intergovernmental organization, dedicated to space exploration and associated scientific research, comprises 22 member states, with the respective national space agencies of these countries represented on ESA's governing Council.

ESA: A Brief Overview Strategic Approach to Near-Earth Object (NEO) Discovery

ESA has progressively built its efforts in Near-Earth Object (NEO) monitoring. Starting with the Spaceguard program in the early 1990s to detect and track NEOs, ESA formalized its approach with the launch of the Space Situational Awareness (SSA) program in 2009. The SSA program includes the dedicated Near-Earth Object Segment (NEO Segment), which coordinates observations and operates the Near-Earth Object

Coordination Centre (NEOCC) in Italy. These initiatives have led to the discovery of hundreds of new asteroids and the confirmation that many others pose no threat, significantly advancing Europe's contribution to planetary defense.

ESA's Planetary Defence Office (PDO): In 2018, the 'Planetary Defence Office (PDO)' was established. Since January 2020, it is part of ESA's Space Safety Programme. (PB-SSA 2018(24). The goals of the Office are to:

- Radar and optical measurements and their simulation
- Become aware of the current and future position of NEOs relative to Earth
- Assess the consequences of any possible impact
- Develop methods to deflect any potentially dangerous asteroids

The Fly-Eye Telescope: The Flyeye telescope, developed by ESA, is an innovative ground-based telescope designed for wide-field surveys to rapidly detect Near-Earth Objects (NEOs) that could pose an impact risk to Earth. Its unique "fly-eye" design, inspired by insect compound eyes, uses a 1-meter class primary mirror and a pyramid-shaped beam splitter to feed 16 smaller secondary mirrors and individual CCD cameras. This allows it to achieve a very wide field of view (around 45 square degrees, about 220 times the area of the full moon) equivalent to a conventional 1-meter telescope with a limiting magnitude of about 21. The planned network of Fly-Eye telescopes (with the first prototype under construction in Italy and a second planned for the Southern Hemisphere) aims to scan the entire sky within 48 hours.

Test-Bed Telescopes: Two 56-cm Test-Bed Telescopes (TBTs) will be primarily used to test the data processing currently being developed for the Fly-Eye telescope.

Optical Ground Station: ESA's Optical Ground Station in Tenerife is equipped with a 1 m-diameter telescope and is the major optical facility used by ESA to follow up asteroid observations. It is typically used for four nights around the New Moon for NEO observations.

Data Sharing "Provision": ESA's Planetary Defence Office (PDO) independently determines NEO orbits and predicts impacts using global telescope and radar data. This system utilizes evolved NEODyS software (Italian origin). The Near-Earth Object Coordination Centre (NEOCC) in Italy gathers data from the Minor Planet Center and cross-checks high-risk impact predictions (Palermo Scale > -2) with JPL/NASA. The NEOCC coordinates small body observations and assesses Earth impact threats. Europe has studied mitigation for common threats (up to a few hundred meters).

Sponsoring European observations: ESA also sponsors other national telescopes in Europe, like the Klet observatory in the Czech Republic and telescopes in Tautenburg, Germany, and Spain. The Agency also works alongside the 0.8m Telescopi Joan Oró in the Spanish Pyrenees, the 0.6m Observatoire des Makes, at Saint-Louis on Réunion Island, and with the International Scientific Optical Network (ISON).

ESA's Enduring Legacy (Post-1975):

- **Independent Launch Capability:** ESA achieves significant success in launching its own satellites, observatories, and diverse space missions.
- **Global Partnerships:** ESA actively collaborates with major international space agencies: NASA, Roscosmos, and JAXA, highlighting the interconnectedness of space exploration

4.2. NASA: A Brief Overview Strategic Approach to Near-Earth Object (NEO) Discovery:

Shifting focus to the United States, **The National Aeronautics and Space Administration (NASA)** is an independent agency of the U.S. federal government responsible for the civilian space program, as well as aeronautics and aerospace research. NASA was established on July 29, 1958, and began operations on October 1, 1958, succeeding the National Advisory Committee for Aeronautics (NACA).

NASA's Planetary Defense Coordination Office (PDCO) The 1908 Tunguska event was a massive explosion in Siberia and the prevailing scientific consensus is that the Tunguska event was caused by a **meteor airburst**. This event and other factors significantly raised awareness about the real dangers posed by asteroids and comets.Recognizing the urgency of the situation, NASA established the Planetary Defense Coordination Office in 2016. Tasked with monitoring the skies for potential hazards, this office was also responsible for coordinating the government's response to any imminent threat.

Overview of NASA NEO Discovery Evolution
In the early 1990s, at the request of the U.S. Congress, NASA conducted a preliminary study to increase the detection rate of NEOs. This led to the proposal of an "International Spaceguard Survey."

In the late 1990s-From 1992 to 1995, the Spaceguard Survey Workshops brought together scientists and experts to discuss strategies, techniques, and future initiatives for discovering and tracking near-Earth objects.

In 1998, the United States Congress issued a directive known as the "George E. Brown Jr. Near-Earth Object Survey" or the "NASA Authorization Act of 1998," mandating NASA to detect and catalog at least 90 percent of NEOs larger than one kilometer by the end of 2008. In response, NASA established the Near-Earth Object Observations (NEOO) program in 1998, which aimed to detect, track, and characterize NEOs to assess the impact hazard they pose to our planet. This program involves ground-based observatories and supports studies to develop methods for deflection or disruption of NEOs on collision courses with Earth.

