

IAC-16

## A Call for Education and Innovation in Planetary Defense

Kristin Shahady<sup>a</sup>

<sup>a</sup> Ball Aerospace, 10 Longs Peak Dr. Broomfield, CO 80021, [ashahady@ball.com](mailto:ashahady@ball.com)

### Abstract

There is only one object, one event in one instance that can unite all of humanity in a moment: Near Earth Objects (NEO). Right now, humanity is far from united or even aware of this threat of extinction. Throughout history NEOs are treated as untouchable objects bringing joy or fear to communities. Social media and informative sites are not accessible or captivately broadcast to inquirers. Surveying the public shows low awareness for planetary defense groups, current scientific capabilities and mitigation methods. This survey presents high usage for social media engagement, specifically through Facebook. Additionally, the survey suggests a considerable interest in viewing NEOs. Utilizing this curiosity can engage the public with government as a result from proper outreach. With amplified visibility and clarity on social media, building awareness will trend and pick up traction with people around the world. Increased awareness will lead to more interest in government and internationally involved planetary defense programs. This involvement combined with public excitement will stimulate new technology developments that execute mitigation missions. New business opportunities will also stem from enthusiasm and increase daily, public viewing opportunities. Government involvement and modernized technology will make planetary defense groups develop solutions to keep the earth intact from a life-ending natural disaster.

**Keywords:** (Near-Earth Object, Asteroid, Comet, Meteor, Public Awareness)

### 1. Introduction

Planetary defense is vital for the safety of mankind. Comets, asteroids and meteors can cause such devastation from one impact and yet the public has uncertainty on the effect of these NEOs, who is responsible for tracking them and deflecting them and what the best method is for tracking and deflecting them. There are no international policies or missions planned that have either the technology developed or the capability to take out an immediate threat. In the United States, there is not enough awareness or urgency with the policy makers to result in more operative plans in planetary defense. Internationally, space law is based on the dated Outer Space Treaty; countries are encouraged but not required to collaborate or create immediate solutions in the near term. Increased interest for an international planetary defense program will consequentially be a result of either destructive events such as the meteor that hit Chelyabinsk, Russia in February 2013 or a significant boost in interest from the public <sup>[1]</sup>. With the appropriate outreach strategies, the near term future will include the international defense program that informs people of an incoming attack similar to weather broadcasting for dangerous weather events and will successfully thwart any globally threatening NEO months or years in advance.

#### 1.1 History and Progression of Public Awareness

Comets and asteroids have different orbits and create a different stir in the public. Understanding previous NEO awareness throughout history is critical to

understand the current state of public awareness and develop a future path of education. .

##### 1.1.1 Halley's Comet

Halley's Comet is the most notable NEO in early civilization to the present, thus making it a suitable control for this study.

##### 1.1.1.1 Pre-1910

Before the 18th century, NEOs were categorized as religious symbols, representing the emotions of each civilization's deities or were scapegoats for tragic instances. Since the comet's appearance coincidentally occurred with negative events in history, the wide-ranging belief for this NEO was it will bring bad luck every 75-76 years. Its periodicity was determined by Edmond Halley in 1705<sup>[2]</sup>. Before the discovery, people observed it, studied it, and drew conclusions about its spiritual significance. After 1705, scientists prepared for better observations. Populations with access to media outlets had the news broadcast to them weeks, even months in advance<sup>[3]</sup>.

The 1759 approach was the first expected return which resulted in a combination of mass produced hysteria and the use of scientific reason to dispute it. For example, the first "End of the world" claims with respect to this comet began. Scientists refuted this claim by reminding the public that the comet had passed before and the world did not end at that time. Regardless of logical claims, the false prophecies managed to persevere through to the 20th century

### 1.1.1.2 1910

. The sighting in 1910 was the first to be photographed and studied with spectroscopy<sup>[4]</sup>. This advancement did not make the public immune to hoax news and false prophecies. Additionally, this approach was unique due to the Earth passing through the tail of the comet<sup>[5]</sup>. Spectroscopy revealed the chemical content of the tail. One of the gases was toxic. This announcement led to the public panicking by buying gas masks and “anti-comet” pills. Astronomers assured them that the gas was so diffused that it would not harm them. It wasn’t until the comet passed that the people calmed<sup>[6]</sup>.

Not everyone sulked in depression. Many had “comet parties” on the rooftops of buildings through until the early morning<sup>[8]</sup>. At the time, science and technology was at its peak. Regardless of the proof that the comet was simply an object consisting of dust and ice that is in a highly elliptical orbit around the sun, the public reacted outlandishly. Luckily, Halley’s Comet had another 75 years to make a better impression.

