Air Force and NASA Activities To Address The Threat of Asteroid/Comet-Earth Impacts

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Space Fundamentals & Issues Electives
Academic Year 1999 – 2000

The awesomely destructive collision of Comet Shoemaker-Levy 9 fragments with Jupiter in July 1994 was a spectacular astronomical event making headline news and providing scientists an incredible research opportunity. Nevertheless, even with the media fanfare and subsequent Hollywood movies Impact and Armageddon, it is this author's opinion that most people do not realize that asteroid and comet[1] impact events with the planets and moons of the solar system, including Earth, have been common, but randomly time-spaced occurrences since the formation of the solar system some four and one-half billion years ago.[2] The impact of a Near-Earth Object (NEO)[3] with Earth is not a Hollywood-invented, fictitious threat, but is a very real threat, just as real as other natural threats such as hurricanes, tornadoes, earthquakes and floods. Furthermore, when--and not if--this threat materializes, it could cause citywide, regional, continental or even global devastation, the latter possibly resulting in the extinction of humankind.[4] Although the estimated statistical frequencies for NEO-Earth impact occurrences are extremely small, ranging from one event per 50-100 years to one event per 50-100 million years,[5] the results of such an impact are so destructive that the threat is a legitimate national security threat.[6] As such, the NEO-Earth impact threat warrants serious consideration, but probably not large monetary investments at this time, by the Department of Defense (DoD). Furthermore, as the DoD's leading space force, and premier space force of the world, the Air Force should assume responsibility for responding to this threat and take the lead in advocating, and eventually acquiring, an international planetary defense system.[7] In this paper, because of the numerous, convincing discussions by others,[8] a planetary defense system and its composition or estimated costs are not argued or discussed. Instead, the paper describes the highest-priority issue with the NEO-Earth impact threat that needs to be addressed now, highlights the current and planned near-term NASA and Air Force activities, and offers some recommendations concerning the Air Force initiating and funding more aggressive U.S. efforts to counter this potentially catastrophic threat.

The highest-priority issue of the NEO-Earth impact threat is best illustrated with the following incident. On March 23, 1989, Asteroid 1989FC, approximately 800 meters in diameter, zipped past the Earth a mere six hours after the planet had been in the asteroid's earth-crossing location. Had a NEO-Earth impact event occurred, it would have resulted in an estimated explosive force of 40,000 megatons of TNT, enough destructive energy to obliterate a continent-size area or larger.[9] Particularly alarming is the fact that nobody knew the asteroid existed until after it had passed. This is the highest-priority NEO threat issue—the scientific community does not know the population or characterization of the asteroids and comets whose orbits place them on collision courses with the Earth. Or, as stated best by James Oberg in his July 23, 1998 presentation at the U.S. Space Command's Futures Focus Day Symposium, "For a future asteroid impact, given our current level of insight into the situation in space, the expected warning time before impact will be zero. Well, say, five or six seconds, since there will be a bright flash that a few people will notice before being pulverized."[10] Currently, scientists estimate there are over 2,000 NEOs (primarily asteroids) with diameters greater than 1 kilometer (such impacts could cause global disaster) and 10,000 or more with diameters greater than 500 meters (the continent killers).[11] Simply stated, it is unknown which one, if any, of these "rocks" is whizzing through space with Earth's name on it. At most, astronomers have discovered only 10-15% of these objects. According to the National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL) NEO Program web page, as of August 25, 1999, 814 NEOs had been discovered--307 are asteroids with diameters of one kilometer or more, with 184 being classified as Potentially Hazardous Asteroids (PHAs), asteroids with the potential to make threateningly close approaches to the Earth.[12] Obviously, there is a need for a concerted effort to detect, track[13] and characterize[14] the PHAs and close-approaching comets. However, until recently, despite the urgency advocated by scientists and some U.S. politicians, little has been accomplished in these areas. Now, in 1999, efforts are finally beginning to accelerate due to Congressional plus-up funding to NASA and some high-level DoD nudging on the Air Force science and technology (S&T) leadership to increase their funding of these activities.