The NASA PDCO (The Planetary Defense Coordination Office) was established in 2016. The United States has been actively involved in detecting and tracking near-Earth objects (NEOs) for decades.

Space-Based Missions

- **WISE/NEOWISE (Wide-field Infrared Survey Explorer):** Launched in 2009, WISE conducted a full-sky survey in infrared wavelengths, identifying numerous NEOs. In 2013, it was reactivated as NEOWISE to continue NEO observations.
- **In 2018, t**he Near-Earth Object Camera (NEOCam) mission was proposed to NASA, aiming to detect and characterize NEOs using infrared technology.
- **NEO Surveyor:** This mission is designed to discover and characterize most of the potentially hazardous asteroids and comets that come within 30 million miles of Earth's orbit. The spacecraft is taking shape, this infrared space telescope is NASA's first space telescope for planetary defense and is schedule to be launched in late 2027.
- Ground-Based Telescopes and Surveys
- **LINEAR (Lincoln Near-Earth Asteroid Research):** Operated from 1996 to 2018, LINEAR was a ground-based survey that discovered thousands of NEOs.
- **Catalina Sky Survey:** An ongoing survey using ground-based telescopes to search for NEOs.
- **Pan-STARRS (Panoramic Survey Telescope and Rapid Response System):** A ground-based survey that uses a large telescope to detect and track NEOs.
- **ATLAS (Asteroid Terrestrial-Impact Last Alert System):** A network of ground-based telescopes designed to detect and track NEOs.
- **Additional Contributions:**
- **Hubble Space Telescope:** Hubble has been used to observe and study individual NEOs, providing valuable data on their properties and orbits.
- **Other NASA Missions:** Missions like Kepler and TESS have also contributed to NEO discovery and characterization as part of their primary scientific objectives.

4.3.. JAXA (The Japan Aerospace Exploration Agency)

It is the Japanese national aerospace agency. JAXA was formed on October 1, 2003, through the merger of three previously independent organizations:

ISAS (Institute of Space and Astronautical Science)
NAL (National Aerospace Laboratory of Japan)
NASDA (National Space Development Agency of Japan)

JAXA is responsible for Japan's space program, as well as aviation and aerospace research and development. It conducts a wide range of activities, from basic research to the development and utilization of space and aeronautical technologies.

Overview of JAXA's NEO Discovery and Planetary Defense Involvement

JAXA's work on NEO discovery and planetary defense has evolved over time, with increasing focus in recent years. Here's a brief chronological overview:

- Early 2000s: JAXA's involvement in planetary defense activities, initially referred to as "Spaceguard" in Japan, began with a focus on protecting Earth from impact events.
- Hayabusa Mission (Launched 2003, Returned 2010): While primarily a mission for asteroid sample return and technology demonstration, Hayabusa provided valuable experience in navigating near-Earth objects and conducting close-proximity operations, crucial for future planetary defense missions.

- Hayabusa2 Mission (Launched 2014, Returned 2020, Extended Mission): This mission to asteroid Ryugu also focused on sample return but included advanced technologies relevant to planetary defense, such as creating an artificial crater and precision navigation for close flybys. The extended mission of Hayabusa2 (Hayabusa2♯) is targeting asteroid 1998 KY26, a rapidly rotating small asteroid, with a planned rendezvous in 2031. High-speed, high-precision flybys during this extended mission aim to develop techniques applicable to investigating and potentially impacting future threatening NEOs.
- Participation in AIDA Collaboration (Ongoing): JAXA is a key partner in the international Asteroid Impact & Deflection Assessment (AIDA) collaboration. Specifically, JAXA is contributing the Thermal InfraRed Imager (TIRI) to ESA's Hera mission, which will study the aftermath of NASA's DART impact on the asteroid Dimorphos. This collaboration directly contributes to understanding asteroid deflection techniques.
- Formal Planetary Defense Team (April 2024): JAXA formally created a Planetary Defence team to support existing programs and drive new initiatives in this field.

5. NON-GOVERNMENTAL ORGANIZATIONS IN PD and NEO RESEARCH

"According to the author of this paper and space industry expert Nancy C. Wolfson, collaboration with groundbreaking NGOs isn't a courtesy; it's a strategic step. These new players are poised to positively disrupt the status quo and inject the dynamism essential for a more cohesive international planetary defense community against NEOs"

5.1 The Importance of Creating New Planetary Defense -NEO Initiatives

Planetary defense and NEO discovery efforts currently experience critical gaps in the international framework due to limited official participation and recognition beyond prominent governmental institutions such as space agencies NASA, ESA, and JAXA, creating a significant concern.

This inherent constraint dangerously excludes numerous countries and regions, leaving them without the necessary Knowledge, understanding, tools and other options that these regions could potentially need to defend their territories against a potentially catastrophic asteroid impact. This exclusion is particularly troubling considering these regions including the Latin American countries have also experienced firsthand devastating cosmic events and impacts Therefore, it is imperative to actively expand global NEO discovery and planetary defense capabilities.

5.2 The Positive Impact of NGO Contributions to Planetary Defense and NEO Research

- **Agile and Innovative Approaches:** NGOs, unburdened by the bureaucratic structures and extensive protocols often associated with governmental bodies, can adopt more agile and innovative approaches to problem-solving. This can manifest in the rapid prototyping and deployment of novel observational techniques, the development of cost-effective data analysis methodologies, and the implementation of creative outreach and public engagement strategies.
- **Democratization of Participation:** Non-governmental initiatives inherently foster a more democratized landscape for participation in planetary defense. By engaging citizen scientists, amateur astronomers, and professionals from diverse, non-traditional backgrounds, these organizations broaden the talent pool and bring fresh perspectives to the challenges of NEO discovery and hazard mitigation. This distributed model of engagement can significantly augment the data collection and analytical capabilities of the broader community.

