7th IAA Planetary Defense Conference

26-30 April 2021, Online Event

Hosted by UNOOSA in collaboration with ESA

Session 12: Public Education & Communication

Chairs: Linda Billings | Alissa J. Haddaji | Alex Karl

Presenters: N. Melamed | A. Nath | J. L. Cano | S. Srivastava | A. Karl | S. Schmalz | C. Nugent

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

AERO CARES

https://www.youtube.com/watch?v=8m9i_wLE97w

The Aerospace Corporation

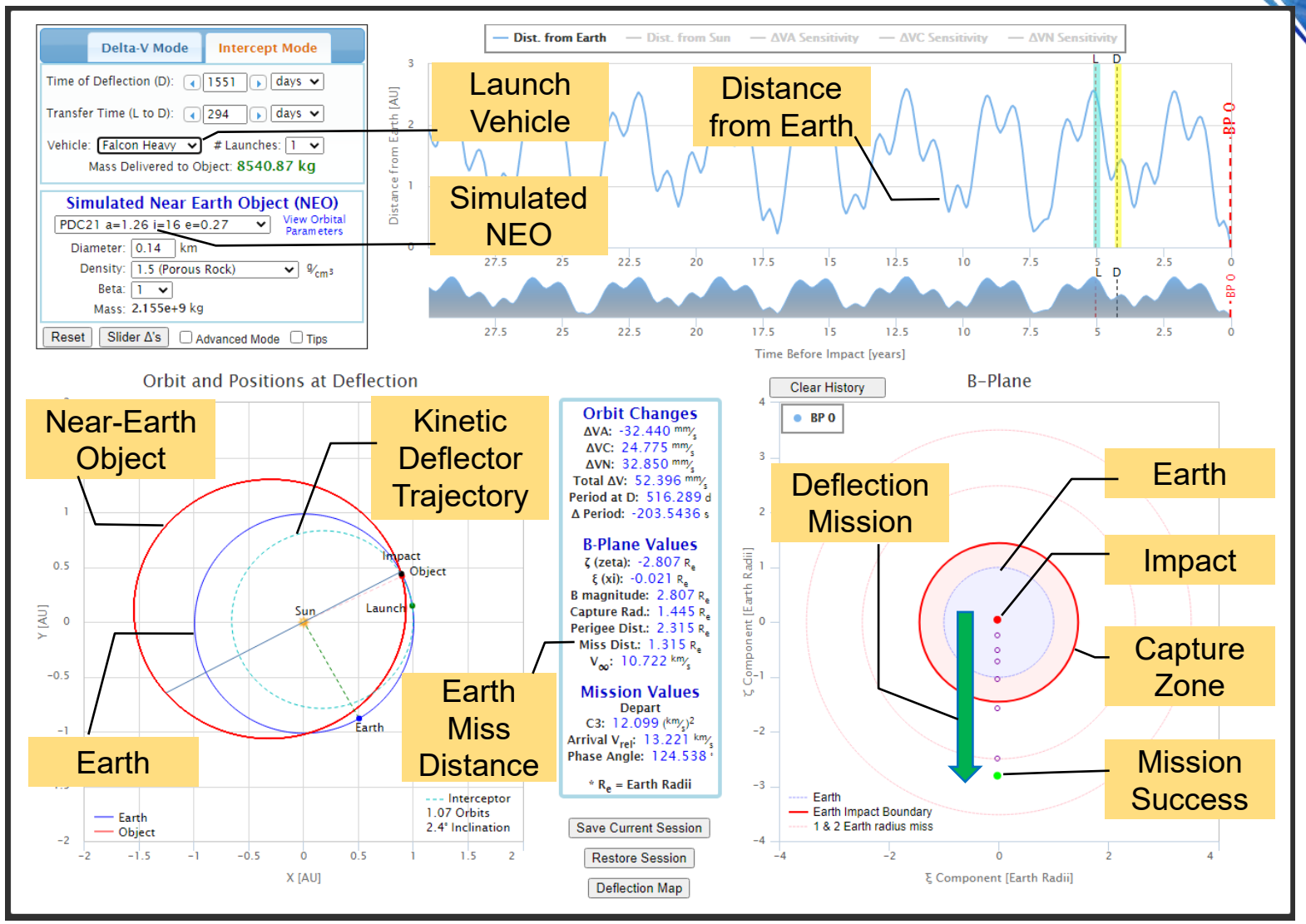
Working for a Brighter Future

- 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

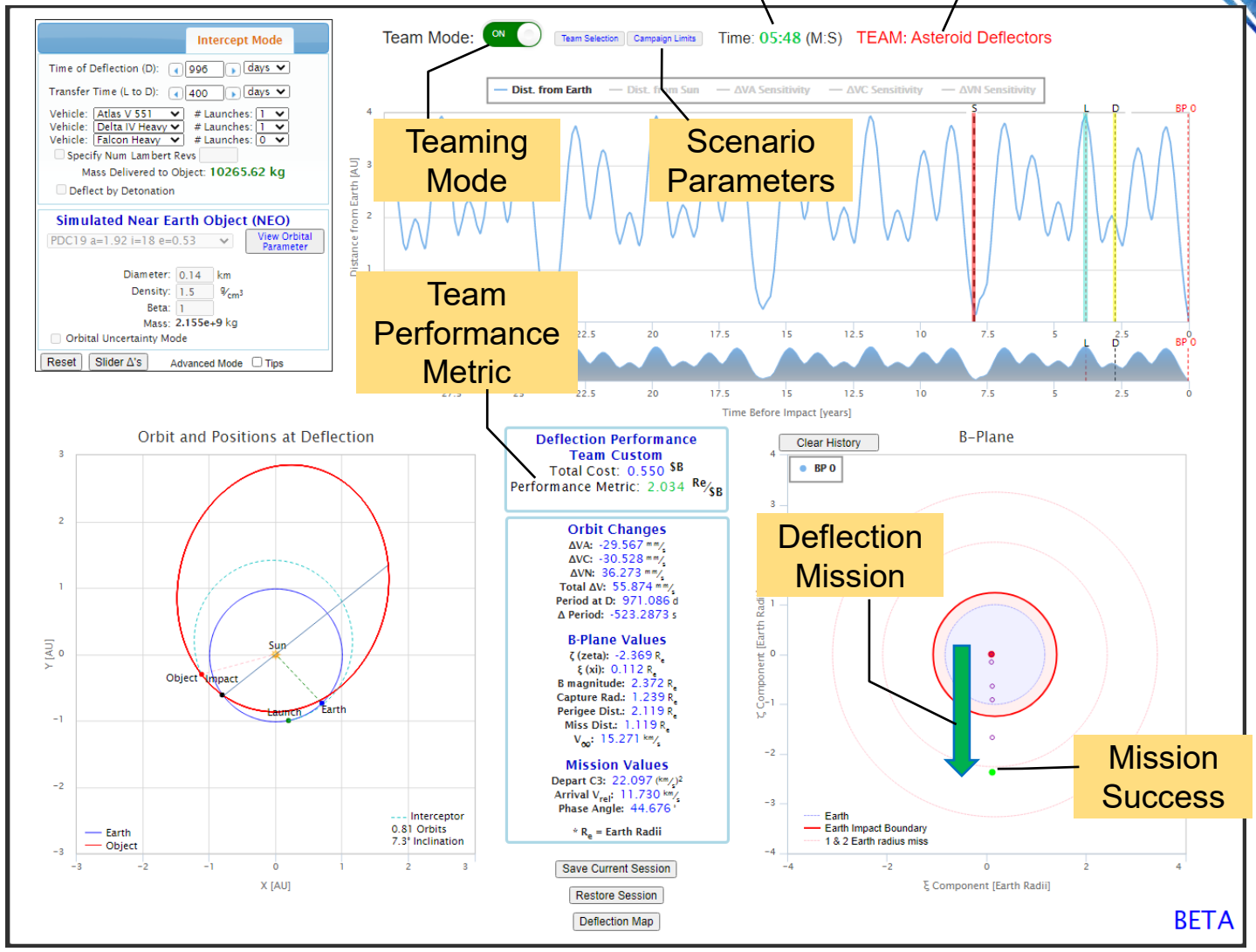


PDC21 successfully deflected with single kinetic deflector spacecraft launched 5 years before projected Earth impact

Teaming App for Asteroid Deflection

An Aerospace Corporation STEM Outreach Workshop Series

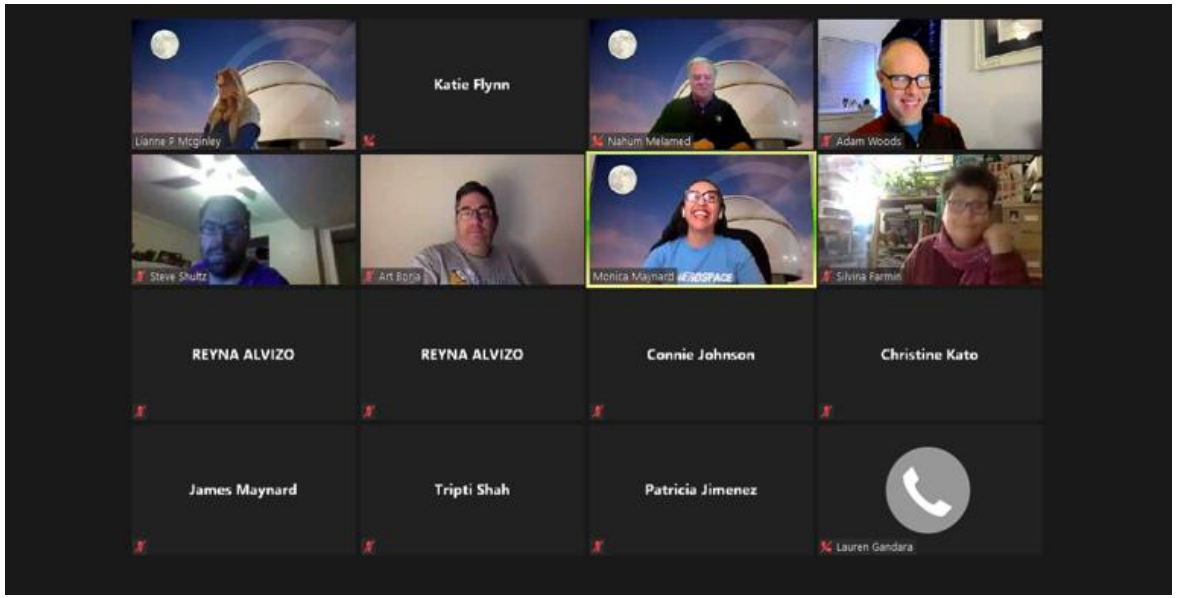
- The Aerospace Corporation has added a collaborative educational context to the App and developed an educational program to conduct asteroid deflection teaming exercises with the NDA
- Several participants are grouped into teams and given an increasingly challenging hypothetical asteroid collision scenario 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?

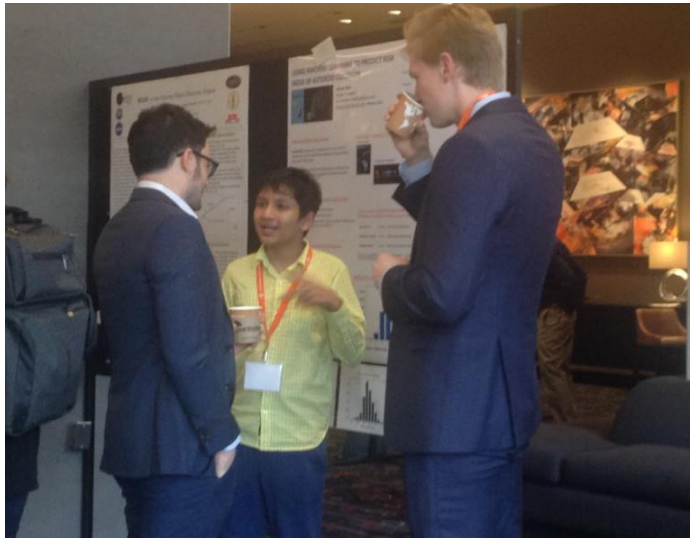
Arushi Nath (Grade 6)
Artash Nath (Grade 9)

7th IAA PDC Conference 2021
30 April 2021

Website: www.HotPopRobot.com
Twitter: @Wonrobot

How Apophis Entered Our Lives ?

