Session 12: Public Education & Communication
Chairs: Linda Billings | Alissa J. Haddaji | Alex Karl

7th IAA Planetary Defense Conference
Planetary Defenders!

Dr. Nahum Melamed
Lianne McGinley
Monica Maynard

26-30 April 2021
Vienna, Austria
Corporate Social Responsibility

K-12 STEM Outreach

https://www.youtube.com/watch?v=8m9i_wLE97w
• No one can predict where the future of space innovation will lead us, but we can help inspire the next generation of scientists and engineers who will guide the way.

• Aerospace’s current K-12 outreach includes:
  – Classroom visits from Aerospace employees, online tutoring, virtual mentoring and more.
  – Partnerships with non-profits and community-based organizations to provide cost-free experiences for students and schools.
The NEO Deflection App (NDA)
Developed by NASA's Jet Propulsion Laboratory (JPL) and The Aerospace Corporation

- Physics-based web app used to evaluate deflection requirements for simulated Near Earth Objects on collision course with Planet Earth
- The NDA is hosted on JPL’s website here: https://cneos.jpl.nasa.gov/nda/, and on Aerospace’s website here: https://planetary-defense.aerospace.org/main
- The NDA applies Orbital Mechanics and Launch Vehicle Performance to approximate NEO deflection missions by High Velocity Kinetic Impact spacecraft

PDC21 successfully deflected with single kinetic deflector spacecraft launched 5 years before projected Earth impact
Teaming App for Asteroid Deflection
An Aerospace Corporation STEM Outreach Workshop Series

- The Aerospace Corporation has added a collaborative educational context to the App and developed an educational program to conduct asteroid deflection teaming exercises with the NDA
- Several participants are grouped into teams and given an increasingly challenging hypothetical asteroid collision scenario to solve
- The team with the highest performance metric wins the competition
- Aerospace has run 9 virtual and in-person asteroid deflection workshops for teachers, students, and the public to date

The teaming NDA is publicly accessible on Aerospace’s website: https://planetary-defense.aerospace.org/
Educational Outreach

• The Aerospace NEO Deflection Teaming App helps participants
  – Investigate world-problems beyond their immediate environment
  – Engage in different perspectives and collaboration
  – Take action and participate in problem solving scenarios
  – Communicate potential solutions with team members and to a broader diverse audience

Joint effort with NASA/JPL - Center for Near-Earth Object Studies (CNEOS)
Educational Outreach

• Presented to teachers, students and public

• Nine (9) workshops have been run using the NEO Deflection App (NDA) since 2018

• ~90% of participants find the workshop Excellent

• 100% stated they would participate again

• Future Plans
  – Continue offering STEM outreach events and workshop series
  – Continue to train teacher to increase impact with students
  – Present at AIAA Asteroid Day event in June 2021
  – Engage more diverse, underrepresented, low socio-economic status groups of students
  – Partner with other organizations

Check out our teacher resources, lesson plans and videos: https://aerospace.org/asteroids
Thank You
AIMING FOR APOPHIS:
How we did Asteroid Astrometry and Taught Others During COVID-19 Lockdowns?

Arushi Nath (Grade 6)
Artash Nath (Grade 9)

7th IAA PDC Conference 2021
30 April 2021

Website: www.HotPopRobot.com
Twitter: @Wonrobot
How Apophis Entered Our Lives?

Artash: Participating and presenting in 6th IAA Planetary Defense Conference 2019, Maryland

Arushi: 3D printed models of Asteroid Apophis
COVID-19: Closed Schools, Open Minds

On Earth

Measuring Impact of COVID-19 Lockdowns on Local Environment

Mar 2020 – Jul 2020

Subsurface

Measuring Impact of COVID-19 Lockdowns on Seismic Vibrations

Jun 2020 – ongoing

Space

Finding APOPHIS!

Nov 2020 - Feb 2021
Imaging Apophis: Robotic Telescopes

Slooh
Chile Two Wide-Field Telescope

432mm Aperture
Field of View: 43 * 43 arcmin

iTelescope
T11 - Deep Space

510mm Aperture
Field of View: 54 * 35 arcmin

Faulkes Telescope Project /
Las Cumbres Observatory
Faulkes Telescope South (FTS)

2000mm Aperture
Field of View: 10 * 10 arcmin

(Image Credit: Gronk Oz - Own work, CC BY-SA 4.0)
Pointing the Faulkes Telescope South to Apophis

Daily Right Ascension and Declination
Values from NASA HORIZON project

<table>
<thead>
<tr>
<th>Date</th>
<th>UT</th>
<th>HR:MN</th>
<th>RA (ICRF)</th>
<th>DEC</th>
<th>APmag</th>
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<td>18.174</td>
</tr>
</tbody>
</table>

Source: https://ssd.jpl.nasa.gov/horizons.cgi

Best Visibility and Time

Source: Telescopius Website. https://telescopius.com/
Scaling our Images taken from the Faulkes Telescope South
To see maximum possible objects: brighter and dimmer