- **Localized and Regional Focus:** Many NGOs operate at a local or regional level, allowing them to address specific geographic observational gaps and cultivate unique community-based outreach programs. Their deep understanding of local contexts, cultural dynamics, and existing professional networks within their regions can facilitate the integration of planetary defense awareness and preparedness at a grassroots level, complementing the top-down approach of governmental agencies.
- **Catalysts for Collaboration:** By demonstrating tangible contributions and establishing operational models, these early-stage NGOs can serve as catalysts for broader collaboration. Their successes can

attract the attention and potential support of governmental institutions, leading to synergistic partnerships that leverage the strengths of both sectors. Furthermore, they can foster connections between diverse professional communities that may not traditionally interact with the planetary defense field, unlocking new avenues for interdisciplinary innovation.

- **Increased Public Awareness and Engagement:** NGOs often prioritize public outreach and education as core components of their mission. Their ability to communicate complex scientific concepts in accessible ways and engage the public through hands-on projects can significantly raise awareness about the importance of planetary defense, fostering greater societal support for these crucial endeavours.

6. INTRODUCING THE PLANETARY DEFENSE AND BEYOND PROGRAM AT THE NSS ISDC

The Planetary Defence and Beyond Program (PD-Beyond Program) at the the National Space Society (NNS) International Space Development Conference was Founded by Nancy C. Wolfson, a longtime member and space industry expert within the National Space Society (NSS), her program received approval in 2023 from both the NSS Organizing Committee and the NSS Board of Directors (BOD). This program was subsequently partially implemented at the 2024 International Space Development Conference (ISDC), featuring key components such as the Planetary Defense (PD) Track, the "NextGen: Look Up is an Asteroid" initiative, and the PD Booth. The 2025 PD-Beyond Program at the NSS ISDC is ongoing and this year we will introduce the Astrometrica Software into our activities.

The National Space Society (NSS) was founded in 1971 by Wernher von Braun, a renowned German-American rocket engineer and a key figure in developing the V-2 rocket and the Saturn V rocket used in the Apollo program. His passion and leadership were instrumental in creating the NSS, initially known as the National Space Council. The NSS organizes the annual International Space Development Conference (ISDC), a platform for scientists, engineers, policymakers, and space enthusiasts to discuss and advance the cause of space exploration.

6.1 The PD-Beyond Program 6 Modules:

The **PD-Beyond Program at the NSS ISDC** utilizes a unique strategic framework and contains 6 Modules within the program, given its ongoing development. We are currently providing a description only of "The Author's Bootcamp

1. Module: Planetary Defense NextGen "Look Up is an Asteroid": Primarily focused on addressing Planetary Defense from science fiction to science for educational events and NextGen special sessions, webinars, articles, reports and similar

2. Module: Planetary Defense Track: This aims to serve as a diverse and multidisciplinary platform where PD experts, the NextGen, and professionals from other areas of the space industry come together to bring fresh perspectives and innovative solutions to the vital mission of planetary defense, ensuring a more sustainable and secure future in space.

3. Module: The Author's Bootcamp - Bridging Your Expertise to Planetary Defense: This program features a novel element unprecedented in other planetary defense initiatives. Details further in this manuscript.

4. Module: PD-Beyond Booth: Its main objective is to complement the program by providing PD-NEO informational material and outreach opportunities to raise awareness, mainly among the general public.

5.Module: The Astrometrica Software Workshop-Training:: This training consists of phases divided into beginner, intermediate, and advanced levels, with the main objective of preparing participants to form a team and actively participate in the NEO discovery opportunities offered by a few existing international campaigns

6. Module: Planetary Defense for Decision Makers Around the World: This focuses on bridging the gap in Planetary Defense knowledge transfer and engagement for emerging space agencies including the Latin American countries and non-governmental organizations worldwide.

6.2 The Planetary Defence and Beyond Program (PD-Beyond Program) Track - 2024 NSS ISDC

Planetary Defense Location: Malibu
Session Date and Time: Friday, May 24 @ 2 - 6 pm

6.3 Our Planetary Defense Track Co-Chairs 2024

NSS ISDC 2024 Planetary Defense Track Co-Chair

Stephan Ulamec - Project Manager, German Aerospace Center (DLR)

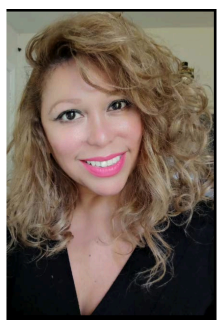
Dr. Stephan Ulamec is a highly skilled and experienced professional with over 20 years of expertise in the development and operations of space systems and instruments. For three decades, he has been associated with the German Aerospace Center, DLR, in Cologne. Dr. Ulamec is well-known for his contributions to the system engineering and project management of the Rosetta Lander, Philae. Currently, he is engaged as payload manager of MASCOT for the JAXA Hayabusa 2 mission and is also part of the science management board for the ESA HERA Mission. He is involved in various studies for in-situ packages for space research. He has contributed to the definition and performance of tests for various mechanisms and surface packages to be operated on planetary surfaces.

Dr. Ulamec's outstanding achievements in the field of space exploration have been recognized with several prestigious awards, including the Juri Gagarin Medal of the Russian Cosmonautics Federation, the Sir Arthur Clark Award, and the International Academy of Astronautics, the IAA Team Award. The International Astronomical Union (IAU) has also named the asteroid (11818) Ulamec after him, further solidifying his contributions to space research.

