# Asteroids Aff

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# 1AC –

## 1AC- Inherency

### Observation One is the Status Quo- Near Earth Objects (or NEOs) will inevitably strike the planet, only early warning through detection can prevent catastrophe.

The Australian Magazine, 2009, October 17, 2009, “'Roid rage - SCIENCE WATCH”, Lexis, 6/27/11, CF

It may sound like the plot of a bad science-fiction movie from the 1990s (think Deep Impact or Armageddon) but there is a one in ten chance Earth will be struck by a dangerous object from space sometime this century, according to a report just published in New Scientist. Advances in telescope technology over the past decade have enabled astronomers to identify at least 20,000 asteroids and comets that pose a risk to our planet. So real is the threat that, for the first time, the US air force recently assembled a team of scientists, military and emergency-response officials to assess the nation's ability to cope should an asteroid or comet strike. Because they're travelling at such great speed (something like 20km a second) asteroids don't have to be huge to do a lot of damage. In 1908 an asteroid estimated to have been 60m across - a mere rock by cosmic standards - exploded as it hit the lower atmosphere over Tunguska, Siberia, flattening hundreds of square kilometres of forest. And a year ago an asteroid the size of a car broke up over Sudan; a telescope observer spotted it just 20 hours before impact. If an asteroid or comet does strike, let's hope it hits land rather than sea: a two-km-wide object hitting an ocean would trigger tsunamis that would turn many of the world's coastal cities into mudflats. Earth has suffered at least 130 major impacts that scientists know of, and at least a handful have been ELEs - "extinction level events", wiping out more than 80 per cent of life on the planet. The greatest threat are from "rogue" comets dislodged by gravity from their orbits in the Oort Cloud, on the outer edge of our solar system. If one of these icy stumps were to hurtle towards Earth millions of us could be at risk. So if a killer asteroid was on a collision course with Earth, what could be done about it? Detonating a nuclear device on it, as in Armageddon, isn't a realistic option. To deflect an asteroid sufficiently from its trajectory, force would need to be applied years in advance, reports New Scientist. The best we can hope for is an early warning system that would allow us to predict the time and location of the impact. Then what? Run like hell.

### Unfortunately, NASA is drastically underprepared for the inevitable NEO strike – NASA doesn’t have adequate detection to provide early warming.

Mercury, 2009 Hobart Mercury, August 14, 2009, Nationwide News Pty Limited, “Lack of funds hampers killer asteroid hunt”, Lexis Nexis, 6/21/11, CF

Top of Form

NASA is supposed to seek out almost all the asteroids that threaten Earth, but lacks the money to do the job. That's because even though US Congress gave the space agency this mission four years ago, it never gave NASA money to build the necessary telescopes, says a report released this week by the National Academy of Sciences. Specifically, NASA has been ordered to spot 90 per cent of potentially deadly rocks hurtling through space by 2020. Even without the money, NASA says it has completed about one-third of its assignment with its current telescope system. The agency estimates about 20,000 asteroids and comets in Earth's solar system bigger than 140m in diameter are potential threats to the planet. So far, scientists know where about 6000 of the objects are. Rocks between 140m and 1000m in diameter can devastate an entire region but not the whole planet, said Lindley Johnson, NASA's manager of the near-Earth objects program. Objects bigger than that are even more threatening. Just last month, astronomers were surprised when an object of unknown size and origin bashed into Jupiter and created an Earth-sized bruise that is still spreading. Jupiter gets slammed more often than Earth because of its immense gravity, enormous size and location. Near misses in previous years have alerted people to the threat. But when it comes to doing something about monitoring the threat, the academy concluded: ``There has been relatively little effort by the US Government.'' And the US Government is practically the only government doing anything at all, the report found. ``It shows we have a problem we're not addressing,'' said Louis Friedman, executive director of the Planetary Society, an advocacy group.

### And, the current NASA mission only allows for ground-based NEO detection, which will fail. Only Space-based detection can adequately solve.

National Academies, 10 [ Over many decades, the National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council have earned a solid reputation as the nation's premier source of independent, expert advice on scientific, engineering, and medical issues, “Defending Planet Earth: Near-Earth Object Surveys and Hazard Mitigation Strategies” http://books.nap.edu/openbook.php?record\_id=12842&page=41]

Congress has established for NASA two mandates addressing near-Earth object (NEO) detection. The first mandate, now known as the Spaceguard Survey, directed the agency to detect 90 percent of near-Earth objects 1 kilometer in diameter or greater by 2008. By 2009, the agency was close to meeting that goal. Although the estimate of this population is continually revised, as astronomers gather additional data about all NEOs (and asteroids and comets in general), these revisions are expected to remain. The 2009 discovery of asteroid 2009 HC82, a 2- to 3-kilometer-diameter NEO in a retrograde (“backwards”) orbit, is, however, a reminder that some NEOs 1 kilometer or greater in diameter remain undetected. The second mandate, the George E. Brown, Jr. Near-Earth Object Survey section of the NASA Authorization Act of 2005 (Public Law 109-155), directed that NASA detect 90 percent of near-Earth objects 140 meters in diameter or greater by 2020. However, what the surveys actually focus on is not all NEOs but the potentially hazardous NEOs. It is possible for an NEO to come close to Earth but never to intersect Earth’s orbit and therefore not be potentially hazardous. The surveys are primarily interested in the potentially hazardous NEOs, and that is the population that is the focus of this chapter. Significant new equipment (i.e., ground-based and/or space-based telescopes) will be required to achieve the latter mandate. The administration did not budget and Congress did not approve new funding for NASA to achieve this goal, and little progress on reaching it has been made during the past 5 years. The criteria for the assessment of the success of an NEO detection mandate rely heavily on estimates that could be in error, such as the size of the NEO population and the average reflectivity properties of an object’s surface. For many years, the average albedo (fraction of incident visible light reflected from an object’s surface) of NEOs was taken to be 0.11. More recent studies (Stuart and Binzel, 2004) determined that the average albedo was more than 25 percent higher, or 0.14, with significant variation in albedo present among the NEOs. The variation among albedos within the NEO population also contributes to the uncertainties in estimates of the expected hazardous NEO population. This difference implies that, on average, NEOs have diameters at least 10 percent smaller than previously thought, changing scientists’ understanding of the distribution of the NEO population by size. Ground-based telescopes have difficulty observing NEOs coming toward Earth from near the Sun’s direction because their close proximity to the Sun—as viewed from Earth—causes sunlight scattered by Earth’s atmosphere to be a problem and also poses risks to the telescopes when they point toward these directions. Objects remaining in those directions have orbits largely interior to Earth’s; the understanding of their number is as yet very uncertain. In addition, there are objects that remain too far from Earth to be detected almost all of the time. The latter include Earth-approaching comets (comets with orbits that approach the Sun at distances less than 1.3 astronomical units [AU] and have periods less than 200 years), of which 151 are currently known. These represent a class of objects probably doomed to be perpetually only partly known, as they are not likely to be detected in advance of a close Earth encounter. These objects, after the completion of exhaustive searches for NEOs, could dominate the impact threat to humanity. Thus, assessing the completeness of the NEO surveys is subject to uncertainties: Some groups of NEOs are particularly difficult to detect. Asteroids and comets are continually lost from the NEO population because they impact the Sun or a planet, or because they are ejected from the solar system. Some asteroids have collisions that change their sizes or orbits. New objects are introduced into the NEO population from more distant reservoirs over hundreds of thousands to millions of years. The undiscovered NEOs could include large objects like 2009 HC82 as well as objects that will be discovered only months or less before Earth impact (“imminent impactors”). Hence, even though 85 percent of NEOs larger than 1 kilometer in diameter might already have been discovered, and eventually more than 90 percent of NEOs larger than 140 meters in diameter will be discovered, NEO surveys should nevertheless continue, because objects not yet discovered pose a statistical risk: Humanity must be constantly vigilant. Finding: Despite progress toward or completion of any survey of near-Earth objects, it is impossible to identify all of these objects because objects’ orbits can change, for example due to collisions. Recommendation: Once a near-Earth object survey has reached its mandated goal, the search for NEOs should not stop. Searching should continue to identify as many of the remaining objects and objects newly injected into the NEO population as possible, especially imminent impactors.

## 1AC – Harms

### Observation Two is Harms

### Scenario One: Armageddon

### A. Large Asteroids cause extinction of nearly all life on the planet – the dinosaurs prove.

Sunfellow ’95, David Sunfellow, a writer for the News Brief, BS in astronomy “Doomsday Asteroids”, Nov 17 1995, June 23, 2011, http://www.nhne.com/articles/saasteroids.html

Using the moon's potholed surface as a reference point, Shoemaker set out to see how often celestial objects smashed into the moon and, by extension, also struck the Earth. With the help of modern satellite and aerial surveillance, Shoemaker and other scientists soon identified over 200 impact sites around the planet. One of these impact sites, which measured 100 miles across and which was buried a mile beneath the Earth surface, dated back 64 million years ago--the exact same time dinosaurs mysteriously vanished from the earth. Supporting the idea that whatever struck the Earth 64 million years ago unleashed a global catastrophe, geologists the world over have discovered a dark ring in the geological history of the planet that contains elements very common to asteroids, but very rare on Earth. The geological records above the dark layer contain records of mammals and other recent life forms, while the geological records below contain the records of dinosaurs and other prehistoric creatures. The dark layer also bears witness to some kind of massive global firestorm. And while scientists still aren't sure how, exactly, the dinosaurs were killed off (or, for that matter, how exactly, two thirds of the rest of the Earth's species were killed off and 90% of the Earth's biomass burned up), there is evidence: The skies of the Earth exploded into flames Wild fires engulfed the planet's forests The skies were probably darkened for months, possibly for years All kinds of geological disturbances, such as volcanic eruptions and lava flows, were ignited

### B. Medium sized Asteroid strike causes global extinction.

Sidle ‘7(Roy, Slope Conservation Section, Geohazards Division, Disaster Prevention Research Institute, Kyoto University, Chapter 23: Hazard Risk Assessment of a Near Earth Object, in *Comet/Asteroid Impacts and Human Society: An Interdisciplinary Approach*, SpringLink)

Very large asteroids (> several km) have impacted Earth in the past, but never in the short history of human habitation. Such catastrophic impacts on Earth are believed to occur on average once in about 300 000 yr (Morrison 1992), although it is difficult to express such infrequent occurrence in terms of probability. The energy released by a 3 km asteroid striking land (1 millionMT) would probably be capable of destroying civilization (Morrison 1992; Chapman 2004). This global catastrophic threshold would be reached primarily by the massive ejection of dust into the atmosphere that would depress temperatures for a least a growing season, leading to global scale crop failures and widespread starvation. Ballistic ejecta re-entering the atmosphere would ignite firestorms throughout areas > 107 km2, which would further reduce incoming solar radiation (Garshnek et al. 2000; Chapman 2004). Nitrous oxide produced by the burning of atmospheric nitrogen would destroy much of the ozone layer and the resulting nitric acid produced would pollute soils, lakes, oceans and streams. Following the clearing of the atmosphere (months after impact), the release of large quantities of water vapor and carbon dioxide would strongly enhance global warming (Morrison 1992; Garshnek et al. 2000). Agriculture and forests would largely be destroyed worldwide, leaving few materials for the survivors, and mass extinctions of plant and animal species would occur. Geomorphic hazards would increase both as the direct result of the impact (e.g. earthquake shock, landslides, rockfalls, ice falls, jökulhlaups, coastal flooding), as well as long after the impact due to widespread devastation of vegetation cover, climate change and other indirect effects (e.g. massive soil erosion, landslides, glacial hazards, permafrost melting, localized flooding). Although any estimates of loss of life in such a global catastrophe are totally speculative, it is conceivable several billon people could die from the initial impact of the disaster together with the resulting secondary impacts and global socio-economic collapse (Chapman 2004). In the case of an ocean impact, huge tsunami would occur globally; heights of several hundreds of meters are likely within impacted ocean basin shorelines (Hills and Goda 1999; Garshnek et al. 2000; Ward and Asphaug 2000; Tate 2000). Many inland areas would be inundated and destroyed, and massive erosion, coastline changes, river rerouting and island destruction would occur. The only survivors would be people living far inland or who have been safely evacuated to such higher elevation areas. Such an impact on ice caps could cause sea level rise and regional coastal flooding.

### C. Even Small asteroids which are undetectable from ground-telescopes cause the “Air Hammer” effect – a giant fireball that outweighs nuclear war.

Arentza et al 2010 NEO Survey: An Efficient Search for Near-Earth Objects by an IR Observatory in a Venus-like Orbit Robert Arentza, Harold Reitsemaa, Jeffrey Van Cleveb and Roger Linfielda a Ball Aerospace & Technologies Corp. 1600 Commerce St. Boulder, CO 80301 303-939-6140; rarentz@ball.com; hreitsema@aol.com; rlinfiel@ball.com b SETI Institute NASA Ames Research Center NS 244-30, Room 107G Moffett Field, CA 94035 650-604-1370 Space, Propulsion & Energy Sciences International Forum

Crucial to the politics of NEO searches is the size-frequency distribution, which until the past two or three years has statistically indicated that the next significant impact is not likely for maybe 1,000 years, enough time for the groundbased community to find most of the NEOs with diameters roughly larger than 100 meters. However, M. Boslough (2009), of Sandia National Labs, has recently changed this argument by applying supercomputing-based numerical codes, used to model nuclear detonations, to the enigma of the Libyan Desert Glass (LDG) event. Boslough concluded that a 100-meter-class NEO disintegrated in the air far above the Saharan desert, with all of its kinetic energy and momentum continuing downwards as something informally referred to as an “air hammer.” When this air hammer struck the Earth’s surface, the entrained fireball initially had core temperatures on the order of 5,000 kelvin. The fireball portion of this complex event then spread laterally to about 20 kilometers in diameter. The air hammer also produced a hypersonic blast wave that extended radially for perhaps 50 kilometers. The fireball portion of the interaction remained on the ground for about 40 seconds and melted a patch of sand some 15 kilometers in diameter and several centimeters thick to produce the Libyan Desert Glass. Occasional expeditions to the site collect 100s of kilograms of the glass and sell it on the internet for a few dollars a gram. Boslough (2009) also modeled the 1908 Tunguska event and rescaled the estimated size of the Tunguska body downwards from ~80 meters to ~30 meters. At this new size, the mean interval between impacts is 150 years. Here is where the astrosociology of this paper’s contents becomes pertinent— This newly recognized threat régime (diameter >30 meters) contains far more objects than the diameter >140 meter NEOs. This 140-meter threshold arose circa 2003 when the United States Congress set the goal of compiling a catalogue complete to 90% by 2020 of all NEOs larger than 140 meters in diameter. This 90%, 140 meter, 2020 set of goals was named in honor of George E. Brown (GEB). Merging the GEB goals to Boslough’s (2009) work gives two results. The first is that all the 1,000-year-interval arguments no longer work. Instead, the mean interval between serious impacts is roughly 150 to 200 years. This shortened mean-interval forcefully argues for an efficient and timely NEO survey being completed in the next few years. Next (and this point is both subtle and powerful), typical arguments against performing a spacebased survey usually begin by a person saying something like-- “Yes, an event similar to Tunguska might happen in the next 100 years, but so what? Roughly six percent of the Earth’s surface is populated, so the next event is likely to be a non-event in terms of fatalities.” However, even though ~6% of the Earth’s surface is populated, the world’s widely distributed infrastructure is vastly larger and extremely vulnerable to the physics of Boslough’s (2009) modeled airbursts. A typical LAA airburst could create a cascade of failures across many distributed and interconnected networks which would be extensive, unpredictable, and impossible to quantify. Additionally consider the following: Suppose a large-scale airburst occurred above the Indian Ocean and killed no one. The resulting psychological trauma around the world could create panic on an unprecedented scale, panic which would at least ripple though the global financial markets. And if such an airburst happened without warning in places like the Middle East, or the much larger, and nuclear- armed areas of Asia or Russia, the resulting response could initiate a chain of human events resulting in severe military action. It’s this nonlinear psychological aspect that needs addressing in this conference because its message has been overlooked in the past. Most risk analyses done to date have only considered what can be quantified—the immediate body count and all the property damage arising from the initial impact. Perhaps this conference should place an added emphasis on the world’s vastly extended infrastructure and its interdependency, as well as the realities of large-scale human reaction to a sudden and catastrophic airburst vent.

### Scenario Two: Broken Arrow

### Due to poor detection we wouldn’t have adequate warning for a NEO strike, Nuclear weapons would be the only option.

Betts ‘9 (Bruce, The Planetary Society, “Final Update from the Planetary Defense Conference,” 4-30, http://www.planetary.org/blog/article/00001927/)

Unless we have a warning time of at least a decade (more for a large asteroid), most scientists and engineers agree that, **at this point**, the **only option** is nuclear weapons. The usual concept is to detonate a nuclear weapon a few tens or hundreds of meters from the NEO, which will vaporize some of its surface. That vaporized rock act like a rocket jet, moving the NEO in the opposite direction. This concept needs a lot of work, though scientists feel they understand the physics of the nuclear explosion extremely well. What isn't well understood is the upper surface of a NEO: solid, fluffy, rubble-pile. Each surface will have a different effect. Then, there is the challenge of getting the nuclear weapon to the asteroid -- possibly very quickly -- and detonating it at the right place. For objects of a few hundred meters or smaller, one may be able to use kinetic impact alone and slam a spacecraft, preferably heavy, into the NEO at very high speed. If there is more lead time, one can use slower impulse methods ranging from gravity tractors, where we actually use the spacecraft's gravity to slowly tug the asteroid. Many more exotic methods were also discussed, from laser ablation creating jets, to tethers, etc. In all cases, these deflection methods need more work and study. Finally, if we have little warning, days for instance, all we can do is attempt to evacuate the area that will be affected. At this conference, there was more emphasis on the case of very short time frame small object impacts than there has been in the past. Part of the reason was because of two small impacts that occurred in the last couple years (since the last Planetary Defense Conference). Asteroid 2008 TC3 was discovered less than 2 days before it impacted over Sudan. But, there were enough observations to generate a prediction of where it would hit. It was the first time a natural object had been observed in space before it entered the Earth's atmosphere, and as a bonus, portions of the space rock were recovered. Though it was a very small object that broke up and caused no more damage than scattering meteorite fragments, it demonstrated that current NEO surveys have a chance to observe a NEO "at the last minute" during its so-called death plunge. This type of observation requires particularly quick action, and for an object much larger than 2008 TC3, would ideally allow time for evacuations. The other impact reported at the conference occurred a couple years ago in Peru -- the Carantas impact. There are indications that it was a relatively small object (2 to 5 meters) that would not have been predicted to make it through the atmosphere in one piece, yet it created a 14 meter crater in a dry river in a field. It occurred at 3800 meters altitude, and the blast wave knocked a man off a bicycle and a bull to the ground. There is also discussions beginning with emergency management agencies across the world about this issue, but lots more is needed. They would be the ones involved in evacuations, and post-disaster assistance. The bottom line is still that impact is a low probability any given day, but it definitely will happen eventually. As I've seen at this conference, we can plan for and perhaps even prevent such an impact, but it will take more investment and work.

### And, Destroying NEOs with nuclear weapons fails, the NEO will hit more cities, morph into a radioactive lump of metal, and causes massive space militarization.

**O'Neill 2008** (IAN O'NEIL, O’Neill is a British solar physics doctor with nearly a decade of physics study and research experience, November 27th, 2008, “ Apollo Astronaut Highlights Threat of Asteroid Impact”, Astroengine.com, accessed 6/22/11, <http://www.astroengine.com/2008/11/apollo-astronaut-highlights-threat-of-asteroid-strike/>, JK)

Unfortunately, the commonly held opinion is to dispense an incoming asteroid or comet with a few carefully placed atomic bombs (by a generic crew of Hollywood oil drillers). Alas, [Armageddon](http://www.imdb.com/title/tt0120591/plotsummary) this ain’t. Even if we were able to get a bomb onto the surface of an incoming object, there is little hope of it doing any good (whether we get Bruce Willis to drop it off or launch it ICBM style… or would that be IPBM, as in Inter**planetary** Ballistic Missile?). What if we are dealing with a near-Earth asteroid composed mainly of metal? A nuclear blast might just turn it into a hot radioactive lump of metal. What if the comet is simply a collection of loosely bound pieces of rock? The force of the blast will probably be absorbed as if nothing happened. In most cases, and if we are faced with an asteroid measuring 10 km across (i.e. a dinosaur killer), it would be like throwing an egg at a speeding train and expecting it to be derailed. There are of course a few situations where a nuclear missile might work too well; blowing the object up into thousands of chunks. But in this case it would be like making the choice between being shot by a single bullet or a shot gun; it’s bad if you have one impact with a single lump of rock, but it might be worse if thousands of smaller pieces make their own smaller impacts all over the planet. If you ever wondered what it might be like to be sandblasted from space, this might be the way to find out! There may be a few situations where nuclear missiles are successful, but their use would be limited. Personally, I think using nuclear weapons against a comet or asteroid is a bad idea, and so does Schweickart. In fact, the ex-astronaut believes there might be some ulterior motives for the push to use nuclear weapons against threatening asteroids. By clearing the use of nuclear weaponry in space (under the guise of “global safety”), [it may open the floodgates for nuclear proliferation in Earth orbit](http://www.universetoday.com/2008/07/27/bad-idea-blowing-up-asteroids-with-nuclear-missiles/). Schweickart has specifically targeted the goal of putting together a non-nuclear solution to the deflection of asteroids. However, mankind will need a massive lead time to enact any avoidance measure. We will therefore need better observation techniques (and we are getting better at spotting and tracking asteroids, [as was the case with asteroid 2008 TC3, the first ever asteroid impact predicted by astronomers](http://www.astroengine.com/?tag=2008-tc3)), and we will need to work on novel deflection techniques.

### And, Nuclear explosions are imprecise and cause fragmentation making the impact worse

Lu ‘4 (Statement of Dr. Ed Lu President, B612 Foundation, “Near-Earth Objects,” testimony before the Committee on Senate Commerce, Science and Transportation Subcommittee on Science, Technology, and Space, Apr.7 CQ, lexis)

Why does the asteroid need to be moved in a "controlled manner"? If the asteroid is not deflected in a controlled manner, we risk simply making the problem worse. Nuclear explosives for example risk breaking up the asteroid into pieces, thus turning a speeding bullet into a shotgun blast of smaller but still possibly deadly fragments. Explosions also have the drawback that we cannot accurately predict the resultant velocity of the asteroid - not a good situation when trying to avert a catastrophe. Conversely, moving an asteroid in a controlled fashion also opens up the possibility of using the same technology to manipulate other asteroids for the purposes of resource utilization.

### And, the resulting fragmentation causes oxygen depletion and extinction

Verschurr ’96(Gerrit, [adjunct professor](http://en.wikipedia.org/wiki/Adjunct_professor) of [physics](http://en.wikipedia.org/wiki/Physics) for the [U of Memphis](http://en.wikipedia.org/wiki/University_of_Memphis), *Impact: The Threat of Asteroids and Comets*, pg. 40)

Did consider are potential risk to earth if it were to run into the head of a comet made up of lots of meteorites. The picture he painted was based on what an earlier astronomer, Sir Simon Newcomb, had written about this possibility. Newcomb admitted that, although there were more likely ways to die than as a result of comet collision, such a fate was real. Should such a collision, occur, Gregory conjured up a picture of what might happen. On the one hand, if the comet head was made up of dust, the earth’s inhabitants would experience nothing more than a stunning display of shooting stars. But if the comet head was made of cannonball sized objects the consequences would be dire. Myriads of meteoritic masses would beat upon the earth, and the burning of the materials of which they are composed would probably use up the oxygen in the atmosphere, in which case, man and all the animal creation would perish. The temperature of the air would be raised to such a degree that all vegetation would be destroyed and our world would be transformed into a desolate and barren rock.

## 1AC – Plan

### Plan: The United States federal government should develop and deploy a space-based Near Earth Object detection system operating on a Venus-like orbit.

This may not be the final plan…

## 1AC – Solvency

### Observation Three is Solvency

### The plan’s deployment of a space-based telescope is critical to solve NEO detection. The Venus-like orbit will allow adequate early warning and far greater precision.

Arentza et al 2010 NEO Survey: An Efficient Search for Near-Earth Objects by an IR Observatory in a Venus-like Orbit Robert Arentza, Harold Reitsemaa, Jeffrey Van Cleveb and Roger Linfielda a Ball Aerospace & Technologies Corp. 1600 Commerce St. Boulder, CO 80301 303-939-6140; rarentz@ball.com; hreitsema@aol.com; rlinfiel@ball.com b SETI Institute NASA Ames Research Center NS 244-30, Room 107G Moffett Field, CA 94035 650-604-1370 Space, Propulsion & Energy Sciences International Forum

The key to mitigation is discovery. And the fastest possible method for finding NEOs is to look for them in the thermal-infrared band from ~6 to ~11 microns with a telescope having an aperture of 50 centimeters that is located in a Venus-like orbit with a semi-major axis of about 0.7-AU. Such a system is presented in this paper and is based on experience gained from two very relevant, deep-space missions: the infrared Spitzer Space Telescope and the large-aperture Kepler mission. Both systems are currently operating and exceeding specifications in deep space. Because the design presented herein is closely based on these two flight systems, the mission described in this paper has a robust cost estimate due to the use of actual final costs for nearly identical systems. Every aspect of this design is a lowering of complexity compared to its flight-heritage program element. A detailed computer model of the flight system and the NEO search process was created by Ball Aerospace to guide the development of this observatory. The main details of this model are included below. The Ball model has been compared against a similar model built for the same purpose by the Jet Propulsion Laboratory (JPL) circa 2003, as well as to another similar model developed by the Large Synoptic Survey Telescope (LSST) for its own purposes. (LSST is not yet in any funding queue, and if built would take perhaps 15 to 30 years after first light to complete the GEB-level mission). Recently, the integrated Ball model, which evaluates only flight systems, has been uploaded into the groundbased-only LSST model, thus providing the community with an improved model that can compare any mission design in any orbit in any passband. The Ball-LSST model has been compared (as separate elements) against the JPL model using test objects, and then with simulated missions, and all three models converge on the same results. All of this modeling supports the 2003 Science Definition Team’s (SDT) conclusion that a half-meter, infrared system operating in a Venus-like orbit, by itself, will find 90 percent of all the greater than 140 meter diameter NEOs in just over seven years. While doing so, it will also find about 70 percent of all the greater than 100 meter diameter NEOs and about 50 percent of all the greater then 50 meter diameter NEOs. Adding a groundbased visible light telescope such as Pan-STARRS1 to this spacebased infrared mission reduces the time-to-90% completion from a little over seven years to a little over five years. It is especially relevant that deep-space-based infrared is the only approach that will meet the performance levels stated above regarding the smaller NEOs, and is the only design that finds them in such numbers at such a high rate. Note well that these smaller NEOs constitute Boslough’s (2009) newly discovered threat régime. If, as moral societies wishing to mitigate the threat of a large-scale loss of human life, unforeseen economic disruption and massive physical infrastructure damage, coupled to the unpredictable reaction of societies to such a trauma, we look at the NEO situation from this new perspective, then for the first time in human history NASA and its industrial base (or ESA and its technical base) have the unprecedented chance, for close to $600M, to deterministically answer the question: are we safe for the next 100 years? If we are, then we, as a population, will have at least attained an extensive data set regarding NEOs for future use. If we are not, then any mission like the one described herein becomes the first vital link for preventing a natural disaster of this scale—the only kind of natural disaster of this scale which humans can prevent, at least in principle. Stated another way, with enough warning time, humans can move an impact off the Earth, thus mitigating a global, life-altering threat. But like treating cancer, the key to survival is early discovery. A mission such as this one represents the fastest possible means to discover, initially track, and then successfully mitigate the threat. This is no longer an arcane scientific discussion—this is now a matter of doing something relatively small and affordable that can act as an insurance policy for everyone on Earth, or in the safest outcome will yield a very large data set about NEOs for future work.

### Only effective detection allows for the development of adequate deflection systems. We have the technology, we’d just need the time to deploy it.

Sayanagi 08, (Kunio M. Sayanagi, 4/4/08, “How to Deflect an Asteroid”, http://arstechnica.com/science/news/2008/04/how-to-deflect-an-asteroid.ars, Kunio M. Sayanagi is a postdoctoral research fellow in the Division for Geological and Planetary Sciences at the California Institute of Technology, SH)

By now, we have all heard about a handful of asteroids that are big enough to level a city or two and have a small but non-negligible chance of hitting Earth. Should we find one heading straight at Earth, what can we do about it, if anything at all? That is the question addressed by Carusi and colleagues in a study published in the April issue of Icarus, a leading international journal in the planetary sciences. They conducted case studies of two near-Earth asteroids (NEAs) known as 99942 Apophis and 2004 VD17, whose initial orbit estimates indicated measurable probabilities of hitting Earth in 2036 and 2102, respectively. Although refinements to their orbital calculations through intensive follow-up observations have substantially lowered their chances of collisions with Earth, the authors treated the asteroids' initial orbital estimates as full-blown drills to study how such asteroids can be deflected, and to build realistic strategies to prepare ourselves for such events. The report presents computer simulations that calculate the minimum orbital velocity change we must impart on the asteroids to deflect them away from Earth. A larger velocity change requires a stronger force, and thus imposes a greater technological and financial challenge. **To make the exercise realistic, the authors considered performing their deflection maneuvers only when the asteroids cross the orbit of Earth—as the asteroids under consideration are NEAs, they have repeated Earth orbit crossings leading up to the predicted impact dates**. As expected, in general, the authors' calculations show that greater speed changes are needed as the hypothesized impact date comes closer. **However, a careful examination also reveals that there are windows of opportunity in which deflection becomes considerably easier largely due to the relative orbital geometry of the asteroids and Earth.** For example, in the case of 99942 Apophis, estimated to be a 400 meter chunk of rock, an impactor with 300 kg mass can deflect the asteroid to safety with a carefully angled interception on January 27th, 2020, about 16 years before impact. **The authors note that such a deflection maneuver is already achievable with currently existing technologies**. **However, their study illustrates that things are not always that easy**. The other asteroid they considered, 2004 VD17, has an orbit closely overlapping that of Earth's over a longer span than 99942 Apophis does, and such orbital characteristics makes its deflection much more tricky. Still, the scientists found windows of opportunity such as one in 2021, 81 years before its hypothesized collision with Earth, in which an impactor weighing about a ton could deflect the asteroid away from Earth. The authors' findings also come with a bit of bad news. While it may be technologically feasible to exert a force large enough to deflect 2004 VD17, their calculations also reveal that the impactor could shatter the asteroid, which is equivalent to converting an approaching rifle bullet into a shotgun round, with consequences that are unpredictable at best. 99942 Apophis, in contrast, should survive the relatively modest forces required to deflect it. **This study by Carusi et al. shows that deflecting real asteroids is within reach of currently existing technologies, given enough time and planning.** By definition, NEAs orbit near Earth, so any that threaten us are expected to have a few close encounters with Earth, during which they are easy to find, before the final collision. **Therefore, the long planning period considered in this study is realistic**. The current study's strategy will not, however, work well for deflecting objects with highly elliptical orbits such as long period comets; nevertheless, most objects that impose significant threats to Earth are NEAs since their orbits bring them so close to here. The study highlights the importance of efforts such as the SpaceWatch project hosted by the University of Arizona—its goal is to find and track all objects with chances of impacting Earth. It may well turn out that spotting an asteroid heading our way before it is too late is far more difficult than developing technologies to deflect them.

### And, only Venus-like orbit can create adequate lead time to allow for mitigation.

Arentza et al 2010 NEO Survey: An Efficient Search for Near-Earth Objects by an IR Observatory in a Venus-like Orbit Robert Arentza, Harold Reitsemaa, Jeffrey Van Cleveb and Roger Linfielda a Ball Aerospace & Technologies Corp. 1600 Commerce St. Boulder, CO 80301 303-939-6140; rarentz@ball.com; hreitsema@aol.com; rlinfiel@ball.com b SETI Institute NASA Ames Research Center NS 244-30, Room 107G Moffett Field, CA 94035 650-604-1370 Space, Propulsion & Energy Sciences International Forum

Groundbased searches at visible wavelengths are nearing 90% completeness for NEOs having diameters greater than 1,000 meters. Extending the effort down to diameters of 140 meters, and smaller, is very challenging from the ground due to visible albedos of ~20% or less, unfavorable phase functions in reflected light, and difficulties observing near the Sun. Use of a dedicated mid-infrared telescope in a Venus-like orbit greatly improves the search efficiency for several reasons such as NEOs in small orbits can be observed at larger solar elongation angles than from the Earth and most of the radiated energy from NEOs emerges in the thermal infrared, meaning that the phase function of infrared (thermal) emission is more favorable than for reflection at visible wavelengths. NEO Survey also accesses a greatly expanded near-Earth region in the FOR as discussed next. Any NEO in roughly an Earth-like orbit will approximately have an Earth-like period and will be hard to detect from the ground for many reasons. For example, if a nearby NEO has an orbit that is similar to, but is 5% different than the Earth’s, then its next Earth-approach will happen in 20 years. During the vast bulk of these 20 years, this NEO will reside in the daytime sky and be unobservable from the ground. Yet when it returns, it will very likely come at the Earth from the daytime sky with little or no warning. But from a Venus-like orbit all such objects are easily detectable on the scale of ~520 days. Thus, 10 to 15 years of advanced warning could be given, time that is vital for any mitigation mission to succeed.

### And, Only US action solves, American leadership is essential to effective planetary defense.

Dinerman ‘9(Taylor, journalist for the Space Review “The new politics of planetary defense,” The Space Review, 7-20, <http://www.thespacereview.com/article/1418/1>)

While the US is obviously going to have to take the lead in any effort to detect and possibly deflect any celestial object that might do our planet harm, it will have to consult with others, both to keep other nations informed and to help make the choices needed to deal with the threat. Yet in the end, it is likely that the decision, if there is one, will rest with the President of the United States. He or she is the only world leader today with the wherewithal to deal with such a threat. This is why any **planning** effort **that leans to heavily on international institutions may endanger the whole planet**. The process inside an organization like the UN would simply get bogged down in procedural and political questions. US leaders may find that the system would be paralyzed while, for example, nations argued over deflection or destructions methods or who would control and pay for them. Precious time would be lost while nations would consider their own best interests in supporting one approach or another. **If the US** is **have any claim to global leadership** in the 21st century **it will have to unambiguously take the lead in planetary defense.** It should do so in an open way and be ready to listen to everyone’s concerns and ideas. But if the Earth is to be effectively protected, the ultimate decisions will have to be American. In this case “global governance” could end up setting the stage for a disaster.

### Finally, US unilateral action is best – NASA and DOD are best suited for the job

Worden ‘2(Brigadier General Simon P., Hearings on the threat of near-Earth asteroids (NEAs) before the Subcommittee on Space and Aeronautics, House Committee on Science, October 3, 2002. http://impact.arc.nasa.gov/gov\_threat\_2002.cfm)

Many have suggested any NEO impact mitigation should be an international operation. In my opinion, the United States should proceed carefully in this area. International space programs, such as the International Space Station, fill many functions. A NEO mitigation program would have only one objective. In my view, a single responsible nation would have the best chance of a successful NEO mitigation mission. The responsible nation would not need to worry about giving up national security sensitive information and technology as it would build and control the entire mission itself. As I have pointed out, the means to identify threats and mitigate them overlap with other national security objectives. It does, however, make sense that the data gathered from surveys and in situ measurements be shared among all. This would maximize the possibility the nation best-positioned to perform a mitigation mission would come forward. One of the first tasks of the Natural Impact Warning Clearinghouse noted above could be to collect and provide a distribution point for such data. Roles of the U.S. Military and NASA Currently, NASA has been assigned the task of addressing some NEO issues. The U.S. DoD has been asked to assist this effort. However, the U.S. DoD has not been assigned tasks, nor has any item relating to NEOs been included in military operational requirements. I believe one option would be for the U.S. DoD to assume the role of collecting available data and assessing what, if any, threat might exist from possible NEO collisions of all sizes. This does not mean other groups, in particular the international scientific community, should not continue their independent efforts. However, the U.S. DoD is likely, for the foreseeable future, to have most of the required sensors to do this job. Moreover, in my view, the U.S. DoD has the discipline and continuity to ensure consistent, long-term focus for this important job. As a consequence of this function, the U.S. DoD might collect a large quantity of important scientific data. To the degree that the vast bulk of this has no military security implications, it could be released to the international scientific community. In addition, I believe NASA should continue the scientific task of assessing the nature of NEOs. Performing the necessary scientific studies, including missions to NEOs to gather data, is among NASA's responsibilities. Like the 1994 U.S. DoD/NASA Clementine probe, these missions could serve as important technological demonstrations for the U.S. DoD, and might be conducted jointly with NASA. Should a threatening NEO be discovered, it is my opinion the U.S. DoD could offer much toward mitigating the threat. Of course, with a funded and focused surveillance program for cataloging and scientific study as outlined above, we should have ample time to debate this issue before it becomes critical.

## 1AC – Framework

### 1. Don’t consider negative impacts - Major war is obsolete

Mandelbaum ’99 (Michael, American Foreign Policy Professor in the School of Advanced International Studies at Johns Hopkins, 2-25, Council on Foreign Relations Great Debate Series, “Is Major War Obsolete?” http://www.ciaonet.org/conf/cfr10/)

So if I am right, then what has been the motor of political history for the last two centuries that has been turned off? This war, I argue, this kind of war, is obsolete; less than impossible, but more than unlikely. What do I mean by obsolete? If I may quote from the article on which this presentation is based, a copy of which you received when coming in, “Major war is obsolete in a way that styles of dress are obsolete. It is something that is out of fashion and, while it could be revived, there is no present demand for it. Major war is obsolete in the way that slavery, dueling, or foot-binding are obsolete. It is a social practice that was once considered normal, useful, even desirable, but that now seems odious. It is obsolete in the way that the central planning of economic activity is obsolete. It is a practice once regarded as a plausible, indeed a superior, way of achieving a socially desirable goal, but that changing conditions have made ineffective at best, counterproductive at worst.” Why is this so? Most simply, the costs have risen and the benefits of major war have shriveled. The costs of fighting such a war are extremely high because of the advent in the middle of this century of nuclear weapons, but they would have been high even had mankind never split the atom. As for the benefits, these now seem, at least from the point of view of the major powers, modest to non-existent. The traditional motives for warfare are in retreat, if not extinct. War is no longer regarded by anyone, probably not even Saddam Hussein after his unhappy experience, as a paying proposition. And as for the ideas on behalf of which major wars have been waged in the past, these are in steep decline. Here the collapse of communism was an important milestone, for that ideology was inherently bellicose. This is not to say that the world has reached the end of ideology; quite the contrary. But the ideology that is now in the ascendant, our own, liberalism, tends to be pacific. Moreover, I would argue that three post-Cold War developments have made major war even less likely than it was after 1945. One of these is the rise of democracy, for democracies, I believe, tend to be peaceful. Now carried to its most extreme conclusion, this eventuates in an argument made by some prominent political scientists that democracies never go to war with one another. I wouldn’t go that far. I don’t believe that this is a law of history, like a law of nature, because I believe there are no such laws of history. But I do believe there is something in it. I believe there is a peaceful tendency inherent in democracy. Now it’s true that one important cause of war has not changed with the end of the Cold War. That is the structure of the international system, which is anarchic. And realists, to whom Fareed has referred and of whom John Mearsheimer and our guest Ken Waltz are perhaps the two most leading exponents in this country and the world at the moment, argue that that structure determines international activity, for it leads sovereign states to have to prepare to defend themselves, and those preparations sooner or later issue in war. I argue, however, that a post-Cold War innovation counteracts the effects of anarchy. This is what I have called in my 1996 book, The Dawn of Peace in Europe, common security. By common security I mean a regime of negotiated arms limits that reduce the insecurity that anarchy inevitably produces by transparency-every state can know what weapons every other state has and what it is doing with them-and through the principle of defense dominance, the reconfiguration through negotiations of military forces to make them more suitable for defense and less for attack. Some caveats are, indeed, in order where common security is concerned. It’s not universal. It exists only in Europe. And there it is certainly not irreversible. And I should add that what I have called common security is not a cause, but a consequence, of the major forces that have made war less likely. States enter into common security arrangements when they have already, for other reasons, decided that they do not wish to go to war. Well, the third feature of the post-Cold War international system that seems to me to lend itself to warlessness is the novel distinction between the periphery and the core, between the powerful states and the less powerful ones. This was previously a cause of conflict and now is far less important. To quote from the article again, “ While for much of recorded history local conflicts were absorbed into great-power conflicts, in the wake of the Cold War, with the industrial democracies debellicised and Russia and China preoccupied with internal affairs, there is no great-power conflict into which the many local conflicts that have erupted can be absorbed. The great chess game of international politics is finished, or at least suspended. A pawn is now just a pawn, not a sentry standing guard against an attack on a king.” Now having made the case for the obsolescence of modern war, I must note that there are two major question marks hanging over it: Russia and China. These are great powers capable of initiating and waging major wars, and in these two countries, the forces of warlessness that I have identified are far less powerful and pervasive than they are in the industrial West and in Japan. These are countries, in political terms, in transition, and the political forms and political culture they eventually will have is unclear. Moreover, each harbors within its politics a potential cause of war that goes with the grain of the post-Cold War period-with it, not against it-a cause of war that enjoys a certain legitimacy even now; namely, irredentism. War to reclaim lost or stolen territory has not been rendered obsolete in the way that the more traditional causes have. China believes that Taiwan properly belongs to it. Russia could come to believe this about Ukraine, which means that the Taiwan Strait and the Russian-Ukrainian border are the most dangerous spots on the planet, the places where World War III could begin. In conclusion, let me say what I’m not arguing. I’m not saying that we’ve reached the end of all conflict, violence or war; indeed, the peace I’ve identified at the core of the international system has made conflict on the periphery more likely. Nor am I suggesting that we have reached the end of modern, as distinct from major, war; modern war involving mechanized weapons, formal battles, and professional troops. Nor am I offering a single-factor explanation. It’s not simply nuclear weapons or just democracy or only a growing aversion to war. It’s not a single thing; it’s everything: values, ideas, institutions, and historical experience. Nor, I should say, do I believe that peace is automatic. Peace does not keep itself. But what I think we may be able to secure is more than the peace of the Cold War based on deterrence. The political scientist Carl Deutcsh once defined a security community as something where warlessness becomes a self-fulfilling prophecy. Well, he was referring to the North Atlantic community, which was bound tightly together because of the Cold War. But to the extent that my argument is right, all of Eurasia and the Asia-Pacific region will become, slowly, haltingly but increasingly, like that.

### 2. Probability and magnitude are 100 percent – our impacts far outweigh nuclear war.

Kunich ’97 (John, Lt. Colonel USAF, B.S., M.S., University of Illinois; J.D., Harvard Law School; LL.M., George Washington University School of Law, Staff Judge Advocate 50th Space Wing, Falcon Air Force Base, 41 Air Force L. Rev. 119, lexis)

Irrespective of the ultimate resolution of these controversies, it is beyond dispute that planet Earth has experienced hundreds of collisions with large objects from space. Moreover, there is no reason to presume that these events are forever relegated exclusively to the distant past. Comparatively small-scale, yet still phenomenally destructive strikes have occurred quite recently. For example, on June 8, 1908, a pale blue fireball appeared in the Siberian sky, moving rapidly northward. The object exploded about 6 kilometers above the forest, creating a column of flame and smoke more than  [\*122]  20 kilometers high. [13](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=6981b603c11791c59b3982172874471a&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLzVlz-zSkAl&_md5=90f0daf744fc5ecf220292f6a674fa1d&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n13" \t "_self) Although no crater was formed, the blast caused the destruction of more than 2,000 square kilometers of Siberian forest in the Tunguska region. This immense area was flattened and burned by the superheated air and the shock wave that literally was felt around the world. It is believed that the source of this devastation was a stony asteroid about 80 meters in diameter, hurtling toward Earth at Mach 45. When it entered the atmosphere at this incredible velocity, it created a shock wave in front of it, which resulted in a pressure gradient that eventually blew the asteroid apart. [14](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=6981b603c11791c59b3982172874471a&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLzVlz-zSkAl&_md5=90f0daf744fc5ecf220292f6a674fa1d&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n14" \t "_self) With this recent, relatively minor incident in mind, the probable consequences of more major collisions will be explored. Currently, astronomers estimate that at least 200 asteroids are in orbits that cross the Earth's orbit, and the number of such known asteroids is rapidly increasing as detection methods improve. [15](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=6981b603c11791c59b3982172874471a&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLzVlz-zSkAl&_md5=90f0daf744fc5ecf220292f6a674fa1d&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n15" \t "_self) Most of these asteroids are larger than 500 meters in diameter (several times larger than the Tunguska asteroid) and would cause massive damage if they were to collide with this planet. In  [\*123]  addition, long-period comets, [16](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=6981b603c11791c59b3982172874471a&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLzVlz-zSkAl&_md5=90f0daf744fc5ecf220292f6a674fa1d&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n16" \t "_self) although less numerous than asteroids, pose a significant threat due to their greater velocities relative to Earth. [17](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=6981b603c11791c59b3982172874471a&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLzVlz-zSkAl&_md5=90f0daf744fc5ecf220292f6a674fa1d&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n17" \t "_self) The history of life on Earth includes several devastating periods of mass extinction [18](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=6981b603c11791c59b3982172874471a&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLzVlz-zSkAl&_md5=90f0daf744fc5ecf220292f6a674fa1d&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n18" \t "_self) during which the vast majority of species then in existence became extinct within a relatively short span of time. [19](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=6981b603c11791c59b3982172874471a&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLzVlz-zSkAl&_md5=90f0daf744fc5ecf220292f6a674fa1d&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n19" \t "_self) The best known of these mass extinctions found the dinosaurs tumbling all the way from their throne as the kings of all living things to the bone pile of archeological history. [20](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=6981b603c11791c59b3982172874471a&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLzVlz-zSkAl&_md5=90f0daf744fc5ecf220292f6a674fa1d&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n20" \t "_self) No less significant, however, were the extinction spasms that wiped out approximately 70 and 90 percent of marine species, respectively. [21](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=6981b603c11791c59b3982172874471a&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLzVlz-zSkAl&_md5=90f0daf744fc5ecf220292f6a674fa1d&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n21" \t "_self) Even the species that survived often experienced catastrophic reductions in their populations. Several scientific studies have linked mass extinctions to collisions between Earth and large objects from space. The hypothesis that these extinction spasms were caused by these collisions and their aftermaths  is supported (1) by the discovery of the now well-documented large impact event at the [Cretaceous/Tertiary] boundary...; (2) by calculations relating to the catastrophic nature of the environmental effects in the aftermath of large impacts; (3) by the discovery of several additional layers of impact debris or possible impact material at, or close to, geologic boundary/extinction events; (4) by evidence that a number of extinctions were abrupt and perhaps catastrophic; and (5) by the accumulation of data on impact craters and astronomical data on comets and asteroids that provide estimates of collision rates of such large bodies with the Earth on long time scales. [22](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=6981b603c11791c59b3982172874471a&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLzVlz-zSkAl&_md5=90f0daf744fc5ecf220292f6a674fa1d&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n22" \t "_self) [\*124]  There are at least six mass extinctions that have been linked with large impacts on Earth from space. [23](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=6981b603c11791c59b3982172874471a&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLzVlz-zSkAl&_md5=90f0daf744fc5ecf220292f6a674fa1d&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n23" \t "_self) But how and why did these impacts have such a profoundly devastating effect on such a vast spectrum of living things? Some scientists maintain that the greatest natural disasters on Earth have been caused by impacts of large asteroids and comets. Although rare compared to "ordinary" floods and earthquakes, they are infinitely more dangerous to life. There are several reasons for this. Initially, of course, a giant object hitting the Earth at spectacular, hypersonic velocity would utterly destroy the local area around the impact. An explosive release of kinetic energy as the object disintegrates in the atmosphere and then strikes the Earth generates a powerful blast wave. The local atmosphere can be literally blown away. If the impact falls on ocean territory, it may create a massive tidal wave or tsunami, with far-reaching effects. [24](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=6981b603c11791c59b3982172874471a&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLzVlz-zSkAl&_md5=90f0daf744fc5ecf220292f6a674fa1d&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n24" \t "_self) When tsunamis strike land, their immense speed decreases, but their height increases. It has been suggested that tsunamis may be the most devastating form of damage produced by relatively small asteroids, i.e., those with diameters between 200 meters and 1 kilometer. "An impact anywhere in the Atlantic Ocean by an asteroid more than 400 meters in diameter would devastate the coasts on both sides of the ocean with tsunami wave runups of over 60 meters high." [25](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=6981b603c11791c59b3982172874471a&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLzVlz-zSkAl&_md5=90f0daf744fc5ecf220292f6a674fa1d&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n25" \t "_self) Horrific as such phenomena are, they are dwarfed by a potentially far greater hazard. The impact of a sufficiently large object on land may cause  a blackout scenario in which dust raised by the impact prevents sunlight from reaching the surface [of the Earth] for several months. Lack of sunlight terminates photosynthesis, prevents creatures from foraging for food, and leads to precipitous temperature declines... Obviously **even** much  [\*125]  **small**er **impacts would** have the potential to seriously **damage human civilization**, perhaps **irreparably**. [26](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=6981b603c11791c59b3982172874471a&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLzVlz-zSkAl&_md5=90f0daf744fc5ecf220292f6a674fa1d&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n26" \t "_self) In addition to the dust raised from the initial impact, smoke and particulate matter from vast, uncontrollable fires may greatly exacerbate this blackout effect. A large space object generates tremendous heat, regardless of whether it is destroyed in the atmosphere or physically hits the surface of the Earth. [27](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=6981b603c11791c59b3982172874471a&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLzVlz-zSkAl&_md5=90f0daf744fc5ecf220292f6a674fa1d&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n27" \t "_self) These fires can reach far beyond the impact area, due to atmospheric phenomena associated with the entry of a huge, ultra-high speed object. [28](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=6981b603c11791c59b3982172874471a&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLzVlz-zSkAl&_md5=90f0daf744fc5ecf220292f6a674fa1d&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n28" \t "_self) A huge mass of dust, smoke, and soot lofted into Earth's atmosphere could lead to effects similar to those associated with the "nuclear winter" theory, [29](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=6981b603c11791c59b3982172874471a&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLzVlz-zSkAl&_md5=90f0daf744fc5ecf220292f6a674fa1d&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n29" \t "_self) but on a much larger, much more deadly scale. Such effects are now widely believed to have been a major factor contributing to the mass extinction spasms. [30](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=6981b603c11791c59b3982172874471a&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLzVlz-zSkAl&_md5=90f0daf744fc5ecf220292f6a674fa1d&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n30" \t "_self) These cataclysmic effects may have been worsened still further by other collateral phenomena associated with the impact. For example, acid rain, pronounced depletion of the ozone layer, and massive injections of water vapor into the upper atmosphere may be indirect effects, each with its own negative consequences for life on Earth. [31](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=6981b603c11791c59b3982172874471a&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLzVlz-zSkAl&_md5=90f0daf744fc5ecf220292f6a674fa1d&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n31" \t "_self) It is true that destructive impacts of gigantic asteroids and comets are extremely rare and infrequent when compared with most other dangers humans face, with the  [\*126]  intervals between even the smallest of such events amounting to many human generations... No one alive today, therefore, has ever witnessed such an event, and indeed there are no credible historical records of human casualties from impacts in the past millennium. Consequently, it is easy to dismiss the hazard as negligible or to ridicule those who suggest that it be treated seriously. [32](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=6981b603c11791c59b3982172874471a&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLzVlz-zSkAl&_md5=90f0daf744fc5ecf220292f6a674fa1d&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n32" \t "_self) On the other hand, as has been explained, when such **impacts** do occur, they **are  capable of producing** destruction and **casualties** on a scale **that far exceed**s any other natural disasters; the results of impact by an object the size of a small mountain exceed the imagined holocaust of **a full-scale nuclear war**... Even the worst storms or floods or earthquakes inflict only local damage, while a large enough impact could have global consequences and place all of society at risk... Impacts are, at once, the least likely but the most dreadful of known natural catastrophes. [33](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=6981b603c11791c59b3982172874471a&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLzVlz-zSkAl&_md5=90f0daf744fc5ecf220292f6a674fa1d&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n33" \t "_self) What is the most prudent course of action when one is confronted with an extremely rare yet enormously destructive risk? Some may be tempted to do nothing, in essence gambling on the odds. But because the consequences of guessing wrong may be so severe as to mean **the end of** virtually **all life on** planet **Earth**, the wiser course of action would be to take reasonable steps to confront the problem. Ultimately, rare though these space strikes are, there is **no doubt** that **they will happen again**, sooner or later. **To do nothing is to** abdicate our duty to defend the United States, and indeed the entire world, and **place our very survival in the uncertain hands of the false god of probabilities**. Thus, the mission of planetary defense might be considered by the United States at some point in time, perhaps with a role played by the military, including the United States Air Force.

### 3. Extinction is categorically different from any other impact—even if they win a nuclear war kills 99 percent of the population, an asteroid strike still outweighs by an order of magnitude

Jason G. Matheny 2007 Department of Health Policy and Management, Bloomberg School of Public Health, Johns Hopkins University “Reducing the Risk of Human Extinction” Risk Analysis, Vol. 27, No. 5, 2007

Even if extinction events are improbable, the expected values of countermeasures could be large, as they include the value of all future lives. This introduces a discontinuity between the CEA of extinction and nonextinction risks. Even though the risk to any existing individual of dying in a car crash is much greater than the risk of dying in an asteroid impact, asteroids pose a much greater risk to the existence of future generations (we are not likely to crash all our cars at once) (Chapman, 2004). The “death-toll” of an extinction-level asteroid impact is the population of Earth, plus all the descendents of that population who would otherwise have existed if not for the impact. There is thus a discontinuity between risks that threaten 99% of humanity and those that threaten 100%.

# A2 – Case Presses

## A2: SQ detection solves

### The deprioitization of NEO detection mission makes finding dangerous asteroids impossible and eliminates the necessary time we would need to adequately deflect an incoming NEO.

Robert Irion , 10, “Asteroid Hunters” (http://www.smithsonianmag.com/specialsections/40th-anniversary/Saving-the-World-From-Asteroids.html?c=y&story=fullstory)( Director, Science Communication Program UC Santa Cruz Educational Institution; 10,001+ employees; Higher Education industry July 2006 – Present (5 years) Director of one-year graduate certificate program to train students with science degrees in the practice of science journalism for print and online audiences. Freelance science writer Self-employed Publishing industry 1997 – Present (14 years) Self-employed science journalist for national magazines and websites, covering astronomy and astrophysics. Main clients: Science, ScienceNOW, New Scientist, Discover, Astronomy, Sky & Telescope, Smithsonian, California Wild, New York Academy of Sciences, Physical Review Focus, U.S. Department of Energy, National Academy of Sciences Campus science writer University of California, Santa Cruz Educational Institution; 1001-5000 employees; Public Relations and Communications industry 1989 – 1997 (8 years) Senior public information officer for the sciences and engineering. News releases, alumni magazine features, campus spokesman for issues in the sciences. Supervised writing interns from the UC Santa Cruz Science Communication Program. Science reporting intern Chicago Tribune Public Company; 10,001+ employees; TRB; Newspapers industry June 1988 – August 1988 (3 months) AAAS Mass Media Fellow at the Chicago Tribune (summer science reporting internship)TT

Most of us do what we can for the environment, but Rik Hill’s actual job is to protect the planet. “Whoa, look at that!” he says, pointing at a moving blip of light on a computer screen. “It’s an unknown object. We just discovered one.” We’re in an observatory on the summit of Mount Lemmon, a 9,000-foot peak north of Tucson, Arizona. Hill’s boss, Ed Beshore, leans in and nods. “That’s an N-E-O,” he says, referring to a near Earth object. “It’s a nice one. It’s bright, and it’s moving fast.” Hill, an astronomer, sends an e-mail to the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts, where the Minor Planet Center monitors hundreds of thousands of small bodies in our solar system. The message gives the object’s coordinates at the time of its discovery so other astronomers can track it. And they’ll want to: an NEO is any asteroid or comet that will come within about 30 million miles of Earth’s orbit. We’ll find out in the morning whether this NEO poses a threat. For now, Hill leans back, a cup of strong coffee in hand, and grins. “It’s not even midnight, and it’s a good night already,” he says. By dawn, he will spot two more. I went to Mount Lemmon to see the top NEO hunters in action. Beshore and Hill are part of the Catalina Sky Survey, which has found about 2,500 NEOs in the past decade—including 577 in 2009, some 70 percent of the total discovered that year. The rocks range from the size of tables to mountains. Most will bypass Earth. But NEOs have plowed into our planet countless times before, and will do so again. In October 2008, the survey’s Rich Kowalski observed a small NEO from this telescope. Within two hours, the Minor Planet Center used sightings by others to chart its trajectory. The asteroid would hit Earth in less than a day. Observers worldwide locked onto it, capturing 570 telescope images. NASA scientists calculated it would strike the Nubian Desert of northern Sudan. It was only the size of a small pickup truck, and most of it would burn up in the atmosphere. Even so, news of the imminent impact went all the way to the White House. About 19 hours after Kowalski discovered it, asteroid 2008 TC3 lit up the sky above Sudan with the energy of more than 1,000 tons of TNT. Black fragments as large as apples landed in the desert. Two months later, NASA-led researchers collected hundreds of the extraterrestrial rocks. In one sense, spotting the incoming asteroid was a triumph, because it demonstrated that astronomers can detect even a small projectile heading our way. But the feat was also sobering, because they saw it too late to do anything about it. Hill and his fellow NEO hunters hope to detect large asteroids sooner, preferably years or decades in advance. “It’s the only natural disaster we can stave off,” says Don Yeomans, manager of NASA’s NEO command center at the Jet Propulsion Laboratory (JPL) in Pasadena, California. Oddballs of the solar system, asteroids are battered chunks of rock and metal that have tumbled around the heavens since the Sun’s eight major planets (plus demoted Pluto) formed about 4.6 billion years ago. Astronomers have cataloged about a half-million asteroids, most in the gap between the orbits of Mars and Jupiter. About 7,000 known NEOs loop wildly among the inner planets, following paths that shift in response to gravity and the Sun’s heat. “Their orbits are all over the place,” says Paul Chodas of JPL. “They’re rebels.” In the desert 175 miles north of Tucson, Meteor Crater is the scar where a boxcar-size hunk of iron slammed into Earth 50,000 years ago. The crater is nearly a mile wide and 550 feet deep, edged with layers of warped and shattered rock. The asteroid blew up with the energy of the largest hydrogen bombs ever detonated on Earth, vaporizing the desert and unleashing deadly supersonic winds for many miles. I visited the crater as night fell, and I felt keenly aware that fragments of the solar system can invade our cozy realm of Earth and Moon. If a 100-foot-wide asteroid hit Earth, the shock wave from its explosion in the atmosphere could flatten trees and kill every large animal for hundreds of square miles. That’s just what happened in 1908 at Tunguska, Siberia. The odds are roughly one in ten that such a blast will occur in the next 40 years. An asteroid 500 feet across could destroy a metropolitan area or spawn massive tsunamis. Those impacts occur every 30,000 years, on average. Hundreds of known NEOs are more than a mile wide. If an asteroid that big struck Earth, firestorms could produce worldwide clouds of soot that would block sunlight and plunge the planet into an “asteroid winter.” That happens every few million years, scientists estimate. Once every 100 million years or so, an even larger asteroid may cause a mass extinction; most scientists believe a six-mile-wide asteroid doomed the dinosaurs 65 million years ago. Astronomers with the Catalina survey find new NEOs almost every night. They start by taking four pictures of the same patch of sky, with ten minutes between each exposure, and compare them on a computer screen. While background stars shine in the same place in each image, NEOs appear as four distinct dots along a straight line. The astronomers are skilled at ruling out man-made satellites, electronic sparks from cosmic rays and other streaking objects that could be mistaken for an NEO. “They look at everything with the human eye,” NASA’s Yeomans says. “They’ve been doing it for so long, and they’re so dedicated.” Hill, who has used telescopes since he was a child during the Sputnik era, has been on the team since 1999. He has found more comets—22—than all but three other people in history. (Comets usually originate in the outer solar system and are less common in Earth’s neighborhood than asteroids.) During my visit to Mount Lemmon, he made a trumpeting noise just before he pointed out the first NEO to us. “I love what I do,” he says. “I would do this for free.” The Catalina Sky Survey consists of nine astronomers using two modest telescopes in Arizona and one in Australia. The team refurbished a long-unused telescope at Mount Lemmon with a 60-inch mirror, small by modern standards. NASA provides $1 million per year—peanuts in astronomy circles. “We’re very careful and meticulous,” says Beshore, a former software engineer who directs the survey. “We get the numbers just right.” As it happens, astronomers at the Catalina telescope in Australia and other sites around the world took pictures of the NEO after Hill discovered it the night of my visit, allowing the Minor Planet Center to calculate its orbit. By the next morning, the results had been posted online: the asteroid didn’t threaten Earth. I felt a bit let down; no worldwide scoop for me. Before Beshore joined the survey in 2002, he was skeptical that he’d spot any hazardous asteroids. “Then I realized, my God, the sky is full of these things,” he says. “I have more perspective that yes, this could happen, we might get hit. It would be really satisfying to find an object and then do something about it.” Don Yeomans often thinks about what that might be. Scale models of asteroids fill the windowsill of his office at JPL in Pasadena. He runs the lab’s NEO clearinghouse, which looks nothing like a Hollywood depiction of a planetary-defense headquarters. There are no wall-size display screens, no blinking panels or red telephones, just ordinary-looking offices. But the workers are well aware of their lofty mission. “We don’t let our guard down, even for a day,” Yeomans says. “It’s our job to monitor the inner solar system and make sure none of these objects gets close to the Earth.” The tracking starts at the Minor Planet Center, which archives data from a global network of professional and amateur astronomers. “We inventory the solar system,” says center director Tim Spahr. “If the world wants to know about an asteroid, we have the catalog.” The JPL team takes orbit data from the Minor Planet Center and refines it, asteroid by asteroid. A computer program called Sentry projects each NEO’s orbit for 100 years. Once an asteroid starts approaching Earth, it will do so again and again in an orbital waltz driven by gravity as both bodies travel around the Sun. Most NEOs will plunge into the Sun after a million years of this pas de deux. “It’s a mathematical problem, and a fascinating one at that,” says JPL’s Chodas. “It’s just exhilarating.” A 900-foot-wide asteroid called Apophis caused a stir in 2004 when JPL calculated there was a 3 percent chance it would slam into Earth in 2029. With the next set of images, JPL’s Steve Chesley forecast a more precise orbit, and he ruled out an impact. However, there’s still a tiny chance it will hit in 2036 or 2068—depending on the exact route the asteroid follows during its next pass near Earth. If Apophis did drift onto a collision course and was headed for Russia, a Russian military official said last year, his country might prepare a mission to knock it off course. But that would be premature, Yeomans says. “You have to be careful about moving asteroids around in space,” he adds, lest a deflection inadvertently steer Apophis toward Earth. “They should only be moved if they are a real threat.” Among the groups studying how best to prevent a collision is the B612 Foundation, named for the asteroid in Antoine de Saint-Exupéry’s The Little Prince. Led by Apollo 9 astronaut Rusty Schweickart, the foundation has proposed a mission to a nonthreatening asteroid to test whether gravity from a hovering spacecraft could shift the asteroid’s orbit. “You don’t want to blow them up,” says Schweickart. “All you need to do to protect Earth is to push them gently.” Exploding an asteroid would require deploying nuclear weapons in space, scientists say. They caution that no one knows how asteroid material would respond to such a blast. Some NEOs are thought to be loosely packed piles of rubble. One recent study suggests that a deliberate explosion would barely disperse the pieces, and they would reassemble under their own gravity. In Yeomans’ mind, scientists have already demonstrated the best technique: ramming. In 2005, a NASA science mission called Deep Impact crashed an 816-pound copper mass into a comet to learn more about its icy interior. If scientists were to detect a 600-foot-wide asteroid ten years in advance, Yeomans says, it could be deflected with a two-ton projectile traveling six miles per second. He says that’s enough to make it miss the Earth. Barely. But given the limited number of astronomers and the small telescopes scanning the sky for asteroid threats, says Yeomans, we probably won’t see a small incoming object until it’s just a week or two away from hitting us. “In that case,” he says, “all you can do is evacuate.”