### 1.1.1.3 1986

Scientists highly anticipated the 1986 arrival since this was the first appearance where the comet could be observed via spacecraft. Unfortunately, it turned into the most disappointing approach. The comet and the earth were at opposing sides of the sun, making the comet faint and difficult to see<sup>[7]</sup>. The public could not spot the comet until its return from around the sun. Various international spacecraft achieved capturing previously unseen details such as the nucleus. Scientists finally had the largest set of data to understand what comets were. Public eagerness improved for this NEO viewing. Newspapers and other media sources told viewers to look for the comet in the morning or evening throughout its visible months. Telescope sales skyrocketed and businessmen capitalized on this interest. They assured the public that they did not believe in the bad omens associated with the comet’s arrival. Expensive and extravagant cruises were set up to view the comet in the southern hemisphere<sup>[8]</sup>. Businessmen created capitalism opportunities surrounding the comet resulting in the public’s newfound excitement to see it. Halley’s Comet comes back in a better position with respect to Earth in 2061<sup>[7]</sup>. With an encouraging outreach strategy, this coming will be a global phenomenon with even more viewers and enthusiasm than ever before.

## 1.2 Planetary Defense Space Policy

The first idea of defending the earth against asteroid and comet strikes developed when astronomers witnessed fragments of the comet Shoemaker-Levy 9 strike Jupiter in July of 1994<sup>[1]</sup>. Shortly after, scientists identified many of the large asteroids whose orbits cross Earth’s. The realization that there were many more undiscovered, small asteroids created defense

concerns for Earth’s wellbeing. The actual catalyst for action was the meteor strike in Chelyabinsk.

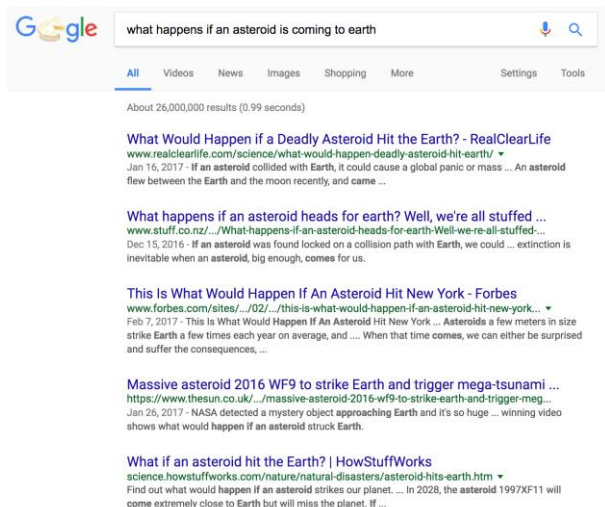
### 1.2.1 Planetary Defense Groups

Eight months after the meteor strike in Russia, the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) agreed to create the International Asteroid Warning Network (IAWN). COPUOS additionally sanctioned the Space Missions Planning Advisory Group (SMPAG) which coordinates international research and studies of technologies for deflection missions<sup>[9]</sup>. IAWN is responsible for tracking and identifying future NEO threats and SMPAG is responsible for preparing the international response to these threats.

NASA is a key player in these groups. NASA’s NEO Observations Program supports NEO surveys and research ranging from within NASA agencies to universities. These surveys located 95% of the known 15,000 NEOs while the program operated on a relatively low budget between 1998 and 2010<sup>[10]</sup>. Thanks to the US President announcing a mission involving humans landing on an asteroid, the NEO Observations Program budget went from \$4 million a year to \$20.4 million a year (now expanded to \$50 million in 2016)<sup>[10]</sup>. However, it devotes a limited amount of funding to NEO impact mitigation and diversion mission planning. In January 2016, NASA created the Planetary Defense Coordination Office (PDCO) which operates within the NEO Observations Program. The PDCO is responsible for facilitating the interactions between scientists, US government offices and the public if a Potentially Hazardous Object (PHO) were discovered. They maintain the Meteoroid Environment Office which monitors the meteoroid environment and provides meteor shower forecasts to NASA spacecraft operators<sup>[10]</sup>. They continue the support of NEO searching surveys and support NASA’s Asteroid Redirect Mission (ARM) which focuses on preparing humans for Mars as well as advancing the capability of planetary defense.

### 1.3 Current methods of Public Outreach

Search engines are now the most common way for anyone to search for information. If someone from the public wants to know about what will happen if an asteroid is coming towards Earth, he or she will most likely enter that into Google. [Figure 1](#) shows the top results from the search.

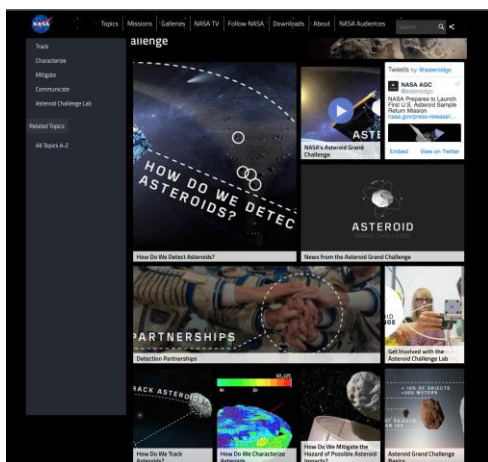


**Figure 1: Top Five Hits from the Google Search: "What happens if an asteroid is coming to Earth?"**

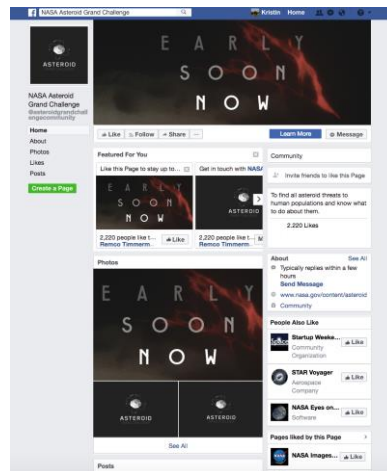
The top hits come from tabloid and life-advising websites. This is not ideal for informing the public with correct information. This leads to additional questions surrounding other public outreach techniques with respect to NEOs.