NSS ISDC 2024 Planetary Defense Track Co-Chair

Claudio Maccone - Technical Director, International Academy of Astronautics

Claudio Maccone is a distinguished Italian SETI astronomer, space scientist, and mathematician. Maccone's groundbreaking work in the field of SETI, or the search for extraterrestrial intelligence, has not only earned him worldwide recognition but has also significantly advanced our understanding of the universe. In 2002, he was awarded the "Giordano Bruno Award" by the SETI League for his efforts to establish a radio observatory on the far side of the moon. He later served as the Chair of the IAA SETI Permanent Committee from 2012 to 2021, where he organized SETI conferences worldwide. Maccone has published 149 scientific and technical papers and authored five highly mathematical books. Maccone is a member of the International Astronomical Union (IAU) and an Associate of Istituto Nazionale di Astrofisica (INAF) in Italy. On September 2, 2001, NASA named the central main-belt binary asteroid 11264 Claudiomaccone in his honor. Since December 2021, Maccone, a respected leader in the field, has been serving as the Chair of the IAA Moon Farside Protection Permanent Committee alongside his Co-Chair, Prof. Jack O. Burns, from the University of Colorado at Boulder.

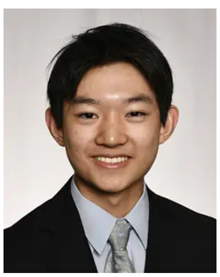


NSS ISDC 2024 Planetary Defense Track Co-Chair

Nancy C. Wolfson - The American institute of Aeronautics and Astronautics (AIAA) Nancy C. Wolfson is a Washington, D.C., US-based scholar, lecturer, and researcher. Nancy is a published author with over 18 years of professional managerial experience. President of Disrupting Space, a company dedicated to analog and risk management space-related research and developing international partnership opportunities for various space activities. Nancy focuses on space exploration, sustainability, and planetary defense research and education. Nancy was elected Vice-Chair of the International Astronautical Federation's (IAF) Planetary Defense (PD) and Near-Earth Objects (NEOs) Technical Committee 2019-2021. Nancy is currently the

Vice-Chair of the IAF Risk Management Committee, where she focuses on research for space and defense activities to identify and mitigate potential threats and exploit opportunities to support decision-makers. Nancy founded the first IAF Planetary Defense and Near-Earth Object Symposium (E10), innovating this initiative by uniting the topics of NEO-Space Debris in a Joint Session, receiving the support of 30 members of two IAF committees, the IAF bureau and the larger Planetary Defense-NEO community. Nancy's current research is in the areas of planetary defense, asteroid missions, multiple applications, and lessons learned from COVID-19. Nancy advocates for increasing space agencies, young professional and citizen scientist-amateurs astronomer's involvement in planetary defense. Nancy is acting as an Expert-Judge for the Unistellar-SETI "Nickname and Asteroid" Program; she provides formal recommendations to the International Astronomical Union (IAU) regarding newly discovered asteroids such as NEA 1999 AP10. She is a signatory to United Nations Asteroid Declaration-100X for Asteroid Day, to mention some.

6.4 NextGen Best Paper Planetary Defense Track



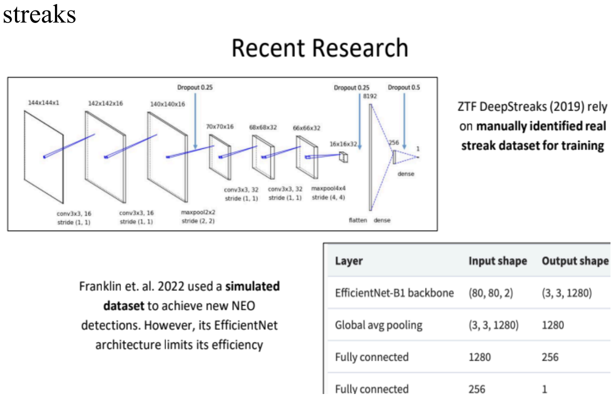
NSS ISDC 2024 Planetary Defense NextGen Best Paper

Minghao Zou: High School Junior, Valley Christian High School

Presentation Title: *Next-Generation Space Science: Young Professionals* Developing CNN-Based Detection of Near-Earth Objects

Minghao Zou - Slides Presentation (5 out 31 slides)

Paper: "Our model detected 14 previously undiscovered streaks

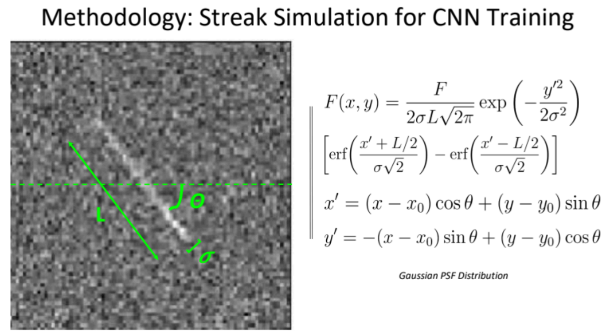


Layer	Input shape	Output shape
EfficientNet-B1 backbone	(80, 80, 2)	(3, 3, 1280)
Global avg pooling	(3, 3, 1280)	1280
Fully connected	1280	256
Fully connected	256	1