### NASA is crazy far behind on where they promised they’d be on asteroid detection, now is the time to act

Mason. 09, August 12th, “NASA falling short of detection goals”, ([http://www.wired.com/wiredscience/2009/08/neoreport/)(Betsy](http://www.wired.com/wiredscience/2009/08/neoreport/%29%28Betsy) Mason: wired science editor)( http://www.wired.com/wiredscience/2009/08/neoreport/)TT

Without more funding, NASA will not meet its goal of tracking 90 percent of all deadly asteroids by 2020, according to a report released today by the National Academy of Sciences. The agency is on track to soon be able to spot 90 percent of the potentially dangerous objects that are at least a kilometer (.6 miles) wide, a goal previously mandated by Congress. Asteroids of this size are estimated to strike Earth once every 500,000 years on average and could be capable of causing a global catastrophe if they hit Earth. In 2008, NASA’s Near Earth Object Program spotted a total of 11,323 objects of all sizes. But without more money in the budget, NASA won’t be able to keep up with a 2005 directive to track 90 percent of objects bigger than 460 feet across. An impact from an asteroid of this size could cause significant damage and be very deadly, particularly if it were to strike near a populated area. Meeting that goal “may require the building of one or more additional observatories, possibly including a space-based observatory,” according to the report. The committee that investigated the issue noted that the United States is getting little help from the rest of the world on this front, and isn’t likely to any time soon. Another report is planned for release by the end of the year that will review what NASA plans to do if we spot a life-threatening asteroid headed our direction. A summary of the report’s findings: Congress has mandated that NASA discover 90 percent of all near-Earth objects 140 meters in diameter or greater by 2020. The administration has not requested and Congress has not appropriated new funds to meet this objective. Only limited facilities are currently involved in this survey/discovery effort, funded by NASA’s existing budget. The current near-Earth object surveys cannot meet the goals of the 2005 NASA Authorization Act directing NASA to discover 90 percent of all near-Earth objects 140 meters in diameter or greater by 2020. The orbit-fitting capabilities of the Minor Planet Center are more than capable of handling the observations of the congressionally mandated survey as long as staffing needs are met. The Arecibo Observatory telescope continues to play a unique role in characterization of NEOs, providing unmatched precision and accuracy in orbit determination and insight into size, shape, surface structure, multiplicity, and other physical properties for objects within its declination coverage and detection range. The United States is the only country that currently has an operating survey/detection program for discovering near-Earth objects; Canada and Germany are both building spacecraft that may contribute to the discovery of near-Earth objects. However, neither mission will detect fainter or smaller objects than ground-based telescopes.

### Detection fails now

Atkinson 1/22/10, Nancy Atkinson, is a science journalist who writes mainly about space exploration and astronomy. She is the Senior Editor and writer for Universe Today, the project manager for the 365 Days of Astronomy podcast, and part of the production team for Astronomy Cast. She also has articles published on Wired.com, Space.com, NASA’s Astrobiology Magazine, Space Times Magazine, and several newspapers in the Midwest.,” Asteroid Detection, Deflection Needs More Money, Report Says,” 1/22/10, 6/25/11, AR.

Are we ready to act if an asteroid or comet were to pose a threat to our planet? No, says a new report from the National Research Council. Plus, we don’t have the resources in place to detect all the possible dangerous objects out there. The report lays out options NASA could follow to detect more near-Earth objects (NEOs) that could potentially cross Earth’s orbit, and says the $4 million the U.S. spends annually to search for NEOs is insufficient to meet a congressionally mandated requirement to detect NEOs that could threaten Earth. “To do what Congress mandated NASA to do is going to take new technology, bigger telescopes with wider fields,” said Don Yeomans, Manager of NASA’s Near Earth Object Program Office, speaking at the American Geophysical Union conference last month. However, Yeomans said work is being done to improve the quality and quantity of the search for potentially dangerous asteroids and comets. “We have a long term goal to have three more 1.8 meter telescopes,” he said, “and the Large Synoptic Survey Telescope with an 8.4 meter aperture in 2016. Once these new facilities are in place, the data input will be like drinking from a fire hose, and the rate of warnings will go up by a factor of 40.” But getting all these facilities, and more, online and running will take continued and additional funding. Congress mandated in 2005 that NASA discover 90 percent of NEOs whose diameter is 140 meters or greater by 2020, and asked the National Research Council in 2008 to form a committee to determine the optimum approach to doing so. In an interim report released last year, the committee concluded that it was impossible for NASA to meet that goal, since Congress has not appropriated new funds for the survey nor has the administration asked for them.

### Congress needs to fund more than $4 million to fund asteroid detection, NASA is unable to do it

MSN 1/23/10, (MSN, 1/23/10, Space.com, http://www.msnbc.msn.com/id/35013963/ns/technology\_and\_science-space/t/experts-say-us-must-do-more-about-asteroids/, SH)

The United States must do more to safeguard Earth against destruction by an asteroid than merely prepping nuclear missiles, a new report has found. The 134-page report, released Friday by the National Academy of Sciences, states that the $4 million spent by the United States annually to identify all potentially dangerous asteroids near Earth is not enough to do the job mandated by Congress in 2005. NASA is in dire need of more funding to meet the challenge, and less than $1 million is currently set aside to research ways to counter space rocks that do endanger the Earth — measures like developing the spacecraft and technology to deflect incoming asteroids — the report states. An early draft of the report, entitled "Defending the Earth: Near-Earth Object Surveys and Hazard-Mitigation Strategies," was released in August 2009. The final report, written by a committee of expert scientists, says NASA is ill-equipped to catalog 90 percent of the nearby asteroids that are 460 feet (140 meters)across or larger, as directed by Congress.

## A2: Hype

### This isn’t hype, the NEO threat is real and imminent – scientists and engineers prove.

Flight International, 04, March 30, 2004, Reed Business Information US, a division of Reed Elsevier Inc., “Deep impact; How serious a threat do near Earth objects pose, and what is being done to prevent the devastation that a collision would inevitably cause?,” Lexis Nexis, 6/22/11,CF

On 18 March a mysterious object raced across the evening sky over the South Atlantic. Large enough to destroy a city, a 30m (100ft)-plus diameter rock with an energy equivalent to a 0.5 megaton bomb brushed past the Earth and hurtled onwards through space. Only two months earlier, the NASA-funded Spaceguard telescope spotted a massive asteroid on an apparent collision course with the planet. With around 24h to go before the estimated impact in the northern hemisphere, astronomers recalculated the near Earth object's (NEO) trajectory and discovered that it would clearly miss the planet. Although this all sounds familiar as the fodder for science fiction writers and "doomsday" movie scripts, the threat to Earth from NEOs is real and immediate, says an international group of scientists and engineers. They hope that news of these two recent incidents, plus revelations of the frequency of other near misses, will be a wake-up call to the international community. "The public has to learn we are living in a shooting gallery," says a delegate at the first American Institute of Aeronautics and Astronautics planetary defence conference held recently in California. With input from the conference, the group is drawing up a "white paper" to help guide what it hopes will be a blueprint for the first organised global defence against asteroids and comets. How real is the threat? Some NEOs -- like the 10km (6.2 miles)-diameter Cretaceous-Tertiary asteroid judged to have possibly led to the extinction of the dinosaurs -- are large enough to destroy the human species, while many smaller ones have the potential to wreak nuclear weapon-like havoc. Previous collisions Large NEOs are known to have hit the planet more than 139 times and evidence exists of more than 93 craters between 5km and 200km in diameter. In 2002 three NEOs came close to the Earth, two of which were not discovered until after they had passed. As recently as 13 January a large NEO, now estimated to be around 500m in diameter, was discovered approaching the planet. Then there are the smaller NEOs, such as the one that grazed the atmosphere on 18 March, which have the potential to cause disaster if they are misinterpreted by a tense nation as a nuclear attack. Outgoing US Air Force Space Command development and transformation director Brig Gen Pete Worden describes one such incident on 6 June 2002 when a "small NEO impact" of around 10 megaton equivalent size lit up the night sky as it exploded in the atmosphere over the Mediterranean. "We were in the middle of a crisis situation as Pakistan and India were at loggerheads with each other. What would have happened if that had gone off over New Delhi or Islamabad? Neither country has the ability to clearly define what has happened. This is the kind of NEO issue we need to deal with -- it's not just about dinosaur bones." A recommendation of the conference will call for the funding of a next-generation Spaceguard survey effort (originally set up with NASA funding in 1998) to detect and catalogue potentially hazardous NEOs larger than 140m, a move em-braced within a bill introduced in the US Congress on 11 February. Similar actions are under way in Europe with plans to support NEO surveys from advanced 3m-class telescopes in the Canary Islands. The US Department of Defense will be asked to speed up the release of data on NEOs and meteorites, particularly over areas where unexpected high-altitude detonations could be misinterpreted. Tracking the threat Thanks largely to NASA's Spaceguard survey conducted through the MIT-Lincoln Lab military telescope in New Mex-ico, and mostly amateur astronomers, more than 680 NEOs with diameters greater than 1km have been discovered and tracked. Between 300 and 500 NEOs in this class are estimated to exist, but remain undetected, says NASA. An estimated 200,000 of the smaller NEOs in the 100m diameter range also await discovery and tracking. One of the expected recommendations from the conference is the need to establish a globally recognised authority or "home" for the planetary defence initiative, as well as the setting up of a chain-of-command structure to handle detec-tion, threat verification, countermeasures and alerting.

## A2: SQ Deflection Solves

### NASA has no planetary defense program now

Easterbrook ‘8(Gregg, Editor of The Atlantic and The New Republic and Sr. Fellow at Brookings, “The Sky is Falling,” June, http://www.theatlantic.com/doc/200806/asteroids)

Given the scientific findings, shouldn’t space rocks be one of NASA’s priorities? You’d think so, but Dallas Abbott says NASA has shown no interest in her group’s work: “The NASA people don’t want to believe me. They won’t even listen.” NASA supports some astronomy to search for near-Earth objects, but the agency’s efforts have been piecemeal and underfunded, backed by less than a tenth of a percent of the NASA budget. And though altering the course of space objects approaching Earth appears technically feasible, NASA possesses no hardware specifically for this purpose, has nearly nothing in development, and has resisted calls to begin work on protection against space strikes. Instead, NASA is enthusiastically preparing to spend hundreds of billions of taxpayers’ dollars on a manned moon base that has little apparent justification. “What is in the best interest of the country is never even mentioned in current NASA planning,” says Russell Schweick­art, one of the *Apollo* astronauts who went into space in 1969, who is leading a campaign to raise awareness of the threat posed by space rocks. “Are we going to let a space strike kill millions of people before we get serious about this?” he asks. In January, I attended an internal NASA conference, held at agency headquarters, during which NASA’s core goals were presented in a PowerPoint slideshow. Nothing was said about protecting Earth from space strikes—not even researching what sorts of spacecraft might be used in an approaching-rock emergency. Goals that *were* listed included “sustained human presence on the moon for national preeminence” and “extend the human presence across the solar system and beyond.” Achieving national preeminence—isn’t the United States pretty well-known already? As for extending our presence, a manned mission to Mars is at least decades away, and human travel to the outer planets is not seriously discussed by even the most zealous advocates of space exploration. Sending people “beyond” the solar system is inconceivable with any technology that can reasonably be foreseen; an interstellar spaceship traveling at the fastest speed ever achieved in space flight would take 60,000 years to reach the next-closest star system. After the presentation, NASA’s administrator, Michael Griffin, came into the room. I asked him why there had been no discussion of space rocks. He said, “We don’t make up our goals. Congress has not instructed us to provide Earth defense. I administer the policy set by Congress and the White House, and that policy calls for a focus on return to the moon. Congress and the White House do not ask me what I think.” I asked what NASA’s priorities would be if he did set the goals. “The same. Our priorities are correct now,” he answered. “We are on the right path. We need to go back to the moon. We don’t need a near-Earth-objects program.” In a public address about a month later, Griffin said that the moon-base plan was “the finest policy framework for United States civil space activities that I have seen in 40 years.”

## A2 – Russia Solves Your Aff

### Russia’s space chief got his facts wrong, he was only referring to a single asteroid that has a zero probability of hitting us, and his sensationalism killed Russian funding for asteroid deflection

[**O'Neill**](http://www.universetoday.com/author/ian/) **1-2-10** (Ian, PhD Solar Physics, “Much Ado About Apophis,” 1-2-10, http://www.astroengine.com/?p=6989)

Apophis is a 300 meter wide asteroid that caused a stir back in 2004. When NASA discovered the near-Earth asteroid (or NEO), it appeared to be tumbling in our direction Armageddon-style and the initial odds for a 2029 impact were 1-in-37. Understandably, people got scared, the media went nuts and astrophysicists were suddenly very interested in space rock deflection techniques. Fortunately for us, NASA has downgraded the threat to a zero (note zero) chance of Apophis bumping into us in 2029, and lowered the risk of a follow-up impact in 2036 from a 1-in-45,000 chance to a 1-in-250,000 chance. It’s important to note that NASA didn’t just pull these numbers out of a hat; the space agency has been tracking Apophis intently since its discovery, plotted its position and projected its location to a very high degree of precision. The more we watch Apophis, the more the world’s scientists are convinced that the asteroid poses a very tiny risk to life on Earth. In fact, giving anything a 1-in-250,000 chance of happening is more of a courtesy than a ‘risk.’ Granted, we’re talking about a global catastrophe should Apophis hit, but would you ever bet on those kinds of odds? Apparently, the Russian space agency thinks it’s more of a game of Russian Roulette than NASA thinks. “I don’t remember exactly, but it seems to me it could hit the Earth by 2032,” said Anatoly Perminov, the head of Roscosmos, [on December 30, 2009](http://news.discovery.com/space/incoming-asteroid-spacecraft-russia.html). “People’s lives are at stake. We should pay several hundred million dollars and build a system that would allow to prevent a collision, rather than sit and wait for it to happen and kill hundreds of thousands of people.” Wait a minute. Does Perminov know something NASA doesn’t? Is he even referring to Apophis? You know, the same asteroid NASA has calculated that has a cat in hell’s chance of causing bother in 2036? And what’s this about the year 2032? Just for the record, Perminov is indeed referring to Apophis, but he got the date wrong (Apophis does not make a flyby in 2032). Perminov also puts a price on saving hundreds of thousands of people… “several hundred million dollars” should do it, apparently. On the one hand I’m impressed that Roscosmos is calling for some kind of anti-asteroid shield, but on the other, Perminov’s concern is terribly misplaced (and potentially damaging). His statement sounds as if he’s only just heard about Apophis and then thrown into a press conference unprepared, then asked what he’s going to do about this impending doom. Naturally, in that situation he would have blurted out the first thing that popped into his head: We need to save the world! However, this isn’t the first time he’d heard about Apophis. Boris Shustov, the director of the Institute of Astronomy under the Russian Academy of Sciences, tried to repair the damage pointing out that Perminov was just using Apophis as a “symbolic example, there are many other dangerous objects we know little about.” However, saving the world from a theoretical “dangerous object” that may or may not hit us for the next few hundred /thousand/million years is less likely to get funding that an imminent 2032… sorry, 2036 impact. Although Perminov might sound reasonable in asking for asteroid deflection funding, using sensationalist means to try to leverage funding only serves to make the same funding hard to come by.

### Russia’s space chief is not credible

**Siemaszko12-31-9** (Corky, staff New York Daily News, “Astro’s Asteroid Fear Soars,” lexis)

**THE HEAD OF RUSSIA'S space agency either knows something we don't - or there's something in his Tang.** Anatoly Perminov stoked up some hysteria yesterday as he sounded the alarm about an asteroid called Apophis that is hurtling in the general direction of Earth. "People's lives are at stake," Perminov told a Russian news agency. "We should pay several hundred million dollars and build a system that would . . . prevent a collision, rather than sit and wait for it to happen and kill hundreds of thousands of people." Never mind that NASA has already placed the odds of the asteroid slamming our planet in 2036 at an extremely remote 1-in-250,000. **Perminov said he heard from a scientist** that the 850-foot asteroid "will surely collide with the Earth in the 2030s."

## A2 Russia Solves: Russia Will use NW

### Russians want to use nuclear missiles.

Russia & CIS General Newswire ’06 (Russia & CIS General Newswire, 11/28/06, “Nuclear missiles may be used to counter asteroids, meteorites,” 6/22/10, LexisNexis, MLK)

Deputy head of the Russian Federal Space Agency Vitaly Davydov does not rule out that mankind may team up to counter asteroids and meteorites and use nuclear missiles to this end. "Humankind may use nuclear missiles to counter the threat of asteroids," Davydov said, commenting on the Federal Space Agency's plans to predict and counter asteroids and meteorites, which might collide with the Earth. According to Davydov, the Russian Federal Space Agency does not have specific programs on countering asteroids and meteorites. "Nevertheless, we will work on the problem," Davydov said. According to him, the threat cannot be ignored, since a single meteorite can throw the mankind several centuries or even millenia back.

### Russia plans to use missiles in case of an asteroid threat

Russia and CIS General Newswire ’11 (Russia and CIS General Newswire, 4/26/11, “New Russian missiles, "Tsar bomb" could help counter asteroids – academician,” 6/23/11, LexisNexis, MLK)

Russia's know-how could be used to counter threats posed to the Earth by asteroids, Academician Andrei Kokoshin, who is also a deputy of the Russian State Duma, told Interfax-AVN on Tuesday. "The Angara new missile will become an important component of Russia's space-based means. Using its new delivery vehicles, Russia is able to make a serious contribution, for example, to the fight against the asteroid threat, which in recent years has been assessed by scientists as considerably higher than in previous decades," Kokoshin said. The results of a recent session held by the board of the Russian Academy of Sciences and the Energia space rocket corporation have "shown that certain plans have already been formulated in our country to build space stations that could help prevent large asteroids and meteorites from colliding with the Earth," he said. "The Soviet experience of designing super-powerful warheads, such as the 50-megatonne RDS-202 bomb, which was blown up near Novaya Zemlya in 1961, could come in handy" while combating asteroid threats at a large distance from the Earth, Kokoshin said.

## A2 – Outer Space Treaty Solves Nuclear Use

### Outer Space Treaty only bans weapons BASED in space—does not prevent use of a nuclear weapon against an asteroid

**Kunich ’97**

(John, Lt. Colonel USAF, B.S., M.S., University of Illinois; J.D., Harvard Law School; LL.M., George Washington University School of Law, Staff Judge Advocate 50th Space Wing, Falcon Air Force Base, 41 Air Force L. Rev. 119, lexis)

**The Outer Space Treaty** [37](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=43c16c591c993122e312c1b0e5434740&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=fab0a853e37d199f31b40e762b2bb19e&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n37" \t "_self) is most directly applicable to planetary defense as a whole, taking into account all of its probable components. The Outer Space Treaty was signed in 1967 by the United States and more than 100 other nations (including the Soviet Union), under United Nations sponsorship. Basically, this Treaty seeks to ensure that space remains free for use and exploration by all nations and not subject to appropriation, as well as to restrict military activities in space and to preserve the use of space for peaceful purposes. Article IV is most on point for purposes of planetary defense. It **provides**: **States Parties to the Treaty undertake not to place in orbit around the Earth any objects carrying nuclear weapons** or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner. The moon and other celestial bodies shall be used by all States Parties to the Treaty exclusively for peaceful purposes. The establishment of military bases, installations and fortifications, the testing of any type of weapons and the conduct of military maneuvers on celestial bodies shall be forbidden. The use of military personnel for scientific research or for any other peaceful purposes shall not be prohibited. The use of any equipment or facility necessary for peaceful exploration of the moon and other celestial bodies shall also not be prohibited. [38](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=43c16c591c993122e312c1b0e5434740&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=fab0a853e37d199f31b40e762b2bb19e&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n38" \t "_self) [\*130] The ambiguities in Article IV are readily apparent. On the most basic level, it is important to know what is meant by "outer space." The term is not defined in the Treaty. There is some support for the proposition the "space powers" have created a rule of customary international law that satellites are considered to be in outer space, and thus national airspace cannot extend beyond the altitude of the orbit of the lowest satellites, which is about 100-110 kilometers above sea level, [39](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=43c16c591c993122e312c1b0e5434740&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=fab0a853e37d199f31b40e762b2bb19e&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n39" \t "_self) although the fact that there is no legal demarcation between outer space and air space has been a matter of debate in the United Nations Committee for the Peaceful Uses of Outer Space (UNCOPUS) for some thirty years. Under this interpretation, outer space could be considered to begin at or near this elevation. The meaning of "weapons of mass destruction" has typically been defined as weapons that are intended to have indiscriminate effect upon large populations and large geographical areas. [40](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=43c16c591c993122e312c1b0e5434740&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=fab0a853e37d199f31b40e762b2bb19e&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n40" \t "_self) The definition excludes conventional artillery munitions, but includes nuclear, as well as biological and chemical weapons; this rather narrow focus reflects the concerns of the era in which the Treaty was negotiated. Then, nations were considering placing nuclear bombs in orbit over other nations, which would be released upon commencement of hostilities. The use of the term "weapons of mass destruction" was thus designed to preclude only this type of orbiting, space-based nuclear or other mass-destruction offensive weapons. Further **evidence that the drafters only intended this paragraph to ban orbiting nuclear-type weapons is the drafters' agreement that the Treaty does not prohibit the stationing of land-based ICBMs, even though their flight trajectory would take them through outer space**. [41](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=43c16c591c993122e312c1b0e5434740&docnum=5&_fmtstr=FULL&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=fab0a853e37d199f31b40e762b2bb19e&focBudTerms=nuclear+w%2F5+%28warhead+or+bomb+or+weapon+or+explosion+or+blast%29+w%2F10+space+w%2F20+%22outer+space+treaty%22&focBudSel=all" \l "n41" \t "_self) Thus, **so long as the weapon itself is not based in space, the fact that the weapon may travel through space when used** (as with a land-based ICBM) **does not cause the weapon to run afoul of the Treaty.** If the opposite interpretation were correct, the Treaty  [\*131]  would ban all land-based ICBMs, but the Parties have never suggested that it does.

# A2 - CPs

## US Key – A2 International CP

### U.S. unilateral action solves best

Barrett ‘6 (Scott, Professor and Director of International Policy, School of Advanced International Studies, Johns Hopkins University and Distinguished Visiting Fellow, Center for the Study of Globalization, Yale University, 6 Chi. J. Int'l L. 527, lexis)

But can we expect that this public good *will* be provided? Or will free riding undermine global provision of asteroid protection? The US would likely have the greatest incentive to provide this public good since it would, in absolute terms, bear the greatest loss from an asteroid collision. Indeed, it is easy to demonstrate that the economics of asteroid protection are so attractive that it would be beneficial for the US to finance the entire protection program. [**40**](http://www.lexis.com/research/retrieve?_m=65fe7099e860d61cf196eafeee25c4fe&csvc=bl&cform=searchForm&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=18b5fc1f51d299cd38a3a153fcb9e62f#n40) Since it pays the US to supply the public good **unilaterally**, theory suggests that the good will be supplied. As it happens, behavior is consistent with this prediction. **The US is already "doing more about N**ear **E**arth **O**bject**s than the rest of the world put together.**" [41](http://www.lexis.com/research/retrieve?_m=65fe7099e860d61cf196eafeee25c4fe&csvc=bl&cform=searchForm&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=18b5fc1f51d299cd38a3a153fcb9e62f#n41) For example, the US has already funded a program to track large objects in space, a prerequisite for further action. (Fortunately, the nature of asteroid travel means that we should have decades, if not centuries, to prepare for a possible collision; however, comets with long-period orbits cannot be observed as easily, and these are thus particularly dangerous.)  [\*538]  What theory cannot predict is how the public good of asteroid defense will be financed. It could be financed entirely by the US, but it could also be financed via any number of other burden-sharing arrangements. **[42](http://www.lexis.com/research/retrieve?_m=65fe7099e860d61cf196eafeee25c4fe&csvc=bl&cform=searchForm&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=18b5fc1f51d299cd38a3a153fcb9e62f" \l "n42" \t "_self)** To illustrate this point, consider the financing of the 1991 Persian Gulf War. Removing Iraqi forces from Kuwait was also a best shot, global public good. It enforced the norm safeguarding a state's territorial sovereignty, stabilized the global oil market, and invigorated the United Nations by carrying out the threat expressed in Security Council Resolution 678, which authorized the use of "all necessary means" to free Kuwait. **[43](http://www.lexis.com/research/retrieve?_m=65fe7099e860d61cf196eafeee25c4fe&csvc=bl&cform=searchForm&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=18b5fc1f51d299cd38a3a153fcb9e62f" \l "n43" \t "_self)** The US would have gained substantially from restoring Kuwait's sovereignty, but so would all other countries. Thus, while the US led the coalition against Iraq, many countries contributed, both financially and in kind. According to a Department of Defense study, foreign governments funded almost 90 percent of the military effort. **[44](http://www.lexis.com/research/retrieve?_m=65fe7099e860d61cf196eafeee25c4fe&csvc=bl&cform=searchForm&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=18b5fc1f51d299cd38a3a153fcb9e62f" \l "n44" \t "_self)** Bennett, Lepgold, and Unger claim that other countries paid because the US would not have intervened without allied contributions. **[45](http://www.lexis.com/research/retrieve?_m=65fe7099e860d61cf196eafeee25c4fe&csvc=bl&cform=searchForm&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=18b5fc1f51d299cd38a3a153fcb9e62f" \l "n45" \t "_self)** However, assuming that was not the case -- meaning that the US was willing to intervene unilaterally -- other countries would likely have contributed anyway. The US would have wanted to share the burden and other countries would have recognized their obligation to pay their fair share.

### US key to coordinating the NEO response.

Keating 2010 Why is it America's job to save the world from asteroids? Foreign Policy Joshua Keating Monday, September 13, 2010 http://blog.foreignpolicy.com/posts/2010/09/13/why\_is\_it\_americas\_job\_to\_save\_the\_world\_from\_asteroids

The U.S. currently spends about $5.5 million per year to track NEO's and less than a million on researching ways to counter them, but is falling far short of asteroid-detection goals. Some might say that's already too much, given the more terrestrial problems the U.S. faces. On the other hand, the United States spends more than $1 billion -- the amount NASA says it needs to meet its goal of detecting all potentially dangerous objects by 2020 -- on far less lofty goals than saving humanity from the fate of the dinosaurs. Even an asteroid just one kilometer in diameter would be enough to cause worldwide crop failures and a shift in the earth's climate. One just a few meters wide could wipe out a major city. But why, in this supposedly post-American world, is the United States expected to take the lead on this? Unlike, say, missile defense, asteroid detection and deterrence benefits all countries -- if NASA does detect a potentially dangerous asteroid, chances are it's probably going to hit somewhere else. And unlike global warming, smaller developing countries can't say that the United States should accept more of the blame for asteroids. (Though Hugo Chavez could certainly try.) Scientists have been urging the United Nations to coordinate international asteroid detection efforts for years. But despite coordinating work by the the U.N. Office for Outer Space Affairs (yes, there is one), progress seems to be slow-going. There are some promising signs of other powers starting to take the lead. The Mexican Ministry of Foreign Affairs hosted a conference on international asteroid tracing earlier this year. Russia's space agency has also proposed a joint asteroid monitoring project with the European Union. The good news is we probably have some time. An object big enough to wipe out a sizeable portion of the earth's population only hits about twice every million years. But the international community's recording in coordinating the international response to much more immediate dangers like global warming its not encouraging for those who would prefer not to rely on Bruce Willis or Morgan Freeman when the big one comes some day.

### The US has obligated itself to take the lead in NEO defense—superiority of US space policy, and customs governing missile defense mean the world will pressure to the US to deflect

Koplow ‘5 (Justin, JD Candidate Georgetown Univ. Law Center, 17 Geo. Int'l Envtl. L. Rev. 273, lexis)

 The fundamental procedures of intercepting an incoming missile and diverting an asteroid are significantly different. But the fundamental legal theory is strikingly similar. What the United States has done through the Bush expansion of missile defense is to make a commitment to aid foreign nations in preventing a disaster that would not cause injury to U.S. territory. In this sense, the foreign impact of an asteroid and the foreign impact of a ballistic missile are remarkably similar and so are the U.S. agreements and legal conceptions of duty and response there under. Many States -- including England, Japan, Australia, Canada, Italy, and Poland -- have shown interest in the U.S. BMD plans. [**119**](http://www.lexis.com/research/retrieve?_m=0a1c270addf8ff3ab6d13f663d730423&csvc=le&cform=&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=4aa6f6bbf78d7b303aaf074d784ec6c8#n119) The desired fruit of discussions with such States is a framework agreement whereby the one party agrees to host U.S. interceptors, radar installations, or related facilities, and the United States agrees that the shield will be extended to the protection of that state. **[120](http://www.lexis.com/research/retrieve?_m=0a1c270addf8ff3ab6d13f663d730423&csvc=le&cform=&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=4aa6f6bbf78d7b303aaf074d784ec6c8" \l "n120" \t "_self)** Presumably typical of such framework agreements is the 2003 Memorandum  [\*299]  of Understanding Between Secretary of Defense on Behalf of the Department of Defense of the United States of America and the Secretary of State for Defense of the United Kingdom of Great Britain and Northern Ireland Concerning Ballistic Missile Defense (MOU). **[121](http://www.lexis.com/research/retrieve?_m=0a1c270addf8ff3ab6d13f663d730423&csvc=le&cform=&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=4aa6f6bbf78d7b303aaf074d784ec6c8" \l "n121" \t "_self)** As stated in its title, the MOU was concluded between U.S. Secretary of Defense Donald Rumsfeld and U.K. Secretary of State for Defense Geoff Hoon to cover the establishment of cooperative relations in missile defense. The introductory section begins with recitation of the "recognitions" that are the foundation for the agreement, including that the United States and the United Kingdom have a "common interest in defense;" that the U.S. government has made the decision to "develop and deploy a set of missile defense capabilities;" and that the cooperation envisioned in the MOU should proceed to the understanding that "security of the Participants will be enhanced." **[122](http://www.lexis.com/research/retrieve?_m=0a1c270addf8ff3ab6d13f663d730423&csvc=le&cform=&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=4aa6f6bbf78d7b303aaf074d784ec6c8" \l "n122" \t "_self)** The MOU's first section, Purpose and Scope, reiterates the basis of the U.S. decision to pursue this line of technology and defense, as well as recalling the Bush line of "friends and allies," before getting to the real substance of the agreement: "the United Kingdom (U.K.) government supports these U.S. [missile defense] efforts and has welcomed assurances that the United States is prepared to extend coverage and make missile defense capabilities available to the U.K." **[123](http://www.lexis.com/research/retrieve?_m=0a1c270addf8ff3ab6d13f663d730423&csvc=le&cform=&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=4aa6f6bbf78d7b303aaf074d784ec6c8" \l "n123" \t "_self)** The subsequent paragraphs establish a few concrete details of the cooperation, including that the United Kingdom will upgrade the early warning radar systems at the Royal Air Force base at Fylingdales; that the United States and United Kingdom will engage in closer technical cooperation in other areas of missile defense; and that the MOU should serve to facilitate opportunities for U.K. and U.S. industries to participate in the U.S. ballistic missile defense system (BMDS) program. **[124](http://www.lexis.com/research/retrieve?_m=0a1c270addf8ff3ab6d13f663d730423&csvc=le&cform=&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=4aa6f6bbf78d7b303aaf074d784ec6c8" \l "n124" \t "_self)** The tangible products of such agreements are also in their effect. While several countries already have a substantial U.S. military presence (such as Fylingdales, the U.S. military bases in Japan, and the jointly-run NORAD system with Canada) that makes cooperation a commonplace occurrence, there are new indications and emplacements that can only be attributed to missile defense commitments and cooperation. In the Pacific theater, where North Korea is the  [\*300]  greatest threat and China a no-less-significant but less likely threat, the United States has moved an Aegis class cruiser equipped with a Standard Missile 3 system to defend against short-or medium-range missiles into permanent patrol on the Sea of Japan. **[125](http://www.lexis.com/research/retrieve?_m=0a1c270addf8ff3ab6d13f663d730423&csvc=le&cform=&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=4aa6f6bbf78d7b303aaf074d784ec6c8" \l "n125" \t "_self)** The Bush administration has also considered selling advanced missile defense systems to Taiwan. **[126](http://www.lexis.com/research/retrieve?_m=0a1c270addf8ff3ab6d13f663d730423&csvc=le&cform=&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=4aa6f6bbf78d7b303aaf074d784ec6c8" \l "n126" \t "_self)** In the European theater, interceptors and sensors have been placed in England, while Poland and Turkey, per strategic geography, would be prime locations for similar installations. **[127](http://www.lexis.com/research/retrieve?_m=0a1c270addf8ff3ab6d13f663d730423&csvc=le&cform=&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=4aa6f6bbf78d7b303aaf074d784ec6c8" \l "n127" \t "_self)** Israel has long been a missile defense partner and permitted use of the Patriot and jointly developed Arrow systems in both Iraq conflicts. **[128](http://www.lexis.com/research/retrieve?_m=0a1c270addf8ff3ab6d13f663d730423&csvc=le&cform=&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=4aa6f6bbf78d7b303aaf074d784ec6c8" \l "n128" \t "_self)** Both wars with Iraq also featured the use of interceptors to combat Iraqi Scud missiles, whether fired at U.S. troops or into Kuwait and neighboring states. **[129](http://www.lexis.com/research/retrieve?_m=0a1c270addf8ff3ab6d13f663d730423&csvc=le&cform=&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=4aa6f6bbf78d7b303aaf074d784ec6c8" \l "n129" \t "_self)** The simple fact is that the United States, and specifically the Bush administration, has made a commitment to missile defense and is willing to export it around the world in the interest of promoting international peace and security. The realities of shooting down a missile in its boost phase, the fundamental logic behind missile defense, and the idea that U.S. national defense is served by having missile interceptors stationed around the globe can each be analogized to the asteroid scenario. In the initial boost phase, it is not immediately apparent what the final target of a missile will be because trajectories can be adjusted and manipulated such that a missile launched from North Korea could be targeted for Seoul, Tokyo, Beijing, Sydney, Honolulu, or Los Angeles. **[130](http://www.lexis.com/research/retrieve?_m=0a1c270addf8ff3ab6d13f663d730423&csvc=le&cform=&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=4aa6f6bbf78d7b303aaf074d784ec6c8" \l "n130" \t "_self)** But despite all of these possibilities in the first few moments, the missile defense systems in the area would activate and attempt to destroy the missile without care for whether a MOU has been worked out with every specific possible target. The rewards, stopping a missile that might hit Japan, a missile defense cooperating State, are far greater than the "risk," a "free rider" concern that, for instance, Beijing would be protected without China having to explicitly agree to cooperate. In essence, what the United States has committed itself to is not defense of specific countries with which it makes explicit agreements, but rather to whole regions, and indeed, to the whole world. This "boost phase anonymity" situation shows how the United States will be willingly acting in the world's interests without a concern for exactly whom it is they are protecting. In any missile launch where there is the possibility that it would be in the United States' interests to prevent the impact, the missile defense system will attempt to do just that.  [\*301]  Under a system of foreign asteroid defense, the United States would be bound to defend countries from an attack little different, save for the presence of an instigating party, from a missile launch. The main difference is that the actual or predicted target would be known in the case of an asteroid; however, as the United States has shown a blanket willingness to protect States under the missile defense system, it would be hard-pressed not to use the tools and methods at its disposal in an asteroid context simply because the area of impact was not politically "desirable." The ultimate question of this note is whether the United States has through its participation in various space and weapons treaties and agreements created a duty by which it would be bound to attempt to avert the catastrophic effects of a foreign asteroid impact. The above explorations demonstrate that there is a large basis for an affirmative answer. Examination of U.S. involvement in space treaties and its own pursuit of international missile defense shows that the United States has created a special relationship from actual and superior knowledge coupled with a situation in which foreign States are being denied normal means and opportunities for self-defense and protection. This would, if it were under Minnesota law, indicate a special relationship and thereby a duty of protection. This is important in an era where space travel is increasingly privatized, and it also points to a possibly emerging custom. [131](http://www.lexis.com/research/retrieve?_m=0a1c270addf8ff3ab6d13f663d730423&csvc=le&cform=&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=4aa6f6bbf78d7b303aaf074d784ec6c8" \l "n131" \t "_self) However, U.S. law neither makes international law nor binds the relationships of the United States and foreign sovereign States. The international community is loath to simply create and foist duties and obligations upon members who did not actively participate in the bargaining for such deals and understandings. [132](http://www.lexis.com/research/retrieve?_m=0a1c270addf8ff3ab6d13f663d730423&csvc=le&cform=&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=4aa6f6bbf78d7b303aaf074d784ec6c8" \l "n132" \t "_self)

### The world is awaiting America’s lead

France ‘2k(Martin, Lt. Colonel, USAF, “Planetary Defense: Eliminating the Giggle Factor, [Air & Space Power Journal](http://www.airpower.maxwell.af.mil/airchronicles/apje.html), http://www.airpower.maxwell.af.mil/airchronicles/cc/france2.html)

A key component of the Shoemaker Report, as in the earlier Spaceguard Survey, was its international character. However, it seems that most **nations interested in the NEO threat are** still **awaiting America’s lead.** Russia, for example, has the technology and interest (Tunguska) among its astronomy and military communities to play a significant role in the Spaceguard Survey, but economic circumstances have precluded them from taking the initiative. Australia has recently backed away from its fledgling telescope program, which played a critical role in confirming NEOs first seen by other telescopes from its unique location in the southern hemisphere, and international attempts to encourage the Australian government to bring its program back into operation have failed.23 The United Kingdom, home of some of the most enthusiastic NEO watchers, formed a "Task Force on NEOs" led by Dr. Harry Atkinson. This group of four scientists has limited funding and is only tasked with making recommendation to Her Majesty’s Government by mid-2000 on how the UK should best contribute to the international effort on NEOs.24 Additionally, Spaceguard is a loose, voluntary consortium of international observatories and interested parties that serves to relay NEO identification to concerned groups and fellow participants.

### Massive timeframe solvency deficit – no other country has the infrastructure for survey

National Academies, 09 [Over many decades, the National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council have earned a solid reputation as the nation's premier source of independent, expert advice on scientific, engineering, and medical issues. “Near-Earth Object Surveys and Hazard Mitigation Strategies:

Interim Report” http://www.nap.edu/catalog.php?record\_id=12738]

 Despite expressions of interest in various countries around the globe, the majority of search efforts and funding for discovering NEOs comes from the United States. Several smaller projects, such as the Beijing Schmidt CCD Asteroid Program (no longer operational) and the Asiago DLR Asteroid Survey (an ongoing joint venture between the German Aerospace Agency’s [DLR’s] Institute of Space Sensor Technology and Planetary Exploration, the University of Asiago, and the Astronomical Observatory of Padua in Italy), have made so me inroads on detecting NEOs, but not on the scale of the U.S. projects. In addition, with the notable exception of Canada, through its Near-Earth Object Surveillance Satellite (NEOSSat) mission, and Germany, via its AsteroidFinder mission, which are both relatively limited in scope, no other countries have committed funding for a “next generation” NEO-discovery program. AsteroidFinder The German Aerospace Agency has selected AsteroidFinder as the first pay load to be launched under its new national compact satellite program. Currently the spacecraft is planned to launch sometime in 2012 with a 1-year baseline-mission duration and the possibility of an extension; this mission is funded through the development stage. It will be equipped with a 30-centimeter telescope mirror. Its primary science goals are to estimate the population of NEOs interior to Earth orbit, their size-frequency distribution, and their orbital properties. AsteroidFinder will also aid in the assessment of the imp act hazard due to NEOs and provide a space-based platform detecting space debris from artificial satellites. Near-Earth Object Surveillance Satellite NEOSSat is currently in development and is being constructed in Canada as a joint venture between the Canadian Space Agency (CSA) and Defense Research and Development Canada, an agency of the Canadian Department of National Defence. NEOSSat is based on a previous satellite, MOST, launched in 2003, that remains operational long after completion of its initial mission. Set to launch in mid 2010, NEOSSat is scheduled to operate continuously for at least one year and should operate considerably longer. NEOSSat will conduct two simultaneous projects during its operational lifetime—High-Earth Orbit Surveillance System (HEOSS), which will monitor and track human-made satellites and orbital debris, and Near-Earth Space Surveillance (NESS), which will discover and track NEOs. NEOSSat will be the first satellite to be built on Canada’s Multi-Mission Microsatellite Bus and will be roughly the size of a large suitcase with a mass of approximately 75 kilograms. It will have a 15-centimeter mirror. This microsatellite will operate in a Sun-synchronous orbit at an altitude of ~700 kilometers. NEOSSat will be the first dedicated space platform designed to obtain observations on both human-made and natural objects in near-Earth space. The NESS project will focus primarily on discovering NEOs whose orbits are partially or fully inside Earth’s. NEOSSat will expand overall knowledge of NEOs, monitor them for cometary activity, perform follow-up tracking of newly discovered targets, aid in the development of asteroid search and tracking algorithms for space-based sensors, and explore the synergies between ground- and space-based facilities involved in NEO discovery and characterization. Finding: The United States is the only country that currently has an operating survey/detection program for discovering near-Earth objects; Canada and Germany are both building spacecraft that may contribute to the discovery of near-Earth objects. However, neither mission will detect fainter or smaller objects than ground-based telescopes.

## A2 – Unilateral Policy Bad / International CP

### Multilateralism in planetary defense causes policy paralysis

Seamone ‘4(Evan, JD Univ. of Iowa College of Law!! and Judge Advocate General for the US Army, 17 Geo. Int'l Envtl. L. Rev. 1, lexis)

Natural impact threats raise a crucial point involving cooperation within and among different nations -- unrestrained **cooperation** and interdisciplinary involvement **can produce chaos rather than effectiveness**. **[93](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&_m=29883116b111aab2782c3966e91afae6&docnum=8&_fmtstr=FULL&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=167211df7d54cf708b11004a0b5470a7&focBudTerms=nuclear+w%2F10+%28asteroid+or+%22near+earth+object%22%29&focBudSel=all" \l "n93" \t "_self)** On a continuum from short-notice threats to long-term ones, as the magnitude of a natural impact threat increases or the response time grows shorter, more agencies will petition for involvement in the decision-making process. While space and military agencies might dominate the initial stages of decision-making, law enforcement, health, environmental, and fiscal agencies will merge into the decision-making framework over time. The influx of agency involvement can, of course, offer alternative perspectives. However, disruption, dilution, or ignorance of established frameworks will, no doubt, limit the overall effectiveness of joint efforts. The solution to this problem of coordination is not necessarily to give the lead to one agency and then prevent other agencies from meaningful modification of existing standards; nor is the answer carving out limited areas in which different agencies should legislate. Instead, the answer is to draw on the experience of all the agencies that could potentially become involved, identify their needs, exchange views, and then incorporate joint considerations into a single set of coordinating instructions. The National Response Plan incorporates many of these lessons.

## A2: EU CP

### Europe does not have a coordinated asteroid defense policy

Task Force ‘2k(British National Space Centre, Report of the Task Force on Potentially Hazardous Near Earth Objects, http://www.spacecentre.co.uk/neo/report.html)

There is no coordinated approach to Near Earth Objects in Europe. The Spaceguard Foundation continues to promote interest and helped organise a major international conference on the subject in Turin in 1999.The Foundation is based in Italy, and is closely linked to the Istituto di Astrofisica Spaziale in Rome, supported by the Italian Research Council. The Institute is building a small survey telescope in Italy, and at Pisa there is a group expert in planetary dynamics and Near Earth Object orbit calculations. There are also related activities in universities and institutes including some in France, Germany, Sweden, Finland, Greece and former Soviet Union countries. Interest in the subject is developing in a number of European institutions, including the Council of Europe. The European Union and its Commission have no formal policy on Near Earth Objects at present.

## A2 Russia CP

### 1. No risk of Apophis strike and sensationalism means no Russian funding deflection of other asteroids

[**O'Neill**](http://www.universetoday.com/author/ian/) **1-2** (Ian, PhD Solar Physics, “Much Ado About Apophis,” 1-2-10, http://www.astroengine.com/?p=6989)

Apophis is a 300 meter wide asteroid that caused a stir back in 2004. When NASA discovered the near-Earth asteroid (or NEO), it appeared to be tumbling in our direction Armageddon-style and the initial odds for a 2029 impact were 1-in-37. Understandably, people got scared, the media went nuts and astrophysicists were suddenly very interested in space rock deflection techniques. Fortunately for us, NASA has downgraded the threat to a zero (note zero) chance of Apophis bumping into us in 2029, and lowered the risk of a follow-up impact in 2036 from a 1-in-45,000 chance to a 1-in-250,000 chance. It’s important to note that NASA didn’t just pull these numbers out of a hat; the space agency has been tracking Apophis intently since its discovery, plotted its position and projected its location to a very high degree of precision. The more we watch Apophis, the more the world’s scientists are convinced that the asteroid poses a very tiny risk to life on Earth. In fact, giving anything a 1-in-250,000 chance of happening is more of a courtesy than a ‘risk.’ Granted, we’re talking about a global catastrophe should Apophis hit, but would you ever bet on those kinds of odds? Apparently, the Russian space agency thinks it’s more of a game of Russian Roulette than NASA thinks. “I don’t remember exactly, but it seems to me it could hit the Earth by 2032,” said Anatoly Perminov, the head of Roscosmos, [on December 30, 2009](http://news.discovery.com/space/incoming-asteroid-spacecraft-russia.html). “People’s lives are at stake. We should pay several hundred million dollars and build a system that would allow to prevent a collision, rather than sit and wait for it to happen and kill hundreds of thousands of people.” Wait a minute. Does Perminov know something NASA doesn’t? Is he even referring to Apophis? You know, the same asteroid NASA has calculated that has a cat in hell’s chance of causing bother in 2036? And what’s this about the year 2032? Just for the record, Perminov is indeed referring to Apophis, but he got the date wrong (Apophis does not make a flyby in 2032). Perminov also puts a price on saving hundreds of thousands of people… “several hundred million dollars” should do it, apparently. On the one hand I’m impressed that Roscosmos is calling for some kind of anti-asteroid shield, but on the other, Perminov’s concern is terribly misplaced (and potentially damaging). His statement sounds as if he’s only just heard about Apophis and then thrown into a press conference unprepared, then asked what he’s going to do about this impending doom. Naturally, in that situation he would have blurted out the first thing that popped into his head: We need to save the world! However, this isn’t the first time he’d heard about Apophis. Boris Shustov, the director of the Institute of Astronomy under the Russian Academy of Sciences, tried to repair the damage pointing out that Perminov was just using Apophis as a “symbolic example, there are many other dangerous objects we know little about.” However, saving the world from a theoretical “dangerous object” that may or may not hit us for the next few hundred /thousand/million years is less likely to get funding that an imminent 2032… sorry, 2036 impact. Although Perminov might sound reasonable in asking for asteroid deflection funding, using sensationalist means to try to leverage funding only serves to make the same funding hard to come by.

### 2. A Russian Apophis mission will CAUSE a collision

**Barry 12-31** (Ellen, NYT staff reporter, NYT, 12-31-09, lexis)
Russell L. Schweickart, a former Apollo astronaut who is chairman of the B612 Foundation, a California group that promotes efforts to deflect asteroids, hailed much of the proposal and said Mr. Perminov was the most influential official ever to articulate a coordinated deflection plan. But he objected to using Apophis to test new deflection methods, saying there was more risk if something went wrong. ''It takes a very small change in the Apophis orbit to cause it to impact the Earth instead of missing it,'' Mr. Schweickart said. ''There are a million asteroids out there. Find another one.''

### 3. Perm: do both

### 4. Empirically, Russian space agency is incompetent

[**O'Neill**](http://www.universetoday.com/author/ian/) **‘8** (Ian, PhD Solar Physics and correspondent for Universe Today, [New Facts Emerge from Soyuz Emergency Landing](http://www.universetoday.com/2008/04/21/new-facts-emerge-from-soyuz-emergency-landing/), 4-21-08, http://www.universetoday.com/2008/04/21/new-facts-emerge-from-soyuz-emergency-landing/)

This incident highlights the risk involved with space travel, and whilst access to space is becoming more and more routine, the fact remains that things can go wrong. Many news sources are highly critical of the Russian space agency, arguing that they are incompetent. This might be a little strong, but in matters such as the safe return of astronauts, absolute clarity is needed. Attempts to cover up technical faults, citing of "bad omens" and misinformation will not help the Russian efforts in space.

### US must take the lead—Russia will use nuclear weapons

**RIA Novosti ‘8** (RIA Novosti, Russian news service, 9-5-08, http://en.rian.ru/russia/20080905/116573883.html)

MOSCOW, September 5 (RIA Novosti) - Russia supports the idea of international cooperation to deal with the threat of an asteroid collision, the head of the federal space agency said on Friday. "The problem really exists, and we need to think about how to solve it - naturally through broad international cooperation within the framework of the UN," Anatoly Perminov said in an interview with the Russian daily Krasnaya Zvezda. He said a Russian radar facility, RF-70, used by the Space Forces, could be useful in dealing with the threat. Russian scientists earlier suggested nuclear explosive devices are the most effective means of protecting the Earth from possible collisions with space bodies, including comets and asteroids.

### US action key to solvency

**Barrett ‘6** (Scott, Professor and Director of International Policy, School of Advanced International Studies, Johns Hopkins University and Distinguished Visiting Fellow, Center for the Study of Globalization, Yale University, 6 Chi. J. Int'l L. 527, lexis)

But can we expect that this public good *will* be provided? Or will free riding undermine global provision of asteroid protection? The US would likely have the greatest incentive to provide this public good since it would, in absolute terms, bear the greatest loss from an asteroid collision. Indeed, it is easy to demonstrate that the economics of asteroid protection are so attractive that it would be beneficial for the US to finance the entire protection program. [**40**](http://www.lexis.com/research/retrieve?_m=65fe7099e860d61cf196eafeee25c4fe&csvc=bl&cform=searchForm&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=18b5fc1f51d299cd38a3a153fcb9e62f#n40) Since it pays the US to supply the public good **unilaterally**, theory suggests that the good will be supplied. As it happens, behavior is consistent with this prediction. **The US is already "doing more about N**ear **E**arth **O**bject**s than the rest of the world put together.**" [41](http://www.lexis.com/research/retrieve?_m=65fe7099e860d61cf196eafeee25c4fe&csvc=bl&cform=searchForm&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=18b5fc1f51d299cd38a3a153fcb9e62f#n41) For example, the US has already funded a program to track large objects in space, a prerequisite for further action. (Fortunately, the nature of asteroid travel means that we should have decades, if not centuries, to prepare for a possible collision; however, comets with long-period orbits cannot be observed as easily, and these are thus particularly dangerous.)  [\*538]  What theory cannot predict is how the public good of asteroid defense will be financed. It could be financed entirely by the US, but it could also be financed via any number of other burden-sharing arrangements. [**42**](http://www.lexis.com/research/retrieve?_m=65fe7099e860d61cf196eafeee25c4fe&csvc=bl&cform=searchForm&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=18b5fc1f51d299cd38a3a153fcb9e62f#n42) To illustrate this point, consider the financing of the 1991 Persian Gulf War. Removing Iraqi forces from Kuwait was also a best shot, global public good. It enforced the norm safeguarding a state's territorial sovereignty, stabilized the global oil market, and invigorated the United Nations by carrying out the threat expressed in Security Council Resolution 678, which authorized the use of "all necessary means" to free Kuwait. [**43**](http://www.lexis.com/research/retrieve?_m=65fe7099e860d61cf196eafeee25c4fe&csvc=bl&cform=searchForm&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=18b5fc1f51d299cd38a3a153fcb9e62f#n43) The US would have gained substantially from restoring Kuwait's sovereignty, but so would all other countries. Thus, while the US led the coalition against Iraq, many countries contributed, both financially and in kind. According to a Department of Defense study, foreign governments funded almost 90 percent of the military effort. [**44**](http://www.lexis.com/research/retrieve?_m=65fe7099e860d61cf196eafeee25c4fe&csvc=bl&cform=searchForm&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=18b5fc1f51d299cd38a3a153fcb9e62f#n44) Bennett, Lepgold, and Unger claim that other countries paid because the US would not have intervened without allied contributions. [**45**](http://www.lexis.com/research/retrieve?_m=65fe7099e860d61cf196eafeee25c4fe&csvc=bl&cform=searchForm&_fmtstr=FULL&docnum=1&_startdoc=1&wchp=dGLbVlb-zSkAb&_md5=18b5fc1f51d299cd38a3a153fcb9e62f#n45) However, assuming that was not the case -- meaning that the US was willing to intervene unilaterally -- other countries would likely have contributed anyway. The US would have wanted to share the burden and other countries would have recognized their obligation to pay their fair share.

### A vote for Russia’s space agency is a vote for patriarchy

[**O'Neill**](http://www.universetoday.com/author/ian/) **‘8** (Ian, PhD Solar Physics and correspondent for Universe Today, [New Facts Emerge from Soyuz Emergency Landing](http://www.universetoday.com/2008/04/21/new-facts-emerge-from-soyuz-emergency-landing/), 4-21-08, http://www.universetoday.com/2008/04/21/new-facts-emerge-from-soyuz-emergency-landing/)

As [previously reported](http://www.universetoday.com/2008/04/20/soyuz-crew-safe-after-a-violent-re-entry-and-landing-400km-off-target/) on the [Universe Today](http://www.universetoday.com/), something went wrong with the Soyuz descent capsule as it completed its return mission from the International Space Station on Saturday. Back then, the Russian space authority reported the capsule had undergone a ballistic re-entry (rather than the planned "guided descent") after the crew changed the flight plan without communicating the alteration to mission control. This was the sole (official) reason given for the hard landing the three crew members suffered. South Korea's first astronaut, Yi So-yeon, Russian [cosmonaut](http://www.universetoday.com/guide-to-space/spaceflight/cosmonaut/) Yuri Malenchenko and American Peggy Whitson endured forces exceeding nine-G (nine-times [Earth](http://www.universetoday.com/guide-to-space/earth/) gravity) as they tumbled through the atmosphere. One Russian space official cited an old naval superstition that having women on board the flight was a "bad omen" and that planners would reconsider having a female-dominant crew in the future. These remarks understandably caused a stir.

### Reject patriarchy

**Reardon ‘93** (Betty A., Director of the Peace Education Program at Teacher’s College Columbia University, Women and Peace: Feminist Visions of Global Security, p. 30-2)

In an article entitled “Naming the Cultural Forces That Push Us toward War” (1983), Charlene Spretnak focused on some of the fundamental cultural factors that deeply influence ways of thinking about security. She argues that patriarchy encourages militarist tendencies. Since a major war now could easily bring on massive annihilation of almost unthinkable proportions, why are discussions in our national forums addressing the madness of the nuclear arms race limited to matters of hardware and statistics? A more comprehensive analysis is badly needed . . . A clearly visible element in the escalating tensions among militarized nations is the macho posturing and the patriarchal ideal of dominance, not parity, which motivates defense ministers and government leaders to “strut their stuff” as we watch with increasing horror. Most men in our patriarchal culture are still acting out old patterns that are radically inappropriate for the nuclear age. To prove dominance and control, to distance one’s character from that of women, to survive the toughest violent initiation, to shed the sacred blood of the hero, to collaborate with death in order to hold it at bay—all of these patriarchal pressures on men have traditionally reached resolution in ritual fashion on the battlefield. But there is no longer any battlefield. Does anyone seriously believe that if a nuclear power were losing a crucial, large-scale conventional war it would refrain from using its multiple-warhead nuclear missiles because of some diplomatic agreement? The military theater of a nuclear exchange today would extend, instantly or eventually, to all living things, all the air, all the soil, all the water. If we believe that war is a “necessary evil,” that patriarchal assumptions are simply “human nature,” then we are locked into a lie, paralyzed. The ultimate result of unchecked terminal patriarchy will be nuclear holocaust. The causes of recurrent warfare are not biological. Neither are they solely economic. They are also a result of patriarchal ways of thinking, which historically have generated considerable pressure for standing armies to be used. (Spretnak 1983) These cultural tendencies have produced our current crisis of a highly militarized, violent world that in spite of the decline of the cold war and the slowing of the military race between the superpowers is still staring into the abyss of nuclear disaster, as described by a leading feminist in an address to the Community Aid Abroad State Convention, Melbourne, Australia: These then are the outward signs of militarism across the world today: weapons-building and trading in them; spheres of influence derived from their supply; intervention—both overt and covert; torture; training of military personnel, and supply of hardware to, and training of police; the positioning of military bases on foreign soil; the despoilation of the planet; ‘intelligence’ networks; the rise in the number of national security states; more and more countries coming under direct military rule; 13 the militarization of diplomacy, and the interlocking and the international nature of the military order which even defines the major rifts in world politics. (Shelly 1983).

## A2 – Referendum CP

### Public doesn’t understand deflection techniques—they’ll demand that we blow it up

Chapman ‘7(Clark, fellow at Southwest Research Institute, Ch. 7: The Asteroid Impact Hazard and Interdisciplinary Issues, in Comet/Asteroid Impacts and Human Society: An Interdisciplinary Approach, SpringLink)

People are inclined to visualize the problem as involving an NEA that is on its way in and the way to deal with it is to “blow it up” shortly before it hits. The picture of an NEA orbiting the Sun countless times (and for decades, centuries, or longer) before it hits – all the while remaining in our cosmic neighborhood, where it is accessible by spacecraft – is difficult to get across.

### NASA supports using nuclear weapons – that’s the 1AC Schweikart and Chapman evidence, and it’s likely that the public will just believe NASA even though NASA is wrong

### Nuclear weapons are our weapon of first resort

Gerrard & Barber ‘97(Michael & Anna, Asteroids and Comets: U.S. and International Law and the Lowest-Probability, Highest Consequence Risk, New York Univ. Environmental Law Journal, http://www1.law.nyu.edu/journals/envtllaw/issues/vol6/1/6nyuelj4.html)

If an NEO is found to be on a collision course with the Earth, some people's first reaction would be to attempt to blow it up with nuclear warheads. This could prove counterproductive, however, if several of the resulting fragments are still on a course to Earth and are large enough to penetrate its atmosphere; this situation could increase rather than decrease the destruction caused by impact with our planet. [27](http://www1.law.nyu.edu/journals/envtllaw/issues/vol6/1/6nyuelj4n.html#fn27) The composition of the object is very important--nickel-iron asteroids will be far more difficult to break apart into multiple small pieces than chrondite **\*10** asteroids or ice-and-dust comets. [28](http://www1.law.nyu.edu/journals/envtllaw/issues/vol6/1/6nyuelj4n.html#fn28) Observation from a spacecraft located close to the object may be required to determine its particular composition. Most astronomers seem to feel that it is usually better to deflect an object than to fragment it if there is enough warning time. The idea is simply to move the asteroid or comet enough so that it and the Earth will not be at the same place at the same time. In the words of John S. Lewis, co-director of the NASA/University of Arizona Space Engineering Research Center, we are not trying to banish the asteroid from the inner solar system; we are merely trying to avoid a single predicted impact with Earth. Suppose our asteroid-search team finds a 250-meter body that is due to hit Earth dead center a few hundred years from now. This same body has probably been crossing Earth's orbit for 10 million to 100 million years without an impact. If we can just ease it by Earth without an impact on this one occasion, we may well buy ourselves another 30 million years to figure out what to do the next time it threatens us. [29](http://www1.law.nyu.edu/journals/envtllaw/issues/vol6/1/6nyuelj4n.html#fn29) To accomplish this diversion, nuclear devices seem to be the only currently available technology that can deliver enough energy to move a large object far enough to avoid an Earth impact. [30](http://www1.law.nyu.edu/journals/envtllaw/issues/vol6/1/6nyuelj4n.html#fn30) According to one analysis, the method that may transfer the momentum from the blast to the object most effectively involves burying the device below the surface of the asteroid. [31](http://www1.law.nyu.edu/journals/envtllaw/issues/vol6/1/6nyuelj4n.html#fn31) Care must be taken not to inadvertently fragment the object. [32](http://www1.law.nyu.edu/journals/envtllaw/issues/vol6/1/6nyuelj4n.html#fn32) Many of the technologies that would be necessary for such a mission-data processing, telemetry, power supply, sensors, propulsion, etc., have been under development for military purposes by \*11 the U.S. Department of Defense's Ballistic Missile Defense Organization, formerly known as the Strategic Defense Initiative Organization (and popularly known as "Star Wars"). [33](http://www1.law.nyu.edu/journals/envtllaw/issues/vol6/1/6nyuelj4n.html#fn33)

## A2 Consult

### Veto vote kills leadership

**Carroll ‘9**

(James, Notes & Comments Editor, Emory International Law Review; J.D., with Honors, Emory University School of Law, attorney for the Huddleston Law Firm, 23 Emory Int'l L. Rev. 167, lexis)

****n221. See Thomas Friedman, Op-Ed., 9/11 is Over, N.Y. Times, Sept. 30, 2007, § 4, at 12. This does not mean, however, that foreign countries should hold a veto over U.S. foreign or domestic policies, particularly policies that are not directly related to their national survival. Allowing foreign countries or international institutions to veto or modify unrelated U.S. policies would make a mockery of our foreign policy and destroy the credibility of American leadership. International cooperation does not require making our policy subservient to the whims of other nations. See generally The Allies and Arms Control (F.O. Hampson et al. eds., 1992). See also Khalilzad, supra note 177.

### Nuclear war

**Khalilzad ‘95**

(Zalmay, RAND policy analyst, Spring, The Washington Quarterly, Vol. 18, No. 2, “Losing the Moment?”)

Under the third option, the United States would seek to retain global leadership and to preclude the rise of a global rival or a return to multipolarity for the indefinite future. On balance, this is the best long-term guiding principle and vision. Such a vision is desirable not as an end in itself, but because a world in which the United States exercises leadership would have tremendous advantages. First, the global environment would be more open and more receptive to American values -- democracy, free markets, and the rule of law. Second, such a world would have a better chance of dealing cooperatively with the world’s major problems, such as nuclear proliferation, threats of regional hegemony by renegade states, and low-level conflicts. Finally, U.S. leadership would help preclude the rise of another hostile global rival, enabling the United States and the world to avoid another global cold or hot war and all the attendant dangers, including a global nuclear exchange. U.S. leadership would therefore be more conducive to global stability than a bipolar or a multipolar balance of power system.

## A2: CP use other Sats

### Only the Venus-orbit solves by providing a comprehensive NEO survey – earth-orbiting telescopes can’t solve.

Dunham & Genoca 2010 Using Venus for Locating Space Observatories to Discover Potentially Hazardous Asteroids D. W. Dunham1 and A. L. Genova2 1 Kinet X, Inc., 7913 Kara Ct., Greenbelt, Maryland 20770􏰄3016, USA 2 NASA Ames Research Center, Moffett Field, California 94035, USA Cosmic Research, 2010, Vol. 48, No. 5 pp. 424–429

CONCLUSIONS The IRAS, and now WISE spacecraft, have proven that NEA’s can be discovered by space missions. NEOSSat and AsteroidFinder promise to accelerate NEA discoveries, and especially those of the possibly hazardous IEO’s, from the Sun-synchronous low- Earth orbit. But being near the Earth, these spacecraft never will be able to perform complete surveys; there will remain objects that are still too close to the Sun or staying too far from the Earth during the limited durations of the missions to be observed. Only the missions which enter heliocentric orbits well within the Earth’s one and “look out” towards it can hope to make comprehensive searches for potentially hazardous NEA’s in relatively few years of operations. It might seem that the complexity of maneuvers to achieve the halo orbit would better be avoided to just use a distant Venus flyby for entering the Venus-like heliocentric orbit like Shield’s Sentries or the NEO Survey mission. Certainly, less propellant would be needed for those missions, only what is enough to correct injection launch errors and to target the Venus B-plane to achieve the desired orbit. But the Venus halo orbit could be used for long-term near-Venus scientific observations, as well as for NEA surveying, because, unlike the other orbits, the Venus halo orbit would provide a nearly constant distance from the spacecraft to the Earth’s orbit, which would simplify coverage strategies and, possibly, thermal control at the more constant distance from the Sun due to Venus’ nearly circular orbit. These operations should not be too intensive, since the small maneuvers needed to maintain the halo would be needed only about every two months, which ensures a small cost relative to the operations that would be needed to acquire and analyze the large body of images for the NEA searches.