NASA established the NEO Program Office at the JPL in mid-1998 to coordinate and serve as the focal point for international NEO detection, tracking and characterization activities. The NEO Program Office is a part of the Planetary Astronomy Program within the Planetary Sciences Office, NASA Headquarters. The goal of the program is to locate at least 90% of the estimated 2000 large NEOs (diameters greater than 1 kilometer) by 2010.[15] During Fiscal Years (FY) 1994 - 1997, NASA spent about $1M per year on NEO observation (detection and tracking) activities. In FY 1998 the funding increased to about $1.8M, and for FY 1999 and beyond, the funding will be approximately $3.5M per year.[16] With this level of funding, completing an accurate NEO inventory is at least a decade-long effort, and probably more. Additionally, even with increased funding, there is concern that NASA's NEO observation efforts, called Near-Earth Asteroid Tracking (NEAT), are not proceeding as well as they could because of inadequate Air Force cooperation. Websites and journal articles provide descriptions of NEAT as a NASA/JPL-Air Force cooperative effort, with the Air Force providing the use (up to six nights per month) of its one-meter Ground-Based Electro-Optical Deep Space Surveillance (GEODSS) telescope on top of Mount Haleakala, Maui.[17] However, according to a senior official of NASA's Planetary Sciences Office, there has been no NEAT observation time on the Haleakala GEODSS telescope for more than one year, and this official does not expect the Air Force to schedule any future telescope time for the program. Furthermore, this official assessed that there is zero Air Force priority for NEO observations along with little, if any, Air Force interest in seriously addressing the NEO threat and planetary defense.

One of the Air Force authors of the SPACECAST 2020 Planetary Defense White Paper with staff experience in the Plans and Programs Directorate of Air Force Space Command (AFSPC), shares the sentiments of the Planetary Sciences Office senior official.[18] According to this Air Force officer, in 1993 and 1994 Congress requested that NASA and the Air Force construct and fund a program to characterize and understand the NEO threat. However, not much has happened in the intervening years because the corporate leadership of both organizations does not seem to consider NEO-Earth impact events as a legitimate threat and, thus, cannot justify a sufficient level of funding to address the threat. Although AFSPC programmers have tried numerous times to place NEO observation "funding wedges" into the Air Force budget, the corporate Air Force has repeatedly rejected funding such activities.

In addition to NEO observation activities, NASA's Planetary Astronomy Program funds spacecraft missions to NEOs to characterize their sizes, compositions and structures.[19] One of these missions, Near-Earth Asteroid Rendezvous (NEAR), was launched in February 1996 and completed successful flybys of Asteroid 243 Mathilde and Asteroid 433 Eros in 1997 and 1998, respectively.[20] The NEAR spacecraft is now returning to the asteroid Eros and will rendezvous in mid-February 2000, placing itself in orbit about Eros for several months. While orbiting the asteroid, the NEAR science instruments will collect information on the physical and chemical properties of the asteroid. This information, along with that obtained from the previous asteroid flybys and planned missions to comets, will be extremely important for future research and development efforts that the U.S. would have to undertake for NEO mitigation systems comprising part of a planetary defense system.[21]

Based only on the research conducted for this paper, the Air Force's efforts to address the NEO threat appear to be comprised solely of NEO observation programs, and these activities have been funded at very low S&T dollar levels, approximately $250K per year since FY 1992, with funding termination originally planned for FY 2000.[22] However, based on the interest of a high-level DoD official expressed directly to the Air Force Research Laboratory Commander, Air Force S&T funding for NEO observations will probably increase to approximately $400K in FY 2000 and then $500K per year beginning in FY 2001.[23] The Air Force Office of Scientific Research (AFOSR) manages the Air Force's NEO observation activities. The overall program consists of two interdependent efforts--the Lincoln Near-Earth Asteroid Research (LINEAR) and University of Arizona Spacewatch programs.[24] The LINEAR system is a one-meter telescope, equipped with a state-of-the-art, large format, highly sensitive charge-coupled device (CCD) developed by the Air Force as part of its GEODSS modernization initiative. The advanced technologies of the LINEAR system allow search of approximately twelve times the sky area of other NEO observation systems. LINEAR has been extremely successful in NEO broad area search. Since March 1998, the program team has been responsible for the discovery of more than 70% of the NEOs detected worldwide.[25] The University of Arizona's Lunar and Planetary Laboratory Spacewatch group conducts the detailed observations of NEOs discovered by the LINEAR team (and others) to determine in-depth orbits required for tracking and to support mission planning for NASA's asteroid/comet spacecraft missions.[26]