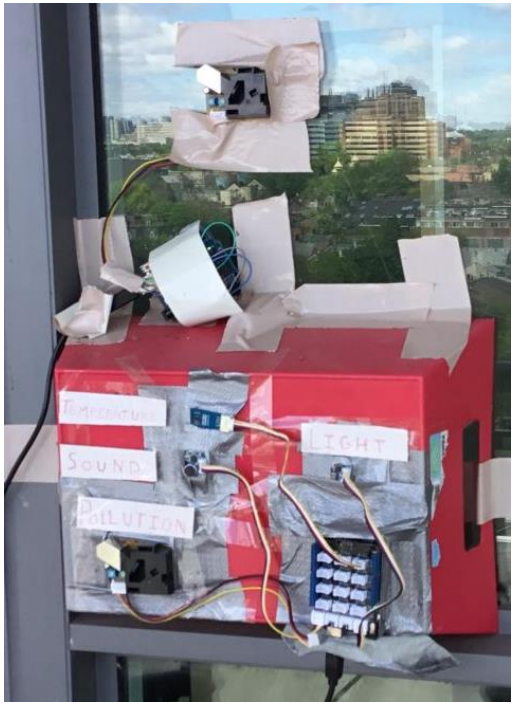
Artash: Participating and presenting in 6th IAA Planetary Defense Conference 2019, Maryland



Arushi: 3D printed models of Asteroid Apophis

COVID-19: Closed Schools, Open Minds

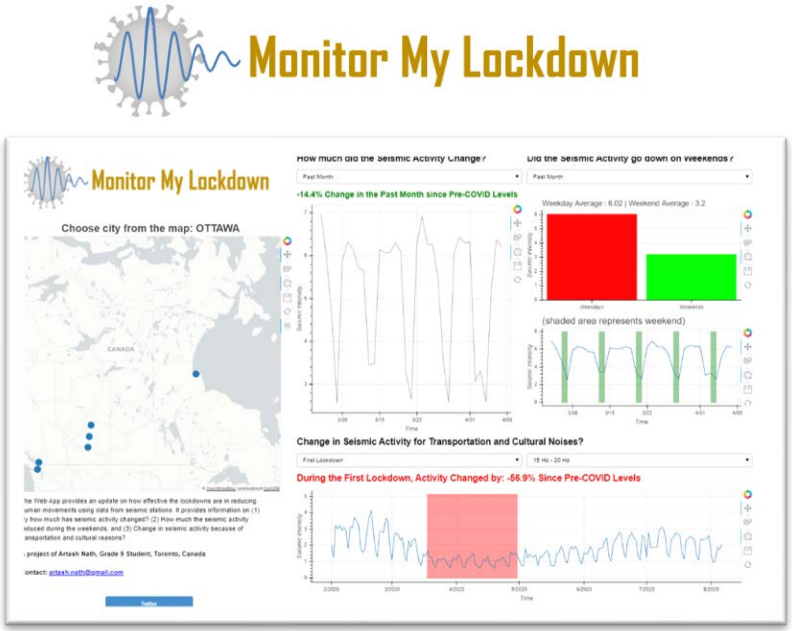
On Earth



Measuring Impact of COVID-19 Lockdowns on Local Environment

Mar 2020 – Jul 2020

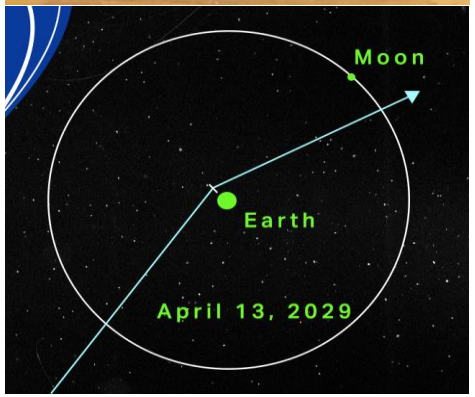
Subsurface



Measuring Impact of COVID-19 Lockdowns on Seismic Vibrations

Jun 2020 – ongoing

Space

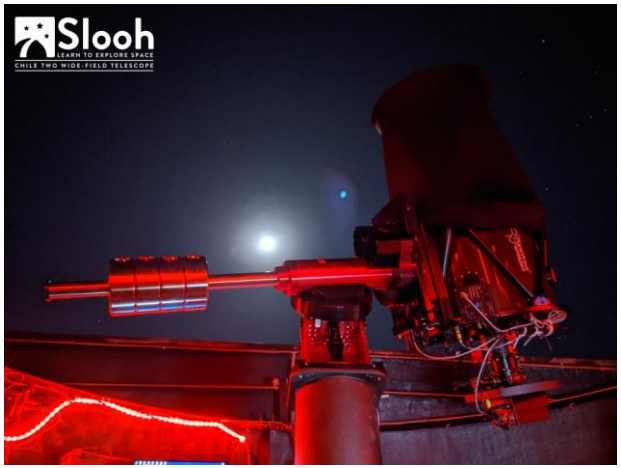


Finding APOPHIS!

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

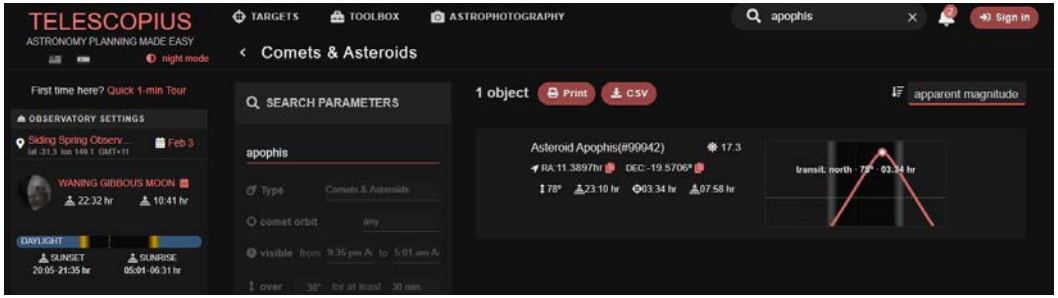
(Image Credit: Gronk Oz - Own work, CC BY-SA 4.0)

Pointing the Faulkes Telescope South to Apophis

Daily Right Ascension and Declination Values from NASA HORIZON project

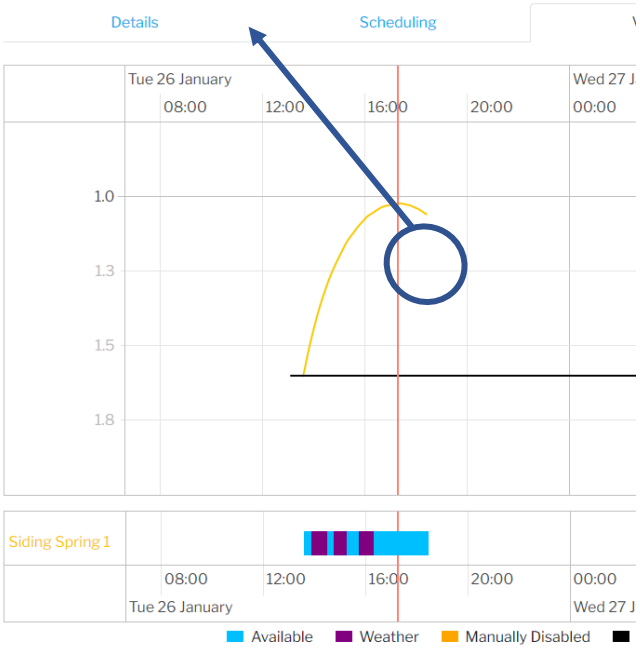
```
 Date__(UT)__HR:MN     R.A._____(ICRF)_____DEC    APmag
*******************************************************
$$SOE
 2021-Jan-10 00:00     11 43 51.55 -16 05 04.7   18.554
 2021-Jan-11 00:00     11 44 00.99 -16 18 09.7   18.515
 2021-Jan-12 00:00     11 44 06.86 -16 31 01.5   18.475
 2021-Jan-13 00:00     11 44 09.00 -16 43 38.9   18.435
 2021-Jan-14 00:00     11 44 07.26 -16 56 00.8   18.393
 2021-Jan-15 00:00     11 44 01.47 -17 08 06.2   18.351
 2021-Jan-16 00:00     11 43 51.49 -17 19 53.9   18.308
 2021-Jan-17 00:00     11 43 37.14 -17 31 22.7   18.264
 2021-Jan-18 00:00     11 43 18.28 -17 42 31.4   18.219
 2021-Jan-19 00:00     11 42 54.72 -17 53 18.7   18.174
```

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



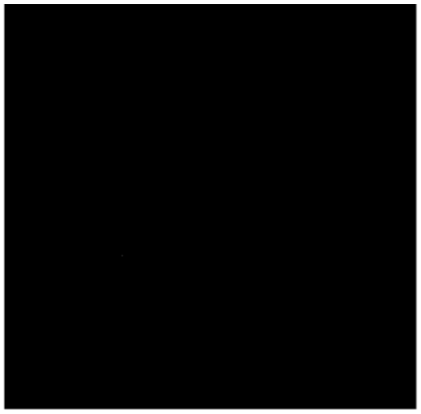
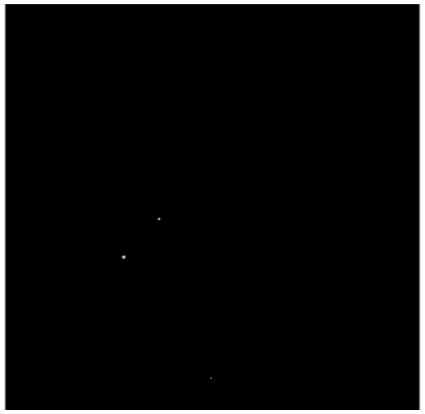
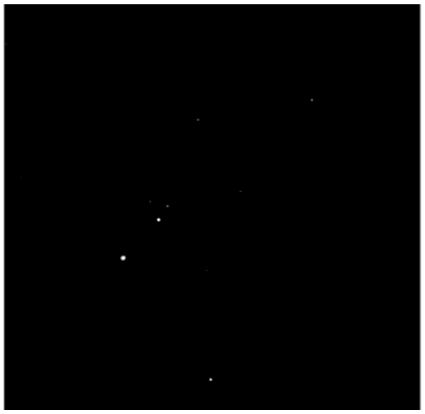
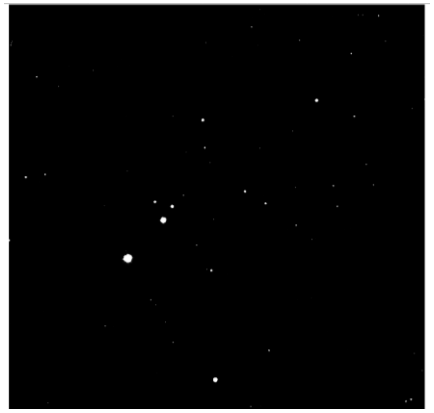
Source: Telescopius Website. https://telescopius.com/

Best Visibility and Time

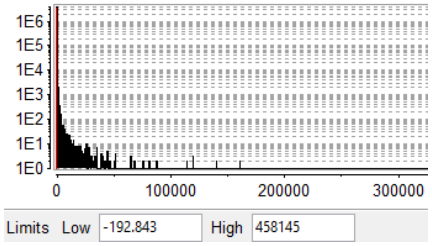


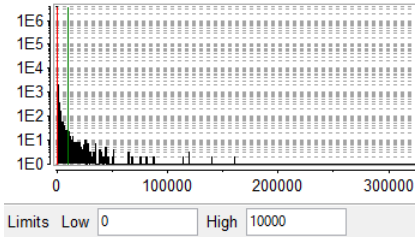
Scaling our Images taken from the Faulkes Telescope South

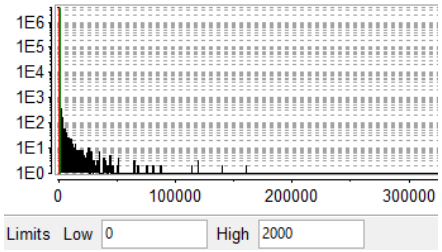
To see maximum possible objects: brighter and dimmer

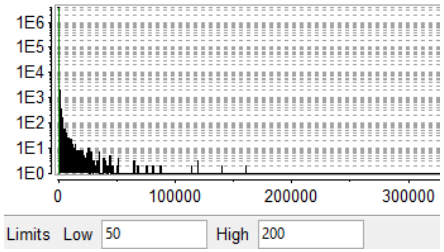





(Modifying Pixel Brightness Range using the Min/Max Function of SAOImage DS9 software, ds9.si.edu)