### 1.3.1 Public Science Competitions

For three years, NASA has spearheaded the Asteroid Grand Challenge. This is NASA's only global challenge that targets government agencies, international partners, industry, academia and citizen scientists to research and provide information and ideas to the NEO Observations Program. In Figure 2, the main webpage has a shambolic appearance and the Facebook page, Figure 3, has limited members and information. Only two posts mention this challenge on the main NASA Facebook page.



**Figure 2: Front Page of NASA's Asteroid Grand Challenge**



**Figure 3: NASA's Asteroid Grand Challenge Facebook Page**

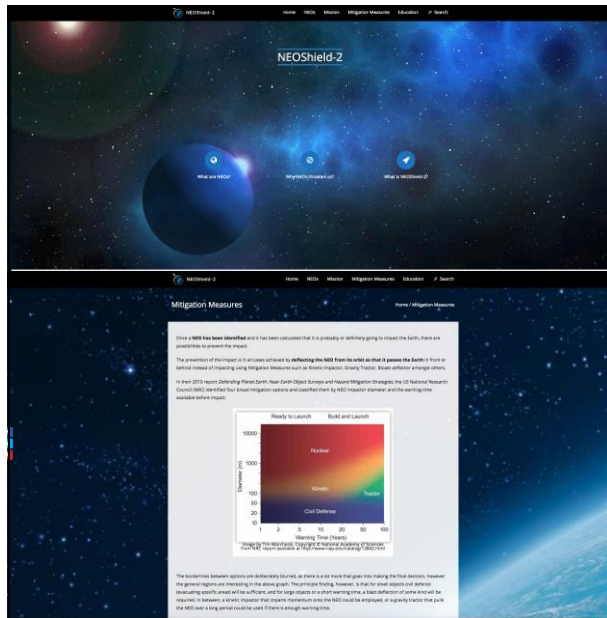
OSIRIS-REx is the asteroid sample return mission launched in 2016. This mission is providing an outreach opportunity known as Target Asteroids! This opportunity requires expensive 8-inch telescopes, CCD cameras and astrometry software to observe the specific targets that the mission group provides annually<sup>[11]</sup>. The incentives are to learn more about NEOs and provide data to the scientific community. Target NEOs! is the Astronomical League's observing program where people observe many NEOs. There are fewer requirements for this opportunity and the incentives for the participants are earning a certificate and/or pin<sup>[12]</sup>. Both challenges require advanced amateur astronomy guidance; both groups do not have Facebook pages nor are mentioned on the main NASA Facebook page.

### 1.3.2 NASA Social Media

The main NASA Facebook page has limited posts related to the #asteroidinitiative or NEOs in general. There was increased activity in 2014 but then only one mention in 2016. Planetary defense, IAWN, or SMPAG are not highlighted on this site either. NASA has the higher following than other space agencies in all social media platforms: Facebook, Twitter and Instagram. NASA is the only agency to provide a Snapchat option for the public. Due to this increased visibility on social media, NASA is the leader for rising awareness in the space sector. NASA's Instagram has a unique monthly segment called "What's Up" for the month describing in detail what can be seen in the night sky and how to find it. NASA also synchronizes their Snapchat stories with their Instagram stories. @AsteroidWatch on Twitter is sponsored by the PDCO. This is the most informative and timely outreach NASA provides to the public on NEOs. This large following and multiple features can be utilized for future outreach programs in planetary defense.

### 1.3.3 NEOShield

The European Commission is funding NEOShield, a group responsible for investigating the three major NEO impact mitigation plans and informing the public on the answers. NEOShield-2 is the currently operating successor responsible for developing the European strategy for future research and mission concepts involving technological development and refining NEO characterization investigated in NEOShield-1<sup>[13]</sup>. NEOShield's website is modern and accessible, shown in Figure 4. The website defines NEOs and why they are a threat. They outline their current tasks they expect to complete and detail all mitigation plans legibly to many types of readers.



**Figure 4: NEOShield's front webpage and Mission Overview webpage**

NEOShield is a highly supportive group of public outreach. They promise pins, flyers, and other paraphernalia to anyone who is hosting a planetary defense outreach event. The host must contact NEOShield and have his or her event verified before receiving these items. Endeavors such as this must be promoted and shared among other planetary defense groups. This group could use more advancement to direct inquirers to this correct NEO information. In the educational partners tab, they provide links to observatories, a museum, and Asteroid Day.

