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Viewpoint

Words matter: A call for responsible communication about asteroid impact hazards and plans for planetary defense

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ABSTRACT

The global community of scientists involved in finding and tracking near-Earth asteroids (NEOs), identifying potentially hazardous NEOs, and characterizing the possible effects of asteroid impacts with Earth is developing an awareness of the need to improve and expand efforts to communicate with policy and decision makers about the work they do.

This paper addresses the criticality of clear, concise, correct communications about asteroid impact risks and hazards, as well as proper distinctions among risks, hazards, and actual threats. It reviews recent progress in communication about NEO hazards and impact risks, including new recommendations from expert groups, guidelines for responsible communication about hazards and risks, communication issues raised in collaborations with disaster planners, and other relevant developments.

The next significant asteroid impact with Earth could be 500 years from now, or next week. The need to be prepared for such an event is clear. Policy and decision makers will depend on the community of experts involved in NEO observations and planning for planetary defense for information on the risks and hazards of asteroid impacts with Earth.

1. Introduction

While solar system exploration and planetary science have advanced by leaps and bounds over the past 50 years, the science of finding, tracking, and characterizing near-Earth asteroids is still relatively new, with NASA creating a near-Earth observation program only in 1998, responding to direction from the U.S. Congress. Finding, tracking, and characterizing asteroids has grown increasingly sophisticated since then, yet a great deal of uncertainty remains embedded in knowledge of the near-Earth asteroid population and the orbital paths and physical characteristics of individual objects.

Over the past five years, developments in space policy and space cooperation coupled with natural events have focused public attention on near-Earth asteroid detection and tracking, the risk of asteroid impacts with Earth, and planning for planetary defense. Consequently, the global community of scientists involved in finding and tracking near-Earth asteroids (NEAs), identifying potentially hazardous asteroids (PHAs), and characterizing the possible effects of asteroid impacts with Earth is developing an awareness of the need to improve and expand efforts to communicate with policy and decision makers about the work they do.

By far the largest funded program in the field, NASA's Near-Earth Object (NEO) Observations Program,[1] managed in the Planetary Science Division of the Science Mission Directorate at NASA Headquarters in Washington, D.C., is responsible for finding, tracking, and characterizing near-Earth objects – asteroids and comets whose orbits periodically bring them close to Earth.

NASA officially established a NEO Observations Program in 1998 in response to congressional direction. The Program has multiple mandates, including:

- A 1994 request from House Committee on Science, Space, and Technology to develop a plan to discover, characterize and

[1] NASA's program is called the Near Earth Object Observations Program. Near-Earth objects, or NEOs, include asteroids and comets that come within a certain distance of Earth in their orbits around the Sun. Near-Earth encounters with comets are far rarer than near-Earth encounters with asteroids. Hence, the science community is focused on assessing the risk of asteroid impacts with Earth. For the sake of simplicity, I am using the terms “asteroid” and “near-Earth asteroid” rather than the scientific term “near-Earth object.”

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catalog within ten years (to the extent practicable), the potentially threatening comets and asteroids larger than 1 km in diameter.
- A 1998 congressional directive to conduct a program to discover at least 90% of 1-km-diameter or larger NEOs within ten years. (This mandate has been met).
- A directive in NASA's fiscal year 2005 authorization act to develop a program by December 28, 2006, to survey 90% of the potentially hazardous objects measuring at least 140 m in diameter by the end of 2020. In addition, this legislation directed the agency to submit an analysis of alternatives it could employ to divert an object on a likely collision course with Earth. (NASA is in the process of complying with these directives.)
- A directive in U.S. National Space Policy of June 28, 2010, to pursue capabilities, in cooperation with other departments, agencies, and commercial partners, to detect, track, catalog, and characterize near-Earth objects to reduce the risk of harm to humans from an unexpected impact on our planet and to identify potentially resource-rich planetary objects. (NASA is in the process of complying with this directive.)