Summarizing the U.S.'s NEO observation efforts, the Air Force and NASA combined will spend approximately $4M per year in FY 2001 and beyond. Is this adequate funding to address the highest-priority issue of the NEO threat, and should more be done? NASA's goal of detecting 90% of the NEOs with diameters greater than one kilometer appears to be too ambitious for the given level of funding and will probably not be achieved by 2010. Furthermore, securing additional NASA and Air Force funding appears unlikely. Discussions with NASA and Air Force officials indicate that the NASA and Air Force senior decision-makers do not consider the finite probability of future NEO-Earth impact events to be a threat that warrants funding. Additionally, the senior official at the Planetary Sciences Office and program managers at AFOSR stated that senior management within their organizations did not like the phrase "NEO threat." Thus, the NASA and Air Force NEO programs are not justified based on a NEO-Earth impact threat, but are justified on gaining a scientific understanding of the primordial mixture which gave birth to the solar system (NASA's case) and obtaining better broad-based and deep space situational awareness capabilities to detect, identify and track unnatural, possibly hostile space objects, such as adversaries' potential "super black" systems in space (AFOSR's case).

In addition to a lack of NASA and Air Force senior leadership funding support to address the NEO threat, neither organization has assumed NEO observation and characterization, or any other necessary planetary defense activity, as a mission. AFSPC and AFOSR senior managers confirmed that planetary defense is not an AFSPC mission.[27] An AFOSR senior official remarked that, from a national security viewpoint, the Air Force should probably play a role in planetary defense, and, if someone was trying to defend the Air Force's role in national security, then perhaps planetary defense should be an Air Force mission. Nonetheless, funding of NEO observations was not a high AFOSR priority.

Based on the author’s understanding of the NEO threat and the current NASA and Air Force activities to address this threat, the following recommendations are offered. First and foremost, better coordination is needed between the NASA and Air Force NEO observation efforts. This is probably best accomplished by someone taking charge--that someone should be the Air Force (through United States Space Command (USSPACECOM) and AFSPC). Taking charge does not necessarily imply making planetary defense a USSPACECOM/AFSPC mission area at this point in time. However, senior-level support in the Air Force will be required, along with some minimal staffing and funding. The coordinated Air Force and NASA NEO observation program must be focused on solidly characterizing the threat. That is, NASA's NEO observation goal needs to be achieved within ten years or less, which will result in a list (hopefully, extremely small) of speeding asteroids with Earth as their bull's eye at some distant time in the future.[28] Once these "killer objects" are identified, the crisis that always seems to be required to legitimize a threat and propel governmental leadership into taking meaningful action will have become apparent.[29] Hopefully, the world will not have to actually experience a NEO-Earth impact event before the threat is taken seriously (especially since the human species might not survive). Solidifying the threat for the senior leadership within ten years or less likely requires an additional $3 to $5M per year for NEO observation programs.[30] However, out of an overall $1.2B Air Force S&T budget, this amount should not be that difficult to acquire. The situation is clear--the NEO threat is real and should be taken seriously, and the Air Force and NASA working cooperatively need to discover and characterize the "killer" NEOs with ample lead time to develop and field a planetary defense system, if required. At the 1998 U.S. Space Command Futures Focus Day Symposium, James Oberg stated: "We know why the dinosaurs died out. It was because they didn't have a space program. More specifically, they didn't have a NASA and a Space Command with the powers that ours soon will possess."[31] Adding to this statement and reflecting the current situation, unless these NASA and Space Command powers are used to address the NEO threat, humans could suffer the same fate as the dinosaurs.

Notes

1. The scientific consensus belief is that asteroids are the remnant debris from the inner solar system formation process approximately 4.6 billion years ago. They are the bits and pieces of material remaining from the initial agglomeration of the inner planets--Mercury, Venus, Earth and Mars--out of the primordial, circumstellar disk material. Most of the asteroids reside within the main asteroid belt, orbiting the sun between Mars and Jupiter. Asteroids range in size from dust particles to so called minor planets, such as the largest known asteroid, Ceres, with a diameter of 913 kilometers. They vary in composition and are categorized as carbonaceous (approximately 75% of the asteroid population), silicaceous (stony and around 15% of the population), metallic (about 10% of the population) and composite (displaying the characteristics of more than one type). Also, some of the asteroid population may be the debris ejected from a comet or the old, inactive comet nuclei themselves. Comets are divided into two classes--short-period comets (orbital periods less than 200 years) and long-period comets (orbital periods greater than 200 years). Short-period comets are believed to have formed near the vicinity of the cold outer planetary system, starting just beyond the orbit of Neptune, 35 to 1000 Astronomical Units (AU) from the Sun. (One AU is the mean distance between the Sun and Earth.) Long-period comets probably formed from the 20,000- to 100,000-AU distant debris cloud surrounding the Sun. Most comets are roughly the same composition--volatile ices, primarily water, mixed with dust and hydrocarbons. They are usually referred to as "dirty snowballs." For more information, see J. R. Tate, "The Threat of Asteroidal and Cometary Impacts," December 1998, n.p.; on-line, Internet, 11 September 1999, available from http://ds.dial.pipex.com/spaceguard/more.htm#usmil and "Near-Earth Objects," 14 September 1999, n.p.; on-line, Internet, 15 September 1999, available from http://neo.jpl.nasa.gov/neo.html.