### 1.3.4 Asteroid Day

So far the most successful public outreach event is every year on June 30th. It began in 2015 with the goal to increase the detection rate to 100,000 asteroids per year: the 100X Declaration<sup>[14]</sup>. Events on Asteroid Day are locally organized and can include lectures,

educational programs or in exceptional cases, live concerts. These events focus on the challenge to raise public awareness of tracking and detecting asteroids. In 2016, over 500 events were organized in 72 countries and its hashtag #ASTEROIDDAY was top ranking internationally and #3 in the United States<sup>[14]</sup>. This event is successful due to the celebrities, business tycoons and astronauts that created it, promote it, and participate in it. It continues to grow through the academic celebrity endorsements and participation. It also grows due to the activists that create events in their hometowns around the world.

## 2. Methods for Understanding the Current State of Public Engagement

To measure the current state of public awareness of NEOs in the 21<sup>st</sup> century, questioning random citizens from various backgrounds is a controlled and effective study. One hundred surveyors completed a basic ten question survey using SurveyMonkey.com. The people chosen for this survey included various nationalities, working classes, ages ranging from 18 to 75, and included a 60/40 female to male ratio. SurveyMonkey.com provided 146 random surveyors. The survey was distributed among college forums and provided 37 random respondents. Due to SurveyMonkey.com restrictions, only 100 responses may be seen.

The data was quantified statistically then provided insights to a percentage of the public's opinions. For example, 89 surveyors claimed to have observed a shooting star. This quantifies to 89% of the public has most likely seen a shooting star. Therefore, 89% of the public is aware that debris from space falls through the atmosphere, burning up along the way. Using this majority, inferences are created to provide recommendations on exploiting this awareness for further education purposes. The resulting minority percentages provided equally compelling quantifications for outreach recommendations.

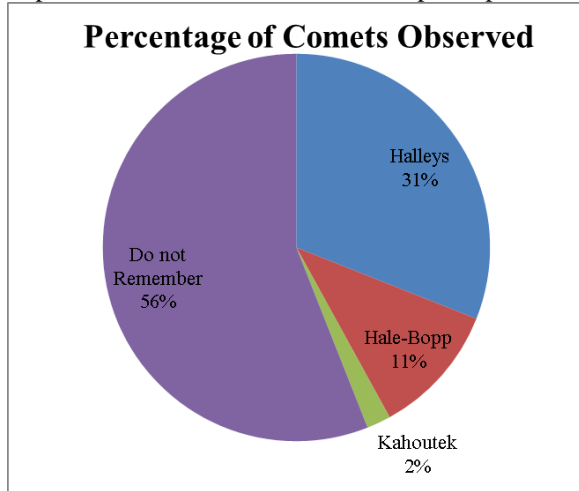
The ten questions focused on:

- Social media use,
- Observing a NEO,
- Watching one of the 1998 pop culture films highlighting NEOs,
- Which planetary defense group the surveyor is familiar with,
- Gauging his/her general awareness on NEOs,
- And how he/she believes the world would react to an incoming NEO.

The entire survey is listed in Appendix A.

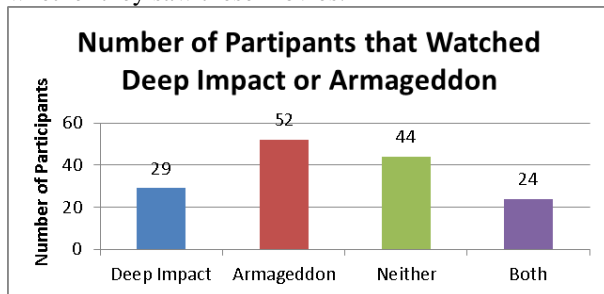
### 3. Results of Awareness Survey

First, to gauge the participants' overall interest in NEOs, the survey asked if they had seen either a shooting star or a comet. 50% of the surveyors claimed to see a comet in his or her lifetime. Figure 5 represents the results to the follow up question relating to comets. The intent for this question is to understand how impressionable each comet was to the participant.



**Figure 5:** This figure represents the percentage of which comet was observed by the surveyors that saw a comet in their lifetime. 86% claimed they did not remember which comet they had seen. 31% saw Halley's Comet, 11% viewed Hale-Bopp and 2% observed Kahoutek.

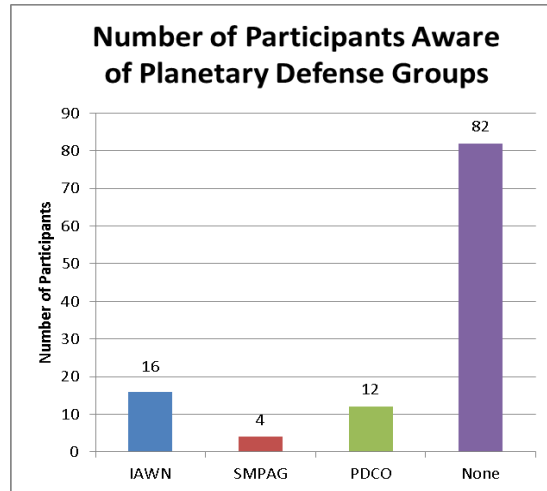
There are two science fiction movies that capture the fear and hysteria of an asteroid or comet's trajectory being straight into Earth: Deep Impact and Armageddon. Both films were released sequentially in 1998 and use nuclear bombs to deflect the NEO from hitting Earth. These two movies are the most successful NEO focused movies in the last thirty years. To gauge general interest and to understand where mitigation ideas may come from, the participants were surveyed on whether they saw these movies.