## A2: Ground-based CP

### Space-based observation of NEOs are vastly more effective – That’s just science.

Galvez et al 2003 THE ROLE OF SPACE MISSIONS IN THE ASSESSMENT OF THE NEO IMPACT HAZARD Andrés Gálvez1, Marcello Coradini2, Franco Ongaro2 1 ESA – ESTEC, Advanced Concepts Team Keplerlaan 1, 2200 AZ, Noordwijk ZH, The Netherlands http://www.esa.int/gsp/ACT/doc/MAD/pub/ACT-RPR-MAD-2003-THE%20ROLE%20OF%20SPACE%20MISSIONS%20IN%20THE%20ASSESSMENT%20OF%20THE%20NEO%20IMPACT.pdf

Space missions dedicated to the detection, tracking (i.e. orbit determination) and remote characterisation (e.g. determination of taxonomic type and surface albedo) would be significantly more capable than most ground-based surveys. The objective of this type of missions would be to improve and expand our catalogue of dangerous objects. Though space borne telescopes cannot be made as large and powerful as their terrestrial counterparts, for these tasks and as a consequence of improved viewing geometry (especially as the observing point moves closer to the Sun) and better observation conditions the space option enables an improved access to certain types of objects: these include Inner to Earth Objects (IEOs) and Atens, that due to their proximity to the Sun in the sky are often difficult to observe. These favourable conditions can also result in efficient and extensive surveys in which smaller objects down to a few hundred meters in size may also be detected. Observation strategies can also be devised to ensure that newly discovered objects are re-detected again after they have moved to a new orbital location, thus providing a set of data that can enable the determination of accurate orbits. This in turn allows their future trajectories (and Earth encounters, if any) to be predicted. Finally, a space observatory can also have an unobstructed access to a broader range of wavelengths (e.g. in the IR) and to achieve a more efficient duty cycle than from below the Earth’s atmosphere, as in the case of ground-based telescopes.

### Space-based observation is critical to ascertaining orbits of NEOs.

Galvez et al 2003 THE ROLE OF SPACE MISSIONS IN THE ASSESSMENT OF THE NEO IMPACT HAZARD Andrés Gálvez1, Marcello Coradini2, Franco Ongaro2 1 ESA – ESTEC, Advanced Concepts Team Keplerlaan 1, 2200 AZ, Noordwijk ZH, The Netherlands http://www.esa.int/gsp/ACT/doc/MAD/pub/ACT-RPR-MAD-2003-THE%20ROLE%20OF%20SPACE%20MISSIONS%20IN%20THE%20ASSESSMENT%20OF%20THE%20NEO%20IMPACT.pdf

The ultimate goal of the NEO surveys is not simply to detect new objects, but to perform an accurate calculation of their orbits. Only this way can their trajectories be determined in order to ascertain whether they represent a serious threat to the Earth. In order to attain this goal it must be ensured that enough observations of an object are available (at least three), and that their spacing in time is long enough so that the ̈arc length ̈ on the sky has a significant angular size. Therefore an observatory must not only be capable of detecting a faint object and identifying it as a NEO, based on its rate of motion against the stars on the sky background. The survey strategy should be such that the same regions of the sky are periodically revisited in order to systematically re-detect, albeit in different positions, the newly discovered -or as it often happens, re-discovered- object. In space sequential observations cannot be hindered by adverse atmospheric weather conditions. Also, favourable NEO visibility conditions are not only limited to a region of the sky close to the opposition point, especially if the telescope is located within the Earth’s orbit. It is therefore much easier to devise a survey strategy that enables successive and repeated observation of sky regions even if the angular separation is important.

### Space-based detection is key to seeing small asteroids – impacts economy and nuclear war.

Arentza et al 2010 NEO Survey: An Efficient Search for Near-Earth Objects by an IR Observatory in a Venus-like Orbit Robert Arentza, Harold Reitsemaa, Jeffrey Van Cleveb and Roger Linfielda a Ball Aerospace & Technologies Corp. 1600 Commerce St. Boulder, CO 80301 303-939-6140; rarentz@ball.com; hreitsema@aol.com; rlinfiel@ball.com b SETI Institute NASA Ames Research Center NS 244-30, Room 107G Moffett Field, CA 94035 650-604-1370 Space, Propulsion & Energy Sciences International Forum

As reviewed in the Introduction, recent work by Boslough (2009) shows that the impact-physics of NEOs having diameters in the 30-100 meter range has been seriously misunderstood due to a process he named a Low-Altitude Airburst (LAA). In an LAA event, the main body of the NEO physically comes apart at high altitudes (~10 to ~80- km), but the object’s mass and kinetic energy are conserved as a fast moving, loosely aggregated, collection of particles that entrain a column of air which reaches the ground as “air hammer.” Boslough’s work shows that the air hammer from NEOs as small as 30 meters will inflict significant damage on the ground, as was seen in the 30- meter-class Tunguska event. Boslough has also shown that an LAA from a ~100 meter diameter NEO melted sand into glass across a region about 10-km in diameter during Libyan Desert Glass impact ~35 million years ago. During this event the LAA-induced fireball settled onto parts of modern Egypt and Libya for about a minute with temperatures approaching 5,000K—hotter than the Sun’s surface. Additionally, the hypersonic blast wave from this event perhaps extended eighty kilometers from the melt zone. Boslough has also shown that the interaction of an LAA with the ocean’s surface is much different from that of a large object striking offshore, therefore the tsunami risk from an LAA event is not well understood, either, but is different than previously thought. Therefore any survey instrument capable of searching well below the GEB limit of 140 meters is quite valuable. The NEO Survey concept 422 shown here captures about half of the >50 meter-class NEOs in its 7-year mission, and the completion rate increases rapidly with increasing diameter up to the design goal of 90% for all 140 meters, and larger, objects. Derating the Tunguska object from ~80 meters to today’s ~30 meters greatly decreases the mean impact interval from ~1,000 years to ~150 years. Given that Tunguska happened 101 years ago, the next impact is arguably 50 to 100 years away, so why the urgency? From contract start, it would take an experienced aerospace contractor about 3 years to build and launch NEO Survey, and then 7 more years (worst case) to complete the catalogue, or 10 years to completion. Assume for the moment that near the end of this period of 10 years, a 50-meter diameter NEO is discovered having an impact date in 50 years. What does this mean? Groundbased systems could easily miss such an object for an apparition or two, resulting in perhaps a few years, or perhaps a few months of warning time before impact. If, by remote chance, it was determined that the strike location was close to a high-density human population, it would force the evacuation of millions of people from a large geographic area and would produce a long-lasting, global sociological disruption that would eventually outweigh the immediate harm resulting from a large-scale loss of human life and damage to a distributed infrastructure. And since there is no predicting the reaction of populations or their governments to such a trauma, such an incident could possibly trigger a chain of events resulting in military action of unforeseeable severity. Clearly, the effect of such an event on the global economy could also be large compared to the cost of flying a sensitive and efficient NEO cataloguing mission. Consider also the value of finally having a deterministic answer to the question: “Are we safe for the next few hundred years?” as opposed to the present case of arguing from statistics. If NEO Survey found an incoming NEO with a warning time of only 50 years, what would it take to execute a successful mitigation effort, and how long would that effort last? To begin with, it would take a year or two for groundbased assets to do detailed follow-up orbital refinements. Then, a space mission to the object would be required for in-situ characterization because all conceivable mitigation techniques require detailed knowledge of the object’s composition, mechanical properties, spin state, whether it has a moonlet, and so on. Only then could the appropriate mitigation solution be chosen and negotiated in a global political setting. It would then take an additional 10 years, approximately, to design, build, fly, and complete the mitigation task. Additionally, the results of any mitigation action would have to be closely monitored, and perhaps a second mitigation mission would be required to produce the desired final result. These timelines are in series and mean that 50 years of lead-time is almost tomorrow. Reliance on groundbased assets to find these smaller NEOs over a period of decades ignores the threats LAAs represent to the modern world. Additionally, the longer the warning time becomes, the less delta-vee is needed to move an impact off the Earth, simplifying the mitigation effort. For example, the difference between 10 years and 20 years of warning time could enable a passive mitigation option compared to a nuclear option.

### Doesn’t solve – atmosphere and sunlight block the scopes

National Academies, 10 [ Over many decades, the National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council have earned a solid reputation as the nation's premier source of independent, expert advice on scientific, engineering, and medical issues, “Defending Planet Earth: Near-Earth Object Surveys and Hazard Mitigation Strategies” http://books.nap.edu/openbook.php?record\_id=12842&page=41]

The 2003 NASA NEO Science Definition Team Study concluded that an infrared space telescope is a powerful and efficient means of obtaining valuable and unique detection and characterization data on NEOs (Stokes et al., 2003). The thermal infrared, which denotes wavelengths of light from about 5 to 10 microns, is the most efficient color regime for an NEO search. An orbiting infrared telescope that detects these wavelengths and has a mirror between 0.5 and 1 meter in diameter is sufficient to satisfy the goal of detecting 90 percent of potentially hazardous NEOs 140 meters in diameter or greater. Also, locating an NEO-finding observatory internal to Earth’s orbit is preferable for identifying NEOs with orbits mostly or entirely inside Earth’s orbit. Specific advantages to space-based observations include the following: A space-based telescope can search for NEOs whose orbits are largely inside Earth’s orbit. These objects are difficult to find using a ground-based telescope, as observations risk interference from the Sun when pointing to the areas of the sky being searched; Thermal-infrared observations are immune to the bias affecting the detection of low-albedo objects in visible or near-infrared light, by observing the thermal signal from the full image of the NEO, providing more accurate albedo measurements (see the discussion above); Space-based searches can be conducted above Earth’s atmosphere, eliminating the need to calibrate the effects introduced by the atmosphere on the light from an NEO; and Observations can be made 24 hours a day.

### Doesn’t solve – inner-earth objects

ESA, 3 [European Space Agency, Jan 2003, “ EARTHGUARD-I A Space-Based NEO Detection System,” http://www.esa.int/gsp/completed/neo/earthguard1\_execsum.pdf]

There is good theoretical evidence, however, to suggest there may be a population of asteroids in orbits that lie entirely within the Earth’s orbit, the so-called “inner-Earth objects” (IEOs) or Apohele asteroids. As a result of perturbation of their orbits by the inner planets they may become Earth crossers but remain virtually undetectable from the Earth. Only with the help of a space-based search telescope observing at small angular distances from the Sun can we hope to close the gap left by the groundbased surveys and facilitate a complete and reliable assessment of the terrestrial impact hazard

## A2 Delay

### Lack of adequate lead time between detection and deflection will cause mission failure. Early warning is key.

Barbee & Nuth 2009 Asteroid Impact Threats: Advancements in Asteroid Science to Enable Rapid and Effective Deflection Missions 1Brent William Barbee, M.S.E., and 2Joseph A. Nuth III, Ph.D. 1Aerospace Engineer and Planetary Defense Scientist, Emergent Space Technologies, Inc., Greenbelt, MD, USA, 2Senior Scientist for Primitive Bodies, Solar System Exploration Division, NASAís Goddard Space Flight Center, Greenbelt, MD, 20771, USA Journal of Cosmology, 2009, Vol 2, pages 386-410. Cosmology, October 31, 2009

Understanding the sequence of events during a hazardous NEO situation highlights the importance of rapid response. Figure 19 shows the hazardous NEO response timeline, with the major events time ordered from left to right. The seven major time intervals are colored red, orange, yellow, green, blue, indigo, and violet. The timeline begins with the detection of the NEO by observational assets. Then there is some time interval (red) during which the observations are collected and processed, improving the accuracy of the orbit determination for the NEO until the impending collision is confirmed or at least the probability of a collision becomes high enough to warrant action. One of the unanswered questions in planetary defense currently is what the probability of collision threshold for action should be. Assuming the NEO is determined to be a threat, the next event is the beginning of mission planning for the deflection of the NEO, which takes place during the orange time interval. It is during this interval that the NEO must be scientifically characterized. At present this would require a precursor scientific characterization mission be sent to the NEO, which would require substantial time. If there is not sufficient time between when the NEO is first detected and the time of undeflected Earth impact, then the precursor science mission might have to be omitted and a deflection mission designed and launched based only on our best guesses of the asteroid’s physical properties, a highly undesirable situation where the likelihood of mission failure is high. The proposed advancements in NEO science presented in a subsequent section herein would be of tremendous aid here. Once enough data has been collected and preliminary mission planning is complete, then the next interval begins (yellow) during which the spacecraft carrying the deflection system and the launch vehicle are constructed and made ready for deployment. Based on actual experience with this process, it can be lengthy. Every effort would be made to hasten this process during a NEO emergency, but rushing it too much might cause mistakes that would lead to fatal mission failure. After the deflection spacecraft launches, it will require time to rendezvous with the NEO (green) and position the deflection system appropriately (blue). While advancements in spacecraft propulsion technology can reduce the flight time to rendezvous with the NEO, the natural orbital mechanics (which we cannot change) is often the limiting factor. This is why early detection and characterization are so important. Finally, once the deflection system is positioned and ready it can be deployed on the NEO, imparting a deflection. The effects of the deflection have time to accumulate during the interval between when the deflection is applied and the time of undeflected Earth impact (indigo). Clearly the goal is to maximize this time interval (by pushing all the other events as far backwards along the timeline as possible in order to stretch out the indigo segment by compressing the preceding intervals). This provides the best chance for causing the incoming asteroid to miss the Earth.

### Any delay kills solvency.

Richard Crowther, 2009 Ph.D. Science and Technology Facilities Council (STFC), Harwell Science and Innovation Campus, Chilton, Oxfordshire OX11 0QX, UK Journal of Cosmology, 2009, Vol 2, pages 411-418. Cosmology, October 31, 2009 Near Earth Object (NEO) Impact Threat: An International Policy Response

A second aspect is when a decision should be made to launch a deflection mission, or otherwise. Although this is somewhat dependent upon the impactor scenario (i.e. the time we would have to make a decision and mount a deflection mission), experience tells us that it would be prudent to make this decision as soon as a credible threat has been identified. These criteria and thresholds would need to agreed in advance of implementation, and hence are an immediate, if not urgent, requirement.

## NASA = Normal Means

### NASA is normal means.

DAVID MORRISON 2010 Director, Carl Sagan Center for Study of Life in the Universe, SETI Institute Senior Scientist, NASA Ames Research Center “Impacts and Evolution: Protecting Earth from Asteroids1” PROCEEDINGS OF THE AMERICAN PHILOSOPHICAL SOCIETY VOL. 154, NO. 4, DECEMBER 2010

Although the impact hazard is clearly a matter that affects all nations, to date only the United States government has taken steps to address the problem directly through scientific research and astronomical observations, as previously described. Further, all governments seem to share a reluctance to include impacts within their disaster planning and responsibility (Garshnek et al. 2000). When this issue does surface, it is likely to be discussed in terms of the smaller impacts. Although as individuals we are more at risk from large impacts with their global reach, a disaster manager or government official is more likely to be faced with a small impact within his or her jurisdiction. Eventually it will be necessary to decide who, or what agency, should be in charge of efforts to deal with the impact hazard, from possible extensions of the Spaceguard Survey to potential testing of defensive systems to preparing to deal with the aftermath of an impact. Within the United States, the president’s science adviser in 2010 officially nominated NASA to be the lead agency for searches, orbit determinations, and impact predictions. Other countries have not yet addressed this issue.

## Role of NASA and DOD

### Congress has delegated NEO detection and deflection mission decisions to NASA

Task Force ‘2k (British National Space Centre, Report of the Task Force on Potentially Hazardous Near Earth Objects, http://www.spacecentre.co.uk/neo/report.html)

The US Congress has named NASA to be responsible in the United States for Near Earth Objects, assisted by the United States Air Force. Within NASA, the Headquarters is responsible for soliciting and selecting all science investigations, ground-based and space-based, for the detection and scientific exploration of Near Earth Objects; for guidance on strategic planning and **mission selection**; and for coordination with other agencies and organisations including international ones. In addition, a specially created Program Office has been set up at NASA’s Jet Propulsion Laboratory to co-ordinate ground-based observations to complete the survey of objects of 1 kilometre and upwards; to facilitate communications within the observing community and between the community and the public regarding potentially hazardous objects; to respond to public inquiries; to maintain a publicly accessible catalogue of Near Earth Objects; to develop a strategy for their scientific exploration including *in situ* investigation by space missions, and to help Headquarters in its role regarding other US agencies and foreign activities. Essential to the coordination and archiving of observations, and the setting of targets for follow-up, is the Minor Planet Center based at the Smithsonian Institute at Harvard. The Minor Planet Center is broadly under the wing of the International Astronomical Union and is funded in part by NASA on an annual basis. In addition we note that the National Science Foundation is responsible for funding basic science including astronomy in universities except for work in planetary science. Some work on Near Earth Objects is nonetheless being done on National Science Foundation funded telescopes. The Department of Defense does not have planetary defence as part of its remit. But in its normal defence role in detecting incoming missiles, it observes many Near Earth Objects from both its ground- and space-based platforms.

# A2: Das & Ks

## A2: Spending

### Cost of detection

Bucknam & Gold ‘8(Mark, Deputy Dir for Plans in the Policy Planning Office of the Office of the US Secretary of Defense, Colonel USAF, PhD in War Studies from U of London, BS in physics, MS in materials science and engineering from Virginia Tech & Robert, Chief Technologist for the Space Department at the Applied Physics Laboratory of Johns Hopkins “Asteroid Threat? The Problem of Planetary Defence,” Survival vol. 50 no. 5 | 2008 | pp. 141–156)

If one or more PHOs are destined to impact Earth in the foreseeable future, the sooner the discovery, the sooner steps can be taken to prepare for and possibly prevent a cataclysm. In addition to a dedicated ground-based telescope such as PanSTARRs or LSST, the advantages of a space-based, dual-band infrared telescope argue persuasively for funding at least one. For approximately $1bn – the amount needed to fund an infrared telescope in a Venus-like orbit – we could greatly improve our knowledge of the scope and details of the threat from asteroids, as well as increase the chances of detecting any particular asteroid before it collides with the Earth. The overall costs of programmes to find and track asteroids, and to rendezvous with and study them, would amount to between $2–6bn, depending on how many rendezvous missions would be launched. The effort could be carried out over a ten-year time frame at a cost of no more than $500m per year, or less than 4% of NASA’s annual budget (approximately $17bn in 2007). By comparison, in fiscal year 2006 alone, the US Congress provided approximately $4bn for avian-flu initiatives21 – a thousand times more than it budgeted for NASA’s Spaceguard Survey programme. In 2006, the World Bank estimated that a severe pandemic with a 1% mortality rate could kill about 70m people and cost upwards of US$1.25 trillion (3.1% of global GDP).22 An asteroid the size of Apophis, which is not particularly large as asteroids go, could cause comparable levels of death and destruction.

## A2 – Moon Base Tradeoff

### International space station triggers the link

**Pasztor ‘9** (Andy, staff writer for WSJ, “NASA Budget Threatens Manned Missions, Group Says,” Wall St. Journal, http://online.wsj.com/article/SB125012680951127905.html)

None of these options solve all of the technical and budget challenges facing NASA. In addition, the White House is under pressure to continue its funding of the International Space Station beyond its current commitment of 2015. That would further siphon off funds from other manned exploration initiatives.

### Asteroid mining will give us more resources and energy than lunar mining

**Lewis & Lewis ‘5** (John S., Professor of Planetary Science and Co-Director, Space Engineering Research Center, University of Arizona, & Christopher F., earned his JD at Brigham Young Univ, 37 Geo. Wash. Int'l L. Rev. 745, lexis)

Approximately 1,400 NEAs with diameters greater than one kilometer (and a million with diameters greater than 100 meters) are presently in orbits that cross or graze Earth's orbit around the Sun. About 20 percent of these are energetically easier to reach and land on than the Moon. Some of these asteroids are extinct comet nuclei with water contents ranging up to about 50 percent; some are huge crystals of iron-nickel alloy; others belong to well over a dozen different composition classes. The NEA Amun, about two kilometers in diameter, contains far more metal than the total amount used by the human race since the beginning of the Bronze Age. Its Earth-surface market value is tens of trillions of dollars, larger than the annual gross global product of Earth. Many NEAs can return materials to Earth at a much lower energy cost than that of returning a similar mass to Earth from the Moon. In extreme cases, the energy advantage of asteroid material return relative to lunar return reaches 2500:1.

### Legal uncertainty prevents lunar mining

**Zell ‘6** (Jeremy, JD Candidate U of Minn. Law School, 15 Minn. J. Int'l L. 489, lexis)

The mining of Earth's Moon, the planet Mars, and Near Earth Asteroids (NEAs) holds the potential to be a very lucrative endeavor. [11](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&brand=&_m=83696659877cf8736a3076ff6f02e8a4&docnum=13&_fmtstr=FULL&_startdoc=1&wchp=dGLbVzz-zSkAA&_md5=468bd50d4fb91313739aa82f3203fdfd&focBudTerms=helium-3&focBudSel=all" \l "n11" \t "_self) Scientists believe that silicon on Mars, Helium-3 on the Moon, and other precious ores such as platinum on NEAs could sustain information and energy technologies on Earth for decades or centuries. [12](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&brand=&_m=83696659877cf8736a3076ff6f02e8a4&docnum=13&_fmtstr=FULL&_startdoc=1&wchp=dGLbVzz-zSkAA&_md5=468bd50d4fb91313739aa82f3203fdfd&focBudTerms=helium-3&focBudSel=all" \l "n12" \t "_self) However, the current legal uncertainty  [\*491]  regarding property rights on the Moon and other celestial bodies limits the possibility of outer space mining. Legal scholars and nations have hotly debated ambiguous language in the Outer Space Treaty and Moon Agreement declaring outer space to be the "common heritage of mankind." [13](http://www.lexis.com/research/retrieve?y=&dom1=&dom2=&dom3=&dom4=&dom5=&crnPrh=&crnSah=&crnSch=&crnLgh=&crnSumm=&crnCt=&cc=&crnCh=&crnGc=&shepSummary=&crnFmt=&shepStateKey=&pushme=1&tmpFBSel=all&totaldocs=&taggedDocs=&toggleValue=&numDocsChked=0&prefFBSel=0&delformat=XCITE&fpDocs=&fpNodeId=&fpCiteReq=&brand=&_m=83696659877cf8736a3076ff6f02e8a4&docnum=13&_fmtstr=FULL&_startdoc=1&wchp=dGLbVzz-zSkAA&_md5=468bd50d4fb91313739aa82f3203fdfd&focBudTerms=helium-3&focBudSel=all#n13) Until this confusion is resolved, it will be difficult or impossible for firms or nations to realistically consider the feasibility of mining outer space, and it will continue to be seen as a science fiction fantasy.

### Space shuttle retirement precludes moon landings

**National Review ‘9** (The Week, 9-7-9, lexis)

The Human Space Flight Plans Committee, a ten-person panel appointed by President Obama to work out a future strategy for NASA, has met with administration officials prior to its final report at the end of August. The committee's deliberations, widely leaked, do not bode well for NASA and its contractors. The space shuttle will be retired next year, leaving the U.S. with no way to put human beings in space. The shuttle's replacement will enter service around 2016 -- just as the International Space Station, a political extravaganza of no scientific value, is likely to be crashed into the Pacific Ocean. Striving to come up with manned missions we can actually afford, the panel may recommend a visit to one of the Lagrange points. These are locations in empty space, on the moon's orbital path, where physics predicts a gravitational "plateau." Some fragmentary loose matter may have settled there: interplanetary dust bunnies. This would not be NASA's most exciting mission; but it's just as far as the moon, without the expensive necessity to land on anything. Such are our current ambitions. What a falling-off was there!

### Budget constraints prevent moon landing

**Achenbach ‘9** (Joel, Washington Post Staff Writer, “NASA's Trajectory Unrealistic, Panel Says,”

http://www.washingtonpost.com/wp-dyn/content/article/2009/08/13/AR2009081302244.html)

NASA doesn't have nearly enough money to meet its goal of putting astronauts back on the moon by 2020 -- and it may be the wrong place to go anyway. That's one of the harsh messages emerging from a sweeping review of NASA's human spaceflight program. Although it is just an advisory panel, the Human Space Flight Plans Committee could turn the entire space program upside down. Appointed by President Obama and headed by retired aerospace executive Norman Augustine, the 10-person panel has held a series of marathon meetings in recent weeks to try to Velcro together some kind of plausible strategy for NASA. The agency's trajectory over the next two decades, as well as the fate of thousands of civil servants and private contractors, could be affected by the group's report, due at the end of this month. The committee members will meet with administration officials Friday and are likely to say that under current funding, there's no realistic way to get Americans back on the moon by 2020, which has been the goal since President George W. Bush signed off on the "Vision for Space Exploration" in 2004. The current NASA plan makes a moon landing in 2020 possible under the budget only if the agency de-orbits the international space station -- crashing it into the South Pacific -- in 2016. Moreover, the current strategy involves retiring the space shuttle in 2010 and replacing it with the new Ares I rocket and the Orion crew capsule, which NASA hopes would be ready to take astronauts to low Earth orbit in 2016. During the long gap in NASA's human spaceflight ability, American astronauts would have to hitch rides into space on Russian rockets. The awkward plan has been seen as a budgetary necessity, with shuttle program money flowing into the new Constellation program that features the new space hardware that could eventually put astronauts on the lunar surface. The committee has chewed over a basic paradox in the plan, which is that, even if everything went smoothly, the new rocket would not be able to get astronauts to low Earth orbit until just about the time that the space station would be fireballing its way back to Earth. Although the station has never been terribly popular with scientists, its $100 billion price tag and role in international aerospace cooperation makes its early demise politically unpalatable. The Augustine panel assumes the station's life will be extended to 2020. But under that budgetary scenario, according to the panel's just-completed analysis, the current NASA budget would not permit the launch of a new heavy-boost moon rocket, the Ares V, until 2028 -- even without any funding for key lunar-base components. "If you're willing to wait until 2028, you've got a heavy-lift vehicle, but you've got nothing to lift," said committee member Sally Ride, the former astronaut, in Washington on Wednesday at the final public meeting of the committee. "You cannot do this program on this budget."

### Agency will not divert funds away from the moon base

**Easterbrook ‘8** (Gregg, Editor of The Atlantic and The New Republic and Sr. Fellow at Brookings, “The Sky is Falling,” June, http://www.theatlantic.com/doc/200806/asteroids)

Actually, Congress *has* asked NASA to pay more attention to space rocks. In 2005, Congress instructed the agency to mount a sophisticated search of the proximate heavens for asteroids and comets, specifically requesting that NASA locate all near-Earth objects 140 meters or larger that are less than 1.3 astronomical units from the sun—roughly out to the orbit of Mars. Last year, NASA gave Congress its reply: an advanced search of the sort Congress was requesting would cost about $1 billion, and the agency had no intention of diverting funds from existing projects, especially the moon-base initiative.

## A2 Nasa Tradeoff DA

### To do anything in space, we must perfect deflecting asteroids

Butler 10, (Katherine Butler is a regular contributor to several green sites, including Ecosalon and MNN, 4/19/10, “NASA's new asteroid mission could avert disaster on Earth”, http://www.mnn.com/earth-matters/space/stories/nasas-new-asteroid-mission-could-avert-disaster-on-earth, SH)

**President Obama recently announced that he wants an American spacecraft to visit an asteroid by 2025**. Experts say this goal will be extremely difficult to attain in 15 years because of the planning needed to rendezvous with an unscheduled asteroid. But Space.com reports that other experts say it is a mission that cannot be completed soon enough — the ability to nudge an a space rock from its path could help deflect future asteroids aimed at Planet Earth. **NASA is focusing its efforts on finding the right asteroid to knock off course. John Grunsfeld is an astrophysicist and a former NASA astronaut who flew on five shuttle missions. As he told Space.com, “by going to a near-Earth object, an asteroid, and perhaps even modifying its trajectory slightly, we would demonstrate a hallmark in human history … [It would be] the first time humans showed that we can make better decisions than the dinosaurs made 65 million years ago." He explained that if scientists don’t work on a solution to changing the path of an asteroid, life as we know it will certainly be ended by one**. According to Space.com, scientists estimate there are about 100,000 asteroids and comets near Earth and that 1,000 of them could be potentially dangerous. About a dozen of these asteroids could be reached by astronauts, but the target would have to be at least 300 feet wide to make it worth the trip. Even so, spacecrafts have landed on asteroids before. Japan's Hayabusa spacecraft just traveled to the asteroid called Itokawa, where it attempted to collected samples for scientists. **Obama’s asteroid mission is the first step in the ultimate goal of landing on Mars.** This mission would be complicated. **First, the flight to a space rock would likely take months. Then astronauts would have to be tethered to the asteroid to keep from floating away, as gravity forces would not be in effect.** In addition, the space flyers would be outside the Earth’s protective magnetosphere and would be exposed to harsh radiation. Nonetheless, some feel this is a risk we should take. TV's Bill Nye the Science Guy, vice president of the Planetary Society, told Space.com that "it's every bit as exciting in a different way, we're going to deep space. You turn around and take a picture of the Earth, and it's going to be a dot. You're not even going to see the atmosphere.” **Sure, it’s risky and dangerous — but saving the planet could be a cool payoff.**

## A2 Zizek

### Zizek votes aff. NEOs are real threats that are not constructed and cannot be answered by philosophy, only dealt with by *real* action.

Slavoj Zizek 2009 your author, celebrity philosopher, future rehab all-star – Interview posted on the web. “Zizek! – Full transcript” http://beanhu.wordpress.com/2009/12/07/zizek/

Let’s show them all, huh? Okay, philosophy. This, I can do it, at least traditionally, in two lines, no? Philosophy does not solve problems. The duty of philosophy is not to solve problems but to redefine problems, to show how what we experience as a problem is a false problem. If what we experience as a problem is a true problem, then you don’t need philosophy. For example, let’s say that now there would be a deadly virus coming from out there in space, so not in any way mediated through our human history, and it would threaten all of us. We don’t need, basically, philosophy there. We simply need good science desperately to find… We would desperately need good science to find the solution, to stop this virus. We don’t need philosophy there,because the threat is a real threat, directly. You cannot play philosophical tricks and say “No, this is not the”… You know what I mean. It’s simply our life would be… or okay, the more vulgar, even, simpler science fiction scenario. It’s kind of “Armageddon” or whatever. No, “Deep Impact.” A big comet threatening to hit Earth. You don’t need philosophy here. You need… I don’t know. To be a little bit naive, I don’t know. Strong atomic bombs to explode, maybe. I think it’s maybe too utopian. But you know what I mean. I mean the threat is there, you see. In such a situation, you don’t need philosophy. I don’t think that philosophers ever provided answers, but I think this was the greatness of philosophy, not in this common sense that philosophers just ask questions and so on.

### Zizek votes aff – most of reality is constructed – asteroids are real threats.

Zizek 2009, Slavoj – your author, celebrity philosopher, future rehab all-star. In Defense of Lost Causes p. 370-1

Is this duality not prefigured in the Heideggeriann struggle between World and Earth, which we encounter, today, in the antinomy that defines our experience? On the one hand, there is the fluidification (volatilization) of our experience, its desubstantialization; this exponentially' exploding " lightness of being" culminate in the cyber-dream of the transformation of our very identity as a human being from hardware to software, to a program able to be reloaded from one to another hardware. Reality is here virtualized, any failure can be undone by rewinding and having another try at it. However, this virtualized world in which we dwell is threatened by the shadow of what we usually designate as the prospect of ecological catastrophe - the imponderable heaviness and complexity, the inertia of Earth catching up, reminding us of the fragile equilibrium which forms the invisible background foundation of our survival on Earth and which We can destroy (and thus destroy ourselves) – through global warming, through new viruses, through a gigantic asteroid hitting the Earth… Never in the history of humanity was the tension so palpable between the unbearable lightness of our being (the media providing us with the strangest sensations with a click, cutting through the resistance of reality, promising a “frictionless” world) and the unpredictable background of the Earth.

## A2 – Doomsaying K

### Must focus on extinction-level event

Cambier & Mead ‘7 (Doctors Jean-Luc & Frank, Air Force Research Laboratory, On NEO Threat Mitigation, Oct. http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA474424&Location=U2&doc=GetTRDoc.pdf)

The diameter threshold between the first and second classes can be set to approximately 140 m, following [1], while the threshold between second and third categories is more of the order of 1 km. It is the class-3 (“Large”) impact which is of concern here. One should not be lulled into a false sense of security by the extreme dilution of the probability distribution of very rare events5 – given the death statistics, any person living in the US can expect to live an average of 50,000 years before being killed by a lightning strike, yet most people take reasonable precautions against such an event. While impacts from smaller objects are more probable within the next few decades, we can always survive those if caught unprepared. It has been repeatedly suggested elsewhere that the effort in NEO threat mitigation should be focused on small objects (< 100 m) (e.g. [5]); while the much higher frequency of such impacts makes the threat more understandable to the general public, the argument that this would result in an active program is highly doubtful. The relatively minor consequences of such an impact inevitably force a comparison with other natural (hurricanes, earthquakes, tsunamis, volcanic eruptions) or man-made (acts of terrorism) event categories, with a lobbying constituency behind each. Given limited resources, it would not be reasonable to expect the U.S. Congress to be more amenable to fund a program preventing an impact by a 100 m asteroid – likely to land in some unpopulated area – as opposed to hurricane or earthquake preparation. On the other hand, there is no comparison to the sheer magnitude of an extinction-class impact. The very low probability of such an event makes it equally difficult for leaders, even with extraordinary vision, to support a mitigation program against this class of threats; nevertheless, it would be prudent to do so, and focusing on minor threats may not enable us to prevent the disaster that really counts…

## A2 – Anthropocentrism K

### We should act to prevent a NEO strike

Morris 2k (Julian, Director of the Environment and Technology Programme at the Institute of Economic Affairs in London, Rethinking risk and the precautionary principle pg 108)

Before considering the implications of applying the precautionary principle to the NEO threat, it is first necessary to ask whether the precautionary principle should be applied to this class of threat at all. From an ecocentric perspective, it might be argued that interfering in the course of nature is wrong. NEOs are no less part of the natural order than are volcanoes and earthquakes, so following ecocentric reasoning nothing should be done about them. However, this objection is convincing only if we are willing from the start to read human being out of nature entirely, that is, if the precautionary principle is not just anti-antropocentric but overtly misanthropic. Other species are, within their capacities, expected to act in ways that preserve themselves and foster the conditions necessary for their existence. Furthermore, if it were possible to forestall an NEO collision, it would not only be humankind that would benefit, but the order of nature on Earth as we presently know it as a whole. Inasmuch as the precautionary principle favours the status quo above anything else, it would seem to be incompatible for the ecocentric argument against actions to avert NEO collisions (O’Riordan and Cameron, 1994b, p.16).

# Asteroids Education – T & Fwk

## Key to solve

### This topic is a unique opportunity for us to educate one another about asteroids. This is an advantage to our interpretation with science education and extinction-level impacts that turn and outweigh the negative’s fairness and education voters.

Hartwell ‘7(William, fellow at Desert Research Institute, Division of Earth and Ecosystem Sciences, Ch. 3: The Sky on the Ground: Celestial Objects and Events in Archaeology and Popular Culture, in *Comet/Asteroid Impacts and Human Society: An Interdisciplinary Approach*, SpringLink)

Although cinematic film can be an excellent tool in raising public awareness, **the task of public education on the true scientific nature of the NEO issue remains an extremely important one, albeit one that perhaps should be undertaken as a part of policy implementation** rather than as a prerequisite. There are several obstacles that will need to be overcome with regards to educating the public about the near-Earth object issue. The first has to do with the general state of the public’s science education, which is necessarily tied to its perception of science and scientists. The general level of science education of members of the public is quite low (speaking from a U.S.-centric position). Even students who take basic core science classes at the university level often complete those classes without a complete understanding of how the process of scientific inquiry works (Mole 2004). Instead, Mole explains, **they are** often **introduced to classes** concerning the interaction of science and society that concentrate on real and imagined deficiencies of science, while **neglecting** important topics such as the history of science, the role of the peer review process, and **discussions on** why individual scientists may have widely **divergent views** on a particular subject. This last point is especially germane when dealing with members of the public who have no science background whatsoever. When addressing an issue such as near- Earth objects, the public can become easily confused by lack of consensus among scientists. The diverse range of views regarding the likelihood of catastrophic impact over a given time period and its resultant effects (e.g. Bryant 2001; Chapman 2004; Chapman and Morrison 2003; Keller 1997; Marsden 2004; Masse, Chap. 2 of this volume; Svetsov 2003; Yabushita 1997) particularly when filtered through various popular science media (e.g. Anonymous 1998; Applegate 1998; Dalton 2003; Hecht 2002; Ravilious 2002) can end with the layperson throwing up his or her hands in exasperation and walking away from the issue altogether. Peer-review, disagreement, and discourse are, after all, part of the process of conducting science, but many in the general public are unaware of this. Finally, cinematic film may do wonders to increase public awareness of important scientific issues, but public perception of science and scientists is, at least in part, shaped by their portrayals in popular cinematic film, and video and TV programs. Such portrayals are often less than flattering, with the “mad” (e.g. Frankenstein) or bumbling scientist stereotype perpetuated and the idea that science itself is responsible for the world’s ills (Haste 1997; Steinmuller 2003). 3.5 Conclusions In industrial societies, the celestial constants and some phenomena have been relegated to the realm of scientific curiosity. However, unusual transient events can trigger significant, albeit often brief, resurgences in public interest. It is clear that public understanding of and interest in the near-Earth object issue has undergone a transformation over the last decade that was initiated by the impact of comet Shoemaker-Levy 9 on Jupiter. This real-world event and the resultant popular cultural cinematic productions helped focus the public on the actual threat that near-Earth objects present, and also greatly increased public awareness and potential support for development and implementation of public policy on the issue. **When targets-of-opportunity arise**, such as feature films addressing topics of serious scientific concern, **scientists should take a proactive role in initiating and participating in frank discussions** that engage the public **on relevant issues** depicted in mass popular culture, **offering correction and explanation** when appropriate, and availing themselves of the opportunity to educate about the process of science at the same time. **Science fiction** film **can also present excellent opportunities to teach students about real science and the process of critical thinking** (Dubeck et al. 1988). As an additional measure, **promoting good general science education at all educational levels** will **ensures that the future public is better equipped to independently evaluate where their support should be focused on such issues.**

### The asteroids debate is an important one—it serves a key educational function that is a prerequisite for us to demand that the government take appropriate action.

**Hermelin ‘7** (Michael, prof at EAFIT Universidad, Medellin, Colombia, Ch. 30: Communicating Impact Risk to the Public, in *Comet/Asteroid Impacts and Human Society: An Interdisciplinary Approach*, SpringLink)

In fact, moviemakers have already discovered the bounty which sensationalism can draw from NEO impacts and have produced at least two memorable films, Armageddon and Deep Impact, which grossly falsify many of the real aspects of the problem. Documents such as the one prepared by the Discovery Channel are of course much more recommendable, but are of relatively limited reach. The challenge for ICSU is the immediate preparation of a worldwide program designed to give people an objective vision about what NEO impacts really mean for humanity. It does not seem convenient to wait until a hazardous one appears to start acting. If this idea is acceptable, ICSU should become the “official voice” and assume responsibilities implied by this role: this would include the fact that information to be broadcast must be “understandable, credible, solicit the proper response and not confuse the public”. Precautions must be taken to ensure that this information can reach marginal and remote populations; this is of great importance in underdeveloped countries (Landis 2003). Finally, once the program has started, communication should be continuous in order to warrant its effectiveness and also the confidence of those who receive the information (Gross 2003). Considering that the challenge is more an **education goal** than a merely informative one, the following scheme is proposed; it must be clearly stated that what is being considered in the actual context is an educational approach, very different from the diffusion of a “before the event” notice implying well-defined measures to be taken by authorities and populace. The expected results would be the motivation on the part of the natural authorities to act in order to implement better comprehension of the NEO problem by their countries’ populations.

## Uniqueness – Asteroid Education Low Now

### Lack of education over the asteroid impact now.

Morrison ‘7(David, PhD and senior scientist at the NASA Astrobiology Institute, Ch. 8: The Impact Hazard: Advanced NEO Surveys and Societal Responses, in *Comet/Asteroid Impacts and Human Society: An Interdisciplinary Approach*, SpringLink)

There are numerous challenges in communicating the nature of the impact hazard to both decision-makers and the public. NEO impacts are qualitatively different from any other hazard, in that the numbers of people killed could be far larger than in any natural disaster that has occurred during historical times, and may approach the whole population of the planet. Because of their rarity, people do not have direct knowledge of the destructive potential of an impact. Many political leaders feel they can ignore this problem, since it is unlikely that anything bad will happen “on their watch.” At the opposite extreme, however, there is a tendency in some quarters to exaggerate the risk and to issue repeated warnings of impacts that never happen.

### Asteroid education is an uphill battle

Reaves 2k(Jessica, reporter for Time, “When Asteroids Attack: Will Killer Rocks Hit the Earth?” 1-4, Time, http://www.time.com/time/arts/article/0,8599,36882,00.html)

This is a case where the public and scientists search for a state of mind that eschews panic but retains its focus. The chance of a truly devastating asteroid hitting the Earth is "small but real," says TIME science writer Jeffrey Kluger. "But let's face it," he adds, "it's like a big billiard table out there," with rocks and planets and moons zipping around each other in space. Some folks may never admit that there is any risk, and reject the need for taxpayer-funded research: Even after the widespread success of the summer disaster movies, "Armageddon" (which Jaroff calls "ridiculous") and the "far more realistic" "Deep Impact," legions of nonbelievers remain. And while Jaroff sometimes finds it difficult to educate the most die-hard skeptics of the real risk posed by asteroids, he keeps trying. "I used to tell people that even if an asteroid were to break into relatively small pieces, each of those pieces would have the power to destroy Cleveland. But," he muses, "no one seemed to care."

## Asteroid Communication k to policy

### Effective communication about asteroid threats is critical to future policymaking.

DAVID MORRISON 2010 Director, Carl Sagan Center for Study of Life in the Universe, SETI Institute Senior Scientist, NASA Ames Research Center “Impacts and Evolution: Protecting Earth from Asteroids1” PROCEEDINGS OF THE AMERICAN PHILOSOPHICAL SOCIETY VOL. 154, NO. 4, DECEMBER 2010

For the non-science policy maker, the impact hazard is a complex problem featuring the interactions of physical, technical, and social systems under conditions of great uncertainty. Communications are key, since in the end it is society’s perception and evaluation of this hazard that are likely to determine what social and economic resources are applied. Policy makers will be dealing implicitly with the costs of action vs. the costs of inaction. From their perspective, even such an “innocent” fi rst step as the Spaceguard Survey may have substantial social or political costs—for example if frequent “false alarms” persuade the public that scientists are incompetent and are squandering public funds, or if the existence of a survey triggers public demand for more expensive defense systems that decision makers are not prepared to provide (Sommer 2005).

# Ethics/Framework

## High Risk of Extinction

### Err Aff – uncertainty means you should default to worst-case predictions – precautionary principle

Seamone, 4 [Evan, J.D., University of Iowa College of Law; M.P.P. and B.A., University of California, Los Angeles. Evan Seamone is an attorney and a Judge Advocate in the U.S. Army stationed at Fort Polk, Louisiana, “The Precautionary Principle as the Law of Planetary Defense: Achieving the Mandate to Defend the Earth Against Asteroid and Comet Impacts While There is Still Time,” Georgetown International Environmental Law Review. Washington: Fall 2004. Vol. 17, Iss. 1; pg. 1, 23 pgs]

Although the topic of asteroids and comets striking the earth (natural impact) has caused innumerable skeptics to roll their eyes condescendingly,1 the public came very close to knowing the horror of an impending asteroid disaster first-hand on January 13, 2004. On the very day before President George W. Bush was expected to deliver a speech on the new American space policy, asteroid threat detection experts contemplated issuing a warning that an asteroid named 2004 ASl could collide with the Earth within 36 hours.2 Unlike other recent "near misses," this one prompted agencies like the National Aeronautics and Space Administration (NASA) to consider their limitations in responding to a short-notice asteroid threat and their subsequent responsibility to notify more capable operational agencies.3 For the first time, scientists were forced to answer the difficult questions that they had previously entertained only as brainteasers: \* which agencies are responsible for planetary defense; \* what options do they have in mounting an effective defense; \* how do they determine unacceptable consequences in their selection of methods to prevent utter chaos; \* who has the final say; and \* what guarantees that nations will cooperate in defensive measures rather than taking a unilateral approach?4 For a brief time while decision-makers confirmed the nature of the threat posed by 2004 ASl, the total lack of answers to these questions indicated to the scientific community the importance of clarifying such "rules of the road" as quickly as possible. Fortunately, the threat posed by 2004 ASl never materialized. Even before the 2004 ASl incident, space policymakers were beginning to recognize the need for mitigation measures.5 While no living person has experienced the horror of a massive asteroid or comet strike, the inherent threats from space debris and deorbiting space stations have independently alerted governments of their need to plan for such dangers. While developing threat response programs to address the falls of Skylab in 1979 and the Mir Space Station in 2001, various agencies considered several different collision scenarios and concluded that no amount of planning fully contain all potential threats.6 Without question, asteroids and comets are distinct from falling space stations or space debris because they are far less predictable and pose much greater harm. First, the lack of a coordinated series of telescopes across the globe makes it impossible for astronomers to monitor all potential asteroid and comet threats.7 As a result, some policymakers have wagered that novice sky watchers will be just as likely as professional astronomers to spot the next significant asteroid or comet threat.8 In addition to inadequate monitoring capabilities, some threats, such as long period comets, may emerge so quickly that they will evade even the best telescopes altogether or until it is too late to respond.9 Second, unlike Skylab or the Mir Space Station, the collision of even a smaller range asteroid can cause damage similar to the detonation of a nuclear bomb.10 While scaremongers or filmmakers may dwell entirely on horrific predictions of significant damage, it is evident to even the most objective scientist that victims of an asteroid or comet impact face severe consequences. Impacts in the oceans will endanger coastal regions with tsunamis; direct impacts with land could result in a host of problems, like earthquakes in proximate regions, individuals losing their hearing from the sound of the strike, and poisoning of the atmosphere.11 Based on predicted harm to earth populations, statistical analyses of the likelihood of another significant impact, and continuing discovery of large asteroid craters across the globe, international policymakers have concluded that a real threat will require international cooperation, and that decisions made in the near-term may have consequences for many generations to come.12 Ultimately, governments can increase the chances of limiting or eliminating threats to an impact zone by detecting such threats long before the impact is due. With enough time to mount defensive measures from a space station or from earth, governments will be able to deflect or destroy the oncoming object. However, even if time is limited or affirmative defensive measures fail, agencies can secure life and property by effectively preparing local governments and their citizens to evacuate and survive under the difficult and undesirable conditions. In light of recent unexpected crises including the international outbreak of Sudden Acute Respiratory Syndrome (SARS), widespread blackouts affecting Canada and the United States, and continued terrorist activities across the globe, planners are beginning to recognize the public's increasing vulnerability to unpredictable threats. Perhaps the greatest stride in planning has been the Department of Homeland security's development of the National Response Plan, which is designed to consolidate various threat-specific policies into a single all-hazards plan to deal with sudden onset harm.13 Natural impact falls within this scope of unpredictable harm because planners suffer from a lack of experience deflecting and destroying threatening space objects.14 In the context of planetary defense, proclamations that nations and local governments must cooperate accomplish nothing of substance. Such gestures are, in fact, not much different from the concerns historically voiced by experts in relation to all space threats. In the 1960s, legal scholars attacked the vague principles regarding cooperation and concern for future generations on the basis that these policies contributed to a "legal vacuum" in space, devoid of practical guidance.15 The greatest problem then, and now, is that well-intentioned principles impair the ability of governments to address foreseeable danger because these vague principles create a false sense that important inroads have been forged.16 Despite the provisions of the existing Outer Space Treaty, and several United Nations policies and proclamations, none of these documents provided clear direction to the international community regarding responsibilities to deal with the fall of Skylab.17 The historical push for greater, more meaningful, regulation of space harm provides a working definition for true progress in planetary defense: "detailed administration," opposed to "the language of agreement,"18 coupled with "methods for reaching specific decisions in particular cases."19 This Article addresses four legal and policy aspects of planning for sizeable asteroid and comet threats. Part II explains specific measures required by the precautionary principle. The purpose of this Part is to provide the general theoretical basis underlying governmental obligations to take certain actions to prepare for, respond to, and recover from natural impact threats. Part III applies Homeland security Presidential Directive/HSPD-5 to the threat of asteroid and comet impact. HSPD-5 is crucial to planetary defense because it reveals that the U.S. Government recognizes an obligation to act preventively against all potentially serious, national-level threats. While the document is still being revised, it must inevitably deal with the problem of natural impact and, as a result, represents a significant stride in space disaster mitigation. Part IV considers the potential liability that governments face for inaction or accidents encountered during deployment of defensive measures. It emphasizes that the need to take preventive action is entirely separate from the issue of how governmental agencies should conduct themselves in an operational sense. While nations have an inherent right to self-defense under the United Nations Charter,20 they cannot defend themselves with any and all possible means. Operational considerations such as necessity and the use of proportional force provide guidance.21 Considerations of governmental liability will assist agencies responding to natural impact in a similar way by providing additional considerations while the agencies act on their obligation to mount defensive measures. Finally, Part V shares helpful lessons in organization and collaboration gleaned from public health, especially in the area of infectious disease law and policy at domestic and international levels. These final considerations emphasize that some problems are so common to all crises that their successful resolution in one context will assist governments in another context, even when, as in this case, it is difficult to appreciate even the possibility of natural impact devastation. All the considerations addressed by this Article apply equally to any asteroid or comet threat regardless of the amount of time existing before an impact is due, including threats that manifest with no notice at all. II. THE PRECAUTIONARY PRINCIPLE The precautionary principle governs responses to unknown types of harm. In many international agreements and other bodies of rules, the principle obligates governments to institute measures to prevent potential harm from a source, even if it is not certain if, when, or where, the harm will occur.22 The current policy of the United States requiring agencies to prevent terrorist attacks before they occur rests squarely within this principle. Mitigation measures contained in this policy depend on preventive and anticipatory action: "[t]he greater the threat, the greater the risk of inaction-and the more compelling the case for taking anticipatory action to defend ourselves, even if uncertainty remains as to time and place of the enemy's attack."23 In the context of planetary defense, the same principle applies because some natural impact threats can strike without notice (e.g., long-period comets). Likewise, in hypothesized situations where asteroids are spotted with some advance notice, response times may require so much preparation that delaying action will preclude effective intervention. In line with the precautionary principle, lawmakers and planners should be cautious of adopting different alternatives to deal with asteroid and comet threats that are projected to occur within different timeframes.24 While some priorities must change over time, such as evacuating people in impact zones closer to the time of impact, governments must be capable of responding to threats of the greatest magnitude at all times. Planning for a "worst case scenario" is common in disaster relief circles. Whether the harm is an earthquake, flood, or other natural disaster, the government's goal must be to withstand maximum harm; not only harm that is considered "normal."25 The logic underlying this practice recognizes that there may only be one chance to avert significant harm. Multiple plans for every imaginable scenario could lead to mass confusion.26

### Probability of extinction level strike is unacceptable

Bucknam & Gold ‘8(Mark, Deputy Dir for Plans in the Policy Planning Office of the Office of the US Secretary of Defense, Colonel USAF, PhD in War Studies from U of London, BS in physics, MS in materials science and engineering from Virginia Tech & Robert, Chief Technologist for the Space Department at the Applied Physics Laboratory of Johns Hopkins “Asteroid Threat? The Problem of Planetary Defence,” Survival vol. 50 no. 5 | 2008 | pp. 141–156)

On 13 April 2029, an asteroid the size of 50 US Navy supercarriers and weighing 200 times as much as the USS Enterprise will hurtle past the Earth at 45,000 kilometres per hour – missing by a mere 32,000km, closer to Earth than the 300 or so communications satellites in geosynchronous orbit. In astronomical terms it will be a very near miss. The asteroid, called 99942 Apophis, is named after an ancient Egyptian god of destruction: for several months after it was discovered in 2004, scientists were concerned that Apophis might strike the Earth. It still might, though not in 2029. If, on its close approach in 2029, Apophis passes through what is known as a ‘gravitational keyhole’, its orbit will be perturbed so as to cause it to hit the Earth in 2036 – striking with an energy equivalent to 400 megatonnes of TNT. Although the chances of a 2036 impact are judged to be just one in 45,000, it is unnerving to recall that until just a few years ago, Apophis was completely unknown to mankind, and that similarly sized asteroids have silently shot past Earth in recent years, only to be discovered after the fact. An asteroid like Apophis would cause considerable damage if it collided with Earth. If it hit on land, it would make a crater about 6km across and the shock wave, ejecta and superheated air would level buildings and trees and ignite fires over a wide area.1 If it hit an ocean, it would cause a devastating cycle of gradually diminishing tsunamis. Scientists cannot yet predict the exact point Apophis might impact in 2036, but their current assessment predicts it would be somewhere along a long, lazy backward ‘S’ running from northeastern Kazakhstan through Siberia, north of Japan and across the Pacific Ocean before dipping south to converge with the west coast of North America; running eastward across Panama, Columbia and Venezuela, and finally terminating around the west coast of Africa near Senegal. The mid-point of this line lies several hundred kilometres west of Mexico’s Baja Peninsula, about midway between Honolulu and Los Angeles. The tsunami from an ocean impact would likely inflict horrific human and economic losses – damage from Apophis could certainly surpass the Indian Ocean tsunami of 26 December 2004, which claimed over 200,000 lives and inflicted damages on the order of $15 billion. Small Probability, Huge Impact Apophis is not the only massive and potentially threatening object crossing Earth’s orbit. Larger objects that could inflict even greater damage also circulate in Earth’s neighbourhood. Fortunately, larger objects are proportionally rarer. There are roughly 100 times as many objects onetenth the size of Apophis, and only one-hundredth as many objects ten times its size. At one-tenth the size of Apophis – approximately 23m across – an asteroid is big enough to make it through Earth’s atmosphere but unlikely to do widespread damage. As a point of comparison, some 50,000 years ago an asteroid roughly 46m in diameter is thought to have created Arizona’s impressive 1,200m-wide Meteor Crater. Scientists estimate impacts from asteroids of that size occur, on average, approximately once every 1,000 years.2 At ten times the size of Apophis – roughly 2.3km across – an asteroid colliding with Earth would cause global effects and could kill tens of millions, if not billions, of people. Finally, the National Aeronautics and Space Administration (NASA) has categorised a strike from a 10km-wide asteroid as ‘an **extinction-class event’**.3 An asteroid of that size is widely believed to have hit the continental shelf off Mexico’s Yucatán Peninsula some 65m years ago, near the present-day town of Chicxulub, wiping out an estimated 70% of all animal species, including the dinosaurs.4 Fortunately, such catastrophes are estimated to occur only once every 100m years.5 On average, a 1.5km asteroid will strike the Earth approximately every 500,000 years. The devastation from such an impact could kill up to 1.5 billion people. In one sense, that puts the risk of dying from an asteroid strike on a par with dying from a passenger-aircraft accident—around 1 in 20,000 averaged over a 65-year lifetime. But half a million years is so long compared to a human lifespan that it defies believable comparison. Twenty thousand generations will go unscathed for each generation that is decimated by a 1.5km asteroid. Aeroplanes have been around for little more than a century, and fatal aircraft accidents occur every year, so it is not difficult to convince people of the risks associated with flying and the need to spend money to improve flying safety standards. The chances of Earth being hit by a comet are even smaller than for asteroids. This is a very good thing: comets travel faster and would deliver about nine times as much energy as comparably sized asteroids. When Comet Shoemaker–Levy 9 broke up and slammed into Jupiter in 1994, one of its fragments delivered energy equivalent to 6 million megatonnes of TNT, hundreds of times more energy than in all of the world’s nuclear arsenals combined. Long-period comets spend most of their existence in the outer regions of the solar system, beyond the orbits of Jupiter, Saturn, Uranus and even Neptune, infrequently visiting the neighbourhood of the inner planets. Unfortunately, such comets, unknown to us, would only become visible when they were within 6–18 months of possibly striking Earth, leaving little time to react. There has not been a single recorded incident of a person being killed by a meteoroid, asteroid or comet, so it is understandable that most people, including scientists, have not traditionally worried about the threat posed by space objects. It is to be hoped that Apophis will not pass through the ‘gravitational keyhole‘ that would put it on course to collide with Earth in 2036, and that there are no undetected asteroids or comets on such a course. But hope is not a strategy, and as small as the probabilities might be, the possible consequences of such an impact merit efforts to mitigate the risk. Despite human inventiveness and rapidly expanding knowledge, the ability to detect threatening asteroids and comets is weak, and there are no proven systems for deflecting them. Scientists have identified the problem and analysed possible approaches for addressing it, but no one has begun to implement any of the proposed techniques. The threat of collision from asteroids and comets calls for a three-step approach to mitigating the risks: first, find and track objects that are potentially hazardous to the Earth; second, study their characteristics so as to understand which mitigation schemes are likely to be effective; and third, test various deflection techniques to ascertain the best way to adjust the orbits of asteroids and comets, and possibly field a planetary-defence system. Each of these steps would benefit from international cooperation or agreement. It takes an asteroid like Apophis, or a comet like Shoemaker–Levy 9, to remind us that the threat from space is real. And while the probabilities of a strike are small, the consequences are potentially cataclysmic, making our current state of near ignorance unacceptable.

## Extinction FW good

### Extinction policymaking frameworks are good.

Jason G. Matheny 2007 Department of Health Policy and Management, Bloomberg School of Public Health, Johns Hopkins University “Reducing the Risk of Human Extinction” Risk Analysis, Vol. 27, No. 5, 2007

We may be poorly equipped to recognize or plan for extinction risks (Yudkowsky, 2007). We may not be good at grasping the significance of very large numbers (catastrophic outcomes) or very small numbers (probabilities) over large timeframes. We struggle with estimating the probabilities of rare or unprecedented events (Kunreuther et al., 2001). Policymakers may not plan far beyond current political administrations and rarely do risk assessments value the existence of future generations.18 We may unjustifiably discount the value of future lives. Finally, extinction risks are market failures where an individual enjoys no perceptible benefit from his or her investment in risk reduction. Human survival may thus be a good requiring deliberate policies to protect.

## Future Discounting

### Future discounting means we should prefer future generations to our own.

Jason G. Matheny 2007 Department of Health Policy and Management, Bloomberg School of Public Health, Johns Hopkins University “Reducing the Risk of Human Extinction” Risk Analysis, Vol. 27, No. 5, 2007

An extinction event today could cause the loss of thousands of generations. This matters to the extent we value future lives. Society places some value on future lives when it accepts the costs of long-term environmental policies or hazardous waste storage. Individuals place some value on future lives when they adopt measures, such as screening for genetic diseases, to ensure the health of children who do not yet exist. Disagreement, then, does not center on whether future lives matter, but on how much they matter.6 Valuing future lives less than current ones (“intergenerational discounting”) has been justified by arguments about time preference, growth in consumption, uncertainty about future existence, and opportunity costs. I will argue that none of these justifications applies to the benefits of delaying human extinction. Under time preference, a good enjoyed in the future is worth less, intrinsically, than a good enjoyed now. The typical justification for time preference is descriptive—most people make decisions that suggest that they value current goods more than future ones. However, it may be that people’s time preference applies only to instrumental goods, like money, whose value predictably decreases in time. In fact, it would be difficult to design an experiment in which time preference for an intrinsic good (like happiness), rather than an instrumental good (like money), is separated from the other forms of discounting discussed below. But even supposing individuals exhibit time preference within their own lives, it is not clear how this would ethically justify discounting across different lives and generations (Frederick, 2006; Schelling, 2000). In practice, discounting the value of future lives would lead to results few of us would accept as being ethical. For instance, if we discounted lives at a 5% annual rate, a life today would have greater intrinsic value than a billion lives 400 years hence (Cowen&Parfit, 1992). Broome (1994) suggests most economists and philosophers recognize that this preference for ourselves over our descendents is unjustifiable and agree that ethical impartiality requires setting the intergenerational discount rate to zero. After all, if we reject spatial discounting and assign equal value to contemporary human lives, whatever their physical distance from us, we have similar reasons to reject temporal discounting, and assign equal value to 6 Some philosophers hold that future lives have no value, but this view is at odds with many of our deepest moral intuitions. See, for instance, Broome (2004), Hare (1993), Holtug (2001), Ng (1989), Parfit (1984), and Sikora (1978). human lives, whatever their temporal distance from us. I Parfit (1984), Cowen (1992), and Blackorby et al. (1995) have similarly argued that time preference across generations is not ethically defensible.7

## OW nuclear war

### Asteroids are deadly- OW nuclear war.

Physorg 08, (“Researchers will study ways to deflect asteroids”, 5/26/08, http://www.physorg.com/news131031466.html, SH)

**Despite the lack of an immediate threat from an asteroid strike, scientific evidence suggests the importance of researching preventive measures**. Sixty-five million years ago, a six-mile-wide asteroid struck near the Yucatan Peninsula in Mexico and created the 106-mile-diameter Chicxulub Crater. Most scientists now believe that a global climate change caused by this asteroid impact may have led to the dinosaur extinction. Seventy-four million years ago, a smaller one-mile-wide asteroid struck in central Iowa, creating the Manson Crater. Now covered with soil, it is the largest crater in North America at more than 23 miles across. **Just 100 years ago**, June 30, 1908, **an asteroid or comet** estimated at 100–200 feet in diameter **exploded in the skies above** Tunguska, **Siberia**. Known as the Tunguska Event, **the explosion flattened trees and killed other vegetation over a 500,000-acre area.** But **if the explosion had occurred four hours later, it would have destroyed St. Petersburg or Moscow with an equivalent energy level of about 500 Hiroshima nuclear bombs.**

## Small Asteroid OW Nuclear War

### Even a small NEO strike outweighs nuclear war

Schweickart ‘4(Russell, Chair of the B612 Foundation, “Near-Earth Objects,” testimony before the Committee on Senate Commerce, Science and Transportation Subcommittee on Science, Technology, and Space, Apr.7 CQ, lexis)

First I'd like to thank you for the invitation to speak with you today about this emerging public policy issue of near Earth objects (NEOs) threatening life on Earth. One might have thought, just a few years ago, that the subject of asteroids was one for space wonks and wanna-be astronauts and astronomers. But today the realization is rapidly dawning on the media and the general public that asteroids are a subject of more than passing interest! More and more people are coming to know that some few of these asteroids do not silently pass the Earth, but indeed crash in, largely unannounced. On the rare occasions when this happens they can wreak havoc of a magnitude unprecedented in human history. At the upper limit impacts by large asteroids have caused global destruction leading to the virtually instantaneous extinction of life for most of the species living at the time. The dinosaurs were momentary witnesses to a billion megaton event of this kind 65 million years ago. At the **lower limit** of concern, but occurring much more frequently, we are dealing with events with an explosive force of 10-15 megatons. It is worth pointing out, however, that these small, most frequent events are more powerful than the blast from the most powerful nuclear weapon in the current U.S. nuclear arsenal.

## Nuclear War ≠ Extinction

### Computer simulations disprove nuclear winter

Seitz ‘6(Russell, former Presidential science advisor and keynote speaker at international science conferences, holds multiple patents and degrees from Harvard and MIT, “The ‘Nuclear Winter’ Meltdown,” 12-20, http://adamant.typepad.com/seitz/2006/12/preherein\_honor.html)

Apocalyptic predictions require, to be taken seriously higher standards of evidence than do assertions on other matters where the stakes are not as great." wrote Sagan in Foreign Affairs, Winter 1983 -84. But that "evidence" was never forthcoming. **'Nuclear Winter' never existed outside of a computer** except as air-brushed animation commissioned by the a PR firm - Porter Novelli Inc. Yet Sagan predicted "the extinction of the human species " as temperatures plummeted 35 degrees C and  the world froze in the aftermath of  a nuclear holocaust.  Last year, Sagan's cohort tried to reanimate the ghost in a machine anti-nuclear activists invoked in the depths of the Cold War, by re-running equally arbitrary scenarios on a modern interactive Global Circulation Model. But the Cold War is history in more ways than one. It is a credit to post-moderncomputer climate simulations that they do not reproduce the apocalyptic resultsof what Sagan oxymoronically termed "a sophisticated one dimensional model. "The subzero 'baseline case' has melted down into a tepid 1.3 degrees of average cooling grey skies do not a Ragnarok make . What remains is just not the stuff that End of the World myths are made of.