2. Tate, "The Threat" section. According to J. R. Tate's article, there is ample direct and indirect evidence that all bodies in the solar system show extensive evidence of cratering, with only two exceptions--Io and Europa, both moons of Jupiter. Io's surface is continually being regenerated with volcanically produced sulfur, and Europa's surface is water ice. Approximately 150 asteroid/comet impact craters globally distributed across the surface of the Earth have been identified, and the list is growing. Some interesting examples aggregated from Tate's article and other articles documented at the end of this note:

- About 214 million years ago, fragments of a comet may have created 5 large impact craters in the Northern Hemisphere, with the resultant, widespread destruction leading to the mass extinction that occurred at the end of the Triassic period. Fossilized evidence indicates that nearly 80% of the species living on the planet at this time became extinct. The geological dates of the large Manicouagan crater (62 miles wide) in Quebec, Canada; the large Rochechouart crater in France; the small crater in Saint Martin, Canada; the small crater in Obolon', Ukraine; and the small crater in Red Wing, North Dakota closely match. Additionally, locating the impact points on a 214 million-year old Earth map reveals an amazing alignment of the craters over a 3,000-mile chain, indicating that the impact objects originated from the same place in the sky, perhaps impacting the earth over a few hours or days time span. Note the similarity to the July 1994 Comet Shoemaker-Levy 9 (a string of comet fragments) impact with Jupiter.

- Around 65 million years ago, it is believed that an asteroid approximately 10 kilometers in diameter impacted the Earth off the coast of Mexico's Yucatan Peninsula with an explosive force of 100 million megatons of TNT, creating a crater 180 kilometers wide. This event probably wiped out the dinosaurs as part of another mass extinction occurring during the Cretaceous period.

- Some 50,000 years ago, a rocky, metallic, roughly 50-meter diameter asteroid impacted the Earth, creating Arizona's Meteor Crater.

- On 30 June 1908, a little more than 91 years ago, an estimated 80-meter diameter asteroid entered the Earth's atmosphere, exploding in the air above the tundra of the Tunguska Valley in Siberia with an explosive force of 10 to 15 megatons of TNT. Had this asteroid entered the atmosphere only 3 hours later, due to the rotation of the earth, instead of devastating 800 square miles of forest and reindeer, the asteroid would have leveled Moscow.

- In 1996, asteroid JA1 sped by the Earth at a speed of 58,000 miles per hour at a distance of only 280,000 miles, just slightly greater than the mean Earth-moon distance of 239,000 miles. This asteroid was discovered only 4 days before zipping by. If JA1 had impacted the Earth, it would have created a destructive force of 2,000 megatons of TNT.

For additional information see Patricia Barnes-Svarney, "Killer Rocks," Popular Science, June 1998, 44-49; Jefferey L. Holt, Lindley N. Johnson, and Greg Williams, "Preparing for Planetary Defense: Detection and Interception of Asteroids on Collision Course with Earth," SPACECAST 2020 Technical Report, Vol. 1, Global Power White Papers, June 1994, R-2-R-13; on-line, Internet, 11 September 1999, available from http://research.maxwell.af.mil/ future_studies_index.htm; Lt Col Rosario Nici and 1st Lt Douglas Kaupa, "Planetary Defense: Department of Defense Cost for the Detection, Exploration, and Rendezvous Mission of Near-Earth Objects," Airpower Journal, Summer 1997, 94-98; and Lt Col John C. Kunich, "Planetary Defense: The Legality of Global Survival," Air Force Law Review 41 (1997): 119-126.