**Figure 6:** Number of Participants that saw Deep Impact or Armageddon.

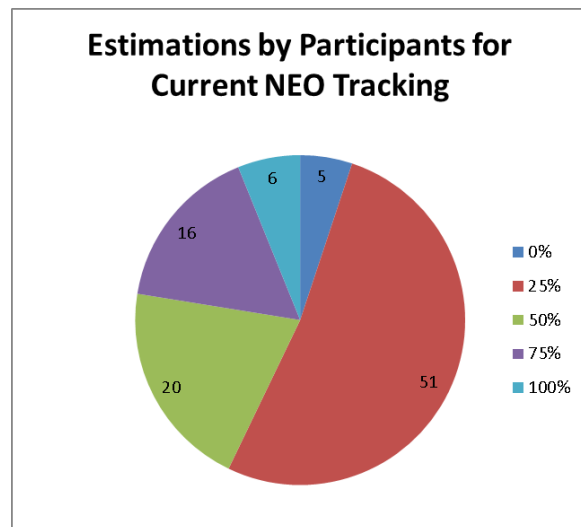
The survey asked the participants to identify planetary defense and monitoring groups. This directly measures

the recognition the public has of the most vital planetary defense groups: IAWN, SMPAG, and PDCO. While IAWN and SMPAG are global efforts, PDCO was inserted into the survey to accommodate the majority of United States citizens.



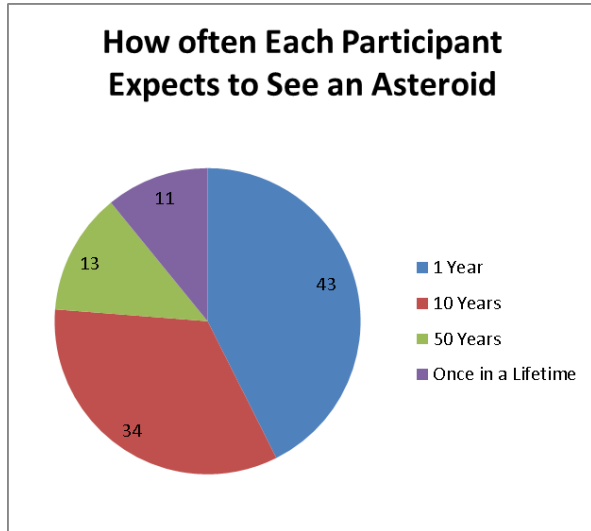
**Figure 7:** This figure represents the number of participants that know of the existing planetary defense groups. Only 18 participants recognized at least one of the groups while 82 did not recognize any.

Scientists are currently tracking the orbits of an estimated 75% of known NEOs. There is an automobile sized asteroid encounter about once every year<sup>[15]</sup>. The surveyors were polled on their knowledge or estimations of these facts.



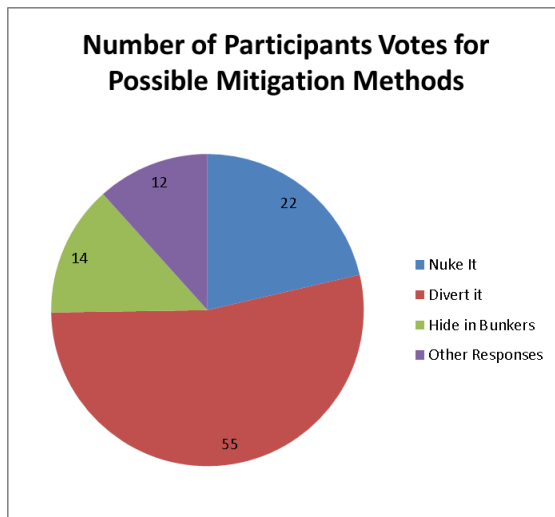
**Figure 8:** This figure represents each participant's estimation on how many NEOs are being tracked. 5 voted 0% are being tracked, 51 voted 25% are being tracked, 20 voted 50% are being tracked, 16 voted 75% are being tracked, and 5 voted 100% of NEOs are being tracked.





**Figure 9:** This figure represents how often each participant expects to see an asteroid. 43 said every 1 year, 34 said every 10 years, 13 said every 50 years and 11 said once in a lifetime.

Finally, the 100 participants were questioned on what mitigation method they believe the collective world will agree upon and execute during an impending NEO impact. The options were broad and had no scientific background associated with the question. The options were either the world will bomb the incoming NEO, with enough time and proper tracking in advance the world will divert it, the world will have no option but to hide its people in bunkers, or the participants could write in a different response.