(Modifying Pixel Brightness Range using the Min/Max Function of SAOImage DS9 software, ds9.si.edu)
Comparing CCD Image with Celestial Field of View

*Image could be rotated or flipped!*

Taken with Faulkes Telescope South on 25th Jan 2021 (RA: 11h 38m 06.99s  Dec: -18° 53’ 59.4” )

Matching of image using AAS WorldWide Telescope
http://worldwidetelescope.org/
Matching Stars in CCD Image with Stars in Celestial Field of View

Querying Star Catalogues Using Astrometrica software:  www.astrometrica.at

Image taken using the Faulkes Telescope South on 25th January 2021 (RA: 11h 38m 06.99s  Dec: -18° 53’ 59.4” )
Finding Apophis!

Overlay the image from Minor Planet Centre (MPC) database using Astrometrica

Image taken using the Faulkes Telescope South on 25th January 2021
(RA: 11h 38m 06.99s  Dec: -18° 53’ 59.4” )
Locating Apophis Twice to Calculate Motion

25th January 2021. 18:07:33 UTC

RA = 11h 37m 58.225s
Dec = -18 54’ 46.6”

Images taken using the Faulkes Telescope South

Time Difference
23 hours 58 min 4 sec

26th January 2021 18:05:37 UTC

RA = 11h 36m 51.98s
Dec = -19 01’ 54.6”
Calculating Proper Motion of Apophis

<table>
<thead>
<tr>
<th>Apophis</th>
<th>Right Ascension</th>
<th>Declination</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 January 2021</td>
<td>11h 37m 58.225s (A)</td>
<td>-18 54' 46.6” (A)</td>
</tr>
<tr>
<td>26 January 2021</td>
<td>11h 36m 51.98s (B)</td>
<td>-19 01’ 54.6” (B)</td>
</tr>
</tbody>
</table>

RA (A) – RA (B) = 174.4917 - 174.2167 = 0.275
Dec (A) – Dec (B) = (-18.9131) - (-19.0319) = 0.1188
Average Declination (Dec avg) = -18.9725
Cos(Dec avg) = 0.95

Arc Length (AB) = 0.286 degrees
Time Taken = 23 hours 58 min 4 sec = 82800 + 3484 = 86284 s

Proper Motion of Apophis = 3.13 * 10^-6 degrees/sec
= 0.011268 arcsec/sec

Source: http://spiff.rit.edu/classes/phys301/lectures/precession/precession.html
Doing Basic Asteroid Astrometry Using Python

**STEPS**

1. Download libraries and open Flexible Image Transport System (FITS) files
2. Scale the images
3. Read FITS header files for RA and Dec, pixel scale, CCD size, and focal length
4. Query ‘Star Catalogues’
5. Match catalogue stars with stars in CCD images
6. Find the asteroid
7. *Plate Solving (arcmin/pixel) to calculate proper motion of asteroid*
Download Python Libraries and Open (FITS) Image Files

```python
# Importing Required Libraries
import numpy as np
from astropy.io import fits
import urllib as url
import os
import matplotlib.pyplot as plt

# Opening FITS Image Files
image_data = fits.getdata(r'FILE PATH\xyz.fits')
plt.imshow(image_data, cmap = 'gray')
plt.colorbar()
```
Scaling of Images Using Python

# Scaling of Images using Standard Deviation Function

```python
plt.figure(figsize=(10, 10))
plt.imshow(image_data, cmap='gray', vmin=image_data.mean()-0.2*image_data.std(), vmax=image_data.mean()+0.2*image_data.std())
```
Reading FITS header and Querying it for RA and Dec, Pixel Scale, CCD Size, and Focal Length

```
SCHEDSEEK= 1.9225850 / [arcsec] Estimated seeing when group scheduled
SCHEDTRN= 'N/A'  / [(0-1)] Estimated transparency when group sched
TRIGGER = 'N/A'  / External trigger ID
ODRECipe = 'N/A'  / Observing Recipes required/used
PCRice = 'N/A'  / Processing Recipes required/used
PRPRecipe = 'N/A'  / Post-Processing Recipes required/used
RA = '11:39:06.4917' / [HH:MM:SS.sss] RA where telescope is pointing
DEC = '-18:54:22.377' / [dd:MM:SS.sss] Dec where telescope is pointing
RAXYS = 'ICRS'  / [[FRS,ICRS]] Fundamental coord. system of the object
LST = '12:24:53.68' / [HH:MM:SS.sss] LST at start of current observation
CAT-RA = '11:39:06.990' / [HH:MM:SS.sss] Catalog RA of the object
CAT-DEC = '-18:53:59.40' / [dd:MM:SS.sss] Catalog Dec of the object
CAT-EPOC = 2000.0000000 / [Year] Catalog epoch of the coordinates
OFF-RA = '11:39:06.990' / [HH:MM:SS.sss] Catalog RA plus pointing offsets
OFF-DEC = '-18:53:59.40' / [dd:MM:SS.sss] Catalog Dec plus pointing offset
OBJEC = 'Apophis' / Object name
SRCYpe = 'EXTRASOLAR' / Source type

#Camera
NAXIS1 = hdu.header['NAXIS1']
NAXIS2 = hdu.header['NAXIS2']
CCDXPIX = hdu.header['CCDXPIX']

#OBJECT
RA = hdu.header['RA']
DEC = hdu.header['DEC']
DATE = hdu.header['DATE-OBS']

#TELESCOPE
Aperture = 2000 #mm
Focal_Ratio = 10
Pixel_Scale = 0.0025 #arcmin/pixel
```
def search_usno(ra_deg, dec_deg, fov_am):
    # RA/Dec in decimal degrees/J2000.0 FOV in arc min.