➢ Most are fainter and move faster than the average NEO

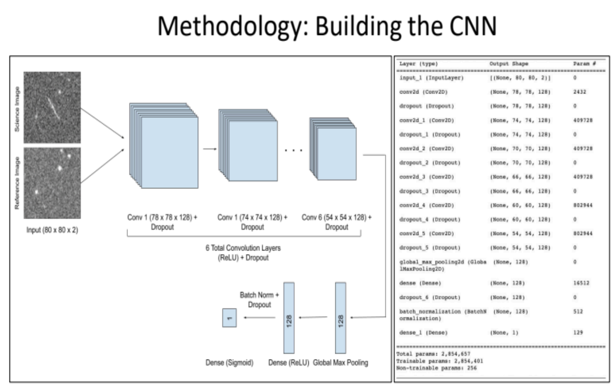
➢ This verifies capability of our model & pipeline and its improvement over
other existing algorithms

❖ The small size of our model and the refined post-processing pipeline allows us to
filter through full nights of data much quicker than existing pipelines



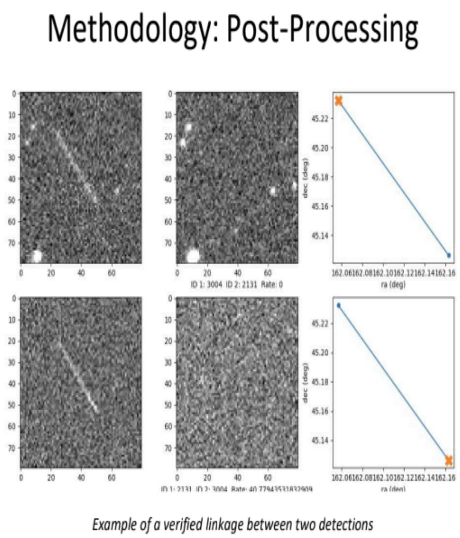
❖ We only used a 2080 TI GPU and a 3090 GPU to process all nights of data, while
current softwares use multiple high-end CPUs

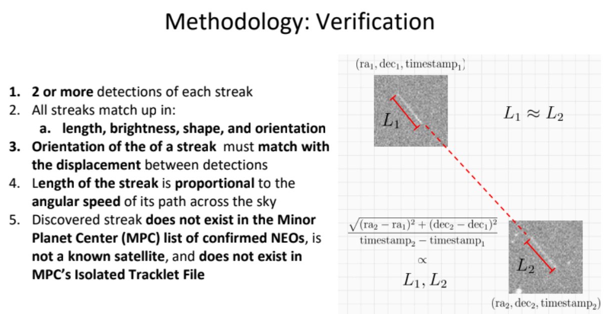
➢ Our method is directly scalable with more abundant compute resources



❖ ZTF only has ~230 confirmed NEO discoveries from more than 1000 nights of data.
Our model can theoretically detect 230 novel NEOs in just 150 nights of data

❖ If integrated into facility softwares, our model has great potential to discover many
more, possibly life-threatening near-Earth objects.

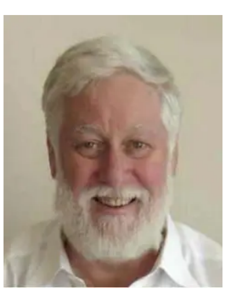




6.5 Planetary Defence and Beyond Program (PD-Beyond Program) at the NSS ISDC 2024 - Track Paper's Authors:

Dr. Nahum Melamed

Project Leader, The Aerospace Corporation
Presentation Title: Defending Earth from Asteroids and Comets: How We Might Respond to the Threat



Dr. Peter A. Swan

Chief Architect, International Space Elevator Consortium
Presentation Title: Apex Anchors – Providing Stereoscopic Surveillance towards the Sun for Planetary Defense

José Pedro Ferreira

Doctoral Researcher, University of Southern California
Presentation Title: Atmospheric Demise of High-Speed Entering Bodies: The Case of Aluminum

Kevin Barry

Business Analyst
Presentation Title: From Ozone Layer to Planetary Defense: Lessons from the Montreal Protocol

6.6 We Implemented Author's Bootcamp for the NSS ISDC PD Track 2024

Bridging Your Expertise to Planetary Defense: This program features a novel element unprecedented in other planetary defense initiatives.

The PD-Beyond Program Author's Bootcamp is a specialized program designed to empower authors from diverse professional backgrounds to connect their seemingly unrelated areas of expertise to the critical field of Planetary Defense (PD). By illuminating existing synergies and fostering a multidisciplinary perspective, this bootcamp aims to cultivate a new generation of thought leaders and collaborators dedicated to safeguarding our planet.:

a) Core Principles:

The program operates on the principle that the challenges of planetary defense are multifaceted and require innovative solutions drawing from a wide array of disciplines. Recognizing and leveraging the inherent overlaps between various space-related activities and planetary defense can drive technological advancements and foster a more comprehensive and robust approach to protecting Earth.

b) **Developmental Stages Under Professional Assessment:**

The program utilizes a unique five-stage methodology. Due to its originality and ongoing refinement, and to safeguard current operational mechanisms under observation by professionals within the National Space Society (NSS) International Space Development Conference (ISDC) and experts from the Planetary Defense Near-Earth Object (NEO) community associated with the Planetary Defense and Beyond Program (PD-Beyond Program), this manuscript will provide a brief description of Step 1 only. Steps 2 through 5 will be outlined briefly at this juncture. However, the initial implementation of the PD-Beyond Program Author's Bootcamp was in 2024, and continued application in 2025 suggest that this comprehensive approach offers a valuable opportunity for space industry professionals to recognize latent synergies within their existing work, thereby providing tangible pathways into the critical field of planetary defense.