### Nuclear winter wouldn’t cause extinction anyway

Holtz ’5(Brian, M.S. in AI from the U. of Michigan, “Possible Future Global Catastrophes,” Human Knowledge: Foundations and Limits,” http://humanknowledge.net/SocialScience/Futurology/Catastrophes.html)

Nuclear Catastrophe. Nuclear power could result in three kinds of catastrophe: radioactive pollution, limited nuclear bombing, and general nuclear war. Accidental or deliberate radioactive pollution could kill tens or hundreds of thousands, but is quite unlikely to happen. Regional nuclear conflict in the Middle East or the Indian subcontinent could kill several million. Nuclear terrorism against Washington D.C. or New York City could kill more than a million and set back human progress by up to a decade. General nuclear war would kill hundreds of millions and could trigger a nuclear winter that might starve hundreds of millions more. While such a worst case would set back human progress by one or two centuries, **existing nuclear arsenals could neither extinct humanity nor end human civilization.**

### Best data proves nuclear war cannot cause nuclear winter

Ball ‘6 (Desmond, prof at the Strategic and Defense Studies Centre at the Australian National Univ, “The Probabilities of On the Beach: Assessing ‘Armageddon Scenarios’ in the 21st Century,” Working Paper No. 401, Strategic and Defence Studies Centre at The Australian National University, http://rspas.anu.edu.au/papers/sdsc/wp/wp\_sdsc\_401.pdf)

I argued vigorously with Sagan about the ‘Nuclear Winter’ hypothesis, both in lengthy correspondence and, in August-September 1985, when I was a guest in the lovely house he and Ann Druyan had overlooking Ithaca in up-state New York. I argued that, with more **realistic data** about the operational characteristics of the respective US and Soviet force configurations (such as bomber delivery profiles, impact footprints of MIRVed warheads) and more **plausible exchange scenarios**, it was **impossible** to generate anywhere near the postulated levels of smoke. The megatonnage expended on cities (economic/industrial targets) was more likely to be around 140-650 than over 1,000; the amount of smoke generated would have ranged from around 18 million tonnes to perhaps 80 million tonnes. In the case of counter-force scenarios, most missile forces were (and still are) located in either ploughed fields or tundra and, even where they are generally located in forested or grassed areas, very few of the actual missile silos are less than several kilometres from combustible material. A target-by-target analysis of the actual locations of the strategic nuclear forces in the United States and the Soviet Union showed that the actual amount of smoke produced even by a 4,000 megaton counter-force scenario would range from only 300 tonnes (if the exchange occurred in January) to 2,000 tonnes (for an exchange in July)—**the worst case being a factor of 40 smaller than that postulated by the ‘Nuclear Winter’ theorists**. I thought that **it was** just as **wrong to overestimate the** possible **consequences of nuclear war, and to raise the spectre of extermination of human life as a serious likelihood**, as to underestimate them (e.g., by omitting fallout casualties).

### No risk of nuclear war or extinction

**Cirincione ‘7**

[Joseph, MS Georgetown School of Foreign Service, Expert advisor to the Congressional Commission on the Strategic Posture to the United States, member of the Advisory Committee to the Commission on the Prevention of WMD Proliferation and Terrorism, Ploughshares Fund President, Bomb Scare p. 85]

The threat of global thermonuclear war is now near zero. The treaties negotiated in the 1980’s, particularly the START agreements that began the reductions in U.S. and Soviet strategic arsenals and the Intermediate Nuclear Forces agreement of 1987 that eliminated an entire class of nuclear weapons (intermediate-range missiles that can travel between 3,000 and 5,500 kilometers), began a process that accelerated with the end of the Cold War. Between 1986 and 2006 the nuclear weapons carried by long-range U.S. and Russian missiles and bombers decreased by 61 percent. These reductions are likely to continue through the current decade. The dangers we face today are very serious, but they are orders of magnitude less severe than those we confronted just two decades ago from the overkill potential of U.S. and Russian arsenals. We no longer worry about the fate of the earth, but we still worry about the fate of our cities.

### Extinction hypothesis not supported by scientific evidence

**Hodder & Martin ‘9** (Patrick Faculty of Arts, U of Wollongong, & Brian, Professor of Social Sciences at the University of Wollongong, “Climate crisis? The politics of emergency framing,” *Economic and Political Weekly*, Vol. 44, No. 36, 5 September 2009, pp. 53-60, <http://www.bmartin.cc/pubs/09epw.html>)

At the time, many people believed that nuclear war meant the destruction of human civilisation or the end of human life on earth (Martin 1982a). Therefore, it might seem, stopping nuclear war from occurring should have been overwhelmingly important. What about the evidence? Strangely enough, there was little scientific backing for the belief that global nuclear war would kill everyone on earth (Martin, 1982b). Blast, heat and fallout would be devastating, but mainly in the areas targeted and downwind, with the likelihood of killing tens or hundreds of millions of people, mainly in western Europe, the Soviet Union and the United States. The majority of the world's population - in places such as Africa, South America and South Asia - would be unscathed. Writer Jonathan Schell in his book The Fate of the Earth argued that nuclear war could indeed lead to human extinction, something he called "the second death" - the first death being one's own death - and therefore the issue was of paramount importance (Schell, 1982). Schell's argument relied on the effects of ozone depletion and was not supported by scientific work at the time. In 1983, scientists reported on new studies of the effect of dust and smoke lofted into the upper atmosphere by nuclear explosions and subsequent fires, blocking the sun and leading to lowered temperatures, a consequence called "nuclear winter." Although once again the spectre of extinction was hinted at, it was never likely that cold weather and darkness could kill everyone; it would affect countries in the northern hemisphere most severely (Pittock, 1987).

## Moral Obligation

### There are lots of asteroids out there, we can’t avoid them forever

NANCY ATKINSON on OCTOBER 29, 2010“Mitigating Asteroid Threats Will Take Global Action” http://www.universetoday.com/76994/mitigating-asteroid-threats-will-take-global-action/

There are likely about one million Near Earth Objects out there that could do substantial damage if one hit the Earth. This isn’t anything new – Earth has been in this same environment billions of years. ―What’s new is that we have now opened our eyes via telescopes and are seeing something flying by our heads, so to speak, said Schweickart during a media event at the workshop. ―When you see something flying by your head, you duck. It turns out we have the capability of ducking and causing these objects to miss us. Because we now know about this threat and because we can in fact prevent an impact, we then have a moral obligation to do so.

# Add-Ons

## Add-on – Space Colonization

### Development of NEO deflection tech leads to space colonization

Cambier & Mead ‘7(Doctors Jean-Luc & Frank, Air Force Research Laboratory, On NEO Threat Mitigation, Oct. http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA474424&Location=U2&doc=GetTRDoc.pdf)

We have alluded in the previous sections that considerable leverage could be obtained for the NEO mitigation mission if a significant “space infrastructure” exists. What do we mean by this? There are several key technologies and capabilities that can be brought to bear in NEO mitigation: – Heavy-launch capability: this obviously facilitates the deployment of the vehicles and payloads for NEO characterization and mitigation missions, but also the deployment of space telescopes (visible and IR) and space-based radar arrays. This launch capability must be highly reliable, especially for mitigation. In the worst-case scenario of a comet-like impact with limited advance warning, it is critical to launch as rapidly as possible with extremely low risk of failure. The same heavy launch capability can be used for NASA missions to the moon, development of space tourism and other commercial activities, and advanced DOD missions (force projection, SBR, space-based missile defense). – Space nuclear power: multi-MW electrical power from nuclear fission reactors will play a key role in the deployment of large platforms for Planetary Defense as well as exploration, commercial and defense missions. For example, nuclear reactors can power high-performance OTVs, provide beam power for high-altitude DOD missions, SBR and missile defense operations. Within this category one could eventually include fusion power in the far future. – Large Structure assembly: such platforms can be used for phased-array radar, solar concentrators, and large radiators for very high power (100 MW-class) platforms. Such large structures could also play a dual role; for example, a very large array at L1 could be a phased-array radar, and very large solar power station for large-scale commercial power to be beamed to Earth, and a screen that reduces the solar flux to the Earth and reduce the effects of global warming. Such concepts are viable only if both transport (see the two previous items) and assembly can be performed reliably and at low cost. The development of robotic technology, self-assembling smart structures, redundant and self-repairing systems for long-term presence in the space environment, is an absolute requirement for this capability. The items listed above describe the leverage of a long-term, systematic space exploration and utilization program which can have in facilitating Planetary Defense. Conversely, a long-term Planetary Defense program yields benefits towards a space utilization program: – Asteroid mining: the same technology that may be required to drill into the core of an asteroid to plant a nuclear device would be an essential first step to mining the same object for essential elements and building blocks for space colonization. The capture and processing of the mined materials is an advanced technology that will also require full automation and large amounts of power. – Asteroid capture: deflecting the asteroid may lead to modifying its orbit to bring it into an Earth-centered or moon-centered orbit to bring raw materials closer for use, or as the anchor mass for space elevator concepts. This may be, however, a difficult mission to perform, and one that is likely to bring trepidations, since errors in trajectory modification may precisely bring about the danger that a Planetary Defense program intends to eliminate. This mission may be more acceptable once deflection missions have been repeatedly demonstrated. – Terra-forming: if comet-like objects or ice satellites from the rings of the gas giants could also be deflected and made to impact at precise locations (e.g. Mars), water ice could be brought to initiate terra-forming. Although these applications may seem far-fetched to some, they are within the realm of possibilities, albeit very long-term. Yet the Planetary Defense and the new NASA “Return to the Moon” programs are essential first steps in that direction. The “space infrastructure” is similar in some respects to the infra-structure developed by the U.S. government that facilitates commercial and national security operations, e.g. road and rail network, shipyards and harbors, airports, communication networks, etc. In space there are no roads, but a space transport and a space power network can play a similar role, using low-cost and/or re-usable access to space, long-duration OTVs, power generation/collection station and beaming, radar and optical/IR tracking stations, and refuel/repair robotic stations. This type of evolved infrastructure goes well beyond exploration missions but is truly a first step towards space utilization and exploitation of natural resources (e.g. [11]). Commercial presence in space is in its infancy and can progress only as far as the infrastructure allows it. In these early days of space utilization, national security, planetary defense and protection of commercial interests still play the most important roles. Therefore, it is logical that the DOD be a key player in the development of this infrastructure, at least in the early stages. Within this long-term context, there are a number of key components of a space infra-structure which must be developed, and for which the DOD is particularly suited in taking a leading role, at least initially, due to National Security needs. These are the following – Component #1: Low-cost, reliable launch. The exploration missions typically conducted by NASA are not sufficiently frequent to drive significant reductions in launch costs, and commercial activities have not yet reached a critical mass to become an economical driving force. However, DOD missions can be the dominant factor. For example, rapid reconstitution of US space assets after a surprise attack would require a high-frequency (“surge”) of launches into LEO and GEO. This requires operational procedures such as rapid launcher assembly, payload matching, and automatic launch and trajectory control. If highly reliable launchers already existed, with highly modular design (multiple booster configurations easily strapped-on for variable payload/orbit requirements), robotic assembly and large-scale routine manufacturing of the launcher components, the problem of rapid reconstitution would be much easier. Clearly this goes beyond the pace and approach of NASA operations. The detailed technology does not need to be specified yet, since competing approaches may be useful, i.e. from vertical launches with no re-usable components to a fully re-usable horizontal launch vehicle. The latter could also be leveraged from technology developed for hypersonic, long-range airplanes, even up to their use as a 1st-stage. By focusing on increased reliability and reduced cost, the DOD would satisfy key requirements for Planetary Defense and greatly stimulate commercial space development (including reducing insurance costs). The issue of heavy payload capability must be addressed immediately for Planetary Defense; thus, it may be that while NASA develops the ARES-V launcher, the DOD could focus on improving the design to increase modularity, automate operations, and increase component reliability. Whether this approach, or continued and parallel development of the Delta-class of launchers, or yet another approach is chosen depends on their respective merits within the framework of a long-term plan; such comparative studies and planning shoud be done with all urgency. – Component #2: Long-duration high-power OTV. These vehicles would be powered by nuclear reactors and have advanced propulsion systems capable of both high thrust and high specific impulse; they would fill the requirements of the first two rows of Table 4 shown in the previous section. As such, they would be essential components of the Planetary Defense campaign, allowing not only the “slow-push” of a large number of possible NEO threats, but also the launching of multiple characterization missions towards their targets in deep space. Such routine operations by high-performance OTVs would also have major implications for National Security, since these “space-tugs” could routinely pick-up satellites from LEO after launch (see component #1) and place them in the proper orbits, or bring back valuable assets for repair/enhancements (see component #4 below). They could also be used to push a large number of picosats for observation and monitoring of other assets, or for self-assembly into large structures (see component #5). Finally, such OTVs would greatly facilitate the current NASA mission for permanent occupation of the Moon and commercial activities in space (asteroid mining, space tourism, power generation stations). The development of this component requires nuclear space power technology, as the power requirements and the spacecraft trajectories preclude solar power. Nuclear space power has been developed through several decades, and operationally demonstrated by the former Soviet Union. A joint DOE/DOD/NASA multi-disciplinary effort can yield a new class of reactor designs with higher performance, longer operational lifetime and very high safety requirements, using the most advanced technologies available (e.g. novel materials from nano-technology). – Component #3: Power generation/beaming. These platforms play multiple key roles, collecting solar power and concentrating it to ablate material from an asteroid for a slow-push, or converting it into electricity and beam it to Earth, to vehicles in transit or space settlements. The deployment of very large-scale solar power stations could then have the benefit of commercial electricity generation (beaming power to Earth), while enabling space transport and Planetary Defense, and could possibly be used as a sun-shield to reduce the impact of global warming. The nuclear reactors of the OTVs (component #2) can also serve a dual-purpose and beam the electrical power to other satellites or vehicles. Of particular interest would be very high-altitude hypersonic vehicles (recon or bombing missions) using air-breathing electric propulsion systems, powered by the microwave beam from an OTV’s nuclear reactor in a high-altitude, nuclear-safe orbit. This would allow such vehicles to fly with unlimited range and loiter indefinitely, as well as having enough power for directed energy weapons, without having to place a nuclear reactor within the vehicle itself – a concept that is surely bound to raise objections. The beamed power can also be used to power that vehicle for orbit insertion, thus also playing a key role in routine, low-cost access to space (component #1). For Planetary Defense, the ability to generate highly-directional microwave beams for power transmission is immediately related to space-based radar and asteroid tracking at long distances. Thus, the same basic technology can be used for deep-space tracking and power beaming to DOD vehicles. One may also consider “relay-stations” over a deep-space network to extend the range and accuracy of the tracking. A similar network in the Earth vicinity would increase redundancy and coverage of the DOD hypersonic vehicles or launchers mentioned above. The same approach could also be used, for example, to beam power from a very large solar collector at L1 towards Earth to provide pollution-free commercial power. – Component #4: Robotic/AI operations. Automatic refueling of satellites and OTVs is another key step towards the space infrastructure development, and preliminary efforts in that direction have been under-way (DARPA). With appropriate system design, robotic mechanisms and AI software, there would be no need for manned operation (i.e. no “station attendant”). Combined with the low-cost launch of supplies from Earth (component #1), the on-orbit refueling stations are an important early step towards infrastructure development. Eventually, the same procedure could be applied in reverse, i.e. receiving raw materials from asteroid or Moon mining operations and transferring them into a vehicle bound back to the Earth surface. Repairing and re-furbishing satellites and transport vehicles would be the next step; new system components (e.g. optics, solar cells, batteries, and antenna), shielding, or nuclear fuel for space reactors could be inserted at the station. Although these procedures appear complex enough to necessitate human control, it is not unconceivable that specialized robots and advanced AI could lead to completely un-manned operations. Such operations would of course have an impact on DOD missions as well as civilian or international exploration missions. The use of an international space station to perform such operations for U.S. military systems would be very problematic; thus, it would be highly advisable to develop the necessary robotic and AI technology to perform these operations in a smaller station, and in a much more cost-effective manner. The same technology can of course be applied to commercial space operations, permanent space settlements and space resource exploitation (component #5). Robotic technology is also needed to drill and bury nuclear devices in the NEO and perform assembly functions of any other concept for mitigation (laser, sail, concentrator, etc.). – Component #5: Large-scale assembly/manufacturing. Some of the concepts for Planetary Defense and space utilization inevitably imply the deployment of very large structures in space. These are, for example, phased-array radars, very high-power solar collectors, highly directional arrays for power beaming and receiving/relay stations. These can be constructed from pre-manufactured modular components launched from Earth and transported to the desired location. These structures have a relatively simple pattern and can be assembled through simple rules, adequate for early phases of robotic and AI technology (component #4). Early phases of large-structure deployment, with implications for DOD missions, also include tethers, “nets” and membranes. These can be used for grappling satellites, protection against ASATs, very large optics for telescopes, space radiators, momentum-exchange boosters (using for example a small captured NEO for anchor), “bags” for raw materials, etc. Other large-scale structures, at increasing levels of complexity include space and lunar settlements (“habitats”) and asteroid mining and material processing (“factories”). This is the last critical step for space colonization.

### That’s key to prevent inevitable extinction of all life

Baum ‘9 (Seth, Prof in the Dept. of Geography & Rock Ethics Institute, Penn. State Univ, “Cost-Benefit Analysis of Space Exploration: Some Ethical Considerations,” *Space Policy*, Vol. 25(2), p.75-80, http://sethbaum.com/ac/2009\_CBA-SpaceExploration.pdf)

Another non-market benefit of space exploration is reduction in the risk of the extinction of humanity and other Earth-originating life. **Without space colonization, the survival of humanity and other Earth-originating life becomes** extremely difficult- perhaps **impossible- over the** very **long-term**. This is because the Sun, like all stars, changes in its composition and radiative output over time. The Sun is gradually converting hydrogen into helium, thereby getting warmer. In approximately 500 million to one billion years, this warming is projected to render Earth uninhabitable to life as we know it [25–26]. Humanity, if it still exists on Earth then, could conceivably develop technology by then to survive on Earth despite these radical conditions. Such technology may descend from present proposals to “geoengineer” the planet in response to anthropogenic climate change [27–28].3 However, the Sun later- approximately seven billion years later- loses mass that spreads into Earth’s orbit, causing Earth to slow, be pulled into the Sun, and evaporate. The only way life could survive on Earth may be if Earth, by sheer coincidence (the odds are on the order of one in 105 to one in 106 [29]) happens to be pulled out of the solar system by a star system that passes by. This process might enable life to survive on Earth much longer, although the chance of this is quite remote. While space colonization would provide a hedge against these very long-term astrological threats, it would also provide a hedge against the more immediate threats that face humanity and other species. These threats include nuclear warfare, pandemics, anthropogenic climate change, and disruptive technology [30]. Because these threats would generally only affect life on Earth and not life elsewhere,4 self-sufficient space colonies would survive these catastrophes, enabling life to persist in the universe. For this reason, space colonization has been advocated as a means of ensuring long-term human survival [32–33]. Space exploration projects can help increase the probability of long-term human survival in other ways as well: technology developed for space exploration is central to proposals to avoid threats from large comet and asteroid impacts [34–35]. However, given the goal of increasing the probability of long-term human survival by a certain amount, there may be more cost-effective options than space colonization (with costs defined in terms of money, effort, or related measures). More cost-effective options may include isolated refuges on Earth to help humans survive a catastrophe [36] and materials to assist survivors, such as a how-to manual for civilization [37] or a seed bank [38]. Further analysis is necessary to determine the most cost-effective means of increasing the probability of long-term human survival.

## I/L – NEO Solve colonization

### NEO deflection facilitates space colonization

Lu ‘4Statement of Dr. Ed Lu President, B612 Foundation, “Near-Earth Objects,” testimony before the Committee on Senate Commerce, Science and Transportation Subcommittee on Science, Technology, and Space, Apr.7 CQ, lexis)

Why does the asteroid need to be moved in a "controlled manner"? If the asteroid is not deflected in a controlled manner, we risk simply making the problem worse. Nuclear explosives for example risk breaking up the asteroid into pieces, thus turning a speeding bullet into a shotgun blast of smaller but still possibly deadly fragments. Explosions also have the drawback that we cannot accurately predict the resultant velocity of the asteroid - not a good situation when trying to avert a catastrophe. Conversely, moving an asteroid in a controlled fashion also opens up the possibility of using the same technology to manipulate other asteroids for the purposes of resource utilization. How can this be accomplished? This mission is well beyond the capability of conventional chemically powered spacecraft. We are proposing a nuclear powered spacecraft using high efficiency propulsion (ion or plasma engines). Such propulsion packages are currently already under development at NASA as part of the Prometheus Project. In fact, the power and thrust requirements are very similar to the Jupiter Icy Moons Orbiter spacecraft, currently planned for launch around 2012. The B612 spacecraft would fly to, rendezvous with, and attach to a suitably chosen target asteroid (there are many candidate asteroids which are known to be nowhere near a collision course with Earth). By continuously thrusting, the spacecraft would slowly alter the velocity of the asteroid by a fraction of a cm/sec - enough to be clearly measurable from Earth. What will we learn from this? It is important to remember that this mission is merely a first attempt to learn more about the mechanics of asteroid deflection. There are a number of technical complications, as well as many unknowns about the structure and composition of asteroids. However, the way to make progress is to build, fly, and test. Much of what we will learn is generic to many proposed asteroid deflection schemes, with the added benefit of being able to answer important scientific questions about asteroids themselves. The best way to learn about asteroids is to go there. How does this fit into the new Exploration Initiative at NASA? In the near term, this mission would be an ideal way to flight test the nuclear propulsion systems under development as part of the Prometheus Project. It could also serve as a precursor to a crewed mission to visit an asteroid. Such missions have been proposed as intermediate steps to test spacecraft systems for eventual longer term crewed missions to Mars. In the longer term, the ability to land on and manipulate asteroids is an enabling technology for extending human and robotic **presence throughout the solar system**. If we are to truly open up the solar system, this mission is a good way to start. It is likely that someday we will utilize asteroids for fuel, building materials, or simply as space habitats. The B612 mission would mark a fundamental change in spacecraft in that it would actually alter in a measurable way an astronomical object, rather than simply observing it. Human beings must eventually take charge of their own destiny in this manner, or we will someday go the way of the dinosaurs when the next great asteroid impact occurs.

### NEO defense network key to future space exploration

NASA ‘6 (“2006 Near-Earth Object Survey and Deflection Study” http://www.b612foundation.org/papers/NASA-finalrpt.pdf)

This study has identified a loose connection between the goals of the Vision for Space Exploration and a program to survey the population of NEOs. There may come a time when Earth’s resources are insufficient or too costly to support the planet’s growing population. Exploring resources that exist on the Moon, other planets, or NEOs may allow further human expansion. The survey assets examined by this study will take 5-10 years to provide an extensive map of the orbits and sizes of NEOs to 140 meters in diameter, as well as information on thousands of smaller objects. If infrared survey assets are built, these assets could be turned to the job of characterizing the composition of these objects. In addition, this study has also identified several funded efforts to survey and characterize the NEO population, which likely will come about with minimal NASA contribution. If asteroid or comet resources prove enabling, having a map of the location and distribution of these assets may prove valuable. An analogy might be the mapping of oases to facilitate transportation across the desert. Assuming that humankind will not be ready to exploit such a map of asteroid resources for at least 30-40 years, it is very likely that this map will be created as a direct product of otherwise funded scientific surveys. If these envisioned efforts do not produce the required information, it is expected that a limited expenditure of time and resources (less than 10 years and $1B) will be needed to produce a map of asteroid and comet resources. 5.20.2.2. Human Visits to Asteroids It is possible that the systems used to return humans to the Moon could be used to visit a NEO. While NASA has no published plans or budget to pursue such a mission, the NEO survey and characterization program could be used to help select the destination for such a mission. A visit to a NEO could be used to demonstrate technologies for lunar missions, or as an interim goal between lunar and Mars missions.

### Asteroid missions maintain political momentum for long-term space exploration

Jones ‘5 (Thomas, PhD, astronaut, “Stepping stones to Mars: The asteroid option,” Aerospace America, lexis)

Another reason we should put NEAs on our path to Mars is to sustain the momentum of this new vision -- a scientific, technical, and cooperative effort of unprecedented ambition. We might be back on the Moon within a decade. But following our lunar return there will necessarily be a long interval when we consolidate our gains and build our experience for the leap to Mars. During this phase, lasting a decade or more under the plan proposed by the president and NASA, we will find it difficult to marshal the political will and steady funding to press on. Asteroid missions give us a way to keep moving forward on a third spiral of capability beyond LEO and the Moon. Venturing to an NEA is a dramatic way to show sustained progress, prove new flight hardware, and return new science and resources while preparing for Mars. Five years after establishing ourselves on the Moon, we could be ready for our first foray to an asteroid. Such an expedition, where astronauts will see the Earth dwindle to Carl Sagan's "pale blue dot," will inject excitement and fresh success into a complex program continually in need of political buttressing.

### Asteroid missions key to space exploration and resource extraction

**Jones ‘5** (Thomas, PhD, astronaut, “Stepping stones to Mars: The asteroid option,” Aerospace America, lexis)

The space between Earth and Mars is far from empty. Our planet orbits the Sun amid a swarm of small bodies known as near-Earth asteroids, or NEAs (short-period comets are a much smaller presence in the inner solar system). Hundreds of thousands of NEAs circle the Sun and approach Earth's orbit, but only a fraction of those are large enough to present an impact hazard to Earth. NASA estimates that about 1,100 are bigger than 1 km in diameter -- with enough kinetic energy to threaten civilization. So far, under NASA's Space-guard Survey, astronomers have charted the orbits of 762 such bodies. Last year, a 300-m asteroid named 2004 MN4 caused a brief flurry of concern when orbital predictions showed it might strike Earth 24 years from now. Within a few days of Christmas, astronomers had additional observations in hand that ruled out an impact (which would be big enough to devastate Texas or the mid-Atlantic states, with the force of 10,000 megatons of TNT). But the object will still startle stargazers on April 13, 2029, when it misses Earth by just 40,000 km, about a tenth the distance to the Moon. When we look up that evening to see 2004 MN4 sailing swiftly across the stars, we may view it as a breathtakingly close call. But if we plan well, the NEAs offer an opportunity -- a chance to convert a peril to a potential resource. Such asteroids can be our stepping stones to Mars. How asteroids fit the vision Given the daunting challenges we must overcome to reach Mars, any approach that makes the journey easier, safer, and less expensive for human explorers should be considered. Our return to the Moon is driven in part by the possible presence of polar ice deposits, a resource that could provide an outpost with water, oxygen, and energetic propellants. At greater expense, we could also crack oxygen from the lunar regolith. These resources will eventually reduce the costs of supporting a lunar outpost, and provide surplus propellant for use in Earth-Moon space and beyond. The president's suggestion in his vision announcement that the Moon's low surface gravity makes it an attractive place to assemble and launch Mars expeditions was probably a simple misunderstanding: The Moon's surface, at the bottom of a still-respectable gravity well, levies a heavy launch energy penalty on anything trying to leave. But there are nearby locations that do carry favorable gravitational "weight" as staging areas for Mars-bound spacecraft. One such location is the Lagrange point called Sun-Earth L2, on the Earth-Sun line 1.5 million km beyond our own planet. Because of its gravitational stability, trajectory experts have long cited "SEL-2" as a useful spacecraft basing node; it is well positioned for both operation of large space observatories and efficient escape trajectories from the Earth-Moon system. But of course at SEL-2, there is no "there" there. By traveling a bit farther, we can reach many NEAs, which offer both resources and an energetically attractive path for shipping them back to near-Earth space. Fifteen years ago, John Lewis, a planetary scientist at the University of Arizona, pointed out how a well-chosen NEA, with its small size and Earth-grazing orbit, makes departure for Earth about as easy as a space maneuver can be. At asteroid 4660 Nereus, for example, a given payload can leave the surface and return to Earth with a velocity change (delta-V) of only 60 m/sec<-1> (just 134 mph). By contrast, Lewis noted, the return delta-V from the Moon is about 3,000 m/sec<-1>. We will have a wide choice of attractive asteroid targets. There are about 300,000 NEAs greater than 100 m in diameter (a 100-m NEA has a mass of roughly 1 million metric tons). A launch opportunity from Earth to a specific NEA occurs about every 2-4 years; thus, if we knew the orbits of 100,000 NEAs, we could expect a launch window to open about every 15 min. The lure of water A round trip to one of the best-situated NEAs requires less delta-V than a one-way trip to the lunar surface. But why should we make asteroids part of our vision for exploration? The first reason is resources. The NEA population may be the most attractive and practical source of shielding, propellants, metals, and refractory elements available to our exploration efforts. As Lewis and his colleagues noted in 1993, NEAs might provide life-support fluids for maintaining a lunar base, propellants for our Mars expeditions, or the building materials for large space structures like solar power satellites.

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## Space-Based Key to Exploration

### Only a space-based survey can detect enough undiscovered asteroids to make exploration viable in the short-run

Elvis et. al, 2011 [ Martin Elvis and Jonathan McDowell Harvard-Smithsonian Center for Astrophysics, Jeffrey A. Hoffman and Richard P. Binzel Massachusetts Institute of Technology, “ Ultra-Low Delta-v Objects and the Human Exploration of Asteroids,” 20 May 2011, http://arxiv.org/ftp/arxiv/papers/1105/1105.4152.pdf]

Clearly a much larger pool of ultra-low delta-v NEOs, with orbits determined over long arcs, is needed in order to have a suitable list of targets for human exploration missions. There is no physical reason that larger diameter ultra-low delta-v NEOs should not exist among the uncataloged ~95% of NEOs. However, ultra-low delta-v NEOs are not readily found. Their closely Earth-like orbits mean that most of the time they are in the daytime sky, as seen from the Earth, and so are effectively undetectable. As they approach within <1AU of the Earth they start to lie near quadrature, and so come into the dawn or dusk sky on Earth. The strong scattered sunlight background makes optical surveys toward the dawn or dusk much less sensitive and, in practice, surveys do not look in these directions, preferring to observe where the sky is dark, within 45 degrees, and at most 60 degrees, of the anti-Sun, opposition, direction. As a consequence the lowest delta-v NEOs are undercounted by current surveys, and the factor by which they are undercounted is not yet known. Harris (2007) estimates that there are ~100,000 NEOs of 140 m diameter or larger (H<22). Of 4247 objects with H<22 from Benner (2010), there are just 2 with delta-v < 4.5 km/s. Harris (2007) predicts ~10 7 NEOs with H<27 (diameters 14m or larger), comparable to the 6 lowest delta-v NEOs. The WISE spacecraft (Wright, 2008) scanned the sky around the terminator line in the midinfrared (mid-IR) and is efficient at finding NEOs (Mainzer et al, 2010; Grav et al, 2010). By the end of the 10-month WISE mission it will be possible to estimate the ultra-low delta-v population. WISE will however only detect a few percent of the ultra-low delta-v population because of its short life. Pan-STARRS-1 (PS1) is a ground-based optical survey using a 1.5m diameter telescope with a wide (7 sq.deg.) field of view that is surveying the sky for 2.5-3 years beginning May 2010 (Kaiser et al, 2002). One of the PS1 Key Projects is KP1 “Populations of Objects in the Inner Solar System”. This survey emphasizes the discovery of NEOs. By concentrating on quadrature, called the NEO ‘sweet spot’ (Chesley and Spahr, 2004), KP1 expects to detect >99% of NEOs down to 300m diameter that come into range during the 3 year program. Objects with longer synodic periods, including most ultra-low delta-v NEOs, will be strongly undersampled. Nonetheless, PS1/KP1 will define the size of the ultra-low delta-v NEO population well. 7. Other Factors affecting human accessible NEOs A large population of ultra-low delta-v NEOs is needed because not all of them will qualify as accessible. Other factors affecting operations, crew safety and proximity operations simplicity will reduce the final sample (Binzel et al. 2004). Rotation: This is the largest factor. The surfaces of small NEOs (e.g. 25143 Itokawa; Demura et al. 2006) can be highly irregular on both large and small scales, including boulders emerging 10s of meters (e.g. Yoshinodai, Pencil; Saito et al. 2006). Astronauts maneuvering within 10s of meters of the surface of a rapidly rotating asteroid would be in hazard 3 Attachment to their . surfaces is difficult given their microgravity (Wilcox, 2010). Most NEOs will be small, as their numbers increase as roughly the inverse square of their diameters (Harris, 2007). Smaller asteroids rotate faster (Binzel et al, 1989; Harris, 2007). While above ~250m dia. asteroids are limited by their tensile strength to periods of ~2 hours or greater, about half of 100-250m dia. asteroids have shorter periods, down to a few minutes. Companions: Orbiting companions to asteroids, when close, constitute an extreme case of an irregular surface. More distant companions increase the stand-off distance for the primary crew exploration vehicle and longer transit times to the NEO from the vehicle for astronauts on EVAs. Some 1/6 of NEOs are binaries down to current detection limits (Walsh and Richardson, 2008). Wobble: Many NEOs do not rotate about their center of mass, leading to irregular motions (wobble) that may pose a hazard. Morphology: A more spherical asteroid poses fewer hazards to astronauts, while a highly elongated ‘bone-shaped’ morphology (e.g. 216 Kleopatra, [Ostro et al, 2000]), could provide useful artificial gravity if astronauts land on one of its approaching ends. Volatiles: If the NEO is a dead comet, volatiles may lie close to the surface and could be exposed by human activities. Whether their sublimation would be sufficiently explosive to cause a hazard is an open question. 8. Launch and Return Windows The NEOs selected for human missions, at least at first, will require both long launch windows, and a robust abort capability, i.e. a long return window with achievable delta-v – the latter requirement has been emphasized by Farquhar et al. (2008). With new systems launch slips are more likely, so it is prudent to select an NEO with a 3-6 month launch window for the first crewed NEO mission. Alternatively, a succession of closely spaced good targets could substitute, so long as the mission profile was sufficiently similar. For example, 1999 AO10 has a second launch window 3 months after the first, but the flight time is 30 days longer (Abell et al, 2009), which may or may not be within the mission architecture capabilities. For crew safety a mission abort must be possible at all times during the mission. The 2025 mission to 1999 AO10 allows a return to Earth one week after the Earth escape maneuver (Farquhar et al, 2008). On the other hand, a human visit to an asteroid should allow time for the human capabilities of exploration, discovery and adaptability to be exercised. A restricted atasteroid stay, e.g. less than 2 weeks, would strongly limit the use of human capabilities. An atasteroid stay of a month begins to allow for true exploration. Jones et al. (2010) have noted that a larger accessible target list set helps to shorten mission duration. In addition, Johnson (2009) emphasizes the need for a low return entry velocity (<12km/s). Abell et al. (2009) looked for NEOs accessible to the Constellation architecture between 2020 and 2035. Out of 1200 candidates they identified 12 opportunities (3 NEOs had 2). The brightest had H=23.4 (~40m dia.), highlighting the question ‘should the asteroid be bigger than the spacecraft?’, and recalls the difficulty of re-acquiring small NEOs noted earlier. Requiring a diameter of at least 70m (H< 23.5), Johnson (2009) finds 6 candidates. Clearly we need a much larger NEO sample in order to have a sufficient sample of good targets.9. Ultra-low delta-v NEO Specific Surveys The choice of 2025 as a target date for NASA to have the capability to undertake a human mission to a NEO (Obama, 2010) brings a new exigency to finding a larger sample of targets. To enable a timely and informed choice of targets, a survey for the bulk of the 100,000 NEOs with dia.>140m needs to be complete by ~2020. This implies a mean discovery rate of 10,000/year, about 10 times the current rate. The Large Synoptic Survey Telescope (LSST) is planned to reach r(AB)=24.5 over 15,000sq.deg every 3 nights, and will find 80% of NEOs >140 m dia. in 10 years of surveying and, potentially, 90% after 12 years if 15% of the observing were optimized for this search. Uniquely the LSST high quality (5milli-mag) photometry in 6 optical (0.3-0.9micron) bands (named u,g,r,i,z,y) will give composition, spin state and shape estimates for the brighter NEOs (LSST, [Jones et al, 2008]). In 12 years roughly half the ultra-low delta-v NEOs will have come within range. LSST is currently planned to begin surveying in 2017, though this is contingent on obtaining funding (Ivezic et al, 2007). This is rather late for the NASA Exploration program. As emphasized above, ground-based surveys are hampered by the dawn/dusk/daylight location of most ultra-low delta-v NEOs. Space based surveys are less limited and so are preferred. The long synodic period of ultra-low delta-v NEOs affects survey strategy. Because the gap between the survey and the first expedition will be 5 years or more, and longer for later missions, the survey needs to span the entirety of the Earth’s orbit; an ultra-low delta-v NEO that comes near the Earth in 10 years time is now behind the Sun. This special feature of ultra-low delta-v NEOs points to a survey carried out from a Venus-like orbit (~0.7AU). Venus has a 584 day synodic period, so that employing three passes to get high survey completeness takes 4.8 years (Reitsema & Arentz 2009). Both optical and thermal infrared surveys have been considered (e.g. NASA 2007) at sizes comparable to Kepler or Spitzer. The infrared has the advantages of providing a more model independent size estimate, and of being sensitive to low albedo asteroids. If the first of the proposed ‘Robotic Precursor Missions’ were a Venus-orbit NEO survey, with selection in FY2012, a 4 year build phase and a 5 year baseline operation phase, then a catalog of ~100,000 NEOs could be ready by 2020. Estimates of the cost of such a mission are not yet certain, but seem likely to be Discovery-class, and to fit within the proposed Exploration Robotic Precursor Mission (xPRM) envelope (NASA FY2011 Budget Request) 10. NEO Survey Value Each of the reasons to explore asteroids benefits from a ultra-low delta-v NEO specific survey. Human Exploration: Having the largest possible choice of destinations for a human NEO mission enhances: payload, operational flexibility, safety and scientific value. By decreasing the requirements on the Earth escape launch vehicle some technologies can be removed from the critical path, increasing the probability of mission success and easing budgetary pressures by not requiring parallel, but rather serial, development. Hazards: An early survey could fulfill the Congressional mandate to find 90% of 140m dia. NEOs within 15 years (George E. Brown, Jr. NEO Survey Act, Public Law No. 109-155), signed into law by President G.W. Bush on December 30, 2005. With good orbits all asteroids will be clearly either hazardous or not, at effectively 100% confidence for the next century, or longer, solving the “potentially hazardous objects” (PHOs) question definitively. Any truly hazardous objects can then be ‘tagged and towed’. Resources: Such a survey will locate the most accessible space resources, a 21 st century Lewis & Clark view of our space back yard. If the survey included a spectroscopic component the nature of these resources would become well known. Science: The number of known NEOs is now somewhat over 6,000. A dedicated survey will increase the known population by more than an order of magnitude. This is similar to the factor by which the Sloan Digital Sky Survey (Gunn et al, 2006) increased the known populations of galaxies and quasars in extragalactic astrophysics. As in that case, a qualitative, revolutionary, change in NEO science will follow. Population studies will uncover the origins of families of NEOs. 11. Summary and Conclusions Human exploration of NEOs requires a number of specific properties in the targets. In particular, ultra-low delta-v (LEO-NEO ~4km/s) produces payload increases by a factor 2 relative to a typical NEO. Such a gain can have important implications for mission architecture, schedule risks, and the funding profile. In a future paper we will explore the volumes of a,e,i parameter space for ultra low delta-v NEOs. At present only a handful of such ultra-low delta-v NEOs are known. The complete population is however much larger. Ground-based telescopes can characterize NEOs, but a dedicated robotic precursor mission comprising a Venus-orbit optical or infrared survey seems to be needed to find all ultra-low delta-v NEOs with diameter >140m. If this were carried out by ~2020 it would enable timely target selection for the 2025 goal for a first human mission

## Add-On Global Warming

### Deflection tech allows us to solve warming and double the lifetime of the planet

Newstex ‘9(“NASA Plan To Solve Global Warming: Move The Planet,” Newstex Web Blogs, 8-4-9, lexis)

Scientists have found an unusual way to prevent our planet overheating: move it to a cooler spot. All you have to do is hurtle a few comets at Earth, and its orbit will be altered. Our world will then be sent spinning into a safer, colder part of the solar system. This startling idea of improving our interplanetary neighbourhood is the brainchild of a group of Nasa engineers and American astronomers who say their plan could add another six billion years to the useful lifetime of our planet - effectively doubling its working life. ˜The technology is not at all far-fetched, said Dr Greg Laughlin, of the Nasa Ames Research Center in California. ˜It involves the same techniques that people now suggest could be used to deflect asteroids or comets heading towards Earth. We dont need raw power to move Earth, we just require delicacy of planning and manoeuvring. The plan put forward by Dr Laughlin, and his colleagues Don Korycansky and Fred Adams, involves carefully directing a comet or asteroid so that it sweeps close past our planet and transfers some of its gravitational energy to Earth. ˜Earths orbital speed would increase as a result and we would move to a higher orbit away from the Sun, Laughlin said.

### NEO deflection tech solves global warming—generates solar power and provides solar screen

Cambier & Mead ‘7(Doctors Jean-Luc & Frank, Air Force Research Laboratory, On NEO Threat Mitigation, Oct. http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA474424&Location=U2&doc=GetTRDoc.pdf)

We have alluded in the previous sections that considerable leverage could be obtained for the NEO mitigation mission if a significant “space infrastructure” exists. What do we mean by this? There are several key technologies and capabilities that can be brought to bear in NEO mitigation: – Heavy-launch capability: this obviously facilitates the deployment of the vehicles and payloads for NEO characterization and mitigation missions, but also the deployment of space telescopes (visible and IR) and space-based radar arrays. This launch capability must be highly reliable, especially for mitigation. In the worst-case scenario of a comet-like impact with limited advance warning, it is critical to launch as rapidly as possible with extremely low risk of failure. The same heavy launch capability can be used for NASA missions to the moon, development of space tourism and other commercial activities, and advanced DOD missions (force projection, SBR, space-based missile defense). – Space nuclear power: multi-MW electrical power from nuclear fission reactors will play a key role in the deployment of large platforms for Planetary Defense as well as exploration, commercial and defense missions. For example, nuclear reactors can power high-performance OTVs, provide beam power for high-altitude DOD missions, SBR and missile defense operations. Within this category one could eventually include fusion power in the far future. – Large Structure assembly: such platforms can be used for phased-array radar, solar concentrators, and large radiators for very high power (100 MW-class) platforms. Such large structures could also play a dual role; for example, a very large array at L1 could be a phased-array radar, and very large solar power station for large-scale commercial power to be beamed to Earth, and a screen that reduces the solar flux to the Earth and reduce the effects of global warming. Such concepts are viable only if both transport (see the two previous items) and assembly can be performed reliably and at low cost. The development of robotic technology, self-assembling smart structures, redundant and self-repairing systems for long-term presence in the space environment, is an absolute requirement for this capability. – Component #3: Power generation/beaming. These platforms play multiple key roles, collecting solar power and concentrating it to ablate material from an asteroid for a slow-push, or converting it into electricity and beam it to Earth, to vehicles in transit or space settlements. The deployment of very large-scale solar power stations could then have the benefit of commercial electricity generation (beaming power to Earth), while enabling space transport and Planetary Defense, and could possibly be used as a sun-shield to reduce the impact of global warming. The nuclear reactors of the OTVs (component #2) can also serve a dual-purpose and beam the electrical power to other satellites or vehicles. Of particular interest would be very high-altitude hypersonic vehicles (recon or bombing missions) using air-breathing electric propulsion systems, powered by the microwave beam from an OTV’s nuclear reactor in a high-altitude, nuclear-safe orbit. This would allow such vehicles to fly with unlimited range and loiter indefinitely, as well as having enough power for directed energy weapons, without having to place a nuclear reactor within the vehicle itself – a concept that is surely bound to raise objections. The beamed power can also be used to power that vehicle for orbit insertion, thus also playing a key role in routine, low-cost access to space (component #1). For Planetary Defense, the ability to generate highly-directional microwave beams for power transmission is immediately related to space-based radar and asteroid tracking at long distances. Thus, the same basic technology can be used for deep-space tracking and power beaming to DOD vehicles. One may also consider “relay-stations” over a deep-space network to extend the range and accuracy of the tracking. A similar network in the Earth vicinity would increase redundancy and coverage of the DOD hypersonic vehicles or launchers mentioned above. The same approach could also be used, for example, to beam power from a very large solar collector at L1 towards Earth to provide pollution-free commercial power.

## Non-prolif leadership Add-on

### Plan is key to non-prolif leadership.

**Boyle ‘7** (Alan, winner of the [AAAS Science Journalism Award](http://www.aaas.org/aboutaaas/awards/sja/2002/boyle.shtml), the [NASW Science-in-Society Award](http://nasw.org/mem-maint/awards/02Boylebio.html), member of the board of the [Council for the Advancement of Science Writing](http://www.casw.org/), and staff writer for MSNBC.com, “Dueling Over Asteroids,” <http://cosmiclog.msnbc.msn.com/archive/2007/03/21/97410.aspx>)

"But beyond that, there is also the issue that people are beginning to wrestle with this question on a much larger basis internationally," he said. "The idea that the only way you can protect Earth from these things is to compromise all your principles about nonproliferation would be shocking to anybody else. Almost anytime the United States is going to say anything about this, eyebrows are going to go up."

## Add-on – Space leadership

### Successful human asteroid mission significantly boosts U.S. leadership

Friedman, 10 [ Lou Friedman recently stepped down after 30 years as Executive Director of The Planetary Society. He continues as Director of the Society's LightSail Program and remains involved in space programs and policy. Before co-founding the Society with Carl Sagan and Bruce Murray, Lou was a Navigation and Mission Analysis Engineer and Manager of Advanced Projects at JPL., “ The case for a human asteroid mission,” December 13, 2010, The Space Review, http://www.thespacereview.com/article/1742/1]

I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a human on a near Earth asteroid and returning him (or her) safely to the Earth. No single space project in this period will be more impressive to humankind, or more important for the long-range exploration of space. Why? Because it will finally be a new human achievement outward from our planet, five decades after our previous giant step outward for humankind. It will be our first dip into the cosmic ocean of interplanetary space. I apologize for stealing President Kennedy’s immortal words of May 25, 1961, and unabashedly adapting them to make my point that a human asteroid mission could and should be an inspiring goal to restore optimism and achievement to human space flight. Even more, it could reinvigorate American leadership in the best of ways, not with chauvinism, but by example and engagement of the whole world. Such leadership could promote international cooperation among the world’s space agencies to expand solar system exploration and development. What has been missing from the debate about the future of space exploration is optimism and confidence. Even President Obama’s effort in this regard in Florida last April was too defensive and mired in politics. An achievement of a three- to six-month journey by astronauts to, around, on, and back from an asteroid would enhance popular interest in, and the perception of value of, space exploration. The sight of astronauts gently bouncing on and off the asteroid, conducting experiments, and digging below the surface would be more engaging than the pale terrestrial “Dancing With the Stars.” What a boost it would give to our understanding about these strange objects, and what an education for our citizenry about a future which will certainly involve deflecting some object threatening our planet. When The Planetary Society presented its Roadmap To Space at the National Press Club in Washington two years ago, one young journalist asked, “How will we feel if [because of this Roadmap], China beats us to the Moon?” Simultaneously and spontaneously several of us on the panel, and Buzz Aldrin in the audience, jumped to our feet and exploded, “We’ve already been first to the Moon!” America can’t be first to the Moon again. No one can. But American leadership would be absolutely secure if we were leading an international mission in deep space beyond Earth orbit, while other nations (and perhaps even private companies) were getting their feet “wet” on the Moon. The spirit of space—optimism for the future—has been sadly lacking in recent years. We are bogged down in small questions looking at our feet instead of using our minds to look at the stars. I have been pretty downbeat myself, as readers of some of my recent columns and articles have noticed. Perhaps the achievement last week of our friend and colleague, Elon Musk, with Falcon 9 and Dragon has provided some buoyancy to my view. Elon’s drive is not just to achieve Earth orbit, but also to help us one day reach Mars. His current achievement is just a milestone on the way. In one of his interviews last week Elon said he is developing this system so that NASA can focus on exploration and new achievements in human space flight. The rubble pile on which the present human space program perches could actually provide enough of a foundation on which to start building. Returning to my use of President Kennedy’s statement, I asserted my view that a human asteroid mission can be done within the decade; that is, by the end of 2020. This is faster than President Obama’s 2025 goal and faster than most folks in the space program feel is possible. I think it can be done within the budget guidelines laid out in the President’s proposed fiscal year 2011 budget (still to be passed by Congress). It’s a push, to be sure, but I was heartened by Lockheed Martin’s recent proposal that they could do such a mission with their Orion Crew Vehicle in that time period. If the established aerospace industry players would cooperate with the government and “NewSpace” companies for new human space achievements, I have no doubt that a 2020 timetable is possible. As SpaceX put it in a Twitter message a half hour after their successful mission: “A big thank you to NASA for their continued support! What an awesome partnership!” The technical requirements of a human asteroid mission are big but straightforward. The mandate for the heavy-lift rocket needed for deep space missions is already in place. So is the crew vehicle, although it may need some kind of service module attachment. The commercial arrangements may even give us some competitive choices in this time period. The longer flight of an asteroid mission will need more supplies. We need to accelerate development of the crew life support capability required for the several-month interplanetary voyage, but we have already agreed to use the International Space Station for that training. International capabilities from the other spacefaring nations can keep the cost within today’s bounds. The rubble pile on which the present human space program perches could actually provide enough of a foundation on which to start building. But the endeavor needs an “architect” to lead it. America and the world need their “can-do” spirit restored. A human asteroid mission is not the answer to all (or even most) of our problems, but like Apollo it can foster the spirit that enables much more to be accomplished. Do we have it in us?

## I/L – Space Leadership K2 Leadership

### Exploration is essential to U.S. global leadership

**King, 8**

[David is director of NASA's Marshall Space Flight Center. “Exploration of space is a key to our role as a global leader”, Huntsville Times, February 24, 2008, Lexis]

Nation's efforts have brought many benefits to all Americans I was surprised to see a Feb. 5 Huntsville Times editorial state that it may be time to rethink America's policy of space exploration and to relinquish our world leadership in space to address more pressing needs at home. That would be exactly the wrong thing to do. Continuing an aggressive space exploration policy is essential to maintaining and advancing the technological superiority that is critical to our nation's prosperity and security in an increasingly competitive and dangerous world. NASA is developing the Orion crew exploration vehicle and the Ares launch vehicles, already four years and many milestones along the road to a first flight test in April 2009. This next-generation space fleet will give our nation access to space unparalleled in the world, and will transport human explorers to the moon and beyond. Some critics question how we, as a nation, can spend billions on space exploration at a time when so many other needs exist, from health care for our citizens to national defense initiatives. These are the same voices and the same concerns raised 50 years ago after the successful flight of America's first satellite, Explorer I, and the formation of NASA. In 1958, Americans were dealing with the post-World War II population boom and with life in a strange, new nuclear age. The civil-rights movement was gaining momentum. Automation had transformed industry, and nearly 5.5 million workers were jobless. A massive construction program was under way, funded two years earlier by the $32 billion Interstate Highway Act - an unimaginable price tag at a time when houses typically cost less than $13,000. Overseas, a regime change in Iraq had our nation pondering its Middle East policies. Soviet Premier Nikita Khrushchev was stoking the Cold War. And America was just a year away from war in Vietnam. With all that uncertainty and strife, no wonder there was widespread concern over the creation of a tax-funded program to loft satellites and science experiments to space. And no wonder that concern grew a few years later, when President Kennedy declared, "We choose to go to the moon in this decade." That line is familiar to many, but fewer may recall that he opened that 1962 speech with remarks about a world struggling to keep pace with economic change and social upheaval: "Such a pace cannot help but create new ills as it dispels old - new ignorance, new problems, new dangers," he said. "Surely the opening vistas of space promise high costs and hardships, as well as high reward. So it is not surprising that some would have us stay where we are a little longer, to rest, to wait." Kennedy knew what astute leaders know today: Doubters can always find reasons not to commit to the complex challenges of exploration and technological advancement. Human progress requires will, determination, foresight and perseverance. In December 2007, NASA Administrator Michael Griffin re-emphasized the true nature of this endeavor. "(Our) goal is not solely to explore our solar system," he said, "but to use accessible space for the benefit of mankind ... to incorporate our solar system into our way of life." I might add that it is the final frontier. For 50 years, we have successfully incorporated the benefits of space exploration into American life. The U.S. space exploration policy will continue that model stewardship of taxpayer dollars, delivering new technologies and capabilities that will bring new benefits to our country and our world. In the midst of challenges global and domestic, the risk lies not in exploring to expand our knowledge and capabilities, but rather in failing to do so. China is investing heavily in building their space capabilities because they understand the value of these activities as a driver for innovation and a source of national pride. This environment in China is breeding thousands of high-tech start-ups. We can afford to do no less. And it is important to remember that our investment in space exploration is spent right here on Earth. None should know that better than the people of Huntsville, the first stop on the road to the moon and beyond.

### U.S. space leadership is a pre-condition for global hegemony

Young et. al, 8 [ Mr. A. Thomas Young, Chairman Lieutenant General Edward Anderson, USA (Ret.) Vice Admiral Lyle Bien, USN (Ret.) General Ronald R. Fogleman, USAF (Ret.) Mr. Keith Hall General Lester Lyles, USAF (Ret.) Dr. Hans Mark, “ Leadership, Management, and Organization for National Security Space,” Institute for Defense Analyses, July 2008 <http://www.armyspace.army.mil/ASJ/Images/National_Security_Space_Study_Final_Sept_16.pdf>]

The IAP’s assessment, our findings, and our recommendations for aggressive action are based on the understanding that space-based capabilities are essential elements of the nation’s economic infrastructure and provide critical underpinnings for national security. Space-based capabilities should not be managed as derivative to other missions, or as a diffuse set of loosely related capabilities. Rather, they must be viewed as essential for restoring and preserving the health of our NSS enterprise. NSS requires top leadership focus and sustained attention. The U.S. space sector, in supporting commercial, scientific, and military applications of space, is embedded in our nation’s economy, providing technological leadership and sustainment of the industrial base. To cite one leading example, the Global Positioning System (GPS) is the world standard for precision navigation and timing, directly and indirectly affecting numerous aspects of everyday life. But other capabilities such as weather services; space-based data, telephone and video communications; and television broadcasts have also become common, routine services. The Space Foundation’s 2008 Space Report indicates that the U.S. commercial satellite services and space infrastructure sector is today approximately a $170 billion annual business. Manned space flight and the unmanned exploration of space continue to represent both symbolic and substantive scientific “high ground” for the nation. The nation’s investments in the International Space Station, the Hubble Telescope, and scientific probes such as Pioneer, Voyager, and Spirit maintain and demonstrate our determination and competence to operate in space. They also spark the interest of the technical, engineering, and scientific communities and capture the imaginations of our youth. 3 The national security contributions of space-based capabilities have become increasingly pervasive, sophisticated, and important. Global awareness provided from space—including intelligence on the military capabilities of potential adversaries, intelligence on the proliferation of weapons of mass destruction, and missile warning and defense—enables effective planning for and response to critical national security requirements. The communications bandwidth employed for Operation Iraqi Freedom today is over 100 times the bandwidth employed at the peak of the first Gulf war. Approximately 80 percent of this bandwidth is being provided by commercial satellite capacity. Military capabilities at all levels—strategic, operational, and tactical— increasingly rely upon the availability of space-based capabilities. Over the recent decades, navigation and precision munitions were being developed and refined based on space-based technologies. Space systems, including precision navigation, satellite communications, weather data, signals intelligence, and imagery, have increasingly provided essential support for military operations, including most recently from the very first days of Operation Enduring Freedom in Afghanistan. Similarly, the operational dominance of coalition forces in the initial phase of Operation Iraqi Freedom provided a textbook application of the power of enhancing situational awareness through the use of space-based services such as precision navigation, weather data management, and communications on the battlefield. These capabilities are continuing to provide major force-multipliers for the soldiers, airmen, sailors, and marines performing stabilization, counter-improvised explosive device (IED), counterterrorism, and other irregular warfare missions in Iraq, Afghanistan, and around the world. As the role and importance of space-based capabilities for military operations grows, the users are demanding that they be more highly integrated with land-, sea-, and air-based capabilities. During the first decades of the Cold War, the premier applications of space could be exemplified by the highly specialized systems that enabled exposed photographic film to be parachuted from space, developed and analyzed by intelligence experts, and rushed to the situation room in the White House for strategic purposes. Space-based capabilities were uniquely capable of providing visibility into areas of denied access. Today and in the future, the employment of space-based capabilities will increasingly support military operations. And for all users, the employment of spacebased capabilities will be more accurately exemplified by sophisticated database searches of a range of relevant commercially available and specialized national security digital information, using tools that integrate such information across all sources. For all the reasons cited here—military, intelligence, commercial, scientific— there can be no doubt that continued leadership in space is a vital national interest that merits strong national leadership and careful stewardship.

## Add-On – Asteroid Mining

### Asteroid missions are a pre-requisite for future asteroid mining

Hopkins et. al, 10 [ Josh Hopkins, Adam Dissel, Mark Jones, James Russell, and Razvan Gaza Lockheed Martin “ Plymouth Rock An Early Human Mission to Near Earth Asteroids Using Orion Spacecraft,” June 2010, http://www.lockheedmartin.com/data/assets/ssc/Orion/Toolkit/OrionAsteroidMissionWhitePaperAug2010.pdf]

Asteroids have long been proposed as potential sources for resource extraction. Volatiles such as water could be gathered for use in space as propellant or life support supplies. Some asteroids are enriched in high-value platinum group metals †† which might be worth the cost of transporting them to Earth if that cost can be reduced in the future. Both the cost of extracting these resources and their value once extracted are still mostly speculative. Human missions to a few asteroids could provide data to determine whether or not asteroid mining may some day be economically viable. Missions to asteroids could determine the abundance of these resources and investigate methods for operating on and near asteroids, including methods for extracting valuable material. Data on the chemical composition and geotechnical characteristics of asteroids would be as useful to engineers as to planetary scientists.

### That’s sustains the earth’s supply of rare-earth metals – initial NASA investments catalyze private development

Space Wealth, 11 [ Space Wealth is dedicated to the proposition that profitable asteroid mining (P@M) is a pragmatic goal. The organization works to bring asteroid researchers, data, and publications together, in order to promote extraterrestrial resource development, Directed by: William BC Crandall, MBA ,Founder, Larry Gorman PhD Professor of Finance

Cal Poly, Peter Howard, PhD, Senior Scientist Exelixis Inc‑, “Is Asteroid Mining A Pragmatic Goal?”, http://spacewealth.org/files/Is-P@M-Pragmatic-2011-02-23.pdf]

 Economic resources in space are of three types: Location, energy, and matter. Some near-Earth locations already support profitable industrial engagements. Low-Earth and geosynchronous Earth orbits host hundreds of revenue-generating satellites (worldwide industry revenues in 2008: >$140 billion). 19 Beyond Earth’s atmosphere, solar radiation is abundant; it powers most satellites. Orbiting space-based solar power systems (SBSP) may be able to deliver huge quantities of clean, sustainable energy to Earth. 20 But to date, nothing from the vast reaches beyond Earth orbit has ever been involved in an economic exchange. To incrementally expand our current off-planet economy, the next resource is clear: NearEarth asteroids. To take this next step, we need our space agencies to make asteroid mining a priority, and demonstrate how it can done. Agencies should support SBSP, but it should not be a top priority for two reasons. First, SBSP already attracts interest from commercial firms and defenserelated institutions. 21 Second, even if SBSP supplied 99% of the world’s electricity, we’re still just in Earth orbit. We haven’t begun to tap the mineral wealth of the inner solar system. We need out space agencies to reach out—with robots, certainly; perhaps with humans— to find, get hold of, and bring back an economically significant chunk of matter, and sell it on the open market. We need them to prime the pump for economically and ecologically sustainable, post-Earthasaclosedsystem, industrial societies. Our space agencies need to enable a revolutionary transformation in the material culture of our home planet. They need to design and launch positive economic feedback systems that utilize off-planet resources. Space agencies need to develop the skills and knowledge required to draw material resources through extraterrestrial supply chains, and put them to use in terrestrial systems of production. Once learned, space agencies need to transfer these skills and understandings to individuals in industry. Civil space agencies also need to help design, publish, and promote the innersolarsystem knowledgebases that will prepare today’s students for profitable extraterrestrial careers. 22 We need our civil space agencies to do these things, because we need the metals that are available in asteroid ore to support our technological societies on Earth, so that they may become ecologically sustainable over the decades and centuries to come. In its 1985 revision of the 1958 Space Act, Congress defined NASA’s #1 Priority: “Seek and encourage, to the maximum extent possible, the fullest commercial use of space.” 23 Given such direction, one might assume that today, 25 years latter, NASA’s top activity would be developing economically promising space resources: energy from the sun and metals from asteroids. Instead, most funds go to programs to put humans in space. 24 Some of these resources have outstanding value. Space agencies intent on addressing fundamental economic needs should focus on these materials. Platinum, for example, has sold at over $1,700/oz since January. 25 Platinum group metals (PGMs) are great catalysts. Used in automotive catalytic converters, which are required by national governments worldwide, 26 PGM supplies are quite limited. Some models point to terrestrial depletion within decades. 27 Platinum group metals are also critical as catalysts in hydrogen fuel cells, which are key to a possible postcarbon, “hydrogen economy.” 28 In 2008, TheNational Research Council identified PGMs as the “most critical” metals for U.S. industrial development. 29 Platinum group metals are abundant in certain types of nearEarth asteroids (NEAs). NEAs that are mineralogically similar to one of the most common types of “observed fall” meteorites (H-type, ordinary chondrites) offer PGM concentrations (4.5 ppm) 30 that are comparable to those found in profitable terrestrial mines (36 ppm). 31 Other meteorites suggest that some asteroids may contain much more valuable metal. 32 The PGM value of a 200 m asteroid can exceed $1 billion, or possibly $25 billion. 33 Over 7,500 NEAs have been detected. 34 Close to a fifth of these are easier to reach than the moon; more than a fifth of those are ≥200 m in diameter: 200+ targets. 35 President Obama requested, and Congress has authorized, a four-fold increase in detection funding ($5.8 m to $20.4 m/year). 36 This could lead to ~10,000 known 200 m NEAs in a decade. 37 But detection is just a start. The costs to locate, extract, and process asteroid ore are not well understood. 38 Before significant private capital is put at risk, we need to learn more. In cooperation with other forward looking nations, 39 the U.S. should purchase an option to develop asteroid resources by investing in the knowledge required to mine asteroids. We can then choose to exercise this option if terrestrial PGM supplies do in fact collapse. Asteroids may also be able to supply other metals that are increasingly at risk. 40 There are several candidates: In 2009, the U.S. imported 100% of 19 key industrial metals. 41 To seek the “fullest commercial use of space,” NASA should buy down the risk of asteroid mining ventures by investing in R&D that can give us the tools to discover, analyze, and process asteroid ore, and deliver it safely to Earth, and to Earth orbit. NASA, with other space agencies, should run demonstrations for this globally important program so that, as the GAO likes to put it, useful “knowledge supplants risk over time.” 42

### Rare-earth metals are running out – lack of new sources ensures global war with China

New Scientist, 7 [David Cohen, “ Earth audit; We are using up minerals at an alarming rate. How long before they run out,” May 26, 2007 FEATURES; Cover Story; Pg. 34-41 Lexis]

This could prove lucrative, but Prichard is motivated by something far more significant than the chance of a quick buck. Platinum is a vital component not only of catalytic converters but also of fuel cells - and supplies are running out. It has been estimated that if all the 500 million vehicles in use today were re-equipped with fuel cells, operating losses would mean that all the world's sources of platinum would be exhausted within 15 years. Unlike with oil or diamonds, there is no synthetic alternative: platinum is a chemical element, and once we have used it all there is no way on earth of getting any more. What price then pollution-free cities? It's not just the world's platinum that is being used up at an alarming rate. The same goes for many other rare metals such as indium, which is being consumed in unprecedented quantities for making LCDs for flat-screen TVs, and the tantalum needed to make compact electronic devices like cellphones. How long will global reserves of uranium last in a new nuclear age? Even reserves of such commonplace elements as zinc, copper, nickel and the phosphorus used in fertiliser will run out in the not-too-distant future. So just what proportion of these materials have we used up so far, and how much is there left to go round? Perhaps surprisingly, given how much we rely on these elements, we can't be sure. For a start, the annual global consumption of most precious metals is not known with any certainty. Estimating the extractable reserves of many metals is also difficult. For rare metals such as indium and gallium, these figures are kept a closely guarded secret by mining companies. Governments and academics are only just starting to realise that there could be a problem looming, so studies of the issue are few and far between. Armin Reller, a materials chemist at the University of Augsburg in Germany, and his colleagues are among the few groups who have been investigating the problem. He estimates that we have, at best, 10 years before we run out of indium. Its impending scarcity could already be reflected in its price: in January 2003 the metal sold for around $60 per kilogram; by August 2006 the price had shot up to over $1000 per kilogram. Uncertainties like this pose far-reaching questions. In particular, they call into doubt dreams that the planet might one day provide all its citizens with the sort of lifestyle now enjoyed in the west. A handful of geologists around the world have calculated the costs of new technologies in terms of the materials they use and the implications of their spreading to the developing world. All agree that the planet's booming population and rising standards of living are set to put unprecedented demands on the materials that only Earth itself can provide. Limitations on how much of these materials is available could even mean that some technologies are not worth pursuing long term. Take the metal gallium, which along with indium is used to make indium gallium arsenide. This is the semiconducting material at the heart of a new generation of solar cells that promise to be up to twice as efficient as conventional designs. Reserves of both metals are disputed, but in a recent report René Kleijn, a chemist at Leiden University in the Netherlands, concludes that current reserves "would not allow a substantial contribution of these cells" to the future supply of solar electricity. He estimates gallium and indium will probably contribute to less than 1 per cent of all future solar cells - a limitation imposed purely by a lack of raw material. To get a feel for the scale of the problem, we have turned to data from the US Geological Survey's annual reports and UN statistics on global population. This has allowed us to estimate the effect that increases in living standards will have on the time it will take for key minerals to run out . How many years, for instance, would these minerals last if every human on the planet were to consume them at just half the rate of an average US resident today? The calculations are crude - they don't take into account any increase in demand due to new technologies, and also assume that current production equals consumption. Yet even based on these assumptions, they point to some alarming conclusions. Without more recycling, antimony, which is used to make flame retardant materials, will run out in 15 years, silver in 10 and indium in under five. In a more sophisticated analysis, Reller has included the effects of new technologies, and projects how many years we have left for some key metals. He estimates that zinc could be used up by 2037, both indium and hafnium - which is increasingly important in computer chips - could be gone by 2017, and terbium - used to make the green phosphors in fluorescent light bulbs - could run out before 2012. It all puts our present rate of consumption into frightening perspective . Our hunger for metals and minerals may not grow indefinitely, however. When Tom Graedel and colleagues at Yale University looked at figures for the consumption of iron - one of our planet's most plentiful metals - they found that per capita consumption in the US levelled off around 1980. "This suggests there might be only so many iron bridges, buildings and cars a member of a technologically advanced society needs," Graedel says. He is now studying whether this plateau is a universal phenomenon, in which case it might be possible to predict the future iron requirements of developing nations. Whether consumption of other metals is also set to plateau seems more questionable. Demand for copper, the only other metal Graedel has studied, shows no sign of levelling off, and based on 2006 figures for per capita consumption he calculates that by 2100 global demand for copper will outstrip the amount extractable from the ground. So what can be done? Reller is unequivocal: "We need to minimise waste, find substitutes where possible, and recycle the rest." Prichard, working with Lynne Macaskie at the University of Birmingham in the UK, has found that platinum makes up as much as 1.5 parts per million of roadside dust. They are now seeking out the largest of these urban platinum deposits, and Macaskie is developing a bacterial process that will efficiently extract the platinum from the dust. Other metals could be obtained in equally unorthodox places. Cities are huge stores of metals that could be repurposed, Kleijn points out. Replacing copper water pipes with plastic, say, would free up large quantities of copper for other uses. Tailings from worked-out mines contain small amounts of minerals that may become economic to extract. Some metals could be taken from seawater. "It's all a matter of energy cost," he says. "You could go to the moon to mine precious materials. The question is: could you afford it?" These may sound like drastic solutions, but as Graedel points out in a paper published last year (Proceedings of the National Academy of Sciences , vol 103, p 1209), "Virgin stocks of several metals appear inadequate to sustain the modern 'developed world' quality of life for all of Earth's people under contemporary technology." And when resources run short, conflict is often not far behind. It is widely acknowledged that one of the key motives for civil war in the Democratic Republic of the Congo between 1998 and 2002 was the riches to be had from the country's mineral resources, including tantalum mines - the biggest in Africa. The war coincided with a surge in the price of the metal caused by the increasing popularity of mobile phones (New Scientist , 7 April 2001, p 46). Similar tensions over supplies of other rare metals are not hard to imagine. The Chinese government is supplementing its natural deposits of rare metals by investing in mineral mines in Africa and buying up high-tech scrap to extract metals that are key to its developing industries. The US now imports over 90 per cent of its so-called "rare earth" metals from China, according to the US Geological Survey. If China decided to cut off the supply, that would create a big risk of conflict, says Reller. Reller and Graedel say urgent action is required. Firstly, we need accurate estimates of global reserves and precise figures for consumption. Then we need to set up an accelerated programme to recycle, reuse and, where possible, replace rare elements with more abundant ones. Without all this, any dream of a more equitable future for humanity will come to nothing. Governments seem, at last, to be taking the issue seriously, and next month an OECD working group will be convened to come up with some of the answers. If that goes to plan, we will soon at least have a clearer idea of the problem. Whether any solution to looming global shortages can then be found remains to be seen.