    # Request to open the USNO-B1 catalog from the internet
    str1 = 'http://webviz.u-strasbg.fr/viz-bin/asu-tsv/?-source=USNO-B1
    str2 = '-c.ra-{:4.6f}&c.dec-{:4.6f}&c.bm-{:4.7f}/{:4.7f}&out.max-unlimited'.format(ra_deg, dec_deg, fov_am, fov_am)
    f = url.request.urlopen(str1+str2)

    # Read from the object, storing the page's contents in 's'.
    s = f.read()
    f.close()
    sl = s.splitlines()
    sl = sl[36:-1]  # get rid of header

http://tdc-www.harvard.edu/catalogs/ub1.html
Matching Catalogue Stars with CCD Stars

```python
# Rotating the USNO-B1 Catalog Stars to Match Stars in CCD Image
import math
def rotate(origin, point, angle):
    ox, oy = origin
    px, py = point
    qx = ox + math.cos(angle) * (px - ox) - math.sin(angle) * (py - oy)
    qy = oy + math.sin(angle) * (px - ox) + math.cos(angle) * (py - oy)
    return qx, qy
```
Finding the Asteroid!

Original Image

Data Reduced and Image Mapped Using Sky Catalogue using Python
Outreach: Reaching to Kids and Families

Royal Astronomical Society of Canada (RASC)

Global Innovation Field Trip (GIFT)

School Show and Tell (Français)

Viser à Apophis: Faites-le Vous-Même Astrométrie Astéroïde à l'Aide de Python

Arushi Nath (6e année)
8 février 2021
site: www.HotPhobos.com
AIMING FOR APOPHIS: How we did Asteroid Astrometry and Taught Others During COVID-19 Lockdowns?

Arushi Nath (Grade 6)
Artash Nath (Grade 9)

7th IAA PDC Conference 2021
30 April 2021

Website: www.HotPopRobot.com
Twitter: @Wonrobot
EVALUATION OF AN NEO CLOSE APPROACH FREQUENCY INDEX FOR PUBLIC/MEDIA RELEASE PURPOSES

Speaker: Juan L. Cano (PDO)
Co-authors: G. Valletta (UniNa), D. Oliviero (PDO), G. Fasano (UniNa), R. Opromolla (UniNa), M. Micheli (PDO), D. Koschny (PDO)

7th IAA Planetary Defense Conference - 30/04/2021
NEO CLOSE APPROACHES IN THE MEDIA

Asteroid close approach: NASA gearing up as asteroid to pass closer than the Moon.

DOOMSDAY DODGED Apophis ‘God of Chaos’ asteroid could hit Earth in over 100 years – as Nasa reveals it will ‘miss’ in 2068

NASA is on alert as a ‘close approach’ to the Moon.

WHERE THE TRUCK Pickup truck-sized ASTEROID came less than 250 miles from hitting Earth, Nasa reveals

Skyscraper-sized asteroid travelling at 11,000mph will zip past Earth at a distance of 3.1 million miles this weekend

- The asteroid has been called 163348 (2002 NN4) and was first spotted in 2002
- It will make its closest approach to Earth on Sunday
- The 1,870ft object poses no threat to Earth

NASA WARNING Asteroid the size of the world’s tallest building to zip past Earth at 56,000mph this week

A GIANTIC asteroid is set to zip past Earth this week, according to Nasa space debris trackers.

The rock is travelling at over 56,000 mph (89,000 kph) and at up to 820 metres (2,700 ft) tall.

Asteroid news: A 1.2 mile rock to zip past Earth today - astronomers can already see it

AN ASTEROID big enough to be dubbed “potentially hazardous” but considered safe by Nasa, has been photographed dashing through the solar system.
FREQUENCY OF A CLOSE APPROACH

• Given the close approach of an NEO to the Earth at distance $d_{CA}$, what is the frequency (or the period) of such event?

• A similar question has been responded in the past: the one associated to the NEO impact frequency

  Why not extending such concept to the close approaches?

• Impact frequency has been extensively discussed in the literature in the last 50 yr

• The frequency is dependent on the NEO population distribution
There is a direct relation between a given population of NEOs and the impact frequency with Earth:

\[ f_0 = k \, N \]

We need a function \( f_{CA} \) that allows the extension of the concept to any close approach conditions.