c) **Summary: PD-Beyond Program Author's Bootcamp Steps 1 to 5:**

The Planetary Defense Session Track acting as the Point of Contact (PO) Bootcamp guides participants through a structured process to identify and articulate the relevance of their expertise to planetary defense

Step 1-A: Initial Abstract Content Evaluation to Identify Core Synergistic Potential

- The PD Track Co-Chair, serving as the primary Point of Contact (POC), will conduct the initial abstract assessment. Subsequently, participants will engage in facilitated preliminary asynchronous discussions and brainstorming via email. Comprehensive and meticulous record-keeping throughout this phase is essential for tracing the evolution of ideas and accurately identifying potential synergistic connections, ensuring the analysis remains focused on the original abstract's core themes and their prospective relevance to planetary defense.
- The program will then introduce key concepts and challenges in planetary defense and NEO (Near-Earth Object) discovery.
- Guided exercises will encourage authors to identify potential **conceptual overlaps** between their area of expertise and the core tenets of planetary defense.

Step 1-B: Example Identifying Core Synergistic Potential

Example: By participating in the Author's Bootcamp Step 1, authors will be encouraged and given the tools to brainstorm synergies, as demonstrated by the brief example below that explores the possible connection between space debris, planetary defense, and NEO detection.

- Drawing upon concrete examples (such as the overlap between space debris tracking and NEO tracking), the bootcamp will illustrate existing technical and operational similarities across different space-related domains.

- Authors will be prompted to consider if their field utilizes similar technologies, data analysis techniques, modeling approaches, or operational strategies that could be adapted or applied to planetary defense challenges.

Example Prompts:
- “Does your field involve sophisticated sensing technologies that could be relevant to NEO detection or characterization?"
- "Are there data analysis or modeling techniques used in your area that could be applied to predicting NEO trajectories or impact probabilities?"
- "Does your work involve interacting with objects in complex environments, offering insights into potential asteroid deflection strategies?

Step 2: Exploring Non-Technical - Technical and Operational Parallels:

Step 3: Questionnaire for Further Discovery of Planetary Defense Synergies: Articulating the "So What?" Can you Demonstrate?, Etc.

Step 4: Track Co-Chairs and External PD Experts Further Evaluation Developing Collaborative Frameworks

Step 5: Abstract Content and Possible Outcomes Evaluation: Involves a final evaluation by the Track Co-Chairs, (this evaluation could also include external PD experts) taking into consideration the author's initial abstract work and goals, while also accounting for new findings and the trustworthiness of the identified connections between the author's original topic and planetary defense/NEO Discovery, all while the PD Track Co-Chair acting as the POC is guiding this process towards its final presentation.

6.7 PD Special Session NextGen : “Look Up is an Asteroid”

thenationalspacesociety

ISDC students attended their final 2024 Student Plenary Panel today, titled "Planetary Defense: Defending Earth from Dangerous Asteroids and Comets." The panel featured esteemed experts: Nancy C. Wolfson from The American Institute of Aeronautics and Astronautics (AIAA), Nahum Melamed, Project Leader at The Aerospace Corporation, Dr. Hao Cao, Assistant Professor at the University of California, Los Angeles (UCLA), and Dr. Peter A. Swan, President of the International Space Elevator Consortium. The team engaged in an in-depth discussion on various methods of defending Earth from space debris and potential threats from asteroids and comets. They covered a range of strategies, from advanced detection systems to potential deflection techniques, emphasizing the importance of continued research in this critical field. We hope our students found the session informative and inspiring, gaining a deeper understanding of the challenges and solutions in planetary defense. [2024 NSS ISDC PD Special Session Nextgen]

#ISDC2024#PlanetaryDefense#SpaceExploration
#AsteroidProtection#StudentPlenary#SpaceSafety
#ISDCStudents#AIAA #UCLA #AerospaceCorporation
#SpaceElevatorConsortium

6.8 Background Overview: PD-Beyond Program at the National Space Society (NSS) International Space Development Conference (ISDC)

In 2022, initial discussions regarding a potential Planetary Defense Program at the National Space Society (NSS) International Space Development Conference (ISDC) were initiated between space industry expert Nancy C. Wolfson and the NSS ISDC Organizing Team, facilitated by mutual professional contacts. Following several months of dialogue during which Ms. Wolfson presented the proposed Planetary Defense and Beyond Program (PD-Beyond Program), including its planned activities and objectives, and both parties established a mutual understanding. In 2023, Ms. Wolfson submitted a formal proposal, titled "Planetary Defense and Beyond Program (PD-Beyond Program)" at the National Space Society (NSS) International Space Development Conference (ISDC)," to the NSS ISDC Organizing Team for consideration and subsequent approval by the NSS Board of Directors. After a series of meetings and discussions, agreement was reached on the program's infrastructure and objectives. Consequently, the Planetary Defense and Beyond Program (PD-Beyond Program) received approval from the NSS ISDC Organizing Team and was ratified by the NSS Board of Directors at the end of 2023, with implementation scheduled for 2024.