All NEO search and tracking projects supported by the Program are required to make their data permanently available in a timely manner to the scientific community. The internationally recognized archive for these data is the International Astronomical Union's (IAU's) Minor Planet Center, located at the Harvard Smithsonian Astrophysical Observatory and supported by the NEO Observation Program.

In conducting its work, the NEO Observations Program collaborates with other U.S. government agencies, other national and international agencies, and professional and amateur astronomers around the world. For example, NASA works closely with the Federal Emergency Management Agency and the Department of State on NEO impact warning, mitigation and response planning. The Program is responsible for facilitating communications between the science community and the public should any potentially hazardous NEO be discovered. The Program also works closely with the United Nations Office of Outer Space Affairs and its Committee on the Peaceful Uses of Outer Space. The NEO Observations Program participates in an International Spaceguard Survey, initiated in 1996 and managed by the Spaceguard Foundation, based in Europe. To date, NASA-sponsored NEO surveys have provided 99% of NEO detections. The NASA program is a member of the International Asteroid Warning Network (IAWN) and the Space Missions Planning Advisory Group (SMPAG), multinational projects recommended by and operating independently of the U.N.[2]

The European Space Agency's Space Situational Awareness Program has a NEO Segment, and NASA's and ESA's NEO programs are closely linked. Other national agencies with an interest in NEO observations and planetary defense are represented in the IAWN and SMPAG.

2. U.S. developments in science and policy, 2010–2015

In January 2010, the National Research Council issued a report, *Defending Planet Earth: Near-Earth Object Surveys and Hazard Mitigation Strategies* [1], which concluded that NASA could not fulfill the 2005 congressional directive for asteroid detection by the 2020 deadline, primarily due to lack of funding.

In April 2010, President Obama announced that he was tasking NASA with the development of a human mission to an asteroid. U.S. national space policy of June 28, 2010, called for NASA to "pursue capabilities, in cooperation with other departments, agencies, and commercial partners, to detect, track, catalog, and characterize near-Earth objects to reduce the risk of harm to humans from an unexpected impact on our planet and to identify potentially resource-rich planetary objects."[3]

Consequently NASA created an Asteroid Initiative. NASA's NEO Observations Program was assigned a role in this initiative: identifying human-accessible asteroids. In October 2010, a NASA Advisory Council Ad Hoc Task Force on Planetary Defense reported back to NASA,[4] and the White House Office of Science and Technology Policy reported to Congress on NASA's progress in NEO observations and U.S. government plans for planetary defense.[5]

The NEO Observations Program had operated on a budget of a few million dollars per year from fiscal year 1998 through fiscal year 2011, at which point the program budget was about $4 million. The President's 2012 budget request included, and Congress provided, $20.4 million for an expanded NASA NEO Observations Program. In 2014, the NEO Observations Program budget rose to $40 million. The President's 2016 budget request included $50 million for the program.

3. Growing consensus: a need to focus on communications

In recent years, various expert groups have offered advice to the science community on communicating about asteroid impact hazards. In 2010, the National Research Council's Committee to Review Near Earth Object Surveys and Hazard Mitigation Strategies reported:

> The statistical risk to human life and property associated with impacts of [asteroids] is real, but it falls outside the everyday experience of most of humanity. This risk must therefore be communicated effectively to the community at large in the context of other natural disasters, particularly those that the local community is likely to encounter. Scientists must carefully assess and explain the hazard so that appropriate public policy measures, commensurate with the level of risk, can be put into action. There must be an assessment of the statistical risk from [asteroids] that is reasonable and acceptable to the general public [1].

In 2011, the Secure World Foundation and the Association of Space Explorers convened a working group on asteroid impact risk communication,[6] for the purpose of providing advice to a U.N. Action Team on NEOs (AT-14) on how to set up and operate an International Asteroid Warning Network (IAWN). This group offered the following recommendations, among others:

- "Make use of the findings of experts in risk communication in designing its communication strategy."
- From the beginning, the network should include "skilled communicators supported by risk analysts, planners, scientists, psychologists, emergency management experts and other functional experts." [2].