Source: Harris, PDC-2019
VARIABILITY WITH THE DISTANCE TO EARTH

• Assuming that the flux of NEOs is roughly uniform in the proximity of the Earth, the number of close approaches with the Earth will increase quadratically with the distance:

\[ f_{CA}(N, b) = f_0(N) \left( \frac{b}{b_0} \right)^2 \]

where \( b \) is the b-plane impact parameter.

• Taking into account the gravitational focusing due to the Earth:

\[ f_{CA}(N, d, v_\infty) = f_0(N) \left( \frac{d}{d_0} \right)^2 \left[ \frac{v_{esc}^2 + v_\infty^2}{v_{esc0}^2 + v_\infty^2} \right] \]

where \( d \) is the CA distance, \( v_\infty \) is the infinite CA velocity, \( v_{esc} \) is the Earth escape velocity, and \( v_{esc0} \) is the initial escape velocity.
NEO POPULATION DISTRIBUTION MODEL

• Several NEO population models have been proposed in the last 25 years
• For our computations we decided to select:
  • The Granvik model (2018) for $H \leq 25$
  • A log-linear extrapolation of that model for $25 < H \leq 28.5$
    \[
    N(\leq H) = 802,404 \times 10^{0.6434(H-25)}
    \]
  • Another log-linear extrapolation with a slope better fitted to smaller asteroid fluxes for $H > 28.5$
    \[
    N(\leq H) = 143,315,474 \times 10^{0.49(H-28.5)}
    \]
NEO POPULATION DISTRIBUTION MODEL

\[ H = 28.5 \]

\[ H = 25 \]
THE IMPACT FREQUENCY CONSTANT

- Proposed values:
  - Shoemaker (1979): \( k = \sim 2.5 \times 10^{-9} \text{ yr}^{-1} \)
  - Brown (2002): \( k = 2 \times 10^{-9} \text{ yr}^{-1} \)
  - Tricarico (2017): \( k = 4 - 6 \times 10^{-9} \text{ yr}^{-1} \)
  - NASA (2017): \( k = 1.66 \times 10^{-9} \text{ yr}^{-1} \)
  - NEOPOP (2020): \( k = 1.89 \times 10^{-9} \text{ yr}^{-1} \)
- We decided to use \( k = 1.66 \times 10^{-9} \text{ yr}^{-1} \), as it was computed over a much larger propagation time (tens of thousands of years).
THE CLOSE APPROACH INDEX

In order to render the final values more manageable:

\[ CAI = \log_{10}(f_{CA}(N, d, v_\infty)) \]

- **CAI > 1**
  - Frequency larger than once per month
  - Very frequent event

- **0 < CAI ≤ 1**
  - Frequency larger than once per year
  - Frequent event

- **-1 < CAI ≤ 0**
  - Frequency larger than once per 10 years
  - Infrequent event

- **-2 < CAI ≤ -1**
  - Frequency larger than once per 100 years
  - Rare event

- **CAI ≤ -2**
  - Frequency smaller than once per 100 years
  - Very rare event
EXAMPLE: NEOCC CLOSE APPROACHES

- Evaluation of close approaches in the last month and in the next year, as provided in NEOCC’s close approach list: [https://neo.ssa.esa.int/close-approaches](https://neo.ssa.esa.int/close-approaches)

<table>
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<tr>
<th>Object designation</th>
<th>Absolute magnitude</th>
<th>Close approach date</th>
<th>CA distance (au)</th>
<th>Infinite velocity (km/s)</th>
<th>CA frequency (y⁻¹)</th>
<th>Close approach index</th>
<th>Close approach ranking</th>
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<tr>
<td>2021 DM</td>
<td>26.1</td>
<td>2021-02-28</td>
<td>0.0327</td>
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<td>1.82E+03</td>
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<td>2021-02-28</td>
<td>0.0457</td>
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<td>2.48</td>
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<td>5.8</td>
<td>1.92E+03</td>
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<td>0.0361</td>
<td>13.6</td>
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<td>1.48</td>
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<td>27.1</td>
<td>2021-03-01</td>
<td>0.0122</td>
<td>4.7</td>
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<td>0.0119</td>
<td>16.9</td>
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<td>2.88E+03</td>
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<tr>
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<tr>
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<td>9.9</td>
<td>1.17E+01</td>
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<td>1.06E+01</td>
<td>1.03</td>
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</tr>
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And many more lines in the table...
**EXAMPLE: NEOCC CLOSE APPROACHES**

- Summary of results (cut-off on 2021-03-29):

<table>
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<tr>
<th>Evaluation</th>
<th>Recent CAs</th>
<th>Upcoming CAs</th>
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<tbody>
<tr>
<td>Very frequent event</td>
<td>124</td>
<td>129</td>
</tr>
<tr>
<td>Frequent event</td>
<td>7</td>
<td>10</td>
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<tr>
<td>Infrequent event</td>
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<td>5</td>
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<tr>
<td>Rare event</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Very rare event</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>132</strong></td>
<td><strong>145</strong></td>
</tr>
</tbody>
</table>
### EXAMPLE: NEOCC CLOSE APPROACHES