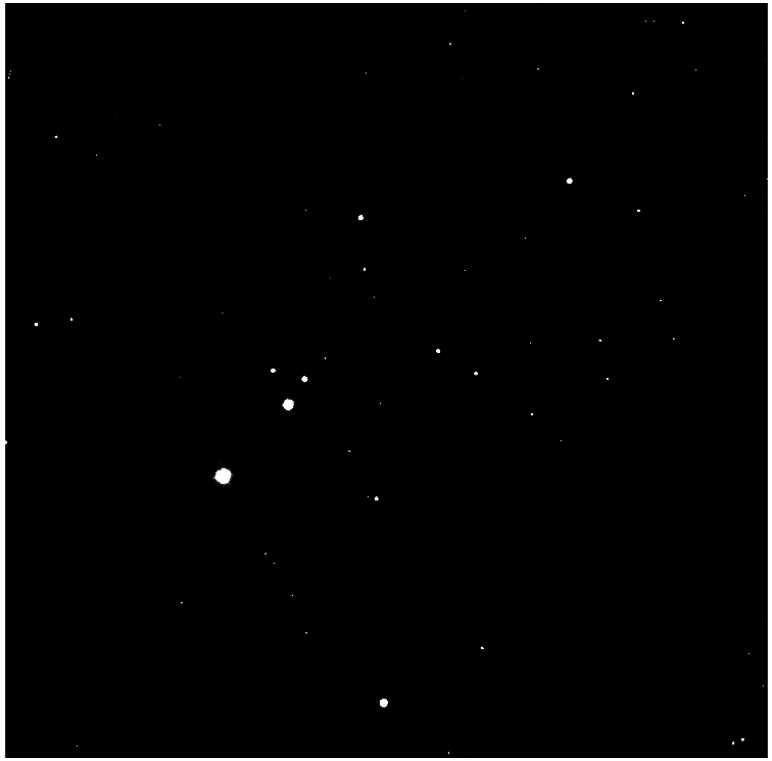






Comparing CCD Image with Celestial Field of View

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

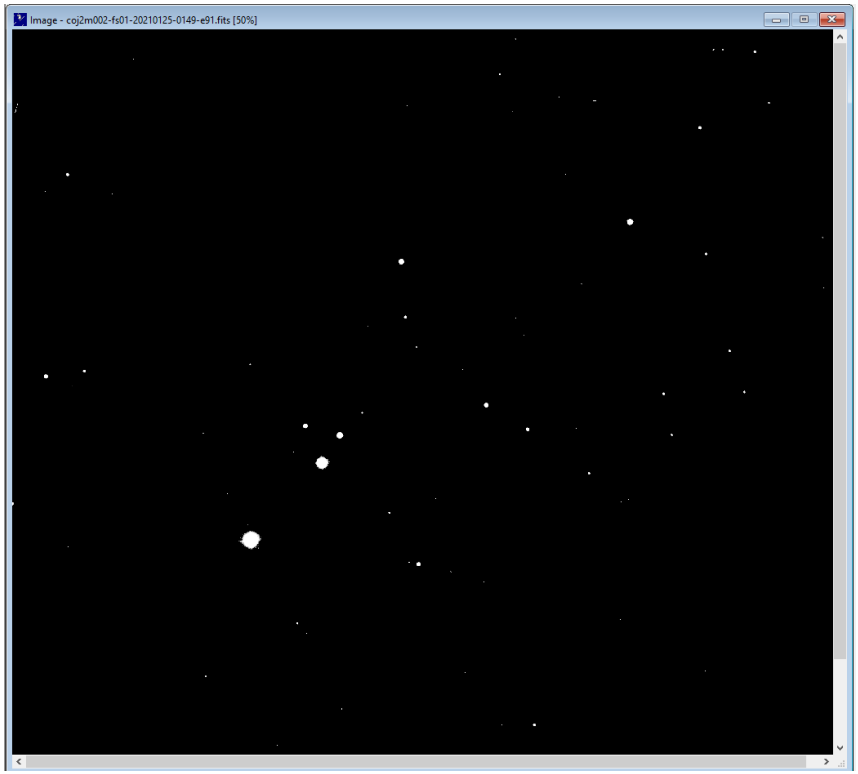
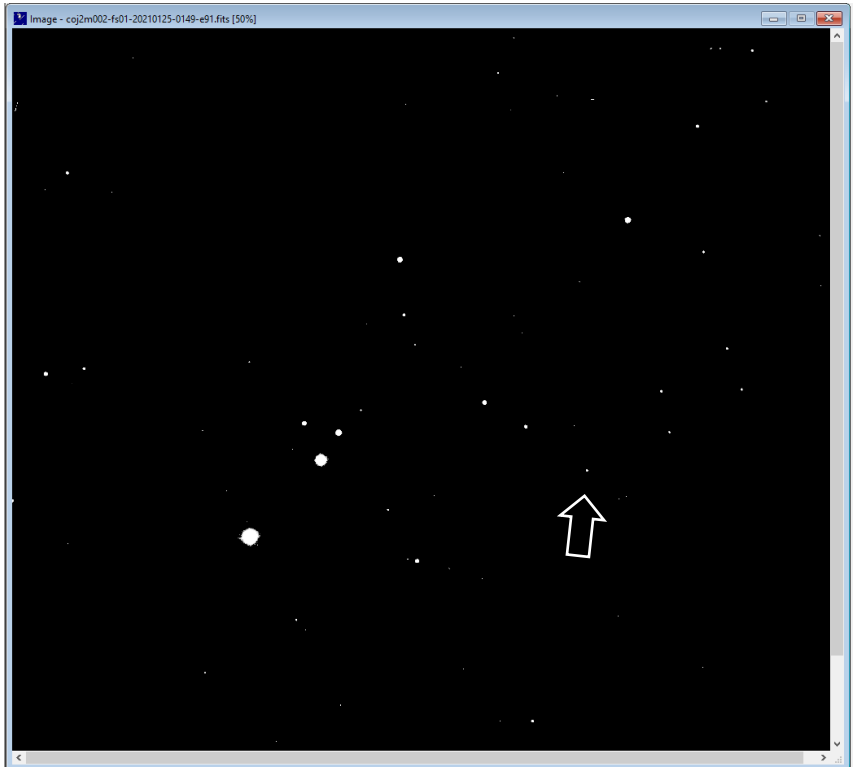


Image taken using the Faulkes Telescope South on 25th January 2021 (RA: 11h 38m 06.99s Dec: -18° 53' 59.4")

Finding Apophis!

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



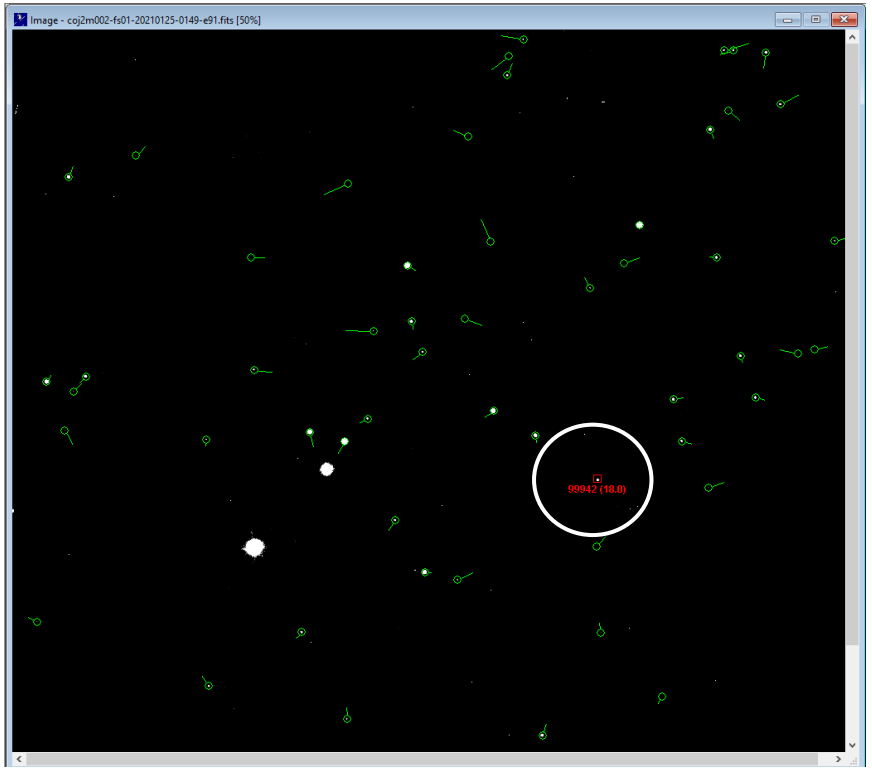
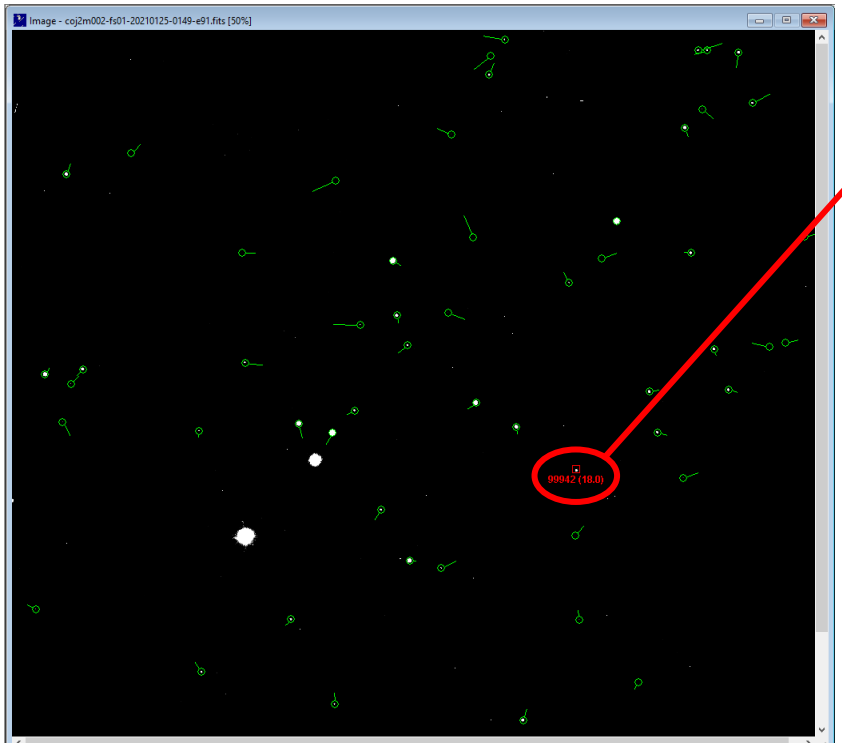


Image taken using the Faulkes Telescope South on 25th January 2021
(RA: 11h 38m 06.99s Dec: -18° 53’ 59.4”)

Locating Apophis Twice to Calculate Motion

25th January 2021. 18:07:33 UTC

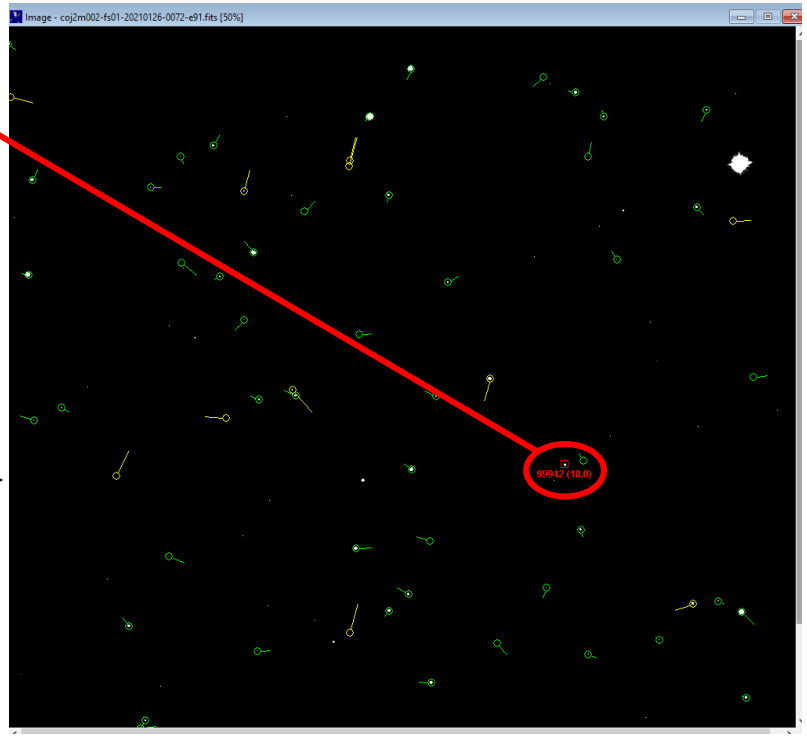


RA = 11h 37m 58.225s
Dec = -18 54’ 46.6”

99942 Apophis

Time Difference
23 hours 58 min 4 sec

26th January 2021 18:05:37 UTC

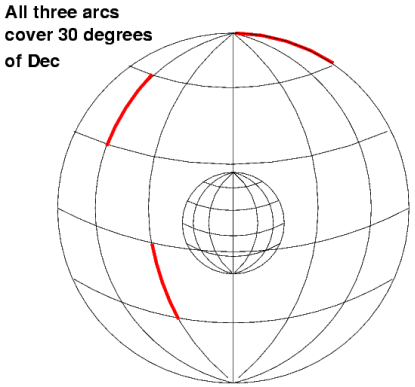


RA = 11h 36m 51.98s
Dec = -19 01’ 54.6”

Images taken using the Faulkes Telescope South

Calculating Proper Motion of Apophis

Apophis	Right Ascension	Declination
25 January 2021	11h 37m 58.225s (A)	-18 54’ 46.6” (A)
26 January 2021	11h 36m 51.98s (B)	-19 01’ 54.6” (B)

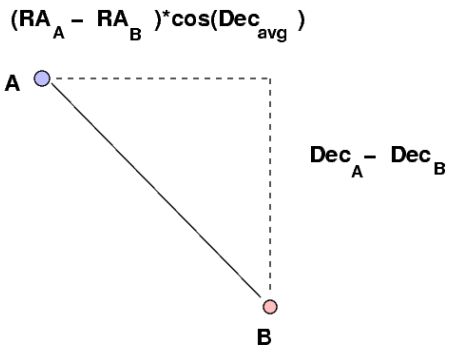


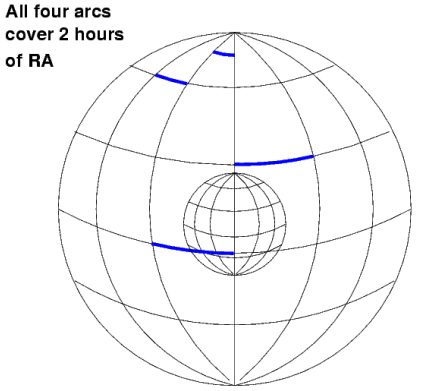
RA (A) – RA (B) = 174.4917 - 174.2167 = 0.275