3. Tate, "Asteroids" section. See also "Near-Earth Objects" and "Potentially Hazardous Asteroids," 8 July 1999, n.p.; on-line, Internet, 15 September 1999, available from http://neo.jpl.nasa.gov/neo/pha.html. Near-Earth Object (NEO) is the name given to an asteroid or comet whose motion has been perturbed by the gravitational disturbances of nearby planets or other solar system objects resulting in orbital characteristics for a close approach to the Earth. Specifically, in terms of orbital elements, NEOs are asteroids and comets with perihelion distances less than 1.3 AU. Most NEOs are asteroids and are referred to as Near-Earth Asteroids (NEAs). The NEAs are divided into Atens (the group of asteroids having orbits that cross the Earth's orbit--referred to as Earth-crossing--with semi-major axes smaller than the Earth's), Apollos (Earth-crossing asteroids with semi-major axes larger than Earth's), Amors (NEAs currently with orbits exterior to Earth's but interior to Mars', but whose orbits will evolve due to gravitational perturbations and thus cross Earth's orbit in the future) and Potentially Hazardous Asteroids (PHAs) (asteroids currently defined based on parameters that measure their potential to make threateningly close approaches to the Earth).

4. "Near-Earth Objects." An asteroid in the size range of 50- to 100-meters in diameter impacting the Earth would be expected to cause local disasters (land impact) or produce tidal waves that

could inundate low-lying coastal areas (ocean impact). Asteroids larger than one kilometer in diameter impacting the Earth could cause global disasters due to massive amounts of impact debris spreading throughout the Earth's atmosphere, resulting in global acid rains, partial blocking of sunlight and devastating firestorms from heated impact debris streaming back down onto the Earth's surface.

5. Tate, "The Threat" section. It is extremely difficult to estimate with much confidence the frequency of asteroid/comet collisions with the Earth. Basically, any frequency estimation is mostly educated guesswork since the population of asteroids and comets closely approaching the Earth is unknown. Furthermore, the estimated collision frequencies are merely statistical averages of random events--an impact could occur at any time. Nonetheless, the following are examples of estimated statistical collision frequencies for various size asteroids/comets.

- For objects less than 10 meters in diameter, atmospheric entry events occur at the rate of one every 1 to 10 days and for 10-meter (or so) diameter objects, around 1 to 2 per month.

- For objects in the 50- to 100-meter diameter range, the time scale is estimated to be one event every 50 to 100 years. Note that up to about 100 meters in diameter, most asteroids/comets explode in the Earth's atmosphere.

- For 1500-meter sized asteroids/comets, impact events are estimated to occur about once every 100,000 years.

- For objects in the 10-kilometer size range, such extinction events are estimated to occur once every 50 to 100 million years.

6. Holt et al., R-1-R-33. See also Col John M. Urias et al., "Planetary Defense: Catastrophic Health Insurance for Planet Earth," Air Force 2025, Vol. 3, Chap. 16, October 1996, n.p.; on-line, Internet, 13 September 1999, available from http://research.maxwell.af.mil/future_studies_index.htm; Rosario and Kaupa, 94-104; and Kunich, 119-159.

7. Planetary defense system refers to the coordinated activities (scientific, research and development, acquisition, policy, etc.) required to detect, track and mitigate a NEO-Earth collision.

8. Holt et al., R-1-R-33. See also Urias et al and Rosario and Kaupa, 94-104.

9. Statement of George E. Brown, Jr., Chairman, H.R. Committee on Science, Space, and Technology, in "The Threat of Large Earth-Orbit Crossing Asteroids," Hearings before the House Subcommittee on Space, on Results of Spaceguard Study, 103rd Cong., 1st sess., 1993.

10. James Oberg, "Planetary Defense, Asteroid Deflection and the Future of Human Intervention in the Earth's Biosphere," presentation at the Futures Focus Day Symposium, U.S. Space Command, Colorado Springs, Colorado, 23 July 1998, 3; on-line, Internet, 13 September 1999, available from http://www.phoenixat.com/~vnn2/PDdebate.html.

11. Jerry Grey, "Commentary," Aerospace America 34, no. 3 (March 1996): 3.

12. "Frequently Asked Questions," 16 July 1999, n.p.; on-line, Internet, 15 September 1999, available from http://neo.jpl.nasa.gov/faq.html.