- **Summary of results (cut-off on 2021-03-29):**

<table>
<thead>
<tr>
<th>Object designation</th>
<th>H</th>
<th>Close approach date</th>
<th>CA distance (au)</th>
<th>Infinite velocity (km/s)</th>
<th>CA frequency (y⁻¹)</th>
<th>Close approach index</th>
<th>Close approach ranking</th>
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<td>2016 AJ193</td>
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<td>0.0229</td>
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<td>-0.02</td>
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<tr>
<td>2019 XS</td>
<td>23.8</td>
<td>2021-11-09</td>
<td>0.0038</td>
<td>10.7</td>
<td>8.45E-01</td>
<td>-0.07</td>
<td>Infrequent event</td>
</tr>
<tr>
<td>(4660) Nereus</td>
<td>18.3</td>
<td>2021-12-11</td>
<td>0.0263</td>
<td>6.6</td>
<td>2.64E-01</td>
<td>-0.58</td>
<td>Infrequent event</td>
</tr>
<tr>
<td>(163899) 2003 SD220</td>
<td>17.7</td>
<td>2021-12-17</td>
<td>0.0363</td>
<td>5.6</td>
<td>2.26E-01</td>
<td>-0.65</td>
<td>Infrequent event</td>
</tr>
<tr>
<td>(7482) 1994 PC1</td>
<td>16.6</td>
<td>2022-01-18</td>
<td>0.0132</td>
<td>19.6</td>
<td>6.23E-02</td>
<td>-1.21</td>
<td>Rare event</td>
</tr>
<tr>
<td>(138971) 2001 CB21</td>
<td>18.4</td>
<td>2022-03-04</td>
<td>0.0328</td>
<td>12.0</td>
<td>9.34E-01</td>
<td>-0.03</td>
<td>Infrequent event</td>
</tr>
<tr>
<td>Apophis</td>
<td>18.9</td>
<td>2029-04-13</td>
<td>0.000254</td>
<td>7.42</td>
<td>7.03E-05</td>
<td>-4.15</td>
<td>Very rare event</td>
</tr>
</tbody>
</table>
SUMMARY

• We are proposing to the community to use an **objective index** to evaluate the **relative importance** of a given close approach

• Such index is based on the **current NEO population models**

• It expands from the concept of **impact frequency with the Earth**

• Uses the $H$ of the object and the **close approach data**

• It yields **5 infrequent events and 1 rare event** in one year

• **Apophis close approach in 2029 will be a very rare event**

• We plan to include the evaluation of this index in **NEOCC’s CA page**
THANK YOU!
Role of SGAC in Global Planetary Defence Outreach
SGAC is a global non-governmental, non-profit organisation and network which aims to represent university students and young space professionals ages 18-35 to the United Nations, space agencies, industry, and academia.


6 Regions, 150 Countries, 15,000+ Members

“To create, within the framework of the Committee on the Peaceful Uses of Outer Space, a consultative mechanism to facilitate the continued participation of young people from all over the world, especially young people from developing countries and young women, in cooperative space-related activities [...].”
SGAC The Five Pillars

Events
Project Groups
Professional Development
Scholarships
UN-related Activities
SGAC Project Groups

Near Earth Objects
Space Safety and Sustainability
Space Law and Policy
Space Exploration
Space and Cybersecurity
Commercial Space
Space Medicine and Life Sciences
Small Satellites
Space Technologies for Earth Applications
Ethics and Human Rights

https://spacegeneration.org/projects
The Near Earth Object (NEO) project group is dedicated to helping the worldwide planetary defence community to meet one of nature’s greatest challenges.

The group provides a youth perspective to planetary defence through annual reports, competitions, conference attendance, and public outreach projects related to Near Earth Objects.

https://spacegeneration.org/projects/near-earth-object
INTERNAL ACTIVITIES
• The campaign was a collaboration between SGAC and the International Astronomical Search Collaboration (IASC)
• Applicants from around the world were invited to participate in this 4 week event with special focus on teams from schools and universities
• The campaign started on schedule receiving a total of 181 participants from teams of 3-5 members located in different countries over the globe. 50 teams were selected to participate this year from more than 15 countries

Find An Asteroid (FAA)

https://spacegeneration.org/neo-iasc2020
• This opportunity challenges students & young professionals worldwide to develop original ideas relating to Near-Earth Objects
• Winners will attend the 2021 SGC and IAC in Dubai
• Topics:
  – Planetary Defence, Exploration
  – NEO Study, Characterisation and Detection
  – NEO Impact Consequences
  – Global NEO Impact Warning System
  – NEO Resource Utilisation
  – Proposals and Concepts for NEO Missions Aiming at NEO Technologies and Resources to Support United Nations Sustainable Development Goals (SDGs)
  – Utilisation of NEO Technologies for Deep Space Exploration and Interplanetary Missions

https://spacegeneration.org/sgc-2020-move-an-asteroid-competition
Mars City Design