6.9 We Hope to Foster NOGs Collaboration with IWAN, SMPAG, UNOOSA and FEMA

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UNOOSA, IAWN and SMPAG

The Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III) occurred in 1999. During the conference, it was recognized that international collaboration was crucial to understand better the threat posed by Near-Earth Objects (NEOs). As a result, the Scientific and Technical Subcommittee of UNCOPUOS added 'Near-Earth Objects' to its agenda, indicating the intention to address the issue of NEOs and their potential hazards. The UN General Assembly welcomed this recommendation in December 2013 through resolution 68/75. As a result of the UN's recommendations, **the International Asteroid Warning Network (IAWN) and the Space Mission Planning Advisory Group (SMPAG)** were established in 2014. These entities play a vital role in globally improving coordination for planetary defense.
IAWN, or the International Asteroid Network, is a collaboration of over 50 members from 20 countries. Its objective is to study the implications and effects of asteroids on Earth by coordinating with space agencies, scientific institutions, and observatories. Members include those involved in observations, modeling, orbit computation, NEO detection, and related activities. IAWN shares the latest findings on NEO detection and characterization with the scientific community and raises awareness among the public. It is the trusted source of information on NEOs and forms an integral part of the communication strategy in case of asteroid impact threats.

The Space Mission Planning Advisory Group (SMPAG) serves as a platform that helps connect space agencies of Member States with other relevant institutions and organizations. Their main goal is to plan space missions and foster international collaboration on technology and techniques used to deflect near-Earth objects. In 2015, SMPAG started developing a work plan to create a global roadmap for planetary defense. This plan has 11 items, each assigned to one or more SMPAG members. It includes agreeing on initial criteria and thresholds for response actions against impact threats, considering different types of mitigation missions and technologies, and mapping threat scenarios to corresponding mission types. If a credible threat is identified, SMPAG has a concrete plan of action. SMPAG's primary areas of focus include reference missions, technology road maps, and collaborative research. The group also focuses on communication and exchange of information, international treaty and policy aspects, and mitigation campaign planning activities.

IAWN and SMPAG both submit an annual report on Near Earth Objects (NEOs) to COPUOS through its Scientific and Technical Subcommittee.

Federal Emergency Management Agency (FEMA): A series of major natural disasters occurred in the 1970s, including Hurricane Agnes in 1972 and the Teton Dam failure in 1975. These events highlighted the need for a more coordinated and effective federal response to disasters. In response to the growing concerns, President Jimmy Carter signed the Federal Emergency Management Agency Act of 1979, which established FEMA as an independent agency within the Department of Homeland Security. Before FEMA's creation, disaster response was fragmented and often inefficient, with various federal agencies and departments overseeing different aspects of relief efforts. FEMA's initial focus was coordinating federal disaster relief efforts and assisting state and local governments. The agency also worked to develop national disaster preparedness plans and improve communication and coordination among federal, state, and local agencies.

Over the years, FEMA has evolved to become a leading federal agency in disaster management. **Planetary Defense Emergency Response:** If a NEO impact event were to occur, FEMA could coordinate the federal response, including providing disaster relief, coordinating search and rescue efforts, and assisting with long-term recovery. While FEMA's role in planetary defense is primarily supportive, its expertise in disaster management and coordination can be valuable in addressing the potential challenges, which are significant, posed by a NEO impact event.

7. NGOs KEY ORGANIZATIONS INVOLVED IN PD-NEO INITIATIVES

Planetary defense and NEO discovery efforts currently experience critical gaps in the international framework due to limited official participation and recognition beyond prominent governmental institutions such as space agencies NASA, ESA, and JAXA, creating a significant concern.

The inherent challenges faced by these newly formed NGOs are considerable, often encompassing limitations in funding, access to advanced infrastructure, and established networks within the traditional space sector. Despite these hurdles, their very existence and demonstrated contributions represent a significant disruption to the status quo such as:

7.1 Asteroid Foundation – UN Sanctioned Asteroid Day: Founded in 2014, Asteroid Day is a global movement dedicated to raising awareness and knowledge about asteroids while advocating for the protection of Earth from their potential impact. The organization was formed with the goal of informing the public and policymakers about the risks asteroids pose to our planet, emphasizing the need for proactive measures to address these threats. The founders of Asteroid Day include Dr. Brian May, the legendary guitarist of the band Queen and an astrophysicist; Danica Remy, a former astronaut candidate and current President of the organization; Grig Richters, an award-winning filmmaker; and the B612 Foundation, which is known for its research and advocacy efforts in planetary defense. The main team behind Asteroid Day consists of a diverse group of scientists, astronauts, artists, and educators who share a common passion for protecting Earth and promoting scientific knowledge. This team includes individuals such as Rusty Schweickart, a former Apollo astronaut, Dorin prenoure a …and Mark Boslough, a renowned physicist and expert on impact modeling.

Every year on June 30th, Asteroid Day is celebrated worldwide, coinciding with the anniversary of the Tunguska event in 1908 when a massive asteroid or comet exploded over Siberia. On this day, a series of events, including workshops, lectures, and documentary screenings, are held in numerous countries to raise public awareness about asteroids, their potential impacts, and the importance of ongoing space exploration and research.

7.2 The International Astronautical Federation & International Astronautical Congress E10 Planetary Defense Symposium

The International Astronautical Federation (IAF), a leading organization in the field of astronautics founded in 1951, boasts a membership of over 513 entities, including space agencies, institutions, and companies from 77 countries. As a cornerstone of the global space community, the IAF organizes the annual International Astronautical Congress (IAC), the world's largest space conference.

The IAF Planetary Defense (PD) Symposium, was founded in 2021 by Nancy C. Wolfson, a distinguished space industry expert and former Vice Chair of the IAF Technical Committee on Planetary Defense & Near Earth Objects (NEOs) from 2019 to 2021. Wolfson's initiative to create this symposium was motivated by the escalating global concern surrounding the potential threat of near-Earth objects (NEOs). Over a two-year period, Wolfson diligently sought support for the proposal from the chairs and members of the Planetary Defense- NEO and Space Traffic Management Committees. Through meticulous planning, extensive documentation, and widespread support from the PD-NEO community, the proposal was ultimately approved by the IAF Bureau in 2021 with code E10 and implemented as part of the IAF's International Astronautical Congress (IAC) program.