### Nuclear war

**Straits Times** (Singapore), June 25, **2000**, “Regional Fallout: No one gains in war over Taiwan,” p. Lexis

THE high-intensity scenario postulates a cross-strait war escalating into a full-scale war between the US and China. If Washington were to conclude that splitting China would better serve its national interests, then a full-scale war becomes unavoidable. Conflict on such a scale would embroil other countries far and near and -- horror of horrors -- raise the possibility of a nuclear war. Beijing has already told the US and Japan privately that it considers any country providing bases and logistics support to any US forces attacking China as belligerent parties open to its retaliation. In the region, this means South Korea, Japan, the Philippines and, to a lesser extent, Singapore. If China were to retaliate, east Asia will be set on fire. And the conflagration may not end there as opportunistic powers elsewhere may try to overturn the existing world order. With the US distracted, Russia may seek to redefine Europe’s political landscape. The balance of power in the Middle East may be similarly upset by the likes of Iraq. In south Asia, hostilities between India and Pakistan, each armed with its own nuclear arsenal, could enter a new and dangerous phase. Will a full-scale Sino-US war lead to a nuclear war? According to General Matthew Ridgeway, commander of the US Eighth Army which fought against the Chinese in the Korean War, the US had at the time thought of using nuclear weapons against China to save the US from military defeat. In his book The Korean War, a personal account of the military and political aspects of the conflict and its implications on future US foreign policy, Gen Ridgeway said that US was confronted with two choices in Korea -- truce or a broadened war, which could have led to the use of nuclear weapons. If the US had to resort to nuclear weaponry to defeat China long before the latter acquired a similar capability, there is little hope of winning a war against China 50 years later, short of using nuclear weapons. The US estimates that China possesses about 20 nuclear warheads that can destroy major American cities. Beijing also seems prepared to go for the nuclear option. A Chinese military officer disclosed recently that Beijing was considering a review of its “non first use” principle regarding nuclear weapons. Major-General Pan Zhangqiang, president of the military-funded Institute for Strategic Studies, told a gathering at the Woodrow Wilson International Centre for Scholars in Washington that although the government still abided by that principle, there were strong pressures from the military to drop it. He said military leaders considered the use of nuclear weapons mandatory if the country risked dismemberment as a result of foreign intervention. Gen Ridgeway said that should that come to pass, we would see the destruction of civilisation. There would be no victors in such a war. While the prospect of a nuclear Armaggedon over Taiwan might seem inconceivable, it cannot be ruled out entirely, for China puts sovereignty above everything else.

## 2ac – Kuiper-Belt Add-on

### Survey leads to more Kuiper Belt discoveries

NASA, 7 [“ Near-Earth Object Survey and Deflection Analysis of Alternatives, Report to Congress,” March 200 http://www.nasa.gov/pdf/171331main\_NEO\_report\_march07.pdf]

A wide area search, such as that being proposed for NEOs, will also substantially increase the identification of Kuiper Belt Objects (KBOs). For example, if 10 percent of 24the observing time on the proposed Dedicated LSST was spent in a KBO search mode, roughly 100,000 faint KBOs should be discovered. An expanded KBO database will allow the study of dynamical distributions, further resonances, the existence of a KBO demarcation beyond 50 AU, high-eccentricity/high-inclination orbits, size distributions, frequency of binary objects and collision rates, chemical compositions and the relationship of objects to dust disks around other stars. The survey will also provide a rich database of targets for future space missions. Detection surveys such as the proposed Pan-STARRS and LSST provide unique solarsystem science because they are designed to detect and perform follow-up studies of moving objects. Centaurs, Jupiter Family Comets, and certain extinct comets may be related through a common origin in the Kuiper Belt. Dedicated assets will assure that appropriate follow-up is carried out over the annual timeframes that are required to produce orbits for the slower-moving objects found in the outer solar system. Thus, a collateral result of the NEO survey program could be both the delineation of the structure of the Kuiper Belt and the discovery of many new minor planet

### Kuiper belt research is essential to discovering the origins of life and the universe

Frueh, 2 [Sara, staff writer – National Academies of Science, “ Missions to Pluto-Kuiper Belt and Europa Should Top NASA's Agenda,” inFocus, Summer/Fall 2002 Vol. 2 No. 2 <http://www.infocusmagazine.org/2.2/eng_space_exploration.html>]

"Data collected on the Kuiper Belt over the last decade suggest that it's made up of innumerable objects, and that they have a bizarre variety of properties," said Michael Belton, president, Belton Space Exploration Initiatives, Tucson, Ariz., and chair of the committee that wrote the report. "A mission would let us study some of those properties more closely." This examination may help scientists understand how the solar system began, because the giant planets are believed to have been created from objects like those in the Kuiper Belt. A mission might also provide clues to the origin of life on Earth, the report says, which may have started with organic material delivered by a comet from the region billions of years ago. A mission to Pluto and the Kuiper Belt has been on and off NASA's agenda for several years. The Bush administration eliminated funding for the mission in NASA's 2003 budget, citing the high cost involved. But the report says that a trip to the Kuiper Belt could gather enough data -- possibly paradigm-shifting information -- to justify its price tag, which is midsize by space-exploration standards. Another reason not to delay the mission is that the time window for studying Pluto is closing. The planet is beginning the leg of its 248-year solar orbit that is farthest from the sun; more of the surface will be shadowed and the atmosphere will freeze, making study impossible. A thaw -- and another chance to survey the brightest object in the murky Kuiper Belt -- won't happen again for more than a century. The report makes several recommendations for NASA's space exploration agenda over the next decade, prioritizing missions within different size classes -- including large missions, which NASA has shied away from in recent years. But giving up larger missions would be a mistake, the committee believes. "For the scientific health of the space program you need a major mission from time to time," said Belton. "They're costly, but they can help us achieve a breadth of knowledge that smaller missions can't." The next large mission should be sent to Jupiter's moon Europa, the report says. The satellite is thought to have an ocean under its icy crust -- which makes it, with Mars, the best place beyond Earth to search for life. The mission would confirm the presence of the ocean, study its qualities, and try to determine whether it does in fact harbor living organisms. Important research can be done from the ground as well, the report notes, urging NASA to partner with the National Science Foundation to build a large-aperture survey telescope, which could survey the faintest objects in the entire northern sky every week. In addition to aiding the study of distant Kuiper Belt objects, the telescope would offer a very concrete benefit: the ability to better detect and assess the risk posed by small asteroids and comets that most frequently collide with Earth.

### That’s key to preserving earth’s biodiversity – impact is extinction

Chung et. al, 10 [ S.Y. Chung P. Ehrenfreund, Space Policy Institute, Elliott School of International Affairs, The George Washington University, J.D. Rummel, Institute for Coastal Science and Policy, East Carolina University and N. Peter, European Space Policy Institute, “ Synergies of Earth science and space exploration,” Advances in Space Research Volume 45, Issue 1, 4 January 2010, Pages 155-168 ]

 Planet Earth is currently the only habitable world we know. Although life may have existed as early as 3.5 billion years ago, humans have lived for only a rather short time on Earth—about 2 million years. Nonetheless, we are (unfortunately) making up for lost time as a factor affecting the habitability of the planet. In the last 200 years humans have changed the Earth dramatically, calling into question how long the Earth and its natural systems can balance its limited energy and material resources against the effects of human-caused pollution. Keeping Earth’s natural “life support” processes operating, and the planet habitable by humans, has become a critical challenge. Space activities, particularly environmental satellites that monitor the biosphere, are becoming essential tools to help us to manage and sustain our very lives (Sadeh et al., 1996). Space observations can tell us about our current biosphere, but the Earth as a system has not always been hospitable to human life. For approximately half of its existence, there was virtually no free oxygen in the Earth’s atmosphere, and a completely different set of biogeochemical cycles operated to keep the Earth relatively stable in that state. Fundamental knowledge of the Earth is of more than casual interest—it is essential that we understand how to keep it from changing back to a stable state with conditions that would not support human life. Astrobiology, the study of life in the universe, seeks answers to fundamental questions on the origin, evolution, distribution and future of life, wherever it may exist. As an interdisciplinary science field that unites astronomers, biologists, physicists, chemists, geologists and many of their subdisciplines it addresses many questions that are relevant for sustaining life on planet Earth—and in particular, the relationships between a planet (especially the Earth) and life, and how each affects the other. Astrobiology provides both the knowledge and perspective to inform us about how to maintain the Earth as a long-term habitable home for humanity. Originally a creation of NASA (under the titles, “exobiology” and “planetary biology”), astrobiology has grown worldwide as a multi- and interdisciplinary endeavor. Together, astrobiologists have collaborated in writing down a “NASA Astrobiology Roadmap” (Des Marais et al., 2008) now in its third iteration that covers seven main goals, given in temporal, and not priority, order. Of particular interest here in joining Earth sciences and space studies is roadmap goal number 6, which states that astrobiology, as a field, should work to, Understand the principles that will shape the future of life, both on Earth and beyond. Elucidate the drivers and effects of microbial ecosystem change as a basis for forecasting future changes on time scales ranging from decades to millions of years, and explore the potential for microbial life to survive and evolve in environments beyond Earth, especially regarding aspects relevant to US Space Policy. Here “US Space Policy” is a reference to the specific US interest in returning to the Moon and going on to Mars, as mentioned above. Astrobiology, and particularly the desire to understand the origin, evolution, and distribution of life in the universe, is one of the chief motivators for expanded human capabilities to conduct science on other worlds (Fig. 1). 3.1. Lessons from astrobiology: conservation of biodiversity and life in extreme environments Over the course of the last 4.5 billion years, Earth has created an ideal environment to sustain life of an astonishing variety. Dynamic processes in the Earth’s interior have established a magnetosphere that protects the Earth from harmful cosmic ray particles. The Earth’s atmosphere, in turn, shields life from harmful ultraviolet radiation and allows for a stable climate and temperature cycle by providing a “greenhouse effect” that retains some of the infrared radiation that is emitted from the Earth’s surface. A brief look at our planetary neighbors shows that Venus, with an average surface temperature of 500 °C (as a result of a “runaway” greenhouse effect), and Mars, with a surface temperature from −60 °C to +10 °C and a thin atmosphere (with an insufficient greenhouse effect), are both unable to sustain life as we know it at the surface. The combination of Earth’s physical and chemical processes (e.g. ocean circulation, atmospheric flows, plate tectonic recycling of the crust, etc.) and living processes, together, form biogeochemical cycles that transform the elements and compounds related to life (the bio-elements such as H, C, O, S, N, P). While humans originally were part of these natural cycles, the discovery and proliferation of human-discovered technology have caused major disruptions to these bio-cycles in many, if not most, parts of the globe. As a consequence, and with the orders-of-magnitude rise in human population over the last 200 years, humans are coming to dominate and destroy the natural cycling of the elements with unpredictable consequences. While it is well known that natural processes have led to extinction of species, other life forms arose over time. Regrettably, the effects of modern human activities are rapid on the evolutionary timescale, and consequently are impacting climate, ecosystems, and other species at a rate that does not allow for natural replacement of ecosystems in the same time-span. Consequently, the loss of ecosystems on which we depend is affecting human habitats adversely, all over the planet. Biodiversity is a measure of the variety and numbers of life found at all levels of biological organization. As a concept, biodiversity can embrace all forms of diversity in biological systems: in genetics, species, and ecosystems. The conservation of biodiversity has become a global concern because different species contribute in essential (and often uncharacterized) ways to the functioning of the Earth’s life support systems, on which we all depend. Effectively, the loss of biodiversity results in the loss of valuable ecosystem services that we take for granted, and which we (if we care to continue to inhabit the Earth) can ill-afford to lose. The ongoing loss of biodiversity is of concern to astrobiologists, in particular, they realize that the Earth, as a system, is quite capable of operating without it—but that it can operate as a system that does not provide essential support (e.g. oxygen in the atmosphere) for human life. In fact, the most critical difference between today’s Earth, and that of 2.5 billion years ago, is biodiversity. The effects of other living systems have made the Earth the extremely habitable planet that it is today, and it would be ironic if humanity’s influence were to destroy those systems on which we all very much depend. Scholes et al. (2008) note that unlike climate change there are no widely accepted and globally available set of measures to assess biodiversity and critical information that can aid in the preservation of biodiversity. Thus, challenges lie in integrating biodiversity data that are diverse, physically dispersed, and in many cases, not organized in a way that makes them accessible to modern researchers. The threat to biological diversity was among the topics discussed at the UN World Summit for Sustainable Development in 2002. At the Summit, the governments adopted the “Convention on Biological Diversity” to conserve biological diversity. “Biodiversity” is one of the nine ‘societal benefit areas’ identified by GEOSS. The Biodiversity Observation Network (BON) (Scholes et al., 2008) is an initiative within GEOSS which establishes a framework for data collection, standardization, and information exchange in biodiversity studies (BON, 2009). NASA and DIVERSITAS, an international program of biodiversity science, is leading the planning phase of GEO-BON, in collaboration with the GEO secretariat. Nine other organizations and programs are participating in this initiative. In a sense, the astrobiological interest of life in extreme environments is complementary to the study and appreciation of biodiversity. Life on Earth is extremely adaptable, and has been shown to overcome extremes in temperature, pH, and pressure in abundance (see Table 1). Equally interesting is the fact that some microbes depend exclusively on abiotic processes for their existence, including organisms in deep mines that survive on the products of radioactivity and organisms at deep sea vents. While it is encouraging that life is so tenacious, it is also humbling in a sense. While these microbes live in “extreme” environments quite successfully (and thus would not be hurt if the Earth, itself, were to become “extreme”) the word “extreme” is used because it connotes an environment where humans could not live, at all. The study of extreme life is important in determining both where life may be found elsewhere, and in understanding the functioning and adaptability of life that we have here on Earth. Both NASA and the US National Science Foundation have had or currently have programs to study “extremophiles” and recently, the European Commission has initiated within its “Framework 7” a program called CAREX (Coordination Action for Research Activities on life in Extreme Environments), that coordinates and sets scientific priorities for research of life in extreme environment (ESF, 2007). CAREX endorses cross-sector interests in microbes, plants, and animals evolving in diverse marine, polar, and terrestrial extreme environment as well as outer space (CAREX, 2008). By relating information on both biodiversity and extreme life, this synergy of Earth and space science can help to provide concepts (based on recent scientific data) on how ecosystems respond to rapid rates of change and determine possible directions by which the Earth and its biosphere (including humans) will survive and co-evolve in the future. This approach requires applying the principles and perspectives of astrobiology to identify options that might allow humanity to halt the destruction of its own habitat as well as the decline of biodiversity on Earth, while addressing a variety of related economic and energy-related scenarios associated with those options.

# \*\*\*\* Supplement Starts HERE \*\*\*\*

# Asteroids Coming

## Brink – Small Asteroids

### Small asteroids come to close all the time, we must take action

MSN 11, (Mike Wall, Reporter for MSN on Space, 6/2/2011, Asteroid zips close to Earth, http://www.msnbc.msn.com/id/43262234/ns/technology\_and\_science-space/, SH)

An asteroid the size of a small motorhome zoomed near Earth on Wednesday night, coming closer to us than the moon ever does. The 23-foot-long (7-meter) space rock, named 2009 BD, came within 215,000 miles (346,000 kilometers) of Earth at around 8:51 p.m. ET. The moon's average distance from us is about 239,000 miles (385,000 kilometers). 2009 BD never threatened to hit Earth on this pass, researchers said. But even if the asteroid had slammed into us, it wouldn't have been a big deal. "2009 BD is a small object, 7 meters, and poses no threat," scientists with NASA's Asteroid Watch program tweeted yesterday. "Rocky objects this size would break apart in our atmosphere and cause no damage." [ Photos of Asteroids in Deep Space ] The asteroid's small size also made it a tough target for skywatchers. A large telescope was necessary to see it on Wednesday night, researchers said.

## Brink – Apophis

### An asteroid will hit the earth by 2036, its either act, or die

Addrisi 11 (Amity Addrisi is a, Reporter at FOX40 News, Reporter / Weather Anchor at KBAK/KBFX TV, KERN 1410 Radio at Kern News Radio, Bakersfeildnow.com, “25 years from extinction? NASA separates fact from fiction”, 5/24/11, http://www.bakersfieldnow.com/news/investigations/122477149.html, accessed 6/27/11, SH)

BAKERSFIELD, Calif. — From the silver screen to science fiction novels, the idea of how the world will meet its end has long fascinated the human race. One particular doomsday theory is anything but crazy, and it has NASA scientists putting money into research that might just save out lives. Right now, astronomers are keeping a close eye on an object flying towards earth. Eyewitness News went to NASA's Jet Propulsion Laboratory in Pasadena and learned that if space really is the final frontier, we may someday have to move off our little blue dot in the universe. On April 13, 2029, an asteroid is set to come very close to earth. On that day, the asteroid Apophis, which is the size of two football fields, will fly by the blue planet. Scientists believe that the asteroid could be affected by earth's gravitational pull, eventually spinning Apophis into our orbit. If all the conditions are right, Apophis could return seven years later and actually hit the planet. Scientists calculate that to happen on April 13, 2036, which happens to be Easter Sunday. At JPL, Don Yeomans is the leading astronomer for NASA's Near Earth Objects, or NEO, program. Yeomans said the asteroid would create, "Substantial regional devastation. We're not talking a city or a county. We're talking a state-sized devastation area." NASA's NEO program monitors comets and asteroids heading towards earth. Right now, scientists are keeping track of approximately 380 such objects at JPL. As they get closer to earth, scientists reassess them and determine if they are a threat of earth impact. Eyewitness News asked NASA if they are confident that they could save the world. "We do have the technology to deal with them if we find them early enough," Yeomans said. "I like to say that the three criteria for near earth objects is we have to find them early, we have to find them early and we have to find them early." So, let’s say scientists found an asteroid bound for earth? What then? "You can run into it, you can with a space craft slow it down so it misses the earth in 10 years time, you could send a nuclear explosive device to either blow it up or slow it down," Yeomans said, listing the options. It's not necessarily the impact of the asteroid that would devastate our planet. If a large enough meteor hit our planet it could create a worldwide dust cloud. That cloud would block out the sun and kill the plants that sustain all life on earth. At this point, NASA has identified 90 percent of the largest asteroids coming towards earth, including Apophis. Yeomans said almost none of them represent a threat for the next 100 years. However, he says that although the threat of asteroids is not immediate, he stresses we should look beyond earth for a new home. "We have two choices, we can either expand our place in the universe or we can die, because we are going to get hit sooner or later," Yeomans said.

### **Apophis will hit Earth in 2036 – we must act immediately**

Helium Astronomy, 11. Jan 28 2011. “Astronomers now predict killer asteroid will hit Earth in 2036”(http://www.helium.com/items/2078149-astronomers-now-predict-killer-asteroid-will-hit-earth-in-2036)TT

Grim astronomers in Russia have recalculated the trajectory of the ominous asteroid Apophis and now predict it will slam into Earth on April 13, 2036. An asteroid struck the Yucatan basin 65 million years ago wiping out the dinosaurs, changing the climate, and destroying much of life on Earth. The asteroid's name, Apophis, is the Greek name for the Egyptian god Apep, also known as "the Uncreator." "Apophis will approach Earth at a distance of 37,000 to 38,000 kilometers on April 13, 2029. Its likely collision with Earth may occur on April 13, 2036," Professor Leonid Sokolov of the St. Petersburg State University stated during an interview with state television and reported by Russian news service RIA Novosti. As more astronomers are recognizing the danger, a major summit has been called. "Russian space officials and members of the European Commission will meet in early July to discuss joining forces against thousands of potentially hazardous asteroids," Anatoly Perminov, the head of the Russian Federal Space Agency Roscosmos stated in an official press release. Largest threat Although large meteors and asteroids whiz by our planet every year—and thousands of tons of space debris falls through our atmosphere annually—Apophis, first seen during 2004, is considered by scientists to be the most imminent threat to the human race. While Russian and European scientists have increased their warnings of the approaching danger the asteroid poses, NASA has charted a different course. In 2010 the American space agency announced it had reduced the chances the object's disastrous collision with Earth. Sokolov believes the project is urgent as each day that passes will make it more difficult to steer the asteroid with current technology. As nations around the world have recognized the threat large space objects such as comets and asteroids pose to life on Earth, no global defense plan has been developed to meet a possible emergency. Without a plan and effective defense, catastrophe might result. A meeting scheduled for July 7, 2011 will consider a proposal to launch a joint asteroid project between Russia and the European Union.

### Apophis will hit the Earth in 2036

R.C. Christian, 3/7/11, writer for Coup Media Group, <http://coupmedia.org/astro-physics/nasa-predicts-astroid-impact-in-2036-apophis-astroid-0206>,

NASA Predicts Astroid Impact in 2036

A new report from Russia seems to indicate that the Mayans were off by just 24 years. According to Russian scientists, in the year 2036, the Apophis asteroid and the Earth may have a date to meet. The report came from UPI, saying that Leonid Sokolov of St. Petersburg State University estimated the asteroid will hit the planet on April 13, 2036. The asteroid has made headlines before as scientists have been keeping a wary eye on the rock two football fields in size hurtling through space since its discovery in 2004 and forecast its near miss in 2029, only to return and hit the earth as it exits the "keyhole" some 7 years later.

### Asteroid threat is very real—Apophis headed for Earth.

Herald Sun, ’06 ( Herald Sun, 5/16/06, “April 13, 2036 - our date with destiny,” 6/21/11, LexisNexis, MLK)

MARK your calendar for Sunday, April 13, 2036. That's when a 300m-wide asteroid named Apophis could hit the Earth and cause massive destruction. The odds of a collision are 1/6250 and, while that's a long shot at the racetrack, the stakes are too high for astronomers to ignore. Apophis represents the most imminent threat from the worst type of natural disaster known, one reason NASA is spending millions to detect the threat from this and other asteroids. A direct hit on an urban area could unleash more destruction than Hurricane Katrina, the 2004 Asian tsunami and the 1906 San Francisco earthquake combined. The blast would equal 880 million tons of TNT, or 65,000 times the power of the atomic bomb on Hiroshima. Objects this size are thought to hit Earth about once every 1000 years. According to recent estimates, the risk of dying from a renegade space rock is comparable to the hazards posed by tornadoes and snakebites.

## A2: Apophis will miss us

### Apophis may not hit us on the first pass, but may hit on the its next flyby.

Barbee & Nuth 2009 Asteroid Impact Threats: Advancements in Asteroid Science to Enable Rapid and Effective Deflection Missions 1Brent William Barbee, M.S.E., and 2Joseph A. Nuth III, Ph.D. 1Aerospace Engineer and Planetary Defense Scientist, Emergent Space Technologies, Inc., Greenbelt, MD, USA, 2Senior Scientist for Primitive Bodies, Solar System Exploration Division, NASAís Goddard Space Flight Center, Greenbelt, MD, 20771, USA Journal of Cosmology, 2009, Vol 2, pages 386-410. Cosmology, October 31, 2009

Of immediate concern is a significant close approach that will occur 20 years from now. The asteroid Apophis will closely approach our planet on Friday, April 13th, 2029 at an altitude of approximately 32,000 km (closer than our geosynchronous satellites). The size of Apophis is currently estimated at 270 m. While the asteroid’s size is well below the 1 km threshold for globally catastrophic impact effects, if it were to strike Earth it would deliver an energy of approximately 500 Mt, causing tremendous local and regional devastation. While we know that Apophis will not collide with Earth in 2029, the 2029 close approach will cause the orbit of Apophis to be radically altered due to Earth’s gravity. The precise manner in which Apophis flies past Earth in 2029 will have a tremendous effect on the asteroid’s post flyby orbit, making it very difficult to predict the future threats that the asteroid may pose to Earth. Until recently the probability of Apophis striking Earth in 2036 was 1 out of 45,000 and new observations have reduced this probability to 1 out of 233,000. The fact that these numbers are only estimates, the size of the asteroid, how extremely close it will come to our planet, and the lack of in-situ orbital or physical observations of the asteroid all mean that it continues to merit our close attention.

## Risk of NEO high

### Risk of a strike is high

Easterbrook ‘8 (Gregg, Editor of The Atlantic and The New Republic and Sr. Fellow at Brookings, “The Sky is Falling,” June, http://www.theatlantic.com/doc/200806/asteroids)

Breakthrough ideas have a way of seeming obvious in retro­spect, and about a decade ago, a Columbia University geophysicist named Dallas Abbott had a breakthrough idea. She had been pondering the craters left by comets and asteroids that smashed into Earth. Geologists had counted them and concluded that space strikes are rare events and had occurred mainly during the era of primordial mists. But, Abbott realized, this deduction was based on the number of craters found on land—and because 70 percent of Earth’s surface is water, wouldn’t most space objects hit the sea? So she began searching for underwater craters caused by impacts rather than by other forces, such as volcanoes. What she has found is spine-chilling: evidence that several enormous asteroids or comets have slammed into our planet quite recently, in geologic terms. If Abbott is right, then you may be here today, reading this magazine, only because by sheer chance those objects struck the ocean rather than land. Abbott believes that a space object about 300 meters in diameter hit the Gulf of Carpentaria, north of Australia, in 536 A.D. An object that size, striking at up to 50,000 miles per hour, could release as much energy as 1,000 nuclear bombs. Debris, dust, and gases thrown into the atmosphere by the impact would have blocked sunlight, temporarily cooling the planet—and indeed, contemporaneous accounts describe dim skies, cold summers, and poor harvests in 536 and 537. “A most dread portent took place,” the Byzantine historian Procopius wrote of 536; the sun “gave forth its light without brightness.” Frost reportedly covered China in the summertime. Still, the harm was mitigated by the ocean impact. When a space object strikes land, it kicks up more dust and debris, increasing the global-cooling effect; at the same time, the combination of shock waves and extreme heating at the point of impact generates nitric and nitrous acids, producing rain as corrosive as battery acid. If the Gulf of Carpentaria object were to strike Miami today, most of the city would be leveled, and the atmospheric effects could trigger crop failures around the world. What’s more, the Gulf of Carpentaria object was a skipping stone compared with an object that Abbott thinks whammed into the Indian Ocean near Madagascar some 4,800 years ago, or about 2,800 B.C. Researchers generally assume that a space object a kilometer or more across would cause significant global harm: widespread destruction, severe acid rain, and dust storms that would darken the world’s skies for decades. The object that hit the Indian Ocean was three to five kilometers across, Abbott believes, and caused a tsunami in the Pacific 600 feet high—many times higher than the 2004 tsunami that struck Southeast Asia. Ancient texts such as Genesis and the Epic of Gilgamesh support her conjecture, describing an unspeakable planetary flood in roughly the same time period. If the Indian Ocean object were to hit the sea now, many of the world’s coastal cities could be flattened. If it were to hit land, much of a continent would be leveled; years of winter and mass starvation would ensue. At the start of her research, which has sparked much debate among specialists, Abbott reasoned that if colossal asteroids or comets strike the sea with about the same frequency as they strike land, then given the number of known land craters, perhaps 100 large impact craters might lie beneath the oceans. In less than a decade of searching, she and a few colleagues have already found what appear to be 14 large underwater impact sites. That they’ve found so many so rapidly is hardly reassuring. Other scientists are making equally unsettling discoveries. Only in the past few decades have astronomers begun to search the nearby skies for objects such as asteroids and comets (for convenience, let’s call them “space rocks”). What they are finding suggests that near-Earth space rocks are more numerous than was once thought, and that their orbits may not be as stable as has been assumed. There is also reason to think that space rocks may not even need to reach Earth’s surface to cause cataclysmic damage. Our solar system appears to be a far more dangerous place than was previously believed. The received wisdom about the origins of the solar system goes something like this: the sun and planets formed about 4.5 billion years ago from a swirling nebula containing huge amounts of gas and dust, as well as relatively small amounts of metals and other dense substances released by ancient supernova explosions. The sun is at the center; the denser planets, including Earth, formed in the middle region, along with many asteroids—the small rocky bodies made of material that failed to incorporate into a planet. Farther out are the gas-giant planets, such as Jupiter, plus vast amounts of light elements, which formed comets on the boundary of the solar system. Early on, asteroids existed by the millions; the planets and their satellites were bombarded by constant, furious strikes. The heat and shock waves generated by these impacts regularly sterilized the young Earth. Only after the rain of space objects ceased could life begin; by then, most asteroids had already either hit something or found stable orbits that do not lead toward planets or moons. Asteroids still exist, but most were assumed to be in the asteroid belt, which lies between Mars and Jupiter, far from our blue world. As for comets, conventional wisdom held that they also bombarded the planets during the early eons. Comets are mostly frozen water mixed with dirt. An ancient deluge of comets may have helped create our oceans; lots of comets hit the moon, too, but there the light elements they were composed of evaporated. As with asteroids, most comets were thought to have smashed into something long ago; and, because the solar system is largely void, researchers deemed it statistically improbable that those remaining would cross the paths of planets. These standard assumptions—that remaining space rocks are few, and that encounters with planets were mainly confined to the past—are being upended. On March 18, 2004, for instance, a 30-meter asteroid designated 2004 FH—a hunk potentially large enough to obliterate a city—shot past Earth, not far above the orbit occupied by telecommunications satellites. (Enter “2004 FH” in the search box at Wikipedia and you can watch film of that asteroid passing through the night sky.) Looking at the broader picture, in 1992 the astronomers David Jewitt, of the University of Hawaii, and Jane Luu, of the Massachusetts Institute of Technology, discovered the Kuiper Belt, a region of asteroids and comets that starts near the orbit of Neptune and extends for immense distances outward. At least 1,000 objects big enough to be seen from Earth have already been located there. These objects are 100 kilometers across or larger, much bigger than whatever dispatched the dinosaurs; space rocks this size are referred to as “planet killers” because their impact would likely **end life on Earth**. Investigation of the Kuiper Belt has just begun, but there appear to be substantially more asteroids in this region than in the asteroid belt, which may need a new name. Beyond the Kuiper Belt may lie the hypothesized Oort Cloud, thought to contain as many as trillions of comets. If the Oort Cloud does exist, the number of extant comets is far greater than was once believed. Some astronomers now think that short-period comets, which swing past the sun frequently, hail from the relatively nearby Kuiper Belt, whereas comets whose return periods are longer originate in the Oort Cloud. But if large numbers of comets and asteroids are still around, several billion years after the formation of the solar system, wouldn’t they by now be in stable orbits—ones that rarely intersect those of the planets? Maybe not. During the past few decades, some astronomers have theorized that the movement of the solar system within the Milky Way varies the gravitational stresses to which the sun, and everything that revolves around it, is exposed. The solar system may periodically pass close to stars or groups of stars whose gravitational pull affects the Oort Cloud, shaking comets and asteroids loose from their orbital moorings and sending them downward, toward the inner planets. Consider objects that are already near Earth, and the picture gets even bleaker. Astronomers traditionally spent little time looking for asteroids, regarding them as a lesser class of celestial bodies, lacking the beauty of comets or the significance of planets and stars. Plus, asteroids are hard to spot—they move rapidly, compared with the rest of the heavens, and even the nearby ones are fainter than other objects in space. Not until the 1980s did scientists begin systematically searching for asteroids near Earth. They have been finding them in disconcerting abundance. In 1980, only 86 near-Earth asteroids and comets were known to exist. By 1990, the figure had risen to 170; by 2000, it was 921; as of this writing, it is 5,388. The Jet Propulsion Laboratory, part of NASA, keeps a running tally at www.neo.jpl.nasa.gov/stats. Ten years ago, 244 near-Earth space rocks one kilometer across or more—the size that would cause global calamity—were known to exist; now 741 are. Of the recently discovered nearby space objects, NASA has classified 186 as “impact risks” (details about these rocks are at www.neo.jpl.nasa.gov/risk). And because most space-rock searches to date have been low-budget affairs, conducted with equipment designed to look deep into the heavens, not at nearby space, the actual number of impact risks is undoubtedly much higher. Extrapolating from recent discoveries, NASA estimates that there are perhaps 20,000 potentially hazardous asteroids and comets in the general vicinity of Earth. There’s still more bad news. Earth has experienced several mass extinctions—the dinosaurs died about 65 million years ago, and something killed off some 96 percent of the world’s marine species about 250 million years ago. Scientists have generally assumed that whatever caused those long-ago mass extinctions—comet impacts, extreme volcanic activity—arose from conditions that have changed and no longer pose much threat. It’s a comforting notion—but what about the mass extinction that occurred close to our era? About 12,000 years ago, many large animals of North America started disappearing—woolly mammoths, saber-toothed cats, mastodons, and others. Some scientists have speculated that Paleo-Indians may have hunted some of the creatures to extinction. A millennia-long mini–Ice Age also may have been a factor. But if that’s the case, what explains the disappearance of the Clovis People, the best-documented Paleo-Indian culture, at about the same time? Their population stretched as far south as Mexico, so the mini–Ice Age probably was not solely responsible for their extinction. A team of researchers led by Richard Firestone, of the Lawrence Berkeley National Laboratory, in California, recently announced the discovery of evidence that one or two huge space rocks, each perhaps several kilometers across, exploded high above Canada 12,900 years ago. The detonation, they believe, caused widespread fires and dust clouds, and disrupted climate patterns so severely that it triggered a prolonged period of global cooling. Mammoths and other species might have been killed either by the impact itself or by starvation after their food supply was disrupted. These conclusions, though hotly disputed by other researchers, were based on extensive examinations of soil samples from across the continent; in strata from that era, scientists found widely distributed soot and also magnetic grains of iridium, an element that is rare on Earth but common in space. Iridium is the meteor-hunter’s lodestar: the discovery of iridium dating back 65 million years is what started the geologist Walter Alvarez on his path-breaking theory about the dinosaurs’ demise. A more recent event gives further cause for concern. As buffs of the television show *The X Files* will recall, just a century ago, in 1908, a huge explosion occurred above Tunguska, Siberia. The cause was not a malfunctioning alien star-cruiser but a small asteroid or comet that detonated as it approached the ground. The blast had hundreds of times the force of the Hiroshima bomb and devastated an area of several hundred square miles. Had the explosion occurred above London or Paris, the city would no longer exist. Mark Boslough, a researcher at the Sandia National Laboratory, in New Mexico, recently concluded that the Tunguska object was surprisingly small, perhaps only 30 meters across. Right now, astronomers are nervously tracking 99942 Apophis, an asteroid with a slight chance of striking Earth in April 2036. Apophis is also small by asteroid standards, perhaps 300 meters across, but it could hit with about 60,000 times the force of the Hiroshima bomb—enough to destroy an area the size of France. In other words, small asteroids may be more dangerous than we used to think—and may do considerable damage even if they don’t reach Earth’s surface. Until recently, nearly all the thinking about the risks of space-rock strikes has focused on counting craters. But what if most impacts don’t leave craters? This is the prospect that troubles Boslough. Exploding in the air, the Tunguska rock did plenty of damage, but if people had not seen the flashes, heard the detonation, and traveled to the remote area to photograph the scorched, flattened wasteland, we’d never know the Tunguska event had happened. Perhaps a comet or two exploding above Canada 12,900 years ago spelled the end for saber-toothed cats and Clovis society. But no obvious crater resulted; clues to the calamity were subtle and hard to come by. Comets, asteroids, and the little meteors that form pleasant shooting stars approach Earth at great speeds—at least 25,000 miles per hour. As they enter the atmosphere they heat up, from friction, and compress, because they decelerate rapidly. Many space rocks explode under this stress, especially small ones; large objects are more likely to reach Earth’s surface. The angle at which objects enter the atmosphere also matters: an asteroid or comet approaching straight down has a better chance of hitting the surface than one entering the atmosphere at a shallow angle, as the latter would have to plow through more air, heating up and compressing as it descended. The object or objects that may have detonated above Canada 12,900 years ago would probably have approached at a shallow angle. If, as Boslough thinks, most asteroids and comets explode before reaching the ground, then this is another reason to fear that the conventional thinking seriously underestimates the frequency of space-rock strikes—the small number of craters may be lulling us into complacency. After all, if a space rock were hurtling toward a city, whether it would leave a crater would not be the issue—the explosion would be the issue. A generation ago, the standard assumption was that a dangerous object would strike Earth perhaps once in a million years. By the mid-1990s, researchers began to say that the threat was greater: perhaps a strike every 300,000 years. This winter, I asked William **Ailor**, an asteroid specialist at The Aerospace Corporation, a think tank for the Air Force, what he **thought the risk was**. Ailor’s answer: **a one-in-10 chance per century of a dangerous space-object strike**. Regardless of which estimate is correct, **the likelihood of an event is**, of course**, no predictor. Even if space strikes are *likely* only once every million years, that doesn’t mean a million years will pass before the next impact**—the sky could suddenly darken tomorrow.Equally important, improbable but cataclysmic dangers ought to command attention because of their scope. A tornado is far more likely than an asteroid strike, but humanity is sure to survive the former. The chances that any one person will die in an airline crash are minute, but this does not prevent us from caring about aviation safety. And as Nathan Myhrvold, the former chief technology officer of Microsoft, put it, “The odds of a space-object strike during your lifetime may be no more than the odds you will die in a plane crash—but with space rocks, it’s like the entire human race is riding on the plane.”

### We’re overdue for a major collision

Ghayur ‘7 (Lecturer, University Institute of Information Technology, UAAR, 07 <A., Developing a Three Period Strategy to Face a Global Threat: A Preliminary Analysis <http://www.aero.org/conferences/planetarydefense/2007papers/P5-1--Ghayur--Paper.pdf>)

Human civilization has come a long way since the Dark Ages of mid twentieth century, however, it is only now that the mankind is realizing the veracity of the apocalyptic scenario – a heavenly body colliding with earth – the Hellish nightmare which troubled Dr. Halley. Although the chances of Halley’s Comet plummeting into earth are nearly nonexistent, the chances nevertheless of another NEO colliding head on with earth are very much there. The battle-scared face of moon and the numerous impact craters on earth are a living testament to it. But all this evidence proved insufficient to turn any heads until 1994 when Shoemaker-Levy Nine crashed into Jupiter. The earth-sized storms created on Jupiter surface sent alarms through the echelons of bureaucracy and politics and suddenly a nonexistent apocalyptic nightmare had become a very much possible scenario. Today, we are sitting in the midst of ever increasing human population on this planet Earth, which in turn is sitting amidst ever increasing number of identified NEOs. We are already overdue for our next big hit; last one occurring 65 million years ago at Chixilub. Any impact of that scale would result in deaths and displacement of billions, if not more. Do we have a global network and an institution to respond timely and effectively?

### Millions of asteroids exist that could hit us

Stone ‘8 (Richard, editor for Science Magazine, National Geographic, “Target Earth,” 8-1, lexis)

An estimated ten million rocky asteroids and ice-and-dirt comets pirouette in outer space, and once in a while their paths fatefully intersect our planet's. One such encounter took place a hundred miles from present-day Washington, D.C., where a 53-mile-wide crater lies buried beneath Chesapeake Bay--the scar left when a two-mile-wide rock smashed into the seafloor 35 million years ago. More notorious is the titan, six miles in diameter, that barreled into the Gulf of Mexico around 65 million years ago, releasing thousands of times more energy than all the nuclear weapons on the planet combined. "The whole Earth burned that day," says Ed Lu, a physicist and former astronaut. Three-quarters of all life-forms, including the dinosaurs, went extinct. Astronomers have identified several hundred asteroids big enough to cause a planetwide disaster. None is on course to do so in our lifetimes. But the heavens teem with smaller, far more numerous asteroids that could strike in the near future, with devastating effects. On June 30, 1908, an object the size of a 15-story building fell in a remote part of Siberia called Tunguska. The object--an asteroid or a small comet--exploded a few miles before impact, scorching and blowing down trees across 800 square miles. The night sky was so bright with dust from the explosion, or icy clouds from the water vapor it blasted into the upper atmosphere, that for days people in Europe could read newspapers outdoors at night. On Tunguska's hundredth anniversary, it's unsettling to note that objects this size crash into Earth every few centuries or so.

### Not a question of if; but when.

Bucknam & Gold ‘8 (Mark, Deputy Dir for Plans in the Policy Planning Office of the Office of the US Secretary of Defense, Colonel USAF, PhD in War Studies from U of London, BS in physics, MS in materials science and engineering from Virginia Tech & Robert, Chief Technologist for the Space Department at the Applied Physics Laboratory of Johns Hopkins “Asteroid Threat? The Problem of Planetary Defence,” Survival vol. 50 no. 5 | 2008 | pp. 141–156)

It is not a question of if Earth will be walloped again by a sizeable asteroid or comet, but when. Learning whether it will happen in the next 100 years ought to be a top global priority. An international consortium could pool resources and enhance the capacity to locate and track PHOs, while simultaneously creating a forum to foster the sort of transparency and removal of legal barriers desirable for developing and fielding a mitigation system. Major spacefaring states – the United States, Russia, China, Japan, India and member states of the European Space Agency – should be enlisted in the effort. The consortium would have to decide whether to collaborate on all areas of the challenge or create a division of labour among its members. That decision would involve weighing concerns over technology transfer against a desire for transparency.

### Risks are undercalculated

Peiser ‘3 <Benny, social anthropologist at [Liverpool John Moores University](http://www.livjm.ac.uk/) in the UK. He has written extensively about the influence of [NEO impacts](http://128.102.38.40/impact/intro_faq.cfm) on human and societal evolution, Great Impact Debates Much Ado About Nothing? 2/17 <http://www.astrobio.net/index.php?option=com_debate&task=detail&id=378>>

Benny Peiser: I'm afraid I regard as misleading allegations that the NEO community (or the missile defense community for that matter) deliberately exaggerate the impact risk for selfish reasons. In reality, most NEO researchers - in particular those in the U.S. - have underrated the potential hazards from space. [NASA](http://www.nasa.gov/) only reluctantly began to address the issue following the considerable 'wake-up call' caused by the impact of comet [Shoemaker-Levy 9](http://nssdc.gsfc.nasa.gov/planetary/comet_body.html) on [Jupiter](http://www.nineplanets.org/jupiter.html) in 1994. Without these harmless reminders, I doubt whether NASA would have established even a rudimentary program to inventory the number of large asteroids out there.

## Global Killer Possible

### We haven’t discovered 1/3 of large asteroids, and need better detection methods to do so

Valsecchi ‘7(G.B., INAF-IASF & A. Milani Comparetti, Department of Mathematics, University of Pisa, Ch. 11: Evaluating the Risk of Impacts and the Efficiency of Risk Reduction in Comet/Asteroid Impacts and Human Society: An Interdisciplinary Approach, SpringLink)

With automated surveys currently operating (LINEAR, LONEOS, NEAT, Catalina, Spacewatch) there has been rapid progress; as of November 2004 more than 700 NEAs with estimated diameter > 1 km have been discovered (and followed up until a reasonably good orbit could be determined). The estimation of the total population is tricky, but about 2/3 of the 1 km NEAs have been discovered. The remaining ones, however, will take long to discover, because their orbits are such that they are less often visible than the ones already discovered (Bottke et al. 2002).

## A2 Not Imminent

### Even if a NEO is not immanent – the plan is critical to set up effective policy frameworks to deal with a NEO when it does come.

Richard Crowther, 2009 Ph.D. Science and Technology Facilities Council (STFC), Harwell Science and Innovation Campus, Chilton, Oxfordshire OX11 0QX, UK Journal of Cosmology, 2009, Vol 2, pages 411-418. Cosmology, October 31, 2009 Near Earth Object (NEO) Impact Threat: An International Policy Response

The evaluation of the NEO risk requires data and expertise from many scientific fields and other domains relevant to risk analysis. It is worth emphasizing however that NEOs do not recognize national boundaries and that the consequences of future impacts are unlikely to be isolated to any individual country or region. For this reason amongst others it is important that the policy framework which is established should encourage nations to work together to share data, expertise and resources to assess and mitigate the risk of a future impact, wherever it may occur on the Earth. In looking for a formal response from government in relation to the NEO hazard, we also need to be realistic and pragmatic. The current surveys have demonstrated that a global-scale asteroid impact is not imminent, and so there are few immediate actions which need to be taken, the most urgent perhaps being the need to reduce the size threshold of detection of the survey programs to include objects which still pose a very significant threat to society should they impact the Earth. Instead we need to exploit existing policy platforms and infrastructures where appropriate, and bridge the gaps in capability (whether it be process or infrastructure) with specific actions related to NEOs. There is however a compelling argument for embarking on the establishment a policy framework to address NEOs now. We need to use this finite window of opportunity, before a specific impact threat has been identified, to develop our policies in a balanced and objective manner. Experience has shown us that decisions made ‘in the heat of the moment’ can be flawed, ill-judged, and compromised by emotion and subjective influences such as exposure to an impact threat (or lack of it). Mitigating the impact of a NEO will represent one of the greatest challenges ever posed to society, and the resulting technical solutions will be intrinsically coupled with wide ranging policy implications. We are obliged to ensure that a policy framework is set in place which will support these efforts rather than undermine them.

## Timeframe – Short

### Strike could come at any time

Gerrard & Barber ’97(Michael & Anna, Asteroids and Comets: U.S. and International Law and the Lowest-Probability, Highest Consequence Risk, New York Univ. Environmental Law Journal, http://www1.law.nyu.edu/journals/envtllaw/issues/vol6/1/6nyuelj4.html)

Asteroids [1](http://www1.law.nyu.edu/journals/envtllaw/issues/vol6/1/6nyuelj4n.html%22%20%5Cl%20%22fn1%22%20%5Ct%20%22Notes) and comets [2](http://www1.law.nyu.edu/journals/envtllaw/issues/vol6/1/6nyuelj4n.html#fn2) pose unique policy problems. They are the ultimate example of a low probability, high consequence event: no one in recorded human history is confirmed to have ever died from an asteroid or a comet, but the odds are that at some time in the next several centuries (and conceivably next year) an asteroid or a comet will cause mass localized destruction and that at some time in the coming half million years (and conceivably next year), an asteroid or a comet will kill several billion people. The sudden extinction of the dinosaurs, and most other species 65 million years ago, is now generally attributed to the impact of a 10-kilometer- wide comet or asteroid at Chicxulub in Mexico's Yucatan Peninsula that left a 110-mile-wide crater. [3](http://www1.law.nyu.edu/journals/envtllaw/issues/vol6/1/6nyuelj4n.html%22%20%5Cl%20%22fn3%22%20%5Ct%20%22Notes) \*5 Even our own century has seen smaller-scale impacts. On June 30, 1908, hundreds of square miles of trees were burned and herds of reindeer may have been incinerated in the Tunguska region of Siberia by an explosion with the force of 1,000 Hiroshima bombs, apparently caused by a 60-meter asteroid. [4](http://www1.law.nyu.edu/journals/envtllaw/issues/vol6/1/6nyuelj4n.html%22%20%5Cl%20%22fn4%22%20%5Ct%20%22Notes) Airborne blasts in the kiloton to megaton range were observed in 1930 at the Curuca River in Brazil; in 1947 at Sikhote-Alin, Siberia; in 1965 over Revelstoke, Canada; and over Ontario in 1966 and Alaska in 1969. [5](http://www1.law.nyu.edu/journals/envtllaw/issues/vol6/1/6nyuelj4n.html%22%20%5Cl%20%22fn5%22%20%5Ct%20%22Notes) Most recently, on November 22, 1996, a meteorite crashed into a coffee field in Honduras, leaving a 165-foot-wide crater. [6](http://www1.law.nyu.edu/journals/envtllaw/issues/vol6/1/6nyuelj4n.html%22%20%5Cl%20%22fn6%22%20%5Ct%20%22Notes)

### Could strike at any time

Chapman ‘3 <Clark, scientist at the [Southwest Research Institute](http://www.swri.edu/default.htm)'s Department of Space Studies, Great Impact Debates, Collision Course for Earth 3/03 <http://www.astrobio.net/index.php?option=com_debate&task=detail&id=389> >

Clark Chapman: Joe Veverka makes a major error when he compares the time scale for a large asteroid collision with the time scale for the sun turning into a red giant. There is ZERO chance that the sun will turn into a red giant during the next century, or even the next billion years, according to our robust understanding of the physics of stellar evolution. But asteroids strike AT RANDOM. If asteroids struck like clockwork, a kilometer-sized body every few hundred thousand years for example, then the analogy might work. But there is roughly a one-in-several-thousand chance that a kilometer-sized asteroid will strike during the 21st century. One could even strike tomorrow. One might well question what level of risk we are willing to accept by doing nothing about one-kilometer asteroids. Joe should argue that he's willing to accept the risk, given other higher priority concerns. But he's wrong, and he hurts his case, to make the classic error people make about [lightning strikes](http://thunder.msfc.nasa.gov/primer/) and hundred-year [floods](http://ks.water.usgs.gov/Kansas/pubs/fact-sheets/fs.024-00.html): "the next one can't happen again soon." It has nothing to do with a "waiting time" or being "over the event horizon." Given that civilization might hang in the balance, we really should think about this issue, despite the low probability that we will have to meet this challenge during our lifetimes. Of course, until such an asteroid is discovered, there certainly are weightier threats facing society, as Joe Veverka argues.

## Timeframe – Overdue

### We’re overdue for an extinction-class event

Cambier & Mead ‘7 (Doctors Jean-Luc & Frank, Air Force Research Laboratory, On NEO Threat Mitigation, Oct. http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA474424&Location=U2&doc=GetTRDoc.pdf)

One can point out that these numbers are extremely low, about an order of magnitude lower than fatalities from automobile accidents nationwide; therefore, on the basis of average numbers of fatalities expected from NEO impacts, there seems to be little reason for the U.S. Congress to be overly concerned and spend significant resources on this issue. However, the problem is not with the average number of fatalities, but the peak number and associated consequences at each event. While the country could certainly recover from impacts of NEOs of diameter ∅=300 m and below, even up to 600 m diameter given sufficient time2, there is no recovery possible from impacts by larger size NEOs, and the day an “extinction”-class event occurs, there is no safety in deep underground bunkers. The last event of this category was 65 Myr ago, and the probability of having had no similar impact in that period of time is approximately 50%. Humans (arguably all mammals in general) can therefore consider themselves reasonably fortunate not to have been wiped out of existence during that gap.

## At Least Every 100 years

### Asteroid Headed Every 100 Years

Kulger 6-27-2011 Jeffrey Kluger senior editor, oversees, attorney, has taught science journalism TIME's science and technology reporting <http://newsfeed.time.com/author/jkluger/#ixzz1QWX2TlAyhttp://newsfeed.time.com/2011/06/27/incoming-asteroids-theyre-here-theyre-near-get-used-to-them/>

The bad news is that the solar system remains a shooting gallery—not the way it was 4.6 billion years ago, when the planets were just forming and debris was everywhere, waiting to be gravitationally gathered in by whatever accreting planet it happened to pass. But still, space rocks abound—and not all are small enough to be eaten by the atmosphere. NASA estimates that about once every 100 years, a space rock larger than 50 meters (164 ft.) should be expected to reach Earth, causing local disasters or tidal waves. Every few hundred thousand years, an asteroid of 1 km (.62 mi.) could strike, causing the kind of global devastation that wiped out the dinosaurs 65 million years ago. Asteroids are so dangerous because they don't hit like a bullet fired at close range, leaving a clean hole wherever they strike. Instead, they come bearing all of the energy they accumulated in their high-speed flight and release it on impact. (To be precise, bullets do that too, but they're so small and their flight is so brief the energy release is not as significant.)

## 2012 Asteroid

### **Asteroid will hit Antartica in 2012 – This is a sign of whats to come**

The European Union Times, 11. Jan 14th 2011. “Huge asteroid will hit Antarctica in 2012”(http://www.eutimes.net/2011/01/huge-asteroid-will-hit-antarctica-in-2012/)TT

If you caught Starfire Tor on CoastToCoastAM last week you may have heard her mention that ‘they’, the PowersThatBe know that an incoming near earth object is going hit earth sometime in the next 2 years. There is evidence to suggest the object is going to strike one of the poles… most likely the south pole. Special Scientific teams have been down in Antarctica mapping the ice shelf for probable weak points. The object is rumored to be 800 meters wide and when it hits the south pole the entire ice shelf will collapse within months. Magnetic pole changes, recent unusual Sun activity, birds and animal acting disoriented… all of these are signs of an approaching object and its gravitational influence on our inner solar system. The PowerThatBe and the super rich are making preparations. They have seed vaults and underground bunkers prepared. This is the reason they do not care about the world’s environment or the financial system. It won’t matter. A billion will die. The oceans will rise 70 meters. Mankind will lose half the food supply. You have 1 year to prepare. The Mayans, the Sumerians, the Babylonian civilization, native Americans and countless other cultures have foretold this event. The earth is going to get hit by a small object that is in tow of a much larger object. The larger object revisits the earth on a predictable cycle. It will flip the earth upside down. Americans Military forces now control all of the high mountain ranges and have been building bunkers for years, this is the reason for staying in Afghanistan. Only the super rich elite will be invited escape the apocalypse. 90% of the death and destruction will come from the panic and wars after the event. Trillions of Dollars have been sucked out of the economy to build news space shuttles and space projects. Most of the UFO sightings are these black-project vehicles. A University of British Columbia Professor published an online article that projected an 800m asteroid would hit Antarctica in the fall of 2012. His article was on the www.phas.ubc.ca website for 2 days before it abruptly disappeared. The initial data was gathered by The Balloon-borne Large-Aperture Submillimeter Telescope (BLAST) at McMurdo Station, Antarctica. The theorized asteroid was then tracked by Canada-France-Hawaii Telescope on Mauna Kea, which (with the Adaptive Optics Bonnette) supplies probably the sharpest images currently obtainable from the ground. The South Pole Telescope One week after this mysterious article disappeared, “Canadian and American astronauts say the world needs to prepare for the big one — the asteroid impact that could one day devastate the Earth.Veteran Canadian astronaut Chris Hadfield is president of the Association of Space Explorers, which has prepared a detailed report on the asteroid threat. The Canadian Space Agency intends to launch NEOSSat next March to look for asteroids that may be hiding near the sun. The $15-million suitcase-sized satellite will circle about 700 kilometres above theEarth . A Canadian Space Agency official says NEOSSat is expected to detect hundreds of new asteroids during its first year of operation. It will also monitor the heavy traffic of satellites now orbiting the Earth to try to prevent possible collisions.” The article hypothesized a 94% probability that the asteroid would impact on the Filchner-Ronne ice shelf and cause 2/3 of ice on Antarctica to crumble into sea. The article surmised the total collapse of all Antarctic ice within 2-4 months after impact. “A deep enough impact would crack the ice shelf like a window and total structural collapse would be inevitable, a few months at the outside.” If the ice on Antarctica was added the the world’s ocean it would raise them by 70 meters. Extremely Important ECM Announcement Coming Tomorrow the Website Earth Changes Media has some kind of news on the 2012 Asteroid.

## NEO in 2098

### Dangerous asteroid could it us within this century.

(Belfast Telegraph,2010), September 29, 2010,”Belfast boffins are scanning the skies for a doomsday asteroid, and now they've found something worth keeping an eye on...”, Lexis, 6/27/11, CF

BE afraid ... be very afraid. Ulster scientists have discovered an asteroid that will come perilously close to our little planet in a couple of weeks' time, and could even strike Earth later in the century. And Northern Ireland-born former politician and self-proclaimed asteroid expert Lembit Opik has said the discovery is a harbinger of impending doom. The asteroid has been discovered by scientists from Queen's University in Belfast using a state-of-the-art telescope. A major sky survey has concluded that it will come within four million miles of Earth in mid-October. And what's more, experts have claimed that it is the first 'Potentially Hazardous Object' (PHO) to be detected by the Pan-STARRS (Panoramic Survey Telescope and Rapid Response System) survey. The asteroid -- which is about 150 feet in diameter and has been given the designation 2010 ST3 -- was captured on images on September 16, when it was 20 million miles away. Astronomers from Queen's Astrophysics Research Centre are involved in the ground-breaking survey, which is generating the largest ever multi-colour survey of the cosmos. The Pan-STARRS camera, known as GPC1, is the world's largest with 1400 megapixels. Built by the University of Hawaii, it is enabling scientists to assess wide areas of sky at a level of detail previously impossible. Former Liberal Democrat MP Mr Opik said it was about time that politicians began to take the threat of asteroids seriously. "We should be afraid, we should be very afraid, because an object that size could incinerate Belfast," he said. "My frustration is that politicians don't seem to be taking the threat seriously, even though we're more likely to die in an astral impact than we're likely to win the national lottery." Dr Robert Jedicke, a University of Hawaii member of the PS1 Scientific Consortium (PS1SC), who is working on the asteroid data from the telescope, said the object won't hit the Earth in the immediate future. But he added: "There is a very slight possibility that ST3 will hit Earth in 2098, so it is definitely worth watching.”

## NEO in 2182

### Massive asteroid could hit Earth in 2182, warn scientists

Firth 7-28-10, <http://www.dailymail.co.uk/sciencetech/article-1298285/Massive-asteroid-hit-Earth-2182-warn-scientists.html>

A massive asteroid might crash into Earth in the year 2182, scientists have warned.

The asteroid, called 1999 RQ36, has a 1-in-1,000 chance of actually hitting the Earth at some point before the year 2200, but is most likely to hit us on 24th September 2182. If an asteroid of this size hit the Earth it would cause widespread devastation and possible mass extinction. While the odds may seem long, they are far shorter than that of the asteroid Apophis, which currently has a 1 in 250,000 chance of striking Earth in 2036 Maria Eugenia Sansaturio and scientists from the Universidad de Valladolid in Spain have used mathematical models to calculate the risk of the asteroid hitting the Earth anytime between now and the year 2200. And they were shocked to discover that there are two potential opportunities for the asteroid to hit Earth in the year 2182. . The odds then drop before rising again in 2162 and 2182. Asteroid 1999 RQ36 is part of the Potentially Hazardous Asteroids (PHA) group, which all have the possibility of hitting the Earth due to their orbits and are all considered likely to cause damage. Even though the asteroid’s orbit is well-known thanks to 290 different observations by telescopes and 13 radar measurements there is uncertainty about its path because of the so-called Yarkovsky effect. This effect, first discovered in 2003 and named after a Russian engineer, is produced by the way an asteroid absorbs energy from the sun and re-radiates it into space as heat. This can subtly alter the asteroid’s flight path. The research, which has been published in Icarus journal, predicts what could happen in the upcoming years considering this effect. Sansaturio said: ‘The consequence of this complex dynamic is not just the likelihood of a comparatively large impact, but also that a realistic deflection procedure (path deviation) could only be made before the impact in 2080, and more easily, before 2060.' She added: ‘If this object had been discovered after 2080, the deflection would require a technology that is not currently available. ‘Therefore, this example suggests that impact monitoring, which up to date does not cover more than 80 or 100 years, may need to encompass more than one century. ‘Thus, the efforts to deviate this type of objects could be conducted with moderate resources, from a technological and financial point of view.’ The impact from the asteroid that created the famous Chicxulub crater in Mexico would have caused 'mega-tsunamis' many thousands of feet high. It is believed that this asteroid led to the extinction of the dinosaurs. Scientists around the world have long been discussing ways of deflecting potentially hazardous asteroids to prevent them hitting Earth.

## Asteroids coming all the time

### Everyday asteroids hit Earth

Hindustan Times ’10 (Hindustan Times, 7/26/10, Research reduces odds of Earth being hit by asteroids by 10-fold, 6/27/11, LexisNexis, MLK)

"On a daily basis, we're hit with basketball-sized objects, and Volkswagen-sized objects come in a few times a year. Fortunately, the limiting size for something that will actually do ground damage is about 30 meters [98 feet], and you'd expect something like that to come in every 200 years or so on average," Discovery News quoted Yeomans as saying. Yeomans heads NASA's Near Earth Object (NEO) Program Office, which continues to spearhead the global effort to identify and track significantly large asteroids in near-Earth space. That directive includes rocks more than a kilometer (0.6 miles) across, which typically hit the Earth in million-year intervals. These asteroids are capable of causing global consequences. Larger objects, including the ten kilometer 'dinosaur killer' that occurred 65 million years ago, are capable of plunging the globe into apocalyptic winters that last for years.

### Asteroids constantly enter the Earth’s atmosphere, sometimes causing destruction.

Symansky ’08 (Paul Symansky, Electrical Engineer at SymTech Laboratories and Boston College graduate, 2/28/08, “Asteroids: A realistic, but very remote threat,” 6/22/11, LexisNexis, MLK)

Asteroids are both majestic celestial bodies and ominous threats to our planet. Hundreds of thousands of asteroids have been identified in our solar system, each with a unique size, trajectory, and composition. While rarely in the news, these chunks of metal and rock strike our planet at an alarmingly high rate: once every few minutes. Granted, we don't hear about them because the majority of them burn up in the atmosphere long before possibly posing a threat to us surface dwellers. In fact, the Earth's atmosphere protects us at least once a year from rather large asteroids, with diameters of 150 feet or more, which have as much energy as the atomic bomb dropped on Hiroshima. The Earth can't protect against all impacts, though. The Alvarez hypothesis, which postulates that an asteroid or meteor is responsible for the last mass extinction event on Earth, is a predominant theory that stands testament to that fact. Exactly 100 years ago, a large asteroid approximately 125 to 200 meters in diameter managed to work its way through the upper atmosphere and exploded in remote Siberia with a force that destroyed 830 square miles of forest. Impact events aren't relegated to the ancient past; they do happen today.