[2] See http://www.minorplanetcenter.net/IAWN/ and http://www.cosmos.esa.int/web/smpag.

[3] http://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf.

[4] http://www.nasa.gov/pdf/490945main_10-10_TFPD.pdf.

[5] http://www.whitehouse.gov/sites/default/files/microsites/ostp/ostp-letter-neo-senate.pdf.

[6] The author was invited to participate in this working group and contributed to recommendations.

A white paper summarizing the proceedings of the International Academy of Astronautics' 2013 Planetary Defense Conference in Flagstaff, Arizona,[7] included a number of recommendations relating to communication across expert-non-expert boundaries, including the need for:

- Expanded efforts in communication.
- Characterization of impact hazards, risks, and effects in ways that are meaningful to decision makers and other non-experts.
- "A clear international chain of command for dealing with NEO risk" and a communication strategy that makes use of findings from experts in communication.
- Open and transparent communication of information about NEO hazards.
- A common language to characterize NEO hazards and impact mitigation options [4].

In the U.S., NASA and the Federal Emergency Management Agency (FEMA) have held two asteroid-impact tabletop exercises, acting out credible scenarios. Both of these exercises highlighted the need for communication planning and coordination. A report on the first NASA-FEMA tabletop exercise,[8] held 5 April 2013 in Washington, D.C., included three main recommendations:

> Improve tools for communications on the nature and evolution of NEO threats to make it more clear to the public and decision makers how an actual threat might evolve. The communications tools should include an authoritative website that would explain orbit position uncertainty and other terms used in describing a threat, discuss options that are available for deflecting or disrupting a threatening object, and describe the nature of an impact disaster…
> Develop a national response plan outlining actions that should be taken to prepare a deflection or disruption mission/campaign and activate preparations for disaster mitigation…
> Explore establishment of a FEMA-led NEO Impact Working Group to guide the evolution of disaster response measures and provide recommendations on future exercises and specific warnings…[5].

Among primary findings of the second NASA-FEMA tabletop exercise,[9] held 20 May 2014 in Washington, D.C., were that responsible parties in the federal government should develop: 1) communications protocols describing actions that will be taking place and agencies responsible for those actions; and 2) a communications plan for describing deflection options, the risk of failure, and the possibility of false alarms to the public [6].

All of these groups appear to have grasped the need to be clear about identifying, explaining, and distinguishing among NEO impact risks and hazards and actual impact threats.

4. Communication planning for the International Asteroid Warning Network

The author was invited to organize a panel discussion on science and risk communication for the first meeting of the International Asteroid Warning Network's Steering Committee, which took place in January 2014 in Cambridge, MA. Expert panelists were Dennis Mileti, Ph.D., Professor Emeritus, Institute of Behavior Science, University of Colorado at Boulder; David Ropeik, M.A., Ropeik & Associates, Instructor, Harvard School of Continuing Education, Environmental Management; and Richard M. Sheldon, Jr., Environmental Practice Leader, Willis North America (a global reinsurance company). This panel stimulated considerable discussion about communication issues. Consequently, the IAWN Steering Committee decided to hold a workshop dedicated to refining messages and improving overall communication strategy and planning regarding NEO impact hazards, focusing on "the analysis of historical and hypothetical messages, strategies, and plans developed by the NEO community to convey information about potentially hazardous asteroids and impact risks." [7].

The author was asked to organize this workshop, which took place in September 2014. The Secure World Foundation hosted the workshop at its Broomfield, Colorado, headquarters, and provided Laura Delgado Lopez as a co-organizer and co-facilitator. The 15 participants were mindfully selected to include scholars and practitioners of science and risk communication as well as relevant government officials. The group included a television producer, an ESA representative, and U.S. government representatives of NASA, FEMA, and the Department of State.