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

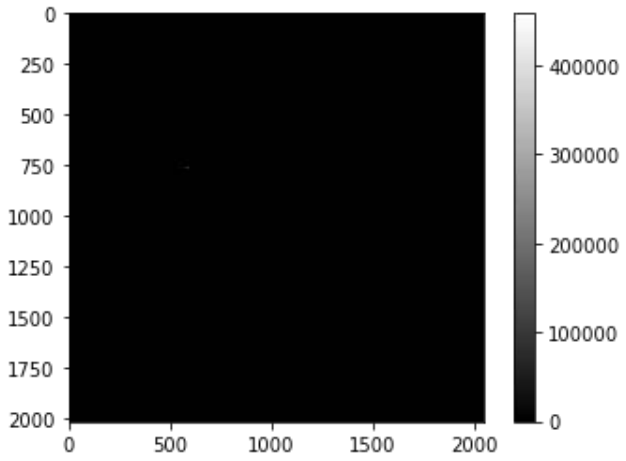
STEPS

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

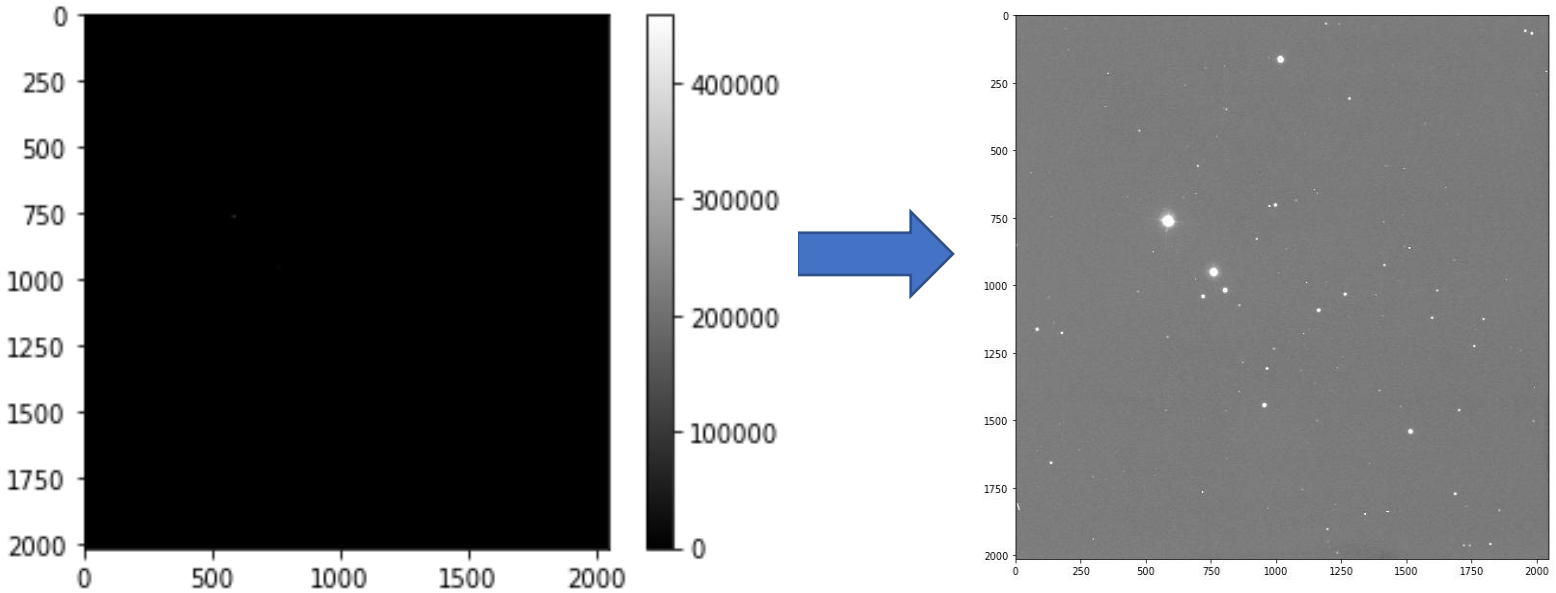
In [1]:
```
# Importing Required Libraries
import numpy as np
from astropy.io import fits
import urllib as url

import os
import matplotlib.pyplot as plt
```

In [ ]:
```
# 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

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

```
SCHEDSEE=            1.9225850 / [arcsec] Estimated seeing when group scheduled
SCHEDTRN= 'N/A     '           / [(0-1)] Estimated transparency when group sched
TRIGGER = 'N/A     '           / External trigger ID
OBRECIPE= 'N/A     '           / Observing Recipes required/used
PCRECIPE= 'N/A     '           / Processing Recipes required/used
PPRECIPE= 'N/A     '           / Post-Processing Recipes required/used
RA      = '11:38:06.4917'      / [HH:MM:SS.sss] RA where telescope is pointing
DEC     = '-18:54:22.377'      / [sDD:MM:SS.ss] Dec where telescope is pointing
RADESYS = 'ICRS    '           / [[FK5,ICRS]] Fundamental coord. system of the o
LST     = '12:24:53.68'        / [HH:MM:SS.ss] LST at start of current observati
CAT-RA  = '11:38:06.990'       / [HH:MM:SS.sss] Catalog RA of the object
CAT-DEC = '-18:53:59.40'       / [sDD:MM:SS.ss] Catalog Dec of the object
CAT-EPOC=         2000.0000000 / [Year] Catalog epoch of the coordinates
OFST-RA = '11:38:06.990'       / [HH:MM:SS.sss] Catalog RA plus pointing offsets
OFST-DEC= '-18:53:59.40'       / [sDD:MM:SS.ss] Catalog Dec plus pointing offset
TPT-RA  = '11:38:58.053'       / [HH:MM:SS.sss] Telescope demand RA
TPT-DEC = '-18:51:10.67'       / [sDD:MM:SS.ss] Telescope demand Dec
OBJECT  = 'Apophis '           / Object name
SRCTYPE = 'EXTRASOLAR'         / Source type
```

```python
#Querying FITS File for Information

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

#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
```

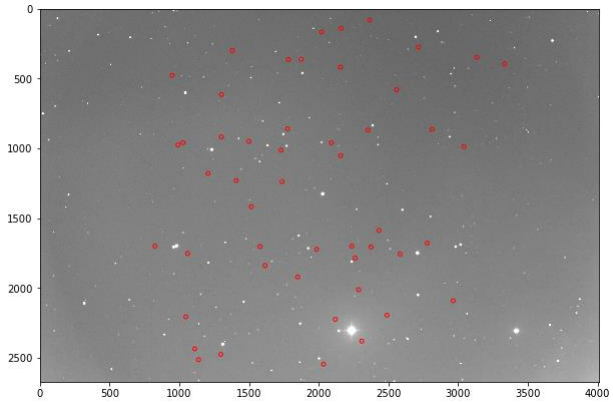
Query Star Catalogue USNO-B 1

```
#Querying Star Catalogue: United States Naval Observatory-B 1 (USNO-B 1)

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
```

The USNO-B1.0 Catalog

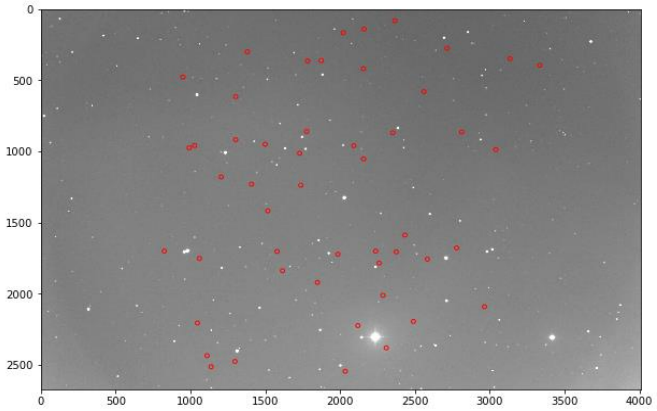
(Entry Format) (B1.0 at USNO)

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):
    """
    Rotate a point counterclockwise by a given angle around a given origin.

    The angle should be given in radians.
    """
    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
```



Unmatched Image

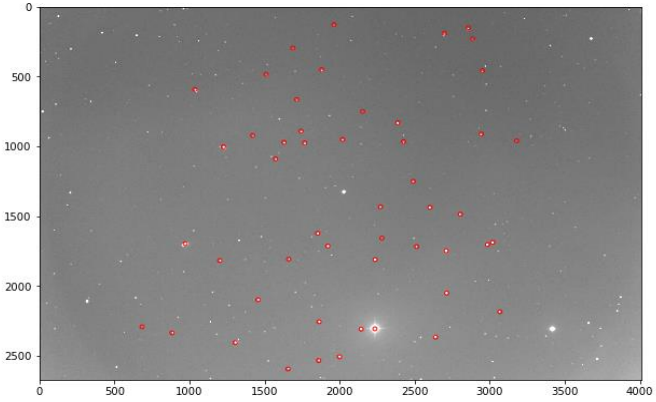
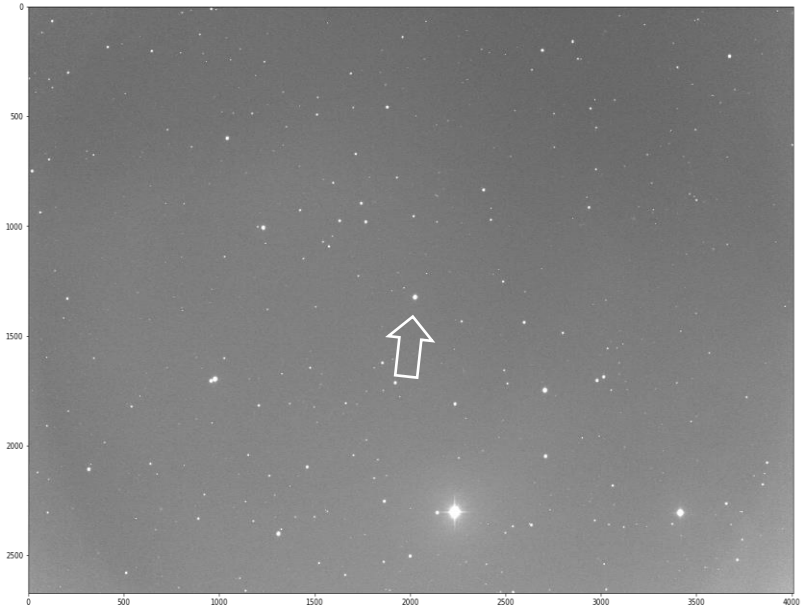
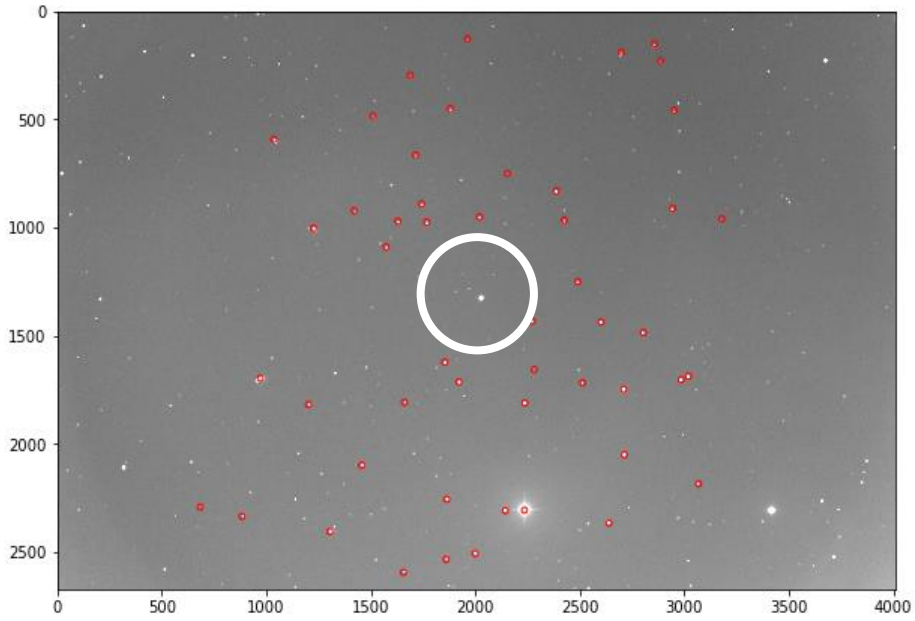


Image matched after rotating 180 degrees

Finding the Asteroid!



Original Image

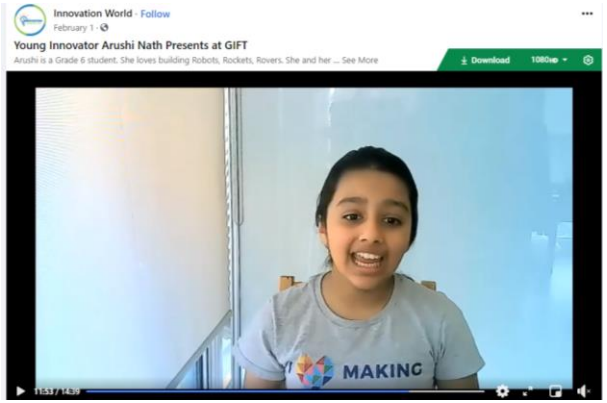


Data Reduced and Image Mapped Using Sky Catalogue using Python

Outreach: Reaching to Kids and Families

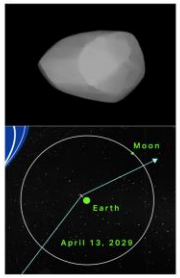
Royal Astronomical Society of Canada (RASC)

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.HotPopRobot.com

Conseil scolaire Viamonde

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA · LA SOCIÉTÉ royale D'ASTRONOMIE DU CANADA

THE GLOBAL INNOVATION FIELD TRIP

Conseil scolaire Viamonde

tout est possible

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

NASA is on alert at
as a 'close approa
Moon.

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

Charlotte Edwards, Digital Technol
29 Mar 2021, 11:06 | Updated: 29 Ma

NASA has removed a huge

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

Jon Lockett
17 Nov 2020, 19:28 | Updated: 17 Nov 2020, 19:33

TEROID the size of a pick-up truck has just skirted within 240 miles
th, NASA has revealed.

eek's very close encounter set a record for the nearest known space
o fly past the planet without actually hitting.

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 i
- The 1,870ft
- It poses no r

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

Harry Pettit, Senior Digital Technology and Science Reporter
24 Nov 2020, 15:14 | Updated: 24 Nov 2020, 15:15

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

The rock is travelling at over 56,000 mph (90,000 kph) and at up to 820
metres (2
tallest bu

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.