7.3 The Planetary Society: It is a non-profit organization dedicated to advancing space exploration and searching for extraterrestrial life. It was founded in 1980 by astronomer Carl Sagan, space science enthusiast Bruce Murray, and space historian Louis Friedman. Carl Sagan, a renowned astrophysicist and popular science communicator, played a pivotal role in forming The Planetary Society. He envisioned the organization as a platform for promoting space exploration and understanding the cosmos. Sagan believed that public interest and support were crucial for the future of space exploration. Bruce Murray, a planetary scientist and former Director of NASA's Jet Propulsion Laboratory, joined Sagan in co-founding The Planetary Society. The Planetary Society was established to empower citizens to actively participate in space exploration and foster public awareness about space science's significance. Over the years, the organization has expanded its advocacy efforts, promoting scientific research, space missions, and the protection of planetary environments.

Bill Nye, popularly known as 'the science guy ', has been at the helm of The Planetary Society as its CEO since 2010. Under his leadership, the Society has continued its mission of exploring other worlds, understanding the universe, and raising awareness about the potential threat of an asteroid impact. Nye's efforts have inspired people globally to support planetary defense initiatives, thereby furthering the Society's mission.

7.4 The International Astronautical Academy Far Side Moon Committee

The IAA Committee was founded by Italian physicist and radio astronomer Claudio Maccone, who is known for his work in the field of interstellar radio communication and his research into means of communicating with potential extraterrestrial civilizations.

The committee was established to explore the possibility of establishing a human presence on the far side of the Moon, a region that is never visible from Earth due to its synchronous rotation with our planet. Maccone believed that establishing a human settlement on the far side of the Moon could provide unique opportunities for scientific research, deep space observation, and potentially serve as a stepping stone for future missions to Mars and beyond and defending the Moon from space hazards is equally important. Overall, the International Astronautical Academy Far Side Moon Committee, under the leadership of Claudio Maccone, serves as a platform for scientists, engineers, and space enthusiasts to collaborate and advance our understanding of the Moon and its potential for future human exploration.

7.5 The B12 Foundation

Co-founded by Dr. Edward Lu and current President Danica Remy. The Asteroid Institute®, a program of the B612 Foundation®, is dedicated to advancing our understanding of the solar system through scientific research and technological innovation. The Institute brings together a team of scientists, researchers, and engineers to develop tools and technologies for mapping, navigating, and understanding asteroids. By leveraging advancements in computer science, instrumentation, and astronomy, the Asteroid Institute aims to find and track asteroids in our solar system. Since its founding in 2002, the B612 Foundation has supported research and technologies to enable the economic development of space and enhance our understanding of the solar system's evolution. Additionally, the Foundation has been involved in educational programs, including the annual Asteroid Day event.

7.5 The IAA Planetary Defense Conference (PDC): The PDC is a global forum dedicated to addressing the challenges of defending Earth from asteroid and comet impacts. It is a key event organized to foster collaboration and discussion among scientists, engineers, policymakers, and other stakeholders involved in planetary defense efforts. The inaugural conference took place in 2006 and was hosted by the International Academy of Astronautics (IAA) in conjunction with other space agencies and organizations interested in planetary defense. The PDC continues to be held biannually, bringing together experts from around the world to share knowledge and coordinate efforts to protect Earth from potential extraterrestrial threats.

8. Conclusion

Therefore, rather than viewing these emerging NGOs as peripheral actors, the established planetary defense community should actively seek to understand, support, and collaborate with them.

Regarding the Planetary Defense and Beyond Program at the National Space Society International Space Development Conferences in 2024 and 2025, it employs a unique strategic approach by addressing the technical, non-technical, policy, communication, education, financial, and demographic-anthropological aspects. This program also addresses the limitations that currently prevent many other countries, including Latin American countries, and non-expert actors from active involvement in Planetary Defense and NEO studies. Investing in the development and implementation of alternative, potentially more accessible NEO discovery tools, **e.g., Astrometrica Software,** could catalyze the tangible immersion of a broader range of countries and local, non-expert actors in this critical endeavor. Establishing a sustainable and truly international planetary defense program, one that effectively complements and integrates with existing international efforts, is crucial for ensuring comprehensive global protection against the undeniable risks posed by Near-Earth Objects.

We also expand our approach to protecting the Moon from Asteroids: A Necessity for Human Presence

As we prepare to establish a permanent human presence on the Moon, protecting our lunar outpost from the threat of asteroid impacts becomes increasingly imperative. The Moon, like Earth, is vulnerable to collisions with celestial objects, and the consequences of such an event could be devastating for our lunar infrastructure and the safety of lunar inhabitants.

Here are some key reasons why protecting the Moon from asteroids is crucial:

Preserving Lunar Infrastructure:

- **Protecting Bases and Habitats:** A
- **Safeguarding Scientific Equipment:**
- **Ensuring Resource Security:**

To protect the Moon from asteroids, we will need to develop advanced technologies for detecting, tracking, and potentially mitigating asteroid threats. This will involve building a robust network of telescopes and sensors, as well as developing spacecraft capable of intercepting and deflecting potentially hazardous asteroids. Additionally, we will need to establish protocols for responding to asteroid threats and ensuring the safety of lunar inhabitants..

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