Workshop participants formulated the following recommendations for IAWN:

- Establish a five-year plan with near and mid-term actions for becoming the global trusted and credible NEO information, notification, and warning network. This plan should consider the fundamental principles of risk communication.
- Employ a full-time communications officer to oversee the development and execution of its five-year plan.
- Sponsor briefings and workshops for reporters to improve NEO education within the mass media community.
- Develop and employ a new, non-probabilistic scale for characterizing asteroid impact hazards and impact effects. The Broomfield Hazard Scale is proposed for IAWN's consideration as an impact effects scale.
- Create a website as soon as possible.
- Employ a full-time Webmaster to create and maintain its website [8].

5. Asteroid impact hazards and the media

While the community of subject matter experts in NEO observations and planetary defense is developing a sharper awareness of the need to take care with language and rhetoric, the language of fear, threats, and apocalypse has not yet faded away – especially in the mass media.

On 25 October 2013, the Association of Space Explorers (ASE) held a media event in New York City to issue "a challenge to the global community to take the next vital steps to confront the threat from dangerous asteroids."

"Asteroid impacts have dramatically altered the course of life on Earth and a rogue asteroid will certainly strike Earth, posing a global threat to human life and society," ex-astronaut and ASE member Tom Jones stated in his opening remarks. "Search efforts to date have discovered scarcely 1% of potentially hazardous near-Earth objects (NEOs), and current telescopes were unable to warn us of the Feb. 2013 Chelyabinsk impact, which released 440 kilotons of explosive energy and injured more than 1000 people. This leaves 99% of the objects big enough to level a major metropolitan area – undiscovered." [9].

Some members of the NEO community were surprised by the proceedings of this event, which was widely publicized and drew considerable media coverage [10].

[7] The author attended this conference, presented a paper on communication issues, and provided input for the conference white paper.
[8] The author observed this exercise and provided input for the exercise report.
[9] The author was a participant in this exercise and contributed to the report on it.

Accomplishments in NEO detection, tracking, and characterization were not mentioned. And in verbal and written statements for this event, the ASE had reported inaccurate information on U.N. activities.

Sergio Camacho, chairman of the U.N. Committee on the Peaceful Uses of Outer Space (COPUOS) Action Team on NEOs (Action Team 14, or AT-14), contacted the ASE to correct the inaccuracies [10]. For example, Camacho noted that the ASE had told the media, "The General Assembly has approved concrete measures to help prevent asteroid disasters." "This phrase is not accurate," he said. "The GA will have approved the recommendations in the STSC [Scientific and Technical Subcommittee, COPUOS] report once it agrees (without a vote) on the draft resolution discussed and agreed upon by the Fourth Committee." The ASE had reported, "The resulting 2013 COPUOS report includes specific language authorizing and endorsing all three of these functions, and the General Assembly has now approved them." "This sentence is not accurate," Camacho said. "The STSC did not include a recommendation on authorization and oversight; also the GA has not yet approved anything." While this sample of a longer list of corrections may seem to be small details, it is important to note that in intergovernmental relations, details matter.

In recent years, the Slooh Observatory has made an effort to attract media and public attention to asteroid close approaches to Earth. During Slooh's live webcast of a March 2014 close approach of asteroid 2014 DX110, commentator Paul Cox said the Slooh crew were not "scare-mongering" by publicizing the NEO impact "threat." "We're doing our best to keep this whole subject in the news," he said, reporting on "what a tremendously serious threat these objects pose to Earth."[10] In January 2015, Slooh's reporting on the close approach of asteroid 2004 BL86 was less dramatic compared to previous fly-by reports, in large part due to improved coordination of communication planning between Slooh and NASA's Near Earth Object Observations Program and Asteroid Grand Challenge (the latter NASA program has partnered with Slooh to help engage citizen scientists in NEO tracking and characterization). For the 2015 event, the Slooh crew focused on reporting what was known about 2004 BL86 and avoided conjuring visions of the end of the world.