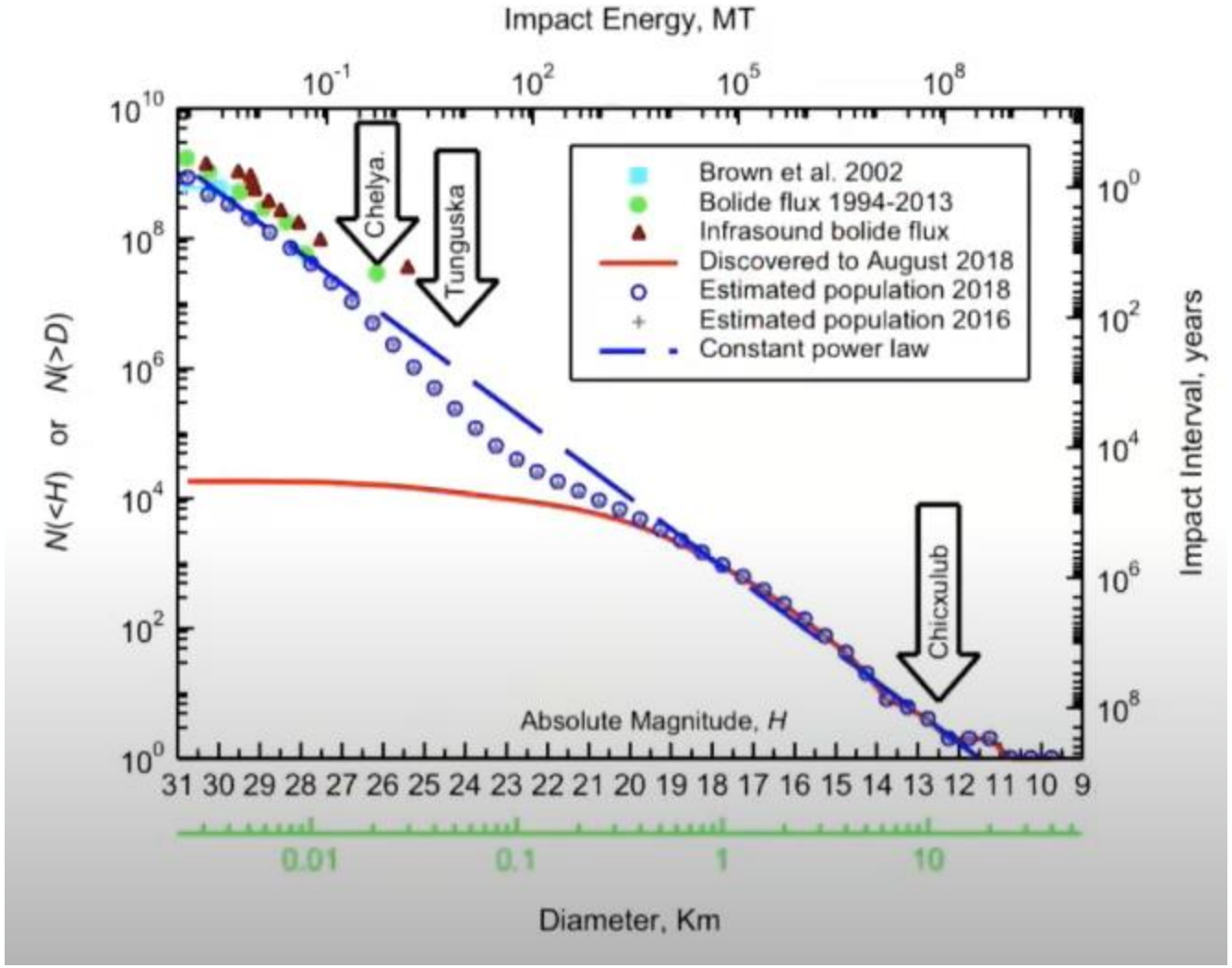
FREQUENCY OF A CLOSE APPROACH

- 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

IMPACT FREQUENCY VS POPULATION MODEL



Source: Harris, PDC-2019

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.

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:

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

b is the b-plane impact parameter

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

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

d is the CA distance
v_∞ is the infinite CA velocity
v_{esc} is the Earth escape vel.

NEO POPULATION DISTRIBUTION MODEL

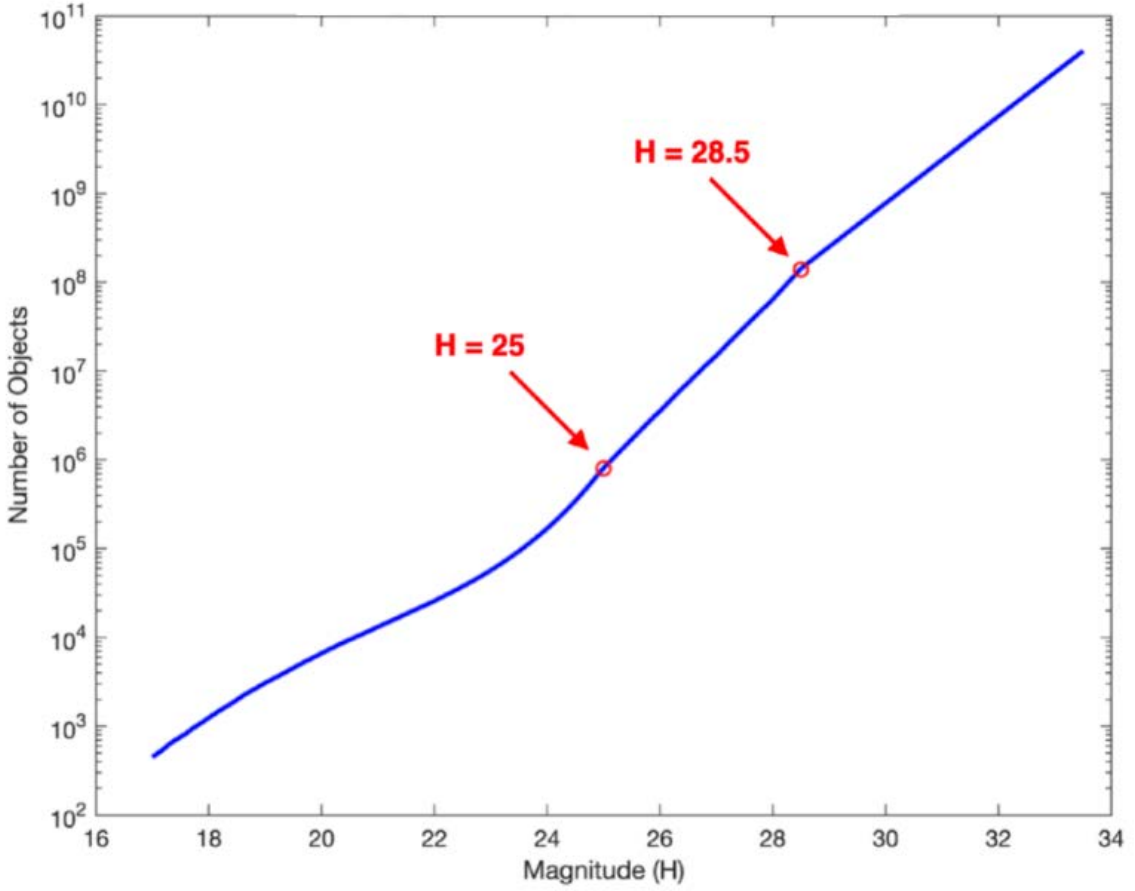
- Several NEO population models have been proposed in the last 25 years
- For our computations we decided to select:
  - The Granvik model (2018) for $H \leq 25$
  - A log-linear extrapolation of that model for $25 < H \leq 28.5$

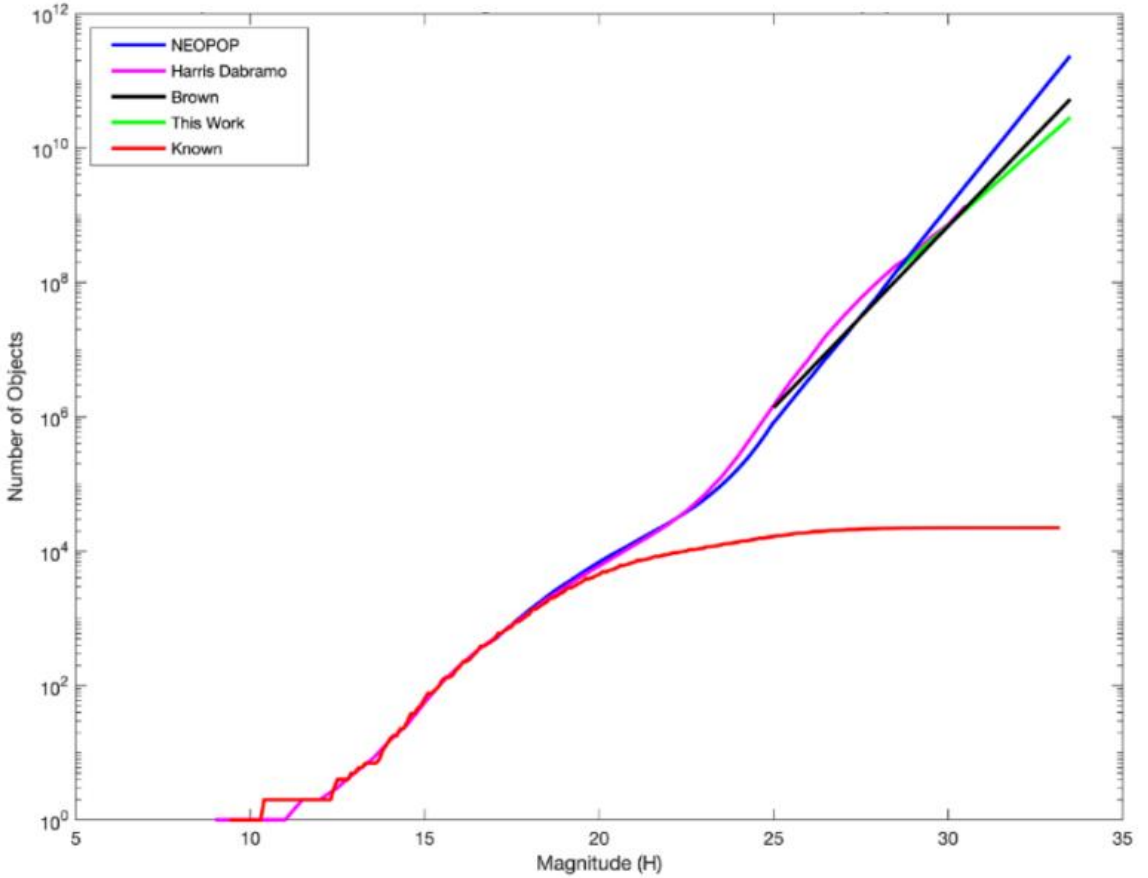
$$N(\leq H) = 802{,}404 \times 10^{\,0.6434\,(H-25)}$$

  - 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





THE IMPACT FREQUENCY CONSTANT

- Proposed values:
  - Shoemaker (1979): $k = \sim 2.5 \times 10^{-9} \ \ yr^{-1}$
  - Brown (2002): $k = 2 \times 10^{-9} \ \ yr^{-1}$
  - Tricarico (2017): $k = 4 - 6 \times 10^{-9} \ \ yr^{-1}$
  - NASA (2017): $k = 1.66 \times 10^{-9} \ \ yr^{-1}$
  - NEOPOP (2020): $k = 1.89 \times 10^{-9} \ \ yr^{-1}$
- We decided to use $k = 1.66 \times 10^{-9} \ \ yr^{-1}$, 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:

$$CAI = \log_{10}\left(f_{CA}(N, d, v_\infty)\right)$$

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

Object designation	Absolute magnitude	Close approach date	CA distance (au)	Infinite velocity (km/s)	CA frequency (y^{-1})	Close approach index	Close approach ranking
2021 DM	26.1	2021-02-28	0.0327	10.2	1.82E+03	3.26	Very frequent event
2021 ET1	24.6	2021-02-28	0.0457	9.0	3.00E+02	2.48	Very frequent event
2021 EH2	26.2	2021-02-28	0.0456	5.8	1.92E+03	3.28	Very frequent event
2011 DW	22.7	2021-03-01	0.0361	13.6	3.05E+01	1.48	Very frequent event
2021 EU3	27.1	2021-03-01	0.0122	4.7	3.77E+02	2.58	Very frequent event
2021 EE	25.8	2021-03-02	0.0119	16.9	2.36E+02	2.37	Very frequent event
2011 EH17	24.9	2021-03-02	0.0342	16.6	4.90E+02	2.69	Very frequent event
2021 EE1	26.0	2021-03-02	0.0473	9.1	2.88E+03	3.46	Very frequent event
2021 EC	27.8	2021-03-02	0.0044	8.7	3.37E+02	2.53	Very frequent event
2021 EA	28.0	2021-03-02	0.0006	9.9	1.17E+01	1.07	Very frequent event
1999 RM45	19.8	2021-03-02	0.0196	20.0	1.58E+00	0.20	Frequent event
2016 DV1	24.8	2021-03-03	0.0053	18.3	1.06E+01	1.03	Very frequent event

And many more lines in the table…

EXAMPLE: NEOCC CLOSE APPROACHES

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

Evaluation	Recent CAs	Upcoming CAs
Very frequent event	124	129
Frequent event	7	10
Infrequent event	1	5
Rare event	0	1
Very rare event	0	0
Total	**132**	**145**

EXAMPLE: NEOCC CLOSE APPROACHES

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

Object designation	H	Close approach date	CA distance (au)	Infinite velocity (km/s)	CA frequency (y^{-1})	Close approach index	Close approach ranking
(231937) 2001 FO32	17.6	2021-03-21	0.0135	34.4	1.29E-01	-0.89	Infrequent event
2016 AJ193	18.7	2021-08-21	0.0229	26.2	9.53E-01	-0.02	Infrequent event
2019 XS	23.8	2021-11-09	0.0038	10.7	8.45E-01	-0.07	Infrequent event
(4660) Nereus	18.3	2021-12-11	0.0263	6.6	2.64E-01	-0.58	Infrequent event
(163899) 2003 SD220	17.7	2021-12-17	0.0363	5.6	2.26E-01	-0.65	Infrequent event
(7482) 1994 PC1	16.6	2022-01-18	0.0132	19.6	6.23E-02	-1.21	Rare event
(138971) 2001 CB21	18.4	2022-03-04	0.0328	12.0	9.34E-01	-0.03	Infrequent event
Apophis	18.9	2029-04-13	0.000254	7.42	7.03E-05	-4.15	Very rare event

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!