A flagship cross-collaboration between teams from 6 different SGAC Project Groups (PGs)

The SGAC team made it to the top 10 finalists for their design

NEO PG contributed by adding detailed research on Mining Technologies - on ground and the asteroid belt

Provided insight into planetary defense technologies-incorporation into the mars city design

SGAC report to be published in the Mars Society’s design book titled “Mars City States: New Societies for a New World”

https://spacegeneration.org/mom-november-2020
NEO Renaissance

• An initiative by NEO PG members to help people by expressing their creative ideas in this stressful time of COVID-19

• NEO themed poster competition where people from space, science and artistic fields came together to submit their imaginative visual ideas as posters on following topics:
  
  – Planetary Defense Heroes
  – New Near-Earth Alternative Destinations
  – How asteroid impacts led to the extinction of the Age of Dinosaurs?

https://spacegeneration.org/sgac-announces-winners-of-the-neo-renaissance-poster-competition
In collaboration with IAF NEO Technical Committee, NEO PG released its First Newsletter on 30th June 2020.

This was the First Newsletter issued by NEO PG with the First Special Edition featuring our SGAC NEO PG founder: Alex Karl, Chair of IAF NEO Technical Committee.

NEO PG Collaborated with Alex for this interview to celebrate the International Asteroid Day.

NEO PG is also supporting the Planetary Defense Conference 2021 organised by UNOOSA through sharing participation calls on the NEO PG monthly newsletters.

https://mailchi.mp/spacegeneration/happy-international-asteroid-day-2020
Collaboration with IAF NEO Technical Committee: AIAA - LA Planetary Defense Virtual Panel

- NEO PG collaborated with Nancy C. Wolfson, the Vice-Chair of IAF NEO Technical Committee

- The Vice-Chair invited Smiriti Srivastava, the NEO PG Co-Lead for a virtual presentation on the topic "Planetary Defense from Near Earth Objects (NEO’s)" at AIAA - LA Planetary Defense Virtual Panel in Dec, 2020 together with Mariella Graziano, an IAF NEO Technical Committee member

[YouTube Video](https://www.youtube.com/watch?v=HLS00vlGW5I)
• NEO Project Group is an annual participant in international conferences like Planetary Defense Conference, IAC, GLEX and SGC

• Projects Focus on Planetary Defense, Readiness levels of Asteroid Mining industry, Space resource utilization missions and Educational, outreach activities to support goals of UNOOSA
UN-RELATED ACTIVITIES
• **Permanent Observer** status at United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS)

• Consultative status at United Nations Economic and Social Committee Representatives (UN ECOSOC)

• SGAC presents the outcomes of all of its conferences and projects at:
  - Scientific and Technical Subcommittee of COPUOS
  - Legal Subcommittee of COPUOS
  - COPUOS General Assembly
The NEO Project Group of SGAC annually submits and presents the results of:

- FAA Campaign
- MAA Competition
- NEO Renaissance Competition
- Published papers at IAC, PDC and GLEX
- NEO Projects that raise awareness about Planetary Defense
- NEO Projects that support UN Sustainable development goals

at the annual session of the UN COPUOS General Assembly, Scientific and Technical Subcommittee and Legal Subcommittee.

IX. Near-Earth objects

170. In accordance with General Assembly resolution 69/85, the Scientific and Technical Subcommittee considered agenda item 11, “Near-Earth objects”.

171. The representatives of Egypt, Germany, Italy, Japan, Pakistan, the Republic of Korea, the Russian Federation and the United States, as well as the representative of Chile, on behalf of the Group of Latin American and Caribbean States, made statements under agenda item 11. During the general exchange of views, statements relating to the item were made by representatives of other member States and by the observers for ESA, SGAC and SWF.
INTERNATIONAL, REGIONAL, LOCAL AND ONLINE EVENTS
Space Generation Congress

- Held in conjunction with the International Astronautical Congress
- +150 delegates from +50 countries
- High-level speakers and Subject Matter Experts from space agencies, academia and industry
- Working Group topics on key issues related to Near Earth Objects
- > 75 SGAC scholarships and awards available

Don’t miss out your opportunity to join our next SGC 2021 in Dubai!

21st - 23rd October 2021
SpaceGen United

- SpaceGen United saw 143 delegates from 53 different countries joining together for 9 day programme
- 14 hours of keynote speeches and panel discussions featuring the space economy and the state of the European space industry
- 7 Workshops took place during the week of SpaceGen United (virtual Hackathon, UN COPUOS simulation)
- The workshops provided a platform for delegates to explore a variety of topics with the support and input of 50 subject matter experts from right across government, industry and academia

https://spacegeneration.org/spacegen-united
SGAC doesn't stop! Make sure to check our running webinars and online events:

https://spacegeneration.org/events/category/webinar

https://www.youtube.com/c/spacegeneration/videos

If you want to organize a webinar, don’t hesitate to reach out to webinars@spacegeneration.org for further information and support!
WHY BECOME A MEMBER?