The NEO community is also paying attention to the ways in which the potential effects of asteroid impacts with Earth (atmospheric, ground, or water) are characterized. Rather than vague and dramatic descriptions of "global firestorms, lethal blast waves, planet-wide tsunamis, consequences worse than a full-scale nuclear war,"[11] subject matter experts are developing more detailed, accurate, and meaningful ways of characterizing possible effects to aid emergency managers. For example, the scenario developed for the 2014 NASA-FEMA tabletop exercise included these descriptions:

> The potential damage to infrastructure from this impact will be similar to that which occurs from the blast wave that accompanies a nuclear explosion. The combination of high peak overpressure, high wind pressure, and compression from the blast wave results in mass distortion of buildings similar to that of earthquakes or hurricanes. Structural resistance to the blast is dependent on the general structural components and size.
> In a 10KT weapon blast (i.e., equivalent to a blast created by 10 kilotons of TNT), severe damage occurs up to 0.4 km (1400 feet) away. For rail transport this indicates cars blown from track and damage to railcars; however, the track is generally left in place. In aboveground facilities such as oil tanks, this means that structures are moved from their foundations. Up to 0.5 km (1600 feet) away, moderate damage may is possible. For rail and construction equipment, this involves overturning of cars and possible distortion in the frames. Light damage would result at distances over 0.5 km, with broken glass and damage to parts, but equipment would be generally usable [6].[12]

6. When does a hazard become a threat?

For all the efforts of members of the NEO community to improve the way they communicate with non-expert audiences about NEO detection and tracking and NEO impact risks and hazards, challenges remain. Scare tactics, misinformation, loaded language, fuzzy thinking, and conspiracy theories are still all too common in the public discourse about NEOs and potentially hazardous asteroids. Meanwhile, even some members of the NEO community appear to remain fond of "threat" language.

In the U.S., NASA's collaboration with FEMA on NEO impact hazard assessment and impact emergency planning is helping the NEO community to learn about emergency management, including emergency communications. The emergency management community is well versed in best practices of risk and crisis communications. NEO scientists can count on emergency managers to tell people what to do in the event of a real impact threat. The NEO community's role in disaster planning is to keep emergency managers informed of NEO impact risks, hazards, and threats.

Another thing that has become clear in working with FEMA and other organizations outside the space community is that probabilistic risk assessments, which are the basis for the NEO community's so-called Torino and Palermo scales of asteroid impact risk, are of limited use in communicating with non-experts about NEO impact risks. NEO scientists are beginning to understand that, to avoid misinterpretation, enable informed decision-making, and sustain public trust, they must find non-statistical ways of characterizing impact risks.

7. Conclusions

To sum up, the community of experts working on NEO observations and planning for planetary defense is coming to recognize the need for clear, concise, correct communications about asteroid impact hazards. This community is coming to understand that the disaster management community is experienced at emergency communications, and the two communities are beginning to work together, in the U.S. and elsewhere. Expert groups have made recommendations for action on communication strategy and planning. Implementing these recommendations will require not only acceptance but also a commitment of resources.

While mass media and social media may continue to overdramatize the details of NEO close approaches and impact risks, the NEO community can and should continue to refine its methods of communication. To start, employment of common terminology would be helpful. Some experts continue to talk about "asteroid threats." A certain impact of an asteroid with Earth is, indeed, a threat. The possibility of asteroid impacts with Earth is a risk or a hazard. Distinguishing among key terms is necessary: a hazard is a potential to cause harm, a risk is an assessment of the probability and extent of harm, and a threat is a declaration or determination to

[10] The author watched the live webcast and took notes, from which these quotes are derived.

[11] The author found this language in a 2002 Space Studies Institute brochure.

[12] Thanks to Mark Boslough and Barbara Jennings of Sandia National Laboratory for these descriptions.

cause harm. It would be useful to choose “hazard” over “threat” whenever it's appropriate and choose “risk” over “danger” whenever possible. The best course of action in communicating about asteroid impact hazards is to stick to the facts, avoid speculation, acknowledge and explain uncertainties, and address all questions and concerns respectfully.

The next significant asteroid impact with Earth could be 500 years from now, or next week. The need to be prepared for such an event is clear. The community of experts involved in NEO observations and planning for planetary defense will do well to speak with one voice in informing policy and decision makers about the risks and hazards of asteroid impacts with Earth.

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