### Asteroids are coming closer and closer all the time

Space.com ’11 (space.com staff, 5/9/11, “Huge asteroid to buzz Earth in November;

On November 8 and 9, the quarter-mile-wide asteroid 2005 YU55 will zoom past the Earth, coming within about 200,000 miles, a distance closer than our moon.” 6/22/11, LexisNexis, MLK)

An asteroid the size of an aircraft carrier will come closer to Earth this autumn than our own moon does, causing scientists to hold their breath as it zooms by. But they'll be nervous with excitement, not with worry about a possible disaster. There's no danger of an impact when the asteroid 2005 YU55 makes its close flyby Nov. 8, coming within 201,700 miles (325,000 kilometers) of Earth, scientists say. So they're looking forward to the encounter, which could help them learn more about big space rocks. "While near-Earth objects of this size have flown within a lunar distance in the past, we did not have the foreknowledge and technology to take advantage of the opportunity," Barbara Wilson, a scientist at NASA's Jet Propulsion Laboratory in Pasadena, Calif., said in a statement. "When it flies past, it should be a great opportunity for science instruments on the ground to get a good look.

### Tunguska devastation caused by a relatively small asteroid—what could a large one do?

Parker ’07 (Randall Parker, Professor of Economics at East Carolina author of Reflections on the Great Depression and The Economics of the Great Depression: A Twenty-First Century Look Back at the Economics of the Interwar Era both published by Edward Elgar, 12/18/07, “Tunguska Simulation Shows Higher Risk From Smaller Asteroids,” 6/21/11, <http://www.futurepundit.com/archives/004871.html>, MLK)

The stunning amount of forest devastation at Tunguska a century ago in Siberia may have been caused by an asteroid only a fraction as large as previously published estimates, Sandia National Laboratories supercomputer simulations suggest. “The asteroid that caused the extensive damage was much smaller than we had thought,” says Sandia principal investigator Mark Boslough of the impact that occurred June 30, 1908. “That such a small object can do this kind of destruction suggests that smaller asteroids are something to consider. Their smaller size indicates such collisions are not as improbable as we had believed.” Because smaller asteroids approach Earth statistically more frequently than larger ones, he says, “We should be making more efforts at detecting the smaller ones than we have till now.”

### The threat of asteroids is very real—we must begin research now.

Parker ’09 (Randall Parker, Professor of Economics at East Carolina author of Reflections on the Great Depression and The Economics of the Great Depression: A Twenty-First Century Look Back at the Economics of the Interwar Era both published by Edward Elgar, 10/27/09, “Asteroid Over Indonesia Triple Hiroshima Bomb Power,” 6/21/11, http://www.futurepundit.com/archives/006659.html, MLK)

On 8 October an asteroid detonated high in the atmosphere above South Sulawesi, Indonesia, releasing about as much energy as 50,000 tons of TNT, according to a NASA estimate released on Friday. That's about three times more powerful than the atomic bomb that leveled Hiroshima, making it one of the largest asteroid explosions ever observed. No telescope spotted it before it entered Earth's atmosphere. Rather than try to return to the Moon or go to Mars I would rather build an asteroid defense system. My motto: First, don't die.

### New asteroid headed for earth on possible collision course.

TNS ’10 (Targeted News Service, 4/27/10, Students Capture Image of Distant Galaxy and Discover a Potential Earth Impactor, 6/22/11, LexisNexis, MLK)

Colleyville astronomy teacher Leslie Howell says, "Our most recent observation was of an asteroid identified by students Dylan Adams, Cole Stuart, Michelle Warnock, and Remi Dimarco. Fortunately, this asteroid is not a threat to Earth, but the objective of the program is to track asteroids and locate new ones that could be on a collision course with Earth." Meanwhile, students in the other ISAC program found exactly that--a virtual Earth impactor. Using telescopes in other locations across the United States, students in Europe and the U.S. have reported five new Main Belt Asteroid discoveries. One of the discoveries is a virtual Earth impactor, which means it has an orbit that poses a potential impact hazard to the Earth. This discovery was made on March 24 by students at the Jesuit College Preparatory School in Dallas.

## Inh- No defense now

### There is no status quo programs with enough money to combat the asteroid problem

USN ’07 (US State News, 3/7/07, DIRECTOR OF ASTRONOMY LAB PROGRAM AT UNIVERSITY OF NORTH TEXAS COMMENTS ON CONFERENCE EXAMINING THREAT FROM ASTEROIDS, 6/22/11, LexisNexis, MLK)

A conference underway this week in Washington D.C. is focusing on the potential threat of an asteroid striking the earth. The director of the astronomy lab program at the University of North Texas says the threat is real, but the problem is there's no money for any tracking efforts. Ron DiIulio says asteroid searches are going on all the time. But he adds to deal with the problem requires a two step approach. He says, "First, we have to identify the potentially hazardous asteroids. Far too often, we see them when they pass away from the earth, but we didn't know they were coming. Secondly, we have to deflect or alter their path. NASA has plans and methods to do this, but what happens is we need to develop interest in it. An asteroid the size of a football field could take out the entire DFW area." The "Planetary Defense Conference" is specifically concentrating on the threat posed by the asteroid Apophis, which could pass within 18,000 miles of Earth twice between 2029 and 2036. NASA predicts it would cost $1billion to find 90 percent of the 20,000 potentially hazardous asteroids and comets by 2020. DiIulio says UNT is already using telescopes at the Monroe Robotic Observatory near Gainesville to track asteroids. "We are using four of our telescopes at the Monroe observatory to look for asteroids. Just last week, we identified three known asteroids." DiIulio hopes that within a year, UNT will be able to take part in the Telescopes In Education program to help track these asteroids.

### There are currently no plans to deal with an asteroid

Gache 2007(Gabriel Gache November 13th, 2007, 08:01 GMT  **“**What Threat Do Asteroids Pose to Earth?” accessed 6/21/11 <http://news.softpedia.com/news/What-Threat-do-Asteroids-pose-to-Earth-70680.shtml>) JK

There are so far no practical plans if an asteroid will be detected on a path heading towards Earth. Several ideas have been proposed, such as sending a massive spacecraft toward the asteroid to redirect its path, by using the ships gravitational field. The idea is theoretically and physically possible, but the technology today does not yet allow us to move massive objects into space. Although NASA says there is no immediate threat for a large object to hit Earth, there are still uncharted objects that could produce extensive regional damage if they would hit the planet. Unfortunately, not enough measures have been taken so far to prepare for such potential disaster.

# Solvency – Detection

## Detection sucks now

### NASA is behind on Asteroid Detection and we need to catch up

Verango. 9. “Panel: NASA needs to do more to spot killer asteroids””USA Today” 8-12-9. Dan Verango( <http://www.usatoday.com/tech/science/space/2009-08-12-nasa-asteroids_N.htm>)( Dan Vergano is a science reporter at USA Today, where he has been since 1999. Previous reporting stints were at Medical Tribune and HealthWeek (PBS), as well as the science intern slot at Science News, freelance work for Men's Health, New Scientist, Science, the Washington Post and others. Dan worked as a space policy analyst for a federally-funded research and development contract organization before his reporting career. He won the 2006 David Perlman Award for Excellence in Science Journalism from the American Geophysical Union for a USA Today cover story on climate change. Dan was a 2007-08 Nieman Fellow at Harvard, where he concentrated on the intersection of science and politics)

NASA is falling well short in its goal to spot huge asteroids that could threaten Earth, and it needs more money and skywatchers to do the job, a science panel said Wednesday. In 2005, Congress asked the space agency to find 90% of all "potentially hazardous" near-Earth asteroids and comets, ones more than 460 feet wide (farther than home plate to deep centerfield in Yankee Stadium), by 2020. Instead, the three current survey efforts dedicated to the problem, supported at current levels, will likely find only about 15%, suggests the National Research Council panel. "For the first time, humanity has the capacity and the audacity to avoid a natural disaster," says Irwin Shapiro of the Harvard-Smithsonian Center for Astrophysics (CfA) in Cambridge, Mass., who headed the panel. "It really is a question of how much to invest in an insurance policy for the planet." Astronomers rate the odds of a civilization-threatening space impact at once every 2 million years. The chances of a smaller impact, such as the 1909 Siberian event that leveled nearly 800 square miles of forest, are rated at once every two centuries, according to a 2008 estimate by space scientist David Morrison of NASA's Ames Research Center in Moffett Field, Calif. The CfA lists 1,060 "potentially hazardous" asteroids or comets on its registry, those that pass within about 4.5 million miles of Earth as they orbit the sun and measure at least 245 feet across. That's big enough to cause a 3-megaton explosion, more than 100 times more powerful than the Hiroshima bomb . Despite the 90% detection mandate, "the administration has not requested and Congress has not appropriated new funds to meet this objective," the report notes. Says Laurence Young of MIT, who reviewed a draft of the report: "The sky is falling, but we don't know how fast, and we don't know where and when. We should be improving our abilities to detect these objects." The NRC report is an interim one, ahead of a final report later this year recommending further options for more asteroid observatories, including spacecraft. At least five new observatories, as well as German and Canadian spacecraft, are under consideration for Earth's asteroid-detecting capabilities. In July, NASA's Jet Propulsion Laboratory started an "Asteroid Watch" website to update the public on near-Earth asteroids and comets. Despite the report, Alan Harris of the Space Science Institute in La Canada, Calif., suggests that new telescopes planned for Hawaii will improve searches and lead to the detection of about 80% of the most threatening asteroids by 2020. "My personal opinion is that the risk reduction to be had by enhancing the discovery rate to literally meet the congressional goal is not worth the costs," Harris says. The panel's final report will examine the 90% goal, warning-time improvement and international collaboration. "I wouldn't get too frightened," Shapiro says. But he adds that all the proposed future observatories for finding more asteroids aren't funded yet. "Without the cameras in place, they aren't going to see anything.

### NEOs have come dangerously close to Earth

Launchspace Staff, ’09 (Launchspace Staff, Space News Magazine, 5/7/09, “The Asteroids are Coming,” 6/21/11, Lexis Nexis, MLK)

Large impacts could cause mass extinctions of species. And....scientists know that most of the larger asteroids are as yet undetected! How do we detect, and better yet, deflect such large asteroids? Eventually, one of these will be spotted. And when that happens, who do we call? Right now there is no one to call, because the world has no defense against pending large asteroid encounters! If this is troubling, here is the bad news. On March 2 of this year, asteroid 2009 DD45 zipped just 41,000 miles above Earth at a speed of 12 miles per second at its closest point to Earth. Amateur astronomers aided professionals at the International Astronomical Union's Minor Planet Center by providing measurements used in refining calculations of the asteroid's orbit. But, astronomers did not even detect the asteroid until just a couple of days before it zoomed by Earth; far too late to take any preventative action. This was not an isolated incident as many NEOs come this close to Earth and zip by undetected!

## Detection – Lead Time

### Scheweickart says it will take 10-15 years to make sure we deflect correctly

Atkinson 10, (Nancy Atkinson is a science journalist who writes mainly about space exploration and astronomy, Universe Today, Outskirts Press, 10/15/10, “How to Deflect an Asteroid with Today’s technology”, http://www.universetoday.com/75816/how-to-deflect-an-asteroid-with-today%E2%80%99s-technology/, SH)

Apollo 9 astronaut Rusty Schweickart is among an international group of people championing the need for the human race to prepare for what will certainly happen one day: an asteroid threat to Earth. In an article on Universe Today published yesterday, **Schweickart said the technology is available today to send a mission to an asteroid in an attempt to move it, or change its orbit so that an asteroid that threatens to hit Earth will pass by harmlessly.** What would such a mission entail? In a phone interview, Schweickart described two types of “deflection campaigns” for a threatening asteroid: a kinetic impact would roughly “push” the asteroid into a different orbit, and a gravity tractor would “tug slowly” on the asteroid to precisely “trim” the resultant change course by using nothing more than the gravitational attraction between the two bodies. Together these two methods comprise a deflection campaign. Artist Impression of Deep Impact - Credit: NASA “In a way, the kinetic impact was demonstrated by the Deep Impact mission back in 2005,” said Schweickart. “But that was a very big target and a small impactor that had relatively no effect on the comet. So, we haven’t really demonstrated the capability to have the guidance necessary to deflect a moderately sized asteroid.” Most important**, the gravity tractor spacecraft would arrive prior to the kinetic impactor, precisely determine the asteroid’s orbit and observe the kinetic impact to determine its effectiveness.** Following the kinetic impact it would then determine whether or not any adjustment trim were required. **“You want to know what happens when you do a kinetic impact, so you want an ‘observer’ spacecraft up there as well,” Schweickart explained.** “You don’t do a kinetic impact without an observation, because the impactor destroys itself in the process and without the observer you wouldn’t know what happened except by tracking the object over time, which is not the best way to find out whether you got the job done.” **So, 10-15 years ahead of an impact threat — or 50 years if you have that much time — an observer spacecraft is sent up. “This, in fact, would also be a gravity tractor,” Schweickart said. “It doesn’t have to be real big, but bigger gets the job done a little faster.** The feature you are interested in the outset is not the gravity tractor but the transponder that flies in formation with the asteroid and you track the NEO, and back on Earth we can know exactly where it is.” Schweickart said even from ground tracking, we couldn’t get as precise an orbit determination of an NEO as we could by sending a spacecraft to the object. Additionally, generally speaking, we may not know when we send an observer spacecraft what action will be required; whether an impact will be required or if we could rely on the gravity tractor. “You may launch at the latest possible time, but at that time the probability of impact may be 1 in 5 or 1 or 2,” Schweickart said. “So the first thing you are going to do with the observer spacecraft is make a precise orbit determination and now you’re going to know if it really will impact Earth and even perhaps where it will impact.” Artist concept of an impactor heading towards an asteroid. Credit: ESA After the precise orbit is known, the required action would be determined. “So now, if needed you launch a kinetic impactor and now you know what job has to be done,” Schweickart said. “As the impactor is getting ready to impact the asteroid, the observer spacecraft pulls back and images what is going on so you can confirm the impact was solid, –not a glancing blow — and then after impact is done, the observer spacecraft goes back in and makes another precision orbit determination so that you can confirm that you changed its velocity so that it no longer will hit the Earth.” **The second issue is, even if the NEO’s orbit has been changed so that it won’t hit Earth this time around, there’s the possibility that during its near miss it might go through what is called a “keyhole,” whereby Earth’s gravity would affect it just enough that it would make an impact during a subsequent encounter with Earth. This is a concern with the asteroid Apophis**, which is projected to miss Earth in 2029, but depending on several factors, could pass through a keyhole causing it to return to hit Earth in 2036. “So if it does go through that keyhole,” said Schweickart, “now you can use the gravity tractor capability of the spacecraft to make a small adjustment so that it goes between keyholes on that close approach. And now you have a complete verified deflection campaign.” **Schweickart said a Delta-sized rocket would be able to get a spacecraft to meet up with an asteroid**. “A Delta rocket would work,” he said, **“but if there is a more challenging orbit we might have to use something bigger, or we may have to use a gravity assist and do mission planning for type of thing which hasn’t been done yet.** So we can get there, we can do it – but ultimately we will probably need a heavy lift vehicle.” As for the spacecraft, we can use a design similar to vehicles that have already been sent into space. “A gravity tractor could be like Deep Space 1 that launched in 1998,” Schweickart said. “ You can make any spacecraft into a gravity tractor fairly easily.” Rusty Schweickart But it hasn’t been demonstrated and Schweickart says we need to do so. “**We need to demonstrate it because w**e – NASA, the technical community, the international community — **need to learn what you find out when you do something for the first time,” he said**. “Playing a concerto in front of an audience is quite different from playing it alone in your house.”

### Lead Time key.

Atkinson 1/22/10, Nancy Atkinson, is a science journalist who writes mainly about space exploration and astronomy. She is the Senior Editor and writer for Universe Today, the project manager for the 365 Days of Astronomy podcast, and part of the production team for Astronomy Cast. She also has articles published on Wired.com, Space.com, NASA’s Astrobiology Magazine, Space Times Magazine, and several newspapers in the Midwest.,” Asteroid Detection, Deflection Needs More Money, Report Says,” 1/22/10, 6/25/11, AR.

Schweickart said making decisions on how to mitigate the threat once a space rock already on the way is too late, and that all the decisions of what will be done, and how, need to be made now. “The real issue here is getting international cooperation, so we can — in a coordinated way — decide what to do and act before it is too late,” he said. “If we procrastinate and argue about this, we’ll argue our way past the point of where it too late and we’ll take the hit.” But this report deals with NASA, and committee from the NRC lays out two approaches that would allow NASA to complete its goal soon after the 2020 deadline; the approach chosen would depend on the priority policymakers attach to spotting NEOs. If finishing NASA’s survey as close as possible to the original 2020 deadline is considered most important, a mission using a space-based telescope conducted in concert with observations from a suitable ground-based telescope is the best approach, the report says. If conserving costs is deemed most important, the use of a ground-based telescope only is preferable. The report also recommends that NASA monitor for smaller objects, and recommends that immediate action be taken to ensure the continued operation of the Arecibo Observatory in Puerto Rico, and support a program at the Goldstone Deep Space Communications Complex. Although these facilities cannot discover NEOs, they play an important role in accurately determining the orbits and characterizing the properties of NEOs. Schweikart quoted Don Yeomans as saying the three most important things about asteroid mitigation is to find them early, find them early and find them early. “We have the technology today to move an asteroid,” Schweikart said. “We just need time. It doesn’t take a huge spacecraft to do the job of altering an asteroid’s course. It just takes time. And the earlier we could send a spacecraft to either move or hit an asteroid, the less it will cost. We could spend a few hundred million dollars to avoid a $4 billion impact.” But the report put out by the NRC stresses the methods for asteroid/comet defense are new and still immature. The committee agreed that with sufficient warning, a suite of four types of mitigation is adequate to meet the threat from all NEOs, except the most energetic ones. • Civil defense (evacuation, sheltering in place, providing emergency infrastructure) is a cost-effective mitigation measure for saving lives from the smallest NEO impact events and is a necessary part of mitigation for larger events. • “Slow push” or “slow pull” methods use a spacecraft to exert force on the target object to gradually change its orbit to avoid collision with the Earth. This technique is practical only for small NEOs (tens of meters to roughly 100 meters in diameter) or possibly for medium-sized objects (hundreds of meters), but would likely require decades of warning. Of the slow push/pull techniques, the gravity tractor appears to be by far the closest to technological readiness. • Kinetic methods, which fly a spacecraft into the NEO to change its orbit, could defend against moderately sized objects (many hundreds of meters to 1 kilometer in diameter), but also may require decades of warning time. • Nuclear explosions are the only current, practical means for dealing with large NEOs (diameters greater than 1 kilometer) or as a backup for smaller ones if other methods were to fail. Although all of these methods are conceptually valid, none is now ready to implement on short notice, the report says. Civil defense and kinetic impactors are probably the closest to readiness, but even these require additional study prior to reliance on them.

### Technology is here now, we just need to come up with a deflection plan.

Millis 2011, (John Millis, Ph.D., is an assistant professor of physics and astronomy at Anderson University, in Anderson Indiana, New York Times, “Killer Asteroids and Comets”, No Date- site was updated in 2011 , http://space.about.com/od/frequentlyaskedquestions/a/KillerAsteroids.htm, SH)

History tells us that large comets or asteroids periodically collide with Earth, and the results can be devastating. There is evidence that a large object collided with Earth about 65 million years ago and caused the extinction of the dinosaurs. More recently, a iron meteorite impacted the Earth in modern day Arizona, leaving a crater that is 34 miles wide. Such a collision almost certainly destroyed all life within hundreds of miles from the impact site. Clearly these types of collisions do not happen very often, but when one does come along, what do we need to do to be ready? **The more time that we have to prepare a plan of action the better. Under ideal circumstances we would have years to prepare a strategy on how to destroy or divert the object in question.** Surprisingly, this is not out of the question. With such a large array of optical and infrared telescopes scanning the night sky, NASA is able to catalog and track the motions of thousands of Near Earth Objects (NEOs). Does NASA ever miss one of these NEOs? Sure, but such objects usually pass right by Earth or burn up in our atmosphere. When one of these objects does reach the ground, it is too small to cause significant damage -- loss of life is rare. **If a NEO is of significant enough size to potentially threaten life on Earth NASA has a very good chance of finding it.**

### We must start working now- A Gravity Tractor would take 15 years in advance to build

BBC 31 August **2009,** British plan to tackle asteroids,6/22/11, http://news.bbc.co.uk/2/hi/science/nature/8230138.stm, AS

The tractor would intercept the asteroid from just 48m away and exert a small gravitational force on it, pulling the rock towards it. The pair would then embark on a slightly different orbit, away from the Earth.It could possibly be powered using solar panels. However, the device would have to be launched at least 15 years before any predicted collision and would need a team to monitor it from the ground during this time.

### We can stop an asteroid, but we need warning

Lynch 07, (David K. Lynch, PhD, is an astronomer and planetary scientist, “How can we detect, measure and deflect them?”, http://geology.com/articles/earth-crossing-asteroids.shtml, SH)

**Can we do anything about an asteroid that is destined to hit the Earth? The answer is, yes**, **providing that it is small enough and that we have enough time to send a spacecraft to deflect it**. As we will see, the longer the warning time we have, the larger the asteroid we will be able manage. Many of the aspects of asteroid impact mitigation were summarized in the Spaceguard Report. **More recently, NASA has also completed a study and is being used by congress to decide what steps the US and other nations can and should take**. **Astronomers have spent a lot of time trying to figure out how to save the Earth from an asteroid impact**. First you have to find all the asteroids, calculate their orbits and see which ones come dangerously close to Earth. Once you know the orbit, you can figure out when it will hit. This tells you how much warning time you have. And finally, **if you can figure out the asteroid’s mass, you can compute how hard you have to push it in order to change its orbit just enough to miss the Earth.** Hollywood’s notion of sending a bomb to “blow it up” is unrealistic because present-day launch vehicles can’t carry a big enough bomb. Besides, instead of one large body, you might end up with many small fragments headed toward Earth.

### We need to act soon to prevent extinction

Niall Firth 6-28-10 “Massive asteroid could hit Earth in 2182, warn scientists

“ Daily Mail (UK) http://www.dailymail.co.uk/home.html?s=y&authornamef=niall+firth

A massive asteroid might crash into Earth in the year 2182, scientists have warned. The asteroid, called 1999 RQ36, has a 1-in-1,000 chance of actually hitting the Earth at some point before the year 2200, but is most likely to hit us on 24th September 2182. It was first discovered in 1999 and is more than 1,800 feet across. If an asteroid of this size hit the Earth it would cause widespread devastation and possible mass extinction. And scientists say that any attempt to try and divert the asteroid will have to take place more than 100 years before it is due to hit to have any chance of success.

### We need a decade to protect ourselves from the only major natural hazard we can

Morrison 04’ (David Morrison is the senior scientist at the NASA Astrobiology Institute, NASA Ames Research Center, Moffett Field, Calif., where he participates in a variety of research programs in astrobiology -- the study of the living universe, 11/04, http://impact.arc.nasa.gov/intro\_faq.cfm, SH)

NEO impacts are the only major natural hazard that we can effectively protect ourselves against, by deflecting (or destroying) the NEO before it hits the Earth. The first step in any program of planetary defense is to find the NEOs; we can't protect against something we don't know exists. We also need a long warning time, at least a decade, to send spacecraft to intercept the object and deflect it. Many defensive schemes have been studied in a preliminary way, but none in detail. In the absence of active defense, warning of the time and place of an impact would at least allow us to store food and supplies and to evacuate regions near ground zero where damage would be the greatest.

### UQ - NEOs are a threat - Four years are needed to take action

(The Dominion, 2000), January 13, 2000, Wellington Newspapers Ltd, “Asteroid threat is real, says astronomer”, Lexis Nexis, 6/21/11, CF

The threat of a large comet or asteroid colliding with the earth is real and not just a Hollywood fantasy, internationally renowned American astronomer Stephen O'Meara says. Mr O'Meara is known for several first sightings of astronomical objects and is in New Zealand as the guest of the Wellington-based Phoenix Astronomical Society. Scientists had estimated from geological records that the earth had been hit on average every millennium by large objects, he said. Mr O'Meara, who writes for the international astronomical magazine Sky and Telescope, said the concept of the devastation that could be caused from a strike by a large near-earth object had been brought home in recent years when Jupiter had been hit by parts of a comet which broke up in space. This had caused the United States Government to look at how the path of a large asteroid approaching earth could be changed to avert a disaster. The announcement last week that the British Government was to put substantial funds into researching the threat was positive news that the problem was not being taken lightly. **If a threatening object could be detected about four years before it was due to strike Earth, there was every chance of nudging it off course with a rocket-borne nuclear explosion that would not split it into many** **fragments**. The knowledge and technologies existed to meet the threat and it was a matter of getting enough funds to search for and find the objects, he said. "It is really a case of getting governments to take responsibility for the future of people on our planet," he said. "Some politicians and government officials are very short-sighted and allow the atmosphere to become polluted, but the near-earth objects are an extraterrestial threat which Jupiter has shown us is real. Any one of the 20-odd objects which hit Jupiter would have caused a global catastrophe if they had come our way," he said.

### Early warning means deflection tech will be ready in time

British National Space Centre ‘2k (British National Space Centre, Report of the Task Force on Potentially Hazardous Near Earth Objects, http://www.spacecentre.co.uk/neo/report.html)

A number of possible mechanisms have been considered for deflecting or breaking up potentially hazardous Near Earth Objects; most would require the use of a spacecraft with some means of transferring energy or momentum to the object, for example by kinetic energy transfer (by heavy projectiles carried on the spacecraft or by causing a collision between asteroids), by chemical or nuclear explosives, or even by mounting “sails” on the object to harness the Sun’s radiation pressure. Some of these mechanisms are more realistic than others. **Given warnings of decades or centuries, new technological developments would** almost **certainly emerge.** The Task Force believes that studies should now be set in hand on an international basis to look into the practical possibilities of deflection.

## Venus Orbit Telescope Solves

### Better detection methods are key to reducing the role of nuclear weapons in asteroid deflection

**Fountain ‘2**

<Henry, New York Times correspondent, Armageddon Can Wait: Stopping Killer Asteroids, November 19, http://www.nytimes.com/2002/11/19/science/space/19ASTE.html>

There is no current detection program for smaller asteroids, of which there are perhaps half a million down to about 50 meters in diameter, the smallest size capable of penetrating Earth's atmosphere (and roughly the size of one that exploded over the Tunguska River in Siberia in 1908, destroying forests for hundreds of square miles). And there is no systematic survey for potentially hazardous comets, which come out of the astronomical equivalent of left field. "So we would either very likely have a lot of warning or none at all," said Dr. Clark Chapman of the Southwest Research Institute in Boulder.

No warning time means no options. A short amount, on the order of a decade or two, might leave a nuclear blast as the **only** choice. But with many decades of warning, there is room to investigate the asteroid first by sending a spacecraft to it, and then use a slow-acting method to divert it, one that wouldn't **require** launching a nuclear weapon. "We would want to seek out every alternative to a nuclear weapon before turning to that technology,'` Dr. Chapman said.

### Infrared Venus orbit telescope key to detection

Chandler ‘7(David, New Scientist, “Could Venus Watch for Earth-Bound Asteroids,” http://www.newscientist.com/article/dn11356-could-venus-watch-for-earthbound-asteroids.html)

A dedicated space-based telescope is needed to achieve a congressionally mandated goal of discovering 90% of all near-Earth asteroids down to a size of 140 metres by the year 2020, says a report NASA sent to the US Congress on Thursday. Asteroids of that size are large enough to destroy a major city or region if they strike the planet - but NASA says it does not have the money to pay for the project. The study says [Venus](http://www.newscientist.com/topic/solar-system) is the best place for the telescope. That is because space rocks within Earth's orbit - where Venus lies - are most likely to be lost in the Sun's glare, potentially catching astronomers off guard. The telescope could be placed either behind or ahead of Venus in its orbit by about 60° - the stable Lagrange points, known as L4 or L5, where the gravity of the Sun and Venus are in balance. "There are quite a few [objects] that are interior to Earth's orbit," NASA's Lindley Johnson told New Scientist. "Those are really hard to detect [from Earth]; the opportunities to see them are very limited." From the orbit of Venus, however, "you're always looking away from the Sun, always looking out", he says. "And, of course, you can observe 24 hours a day - you don't have to worry about night and day." Even from Earth orbit, a telescope's view of any given part of the sky is blocked about half the time by the Earth itself. In addition, because Venus orbits the Sun in about two-thirds the time the Earth does, a telescope in that orbit would catch up with any near-Earth asteroids in their orbits more frequently than Earth does, offering more opportunities for discovery. "You're able to sample that population more rapidly in the same amount of time," Johnson says. Missed deadline An infrared telescope would be more effective than one that studies visible light, because asteroids reflect sunlight more strongly at infrared wavelengths. The background sky is also much less bright in the infrared, providing better contrast for discovering even small, faint asteroids. With the Venus-orbit IR telescope, NASA could exceed its goal by three years, finding 90% of the most dangerous space rocks by 2017. But the space telescope is estimated to cost $1.1 billion for 15 years of operation, and NASA says there is currently no money in its budget to pursue any of the search proposals it studied.

### But there are no current plans for the Venus telescope

Easterbrook ‘8(Gregg, Editor of The Atlantic and The New Republic and Sr. Fellow at Brookings, “The Sky is Falling,” June, http://www.theatlantic.com/doc/200806/asteroids)

Current telescopes cannot track asteroids or comets accurately enough for researchers to be sure of their courses. When 99942 Apophis was spotted, for example, some calculations suggested it would strike Earth in April 2029, but further study indicates it won’t—instead, Apophis should pass between Earth and the moon, during which time it may be visible to the naked eye. The Pan-STARRS telescope complex will greatly improve astronomers’ ability to find and track space rocks, and it may be joined by the Large Synoptic Survey Telescope, which would similarly scan the entire sky. Earlier this year, the software billionaires Bill Gates and Charles Simonyi pledged $30 million for work on the LSST, which proponents hope to erect in the mountains of Chile. If it is built, it will be the first major telescope to broadcast its data live over the Web, allowing countless professional and amateur astronomers to look for undiscovered asteroids. Schweickart thinks, however, that even these instruments will not be able to plot the courses of space rocks with absolute precision. NASA has said that an infrared telescope launched into an orbit near Venus could provide detailed information on the exact courses of space rocks. Such a telescope would look outward from the inner solar system toward Earth, detect the slight warmth of asteroids and comets against the cold background of the cosmos, and track their movements with precision. Congress would need to fund a near-Venus telescope, though, and NASA would need to build it—neither of which is happening.

### NASA wants a venus orbit infrared telescope

Bucknam & Gold ‘8(Mark, Deputy Dir for Plans in the Policy Planning Office of the Office of the US Secretary of Defense, Colonel USAF, PhD in War Studies from U of London, BS in physics, MS in materials science and engineering from Virginia Tech & Robert, Chief Technologist for the Space Department at the Applied Physics Laboratory of Johns Hopkins “Asteroid Threat? The Problem of Planetary Defence,” Survival vol. 50 no. 5 | 2008 | pp. 141–156)

NASA analysed options for better detecting PHOs, ranging from continuing the current terrestrial-based Spaceguard Survey to putting visual or infrared sensors on satellites in space. The existing Spaceguard techniques have little to contribute to the expanded goal of detecting objects on the scale of 140m, and NASA estimates Spaceguard could only detect approximately 14% of the 140m-or-larger PHOs by 2020,10 well short of Congress’ goal of 90%. The addition of a ground-based telescope, such as the University of Hawaii’s planned Panoramic Survey Telescope and Rapid Response System (PanSTARRS 4)11 or the proposed Large Synoptic Survey Telescope (LSST),12 would boost the results to 75–85%, depending on whether NASA shared the telescope with another agency or supported building an additional copy of its own. The most efficient means of finding PHOs would be to place an infrared sensor in a Venus-like orbit – that is, 0.7 astronomical units from the sun. By itself such a sensor system could find 90% of PHOs larger than 140m by 2020. Furthermore, a space-based infrared telescope would allow scientists to reduce the uncertainties in determining the size of PHOs to 20% from over 200% for optical telescopes.13 A factor-of-two uncertainty – the limit of accuracy with optical telescopes – equates to a factor-of-eight uncertainty in mass. Because the size and mass of a PHO are important characteristics for assessing the danger it could pose, the added performance of a space-based infrared telescope warrants serious consideration. Moreover, an infrared telescope in a Venus-like orbit could efficiently detect PHOs that primarily orbit between the Earth and the Sun; these are difficult to detect from Earth and, according to NASA, have a chance of being perturbed by gravity and becoming a threat. The cost of such a system is on the order of $1bn, and the harsh space environment would likely limit its useful life to around seven to ten years.14 Though radar telescopes, such as the giant 305m dish at Arecibo, Puerto Rico, enable rapid and accurate assessments of PHO size and orbit, they are only useful when the objects pass within a few million kilometres of Earth. NASA recommended against developing a radar specifically for finding and tracking PHOs, stating that ‘orbits determined from optical data alone will nearly match the accuracy of radar-improved orbits after one to two decades of observation’.15 Existing radar telescopes should be used as far as possible to refine predictions of Apophis’s trajectory – either confirming or ruling out the potential for an impact in 2036. In addition to fielding new Earth- and space-based sensors as suggested by NASA, former astronaut Rusty Schweickert called for placing a transponder on Apophis during a close approach in 2013 to help determine whether a 2036 collision is likely.16 This could save years of worrying, or give us extra years to prepare and act. Such a mission would cost on the order of a few hundred million dollars. In addition to new sensors, NASA will need new data-processing capabilities for the expanded effort to find, track, characterise, catalogue and then store and distribute the data for the estimated 18,000 PHOs larger than 140m that the space agency will be expected to monitor. Today, NASA’s Jet Propulsion Laboratory uses a system called Sentry to turn known PHO data into predictions of PHO orbits projected 100 years into the future. Though NASA’s March 2007 report briefly described four possible alternatives for managing data, it left out details on the costs of going from tracking nearly 800 PHOs today to a system that could handle 18,000 PHOs.

### NASA favors using an infrared Venus orbit telescope

NASA ‘6(“2006 Near-Earth Object Survey and Deflection Study” http://www.b612foundation.org/papers/NASA-finalrpt.pdf)

Detection and tracking alternatives identified by the study team included optical systems located on the ground and optical and infrared assets located in space. For ground-based alternatives, the study team considered sharing planned observatories such as PanSTARRS 4 (PS4), funded by the U.S. Air Force, and the Large Synoptic Survey Telescope (LSST), partially funded by the National Science Foundation. The team also considered new NASA-funded facilities that would be dedicated to the search for hazardous objects and would be based on these planned observatories. Although cost margin was applied to alternatives that leveraged planned assets, programs that rely on these projects may carry additional cost and schedule risk. Specific results include: • An architecture, which combines the sharing of the planned PS4 and LSST systems with a second, dedicated NASA-funded LSST, was the only groundbased alternative able to meet the congressional goal of identifying 90% of the hazardous objects by 2020. This combination is estimated to have a life-cycle cost of $820M ($FY06). • A shared PS4, a shared LSST, and a dedicated NASA-funded PS8 were able to catalog 90% of hazardous objects by 2024, with a life-cycle cost of $560M. • A dedicated, NASA-funded observatory based on LSST’s design was also able to catalog 90% of potentially hazardous objects in 2024 without the contributions of other programs. Its estimated life-cycle cost is $870M. Space-based search alternatives were located in low-Earth orbit, at Sun-Earth Lagrange points, and in heliocentric Venus-like orbits. **Only an infrared system operating in a Venus-like orbit was able meet the congressional goals** without the contribution of shared ground-based assets. All space-based alternatives were able to meet the goals when combined with a ground-based baseline of a shared PS4 and a shared LSST. A space mission failure could delay achieving the 90% goal by up to 5 years, after which the catalog could be completed with shared ground-based assets. Infrared systems operating in space could provide more accurate size estimates of up to 80% of objects in the catalog. Observatories located in a Venus-like orbit are the most efficient at finding objects inside Earth’s orbit, a potentially underestimated population. Additionally, **by the end of 2020, infrared systems in Venus-like orbits can find 90% of the objects measuring over about 80 meters,** exceeding the 140-meter requirement. Finally, space-based systems have much less uncertainty in the date of reaching 90% due to their superior sensitivity. Selected space-based alternatives include: • A 0.5-meter infrared system operating in a Venus-like heliocentric orbit completes 89% of the survey by 2020 which is within the uncertainty of the analysis. This system has a life-cycle cost of $840M ($FY06). • A similar 0.5-meter infrared system operating in a Venus-like orbit and working in concert with a shared PS4 and a shared LSST completes 90% of the survey in 2018, with a life-cycle cost of $1B through 2018. • A 0.5-meter infrared system operating at Sun-Earth L1 in conjunction with the baseline finishes 90% of the survey in 2020. Its life-cycle cost is $1.1B. Infrared systems with a 1.0-meter aperture complete the survey about 1 year earlier than the 0.5-meter alternatives described above, and have life-cycle costs about $300M higher. Optical systems with 1.0-meter and 2.0-meter apertures in Venus-like orbits, combined with the baseline ground-based systems, completed the survey by 2017 and 2019 respectively, with life-cycle costs in excess of $1.7B. The visible system with a 2.0-meter aperture progressed more slowly than the 1.0-meter system due to differences in development time. Acquisition of new systems was assumed to start October 1, 2007, and delays in funding will affect the ability of some alternatives to meet the 90% completeness goal by the end of 2020. Congress provided two objectives for characterizing potentially hazardous objects. The first objective, to “assess the threat,” requires analysts to determine the orbit and approximate the mass of each hazard. Detection and tracking systems with judicious follow-up are all able to provide warning, and some are able to provide very good size and mass estimates. Systems operating in the visible spectrum are limited by a factor of two for size estimates, resulting in a factor-of-eight uncertainty in mass. Infrared systems provide data for much more accurate size estimates. If detection systems must characterize the catalog, the time to complete the survey to a 90% completion level will be extended. Furthermore, the costs of these systems may increase $100M-$400M to accommodate filters and additional data processing. In addition, the smallest and faintest objects may remain visible to sensors only for a few days or weeks. Therefore, if characterization is required and it is not performed by detection systems, either formal relationships with extant observatories for “on demand” access must be negotiated or new dedicated characterization facilities will be needed. Radar may quickly and precisely characterize and determine the orbit of about 10-25% of the objects of interest within 5 years of their detection. While the number of objects observed by radar increases with time, the relative value of radar to precisely determine the orbits of the full catalog declines over the same period. Orbits determined from optical data alone will nearly match the accuracy of radar-improved orbits after decades of observation. Therefore, the utility of radar is limited to a relatively few “short warning” cases that may be of very high interest during the survey. Up to $100M in funding (not included in detection and tracking life-cycle costs) may be required to maintain radar capability through 2020, as NASA and National Science Foundation funding for existing radars is currently in flux. The second objective of characterization is to “inform mitigation.” Depending on the mitigation strategy selected, this objective may require information beyond the size and orbit of potential threats. This information may include the structure, porosity, rotation rate, material composition, and surface features of the threats. The deflection alternatives considered are sensitive to the maximum mass that needs to be deflected, but some alternatives are orders of magnitude less sensitive than others. Characterization by remote sensing provides some information about the diversity of objects in the population. From this information, analysts build models that can be used to infer a limited number of characteristics of a particular object. Only in-situ encounters can provide the definitive observations necessary to calibrate the remote observations. More importantly, only in-situ visits can obtain the information needed by some of the deflection alternatives to mitigate a specific threat. For credible threats with sufficient warning, it is expected that in-situ characterization will always be performed to both confirm the probability of impact (with a transponder, for example) and to characterize the potential threat if deflection is necessary. This study has determined that it is premature to set specific characterization requirements to enable mitigation until a mitigation strategy has been determined; therefore, the study has developed characterization options that provide a range of capabilities. These options included the use of detection and tracking assets, dedicated ground and space systems for remote observation, and in-situ missions to inform mitigation of threats with sufficiently high impact probabilities. These options have lifecycle costs ranging from $50M-$8B ($FY06) over several decades. It is expected that during the 5-10 years of a survey, a total of 500,000 objects will be discovered by more than 2 million individual observations. About 21,000 of these objects will measure 140 meters or larger and be tracked as potentially hazardous. Although this study uses an estimate of the population of potentially hazardous objects based on statistical projections, the actual number of objects will not affect the date of reaching the 90% goal as long as the objects are approximately distributed in orbits as predicted. This volume of observations will require a data-processing capability that is 100 times more capable than current cataloguing systems. After objects are detected, the system must be able to obtain follow-up observations, store and distribute collected data, and analyze these data for observed but previously undetected objects. Currently, uncompensated or under-funded analysts perform many of these functions. Such an approach likely will not remain viable. Finally, either the NASA Survey or otherwise funded activities, such as PS4 and LSST, are expected to produce impact warnings at a rate that is 40 times greater than what is experienced today. This much higher rate of warnings will start as early as 2010.

## Solvency – Venus Satellite

### Venus satellite solves

Reich 2010 [Eugenie Samuel, Scientific American, “NASA panel weighs asteroid danger”, <http://www.scientificamerican.com/article.cfm?id=nasa-panel-weighs-asteroid-danger>]

One solution from the panel is to increase the amount that the United States invests in NEO detection and tracking from the current $5.5 million a year. The panel may also recommend the launch of a survey telescope into a solar orbit similar to that of Venus. It would orbit faster than Earth and, looking outwards, would see asteroids in Earth-crossing orbits more often than would ground-based instruments. This could improve follow-up observations, narrow estimated trajectories and remove as many asteroids as possible from the threat list. It could also spot and track asteroids on the sunward side of Earth, removing a worrisome blind spot in ground-based surveys. "It is a wonderful rapid technique to track bodies down to 140 meters and smaller," says Tom Jones, a former astronaut and panel co-chair.

## I/L - Survey key to deflection

### And detection now is a pre-requisite to effective deflection

Schweickart, 10 [Russell, former astronaut, was the co-chairman of the Task Force on Planetary Defense of the NASA Advisory Council, “ Humans to Asteroids: Watch Out!,” October 25, 2010, NY Times, <http://www.nytimes.com/2010/10/26/opinion/26schweickart.html?scp=1&sq=humans%20to%20asteroids:%20watch%20out!&st=cse>]

A FEW weeks ago, an asteroid almost 30 feet across and zipping along at 38,000 miles per hour flew 28,000 miles above Singapore. Why, you might reasonably ask, should non-astronomy buffs care about a near miss from such a tiny rock? Well, I can give you one very good reason: asteroids don’t always miss. If even a relatively little object was to strike a city, millions of people could be wiped out. Thanks to telescopes that can see ever smaller objects at ever greater distances, we can now predict dangerous asteroid impacts decades ahead of time. We can even use current space technology and fairly simple spacecraft to alter an asteroid’s orbit enough to avoid a collision. We simply need to get this detection-and-deflection program up and running. President Obama has already announced a goal of landing astronauts on an asteroid by 2025 as a precursor to a human mission to Mars. Asteroids are deep-space bodies, orbiting the Sun, not the Earth, and traveling to one would mean sending humans into solar orbit for the very first time. Facing those challenges of radiation, navigation and life support on a months-long trip millions of miles from home would be a perfect learning journey before a Mars trip. Near-Earth objects like asteroids and comets — mineral-rich bodies bathed in a continuous flood of sunlight — may also be the ultimate resource depots for the long-term exploration of space. It is fantastic to think that one day we may be able to access fuel, materials and even water in space instead of digging deeper and deeper into our planet for what we need and then dragging it all up into orbit, against Earth’s gravity. Most important, our asteroid efforts may be the key to the survival of millions, if not our species. That’s why planetary defense has occupied my work with two nonprofits over the past decade. To be fair, no one has ever seen the sort of impact that would destroy a city. The most instructive incident took place in 1908 in the remote Tunguska region of Siberia, when a 120-foot-diameter asteroid exploded early one morning. It probably killed nothing except reindeer but it flattened 800 square miles of forest. Statistically, that kind of event occurs every 200 to 300 years. Luckily, larger asteroids are even fewer and farther between — but they are much, much more destructive. Just think of the asteroid seven to eight miles across that annihilated the dinosaurs (and 75 percent of all species) 65 million years ago. With a readily achievable detection and deflection system we can avoid their same fate. Professional (and a few amateur) telescopes and radar already function as a nascent early warning system, working every night to discover and track those planet-killers. Happily, none of the 903 we’ve found so far seriously threaten an impact in the next 100 years. Although catastrophic hits are rare, enough of these objects appear to be or are heading our way to require us to make deflection decisions every decade or so. Certainly, when it comes to the far more numerous Tunguska-sized objects, to date we think we’ve discovered less than a half of 1 percent of the million or so that cross Earth’s orbit every year. We need to pinpoint many more of these objects and predict whether they will hit us before it’s too late to do anything other than evacuate ground zero and try to save as many lives as we can. So, how do we turn a hit into a miss? While there are technical details galore, the most sensible approach involves rear-ending the asteroid. A decade or so ahead of an expected impact, we would need to ram a hunk of copper or lead into an asteroid in order to slightly change its velocity. In July 2005, we crashed the Deep Impact spacecraft into comet Tempel 1 to learn more about comets’ chemical composition, and this proved to be a crude but effective method. It may be necessary to make a further refinement to the object’s course. In that case, we could use a gravity tractor — an ordinary spacecraft that simply hovers in front of the asteroid and employs the ship’s weak gravitational attraction as a tow-rope. But we don’t want to wait to test this scheme when potentially millions of lives are at stake. Let’s rehearse, at least once, before performing at the Met! The White House Office of Science and Technology Policy has just recommended to Congress that NASA begin preparing a deflection capacity. In parallel, my fellow astronaut Tom Jones and I led the Task Force on Planetary Defense of the NASA Advisory Council. We released our report a couple of weeks ago, strongly urging that the financing required for this public safety issue be added to NASA’s budget. This is, surprisingly, not an expensive undertaking. Adding just $250 million to $300 million to NASA’s budget would, over the next 10 years, allow for a full inventory of the near-Earth asteroids that could do us harm, and the development and testing of a deflection capacity. Then all we’d need would be an annual maintenance budget of $50 million to $75 million. By preventing dangerous asteroid strikes, we can save millions of people, or even our entire species. And, as human beings, we can take responsibility for preserving this amazing evolutionary experiment of which we and all life on Earth are a part.

### Only effective detection provides enough lead-time to deflect the asteroid

Yeomans, 7 [DONALD K. YEOMANS, MANAGER, NEAREARTH OBJECT PROGRAM OFFICE, JET PROPULSION LABORATORY “ NEAR-EARTH OBJECTS (NEOS)—STATUS OF THE SURVEY PROGRAM AND REVIEW OF NASA’S 2007 REPORT TO CONGRESS,” NOVEMBER 8, 2007 http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110\_house\_hearings&docid=f:38057.pdf]

A number of existing technologies can deflect an Earth-threatening asteroid if there is time. The primary goal of the potentially hazardous asteroid survey programs is to discover them early and provide the necessary time. An asteroid that is predicted to hit Earth would require a change in its velocity of only three millimeters per second, if this impulse were applied 20 years in advance of the impact itself. The key to a successful deflection is having sufficient time to carry it out, whether it is a slow, gentle drag of a gravity tractor, or the more impulsive shove from an impacting spacecraft or explosive device. In either case, the verification process will be required to ensure the deflection maneuver was successful, and to ensure the object’s subsequent motion would not put it on yet another Earth-impacting trajectory. While suitable deflection technologies exist, none of them can be effective if we are taken by surprise. It is the aggressive survey efforts and robust radar systems that must ensure that the vast majority of potentially hazardous objects are discovered and tracked well in advance of any Earth-threatening encounters

## A2: No Deflection – Won’t co-operate

### Detection guarantees deflection - Incentives mean U.S. will invest all resources available

Barrett, 6 [Scott, Professor and Director of International Policy, School of Advanced International Studies, Johns Hopkins University and Distinguished Visiting Fellow, Center for the Study of Globalization, Yale University, “ SYMPOSIUM: CATASTROPHE: The Problem of Averting Global Catastrophe,” Winter, 2006 6 Chi. J. Int'l L. 527 ]

 Protection of the Earth from asteroids is a global public good. No country could be excluded from the benefit of protection, and one country's consumption of that protection would not diminish the amount available to others. More specifically, asteroid defense is a "best shot" public good; only one (successful) intervention is needed to supply the public good. n33 Asteroid defense [\*536] is thus analogous to eliminating a global pandemic at the source, before it has had the chance to spread. It is to be contrasted with other global public goods, like ozone layer protection, the provision of which depends on the aggregate effort of a large number of countries (a "summation" global public good), or disease eradication, which requires the participation of every country (a "weakest link" global public good). Should the world supply the global public good of asteroid protection? As noted by Schweickart, "An asteroid collision with Earth would be so potentially devastating that preventing it would be worth almost any cost." n34 Of course, this assumes that the collision would occur with certainty if actions were not taken to avert it. But if we were able to identify and track all asteroids, and spotted a very large one heading toward the Earth, then this is precisely the situation we would face. In this case, because human survival would depend on success, it would pay to devote any amount of resources to protection. The calculus would be different as regards small asteroids, or measures that would reduce the risk of a large asteroid hitting the Earth. In these cases, the expected benefits of providing the global public good of asteroid protection would be finite, and to know whether the investment would be worth making would require comparing this benefit with the associated cost. Schweickart and his coauthors suggest that a space tug would cost about $ 1 billion. n35 According to Milani, a catastrophic collision would cause the equivalent of about one thousand expected deaths a year. n36 Avoiding such a collision would therefore save about one thousand lives a year. Very crudely, investment in the tug would be worthwhile if the benefit in lives saved exceeded the tug's cost. To make a comparison, this benefit needs to be expressed in dollar terms. Moreover, since the benefit would not be realized until some time in the future, it needs to be discounted to a "present value." Denote the benefit per life saved by b and assume that the discount rate is 3 percent (the qualitative results are not sensitive to this choice). n37 It can then be shown that the investment is worthwhile [\*537] provided b > $ 30,000. n38 The benefit of a life saved can be approximated by the value of a statistical life -- the value implicit in the choices individuals make routinely in trading off increased risk for increased money payments. The value of a statistical life even for poor countries substantially exceeds this value, and so we can conclude that asteroid protection is a sound global investment. n39 This is a global public good that should be provided. But can we expect that this public good will be provided? Or will free riding undermine global provision of asteroid protection? The US would likely have the greatest incentive to provide this public good since it would, in absolute terms, bear the greatest loss from an asteroid collision. Indeed, it is easy to demonstrate that the economics of asteroid protection are so attractive that it would be beneficial for the US to finance the entire protection program. n40 Since it pays the US to supply the public good unilaterally, theory suggests that the good will be supplied. As it happens, behavior is consistent with this prediction. The US is already "doing more about Near Earth Objects than the rest of the world put together." n41 For example, the US has already funded a program to track large objects in space, a prerequisite for further action. (Fortunately, the nature of asteroid travel means that we should have decades, if not centuries, to prepare for a possible collision; however, comets with long-period orbits cannot be observed as easily, and these are thus particularly dangerous.)

## A2: Squo funding Solves

### Not enough of an increase to make a dent

National Academies, 10

[ Over many decades, the National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council have earned a solid reputation as the nation's premier source of independent, expert advice on scientific, engineering, and medical issues, “Defending Planet Earth: Near-Earth Object Surveys and Hazard Mitigation Strategies” http://books.nap.edu/openbook.php?record\_id=12842&page=41]

The $10-million funding level would not allow on any time scale the completion of the mandated survey to discover 90 percent of near-Earth objects of 140 meters in diameter or greater. Also lost would be any possibility for mounting spacecraft missions—for example, to test active mitigation techniques in situ. (A caveat: The funds designated above to support radar observations are for these observations alone; were the maintenance and operations of the radar-telescope sites not supported as at present, there would be a very large shortfall for both sites: about $10 million annually for the Arecibo Observatory and likely a larger figure for the Goldstone Observatory.) $50-million level. At a $50-million annual appropriations level, in addition to the tasks listed above, the committee notes that the remaining $40 million could be used for the following: Support of a ground-based facility, as discussed in Chapter 3, to enable the completion of the congressionally mandated survey to detect 90 percent of near-Earth objects of 140 meters in diameter or greater by the delayed date of 2030. The $50-million funding level would likely not be sufficient for the United States alone to conduct space telescope missions that might be able to carry through a more complete survey faster. In addition, this funding level is insufficient for the development and testing of mitigation techniques in situ. However, such missions might be feasible to undertake if conducted internationally, either in cooperation with traditional space partners or as part of an international entity created to work on the NEO hazards issue. Accommodating both the advanced survey and a mitigation mission at this funding level is very unlikely to be feasible, except on a time scale extended by decades.

### Space-based telescopes are not on the agenda

National Academies, 09

[Over many decades, the National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council have earned a solid reputation as the nation's premier source of independent, expert advice on scientific, engineering, and medical issues. “Near-Earth Object Surveys and Hazard Mitigation Strategies:

Interim Report” http://www.nap.edu/catalog.php?record\_id=12738]

These are only a few of the many options considered by the NASA team. The study named some advantages to employing space-based observation capabilities, including the ability to detect objects as small as ~80 meters in diameter, exceeding the 140-meter requirement set by Congress. The study assumed a start of October 1, 2007, for acquisition of new systems. This start did not occur, and none of the possible NEO search systems is fully funded. Although Congress mandated as a goal the discovery of 90 percent of all NEOs 140 meters in diameter or greater by 2020, and NASA has studied possible methods for accomplishing this goal, neither the administration nor Congress has sought to provide the funding required to achieve this goal. Several possible solutions could be pursued to discover such NEOs and meet the goal, but all require the rapid construction of new hardware and facilities such as ground and/or space-based telescopes. Primarily because none of them has been explicitly funded since the goal was established in 2005, there is less time available to meet the 2020 date, and it is consequently more difficult to meet this goal. Finding: Congress has mandated that NASA discover 90 percent of all near-Earth objects 140 meters in diameter or greater by 2020. The administration has not requested and Congress has not appropriated new funds to meet this objective. Only limited facilities are currently involved in this survey/discovery effort, funded by NASA’s existing budget.

## Deflection good – Detection Needed

### Asteriods detected- funding necessary to change its deathly path

Mills 09 (Cynthis Mills is a veterinarian/writer, 12/17/09, “The Art of Asteriod Deflection”, http://news.discovery.com/space/near-earth-asteroid-threat.html, SH)

There's really nothing to worry about. These guys have got it handled. All they need is to convince Congress they need $500 million and the international community to agree on which direction to go to push a hurtling asteroid off its path of fiery Earth annihilation. These guys are a loose association of scientists, including a retired astronaut and many **work for NASA's Jet Propulsion Laboratory**. Together they study the risk of an Earth impact from an asteroid big enough to do damage, you know, like the one that caused all the dinosaurs to become extinct. Only **they don't call it an "asteroid" -- instead they use a more general term: Near Earth Object (NEO**). **They concentrate on anything bigger than 140 meters across** (but mostly worry about the ones at least a mile across) and traveling on a trajectory that brings them within 4.6 million miles of the earth. They're watching, calculating and ready to do something. These scientists have recruited observatories like Arecibo in Puerto Rico and telescopes in Hawaii and Arizona. **They use radar, honed to resolutions down to less than 10 meters to precisely image the surfaces -- looking for places to land.** Now, don't conjure up the movie Armageddon for this one**; they're not talking exploding the asteroid or even using a nuclear device to deflect it.** These are sensitive guys with a far gentler plan -- live and let the icy-rock-of-space-death live. Plus **there is too big a chance the asteroid would just reassemble** -- gravity bringing the pieces back together in space and continue on its merry way. They will, however, show you a simulation of the 15 square kilometer tower of fire that happens when an asteroid hits. And show you the piece of piece of asteroid-impact-melted-Libyan-desert that was carved into a scarab for King Tut. Instead, they propose to just nudge the errant little planetoid thing. **Push it a little bit faster or perhaps a little head-on bump to just slow the thing down a bit** -- essentially they want to play bumper cars with asteroids; just to persuade them not to hit the earth as a 200,000-megaton fireball plus cataclysmic shock wave. We're not talking about the puny atmospheric fireball like the one that leveled 800 square miles of trees in Tunguska, Siberia in 1908. That was just a little guy -- maybe 40 meters across. **All we really have to do is detect the next dangerous NEO early. Say, ten years or so**. Although there is no guarantee we'll get that much notice, the earth doesn't appear to be threatened by any asteroids from deep space for now. As the scientists describe it, catastrophe is just a matter of bad timing and three-dimensional space. There is only a tiny point in space and time where the orbits of the Earth and any of these near earth objects might meet. Then it comes down to whether or not they get to that point at the same time -- move either one a little faster or slower and, whoosh, just a close call. **There are a lot of NEOs** and these are only the ones we know about. Some 6613 have been identified, **of which 800 are bigger than 1 kilometer across and about 146 are identified as PHA's ("potentially hazardous asteroids," a.k.a. "near-earth-objects-that-can-kill-us-all")**. Wonderfully, there is a lovely web site called Asteroid Watch that cheerfully keeps you updated on just which one is just about to get us. You can even have this information a tweeted to you. As Don Yeomans put it, "Nothing is held back." They are happy to let us know **which asteroid, say Apophis, Tootatis, Castelia or Golevka, has your and my name on it.** But really, it is hard for me to tell what is more impressive, the scientific handle these scientists have on the whole fiery ball of death from space thing or their supreme confidence that, given the resources, that they can so completely handle it. As retired astronaut Rusty Schweickart put it: "It's simple, really, we can do this."

## A2: No Panic

### Panic is inevitable – asteroids are uniquely scary

Chapman, 3

[Clark,, SwRI, Boulder CO USA, 9 Jan 2003, “How a near earth object might affect society”, Commissioned by the Global Science Forum, OECD, for "Workshop on Near Earth Objects: Risks, Policies, and Actions," January 2003, Frascati, Italy ]

The impact hazard has captured public imagination, thanks to blockbuster motion pictures and frequent news reports of predicted "near misses," and it is now regularly used as an often humorous metaphor for the risks of modern life. Yet an impact disaster has not been experienced by anyone now alive nor are there compelling examples of such a calamity in19 human history. (Indeed, most people in the world remain wholly oblivious to this hazard and its potential manifestations.) Thus, at best, it retains a fictional, out-of-this-world character for people aware of it. However, there have been instances during the past decade -- thanks to media hyperbole or mistakes -- when the impact threat has become real for some people. Brief "mass panic" in China in December 1989 was ascribed to a mistaken, nationally televised news story. The headline-producing but mistaken predictions in March 1999 of a close encounter, and non-negligible chances for impact three decades hence, by the mile-wide asteroid 1998 XF11 (Chapman, 2000) frightened some susceptible individuals (e.g. schoolchildren) around the world. Thus there is every expectation that, as risk perception experts have forecast, a predicted or actual impact event might elicit the often exaggerated reactions evoked by the subset of risks classified as uncontrollable, involuntary, fatal, catastrophic, and "dreadful" in the risk perception literature (Slovic, 1987); other features of the impact hazard that predict exaggerated public concern are that it is a newly recognized hazard, due to unobservable agents, as well as a perception that the risk is increasing (the latter isn’t actually true, but the augmented telescopic discovery programs are finding "near miss" objects ever more frequently, and the news media are reporting them). We may hope that such widespread apprehension as when the Earth passed harmlessly through the tail of Halley’s Comet in 1910 may not recur in our enlightened, modern times. However, momentous cosmic events often evoke religious or superstitious connections for many people (the titles of two science fiction novels dealing with cosmic impacts exemplify such themes: Niven and Pournelle’s "Lucifer’s Hammer" and Arthur C. Clarke’s "The Hammer of God"). The predicted fiery, but almost certainly harmless, atmospheric re-entry of the Skylab space module in 1979 caused public concern in many nations; efforts at public education may have helped lessen similar fears prior to the re-entry of the larger Mir space station in 2001. However, these real space-related events may be less relevant as analogs for public reaction to many of the more substantial impact scenarios discussed here than such larger natural disasters as the ten-or-so that have each killed more than 10,000 people (a few over 100,000) in the last three decades, or than the horrors of mass terrorism, war, genocide, or epidemic.

### Asteroids are unique – September 11 proves overreaction

Chapman, 4

[Clark, Southwest Research Institute, Boulder CO, “The hazard of near-Earth asteroid impacts on earth” Earth and Planetary Science Letters 222 (2004) 1 – 15 ]

It is subjective to compare the impact hazard, given its inherent low-probability high-consequence character, with other societal hazards. I consider mortality rather than property damage as being more central to fears of impacts. But neither mortality nor economic loss estimates provide a good forecast of how societies respond to different kinds of hazards. The f 3000 deaths from the terrorist attacks of September 11, 2001 had dramatic national and international consequences (involving economics, politics, war, etc.), while a similar number of U.S. highway fatalities during the same month were hardly noticed, except by family members and associates of the deceased. Risk perception expert Paul Slovic believes that asteroid impacts have many elements of a ‘‘dreadful’’ hazard (being perceived as being involuntary, fatal, uncontrollable, catastrophic and increasing [increasing in news reports, anyway]), like terrorism or nuclear threats, in contrast with more mundane hazards that may be more serious measured by objective criteria [67]. Society often spends much—even orders of magnitude— more per life saved to reduce ‘‘dreadful’’ hazards than mundane ones. For this reason, efforts to reduce the impact hazard and to plan for mitigation (e.g., evacuation of ground zero, storing food supplies in order to survive a global agricultural disaster or developing capabilities to deflect a threatening NEO) may be perceived by many citizens as money well spent. On the other hand, Slovic’s public opinion polls show that many others regard the impact hazard as being trivial.

## A2: Deflection Dilemma (Sagan)

### Zero chance

Schweickart, 4

[Russell, AIAA Associate Fellow, Chairman, B612 Foundation, “ THE REAL DEFLECTION DILEMMA,” 2004 Planetary Defense Conference: Protecting Earth from Asteroids Orange County, California February 23-26, 2004 ]

 While counter arguments can certainly be made the risk or threat level posed by the original deflection dilemma can be put into perspective by considering the specifics of the opportunity for malicious use of a realistic asteroid deflection capability. An operational deflection mission would likely be launched with only enough propulsive capability to deflect the incoming asteroid to a safe miss distance above the atmosphere, accounting for various uncertainties. While different deflection concepts will have greater or lesser precision in applying the required delta V to the asteroid, it would be a wasteful expense if the targeted miss distance beyond the atmosphere were to exceed 1600 miles or so. In other words a reasonable mission capability would be to deflect an asteroid bound for a vertical impact to a miss distance of 1.4 earth radii. In all likelihood most systems that would be considered for operational use would permit a much smaller miss distance while still accounting for all uncertainties and necessary safety criteria. By way of illustration then, using this specific conservative example the deflection system would be able to deflect either a vertically impacting asteroid out to 1.4 Earth radii, or conversely, if used for nefarious purpose, deflect an asteroid which would otherwise have missed impacting the Earth by 1.4 Earth radii or less to an impact at the “center of the Earth”. How often might a “useful” asteroid of opportunity appear within this radius for someone with malicious intent to take advantage of it? In this example, precisely twice the frequency at which such an asteroid would have impacted the Earth on its own. I.e., the cross sectional area of concern here is double the cross sectional area of the Earth itself (1.4 squared). If then, a “useful” asteroid were to be defined as one between 75 and 150 meters in diameter, such an opportunity might present itself for nefarious use once every 1000 years or so. This is hardly the kind of opportunity that comprises a serious national security threat, or military opportunity

## A2: Climate Change Outweighs

### Your methodology fails – expected value calculations can’t quantify existential risks

Chichilnsky and Eisenberger, 10

[Graciela Chichilnisky and Peter Eisenberger, Columbia University, “ Asteroids: Assessing Catastrophic Risks,” Journal of Probability and Statistics Volume 2010]

 The task is not easy. Classic tools for risk management are notoriously poor for managing catastrophic risks, see Posner 2 and Chichilnisky 3, 4. There is an understandable tendency to ignore rare events, such as an asteroid impact, which are unlikely to occur in our lifetimes or those of our families 2, 5. Yes this is a questionable instinct at this stage of human evolution where our knowledge enables to identify such risks. Standard decision tools make this task difficult. We show using the existing data that a major disturbance caused by global warming of less than 1% of GDP overwhelms in expected value the costs associated with an asteroid impact that can plausibly lead to the extinction of the human species. We show that the expected value of the loss caused by an asteroid that leads to extinction—is between $500 million and $92 billion. A loss of this magnitude is smaller than that of a failure of a single atomic plant—the Russians lost more than $140 billion with the accident at Chernobyl—or with the potential risks involved in global warming that is between $890 billion and $9.7 trillion 2. Using expected values therefore we are led to believe that preventing asteroid impacts should not rank high in our policy priorities. Common sense rebels against the computation we just provided. The ability to anticipate and plan for threats that have never been experienced by any current or past member of the species and are unlikely to happen in our lifespans, appears to be unique to our species. We need to use a risk management approach that enables us to deal more effectively with such threats 2. To overcome this problem this paper summarizes a new axiomatic approach to catastrophic risks that updates current methods developed initially by John Von Neumann, see Chichilnisky 3, 4, 6–9, and offers practical figures to evaluate possible policies that would protect us from asteroid impacts. Our conclusion is that we are underinvesting in preventing the risk of asteroid like threats. Much can and should be done at a relatively small cost; this paper suggests a methodology and a range of dollar values that should be spent to protect against such risks to help prevent the extinction of our species. 2. Catastrophes and the Survival of the Species A catastrophe is a rare event with enormous consequences. In a recent book, Posner 2 classifies catastrophes into various types, each of which threats the survival of our species. He uses a classic approach to value the importance of a risk by quantifying its expected value, namely, the product of the probability times the loss. For example, the expected value of an event that occurs with ten percent probability and involves $1 billion loss is $109×10−1 $100 million. This approach is used by actuaries to price the cost of life insurance policies, and is also by law the measure used in US Congress when evaluating budget plans with uncertain outcomes. The notion of expected value started with Von Neumann and Morgenstern about 60 years ago 10, and it is based on their axioms or principles for decision making under uncertainty formalized in 11, 12. Posner 2 uses the concept of expected value to evaluate risks but warns the reader about its weaknesses for evaluating catastrophic risks see Posner 2, Chapter 3, pages 150–154. This weakness is exposed in the case of asteroids, when we ask how much we should invest in preventing the impact of an asteroid that can destroy all of the earth’s economic value forever. Posner 2 argues that expected value does not capture the true impact of such a catastrophe; that something else is at stake. Because of his loyalty to the concept of expected value, which does not work well in these cases, Posner appears to be arguing that rationality does not work in the case of catastrophes, that we cannot deal rationally with small probabilities events that cause such large and irreversible damage. Perhaps the problem is not one of rationality. There may be a different rationality needed when considering the long-range future of the species. It could be that expected value is a good measure for evaluating risks that have a good chance to occur in our lifetime, but not for evaluating risks that are important but have essentially a zero chance to occur while we are alive. For such risks we may need another approach overall, for both the present and the future. In our current state of evolution it would seem useful to oppose a human tendency based on our hunter-gatherer origins to give preference to immediate outcomes as opposed to more distant ones; see the study by McClure et al. 5.When using expected value the response we obtain seems to clash with our intuition because the probabilities involved are so small that they render the computation almost meaningless, as seen numerically in the examples provided below. The experimental evidence summarized below provides further support for this view.