**Figure 10:** This figure represents the number of participants voting for different mitigation methods. 22 voted to nuke an incoming NEO, 55 voted to divert it far in advance, 14 voted to hide in bunkers, and 12 proposed alternative solutions.

Additionally, the results from Figure 6 were correlated with the results from Figure 10 to estimate the influence the pop-culture movies had on the public. 78% of the “Nuke It” response and 75% of the “Divert It” response watched at least one of the movies.

### 3.1.1 Social Media

Table 1 shows the favored social media platform to develop the most ideal, future method of education and public outreach.

**Table 1: Social Media Results**

Number of participants that use this platform	Snapchat	Facebook	Twitter	Instagram
The most	7	64	5	8
Second highest	14	6	13	14
Third highest	7	6	5	11
The least	2	1	7	3

## 4. Discussion

The first results of the survey imply 89% of the participants should be willing to engage on the topic of NEOs after witnessing a shooting star. This shows a large majority will have a future interest in observing NEOs pass. However while half of the participants remember seeing a comet in his or her lifetime, Figure 5 shows half of these participants cannot identify the comet. Since comets are much rarer to see, this suggests the forgotten comets were simply not promoted enough. Figure 5 also shows Halley’s Comet was more memorable than Hale-Bopp even though the latter was visible for a longer period of time resulting in more media coverage. Hale-Bopp did not arrive with the same deep history that Halley’s brought; this implies the media’s portrayal of a NEO arrival affects the lasting impressions upon the public. With better promotion methods on the media and social media, these objects will become unforgettable.

In the correlation for Figure 6, many of the respondents in each group that believe that taking action will be successful also watched the science fiction movies. While there is a possibility otherwise, there is not enough data to conclude that participants were influenced by the films.

The staggering results in Figure 7 highlight the limited understanding the public has of planetary defense and awareness groups that work daily to protect them. Yet, the results from Figure 10 expose the majority of the participants believe that a NEO would be deflected by an unknown, collaborative working group. This result alerts the need for better education and enticing motivators to learn about these groups.

According to Figure 8, the public does not have confidence in the scientific community to be tracking NEOs. It is essential for the scientific community to publicize that over 75% of NEOs that can orbit within Earth's orbit are known. This requires improved outreach programs from the IAWN and PDCO.

In Figure 9, the majority of participants either guessed or knew correctly that vehicle-sized asteroid encounters occur at least once a year. This question was not explicit which implies participants were potentially confused if the answer was directed towards catastrophic asteroid events. The participants could have also confused comets with asteroids. If the majority of the public is truly aware of these yearly encounters then this is an ideal scenario for outreach programs to capitalize on once a year.

The analysis for Figure 10 shows the popular response for mitigating an incoming NEO is to track it and divert it well in advance of impact. Correlating with the results in Figure 8, 29 of these 55 responses believed scientists are only tracking 25% of potential NEOs. These respondents are not confident that someone can track an object plummeting towards Earth with enough time to execute a successful diversion mission but still expect this to happen. This shows the public cares little for how they remain safe as long as it happens. In order to keep them safe, they need to be concerned with how mitigation plans will be executed otherwise there will be no funding towards this research.

Social media has revolutionized how people stay informed on either news or gossip so evaluating social media usage is essential to push forward with education strategies. In Table 1, Facebook is the winning platform to push awareness of NEO encounters, the groups watching them and preparing for impacts. It can also push the celebration of viewing them and their advancements for science. Facebook provides many ways to broadcast plenty of information; however, it is dynamic. While this is the commonly used platform, it will be the most challenging to achieve the desired impact.

Snapchat and Instagram have equal second highest usage. Instagram has a permanent platform and Snapchat's information disappears every 24 hours; however they both use the newer stories feature. These can easily be synchronized between both platforms to reach different audiences.

Twitter ranked first for the least used and ranked last for the most used social media platform. Twitter is helpful for spreading news quickly and providing simple updates to the public. Since it ranked last in this survey, it will not be used as a primary tool for spreading awareness and informing the public.

## 5. Recommendations

The survey confirmed that the majority is not aware of the active planetary defense groups. The public could panic and most likely turn to their national governments for solutions instead of the global solution SMPAG plans to achieve. Public NEO incoming alerts need to be swift and more advanced to avoid catastrophic incidents similar to Chelyabinsk. Finally, interest will not peak until people have easier and more accessible methods to observe NEOs.

Recommendations are provided using the public engagement survey and building off of the current state of public outreach programs. The increased visibility on social media, search engines and news outlets will encourage interest in the public. This increased interest will directly influence national governments to also increase funding to international planetary defense programs.

### 5.1 Social Media

The NASA sponsored asteroid challenges need extensive rebranding or a complete restructure to receive traction. Its Facebook page will be more informative and interactive with other amateur astronomers and scientists from the PDCO, IAWN and SMPAG. Similar to the NASA's Space Poop Challenge, the Asteroid Grand Challenge needs either monetary incentives or paid trips to NASA facilities, launches, or observatories. NASA's main Facebook page will promote the re-launched challenge and include more updates and links to the IAWN and SMPAG.