Our partners and sponsors (over 100 and counting) around the world work closely with SGAC to help make our events and activities possible.

The aim of this mentorship program is:

1. Connect SGAC members with experts in the space field
2. The members will be able to receive support and guidance as they continue to advance in their careers.

Why Join Us?

https://spacegeneration.org/vacancies

https://spacegeneration.org/about/sponsor-us

https://spacegeneration.org/mentoring
Be part of the Space Generation

Become a member
- Register yourself on the SGAC webpage (FREE membership)

Be informed
- Subscribe to the SGAC NEO Mailing Lists
- Join the NEO PG Channel #pg-neos on SGAC Slack
- Contact your NPoC and join your local network

Be involved
- Keep a look out for vacancies and opportunities
- Keep a look for scholarships opportunities
- Attend events and conferences
Future goals

- We intend to continue the current activities like (MAA, FAA, NEO Renaissance) campaigns, competitions with much higher engagement levels and global participation.
- We have active participation in the UN activities, meetings and involvement with international space committees like IAF.
- Also focusing on organising more webinars and talks focusing on NEOs and the threat the near earth objects possess to our humankind.
- To create more awareness about the NEO’s through social media activities, engaging more via the digital platform.
THANK YOU

Smiriti Srivastava
Co-lead of SGAC Near Earth Object (NEO) Project Group
smiriti.srivastava@spacegeneration.org
Engaging the audience – what can we learn from them?

Alex KARL
IAF Technical Committee on NEOs
IAA-PDC-21-12-05
Get ready to protect Earth from asteroids – Planetary Defense in your hands, SpS IAC 2019

- Bill Nye
- Lindley Johnson
- Dorin Prunariu
- Mariella Graziano
- Alex Karl
Engaging the audience

- 200-250 people
- ~60 poll participants
- 40 questions received, 90 upvotes

- 2019 PDC Hypothetical Asteroid Impact Scenario
- 5 scenarios + polls
- Poll limitations
Exercise Inject#1: Oct 21, 2019: NEWLY DISCOVERED ASTEROID POSES SMALL RISK OF EARTH IMPACT

- small chance (1%) of asteroid impacting our planet 8 years from now.
- Size estimate: 100-300m

Multiple-choice poll

Poll#1: What is your reaction?

A: 1% and 8 years? Nothing to worry about.
  2 %

B: Let’s wait. Once we know if and where it will hit, there’s plenty of time to react if needed.
  5 %

C: Just in case, let’s get ready. Better safe than sorry.
  76 %

D: I’m really worried and losing sleep – we need to act now!
  17 %
Exercise Inject#2: Jan 21, 2020: ASTEROID NOW HAS 1 IN 10 CHANCE TO IMPACT EARTH

• 10% chance of asteroid impacting our planet ~7.5 years from now.
• Size estimate: 140-260m (could produce serious devastation over a large region but too small to cause globally damaging effects)
• SMPAG calls meeting

Poll#2: What is your reaction?

A: 10% and 7 years, 9 months? Still nothing to worry about. 5%

B: Let’s wait until we know if and where it will hit and base our response on that. There is plenty of time. 2%

C: Let’s get ready and prepare for the worst. Better safe than sorry. 51%

D: I’m really worried and losing sleep – we need to act now! 42%
Exercise Inject#3: Jun 21, 2022: ASTEROID PREDICTED TO IMPACT NEAR DENVER, COLORADO ON OCTOBER 21, 2027: EFFORTS TO PREVENT IMPACT ACCELERATE

- 100% chance of asteroid impacting ~5 years from now.
- Contact binary, 140-220 m. The asteroid is large enough to cause major damage over a large region around the Denver area.
- Fleet of 6 kinetic impactors will need to be build and launched by space agencies as well as two rendezvous spacecraft to gather data on asteroid.

Poll#3: What do you think about the plans to deflect the asteroid?

A: We should do nothing, as I don’t think it will work and will just waste resources
- 3%

B: We should rather prepare Denver for impact than risking to fail and ending up in a new situation with less time
- 5%

C: We need to act but must make sure we are ready for all possible outcomes
- 62%

D: It is our responsibility to act when we can prevent disaster no matter what
- 30%
Exercise Inject#4: Feb 23, 2025: DEFLECTION PARTIALLY SUCCESSFUL BUT LARGE FRAGMENT REMAINS ON IMPACT TRAJECTORY, U.S. IMPACT STILL POSSIBLE

- 3 kinetic impactors were successful in deflection main body but large piece broke off, still on course
- Fragment estimated to be 50-80 m. Exact location not yet known exactly
- No active spacecraft left from original fleet
- SMPAG and UN considering to launch nuclear device for deflection

Multiple-choice poll

Poll#4: Now what?