SPACE GENERATION
ADVISORY COUNCIL

PLANETARY DEFENSE CONFERENCE
PDC 2021
Vienna, Austria

Role of SGAC in Global Planetary Defence Outreach

SGAC Origins

SPACE GENERATION ADVISORY COUNCIL

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.

Conceived at the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III) in Vienna in 1999.

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

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SGAC Project Groups

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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

Near Earth Objects Project Group

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- 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

Near Earth Objects Project Group

https://spacegeneration.org/projects/near-earth-object

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INTERNAL ACTIVITIES

Find An Asteroid (FAA)

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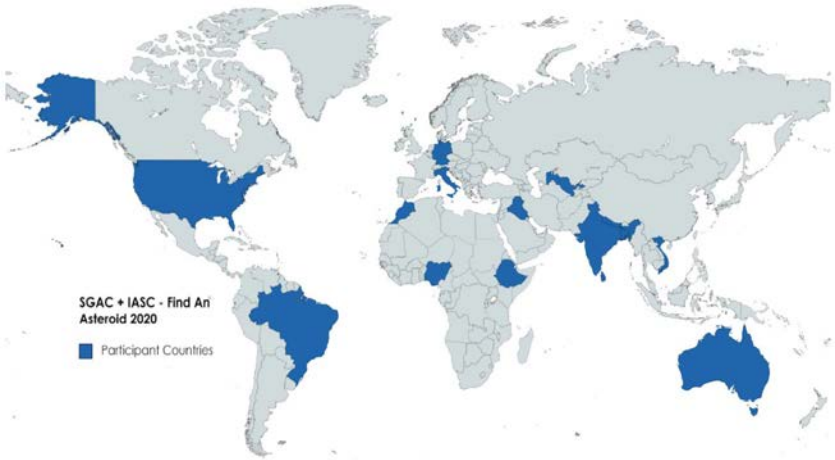
- The campaign was a collaboration between **SGAC** and the **International Astronomical Search Collaboration (IASC)**
- Applicants from around the world were invited to participate in this 4 week event with special focus on teams from schools and universities
- The campaign started on schedule receiving 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**



https://spacegeneration.org/neo-iasc2020

Move An Asteroid (MAA)

SPACE GENERATION ADVISORY COUNCIL

- 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-incorproation 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

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NEO Renaissance

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- 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

Collaboration with IAF NEO Technical Committee : International Asteroid Day 2020

- 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

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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

AIAA LA LV December 5 Ms. Mariella Graziano, Ms. Nancy C Wolfson, and Ms. Smiriti Srivastava

https://www.youtube.com/watch?v=HLS00vlGW5I

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Conferences

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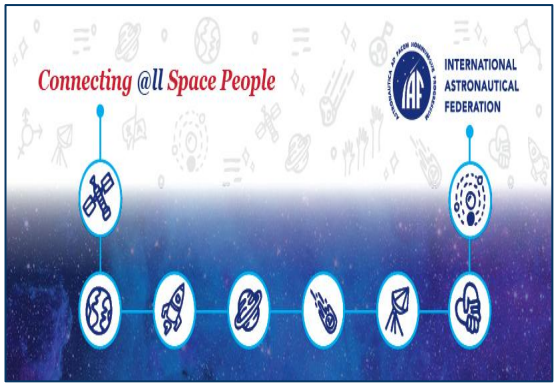
- NEO Project Group is an annual participant in international conferences like Planetary Defense Conference, IAC, GLEX and SGC

- Projects Focus on Planetary Defense, Readiness levels of Asteroid Mining industry, Space resource utilization missions and Educational, outreach activities to support goals of UNOOSA



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UN-RELATED ACTIVITIES

COPUOS

SPACE GENERATION ADVISORY COUNCIL

- **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

COPUOS

SPACE GENERATION ADVISORY COUNCIL

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.

SPACE GENERATION ADVISORY COUNCIL

INTERNATIONAL, REGIONAL, LOCAL AND ONLINE EVENTS

Space Generation Congress

SPACE GENERATION ADVISORY COUNCIL

SGC 2018 Bremen • Germany

SGC 2019 WASHINGTON • D.C.

- 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

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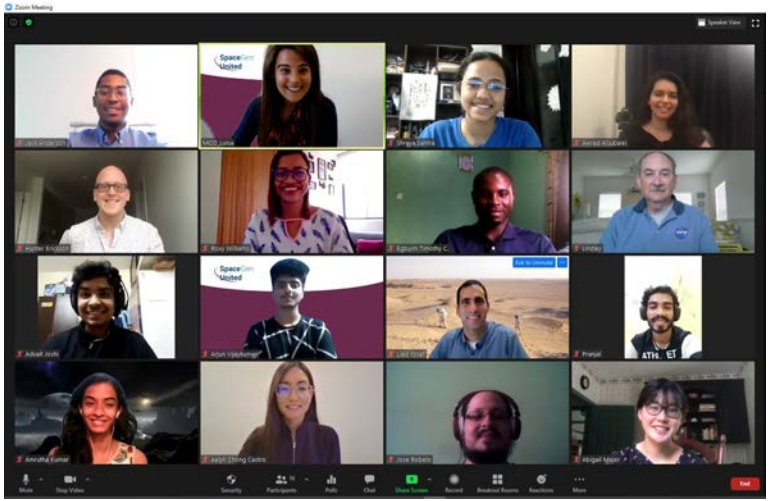
- SpaceGen United saw **143 delegates** from **53 different countries** joining together for **9 day** programme
- **14 hours** of keynote speeches and panel discussions featuring the **space economy** and the **state of the European space industry**
- **7 Workshops** took place during the week of SpaceGen 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

SpaceGen United

SGAC Webinars

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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

> 50 webinars	> 110 Nationalities
	100 - 1500 Viewers

Emerging Space Program: Lessons Learned for the...

SGAC Webinar - Space for Urban Planning

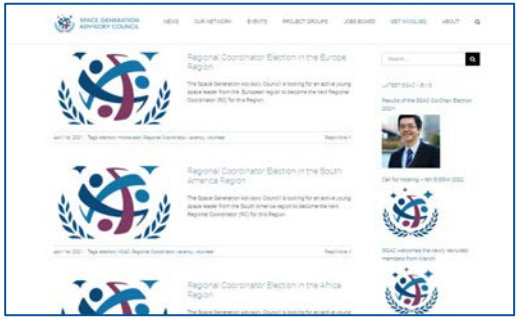
ISSC2 Webinar - Entrepreneurship and Spac...

Health in Space Series: Women's health in space

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?

SPACE GENERATION ADVISORY COUNCIL



https://spacegeneration.org/vacancies

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 able to receive support and guidance as they continue to advance in their careers.

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

https://spacegeneration.org/mentoring

Be part of the Space Generation

SPACE GENERATION ADVISORY COUNCIL

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

SPACE GENERATION ADVISORY COUNCIL

THANK YOU

Smiriti Srivastava
Co-lead of SGAC Near Earth Object (NEO) Project Group
smiriti.srivastava@spacegeneration.org

SPACE GENERATION ADVISORY COUNCIL

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

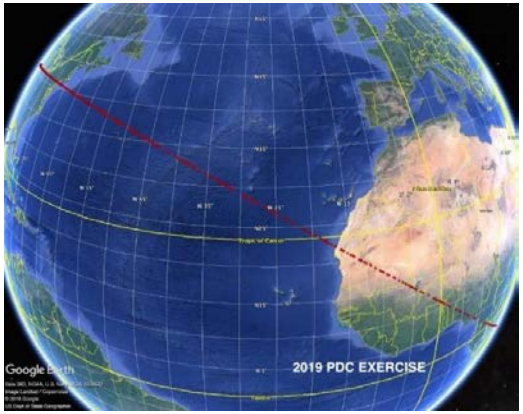
Poll#1: What is your reaction? 0 4 1

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

Multiple-choice poll

Poll#2: What is your reaction?

0 5 9

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.

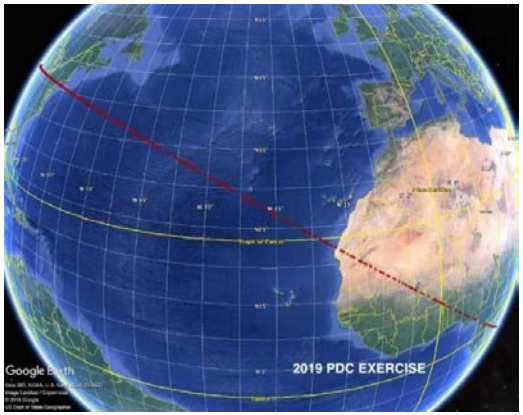
2 %

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

Multiple-choice poll

Poll#3: What do you think about the plans to deflect the asteroid? 0 6 1

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

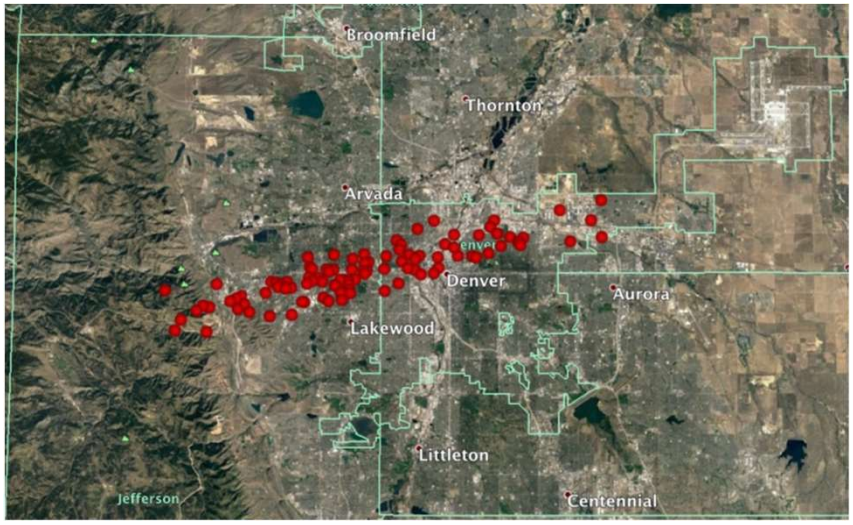
5 %

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

62 %

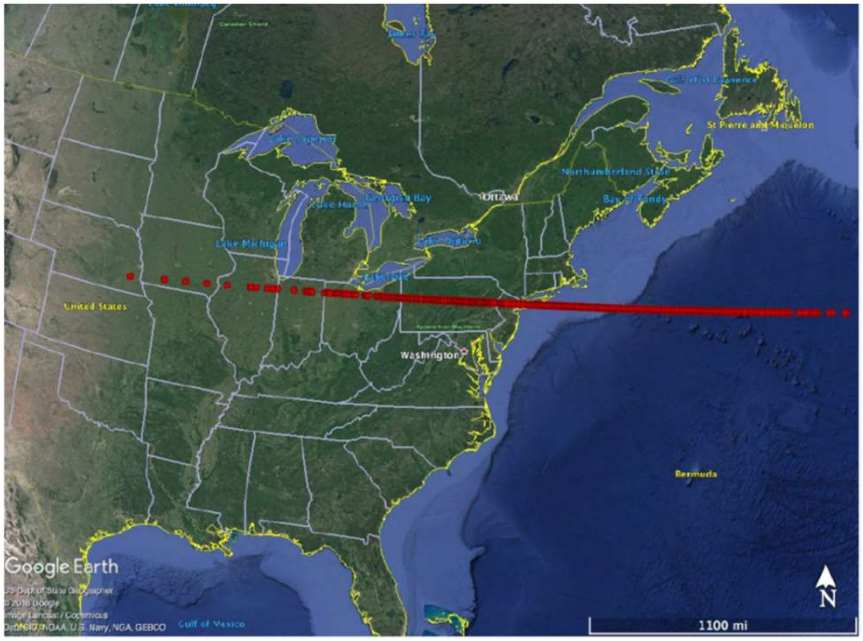
D: It is our responsibility to act when we can prevent disaster no matter what

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?