## Atlas good

### ATLAS can detect both very large and very small asteroids across the solar system

Tonry. 10. “An Early Warning System for Asteroid Impact” (<http://www.fallingstar.com/> )(John L. Tonry, Professor University of Hawaii Institute for Astronomy, 2680 Woodlawn Dr., Honolulu, HI 96822 Phone: (808) 956-8701 jt at ifa dot hawaii dot edu Areas of Interest Cosmology, Large Scale Structure of the Universe, Distance Scale, Time Domain Astronomy, Structure of Galaxies, Dense Stellar Systems, Black Holes in Galactic Nuclei, Image Processing)TT

We have all worked for years on the Pan-STARRS project, which is also trying to find near-Earth objects (NEOs) among other things. Pan-STARRS is designed to discover NEOs throughout the Solar System, long before they might strike us. This is an extremely difficult job, and although the warning time provided by Pan-STARRS can be very long, Pan-STARRS will have a very poor chance of finding very small asteroids, even if they are going to impact the Earth. Pan-STARRS observes "deep but narrow", needing months to patrol the whole sky. It occurred to us that a complementary job could be done by observing "shallow but wide". Any asteroid that is actually going to hit us will eventually get very close to the Earth on its final approach, and that will make it very bright. So if we can relieve ourselves of the need to look all the way across the Solar System we can afford to canvas the sky much more frequently. This will probably not provide enough warning to deflect the asteroid -- it's intended to provide warning of impending impact. As with the asteroid impact over Sudan in 2008 described below, however, the accuracy possible of when and where the strike will occur can be exquisite. The amount of warning time is proportional to how distant the asteroid is when we first spot it, and that depends on how big the asteroid is and on how faint our system can see things. We decided that a large explosion of a few Mton required a week's warning and a giant explosion of 100 Mton would need three weeks of warning in order for effective civil defense. The trick to having a good chance of seeing an asteroid before it hits us is to look everywhere possible in the sky. There is a big portion of the sky towards the Sun, about one quarter of the total, that is impossible to look into from the ground without seeing daylight and losing all sensitivity. Another quarter of the sky in the south cannot be seen from the northern hemisphere. This leaves half of the entire sky that can in principle be seen over the course of a night from a single, north latitude site. We decided that we ought to try to cover that entire area twice a night. This gives us a decent chance of observing an incoming asteroid that is so small that we can only detect it on the very last night before it hits us. Of course this corresponds to a relatively harmless asteroid of only a few meters in diameter that probably would not survive passage through the atmosphere. It's simple enough to survey the entire sky with a 35mm camera, but the sensitivity doesn't give us enough warning time. It's easy enough to survey portions of the sky to very good sensitivity (which is what Pan-STARRS and the other NEO surveys are doing), but the coverage is slow enough that a large fraction of impactors can sneak by when the system is looking elsewhere. We realized that it's possible to use an array of 10-inch, commercial telescopes with some really hot CCD cameras that we know how to build to do this scan of the entire, visible sky twice a night. We also know how to write software that will automatically sift through 500MB a minute in real time right down to the photon limit, to discover everything that has changed or moved since the last time we looked. We're proposing to build a set of eight such telescopes and cameras on two mounts at two locations as illustrated. The advantage of having two sites is that we can triangulate the 3D position of asteroids that are within a week of impact, and therefore know immediately whether or not it's something to worry about. ATLAS will issue alerts to the Minor Planet Center in real time of any new detections, and we are confident that anything threatening would immediately trigger many other professionals and amateurs to start collecting data that will verify the impending impact and refine the orbit so that we can predict the moment and place of impact accurately. The ATLAS can detect objects to magnitude 20, which is astronomer-speak for "respectably, but not extremely faint". It corresponds to a match flame in New York viewed from San Francisco (if somebody would move the intervening Earth out of the way!). When we run simulations of how well ATLAS will perform, allowing for weather and using a realistic distribution of approach directions of impactors, we find that ATLAS has a better than 50-50 chance of seeing a 50m (160 ft, few-Mton) impactor and a better than 60% chance of seeing a larger, 140m (500 ft, 100 Mton) asteroid, as shown on the right. The chances of seeing smaller, less dangerous asteroids is less because ATLAS cannot see them until they are much closer, so the probability of having at least one clear chance to observe it are lower. There's a characteristic leveling-off of the probability right around 60% because of the half of the sky we cannot see because of the Sun and because of the southern blind spot. Much larger asteroids we have a better chance of seeing because we'll spot them many orbits before their final approach. When ATLAS does spot an incoming asteroid there is a distribution of warning times, depending on whether the incoming trajectory is favorable to make the asteroid bright and on the luck with the weather. The graph on the right shows this distribution of warning time that ATLAS can provide for incoming asteroids of size 50m and 140m. We think that constructing and operating ATLAS is a difficult, challenging, but ultimately straightforward job. Experience building Pan-STARRS and other projects has taught us a lot about how to get things built and going. To the greatest extent possible we want to just buy things like telescopes, mounts, enclosures, and the like; we want to just recycle things like camera designs, and software; and we want to use CCD detectors that we already have available.

### ATLAS is the cheapest option for this advanced detection technology

Tonry. 10. “An Early Warning System for Asteroid Impact” (<http://www.fallingstar.com/> )(John L. Tonry, Professor University of Hawaii Institute for Astronomy, 2680 Woodlawn Dr., Honolulu, HI 96822 Phone: (808) 956-8701 jt at ifa dot hawaii dot edu Areas of Interest Cosmology, Large Scale Structure of the Universe, Distance Scale, Time Domain Astronomy, Structure of Galaxies, Dense Stellar Systems, Black Holes in Galactic Nuclei, Image Processing)TT

We also want this system operate robotically, requiring only very light human oversight to make sure that things are working properly. We think we can build one system (eight telescopes at two sites) for about $2M, and we think we can operate it for about $0.5M per year. While this is a lot of money, it's quite cheap compared to the other surveys going on, and ATLAS has a unique mission that the other surveys cannot do nearly as well. Out best guess is that it will take us about 2 years to get everything built, up, and running -- end of 2012 if we can start in early 2011. We have written a proposal, 10-NEOO10-0009, to the NASA Near-Earth Object Observation (NEOO) program requesting funding for the ATLAS project, and right now we're waiting to hear from reviewers. The congressional mandate to discover NEOs is supposed to increase the NEOO program funding by a very substantial amount, so we are hopeful. We're proposing to build the eight telescope system, placing one set of telescopes on Haleakala and the other on the slopes of Mauna Kea, at the Hale Pohaku Visitor's Center. We could equally well deploy in California, at Mt. Palomar and Mt. Laguna, for example, or in Arizona on Kitt Peak, Mt. Hopkins, or Mt. Lemmon. It has not escaped our attention that ATLAS is extremely modular, and that it would be relatively easy to build another unit, deploy it in Australia, and close the southern hole through which asteroids can approach unseen. Deploying more units in Hawaii and California and Arizona would help mitigate the blind spots from weather. And of course, distributing units in longitude would enable us to view the night sky 24/7. We are being careful to ensure that each unit has enough local computer power to operate by itself but has enough internet connectivity that we can network together as many units as we want. The initial ATLAS with the two sites for triangulation will be a proof of concept that we can effectively link multiple sites. There's a lot of cool stuff that ATLAS can do besides watch for killer asteroids. Look for denizens of the outer Solar System, such as dwarf planets like Pluto or Eris or a Nemesis star. Detect gravitational lensing when nearby stars pass in front of distant ones. Collect light curves of almost all of the variable stars in our Galaxy. Detect thousands of Type Ia supernova explosions to a redshift of 0.1 within the visible sky. See the flashes of light when a star is gobbled up by a super-massive black hole in a distant galaxy. Nightly monitoring of the activity of 100,000 active galactic nuclei caused by black holes at the centers of galaxies.

# Solvency – Deflection

## Solvency – Laundry List

### Many non-nuclear deflection mechanisms are possible

Foster ‘7(Harold, Geography Prof at U of Victoria, Chapter 27: Disaster Planning for Cosmic Impacts: Progress and Weaknesses, in *Comet/Asteroid Impacts and Human Society: An Interdisciplinary Approach*, SpringLink)

Two of the most important planning issues are briefly examined here. Firstly, the possibility of deflecting or destroying smaller comets or asteroids, so that an Earth impact is prevented, needs detailed consideration. A wide range of approaches to impact prevention has been put forward in the literature. Mitigation subsystems might involve rocket propulsion, rocket-delivered nuclear warheads, kinetic energy systems using projectiles, directed energy from lasers, mass drivers, solar sails and biological, chemical or mechanical asteroid and/or comet “eaters”. Suggestions have been made also of super magnetic field generators and futuristic force fields, tractor beams and gravity manipulation (Morrison 1996, 2004a; Simon 2002). Considerable progress has been made very recently in this area. The NASA Institute for Advanced Concepts has just announced five Phase II awards for the further development of revolutionary advanced concepts to help protect the Earth from cosmic collision (NIAC 2004). Beyond this, the European Space Agency has given priority to “Don Quijoté”, selected from six potential asteroid protection missions. This will involve an asteroid 500 meters in diameter and two spacecraft, Sancho and Hidalgo. Sancho will arrive first and orbit the asteroid for several months, deploying penetrating probes to form a seismic network. When this is ready, and adequate data has been collected, Hidalgo will arrive, crashing into the asteroid at about 10 kilometers per second. Sancho would then study the changes in the asteroid’s orbit, rotation and structure caused by Hidalgo’s impact. This information will give insights into what is needed to modify the orbit of any similar asteroid that may threaten Earth (Morrison 2004b). The United States is currently installing a missile defense system (Missile Defense Agency 2005). With greater international cooperation, this might be expanded to provide the capacity to protect the planet against errant near-Earth-objects, including medium-sized asteroids. Disaster plans should be tested long before they are needed in earnest. After an expert panel has evaluated such potential technologies for impact mitigation, two or three of the most promising should be tested on small, non-threatening asteroids. The sooner the planet has a functional defense system, the better. The technology required to provide one already exists. What is lacking is the political will and the financing required.

## Solvency – Must Use Multiple Deflection Methods

### Deflection technologies can work together

Schweickart ‘7 (Rusty, former astronaut head of B612 Foundation, The Sky Is Falling. Really. March 16, <http://www.nytimes.com/2007/03/16/opinion/16schweickart.html?_r=1>)

The good news is that scientists feel we have the technology to intercept and deflect many asteroids headed toward Earth. Basically, if we have early enough warning, a robotic space mission could slightly change the orbit of a dangerous asteroid so that it would subsequently miss the planet. Two potential deflection techniques appear to work nicely together — first we would deflect the asteroid with kinetic impact from a missile (that is, running into it); then we would use the slight pull of a “gravity tractor” — a satellite that would hover near the asteroid — to fine-tune its new trajectory to our liking.

### Must use multiple deflection methods

IAA ‘9(International Academy of Astronautics, “Dealing with the Threat To Earth From Asteroids and Comets,” <http://iaaweb.org/iaa/Scientific%20Activity/Study%20Groups/SG%20Commission%203/sg35/sg35finalreport.pdf>)

The probability of successfully deflecting a NEO with a single mission using any known concept and developed technologies is unacceptably low, given the likely scale of the consequences of a failure. It is therefore clear that the development and deployment of a robust multiple option, redundant, coordinated system of diverse systems is needed. The deflection of a NEO cannot be a mission but must rather be a campaign of multiple orchestrated missions deployed sequentially in increasingly capable stages, with means emplaced to rapidly assess the status and effects of the missions as they unfold.

## Deflection

### Deflection technology development is critical to avert extinction.

Gianmarco Radice, 2009 Ph.D. Space Advanced Research Team University of Glasgow, UK Journal of Cosmology, 2009, Vol 2, pages 440-451. Cosmology, November 16, 2009 Avoiding Another Mass Extinction Due to N.E.O. Impact

Over the last decade the possibility of an asteroid, large enough to cause world-wide destruction, impacting the Earth has stimulated an intense debate among the scientific community on possible deflection methods. A large range of mitigation strategies have been proposed and compared in literature (Barbee and Nuth, 2009; Cambier et al., 2009; Crowther, 2009; Sanchez et al, 2009). The broad overview presented in this paper does not intend to rule out other possible methods not analysed here, although some could be considered as a combination of the methodologies introduced above. For the first time in the history of mankind, we have the technological capabilities and scientific know-how to protect ourselves from a catastrophe of truly cosmic proportions. We cannot rely on statistics alone to protect us from catastrophe; we cannot afford to wait for the first modern occurrence of a devastating NEO impact before taking steps to adequately address this threat. It is now time for mankind to develop practical and viable strategies to protect Earth from asteroid impact; if not we will go the way of the dinosaurs.

### Impacts may be rare- but when they occur we need to be ready

The Independent 08’, (The Independent, 7/2/08, “Impact Earth: Could we divert a giant asteroid?”, http://www.independent.co.uk/news/science/impact-earth-could-we-divert-a-giant-asteroid-858189.html, SH)

Dr Yeomans is part of a band of scientists lobbying for more research to investigate the orbits of the near-Earth objects that could pose a threat. **With enough warning of an asteroid heading our way, it may be possible to deflect it if it appears to be on a collision course.** Such surveys are under way. "We're identifying problems and hope to be able to do something about it," says Dr Yeomans. Nasa hopes to identify and track 90 per cent of all hazardous objects greater than 450 feet in diameter by the end of 2020. Scientists say that if ever a large object is discovered on a collision course with Earth, it might be possible to send up a nuclear-tipped rocket to blast it off course. A safer way would be **to nudge it aside with smaller impacts, or even a "space sail" that uses the solar wind.** One of the lessons from Tunguska is that, **although we are vulnerable to the threat, it is not something that should turn us to despair – such massive impacts are rare.** As Dr Yeomans says: "I think about Tunguska all the time from a scientific point of view, but the thought of another Tunguska does not keep me up at night."

## Direct Push

### Direct push solves

Schweickart ‘4 (Russell, Chair of the B612 Foundation, former astronaut, Executive Vice President of CTA Commercial Systems, Inc. and Director of Low Earth Orbit (LEO) Systems and research, and scientist at the Experimental Astronomy Laboratory of the Massachusetts Institute of Technology (MIT), “Asteroid Deflection; Hopes and Fears,” Aug., Presented at the World Federation of Scientists Workshop on Planetary Emergencies, Erice, Sicily, August 2004 http://www.b612foundation.org/papers/Asteroid\_Deflection.doc)

Finally there is the concept of the direct push, most fully championed by the B612 Foundation, for which I serve as Chairman of the Board. The idea for the Foundation emerged from an October 2001 meeting of NEA-fluent astronomers, engineers and astronauts who decided to explore the possibility of seriously initiating work on NEA deflection. Our choice to develop the direct soft push concept was driven primarily by two considerations; our sense that a demonstration of capability should be demonstrated within the next 20 years (given the anticipated public policy demand), and the fact that there were several cost-effective key technologies that were developing rapidly. The concept, simply stated, is to land on an asteroid, and using the power and propulsion systems used to get there, control the spin axis of the asteroid and directly push on the surface of the asteroid to accelerate it in the desired direction. While the challenge of performing such an operation on a 1 km asteroid would be out of reach for decades we realized that with advanced nuclear electric power systems and plasma propulsion systems operating in the laboratory today, that a demonstration mission to a 200 meter diameter asteroid could be accomplished in a bit over a decade. With a space qualified nuclear electric reactor of about 1 megawatt and a plasma propulsion system which could generate 2.5 newtons with an exhaust velocity of 100,000 meters/sec a representative demonstration of asteroid deflection could be made by 2015. We therefore established the B612 goal to significantly alter the orbit of an asteroid, in a controlled manner, by 2015. After working through several mission designs, primarily addressing the challenge of thrusting continuously in the desired direction (given a rotating asteroid), we settled on an elegant mission design that first torques the spin axis of the rotating asteroid to a desired angle with respect to the orbit plane and then pushes directly parallel to the instantaneous velocity vector until the desired change in velocity is achieved. This demonstration mission design was presented in a recent Scientific American article. This rather ambitious agenda is surprisingly straight forward, but for one significant challenge, and that is the great unknown of how to attach the spacecraft (or anything) to the surface of an asteroid. In particular, while the spacecraft axis would be oriented vertically with the engine pointing radially outward, the engine would have to continuously thrust off the vertical axis to enable the necessary control of the asteroid spin axis. To achieve this capability the spacecraft would have to have lateral support in order to maintain its vertical position while thrusting at as much as 90 degrees off the vertical. While several concepts for providing such stabilization exist, none will become viable until we can visit one or more asteroids to understand better the near-surface structural characteristics of these bodies. Within several months after identifying the performance needed to accomplish the B612 demonstration mission NASA announced the formation of its Prometheus program targeted to develop and demonstrate the very same power and propulsion technologies that we had integrated into our design. In another few months NASA defined its first Prometheus mission utilizing these powerful new capabilities, a mission to orbit the icy moons of Jupiter (JIMO). At this point it became clear to us that we could quite easily adapt our preliminary mission design to utilize the specific power and propulsion systems which would be developed by NASA for the JIMO mission. Our task had then shifted quite dramatically to “convincing” NASA that one of its immediate follow-on Prometheus missions should be the B612 mission to a near Earth asteroid. Our efforts to convince NASA to adopt this goal have included both popular and technical papers defining the mission and designing specific techniques for various mission operations, the production of several commercial TV films supporting the mission rationale, participation in various international meetings on the subject of threat assessment and asteroid deflection, and testimony before the US Senate, the National Academy of Sciences, and others. To date NASA has shown polite interest but nothing more.

## Solvency – Screw Rockets / Mass Driver

### Screw rockets solve

Merali ‘7(Zeeya, phd in physics, New Scientist, “"Screw rockets" could save Earth from asteroid catastrophe;” 8-11, lexis)

WE'VE been told to nuke 'em, tug 'em and even paint 'em. But burrowing into killer asteroids on a collision course with Earth might be the best way to deflect them. In 2029, the asteroid Apophis will pass near Earth, and our planet's gravity may then put it on collision course for when it comes back round in 2036. Although the chance of an impact is only 1 in 45,000, developing methods to save us from such near-Earth asteroids (NEAs) is vital, and current proposals simply aren't up to the job, says Daniele Fargion of the University of Rome La Sapienza, Italy. Proposals for deflecting NEAs have included blasting them with nuclear explosives, tugging them with nuclear-powered spacecraft or painting them white on one side so that reflected solar energy will nudge the asteroid off course. Blowing up the asteroid could leave vast fragments still Earthbound, however, and tugging and painting can only push the asteroid a few kilometres off course, says Fargion. He proposes an alternative, inspired by the way rockets are propelled forward as they eject mass when burning fuel. He suggests dropping nuclear-powered rockets, each tipped with a screw-shaped drill, onto the asteroid from a mother ship. After latching onto the asteroid's surface - not easy in almost zero gravity - each "screw rocket" will drill deep into the asteroid, projecting the rocky spoil behind it into space at high speed and pushing the asteroid off course. Fargion's calculations show that over 10 years, screw rockets could deflect a 1-cubic-kilometre asteroid by 30,000 kilometres. "Instead of carrying huge amounts of fuel from Earth to propel the asteroid this large distance, we simply exploit the asteroid's own material," he says.

### Drilling techniques solve

Telegraph, 07<Hollywood got it wrong, this is how you stop an apocalyptic asteroid Richard Gray, Science Correspondent 25 Feb <http://www.telegraph.co.uk/news/uknews/1543792/Hollywood-got-it-wrong-this-is-how-you-stop-an-apocalyptic-asteroid.html>>

Rather than Hollywood's preferred option, engineers are trying to develop unmanned rockets that can land on space rocks and use the asteroids' own material to propel them into a safer orbit. The plan will be detailed at a conference, sponsored by Nasa next month, at which its scientists will reveal their -estimate that 100,000 asteroids orbiting near Earth are large enough to destroy a city. So far the agency has only been able to identify and track 4,000 of them. Just one football pitch-sized asteroid smashing into the planet would create destruction on a terrifying scale, wiping out any area it hit, sending flaming debris into the atmosphere and causing tidal waves. Scientists claim that it is only a matter of time before one is found on a collision course. Research to be unveiled at the three-day Planetary Defence Conference in Washington DC will reveal that defending the Earth may not be as simple as suggested by films such as Armageddon in which Bruce Willis's character destroys a giant asteroid using a nuclear bomb. Gianmarco Radice of Glasgow University will be one of more than 200 scientists at the conference. He said: "A nuclear blast may cause it to fragment. So instead of having one large object on an impact course, you have five largish objects. "Also, we do not know a huge amount about the composition of these asteroids. Some are made of rock, others are ice while others are just piles of rubble. If you smash something into a pile of rubble, it will just break up and then reform by gravity." Nasa has already tested the approach by smashing a spacecraft into an asteroid in its Deep Impact mission last year. The European Space Agency is planning a similar test, sending a craft to smash into a 500-yard wide asteroid while another spacecraft -monitors the results. Now an engineering firm in Atlanta, Georgia, has been commissioned by Nasa to develop a new kind of mission to land on an asteroid, drill through the surface and pump the debris into space. Anchoring several unmanned spacecraft, nicknamed Madmen, to an asteroid and ejecting material, would produce enough force in the opposite direction to push an asteroid slowly off its dangerous course. "It is like throwing rocks out of a rowing boat on a lake. The rocks go in one direction and the boat is slowly pushed in the other under the laws of physics," said John Olds, the chief executive of SpaceWorks, the firm behind the scheme. "Over several months we think we can make the difference between a hit and a miss."

## Lasers

### Scientist study lasers, hope to one day implement it too deflect lasers

Space Daily 07**,** (2/22/07, “Scientists Working To Deflect Asteroids Threatening Earth”, Space Daily, http://www.spacedaily.com/reports/Scientists\_Working\_To\_Deflect\_Asteroids\_Threatening\_Earth\_999.html, SH)

It sounds like science fiction, but **Fork, who has a doctorate from Massachusetts Institute of Technology and more than 40 years of experience working with lasers, said someday it could be possible to locate a laser in space or on the moon to look at the properties of asteroids and perhaps alter their trajectories away from Earth**. The research has students excited about using lasers for space-related applications. Graduate student Blake Anderton wrote his master's thesis on "Application of Mode-locked lasers to asteroid characterization and mitigation." Undergraduate Gordon Aiken won a prize at a recent student conference for his poster and presentation "Space positioned LIDAR system for characterization and mitigation of Near Earth Objects." **And members of the group are building a laser system "that is the grandfather of the laser that will push the asteroids," Fork said**. Anderton said his thesis discusses "a way to look at asteroids at maximum range, which means early detection." According to his calculations, an asteroid could be characterized up to 1 AU away (1.5 x 10 to the 11 meters). Arecibo and other radar observatories can only detect objects up to 0.1 AU away, so in theory a laser would represent a vast improvement over radar. Anderton is an engineer at Raytheon Corp. in Huntsville, Ala. He said the project was a good one for him at this point in his career because of his interests in optical and laser physics. At Raytheon he's involved in radar work for the National Missile **Defense radar systems, but he's poised to move into optical and laser physics work, so the masters degree in electrical and computer engineering with an emphasis on optics helped him prepare for his next job assignment**. The thesis was a stepping stone that "opened doors" for him at his job, he said. But Anderton added he has a personal interest in the asteroid mitigation problem. "**We only have one Earth and you don't want to lose it**." Anderton shared a LSEG office with undergraduate Gordon Aiken. The two students talked about their interests. The result of their collaboration is a sharing of knowledge in their academic research pursuits. Aiken started out in mechanical engineering, then transferred to optical engineering when he discovered that UAH is one of just a few colleges in the U.S. with an undergraduate program in optical engineering. When Fork spoke of his research to one of Aiken's engineering classes, Aiken expressed interest and landed a REU grant (Research Experience for Undergraduates) for the summer of 2006. At the end of the REU, Aiken made a presentation on what he'd learned, and Dr. Vernhard Vogler, of UAH's Chemistry Department, suggested Aiken submit his poster to a new annual UAH student research conference, held last year. Aiken won the prize for best undergraduate poster and presentation. "I really like optics. I wanted to get into the field of working with lasers," said the sophomore, who served as a medic in the Army before coming to UAH. "The school has been amazing for me ... If you show interest, they're going to find something for you to do. This has all fallen into place for me." Putting graduate students together with undergraduates is a great idea, he noted. "It's a good mixture of talent." Fork said the current research relates back to work he performed in the mid-1980s, when he and other researchers at AT&T Bell Laboratories developed the first femtosecond lasers. They used one of the lasers to ablate material by ultra-intense laser pulses with femtosecond time resolution ("Femtosecond imaging of melting and evaporation at a photo excited silicon surface," M. C. Downer, R.L. Fork and C.V. Shank, Journal of the Optical Society of America B2,595-599 (1985)). "The laser we are developing now is also being developed to ablate materials," Fork said, but the device would be "a substantial distance" from the target. The system includes an argon laser, a mode-locked Ti-sapphire oscillator, a regenerative Ti-sapphire amplifier, a doubled neodymium-yag pulsed laser and helium-neon line-up lasers, according to Dr. Fork. The short-term goal of the work is "to amplify femtosecond pulses to high peak power at high average power for remote sensing," using unique features associated with the high pulse intensity, Fork said. The work is funded by the U.S. Army and involves a local company that employs several of Fork's former students. The research does not concern characterizing or deflecting asteroids, but Fork sees a connection. **"My vision is that this system is the progenitor of the laser that could characterize and deflect asteroids," he said.**

### Lasers solve

Shiga ‘9(David, New Scientist, “Saving Earth from an asteroid strike,” 3-28, lexis)

A less established and gentler approach would be to nudge the asteroid away from Earth using lasers. In this theory, being investigated by Massimiliano Vasile of the University of Glasgow in the UK and colleagues with funding from the European Space Agency, a fleet of eight or more spacecraft, each carrying a laser, would be sent to rendezvous with the asteroid. Hovering a few kilometres away, each craft would unfurl a 20-metre-wide mirror made of a flexible material such as Mylar. The mirror would focus the sun's rays onto the spacecraft's solar panels, powering the laser. All eight lasers would then be simultaneously fired at a single spot on the asteroid's surface, vaporising that region and creating a plume of gas that should provide enough thrust to push the asteroid off course . This relatively gentle nudging, over a period of months or years, would not break the asteroid up into any smaller pieces, the team say. Vasile, who will also be presenting his idea at the conference, touts the flexibility and reliability of the approach. "You have a formation of satellites and if one breaks you have the others [for back-up]," he says. "And it's scalable, so if you have a bigger asteroid or you want to have a faster deflection then you add more spacecraft."

## Mirrors

### Mirrors is the best way to deflect

Miller 07, (New York Times, Lia Miller, 12/9/07, “The Best Way To Deflect an Asteroid”, http://www.google.com/search?sourceid=chrome&ie=UTF-8&q=%22Nancy+Atkinson+is%22#hl=en&authuser=0&q=related:arstechnica.com/science/news/2008/04/how-to-deflect-an-asteroid.ars+deflecting+asteroids&tbo=1&sa=X&ei=KzkBTpHuGsmBtgetqeTtDQ&sqi=2&ved=0CD8QHzAE&bav=on.2,or.r\_gc.r\_pw.&fp=4afc07978b3d329f&biw=1246&bih=600, SH)

In 1908, an asteroid is thought to have entered the earth’s atmosphere and exploded over a Siberian forest, leveling some 800 square miles of trees in what is known as the Tunguska Event. If we knew today that another asteroid were on a path to intersect with our planet, what could we do? Massimiliano **Vasile, a** lecturer in aerospace engineering at the University of Glasgow, recently concluded a two-year study comparing nine asteroid-deflection methods, rating them for efficiency, complexity and launch readiness. The best method, called “mirror bees,” entails sending a group of small satellites equipped with mirrors 30 to **100 feet wide into space to “swarm” around an asteroid and trail it**, Vasile explains. **The mirrors would be tilted to reflect sunlight onto the asteroid, vaporizing one spot and releasing a stream of gases that would slowly move it off course.** Vasile says this method is especially appealing because it could be scaled easily: 25 to 5,000 satellites could be used, depending on the size of the rock. The losing ideas — satellites equipped with lasers; detonating a nuclear explosion; pushing the asteroid with a spacecraft, to name a few — might still have their place. Vasile says improved technologies could make others appealing in the future. (In March, NASA released a report on “near Earth objects” that deemed the nuclear-explosion method the most effective.) Michael Gaffey, professor of space studies at the University of North Dakota, says the risk of dying from an asteroid strike is about 1 in 2 million. **The problem is that the consequences are tremendous**; a half-mile-wide asteroid or larger, of which there are more than 700 that come close to Earth’s orbit, **could have an impact equal to 60 billion tons of TNT**. While it is not likely to happen, you still want to be prepared. “You don’t panic, you don’t have to run around screaming and waving your hands,” Gaffey says. “But you do need to devote resources to it.

### Mirrors solve

Engineer ‘7(The Engineer, The Big Picture: Mirrored Army to Protect Earth, 10-15, lexis)

A fleet of satellites carrying large mirrors, flying in close formation, could save the Earth from a direct hit by an asteroid, according to space scientists at Glasgow University. The 'Mirror Bee' concept is the best method for deflecting asteroids on a collision course with Earth, said Massimiliano Vasile of the university's Space Advanced Research Team (SpaceART). Vasile and his team studied nine methods of deflecting asteroids but the Mirror Bee option appeared most feasible. It uses concave mirrors mounted on satellites to focus the Sun's rays on to the asteroid and heat its surface so it sublimes into a plume of gas, which will create a thrust. A single mirror would be effective, but it would need to be up to 10km across, Vasile said. Using technology from missions involving constellations of satellites, multiple spacecraft could be flown in formation, with smaller mirrors, to focus the sunlight on to a single spot, 1-1.5m across. 'If we have a satellite with a mirror 2m in diameter, we would need 1,000 of them, and they'd have to focus the sunlight for 90 days to deflect an asteroid,' he said. 'But if we go up to 20m, we'd need 10 satellites and 200 days.'

### Mirrors deflection idea

Lamb Nodate, (Robert Lamb is a senior fellow and deputy director of the Program on Crisis, Conflict, and Cooperation (C3) at CSIS, researching governance and development amid conflict, Howstuffworks.com, “TOP 10 WAYS TO STOP AN ASTEROID”, http://dsc.discovery.com/space/top-10/asteroid-stopping-technology/index-03.html, SH)

Mirrors work on vampires and gorgons, so why not monstrous asteroids? Brandishing a mirror against an asteroid actually has much more in common with the nuclear option mentioned before. Strategically positioned mirrors could concentrate solar rays, heat a small portion of an asteroid's surface, and cause it to spew vapors. As this material ejects from the asteroid, it would provide a little thrust to alter the space rock's path. Early ideas called for a colossal single space mirror, but modern revisions lean toward a multiple-mirror system to work in unison. Among scientists, the mirror strategy is referred to as laser sublimation.

## Solvency – Lasers & Mirrors

### Laser or mirror ablation solves

Schweickart ‘4(Russell, Chair of the B612 Foundation, former astronaut, Executive Vice President of CTA Commercial Systems, Inc. and Director of Low Earth Orbit (LEO) Systems and research, and scientist at the Experimental Astronomy Laboratory of the Massachusetts Institute of Technology (MIT), “Asteroid Deflection; Hopes and Fears,” Aug., Presented at the World Federation of Scientists Workshop on Planetary Emergencies, Erice, Sicily, August 2004 http://www.b612foundation.org/papers/Asteroid\_Deflection.doc)

Again, simplifying for brevity, both the laser and mirror ablation concepts utilize high energy electromagnetic radiation to heat a localized portion of the asteroid surface from a station keeping stand-off position either ahead of or behind the asteroid. Vaporizing the surface will generate a small, but potentially significant thrust opposite to the direction of the gases as they escape the asteroid surface. In the case of the laser a very high temperature must be generated to vaporize the surface and the surface must maintain high temperatures despite the fact that the spot is continually moving out of the laser beam due to asteroid rotation. Clearly a pulsed laser system of higher power could be substituted to partially avoid this effect. One challenge for the laser is to maintain a station keeping position with respect to the asteroid for considerable lengths of time while precisely pointing the laser beam. Additionally to provide the very high energy to power the laser will likely require a space nuclear electric system in order to reliably provide the necessary electricity at reasonable launch weight. Finally an intrinsic problem with all the optical ablation concepts is that the ablating gases from the asteroid will gradually tend to coat all optical surfaces and some self-cleaning design may well have to be built in to the design. Mirror ablation is similar in kind to the laser systems with the exception that concentrated and focused sunlight is heating mechanism. While this requires no or little electrical energy to operate the area of the solar collecting concentrator must be very large, probably several square kilometers. Assuming that the deployment and figure control of such a large surface can be successfully addressed both the station keeping, attitude control, and vapor deposition degradation issues are daunting, to understate the challenge. When all is said and done the launch weight of such an alternative will be substantial if not prohibitive.

## Gravity Tractor – Solves

### Gravity tractor solves

Stone ‘8(Richard, editor for Science Magazine, National Geographic, “Target Earth,” 8-1, lexis)

Then he and Stanley Love, a fellow astronaut, realized pulling would be much easier. A spacecraft could hover nearby and fire its thrusters, gently tugging the asteroid along. No harpooning or lassoing would be required. "Rather than having a physical line between you and the thing you're towing, you're just using the force of gravity between them," Lu says. The "gravity tractor" would tug the asteroid off course at a mere fraction of a mile an hour. But this subtle shift, magnified over the vastness of space, could mean missing Earth by tens of thousands of miles.

### Gravity tractor solves

Easterbrook ‘8(Gregg, Editor of The Atlantic and The New Republic and Sr. Fellow at Brookings, “The Sky is Falling,” June, http://www.theatlantic.com/doc/200806/asteroids)

Then what? In the movies, nuclear bombs are used to destroy space rocks. In NASA’s 2007 report to Congress, the agency suggested a similar approach. But nukes are a brute-force solution, and because an international treaty bans nuclear warheads in space, any proposal to use them against an asteroid would require complex diplomatic agreements. Fortunately, it’s likely that just causing a slight change in course would avert a strike. The reason is the mechanics of orbits. Many people think of a planet as a vacuum cleaner whose gravity sucks in everything in its vicinity. It’s true that a free-falling body will plummet toward the nearest source of gravity—but in space, free-falling bodies are rare. Earth does not plummet into the sun, because the angular momentum of Earth’s orbit is in equilibrium with the sun’s gravity. And asteroids and comets swirl around the sun with tremendous angular momentum, which prevents them from falling toward most of the bodies they pass, including Earth. For any space object approaching a planet, there exists a “keyhole”—a patch in space where the planet’s gravity and the object’s momentum align, causing the asteroid or comet to hurtle toward the planet. Researchers have calculated the keyholes for a few space objects and found that they are tiny, only a few hundred meters across—pinpoints in the immensity of the solar system. You might think of a keyhole as the win-a-free-game opening on the 18th tee of a cheesy, incredibly elaborate miniature-golf course. All around the opening are rotating windmills, giants stomping their feet, dragons walking past, and other obstacles. If your golf ball hits the opening precisely, it will roll down a pipe for a hole in one. Miss by even a bit, and the ball caroms away. Tiny alterations might be enough to deflect a space rock headed toward a keyhole. “The reason I am optimistic about stopping near-Earth-object impacts is that it looks like we won’t need to use fantastic levels of force,” Schweickart says. He envisions a “gravitational tractor,” a spacecraft weighing only a few tons—enough to have a slight gravitational field. If an asteroid’s movements were precisely understood, placing a gravitational tractor in exactly the right place should, ever so slowly, alter the rock’s course, because low levels of gravity from the tractor would tug at the asteroid. The rock’s course would change only by a minuscule amount, but it would miss the hole-in-one pipe to Earth.

### Gravity tractor solves best—simplest and most feasible option

Merali ‘5(Zeeya, phd in physics, New Scientist, lexis)
WHEN it comes to deflecting an asteroid that is on a collision course with Earth, "most people think of the Hollywood treatment – throw a nuclear weapon at it", says NASA astronaut Edward Lu. "That's the blast-and-hope strategy." It is hard to predict where the shattered pieces would go, and many smaller chunks might still head towards Earth. Now Lu and fellow astronaut Stanley Love at NASA's Johnson Space Center in Houston, Texas, have come up with the simplest – and least glamorous – solution yet: park a heavy spacecraft near the asteroid and use gravity as an invisible towline to tug the rock off its deadly course. Other ideas for dealing with such threats have included detonating nuclear bombs near the asteroid – rather than nuking it directly – to nudge it off track. But this carries the same risks as shattering the asteroid. Some have advocated painting the asteroid white to change the amount of solar energy it reflects, thus altering the forces acting upon it and hopefully changing its course. However, the sheer amount of paint this would require makes it impractical, says Lu. In another attempt to come up with a practical solution, the researchers envisioned landing a spacecraft on an asteroid and then steering it off course using the craft's propulsion. But an asteroid's weak gravity may not hold the spacecraft down, so it would have to be anchored to the surface – a complicated task on a surface that could be loose rubble, says Lu. To make matters worse, asteroids often rotate, and pushing on one might just set it spinning faster rather than alter its trajectory. It was then that Lu and Love realised that the spacecraft does not need to land. Just getting close and staying there is enough. For instance, their calculations showed that for a 200-metre asteroid, a 20-tonne spacecraft hovering 50 metres above the rock for about a year would change the asteroid's speed by roughly 2 millimetres per second – enough to knock it off course given time (*Nature* , vol 438, p 177). "This is hands down the best idea I have seen," says Erik Asphaug, an asteroid and comet specialist at the University of California, Santa Cruz. "This will work. But you need to put a large enough spacecraft out there at the right time." The spacecraft would need to begin deflecting the asteroid 20 years before a potential impact with Earth, but that is feasible, given that astronomers can predict asteroid paths decades in advance. And such large spacecraft launches are within our grasp, Lu says. NASA's multi-billion-dollar Prometheus programme, which was set to explore the outer solar system but has now been delayed, included just such a heavy vehicle, propelled by nuclear fission.

### Gravity tractor better than any alternative

Chapman ‘7(Clark, senior scientist at the Southwest Research Institute and president of B612 Foundation, response to Andrew Hicks & Harris Park, “Asteroid Deflection,” New Scientist, Aug. 4, lexis)

Clark Chapman writes: \* though there wasn't space in my comment to describe the various deflection technologies, but these things have in fact been thought about. The thrusters on the gravity tractor would be canted at about a 45-degree angle, so that their thrust misses the asteroid, yet provides the balance required. (It would be a "fatal flaw" and remarkably stupid to do otherwise, for the reason Andrew Hicks mentions.) The gravity tractor that has been discussed need not be massive. The mass of an ordinary deep-space spacecraft is sufficient to move a very small near-Earth object away from the Earth, or an NEO of almost any size away from a keyhole. As for his preferred option of using a series of explosive charges, they don't need to be explosive at all. Simply colliding with the asteroid at high velocity provides plenty of wallop. This, indeed, would be the way to deal with cases requiring more momentum than a gravity tractor can provide. Any method that requires interaction with the surface - whether those "kinetic impactors", nuclear blasts, or almost any other approach besides the gravity tractor - has a lot of uncertainties about how the asteroid will respond. It is not simple like billiard balls. As the Deep Impact mission showed when it fired a projectile into a comet, there can be an enormous blow-back of ejecta, providing additional momentum. You can't calculate in a computer how much blow-back there will be (or even spallation of a piece off the opposite side of the body) without knowing a lot about what the body is made of, its internal structure, and so on. That's the beauty of the gravity tractor. The amount of acceleration is precisely known and continuously measured during the drawn-out deflection phase. Unfortunately, there are cases for which the gravity tractor won't be powerful enough. The good news, however, is that small NEOs with long warning times are the cases we are most likely to face, not the big ones with short warning times that would have to be dealt with by kinetic impactors or even nukes.

### 1000s of killer asteroids, -center of gravity trick

Space Daily 09, (4/20/09, Space Daily, How to deflect asteroids and save the earth”, http://www.sciencedaily.com/releases/2009/04/090416125212.htm, SH)

French, **a doctoral candidate in aerospace engineering at North Carolina State University, has determined a way to effectively divert asteroids and other threatening objects from impacting Earth by attaching a long tether and ballast to the incoming object.** By attaching the ballast, French explains, "**you change the object's center of mass, effectively changing the object's orbit and allowing it to pass by the Earth, rather than impacting it."** Sound far-fetched? NASA's Near Earth Object Program has identified more than 1,000 "potentially hazardous asteroids" and they are finding more all the time. "While none of these objects is currently projected to hit Earth in the near future, slight changes in the orbits of these bodies, which could be caused by the gravitational pull of other objects, push from the solar wind, or some other effect could cause an intersection," French explains. So French, and NC State Associate Professor of Mechanical and Aerospace Engineering Andre Mazzoleni, studied whether an asteroid-tether-ballast system could effectively alter the motion of an asteroid to ensure it missed hitting Earth. The answer? Yes. "It's hard to imagine the scale of both the problem and the potential solutions," French says. "**The Earth has been hit by objects from space many times before, so we know how bad the effects could be. For example, about 65 million years ago, a very large asteroid is thought to have hit the Earth in the southern Gulf of Mexico, wiping out the dinosaurs**, and, in 1907, a very small airburst of a comet over Siberia flattened a forest over an area equal in size to New York City. The scale of our solution is similarly hard to imagine. "Using a tether somewhere between 1,000 kilometers (roughly the distance from Raleigh to Miami) to 100,000 kilometers (you could wrap this around the Earth two and a half times) to divert an asteroid sounds extreme. But compare it to other schemes," French says, "They are all pretty far out. Other schemes include: a call for painting the asteroids in order to alter how light may influence their orbit; a plan that would guide a second asteroid into the threatening one; and of course, there are nukes. Nuclear weapons are an intriguing possibility, but have considerable political and technical obstacles. Would the rest of the world trust us to nuke an asteroid? Would we trust anyone else? And would the asteroid break into multiple asteroids, giving us more problems to solve?" The research was first presented last month at the NC State Graduate Student Research Symposium in Raleigh, N.C. The research, **"Trajectory Diversion of an Earth-Threatening Asteroid via Elastic, Massive Tether-Ballast System," has also been reviewed and accepted for presentation this September** at the American Institute of Aeronautics and Astronautics SPACE 2009 Conference and Exposition in Pasadena, CA.

## Solvency – Kinetic Impactors

### Kinetic impactor solves

Koenig & Chyba ‘7(Jesse D. and Christopher F., SpaceDev Inc and Department of Astrophysical Sciences and Program on Science and Global Security, Woodrow Wilson School of Public and International Affairs, Impact Deflection of Potentially Hazardous Asteroids Using Current Launch Vehicles, http://www.aero.org/conferences/planetarydefense/2007papers/S2-3--Koenig-Paper.pdf)

Nuclear explosions, and a wide variety of technologies not yet realized, have been proposed to deflect asteroids away from collision with Earth. In contrast, here we present realistic models for simple kinetic energy impact deflection, using the actual orbital elements of 795 catalogued Potentially Hazardous Asteroids, and impactor masses launched to intercept trajectories by Atlas V HLV rockets or equivalent. We take asteroid diameter, density, cratering characteristics, and Earth-collision lead time as parameters whose influence is to be investigated. Assuming asteroids of rock-like density, we find deflection off of Earth-collision to be achievable given 5- year lead time with a single kinetic energy intercept for 100% of 250 m diameter PHAs, 20-year lead with a single intercept for 93% of 500 m PHAs, 20-year lead with five and ten intercepts respectively for 55% and 94% of 1 km PHAs, or 100- year lead with one and two intercepts respectively for 55% and 94% of 1 km PHAs. Considering likely future lead times for Near-Earth Objects, simple impact deflection using current launch vehicles is therefore a viable strategy for up to kilometer-diameter asteroids. This method has important advantages over other proposals: it requires no new technologies, would not require development or testing of nuclear warheads, and would likely be the least costly, least risky, and fastest to effect.

### They work for big asteroids and can be deployed in a short timeframe

**Koenig and Chyba, 07**

< Jesse D. and Christopher F., SpaceDev Inc and Department of Astrophysical Sciences and Program on Science and Global Security, Woodrow Wilson School of Public and International Affairs, Impact Deflection of Potentially Hazardous Asteroids Using Current Launch Vehicles, http://www.aero.org/conferences/planetarydefense/2007papers/S2-3--Koenig-Paper.pdf>

Assuming lead time of two decades, simple impact is an effective deflection method with few launches (1 to 3) for PHAs up to 500 m, either with rock-like density (3 g/cm3) and significant cratering ejecta, or with low density (0.5 g/cm3) and no ejecta— encompassing the majority of potential threats. It is important to note that we make no assumptions of extraordinary amounts of ejecta. In fact, our cratering model gives ejecta momentum ratios far lower than some others found in the literature (e.g. the ratios shown in Figure 2D, typically in the range 8 to 10, vs. the ratio of 38.5 in the model due to Holsapple20). Different asteroids have different physical properties, so will have different cratering behavior; porous and incoherent asteroids may give very little ejecta, and therefore we also simulated impacts with zero ejecta to provide a worst case extreme in this regard. Assuming lead time of a century and few launches, impact deflection is effective with significant cratering for the vast majority of rock-like PHAs up to 1 km, and without ejecta for 400 m rock-like PHAs or 750 m low-density PHAs. Furthermore, because of its simplicity, technological readiness, and low risk level, kinetic energy impact may still be the preferred option in the case that more numerous launches are required, for especially large asteroids or short warning times. With 20-year lead, five and ten intercepts will successfully deflect 55% and 94%, respectively, of 1 km rock-like PHAs.

### Kinetic impactor solves

**Valsecchi ‘7**

(G.B., INAF-IASF & A. Milani Comparetti, Department of Mathematics, University of Pisa, Ch. 11: Evaluating the Risk of Impacts and the Efficiency of Risk Reduction, in Comet/Asteroid Impacts and Human Society: An Interdisciplinary Approach, SpringLink)

A quantitative analysis of the problem shows that, if the two conditions just mentioned are met, then a relatively small mass spacecraft (about 500 kg), impacting at a speed of the order of 10 kms–1, could transfer enough linear momentum to deflect a NEA of 300–500 m diameter away from its Earth-colliding orbit. In fact, the largest unknown in this scenario is the amount of linear momentum transferred, that depends not only on the mass and speed of the impacting spacecraft, but also on the detailed physics of the formation of a crater on the NEA, with the ensuing ejection of material in the direction opposite to that from which the spacecraft arrives.

### They work for big asteroids and can be deployed in a short timeframe

Koenig and Chyba, 07< Jesse D. and Christopher F., SpaceDev Inc and Department of Astrophysical Sciences and Program on Science and Global Security, Woodrow Wilson School of Public and International Affairs, Impact Deflection of Potentially Hazardous Asteroids Using Current Launch Vehicles, http://www.aero.org/conferences/planetarydefense/2007papers/S2-3--Koenig-Paper.pdf>

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### Hitting an asteroid idea

Lamb Nodate, (Robert Lamb is a senior fellow and deputy director of the Program on Crisis, Conflict, and Cooperation (C3) at CSIS, researching governance and development amid conflict, Howstuffworks.com, “TOP 10 WAYS TO STOP AN ASTEROID”, http://dsc.discovery.com/space/top-10/asteroid-stopping-technology/index-03.html, SH)

Some scientists think the whole "nuke the asteroid" strategy is overreacting. Why not give it a kinetic love tap? Enter NASA's alternative "kinetic interceptor," which would deflect an incoming asteroid by smacking into it. Like shooting a rolling bowling ball with a pellet gun, the idea is to just barely nudge the asteroid off course -- but not hard enough to fracture it. According to Space.com, a mere 1 mile-per-hour (1.6 kilometer-per-hour) impact would be enough to divert an asteroid by 170,000 miles (273,500 kilometers) if we hit it 20 years before the predicted collision.

## Paint

### The paint it idea

Lamb Nodate, (Robert Lamb is a senior fellow and deputy director of the Program on Crisis, Conflict, and Cooperation (C3) at CSIS, researching governance and development amid conflict, Howstuffworks.com, “TOP 10 WAYS TO STOP AN ASTEROID”, http://dsc.discovery.com/space/top-10/asteroid-stopping-technology/index-03.html, SH)

Painting an asteroid may sound ludicrous: When impending doom is headed straight for Earth, is it really the time to think about redecorating? If you factor in something called "solar powered orbital mechanics," it's a great time. On a hot and sunny day, would you wear a white shirt or a black shirt? Black might be the new black again by the time you read this, but the smart choice is white; it reflects more solar radiation (while dark colors absorb it). Similarly, paint part of an asteroid white and the colored section will feel more "push" from solar radiation, providing a slight nudge to push it gradually off of a course to kiss Earth goodbye. The "paint" in question could also take the form of light-colored dust or chalk -- anything to change the ratio between absorbed and reflected radiation.

## Solar Sail

### The solarwind it idea

Lamb Nodate, (Robert Lamb is a senior fellow and deputy director of the Program on Crisis, Conflict, and Cooperation (C3) at CSIS, researching governance and development amid conflict, Howstuffworks.com, “TOP 10 WAYS TO STOP AN ASTEROID”, http://dsc.discovery.com/space/top-10/asteroid-stopping-technology/index-03.html, SH)

Paint may not appeal to everyone, but using the sun's powerful wind of energy against an incoming asteroid plays a crucial role in several deflection strategies. Take, for instance, sending a spacecraft to attach a giant solar sail to the surface of a near-Earth asteroid. This structure, once unfurled, would reflect solar radiation and gently push an asteroid away from its original destination. In some plans, the sail would even be adjustable to provide a certain degree of remote control. Many experts doubt about attaching anything to an asteroid, however, is a wise idea. After all, these rocks are tumbling and spinning and, while we've landed unmanned vessels on asteroids before, we've hardly set up anything as complex as a working solar sail there.

## Nets

### The net it idea

Lamb Nodate, (Robert Lamb is a senior fellow and deputy director of the Program on Crisis, Conflict, and Cooperation (C3) at CSIS, researching governance and development amid conflict, Howstuffworks.com, “TOP 10 WAYS TO STOP AN ASTEROID”, http://dsc.discovery.com/space/top-10/asteroid-stopping-technology/index-03.html, SH)

Netting a rogue asteroid may sound too much like a Wile E. Coyote ploy, but NASA has given the prospect some serious thought (and with nary an ACME Corporation mail-order catalog in sight). Scientists within the space agency think a carbon-fiber mesh weighing somewhere in the neighborhood of 550 pounds (249 kilograms) could be enough to change the potentially incoming asteroid Apophis' course. The idea? The net material would act like a solar sail, increasing the amount of solar radiation absorbed and emitted by the asteroid. Apophis isn't slated to come dangerously close to Earth until 2029, and then again in 2036 if it's just teasing us the first time. Scientists predict a mere 18 years of entanglement in the net could cast such a doomsday object clear of our world for the foreseeable future.

## Gravity Tractors

### The gravity tractor idea

Lamb Nodate, (Robert Lamb is a senior fellow and deputy director of the Program on Crisis, Conflict, and Cooperation (C3) at CSIS, researching governance and development amid conflict, Howstuffworks.com, “TOP 10 WAYS TO STOP AN ASTEROID”, http://dsc.discovery.com/space/top-10/asteroid-stopping-technology/index-03.html, SH)

To many people, "gravitational tractor" may sound like some made-up technology in an episode of Star Trek, but the premise is fairly simple. Every object in the universe exerts a gravitational pull, including asteroids and man-made spacecraft. Gravity may be one of the weakest forces in the universe, but is also the most "ready-to-use" since all you need is a little mass -- so it makes sense to unleash it against asteroids. Theoretically, all we'd have to do is navigate a hefty robot close to the asteroid and tow it away with the gentle pull gravity. Not everybody's onboard with this method, however. To keep a spacecraft from crashing into the surface of the asteroid, thruster may need to be aimed in the asteroid's direction. This could push against the asteroid enough to counter any towing action. Plus, the cost may be astronomical compared to other methods... How much was that painting idea again?

## Mission to Asteroid

### A Mission to a nearby asteroid will help us learn vital skills to combat them later.

Dickinson 2011 (David Dickinson January 12, 2011 “Near Earth Objects: Mitigating the Threat.” Accessed 6/21/11 <http://astroguyz.com/2011/01/12/near-earth-objects-mitigating-the-threat/>) JK

Of course, a manned mission to a Near Earth Asteroid would be immensely beneficial, as well as raise public consciousness (and hopefully, funding). We could land, practice deflection skills, and study these curious beasts. An asteroid mission would also be a good stepping stone in getting us into manned interplanetary travel. The Obama administration has taken some steps in this direction in the past year; it remains to be seen if we have the resolve to commit to such a goal over the long term. One such tantalizing target could be the asteroid [99942 Apophis](http://en.wikipedia.org/wiki/99942_Apophis). Discovered in 2004, this asteroid caused a brief stir when it was discovered to have a close pass on April (Friday!) the 13th, 2029 and again in 2036. Later observations lowered its rating on the Torino scale to mostly harmless, but a mission in 2029 could be feasible if the technology is in place. Such a mission could plant a transmitter on the surface for more accurate future tracking of Apophis. One such organization that is taking a grass-roots approach to NEO hazard mitigation is the B612 Foundation. Their stated goal is to “significantly alter the orbit of an asteroid in a controlled manner by 2015.” Co-founded by astronaut Rusty Schweickart, this endeavor definitely has the ear of Congress.

## Apophis – Gravity Tractor

### Gravity tractor can solve Apophis

**NASA ‘6** (“2006 Near-Earth Object Survey and Deflection Study” http://www.b612foundation.org/papers/NASA-finalrpt.pdf)

The gravity tractor has been suggested to deliver the small momentum changes required for the keyhole deflection of Apophis. For this concept, the most mass at the PHO provides the most momentum change; therefore, an ion engine would be used to propel the vehicle. To provide enough thrust to reach the asteroid in a short period of time and rendezvous with the asteroid, eight NEXIS thrusters, similar to those used on the Jupiter Icy Moons Orbiter (JIMO), is used as the tractor’s propulsion system. The propellant mass used for transit, rendezvous, and hovering would be roughly 5000 kg, allowing for a mass of 20,000 kg to produce the gravitational force on the asteroid. Different deflection opportunities would change the available lead-time for the gravity tractor. Assuming a few years transit time for the low-thrust system, the gravity tractor may need to be launched in advance of the 2021 observation opportunity. Here, a 3-year transit time and a 6-year action time are assumed. If a mass of 20,000 kg were applied for 6 years against Apophis, it would impart a change in momentum of 4.8 x 107 kg m/s. This would change the asteroid velocity by 1 mm/s (0.001 m/s), insufficient to meet the 2019 opportunity (Design Point 1), but sufficient to avoid the keyhole, assuming improved tracking accuracy for the 2023 opportunity (Design Point 2). To achieve a change of one Earth radius in the short time span, the tractor’s mass would need to be about 150,000 kg.

## Apophis – Space Tug

### Space tug solves Apophis

**NASA ‘6** (“2006 Near-Earth Object Survey and Deflection Study” http://www.b612foundation.org/papers/NASA-finalrpt.pdf)

The space tug is another slow push technique, and its use assumes that Apophis is structurally able to support attachment. The vehicle’s design could be similar to JIMO’s. The JIMO vehicle used eight NEXIS ion thrusters to propel an 18,000-kg spacecraft. If a Delta IV Heavy were used to launch the spacecraft, only 7,000 kg of fuel would be required, with 4,000 kg required for the 3-year transit period and rendezvous/docking, leaving 3,000 kg of fuel to produce a change in Apophis’s momentum. If the thrusters perform at full power, the active push time will be approximately 2.25 years, producing a change in momentum of 2.3 x 108 kg m/s. It is estimated that this would be sufficient for both the 2019 and the 2023 opportunities. A factor-of-eight increase in the mass of the PHO would increase the push time for the tractor by more than 14 years, exceeding the time available for this design. Building a system that is somewhat larger than JIMO using on-orbit assembly techniques could possibly solve the problem. Although relatively little momentum change is required to prevent Apophis from passing through the keyhole, many of the deflection techniques are simply too massive for current lift capabilities for the first design point. If the extremely limited requirements of Design Point 2 are considered, all concepts could hypothetically deflect the threat. A mission to prevent Apophis from passing through the 2026 keyhole appears to be possible with current technologies.

# Nuclear Weapons

## NW Now

### NASA is committing the US into a nuclear-only deflection system that’s doomed to fail

**Chapman ‘6** <Clark, Senior Scientist, Southwest Research Institute Dept. of Space Studies, Boulder CO and Member of the Board, B612 Foundation, Critique of "2006 Near-Earth Object Survey and Deflection Study: Final Report" Published 28 Dec. 2006 by NASA Hq. Program Analysis & Evaluation Office, http://www.b612foundation.org/papers/NASA-CritChap.doc>

Furthermore, the Report takes a totally backwards approach to characterization, saying that we first need to determine what deflection system we will use before addressing what characterization option we will try to build and implement. The "logic" is not what it should be, namely that we will select (from a tool-kit of relevant technologies) what deflection approach would be appropriate for an \*identified\* threatening NEO of a particular size; rather, it says (specifically in the last paragraph of pg. 73) that **we will** soon **select a one-approach-fits-all deflection system (e.g**. stand-off **nuclear) as the preferred generic deflection scheme** andonly then design a characterization effort that will address the needs of that **sole** deflection approach. (The seriousness of this error is illustrated by the fact that the Report seems to select stand-off nuclear as the preferred approach -- because it is "most effective" -- and then ridiculously concludes that we need to know \*less\* about the physical nature of the NEO for stand-off nuclear than for all other deflection options! [This absurd argument is "developed" in the middle paragraph of pg. 61.].)

### NASA currently plans to fire nuclear missiles at threatening asteroids

**O'Neill 2008** (IAN O'NEIL, O’Neill is a British solar physics doctor with nearly a decade of physics study and research experience, JULY 27, 2008, “ Bad Idea: Blowing Up Asteroids with Nuclear Missiles”, Universe Today, Accessed 6/21/11, <http://www.universetoday.com/16066/bad-idea-blowing-up-asteroids-with-nuclear-missiles/>, JK)

The first thing that comes to mind when someone asks: "How do we deflect a near [Earth](http://www.universetoday.com/guide-to-space/earth/) asteroid?" is "Fire some nuclear missiles at it." However, this might not be the best course of action. Akin to opening a walnut with a sledgehammer, there might be a better, less messy option. This is what Apollo astronaut Rusty Schweickart thinks at least. Last year, NASA issued a report suggesting they were seriously considering a nuclear option should an asteroid threaten Earth. However, the ex-lunar module pilot believes this decision was manipulated by political pressure, possibly indicating the [asteroid](http://www.optcorp.com/edu/articleListEDU.aspx?cid=47)threat was being used to speed up nuclear proliferation in space…

### NASA plans to fire nuclear missles at an asteroid in order to nudge it off course.

**Cosmic Log 2007** (Cosmic Logic, March 21, 2007, Dueling over asteroids, Cosmic Log, accessed 6/23/11, <http://cosmiclog.msnbc.msn.com/_news/2007/03/21/4350661-dueling-over-asteroids>, JK)

Those plans came out this month in the form of a [report to Congress](http://neo.jpl.nasa.gov/neo/report2007.html), laying out an analysis of the various methods for detecting and dealing with potentially hazardous asteroids and comets. It's all part of NASA's legislative mandate to find 90 percent of such near-Earth objects, or NEOs, wider than 460 feet (140 meters) by the year 2020. An asteroid that big could devastate a city-sized region if it were to hit Earth. Schweickart, who flew on Apollo 9 in 1969, set up the [B612 Foundation](http://www.b612foundation.org/) to raise awareness about NEO threats - and he's organizing a series of workshops under the aegis of the [Association of Space Explorers](http://www.space-explorers.org/) to develop an international plan for dealing with them. "Not to make it sound overly dramatic, but you're not dealing with just science, you're dealing with public safety issues," he told me today. "You're dealing with the [survival of life.](http://www.msnbc.msn.com/id/12665493/)" That's why he's taking the new report so seriously. NASA's official view is that the most efficient way to divert a potentially threatening NEO is by setting off a nuclear bomb nearby, to nudge it into a safe orbit. "The implication is that it is the preferred way to go to deflect essentially any near-Earth object," Schweickart complained. In contrast, Schweickart argues that the so-called "nuclear standoff" option should be used only as a last resort. He contends that 98 percent of the potential threats can be mitigated by using less extreme measures. For example, he favors the development of a ["gravity tractor"](http://www.msnbc.msn.com/id/16788616/) - a spacecraft that would hover near an asteroid for years at a time, using subtle gravitational attraction to draw the space rock out of a worrisome path.

### NASA’s current plan to deal with Near Earth Objects is to explode it with nuclear weapons

**Graham and** [**Schweickart**](http://www.scientificamerican.com/author.cfm?id=1476) **2008**  ([Thomas Graham Jr.](http://www.scientificamerican.com/author.cfm?id=1475) and [Russell L. Schweickart](http://www.scientificamerican.com/author.cfm?id=1476), Ambassador Thomas Graham Jr. is a former senior-level diplomat and a world-renowned authority on nuclear nonproliferation, Russell L. Schweickart is a former Apollo astronaut and chairman of the B612 Foundation, February 18, 2008, “NASA's Flimsy Argument for Nuclear Weapons”, Scientific American, accessed 6/21/11, <http://www.scientificamerican.com/article.cfm?id=nasas-flimsy-argument-for-nuclear-weapons>, JK)

 Recently, however, a counterargument has been advanced—by NASA. In 2005 Congress ordered the space agency to analyze the alternatives that it could employ to divert a near-Earth object (NEO)—an asteroid or comet—if one was found to be on a collision course with our planet. Last March, NASA submitted a report entitled “Near-Earth Object Survey and Deflection Analysis of Alternatives,” having first coordinated its response with the White House, the Department of Defense and the Department of Energy. In its report NASA chose to analyze only the highly improbable threat posed by large NEOs, which very rarely strike Earth, in lieu of the more realistic danger of a collision with one of the cohort of smaller NEOs, which are far more numerous. What is more, the report emphasized the effectiveness of nuclear explosions in providing the force to deflect an NEO from a collision course, but it completely neglected the need for precision in such a procedure.