A new Planetary Defense Facebook page will be created in combination by IAWN and SMPAG. It will include all updates that IAWN puts on its main webpage. It will highlight updates from the SMPAG international twice-yearly meetings. ESA's public outreach office will help contribute to this page since SMPAG's website is sponsored by ESA. The additional support from NASA's public outreach office will help make the Facebook page aesthetically appealing, informative, and linked to the other successful outreach sites: NEOShield and Asteroid Day. This page will intrigue the public with forum questions relating to NEO impact possibilities.

Sharing posts is the most successful way to spread information on Facebook. NASA's Facebook page has 23 million followers; however this still excludes many users that do not follow the site. If international space agencies pay to boost posts relating to the re-launched Asteroid Grand Challenge and the new Planetary Defense Facebook page, the information will spread to people who do not follow the sites and get promoted within its followers. With enough public shares, other science, news and gossip sites will share the information creating a large trend relating to NEOs.

Snapchat and Instagram shall continue to synchronize stories and create one page updates informing the public on which object is nearing Earth. On April 19, 2017, Snapchat included this one page slide broadcasting asteroid JO25 shown in Figure 11.



**Figure 11: Snapchat story highlighting asteroid JO25 featured on NowThis, April 19, 2017.**

Snapchat and Instagram can encourage more news sources to feature these pages on their stories. The feature should become more interactive, allowing users to swipe up and receive specific viewing instructions depending on location. National Geographic and NASA both have large followings who can keep records of these asteroid sightings.

Celebrities have the largest followings on most social media platforms, including Twitter. Encouraging celebrities who promote science to share asteroid and meteor shower updates will be the most successful way to reach the Twitter audience.

These social media changes will steadily increase the subconscious awareness within the public. News outlets, congressional support and technological updates will result from this change.

### 5.2 News Outlets

Once this information is subconsciously in the minds of the people, they will turn to the internet for more information. The Google search provided insight to the top results for asteroid impact questions. IAWN, SMPAG, and PDCO need to purchase internet trafficking to increase any associated keywords directly to their websites.

Some of the largest news networks, CNN, MSNBC and the Weather Channel, are attempting to create space-only covered pages on their websites. The Weather Channel's has the most updated information and highlights viewing conditions. Once the public expresses a larger interest for more frequent updates on NEO sightings, these news channels will increase visibility on these objects and how to view them. The

Weather Channel highlights civilian photography capturing weather and other natural phenomena. Other news outlets can begin this process with respect to NEOs. They can combine these photographs with professional ones provided by space agencies and observatories from around the world.

Ultimately, the key issue these media channels must highlight are NEO's frequency and the potential danger that comes from how many NEOs exist.

### 5.3 Congressional Support

With the help of media outlets and continuous popularity increase on social media, the public will begin to demand planetary defense onto their congressional representatives' platforms. IAWN and SMPAG will encourage their followers to call government officials requesting more funding for planetary defense via their new, multiple public outreach sources. The PDCO will encourage third-party organized planetary defense lobbying efforts in Washington D.C. These efforts will focus on funding for the PDCO but also the international efforts. These efforts will also focus on the boost to the economy as a result of growing NEO groups. The defense groups will require more technology and more trackers which in turn provide jobs to scientists and the industry. Aside from direct lobbying, the awareness celebrations such as Asteroid Day and other future efforts will benefit planetary defense world-wide.

### 5.4 Technological Updates

Parallel to the increased media and lobbying efforts, technology will modernize, become more accessible to the public and provide better tracking updates.

Modern lenses in smart phones are so advanced that they can be used as attachments for personal telescopes with apps. There are apps such as SkyView that show the object in the nighttime sky on the users' screens as they point to it. An app similar to this can include instructions and arrows to find incoming objects given by NEO tracking groups. Eventually, the process can be so simple that a user will see an asteroid update on one of his or her social media platforms, click on it, and it will instantly load the telescope app and allow the user to begin tracking it and imaging it. This technology must be affordable to the public and will be a guaranteed way to increase excitement for NEO awareness. Creating these apps and smartphone attachments will create new business opportunities and jobs.

With increased funding to planetary defense groups, IAWN can sanction an international effort for an advanced solar system object tracking space telescope. The international space agencies that participate in IAWN will each contribute to this project resulting in partial ownership for many countries; IAWN will run



mission operations. To receive congressional support, the main mission will be obtaining real-time updates to the public for any incoming object. This capability will warn countries in advance if they are projected to be hit by meteors for everyone to safely evacuate the area. Other usages will be similar to weather satellites providing instantaneous NEO forecasts. This information will be shown on additional widgets on website homepages and news outlets. Many jobs will be created to create the telescope, provide mission operational support, and create the future incoming NEO channels and updates.

### 5.5 Public Awareness Events

Asteroid Day will continue to grow in popularity. These events will show exclusive informative videos with celebrities speaking to planetary defense programs. Some movie screenings will even include Deep Impact or Armageddon. Ideally it will include more festive events with live music concerts, planetary defense tents giving away NEO paraphernalia, and daytime activities and competitions. These events will continue to spread worldwide and be a large celebration in each major city. Its popularity will grow thanks to promotions on social media. Local stores will prepare food, toys, balloons and more to help promote these local events.