0 6 6

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

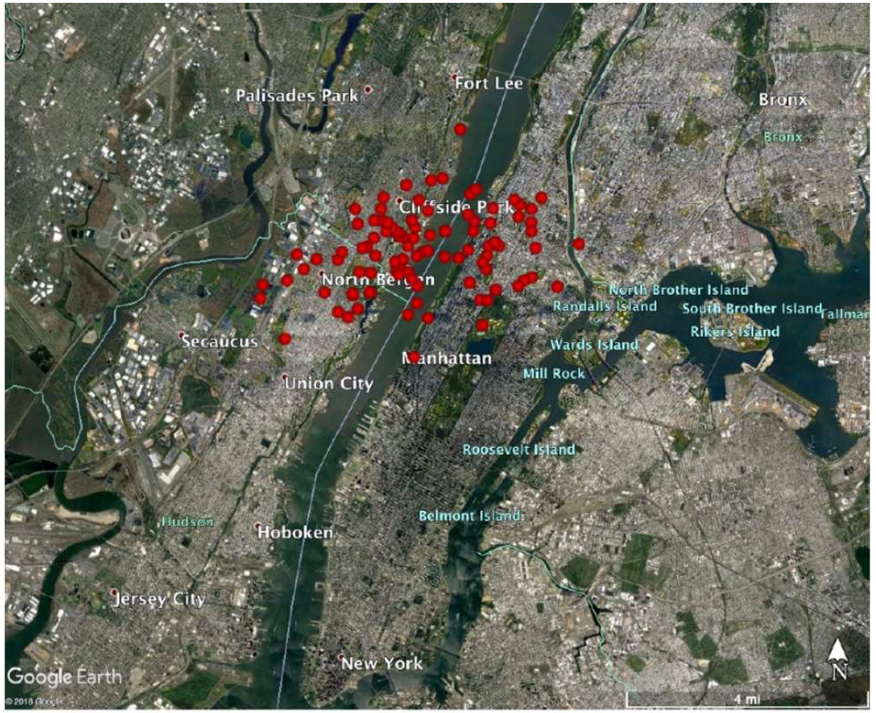
39 %

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



Multiple-choice poll

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

0 6 6

A: Our detection capability — 14 %

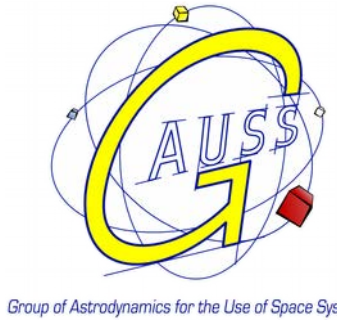
B: Establishing geopolitical agreements — 6 %

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)

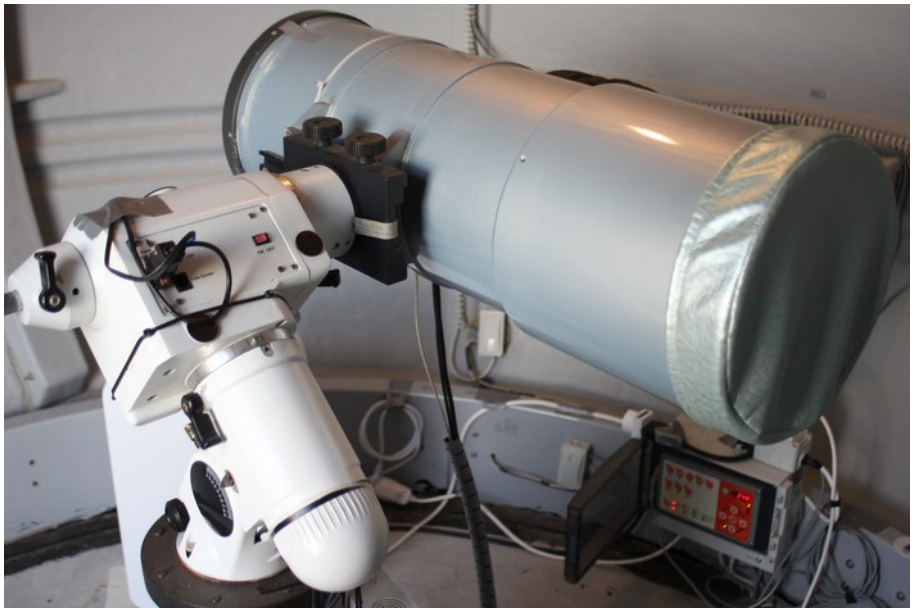
Sergei Schmalz[1], Filippo Graziani[2], Riccardo di Roberto[2], Viktor Voropaev[1]

[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_{mag} ~17) → published MPECs
- NEA photometry (lim_{mag} ~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**

ROMA

Le Cronache LUCANE
www.lecronache.info

potenza21
CITTÀ EUROPEA DELLO SPORT

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Dall'osservatorio di Castelgrande l'astronomo Schmalz rassicura: «Disterà oltre 6 milioni di km da noi»

«Nessun allarme: l'asteroide passerà lontano dalla Terra»

Ci mancava l'asteroide in avvicinamento verso la Terra, a far salire la tensione in questo momento storico già di per sé particolarissimo e delicato, sotto ogni punto di vista. Per saperne di più, sfatare qualche fake news e capire cosa accadrà, abbiamo interpellato l'astronomo russo Sergei Schmalzche (*in foto*) dal 2012 al 2015 ha lavorato come assistente all'Istituto Astrofisico di Potsdam in Germania; ha studiato astrofisica all'Università tecnica di Berlino per 3 semestri, hasvolto collaborazioni con diversi astronomi e astrofisici negli anni passati con gli astronomi dell'istituto KIAM di Mosca. Dal 2014 ha osservato i satelliti e i detriti spaziali in Mongolia, da remoto, e dal settembre 2017 vive e lavora presso l'Osservatorio astronomico del comune lucano di Castelgrande. Nel 2016 «i miei colleghi da KIAM mi hanno raccontato che avevano bisogno di un osservatore all'osservatorio di Castelgrande (dal 2014 c'era già un telescopio là, ma non c'era un osservatore), ho subito accettato e non lo rimpiango per nulla» ci racconta.

Venendo all'asteroide, dunque,quando è stato scoperto e come sono le sue dimensioni?

«L'asteroide si chiama "52768" oppure "1998 OR22", ed è stato scoperto il 24 luglio nel 1998, come il nome rivela,nel corso del progetto americano NEAT -Near Earth Asteroid Tracking dell'Osservatorio astronomico situato sul vulcano Haleakala alle Hawaii.Secondo le informazioni sul sito web dell'ESA il diametro dell'asteroide è di 2.100 metri».

È possibile calcolare precisamente i suoi spostamenti?

«Secondo le informazioni del sito web del MPC -Minor Planet Center l'incertezza dell'orbita di 52768 è 0:questo significa, che gli astronomi possono pre-calcolare la sua posizione molto precisamente almeno per i prossimi 100-200 anni».

Sul web si susseguono notizie di pericolo e probabile impatto dell'asteroide con la Terra, ma qual è la reale situazione?

«L'asteroide si avvicinerà alla Terra il 29-30 aprile 2020, ma la distanza fra essi sarà 0.042 unità astronomiche o 6 milioni e 300.000 chilometri, si pensi che la distanza dalla Terra alla Luna è 384000 km. Quindi possiamo dire in modo assolutamente sicuro che la probabilità di collisione dell'asteroide con la Terra in aprile praticamente non esiste, ma nemmeno in futuro, perché il cosiddetto valore MOID (minima distanza all'intersezione orbitale) è 0.015 unità astronomiche, ovvero 2 milioni e 250.000 chilometri».

Per gli appassionati, o per i curiosi, è possibile osservarlo anche da casa?

«L'asteroide è abbastanza grande e luminoso, in questi giorni registriamo 14 magnitudini stellari e alla fine aprile 11 magnitudini, perciò può essere osservato anche da telescopi piccoli, basta un'apertura di 10-15 cm, come all'osservatorio astronomico di Castelgrande. Anch'io lo osserverò per trovare il suo periodo di rotazione: attualmente ci sono due probabili periodi di 4.112 o 3.198 ore. Anche il famoso radiotelescopio di Arecibo osserverà l'asteroide per ottenere informazioni sulla sua forma». Schmalz che lavora in pianta stabile presso l'osservatorio di

Castelgrande, vola spesso in Russia, Germania, Egitto, per presentare i risultati delle sue osservazioni di asteroidi o detriti spaziali e aprire il confronto con gli altri studiosi internazionali. **Asserito che potremo stare tranquilli, è già possibile prevedere se lo stesso asteroide tornerà a farci visita in futuro?**

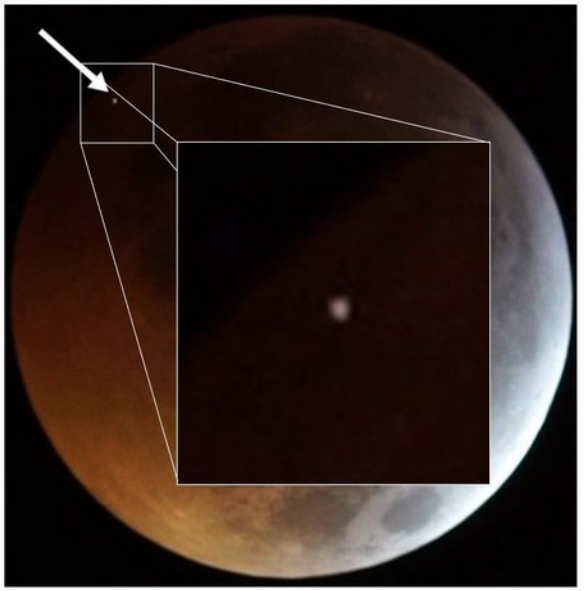
«Certo, nella banca di dati dell'ESA-Agenzia Spaziale Europea sono disponibili già i prossimi riavvicinamenti dell'asteroide con la Terra:18/05/2031 a 19.050.000 chilometri, il 16/04/2079 passerà ad 1 milione 777.350 chilometri del nostro Pianeta, dunque più vicino di quest'anno, e infine l'ultima previsione è per il 17/05/2090 quando transiterà a 17.246.700 chilometri» da noi, o per meglio dire da chi abiterà il pianeta Terra in quell'epoca».

La stazione di osservazione dei detritispaziali dell'Osservatorio Astronomico di Castelgrande si interfaccia su orizzonti internazionali. Il lavoro notturno, si inserisce nel più ampio progetto denominato "Castelgauss" ideato dalla Scuola di Ingegneria spaziale dell'Università La Sapienza di Roma.

EMANUELA CALABRESE

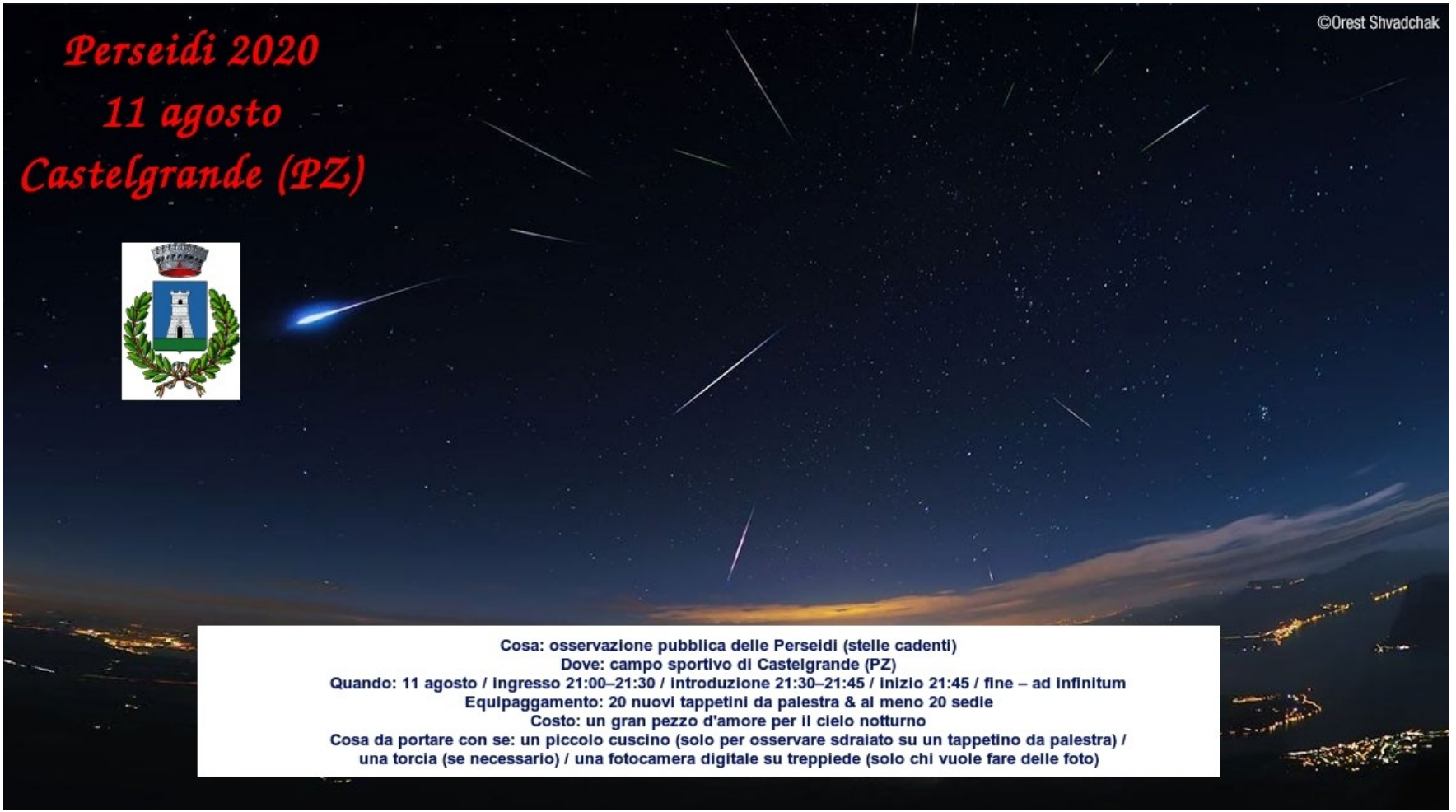
National Public Outreach

- 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!