A: Space is hard, let’s try again and send the nuke  
47 %

B: They failed, my trust in NASA and the other space agencies is gone  
2 %

C: The nuke is too risky, there must be another option for deflection  
39 %

D: Too late for deflection, we must prepare for impact  
12 %
Exercise Inject#5: Oct 11, 2027: SMALL ASTEROID TO IMPACT OVER NEW YORK CITY IN 10 DAYS

- 60m fragment to hit NY Central Park
- It was too late to launch NED
- FEMA evacuating residents and preparing infrastructure

Poll#5: What do you think we need to work on most urgently?

A: Our detection capability
   14%

B: Establishing geopolitical agreements
   6%

C: Our deflection capabilities
   27%

D: Communication with the public
   53%
Conclusions

• A vast majority (~90%) of the audience is in favour of being prepared and taking action.

• Risk perception needs to be taken into account when communicating to the public. (a change from 1% to 10% impact probability leads to additional 25% of audience to get worried)

• The potential effects of warnings on mental health should be considered and addressed. (40% of the people start to worry and are losing sleep almost 8 years ahead of an event that is very likely (90%) not going to happen)

• The use of NEDs is controversial (47% – 53%).

• More than half of the audience thinks communication with the public is the most urgent matter to work on for the planetary defense community.

• Polls are a good way to engage audience, received lots of positive feedback
Observations of NEAs and National Public Outreach at the Astronomical Observatory of Castelgrande (Italy)

Sergei Schmalz¹, Filippo Graziani², Riccardo di Roberto², Viktor Voropaev¹

¹ Keldysh Institute of Applied Mathematics of Russian Academy of Sciences
² GAUSS Srl

7th Planetary Defence Conference
April 26–30, 2021
Vienna, Austria
Observations of NEAs

- MPC code L28 (ISON-Castelgrande Observatory) received in June 2018
- MPC NEOCP & PCCP follow-up (lim $\sim$17) → published MPECs
- NEA photometry (lim $\sim$16)

- NEA 2019 OK in July 2019 – first astro-photometric collaboration with ESA
- NEA (52768) 1998 OR 2 – first photometric collaboration with the Observatory of the Kuban State University (Russia) since March 2020 → APT (Asteroid Photometry Team) collaboration of 8 observatories in Italy, Russia, Kazakhstan, Mexico, Uzbekistan since June 2020 → ~20 NEAs observed so far → first publications of results in Minor Planet Bulletin soon
National Public Outreach

- interviews with the regional and national RAI television
National Public Outreach

- publications in local daily newspaper “Le Cronache Lucane”, e.g. about NEA (52768) 1998 OR 2
National Public Outreach

- participation in Asteroid Day 2020 presented on the web site of “Le Cronache Lucane”; participation International Observe the Moon Night (La Notte della Luna) 2020 → 1) NEA 2020 CD3 (“second” moon), 2) lunar impacts (MIDAS project)
National Public Outreach

- first public observation of Perseid maximum on August 11, 2020
National Public Outreach

- lectures for visitor groups at the observatory (conference hall with 100 seats)

NEA 2019 OK
distance from Earth
in Earth radii
In Preparation

- national web-site on PHA/NEA (professional data from MPC, NEODyS, JPL presented in easy-to-use format)
- Astrodomus (3D-cinema with 25 seats, 4 large touch-screens)
- online lectures
- UNI TRE astronomy course at Muro Lucano village
- Asteroid Day workshop
Thank you!

Contact:
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+49 170 7527721
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WhatsApp, Telegram, Facebook
Public Communication in the Case of an Impending Impact
Lessons from the COVID-19 Pandemic

Carrie Nugent\textsuperscript{1} and Linda Billings\textsuperscript{2}
\textsuperscript{1}Olin College of Engineering
\textsuperscript{2}Consultant to NASA's Planetary Defense Coordination Office
Be Apolitical.

Dr. Anthony Fauci has worked for Republican and Democrat administrations.
Present a single, simple message.

#KeepHandsClean
by scrubbing your hands for 20 seconds with soap and water.

www.cdc.gov/handwashing
Show, don’t tell.
Show, don’t tell.

Myrick and Willoughby, 2020
When communicating numerical information:

- Use frequencies, not percentages (Peters, 2017)
- Use graphics

Effective visualization of COVID-19 infection rates by the Washington Post
Be prepared to fight misinformation

- Monitor social media to combat misinformation
- Establish relationships with social media companies in advance
Prevent fatigue

• Be cautious when asking public to make long-term sacrifices
Thank you!

• For more information,
  • Download the CDC handbook (link via the QR code below)
  • *The Oxford Handbook of the Science of Science Communication* (Jamieson, Kahan, Scheufele, 2017)
• To contact us: cnugent@olin.edu, billingslinda1@gmail.com
Q&A
Session 12: Public Education & Communication
Break

Up next: Session 13 - Apophis and Others, Far and Near: Future Characterization Opportunities from NEO Close Approaches