The viewing parties for Halley's Comet proved successful for positive NEO public awareness. While major comets are rare sights, scientists predict asteroid trajectories that will pass near earth each year. Only once a year, space agencies, universities and observatories should provide support to amateur astronomers for viewing parties. While decent viewing equipment still isn't accessible to the public, these groups will need to provide this equipment to them. Once phones obtain this capability, this will be replaced by social gatherings in more areas. These events will be promoted via Asteroid Days, social media and the planetary defense groups.

### 5.6 Conclusion

Public awareness for NEOs is at a shocking and unsafe low. With help from space agencies, news outlets and the current international planetary defense groups, raising public awareness for NEOs will provide many business opportunities and wide-spread space situational awareness. Raised public awareness will trigger support for the groups that are planning to prevent world-wide destruction by a meteor, asteroid or comet. This support will allow the Earth to have a near-term solution to a potential and imminent disaster.

## Appendix A: Survey Questions

### References

- [1] Howe, James C. "US space policy and planetary defense." *The Space Review: US space policy and planetary defense*. The Space Review, 6 Oct. 2014. Web. 30 Apr. 2017.
- [2] D. W. Hughes; et al. (1987). "The History of Halley's Comet". *Philosophical Transactions of the Royal Society A*. 323 (1572): 349–367.
- [3] Waff, Craig B. "Comet Halley's First Expected Return: English Public Apprehensions, 1755–58." *Journal for the History of Astronomy* 17.1 (1986): 1-37. Web. 30 Apr. 2017.
- [4] Mendis, D. "A Postencounter View Of Comets." *Annual Review of Astronomy and Astrophysics* 26.1 (1988): 11-49. Web. 30 Apr. 2017.
- [5] Brian Nunnally (16 May 2011). "This Week in Science History: Halley's Comet". pfizer: ThinkScience Now. 30 April 2017.
- [6] Mark Strauss (November 2009). "Ten Notable Apocalypses That (Obviously) Didn't Happen". *Smithsonian*. Web. 30 April 2017.
- [7] Howell, Elizabeth. "Halley's Comet: Facts about the Most Famous Comet." *Space.com*. Space.com, 20 Feb. 2013. Web. 30 Apr. 2017.
- [8] Belkin, Lisa. "HALLEY'S COMET NEARS, PRESAGING PROFITS." *The New York Times*. The New York Times, 17 May 1985. Web. 30 Apr. 2017.
- [9] Aron, Jacob. UN Sets Up Asteroid Peacekeepers to Defend Earth, *New Scientist* website, October 28, 2013. Web. 30 Apr. 2017..
- [10] Keeter, Bill. "Planetary Defense Coordination Office." *NASA*. NASA, 22 Dec. 2015. Web. 30 Apr. 2017.
- [11] "Target Asteroids!" *OSIRIS-REx Mission*. N.p., n.d. Web. 30 Apr. 2017
- [12] "Target NEOs! Observing Program Introduction." N.p., n.d. Web. 30 Apr. 2017.
- [13] "Science & Technology for Asteroid Impact Prevention." *NEOShield*. N.p., n.d. Web. 30 Apr. 2017.
- [14] "Home." *Asteroid Day*. N.p., n.d. Web. 30 Apr. 2017. <<https://asteroidday.org/>>
- [15] Dunbar, Brian. "Asteroid Fast Facts." *NASA*. NASA, 24 Mar. 2015. Web. 30 Apr. 2017.

### Appendix A: Survey Questions

Title: What do you know about comets and asteroids?

1. Please rank the platforms of social media you use the most (1 being the most used)
  - a. Snapchat
  - b. Facebook
  - c. Twitter
  - d. Instagram
  - e. Other \_\_\_\_\_
2. Have you ever seen a shooting star? (Y/N)
3. Have you ever seen a comet? (Y/N)
4. If yes, do you remember which one it was? \_\_\_\_\_
5. Have you seen the movie Deep Impact or Armageddon? (Select all that apply)
  - a. Deep Impact
  - b. Armageddon
  - c. None
6. Have you heard of the International Asteroid Warning Network (IAWN), Space Mission Planning Advisory Group (SMPAG), or NASA's Planetary Defense Coordination Office (PDCO)? (Select all that apply)
  - a. IAWN
  - b. SMPAG
  - c. PDCO
  - d. None
7. How many of the asteroids and comets out there do you think scientists are currently tracking?
  - a. 100%
  - b. 75%
  - c. 50%
  - d. 25%
  - e. 0%
8. In your lifetime, how many asteroids do you think you will see either hit Earth or pass closely to it?
  - a. 1 every years
  - b. 1 every 10 years
  - c. 1 every 50 years
  - d. 1 total
9. If an asteroid or comet is coming straight towards earth, how do you think the public would react and consequentially expect the world to do?
  - a. Explode it with a nuclear bomb
  - b. If we know far enough in advance, we can divert it far away from Earth
  - c. Hide in bunkers
  - d. Other
10. If other please specify: \_\_\_\_\_