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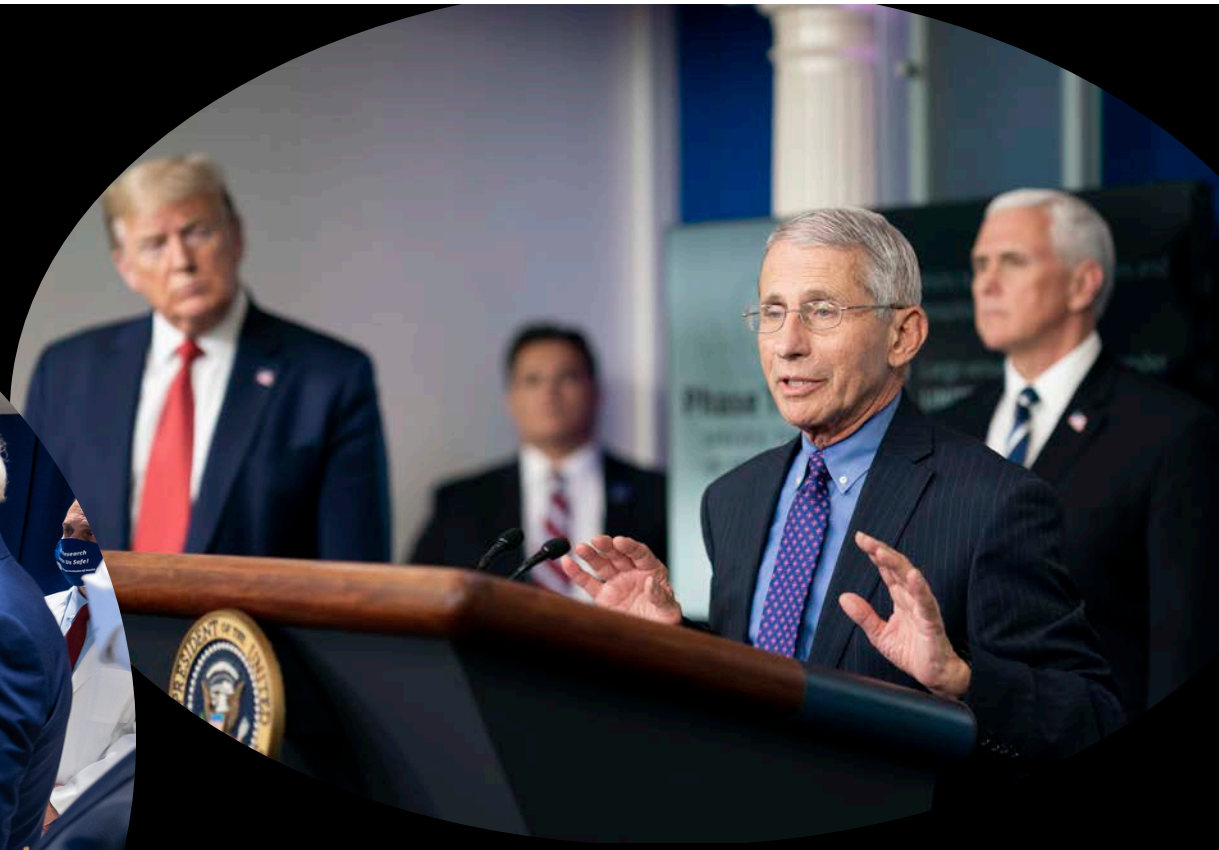
Public Communication in the Case of an Impending Impact

Lessons from the COVID-19 Pandemic

Carrie Nugent[1] and Linda Billings[2]
[1]Olin College of Engineering
[2]Consultant to NASA's Planetary Defense Coordination Office

Be Apolitical.



Dr. Anthony Fauci has worked for Republican and Democrat administrations.

Photos: White House

Present a single, simple message.

Show, don’t tell.

Photo: WikiMedia user Coolcaesar

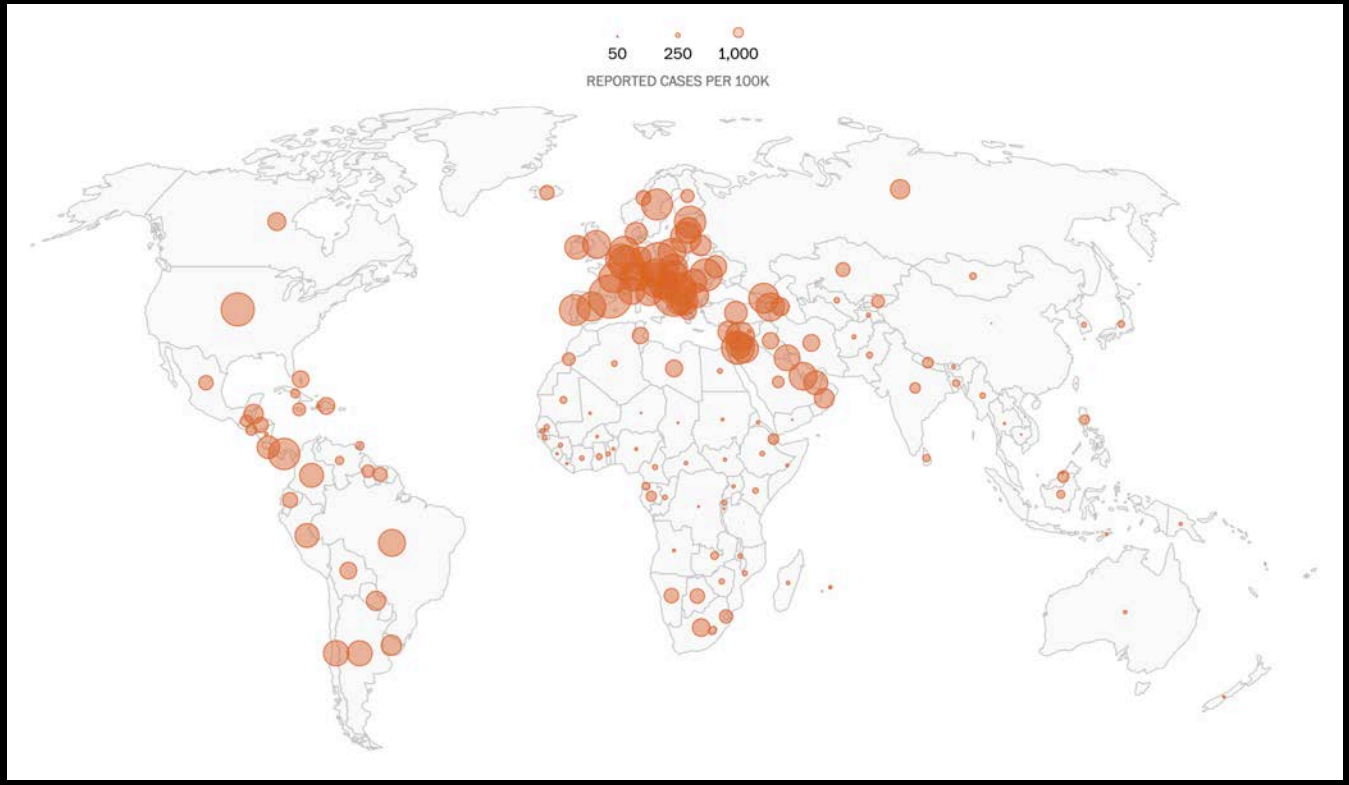
Show, don’t tell.

Myrick and Willoughby, 2020

Image: Tom Hanks’ twitter account

When communicating numerical information:

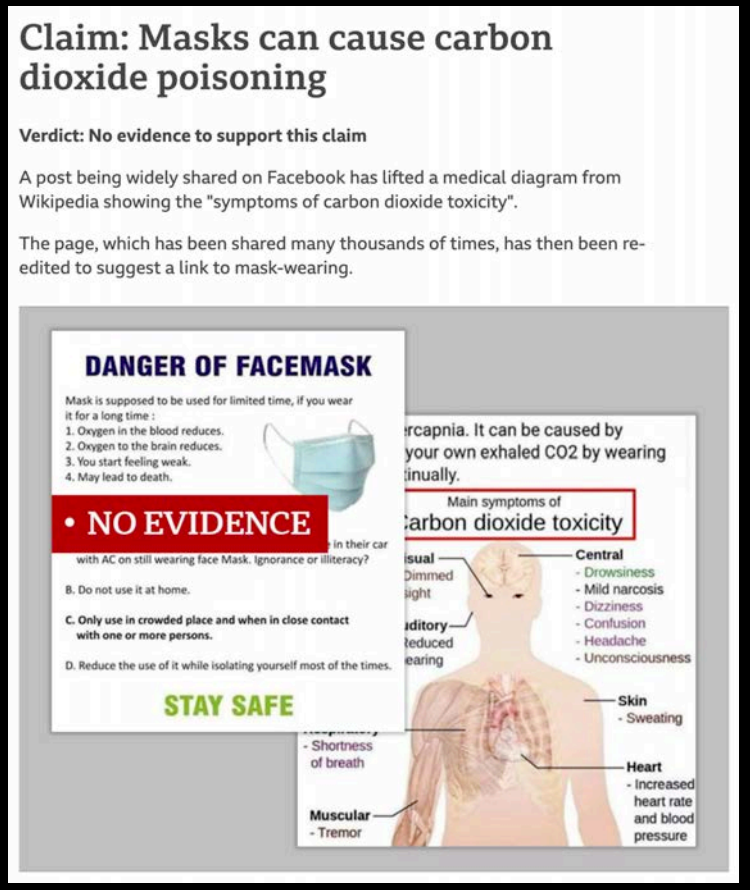
- Use frequencies, not percentages (Peters, 2017)
- Use graphics



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



BBC News debunks mask misinformation

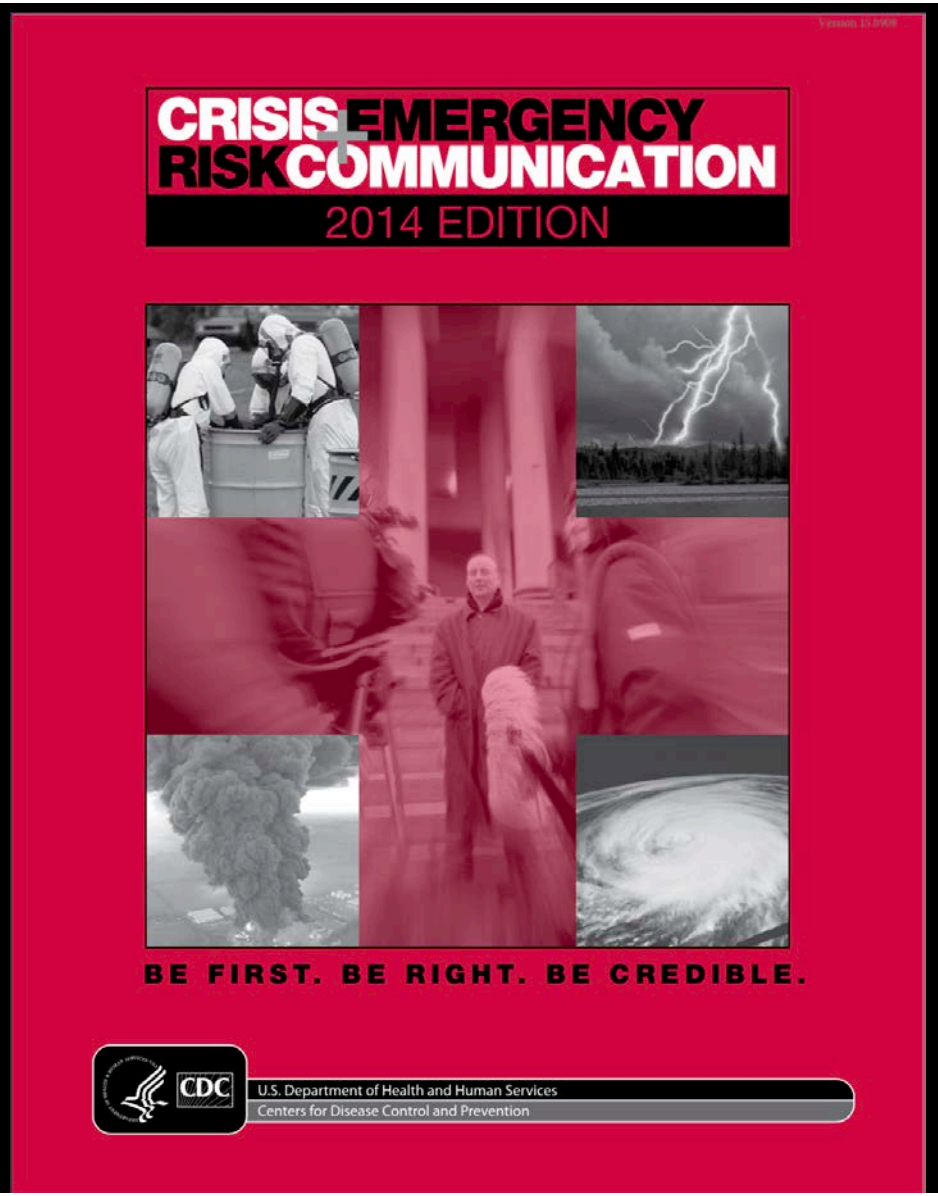
Prevent fatigue

- Be cautious when asking public to make long-term sacrifices

Ivan Radic, Flickr

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



7th IAA Planetary Defense Conference

26-30 April 2021, Online Event

Hosted by UNOOSA in collaboration with ESA

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