13. In addition to detecting NEOs, they must be tracked. Over long periods of time, small uncertainties in an object's orbit, gravitational perturbations, inadequacies in the orbital dynamics models, and other effects, accumulate so that the predicted trajectories will deviate from the actual trajectories. Therefore, measurements will be required to revise and update the predicted trajectories.

14. Currently, the physical and chemical properties of NEOs are poorly understood. Understanding these properties, that is, characterizing the NEO, will be essential in developing mitigation methods, such as destruction or deflection, for a NEO on a collision course with Earth. Although scientists have developed many mitigation methods and theoretical models, they are purely speculation because of the current extremely limited knowledge base of the composition, density, structural integrity, etc., of asteroids and comets.

15. "Near-Earth Object Program," 23 January 1999, n.p.; on-line, Internet, 18 September 1999, available from http://neo.jpl.nasa.gov/program/neo.html.

16. Senior official, Planetary Astronomy Program, Planetary Sciences Office, NASA Headquarters, Virginia, telephone conversation with author, September 1999.

17. Barnes-Svarney, 49. See also "Near-Earth Asteroid Tracking (NEAT)," 23 January 1999, n.p.; on-line, Internet, 18 September 1999, available from http://neo.jpl.nasa.gov/missions/neat.html and "General Information: Near-Earth Asteroid Tracking (NEAT), n.p.; on-line, Internet, 15 September 1999, available from http://huey.jpl.nasa.gov/~spravdo/neatintr.html.

18. Air Force officer, Air Force Space Command, Colorado Springs, Colorado, telephone conversation with author, September 1999.

19. Senior official, Planetary Astronomy Program. See also "Frequently Asked Questions."

20. "Near-Earth Asteroid Rendezvous (NEAR)," 23 January 1999, n.p.; on-line, Internet, 15 September 1999, available from http://neo.jpl.nasa.gov/missions/near.html.

21. Senior official, Planetary Astronomy Program. As an example, images of the asteroid Mathilde taken by the NEAR spacecraft, show that the asteroid is a collection of rocky fragments (a rubble pile) instead of a single, monolithic rock as conjectured based on earth observations only. Therefore, such an asteroid has the capability of absorbing large amounts of energy without breaking apart, a feature that would be a significant factor in determining mitigation techniques.

22. Facsimile, Air Force Office of Scientific Research (AFOSR) NEO Observations Program Funding, September 1999.

23. Senior official and program manager, AFOSR, Air Force Research Laboratory, Arlington, Virginia, telephone conversation with author, September 1999.

24. Facsimile, AFOSR Program Notes on NEO Observation Activities, September 1999.

25. "Space Tracking Technology Focuses on Deep Space," AFOSR Research Highlights, May/June 1999, n.p.; on-line, Internet, 17 September 1999, available from http://ecs.rams.com/ afosr/afr/afo/any/test/any/ rhjun99.htm.

26. "Spacewatch," 23 January 1999, n.p.; on-line, Internet, 15 September 1999, available from http://neo.jpl.nasa.gov/missions/spacewatch.html. See also "The Spacewatch Project," 27 July 1999, n.p.; on-line, Internet, 15 September 1999, available from http:// pirlwww.lpl.arizona.edu/spacewatch/.

27. Senior official, Air Force Space Command, Colorado Springs, Colorado, telephone conversation with author, September 1999.

28. There is nothing special about ten years. What is important is that a complete NEO inventory be acquired as quickly as reasonably possible because development of a mitigation capability for NEOs predicted to collide with the Earth will take a fairly long period of time. A senior scientist at AFOSR told the author that one of his colleagues, who is well respected in the NEO/planetary defense scientific community, estimates the U.S. would need thirty years or more to develop a sufficient capability to mitigate Earth-threatening NEOs.

29. The current leadership view of the NEO threat is strikingly reminiscent of the leadership view just a few years ago when the threat of the terrorist use of weapons of mass destruction against the U.S. was given "lip service" but not taken seriously in terms of funding and programs. However, when events such as the World Trade Center and Oklahoma City bombings occurred within U.S. borders, and the Aum Shinrikyo cult used a deadly chemical warfare agent against urban civilians, the threat was almost instantaneously legitimized and generated a flurry of political activity and subsequent funding of a multitude of national programs.

30. Author’s estimate based on the research conducted for this paper.

31. Oberg, 3.