### The only way to deal with asteroids with our current technology is to push them out of orbit with nuclear weapons

**HSNW 2010** (Homeland Security News Wire (HSNW), 30 June 2010, “ Scientist says nuclear weapons best bet for saving Earth from asteroids”, HSNW, Accessed 6/21/11, <http://www.homelandsecuritynewswire.com/scientist-says-nuclear-weapons-best-bet-saving-earth-asteroids>, JK)

In the current state of human technology, the NRC warns, the only way to be sure is to use nuclear weapons to push these threat out of orbit: “Nuclear explosions are the only current, practical means for dealing with large NEOs (diameters greater than 1 kilometer) or as a backup for smaller ones if other methods were to fail.” Page notes that if this is indeed the case, then the [current plans](http://www.america.gov/st/peacesec-english/2009/April/20090405150637DMslahrelleK0.8071558.html) by President Obama to strive for “a world free of nuclear weapons” would have to be modified to allow for a few nuclear weapons to remain available for planetary defense.

### NASA currently plans to use an Ares V rocket to launch nuclear weapons at a threatening asteroid

**Wagenseil 2007** (Paul Wagenseil, Paul Wagenseil is the managing editor of[SecurityNewsDaily](http://www.securitynewsdaily.com/), August 08, 2007, “ NASA Researchers Ponder Nuclear Asteroid Deflector”, foxnews,com, accessed 6/22/11, [http://www.foxnews.com/story/0,2933,292464,00.html](http://www.foxnews.com/story/0%2C2933%2C292464%2C00.html), JK)

NASA scientists have proposed a [spacecraft](http://www.foxnews.com/story/0%2C2933%2C292464%2C00.html) that would use atomic blasts to deflect asteroids on collision courses with Earth. Researchers from the Advanced Concepts Office at NASA's [Marshall Space Flight Center](http://www.nasa.gov/centers/marshall/home/index.html) in Huntsville, Ala., presented the idea at the 2007 [Planetary Defense Conference](http://www.aero.org/conferences/planetarydefense/), held in early March in Washington, D.C. [• Click here to view the slides from the presentation (PDF format).](http://www.aero.org/conferences/planetarydefense/2007papers/S3-8--Adams-Brief.pdf) The asteroid deflector would be launched from low Earth orbit by an Ares V rocket, NASA's next-generation heavy-cargo lifter, scheduled to go into service in 2020 As it approached the [asteroid](http://www.foxnews.com/story/0%2C2933%2C292464%2C00.html), the craft would at one-hour intervals release six missile-like interceptors, each tipped with a B83 one-megaton nuclear warhead. The warheads would detonate one by one near the surface of the asteroid, pushing it far enough off course so that it passes comfortably wide of [Earth](http://www.foxnews.com/story/0%2C2933%2C292464%2C00.html).

## NWs Fail – explode on Earth

### Our nuclear deflection method will fail, and the warheads will explode on Earth

IAA ‘9(International Academy of Astronautics, “Dealing with the Threat To Earth From Asteroids and Comets,”<http://iaaweb.org/iaa/Scientific%20Activity/Study%20Groups/SG%20Commission%203/sg35/sg35finalreport.pdf>)

There is a persistent notion in lay circles that the way to deal with a dangerous NEO is to simply hit it with an ICBM and vaporize it in space. Unfortunately, reality is far removed from this illusion. While it is likely that we may be able to rapidly reconfigure an ICBM computer guidance system to intercept a point or object in near-Earth space, ICBM propulsion system performance is insufficient to enable intercept beyond a few hundred kilometers above the Earth’s surface. Stages must be added to an ICBM to enable it to achieve the necessary escape velocity and to place the weapon on an intercept trajectory with a NEO. While these upper stage technologies are space qualified, such a system would have too low a reliability for the NEO intercept mission given the potentially horrendous consequences of an Earth impact, and might thus require many sequential launches of several such vehicles to have any reasonable chance of successfully deflecting a NEO. Such attempts would be part of a dedicated “campaign” utilizing several different launch vehicle types, designed with different upper stages, using different end game techniques, and different nuclear warhead types, in order to obtain a high probability of success. Furthermore at least one failed launch attempt is likely if many are required, and with a nuclear payload this could result in serious environmental effects in and of itself. Thus, it is clear that for the nuclear concept several dedicated designs of a inherently highly reliable launch vehicles and multi-stage interceptors would be extremely desirable to loft the nuclear warheads, and thus the use of existing ICBMs, even if outfitted with current technology upper stages, is highly undesirable if not essentially ruled out.

### We can’t just nuke an asteroid, the study is very precise

Daily News & Analysis 11, (2/1/11, DNA, http://www.dnaindia.com/scitech/report\_study-sheds-light-on-asteroid-deflection-strategy-to-avert-collision\_1501753, SH)

A new study from New York City College of Technology sheds light on how a deflection strategy would work best in order to avoid collision with giant space objects such as asteroids. "A collision with an object of this size traveling at an estimated 30,000 to 40,000 mile per hour would be catastrophic," said NASA researcher and New York City College of Technology (City Tech) associate professor of physics Gregory L Matloff. His advice is to "either destroy the object or alter its trajectory." In 2029 and 2036, the asteroid Apophis (named after the Egyptian god of darkness and the void), at least 1,100 feet in diameter, 90 stories tall, and weighing an estimated 25 million tons, will make two close passes by Earth at a distance of about 22,600 miles. According to the researcher, diverting objects such as these is a better option than exploding them as the debris itself could bathe Earth in a radioactive shower. His study indicates that an asteroid could be diverted by heating its surface to create a jet stream, which would alter its trajectory, causing it to veer off course. And to do that, one needs to know how deeply the light would need to penetrate the NEO's (near Earth object) surface. "A beam that penetrates too deeply would simply heat an asteroid but a beam that penetrates just the right amount - perhaps about a tenth of a millimeter - would create a steerable jet and achieve the purpose of deflecting the asteroid," said Matloff. Matloff and his colleagues have been experimenting with red and green lasers to see how deeply they penetrate asteroidal rock, using solid and powdered (regolith) samples from the Allende meteorite that fell in Chihuahua, Mexico in 1969. "For certain types of NEOs, by Newton's Third Law, the jet stream created would alter the object's solar orbit, hopefully converting an Earth impact to a near miss," Matloff stated. However, he cautioned, "Before concluding that the SC will work as predicted on an actual NEO, samples from other extraterrestrial sources must be analysed." Matloff presented a paper on the results of the City Tech team's optical transmission experiments, "Optical Transmission of an Allende Meteorite Thin Section and Simulated Regolith," at the 73rd Annual Meeting of the international Meteoritical Society, held at the American Museum of Natural History and the Park Central Hotel in New York City.

## NW Fail - Fragmentation

### Even dust fragments cause an explosion on Earth

Nemchinov et al. ‘8(Ivan Nemchinov, Valery Shuvalov, & Vladmir Svetsov, Institute for Dynamics of Geospheres, Russian Academy of Sciences, “Main Factors of Hazards Due to Comets and Asteroids,” in *Catastrophic Events Caused by Cosmic Objects*, pg 58-59)

If the NEO cannot be deflected away from Earth’s orbit as a whole object, it seems reasonable to fragment it into several or a large number of pieces, or even pulverize it. Estimates by Simonenko et al. (1994) show that if a nuclear explosion pulverizes a small asteroid at distances of about 0.01 AU, i.e., 1.5.106 km from the Earth, the average density of particle flow at the Earth will be from i0 to 10—6 g.crn3. The characteristic dimension of such a cloud striking the Earth is on the order of 102\_103 km. One could think that fine asteroidal dust will simply evaporate at high altitudes in the Earth atmosphere, as small meteors do, and not produce any damage. However, the dust particles will not penetrate the atmosphere independently one from another, they will act collectively as a fluid-like stream. A huge explosion will occur in the atmosphere, producing both a radiation impulse and a shock wave at the Earth’s surface. Assume that the average size of fragments is much larger, e.g., 1—2 m. As observations of bolides show, such meteoroids decelerate and produce bright flashes at altitudes of 25—30 km. The diameter of a meteor trail behind such a body is about 0.1 km. The penetration of asteroidal fragments into the atmosphere will be independent from one another if the distance between them is larger. If a 200-rn asteroid is broken into 2-rn-diameter fragments, their number is 106. Therefore, the total cross-section of all wakes, if the fragments simultaneously enter the Earth’s atmosphere will be 0.3.1010 m2. This is equivalent to a circle with a radius of 30 km. If each fragment emits radiation like a typical 1—10 m bolide, i.e., emits about 10% of its kinetic energy, the total radiated energy will be about 4.1011 MI, or the fluence per unit area will be 104J.cm2. The estimated fluence substantially exceeds the fire ignition threshold in the case of fine weather. This model assumes that the fragments decelerate at altitudes 25—30 km and cover an area with a size of the same order. Shock waves from all bolides will unite in the atmosphere and the amplitude of a shock wave at the Earth’s surface will be large enough to break up buildings. Numerical simulations of the entry of a rarefied water vapor stream with a radius of 10 km and density of 102kg.m3 to the atmosphere were made by Teterev (1998). For the entry velocity of 10 km.s, the initial kinetic energy of a stream was about 250 Mt TNT. Strong deformation of the stream begins at altitudes of 40—50 km. In 18 s a shock wave separates from the water vapor cloud. The water mass decelerates at altitudes of about 20 km. The shock wave reaches the Earth’s surface in 23 s. Its amplitude is sufficient to produce strong devastation on the ground. After the impact heated atmospheric gas and vapor expand to the upper atmosphere, and in ‘300 s fall back at a distance of 1,000 km. The atmosphere is heated at altitudes of 70—100 km and the ionospheric layers oscillate. Therefore fragmentation into fine powder or rather large fragments cannot save on-the-ground objects and population. The size of asteroidal fragments depends on the yield of a nuclear device and the structure, shape, porosity, and strength of a cosmic body. Continuation of observations from ground telescopes or satellites and space missions is essential for obtaining such data for small cosmic objects.

### Nuclear explosion fragments the asteroid, making the impact worse

**Prantzos ‘2k**

(Nikos, researcher at the Paris Institute of Astrophysics, *Our Cosmic Future: Humanity’s Fate in the Universe*, p. 199)

Future civilizations will no doubt find a way of protecting themselves against asteroid impacts on Earth. However, no effective means of defence is known today. In the case of a relatively small object, we could only organize an evacuation of the region surrounding the point of impact. Unfortunately, the exact location of this point would only be known with any accuracy a few days before impact. In the case of massive objects the time factor is of capital importance. An effective parry could not be envisioned in under a few months, or even years. In science fiction, there is a widespread idea that megatonne nuclear weapons could be used to explode the projectile. But this would serve no useful purpose. An object of this mass cannot be pulverised. At best, it would be shattered into several dozen pieces, each measuring hundreds of metres in diameter, and these would continue along their fateful trajectories. This is precisely what happened to comet Shomaker-Levy in 1994. It had long been fragmented by Jupiter’s gravitational forces and the various pieces ploughed into the surface in quick succession. The destruction resulting from a series of projectiles of these dimensions showing down on Earth would be even more disastrous than if the asteroid had struck intact.

### Nuclear weapons will fragment the asteroid, not deflect it

**Griffin ‘4**

(Dr. Michael, Head of the Space Department John Hopkins University Applied Physics Lab, “Near-Earth Objects,” testimony before the Committee on Senate Commerce, Science and Transportation Subcommittee on Science, Technology, and Space, Apr.7 CQ, lexis)

The deflection technologies available today, which are chemical rockets and nuclear weapons, both have limited abilities to slow down or speed up an asteroid. A 100 m object has a mass of the order of 1 million tons, and a 1 km object has a mass of the order of 1 billion tons. To prevent an object from colliding with Earth, it must be sped up or slowed down by about 7 cm/s (about 1/6 of an mile per hour) divided by the number of years in advance that the change is applied. The fuel that can be contained in a medium-sized scientific spacecraft could successfully deflect a 100 m body if it were pushed about 15 years in advance. The Space Shuttle's main engines and the fuel contained in the large external tank could successfully deflect a 1 km diameter object if it were applied about 20 years in advance. Nuclear weapons carry much greater impulse for their mass. However, they deliver that impulse so quickly that they are more likely to break up the body than to deflect it. Because NEOs are in their own orbits around the Sun, the pieces of a disrupted object will tend to come together one half of an orbital period later. Therefore, the successful use of nuclear weapons for deflection will require the development of techniques for slowing the delivery of the impulse to the NEO and will probably also require many small weapons to be used to deflect a single NEO.

### Nuclear explosion will fragment the asteroid and increase the impact

**Schweickart ‘4**

(Russell, Chair of the B612 Foundation, former astronaut, Executive Vice President of CTA Commercial Systems, Inc. and Director of Low Earth Orbit (LEO) Systems and research, and scientist at the Experimental Astronomy Laboratory of the Massachusetts Institute of Technology (MIT), “Asteroid Deflection; Hopes and Fears,” Aug., Presented at the World Federation of Scientists Workshop on Planetary Emergencies, Erice, Sicily, August 2004 http://www.b612foundation.org/papers/Asteroid\_Deflection.doc)

The hard options consist of various forms of nuclear explosion as well as that of direct (or kinetic) impact. In each case, however, to be effective the resultant force must be applied along the NEA’s velocity vector, with the exception of two cases. If one considers the option of fragmenting the NEA a viable option (i.e., blowing it to pieces) then the direction of impulse becomes meaningless. While there are many uncertainties regarding the effect of a nuclear explosion intended to fragment an asteroid (generally assumed to be a sub-surface burst) it seems clear that, given a large enough nuclear weapon, the fragmentation could be achieved. Arguments have been made from the first discussion of this option, however, that **such a strategy would be unwise since the possibility exists that the resultant fragmentation could actually increase the overall threat and not eliminate it.** No general answer to this debate will likely evolve since it is highly dependent on the structural character of the asteroid in question.

### Nuclear weapons increase the impact by fragmenting the NEO

**Spaceguard - No Date**

(United Kingdom Spaceguard Centre, Mitigation, http://www.spaceguarduk.com/mitigation)

The possibility of destroying potential impactors, probably with high yield nuclear weapons, has been studied in some detail. With the current lack of detailed knowledge of the exact composition of particular objects, and their structural strength, there is an element of doubt as to the effectiveness of this course of action. The fear would be that incomplete disruption of the object would subject the Earth to multiple impacts from pieces of the original body. The effects of transforming a cannon ball into a cluster bomb could be more far-reaching than the original threat.

### Nuclear weapons increase the impact by fragmenting the NEO

**Task Force ‘2k**

(British National Space Centre, Report of the Task Force on Potentially Hazardous Near Earth Objects, http://www.spacecentre.co.uk/neo/report.html)

To try to destroy an asteroid or comet in space by a single explosive charge on or below its surface would risk breaking it uncontrollably into a number of large pieces which could still hit the Earth, doing even more damage. A more promising method would be to fly a spacecraft alongside the object, perhaps for months or years, nudging it in a controlled way from time to time with explosives or other means. This relatively gentle approach is particularly important because many asteroids and comets are held together only by their own very weak gravitational fields. The longer the time before impact, the more effective even a small nudge would be. This is not science fiction. When NASA launches its Deep Impact mission to comet Tempel 1 in 2004, the spacecraft will eventually release a half tonne lump of copper to cause a huge crater in the comet. Although this is not the objective, the result will also be to deflect the comet’s orbit. However, the deflection in this case will be small in comparison to that required to deal with a real threat.

## Frag Bad – prevents deflection

### Fragmentation prevents other forms of deflection

Chapman ‘3(Clark, scientist at the [Southwest Research Institute](http://www.swri.edu/default.htm)'s Department of Space Studies, Great Impact Debates, Collision Course for Earth 3/03 <http://www.astrobio.net/index.php?option=com_debate&task=detail&id=389>)

Clark Chapman: The advantage of using nuclear weapons to destroy asteroids is that they are our most powerful devices by far. But the disadvantages are many. In particular, the more we learn about [asteroids and comets](http://nssdc.gsfc.nasa.gov/planetary/planets/asteroidpage.html), the more we realize that they are incredibly fragile. Most asteroids larger than a few hundred meters across are now thought to be "rubble piles" -- collections of rocks, boulders, and "mountains" simply resting against each other, loosely held together by the tenuous gravitational field of the ensemble.   Any sudden force applied to such an object would likely tear it apart into a swarm of objects. The total impacting energy of the swarm would be the same as the original asteroid, but spread out across the Earth's surface. In any case, **once you disrupt a**[**comet**](http://www.nineplanets.org/comets.html)**or asteroid into many different chunks, you've lost all ability to affect what happens next**. In short, it is a very bad idea.

## NW Fail – Standoff blast fails

### Stand-off blast fails

Schweickart ‘4(Russell, Chair of the B612 Foundation, former astronaut, Executive Vice President of CTA Commercial Systems, Inc. and Director of Low Earth Orbit (LEO) Systems and research, and scientist at the Experimental Astronomy Laboratory of the Massachusetts Institute of Technology (MIT), “Asteroid Deflection; Hopes and Fears,” Aug., Presented at the World Federation of Scientists Workshop on Planetary Emergencies, Erice, Sicily, August 2004 http://www.b612foundation.org/papers/Asteroid\_Deflection.doc)

The hard options consist of various forms of nuclear explosion as well as that of direct (or kinetic) impact. In each case, however, to be effective the resultant force must be applied along the NEA’s velocity vector, with the exception of two cases. If one considers the option of fragmenting the NEA a viable option (i.e., blowing it to pieces) then the direction of impulse becomes meaningless. While there are many uncertainties regarding the effect of a nuclear explosion intended to fragment an asteroid (generally assumed to be a sub-surface burst) it seems clear that, given a large enough nuclear weapon, the fragmentation could be achieved. Arguments have been made from the first discussion of this option, however, that such a strategy would be unwise since the possibility exists that the resultant fragmentation could actually increase the overall threat and not eliminate it. No general answer to this debate will likely evolve since it is highly dependent on the structural character of the asteroid in question. The more favored nuclear options are intended not to fragment the asteroid but rather to accelerate it in a preferred direction adequate to cause it to miss its rendezvous with Earth. While quite distinct in specifics two examples serve to illustrate the options here. One a surface burst designed to excavate asteroidal materials and eject them in a preferred direction. Alternatively a stand-off explosion, probably maximizing the neutron flux directed at the surface of the asteroid to cause an explosive boil-off of the surface to generate the desired impulse. In both these cases the characteristics of the specific asteroid are clearly critical. In addition to this uncertainty the placement of the nuclear explosive in each case must be quite precise in order for the resultant impulse to be generated in the desired direction. The certainty of such a placement is profoundly enhanced if the explosive it positioned by a spacecraft which has fully rendezvoused with the asteroid; i.e., if the spacecraft has matched velocity with the asteroid. Such a rendezvous however, requires considerable fuel compared with a flyby where the spacecraft simply flys by at a precise distance at high speed and the nuclear warhead explodes at precisely the correct time. The cumulative uncertainties intrinsic in this design, combined with the unknowns about the structural characteristics of asteroids lead many proponents of deflection to remain skeptical about the nuclear options.

### Stand-off blast will be absorbed

Fountain ‘2 (Henry, New York Times correspondent, Armageddon Can Wait: Stopping Killer Asteroids, November 19, http://www.nytimes.com/2002/11/19/science/space/19ASTE.html)

But it is becoming clear that a longtime assumption of many scientists ? and of Hollywood filmmakers ? that a nuclear weapon is the best way to save the planet from a threatening asteroid is no longer in such favor. Increasingly, those scientists who study asteroid hazards say that a subtler, quieter, slower approach might be called for. These scientists are turning T. S. Eliot on his head: it's not that the world will end with a whimper rather than a bang, they say. It's that it may not end that way. A nuclear detonation, some scientists say, could break the asteroid into several large pieces, increasing, rather than eliminating, the threat. And a blast some distance from an asteroid, designed to shove it into a slightly different orbit, might not work either; the asteroid might soak up the energy like a sponge. "I'd say forget that," said Dr. Keith A. Holsapple, a professor at the University of Washington who studies the effects of simulated nuclear explosions. By contrast, most of the alternative approaches would build up force gradually, gently nudging, rather than shoving, the asteroid. They would rely on the same basic Newtonian principle ? that for every action there is an equal and opposite reaction ? only written small, with tiny actions creating tiny opposite reactions that, given enough time, could shift an asteroid's orbit enough to change a hit into a close call.

### Standoff blast carries the same risk as a direct strike

Merali ‘5(Zeeya, PhD in physics, New Scientist, lexis)

WHEN it comes to deflecting an asteroid that is on a collision course with Earth, "most people think of the Hollywood treatment – throw a nuclear weapon at it", says NASA astronaut Edward Lu. "That's the blast-and-hope strategy." It is hard to predict where the shattered pieces would go, and many smaller chunks might still head towards Earth. Now Lu and fellow astronaut Stanley Love at NASA's Johnson Space Center in Houston, Texas, have come up with the simplest – and least glamorous – solution yet: park a heavy spacecraft near the asteroid and use gravity as an invisible towline to tug the rock off its deadly course. Other ideas for dealing with such threats have included detonating nuclear bombs near the asteroid – rather than nuking it directly – to nudge it off track. But **this carries the same risks as shattering the asteroid**. Some have advocated painting the asteroid white to change the amount of solar energy it reflects, thus altering the forces acting upon it and hopefully changing its course. However, the sheer amount of paint this would require makes it impractical, says Lu.

## Asteroids = Excuse for Nuclear Weapons

### The threat of an asteroid provides an excuse to deploy nuclear weapons—causes accidental launch

**Gerrard & Barber ‘97**

(Michael & Anna, Asteroids and Comets: U.S. and International Law and the Lowest-Probability, Highest Consequence Risk, New York Univ. Environmental Law Journal, http://www1.law.nyu.edu/journals/envtllaw/issues/vol6/1/6nyuelj4.html)

Perhaps the biggest threat that asteroids pose to mankind today is the excuse they provide for continuing to deploy nuclear weapons. In 1996 there were two stark examples of this. In April, China refused to sign a treaty with Russia banning nuclear weapons testing, on the stated grounds that such weapons might be needed to combat the asteroid threat. [68](http://www1.law.nyu.edu/journals/envtllaw/issues/vol6/1/6nyuelj4n.html%22%20%5Cl%20%22fn68%22%20%5Ct%20%22Notes) In September, a "Space Protection of Earth" conference was held at the Russian Federal Nuclear Center in Snezhinsk, and the sole American scientist to attend reported that the Russians are considering building a system of nuclear-armed missiles that could be readied for launch in ninety minutes if an incoming asteroid were spotted. [69](http://www1.law.nyu.edu/journals/envtllaw/issues/vol6/1/6nyuelj4n.html%22%20%5Cl%20%22fn69%22%20%5Ct%20%22Notes) It seems obvious that the deployment of a nuclear weapons system in China, Russia, or anywhere else poses a threat of accidental or malevolent mass destruction that dwarfs the odds that such a system will be suddenly needed to beat back a long-period comet or another atypical threat that arises with too little warning for us to develop a defensive system from scratch. Some U.S. scientists today advocate a testing program for nuclear explosions at remote asteroids to determine the parameters under which defensive measures would work best. The most visible proponent of this approach is the eighty- nine year old Dr. Edward Teller, who is better known as the "father" of the hydrogen bomb. [70](http://www1.law.nyu.edu/journals/envtllaw/issues/vol6/1/6nyuelj4n.html%22%20%5Cl%20%22fn70%22%20%5Ct%20%22Notes) Representatives of the Ballistic Missile Defense Organization have also recently advocated an accelerated program of testing (not necessarily with nuclear warheads) utilizing some of the several hundred Russian intercontinental ballistic missiles (ICBMs) that must be destroyed by 2002 in accordance with the START II treaty. [71](http://www1.law.nyu.edu/journals/envtllaw/issues/vol6/1/6nyuelj4n.html%22%20%5Cl%20%22fn71%22%20%5Ct%20%22Notes) One physicist who has studied the issue, \*19 while not explicitly advocating the testing of nuclear devices, has written: Clearly, the NEO hazard threat cannot be used as a pretext for rearmament and appropriate safeguards must be taken to minimize the threat of misuse. If mitigation methods and devices are to be developed, safeguards and rigorous controls against their misuse must play a dominant role at every state of design, development, testing, and deployment. However, in the absence of specifically developed mitigation technology it would be prudent to have available that technology and hardware which can most effectively deal with an Earth threatening NEO. We must and can establish the appropriate custodial mechanisms that allow us to maintain those options which can best protect the Earth. [72](http://www1.law.nyu.edu/journals/envtllaw/issues/vol6/1/6nyuelj4n.html%22%20%5Cl%20%22fn72%22%20%5Ct%20%22Notes)

## NWs Fail – Porous NEOs

### Nuclear weapons fail to deflect porous NEOs

Fountain ‘2 (Henry, New York Times correspondent, Armageddon Can Wait: Stopping Killer Asteroids, November 19, http://www.nytimes.com/2002/11/19/science/space/19ASTE.html)

What makes some of these alternatives promising is what scientists have come to understand about asteroids. Many of them, the scientists say, are rather loose agglomerations of stony fragments that have stuck together over time in the cosmic rock tumbler that is the solar system. They are not giant solid boulders. "Maybe something like a popcorn ball is a better way to describe it," Dr. Holsapple said. Such porous objects would be hard to obliterate or move with a nuclear blast, even one some distance from the surface, he said. "But **pushing a little bit for a long time would work equally well whether an asteroid is porous or not,"** he added.

### Most NEOs are porous

Housen ‘3 (Kevin and Keith Holsapple, Physical Sciences, MS 2T-50, The Boeing Company and Department of Aeronautics and Astronautics, 352400, U of Washington Impact cratering on porous asteroids, Icarus 163 (2003) 102–119)

Although asteroids have long been suspected of having porous interiors (Chapman et al., 1977; Watson, 1978), compelling evidence of porosity has come only recently. Results from spacecraft missions and major improvements in ground-based optical and radar observation techniques have now provided reliable bulk density estimates for 23 asteroids (Britt et al., 2002). Ten of these objects have density less than about 2.0 g/cm3, and five are below 1.5 g/cm3, which suggests that much of their interiors could be void space. Flynn (1994) noted that many interplanetary dust particles have high porosities, suggesting that the asteroids that they sample may be porous as well. Quantitative estimates of porosity have been made by associating various taxonomic classes of asteroids with analogue classes of meteorites. The bulk porosity of an asteroid, i.e., the fraction of an asteroid’s volume that is void, is estimated from the known bulk density of the asteroid and the measured density of mineral grains in the corresponding analogue meteorite type. Such calculations show that many asteroids have significant pore space (Consolmagno and Britt, 1998; Flynn et al., 1999; Wilson et al., 1999; Britt and Consolmagno, 2000; Wilkison et al., 2001). For example, Britt et al. (2002) found porosities as high as 75%, with a clustering of objects in the range of 25–55%. Comets are also thought to have highly porous structures. Empirical and theoretical data on the density of meteors, along with modeling of interstellar dust grain formation and aggregation indicate that cometary nuclei could have as much as 60–80% void space (e.g., Greenberg, 1986; Sirono and Greenberg, 2000). Spacecraft observations of asteroid Mathilde strongly suggest that porosity has an important effect on the collisional evolution of asteroids. Mathilde, a C-type asteroid 66 \_ 48 \_ 46 km in size, has a measured bulk density of \_1.3 g/cm3, and an estimated porosity of \_50% (Veverka et al., 1999; Britt et al., 2002).

# Impacts – Asteroid Strikes

## Impact Calc-Err Aff

### Err on the side of larger impact probability – uncertainty means you prefer the upper bound

Ord et. al, 10 [ Toby Ord, Future of Humanity Institute, University of Oxford , Rafaela Hillerbrand, Ethics for Energy Technologies, Human Technology Center, RWTH Aachen University and Anders Sandberg, Future of Humanity Institute, University of Oxford, “ Probing the improbable: methodological challenges for risks with low probabilities and high stakes,” Journal of Risk Research Vol. 13, No. 2, March 2010, 191–205]

Large asteroid impacts are highly unlikely events. Nonetheless, governments spend large sums on assessing the associated risks. It is the high stakes that make these otherwise rare events worth examining. Assessing a risk involves consideration of both the stakes involved and the likelihood of the hazard occurring. If a risk threatens the lives of a great many people, it is not only rational but morally imperative to examine the risk in some detail and to see what we can do to reduce it. This paper focuses on low-probability high-stakes risks. In Section 2, we show that the probability estimates in scientific analysis cannot be equated with the likelihood of these events occurring. Instead of the probability of the event occurring, scientific analysis gives the event’s probability conditioned on the given argument being sound. Though this is the case in all probability estimates, we show how it becomes crucial when the estimated probabilities are smaller than a certain threshold. To proceed, we need to know something about the reliability of the argument. To do so, risk analysis commonly falls back on the distinction between model and parameter uncertainty. We argue that this dichotomy is not well suited for incorporating information about the reliability of the theories involved in the risk assessment. Furthermore, the distinction does not account for mistakes made unknowingly. In Section 3, we therefore propose a three-fold distinction between an argument’s theory, its model and its calculations. While explaining this distinction in more detail, we illustrate it with historic examples of errors in each of the three areas. We indicate how specific risk assessment can make use of the proposed theory–model–calculation distinction in order to evaluate the reliability of the given argument and thus improve the reliability of their probability estimate for rare events. Recently, concerns have been raised that high-energy experiments in particle physics, such as the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory or the Large Hadron Collider (LHC) at CERN, Geneva, may threaten humanity. If these fears are justified, these experiments pose a risk to humanity that can be avoided by simply not turning on the experiment. In Section 4, we use the methods of this paper to address the current debate on the safety of experiments within particle physics. We evaluate current reports in the light of our findings and give suggestions for future research. The final section brings the debate back to the general issue of assessing low-probability risk. We stress that the findings in this paper are not to be interpreted as an argument for anti-intellectualism, but rather as arguments for making the noisy and fallible nature of scientific and technical research subject to intellectual reasoning, especially in situations where the probabilities are very low and the stakes are very high. Suppose you read a report which examines a potentially catastrophic risk and concludes that the probability of catastrophe is one in a billion. What probability should you assign to the catastrophe occurring? We argue that direct use of the report’s estimate of one in a billion is naive. This is because the report’s authors are not infallible and their argument might have a hidden flaw. What the report has told us is not the probability of the catastrophe occurring, but the probability of the catastrophe occurring, given that the included argument is sound. Even if the argument looks watertight, the chance that it contains a critical flaw may well be much larger than one in a billion. After all, in a sample of a billion apparently watertight arguments you are likely to see many that have hidden flaws. Our best estimate of the probability of catastrophe may thus end up noticeably higher than the report’s estimate. 2 Let us use the following notation: X, the catastrophe occurs; A, the argument is sound; P(X), the probability of X and P(X|A), the probability of X given A. While we are actually interested in P(X), the report provides us only with an estimate of P(X|A), since it cannot fully take into account the possibility that it is in error. 3,4 From the axioms of probability theory, we know that P(X) is related to P(X|A) by the following formula: P X P X A P A P X A P A = + ( ) ( | ) ( ) ( | ) ( ). ( ) To use this formula to derive P(X), we would require estimates for the probability that the argument is sound, P(A), and the probability of the catastrophe occurring, given that the argument is unsound, P(X|A). We are highly unlikely to be able to acquire accurate values for these probabilities in practice, but we shall see that even crude estimates are enough to change the way we look at certain risk calculations. A special case, which occurs quite frequently, is for reports to claim that X is completely impossible. However, this just tells us that X is impossible, given that all our current beliefs are correct, that is P(X|A) = 0. By Equation (1) we can see that this is entirely consistent with P(X) > 0, as the argument may be flawed. Figure 1 is a simple graphical representation of our main point. The square on the left represents the space of probabilities as described in the scientific report, where the black area represents the catastrophe occurring and the white area represents not occurring. The normalized vertical axis denotes the probabilities for the event occurring and not occurring. This representation ignores the possibility of the argument being unsound. To accommodate this possibility, we can revise it in the form of the square on the right. The black and white areas have shrunk in proportion to the probability that the argument is sound and a new grey area represents the possibility that the argument is unsound. Now, the horizontal axis is also normalized and represents the probability that the argument is sound. Figure 1. The left panel depicts a report’s view on the probability of an event occurring. The black area represents the chance of the event occurring, the white area represents it not occurring. The right-hand panel is the more comprehensive picture, taking into account the possibility that the argument is flawed and that we thus face a grey area containing an unknown amount of risk. To continue our example, let us suppose that the argument made in the report looks very solid, and that our best estimate of the probability that it is flawed is one in a thousand, (P(A) = 10 !3 ). The other unknown term in Equation (1), P(X|A), is generally even more difficult to evaluate, but for the purposes of the current example, let us suppose that we think it highly unlikely that the event will occur even if the argument is not sound and treat this probability as one in a thousand as well. Equation (1) tells us that the probability of catastrophe would then be just over one in a million – an estimate which is a thousand times higher than that in the report itself. This reflects the fact that if the catastrophe were to actually occur, it is much more likely that this was because there was a flaw in the report’s argument than that a one in a billion event took place. Flawed arguments are not rare. One way to estimate the frequency of major flaws in academic papers is to look at the proportions which are formally retracted after publication. While some retractions are due to misconduct, most are due to unintentional errors. 5 Using the MEDLINE database, 7 Cokol et al. (2007) found a raw Figure 1. The left panel depicts a report’s view on the probability of an event occurring. The black area represents the chance of the event occurring, the white area represents it not occurring. The right-hand panel is the more comprehensive picture, taking into account the possibility that the argument is flawed and that we thus face a grey area containing an unknown amount of risk. rate of 6.3 " 10 !5 , but used a statistical model to estimate that the retraction rate would actually be between 0.001 and 0.01 if all journals received the same level of scrutiny as those in the top tier. This would suggest that P(A) > 0.001 making our earlier estimate rather optimistic. We must also remember that an argument can easily be flawed without warranting retraction. Retraction is only called for when the underlying flaws are not trivial and are immediately noticeable by the academic community. The retraction rate for a field would thus provide a lower bound for the rate of serious flaws. Of course, we must also keep in mind the possibility that different branches of science may have different retraction rates and different error rates: the hard sciences may be less prone to error than the more applied sciences. Finally, we can have more confidence in an article, the longer it has been open to public scrutiny without a flaw being detected. It is important to note the particular connection between the present analysis and high-stakes low-probability risks. While our analysis could be applied to any risk, it is much more useful for those in this category. For it is only when P(X|A) is very low that the grey area has a relatively large role to play. If P(X|A) is moderately high, then the small contribution of the error term is of little significance in the overall probability estimate, perhaps making the difference between 10 and 10.001% rather than the difference between 0.001 and 0.002%. The stakes must also be very high to warrant this additional analysis of the risk, for the adjustment to the estimated probability will typically be very small in absolute terms. While an additional one in a million chance of a billion deaths certainly warrants further consideration, an additional one in a million chance of a house fire may not. One might object to our approach on the grounds that we have shown only that the uncertainty is greater than previously acknowledged, but not that the probability of the event is greater than estimated: the additional uncertainty could just as well decrease the probability of the event occurring. When applying our approach to arbitrary examples, this objection would succeed; however in this paper, we are specifically looking at cases where there is an extremely low value of P(X|A), so practically any value of P(X|A) will be higher and thus drive the combined probability estimate upwards. The situation is symmetric with regard to extremely high estimates of P(X|A), where increased uncertainty about the argument will reduce the probability estimate, the symmetry is broken only by our focus on arguments which claim that an event is very unlikely.

### Err on the side of caution – being wrong once means extinction

Barbee, 9 [Brent, BS, Aerospace Engineering degree from UT Austin; MS in Engineering from the Department of Aerospace Engineering and Engineering Mechanics at the University of Texas, Austin specializing in Astrodynamics and Spacecraft Mission Design), is currently working as an Aerospace Engineer and Planetary Defense Scientist with the Emergent Space Technologies company in Greenbelt, Maryland. He also teaches graduate Astrodynamics in the Department of Aerospace Engineering at The University of Maryland,“ Planetary Defense

Near-Earth Object Deflection Strategies,” Air & Space Power Journal, April 2009, <http://www.airpower.au.af.mil/apjinternational//apj-s/2009/1tri09/barbeeeng.htm>]

 It is generally accepted that statistics and probability theory is the best way to handle partial information problems. Gamblers and insurance companies employ it extensively. However, one of the underlying premises is that it is acceptable to be wrong sometimes. If a gambler makes a bad play, the hope is that the gambler has made more good plays than bad ones and still comes out ahead. This however is not applicable to planetary defense against NEOs. Being wrong just once may prove fatal to millions of people or to our entire species. If we trust our statistical estimates of the NEO population and our perceived collision probabilities too much, we risk horrific damage or even extinction. This is how we must define the limit for how useful probability theory is in the decision-making process for defense against NEOs.

## Probability High

### NEOs are as probable as air crashes, train crashes, and nuclear emissions from reactors

The Independent (London), 2000 September 3, 2000, “END OF THE WORLD IS (ALMOST) NIGH; IT'S OFFICIAL - THE POSSIBILITY OF ASTEROIDS DEVASTATING THE EARTH IS NO LONGER CONFINED TO HOLLYWOOD SCIENCE -FICTION”, Lexis Nexis, 6/21/11, CF

IT'S OFFICIAL: the Earth is at risk from falling asteroids. A Government task force has concluded that the threat of asteroids crashing to Earth as portrayed in Hollywood movies Deep Impact and Armageddon is not the stuff of science fiction - it's very, very real. The task force on Near Earth Objects (NEOs) will publish its findings later this month. It will confirm that there is a distinct possibility of asteroids and comets hurtling to Earth and will urge the Government to take a lead in seeking international action to avert the threat. The recommendations include more work to identify the asteroids or comets that could present a risk, including building a new telescope, possibly in the southern hemisphere, to help to track the objects far out in space and to study the physical properties of NEOs. "It says the threat is serious. There is absolutely no doubt about that at all, and it goes into a great deal of detail. It says the threat is significant enough to warrant action," said one source who has seen the report. "A risk assessment shows that the risk from NEOs is up there with air crashes, train crashes, emissions from nuclear reactors like Chernobyl. It is above the line of tolerability set by the health and safety executive. If this threat was owned by somebody, it would be an offence - that is the sort of analogy that has grabbed the politicians." Until recently the Government had been sceptical about the hazards but science minister Lord Sainsbury was persuaded to set up the task force in January following a campaign by scientific experts. It marks a personal victory for the Liberal Democrat MP Lembit Opik, who has waged a lone campaign in the Commons for the issue to be taken seriously. "I don't think that people are laughing any more at the idea that NEOs are a real threat. Two or three years ago there was a high giggle factor about NEOs but in the last 18 months the scientific community and the general public have changed their view measurably. The popular media has woken up to the threat because of Deep Impact and Armageddon. It is literally a matter of life and death if there is an impact." Mr Opik became fascinated with the issue because his grandfather, Ernst, was an astronomer who discovered a cloud of a trillion comets in the outer solar system. "It's called the Oort cloud but it was nearly called the Opik cloud," said the MP. There has been growing acceptance that the dinosaurs may have been wiped out by a catastrophic asteroid or comet strike in the Gulf of Mexico. There is also evidence that more recent strikes on the Earth included one in 1904 that had the impact of a nuclear explosion in Tunguska, Siberia, felling huge areas of forest. The most recent scare was raised in March 1998, when scientists identified an asteroid which they thought could hit the Earth in 2028. The asteroid's trajectory has since been dismissed as a "near miss" but it galvanised politicians to take the threat of objects falling from space more seriously. The three-man working party, chaired by Dr Harry Atkinson, with Professor David Williams and Sir Crispin Tickell, consulted with leading experts in the UK, Europe and the United States when investigating the magnitude of the hazard and is understood to have delivered its report in July to Lord Sainsbury. The team was told by experts that the US is already taking the threat seriously but closer observations were needed to fill gaps in the American checks on space. Nasa has been ordered to identify within the next decade all the large NEOs of more than 1km - just over half a mile - across which present a threat to Earth. British experts warned the committee that smaller objects may not obliterate the planet, but they could destroy whole cities. The working party is understood to have agreed with the scientific experts that closer studies are needed, and it can be done only through international co-operation. It then leaves Tony Blair's government a headache: if they do find an asteroid or comet that may hit the Earth, what can they do about it? Jonathan Tate, who runs Spaceguard, a voluntary group of experts dedicated to NEOs, said they could deflect the asteroids by attaching rockets to blast them out of the Earth's orbit. Another option would be to vaporise part of the object with a nuclear explosion in space. Major Tate, who took up the issue after watching the Shoemaker-Levy comet, said: "One of the main things we have to do is educate the public. We now know that impacts have happened in the past and could affect the global environment. People are now looking back through history to see whether, for instance, an impact in 540 caused the Dark Ages. The global economy is pretty fragile - look what happened after the earthquake in Japan. That was peanuts compared to what would happen if an asteroid took out a major city and at the moment, we just don't know."

## OWs Nuclear War

### There is no status quo programs with enough money to combat the asteroid problem

USN ’07 (US State News, 3/7/07, DIRECTOR OF ASTRONOMY LAB PROGRAM AT UNIVERSITY OF NORTH TEXAS COMMENTS ON CONFERENCE EXAMINING THREAT FROM ASTEROIDS, 6/22/11, LexisNexis, MLK)

A conference underway this week in Washington D.C. is focusing on the potential threat of an asteroid striking the earth. The director of the astronomy lab program at the University of North Texas says the threat is real, but the problem is there's no money for any tracking efforts. Ron DiIulio says asteroid searches are going on all the time. But he adds to deal with the problem requires a two step approach. He says, "First, we have to identify the potentially hazardous asteroids. Far too often, we see them when they pass away from the earth, but we didn't know they were coming. Secondly, we have to deflect or alter their path. NASA has plans and methods to do this, but what happens is we need to develop interest in it. An asteroid the size of a football field could take out the entire DFW area." The "Planetary Defense Conference" is specifically concentrating on the threat posed by the asteroid Apophis, which could pass within 18,000 miles of Earth twice between 2029 and 2036. NASA predicts it would cost $1billion to find 90 percent of the 20,000 potentially hazardous asteroids and comets by 2020. DiIulio says UNT is already using telescopes at the Monroe Robotic Observatory near Gainesville to track asteroids. "We are using four of our telescopes at the Monroe observatory to look for asteroids. Just last week, we identified three known asteroids." DiIulio hopes that within a year, UNT will be able to take part in the Telescopes In Education program to help track these asteroids.

## A2 – We Can Recover / Adapt

### Resources are not sufficient for us to adapt from Comet/Asteroid Impact

**Wisner ‘7** (Ben, prof of environmental studies at Oberlin College, and Crisis States Programme, Development Studies Institute, London School of Economics , Chapter 26: The Societal Implications of a Comet/Asteroid Impact on Earth: a Perspective from International Development Studies, in *Comet/Asteroid Impacts and Human Society: An Interdisciplinary Approach*, SpringLink)

So, perhaps, we needn’t worry that much about CAI? The problem, however, is that the ecological context of all previous challenges and responses was different. Recall the likely state of humanity and planet Earth when CAI will occur. In situ biodiversity will be eroded. Fresh water resources will have been diverted from irrigated agriculture to meet growing urban industrial needs. Fossil fuels used to synthesize artificial fertilizers and other agricultural chemicals will be much more expensive and scarce – in competition with end uses for generation of energy and mobility. And there will be 8 billion of us. In short, **humanity will not have the luxury of “starting over” with the domestication of plants and animals and creation of agriculture.** British economist Malcolm Caldwell wrote a book, entitled The Wealth of Some Nations in which he demonstrated that the petroleum and other fossil fuel resources of this planet are not sufficient for a second great agricultural and industrial revolution as we saw in Europe in the past few centuries. At that time, Europe had benefited since the 1500s from import of wealth (gold, silver) and later massive amounts of organic matter (guano) and energy. Such “primitive accumulation” cannot be repeated, Caldwell argued.

**\*CAI = Comet/Asteroid Impact**

### Resource scarcity means we won’t be able to recover from a NEO strike

**Wisner ‘7** (Ben, prof of environmental studies at Oberlin College, and Crisis States Programme, Development Studies Institute, London School of Economics , Chapter 26: The Societal Implications of a Comet/Asteroid Impact on Earth: a Perspective from International Development Studies, in *Comet/Asteroid Impacts and Human Society: An Interdisciplinary Approach*, SpringLink)

However, even if we imagine a relatively peaceful world with a well-connected and well-financed international disaster response mechanism, would that be enough to cope with a CAI? The answer is probably no. The scale of urban destruction would be great. It would include the obliteration of port facilities that are the still the heart of international trade. International financial transactions would be disrupted for a period. The cost and logistical requirements to meet the needs of displaced persons would be great, but that is not the main problem. The Marshall Plan dispensed $ 13 billion between 1947–1953 to feed and clothe a large part of the European population following World War II and to begin to rebuild livelihoods (US Department of State 2004). This is approximately $ 238 billion in the value of 2004 dollars, a considerable investment by the Marshall Plan in a kind of disaster response. The problem is that now, and certainly by the time we suffer a CAI, the urban industrial system will be (a) larger and more mutually interdependent and (b) already stressed during the final decades of petroleum availability (Heinberg 2003; Shah 2004). One estimate of the impact of a recurrence of the 1923 earthquake in Tokyo produced by the consulting firm Risk Management Solutions considers the cost of disrupted markets plus the cost of the physical damage to a much larger metro area. The number they got was $ 2.1–3.3 trillion (Stanford 1996). The knock on effect of such an event – a simple earthquake of known size and location – would be world wide. This loss estimate dwarfs even the considerable economic destruction caused by the 26 December 2004 tsunami that affected 11 countries in Southeast Asia, South Asia, the Indian Ocean and coastal East Africa. Even a very rich country such as the U.S. has a hard time absorbing the economic shock of a single large hurricane when it hits the heart of one of its main petroleum production regions and a major city. Hurricane Katrina, which flooded New Orleans and did catastrophic damage to the Gulf Coast of Mississippi, is at the time of writing likely to be the most costly disaster triggered by a natural event in U.S. history, surpassing the $ 48.4 billion cost of hurricane Andrew that devastated Miami in 1992 (Fields and Rogers 2005).

### Environmental stresses mean no recovery possible

**MacCracken ‘7** < Michael C., Climate Institute, Comet/Asteroid Impacts and Human Society, The Climatic Effects of Asteroid and Comet Impacts: Consequences for an Increasingly Interconnected Society. pg 277

Four trends, however, are likely actually increasing the vulnerability of society to environmental stresses. First, the world population is increasing, with projections being that over the 21st century the number of people spread across the Earth will rise from about 6 billion to 8 to 12 billion. A result of this is that there is less and less unoccupied arable land, thereby restricting relocation as an adaptation option. Native Americans used to adapt to climate fluctuations by following the buffalo to non-impacted regions and large numbers of north eastern Brazilians relocated to avoid El Niño-induced droughts. Now the areas to which they formerly moved hold other people or are being used to provide resources to take care of others, and many regions are now so populated that transportation routes are not adequate for full evacuation. For example, even with a few days warning, there is no way that Long Island, New Orleans, or Haiti can be evacuated when a major hurricane is imminent. And the situation is no better for non-human species, which have become increasingly isolated in smaller and smaller domains that can more and more easily be disrupted, meaning that smaller and smaller stresses could adversely impact biodiversity and ecologically provided resources. Second, the push to optimize the global market economy has led to lower and lower reserves of food, seeds, medicine, and other necessary resources. Global grain reserves have been continuing to decline and now amount to less than a two month supply. This amount is less than the amount produced during a typical growing season, and is certainly much less than the amount by which production could be increased in the next growing season to replace the loss of a season or year’s production. While the standard-of-living globally is rising for many people, this is often a result of dependence upon a continuing and growing stream of “necessities;” we have all become dependent on the routine functioning of more and more nodes and channels, and so the range of possibilities that could lead to disruption seems to be actually increasing.’ No longer is it really small changes in the multi-year statistical-average climate that is the main concern; with the economic system so tightly interconnected, disruption of the weather over a month or season is all that is needed to create significant economic disruption. Although survival might not be immediately threatened, extreme events such as El Niño episodes can cause not only regional environmental problems (e.g. the drought in Indonesia and Southeast Asia several years ago caused both local and international economic impacts), but also can affect nations around the world. Third, as the market economy has developed, there has been a tendency for particular locations to each become specialized in particular economic activities. For example, virtually all of the grain traded internationally (and so the supplies needed to sustain peoples in many nations around the world) comes from only a few regions (i.e. U.S., Russia, China, Australia, Argentina and India), and failures in even one region can cause a significant disturbance in world prices; clearly, simultaneous crop failures in more than one region could significantly increase prices, exposing large populations to reduced food supplies. The specialized seeds that underpin the green revolution and the needed fertilizers also come from a relatively few locations. As pursuit of economic efficiency has driven the international economic system to become more concentrated, interdependencies have increased and few regions remain independent of vital services and supplies from other regions. Just as wider groups of people in a community became more vulnerable to disruption due to floods when modern sewage treatment plants near rivers and coastlines replaced personal outhouses, society has become more vulnerable because activities are now much more concentrated in our interdependent world. Fourth, due to an unusual geological roll of the dice, the natural environment to which we have become adapted has been unusually stable over recent centuries. As a result, society is not particularly well prepared for the wider range of possible conditions that have occurred naturally or for the increasing intensity of extreme events being brought on by anthropogenic climate change. Natural oscillations, such as the El Nifio/Southern Oscillation and the North Atlantic Oscillation, already demonstrate that relatively limited changes in climate in particular regions can influence seasonal to decadal weather patterns in significant ways over large regions. While the Holocene as a whole has been a time of unusually low climatic variability, records for the last 100, 000 years (and longer) from the Greenland ice core (NRC 2002) provide indications of large shifts in temperature that were comparable in their mid-latitude effects to going from interglacial to glacial conditions (or at least for the atmospheric and oceanic circulations that over time have created the climate). It is thought that these interglacial to glacial transitions, which occurred over a few years and typically lasted several centuries, resulted from an outbreak of glacial meltwater into the North Atlantic, but whatever the cause, the lesson is that a stable climate cannot be taken for granted, and that relatively modest events have the potential, if they occur in the right location, to prompt rather large, persistent shifts in climatic conditions over very large regions. What is particularly disturbing is that all of these factors are increasing societal vulnerability at the same time. More and more people are crowding into vulnerable coastal areas, and more and more people are dependent on the well-timed, long-distance transmission of critical resources (e.g. water, food, fuel, electricity, etc.). In addition, the range of climatic extremes is increasing as the world warms, with, for example, more intense precipitation events already documented and more intense tropical cyclones projected (e.g. see Sect. 2.7 in IPCC 2001).

## Asteroid Impact – Extinction

### Strike kills ozone, causes acid rain, and volcanic eruptions, leading to global extinction

Marusek ‘7(James, nuclear physicist & engineer, American Institute of Aeronautics and Astronautics, “Comet and Asteroid Threat Impact Analysis,” http://www.aero.org/conferences/planetarydefense/2007papers/P4-3--Marusek-Paper.pdf)

The ionization of the air during a large comet or asteroid impact will produce large volumes of nitric oxide and nitrogen dioxide carrying it well up into the stratosphere, where these aerosols will severely damage and destroy the ozone layer.29 As a result; high levels of ultraviolet radiation, that is normally shielded by the ozone layer, will reach the surface of the Earth. Ultraviolet radiation can cause serious sunburn, increased incidences of skin cancer and eye damage. Ultraviolet radiation can cause some genetic damage in plants, but the damage will be limited. The ozone molecules will be steadily regenerated by solar radiation after the impact. Complete regeneration and recovery could take several years.30 Mass fires and volcanic activity can produce large volumes of hazardous or poisonous gases including carbon dioxide, sulfur dioxide, carbon monoxide, hydrogen sulfide, hydrogen chloride and hydrogen fluoride.2,31,32 Breathing several of these gases can result in severe lung damage, lung edema and death.2 Fortunately, many of these very deadly gases will react quickly with moisture in the air and convert to a less dangerous acid mist. In normal to high humidity environments, this conversion will take place within 1 - 4 miles (1.6-6.4 km). But under the following conditions, the range will be significantly greater: • Dry, arid desert environments. • Winter freezing environments that produce very low humidity levels. • High elevation in the atmosphere where the temperature is below freezing. • Very dense gas cloud concentrations. As these gases combine with the moisture in the air, strong acids will form. This intense acid rain including carbonic acid, nitric acid, hydrated sulfur dioxide, and hydrochloric acid will fall to earth.2,12,31,32 Some of the most intense periods of acid rainfall may occur within the few days immediately following the impact. These acid rainfalls may be very intense localized concentrations and a function of prevailing wind patterns. Acid rain can harm vegetation. Acid rain can pollute the waters in rivers, streams, lakes and oceans. This rainfall can contaminate drinking water for humans, mammals, amphibians, reptiles and birds. Slight acidification of the ocean can destroy calcareous nanoplankton. It can also produce large fish kills. In my opinion, **the evolved gases from the mantle plume volcanism and the resulting acidification of the terrestrial and marine environments and the corresponding draw down of oxygen levels are the primary killer of life during past impact induced mass extinction events**. A deep impact from a comet that penetrates the Earth’s crust can trigger massive mantle plume volcanism on the other side of the planet.4,5 In general; volcanoes release minute quantities of magma. For example, the Mount St. Helen eruption of May 18, 1980 produced only 0.5 km3 of magma. Large flood volcanic eruptions, on the other hand, can produce a significant up-tick of magma levels. The Lakagigar Eruption in Iceland of June 8, 1783, for example, produced 14.7 km3 of basalt. This eruption had a major stranglehold on the Northern Hemisphere for several years. Large-scale flood volcanic eruptions such as those associated with the end-Permian extinction (the Emeishan & Siberian Traps) released 3 – 5 million km3 of magma. The Deccan Traps associated with the end-Cretaceous mass extinction released 5 million km3 of magma. Volcanic eruptions produce several gases: water vapor, carbon dioxide, sulfur dioxide, hydrogen sulfide, hydrogen, hydrogen chloride, carbon monoxide, hydrogen fluoride and helium. Table 7 describes the gas concentration levels from volcanic activity similar to a mantle plume eruption.32 Massive mantle plume volcanism will release very high concentrations of light sulfur gases that will rise high in the atmosphere driving Earth’s albedo upward; blocking off sunlight. Very high concentrations of carbon dioxide being heavier than air will cling to the planet’s surface acting like a thermal blanket, holding in trapped heat. Magma thermal heat will be released (for the end-Permian and end Cretaceous extinctions this was on-the-order-of 5 years of solar heat energy). This is a significant quantity of thermal heat if the magma was release during a short time interval. The magma heat will turn the area thousands of miles near the mantle plume volcanism into a dark inferno. Forest will die and become bone dry. Volcanic induced lightning will ignite these forests producing great mass fires that will add to the scope of the disaster. In my opinion, acidic gases released from magma were the leading cause of the past ocean and terrestrial mass extinctions.

### Asteroid impact ends all life—NASA proves.

Glover, ’10 (Jason Glover, Online Marketing Expert and Technology Researcher, 8/30/10, “5 Natural Disasters Threatening the End of the World,” 6/21/11, <<http://www.suite101.com/content/5-natural-disasters-threatening-the-end-of-the-world-a280014>>, MLK)

The favorite 'weapon' of destruction in blockbuster Hollywood movies such as Armageddon and Deep Impact, asteroid impact is a very real threat and is what experts believed caused the extinction of the dinosaurs 65 million years ago. The main asteroid belt between Mars and Jupiter is believed to have up to 1.7 million asteroids and more than 200 are already known to exist that are over 100 kilometer in size. NASA estimates there are between [500 to 1,000 near-Earth asteroids that are over 1 kilometer](http://www.jpl.nasa.gov/releases/2000/neat.html) and one that is 32 kilometers. Collision with a comet travelling through the Solar System could knock any of them towards our world. A big asteroid impact on Earth would have a devastating effect, whether it hit the ocean or land, causing giant tsunamis or throwing enough dirt into the air to block out the sun and cause all life to either suffocate or starve to death.

### Asteroid ensures devastation.

Armageddon Online June ’07, “What damage would an Asteroid Impact cause?” June 04, 2007, June 23, 2011, http://www.armageddononline.org/asteroid-and-meteor-impacts.html

A near earth Object (NEO) does not need to be large to devastate. One the size of a small garage would annihilate a large city. One big enough to leave a 10km crater, still nowhere near the size of the biggest (there is a 300km crater on Earth), would have the destructive force of every one of the world's 10,000 nuclear warhead combined.

### Catastrophe will happen if asteroid hits

Sunfellow ’95, David Sunfellow, a writer for the News Brief, BS in astronomy “Doomsday Asteroids”, Nov 17 1995, June 23, 2011, http://www.nhne.com/articles/saasteroids.html

Using the moon's potholed surface as a reference point, Shoemaker set out to see how often celestial objects smashed into the moon and, by extension, also struck the Earth. With the help of modern satellite and aerial surveillance, Shoemaker and other scientists soon identified over 200 impact sites around the planet. One of these impact sites, which measured 100 miles across and which was buried a mile beneath the Earth surface, dated back 64 million years ago--the exact same time dinosaurs mysteriously vanished from the earth. Supporting the idea that whatever struck the Earth 64 million years ago unleashed a global catastrophe, geologists the world over have discovered a dark ring in the geological history of the planet that contains elements very common to asteroids, but very rare on Earth. The geological records above the dark layer contain records of mammals and other recent life forms, while the geological records below contain the records of dinosaurs and other prehistoric creatures. The dark layer also bears witness to some kind of massive global firestorm. And while scientists still aren't sure how, exactly, the dinosaurs were killed off (or, for that matter, how exactly, two thirds of the rest of the Earth's species were killed off and 90% of the Earth's biomass burned up), there is evidence: The skies of the Earth exploded into flames Wild fires engulfed the planet's forests The skies were probably darkened for months, possibly for years All kinds of geological disturbances, such as volcanic eruptions and lava flows, were ignited

### Cumulative effects of a strike will kill the planet

Marusek ‘7 (James, nuclear physicist & engineer, American Institute of Aeronautics and Astronautics, “Comet and Asteroid Threat Impact Analysis,” http://www.aero.org/conferences/planetarydefense/2007papers/P4-3--Marusek-Paper.pdf)

A comet or asteroid impact event can release tremendous destruction which has been compared to the damage released from a very large thermonuclear explosion. This is a fairly useful analogy. The nuclear explosion effects are a well-studied science that can be directly applied to the study of impacts. This paper provides formulas for converting impactor size, speed and density into impact energy (megatons of TNT equivalent). The level of impact energy is then applied to nuclear weapon effects tables to provide estimates for the magnitude of damage as a function of distance from point-of-impact. As a means of validating the threat model, the analysis of damage effects integrates information gleaned from eyewitness accounts of impacts within recorded history and from geological information from early impact events. Impact effects are broken down into five main areas: shock wave, thermal radiation, debris and aerosols, electromagnetic effects and secondary effects. The shock wave section describes the atmospheric blast wave, ground shock and the water compression wave (tsunami). The thermal radiation section describes the flash and fireball. As the asteroid or comet strikes the Earth, the tremendous heat produced by the impact will melt and vaporize rock. The blast will also eject debris into the upper atmosphere and into space in a ballistic trajectory. The debris and aerosols section will cover this effect. The electromagnetic effects section describes the electromagnetic pulse, ionizing radiation and electrophonic bursters. The final section describes secondary effects including mass fires (conflagration and global firestorms); secondary earthquakes, landslides, volcanoes, & lava flows; dust & impact winter; gas evolution and acid rain (large volumes of gases can be released by an impact including nitric oxide, nitrogen dioxide, carbon dioxide, sulfur dioxide, carbon monoxide, hydrogen sulfide, hydrogen chloride and hydrogen fluoride – some are hazardous or poisonous); upper atmospheric effects (such as expansion of the stratospheric envelope); oxygen depletion; magnetic pole reversals; energetic weather conditions (such as black rain); starvation and plagues. These effects are discussed in detail and an analytical assessment is provided. The following impact scenario is included as an Appendix within the paper. An asteroid strikes the Earth without warning. The asteroid 5.8 kilometers in diameter crashes into the Atlantic Ocean at Longitude 72° 49’ West, Latitude 28° 0’ North. The asteroid is traveling at a velocity of 20 km/s and has a density of 2.0 g/cm3. The asteroid is spherical in shape. It is not a binary asteroid. The impact occurs at 9:45 PM Eastern Time in the middle of June. The asteroid collides with Earth nearly head-on (2 degrees from true vertical) in a slight East to West direction. The scenario is assessed at the following locations: Bermuda, Washington D.C., New York City, town near Indianapolis, Chicago, Dallas, Lincoln, and Los Angeles. This scenario is beneficial to the discussion because it portrays the interconnectivity and timing of hazards and provides a methodology for describing the effects. An accurate assessment of impact hazards is absolutely critical in developing comprehensive disaster preparedness planning.

### Extinction level asteroid is due in the next 100 years

Griffin ‘4 (Dr. Michael, Head of the Space Department John Hopkins University Applied Physics Lab, “Near-Earth Objects,” testimony before the Committee on Senate Commerce, Science and Transportation Subcommittee on Science, Technology, and Space, Apr.7 CQ, lexis)

Mister Chairman and members of the subcommittee, thank you for giving me this opportunity to comment on the greatest natural threat to the long-term survivability of mankind, an asteroid impact with the Earth. Throughout its history, the Earth has continuously been bombarded by objects ranging in size from dust particles to comets or asteroids greater than 10 km in diameter. Although the probability of the Earth being hit by a large object in this century is low, the effects of an impact are so catastrophic that it is essential to prepare a defense against such an occurrence. The first step in that defense is a system to identify and catalog all potential impactors above the threshold of significant damage, approximately 100 meters in diameter. Later, the remainder of a comprehensive Earth-protection system could be assembled so that it would be ready to deflect a potential impactor shortly after it is identified. In 1998, NASA embraced the goal of finding and cataloging, within 10 years, 90% of all near-Earth objects (NEOs) with diameters greater than 1 km. **Impacts** by objects of this size and larger **could result** **in** worldwide damage, and **the** possible **elimination of the human race**. The current system is not sufficient to catalog the population of smaller NEOs. While there are thought to be nearly a thousand objects with diameters greater than 1 km, there are a great many smaller NEOs that could devastate a region or local area. The exact NEO size distribution is not known; however a good current estimate is that there are more than 5 times as many objects with diameters greater than 1/2 km than there are with diameters greater than 1 km. This multiplication of numbers for smaller diameters continues for all sizes at least down to those just large enough to make it through the atmosphere. Thus, if there are about 700 NEOs of 1 km or greater, there are more than 150,000 NEOs with diameters greater than 100 m. The Tunguska event in Siberia in 1908 destroyed an area 50 km in diameter and is believed to have been caused by an impactor less than 50 m in diameter. The average speed of objects colliding with Earth is about 20 km/s (about 45,000 miles per hour). At these speeds the energy of impact is 44 times the explosive power of the same mass of TNT. Thus, the energy released by the impact of a 100 m object is about equivalent to a 50 megaton bomb. The impacts at Tunguska in 1908, Sikhote-Alin (about 270 miles northeast of Vladivostok) in February 1947, and the recently identified objects that have had near misses with Earth, all show us that impacts with the ability to wipe a large metropolitan area can be expected during the **next 100 years.**

## Asteroid 🡪 Extinction / Short Timeframe

### Extinction level event could come at any time

**Johnson ‘4** (Dr. Lindley Johnson Program Manager, Near Earth Objects Observation Program at NASA, “Near-Earth Objects,” testimony before the Committee on Senate Commerce, Science and Transportation Subcommittee on Science, Technology, and Space, Apr.7 CQ, lexis)

Though collisions with larger bodies are much less frequent now than in the early stages of planet formation in the Solar System, they do still occur. Very significant events, capable of causing damage at the surface, will happen on scales of a few hundred to a thousand years. But we do not know when the next impact of an object of sufficient size to cause widespread devastation at ground level may occur. At the current state of knowledge, it is about as likely to happen next week as in a randomly selected week a thousand years from now. The Survey In an effort to gain better understanding of this hazard, NASA has been conducting a search of space near the Earth's orbit to understand the population of objects that could do significant damage to the planet should there be a collision. Commonly referred to as the "Spaceguard Survey", NASA's Office of Space Science conducts this research effort on "Near Earth Objects (NEOs)" -- that is, asteroids and comets that come within an astronomically close distance, <50 million kilometers of Earth. The objective of this survey is to detect, within a 10-year period, at least 90% of the NEOs that are greater than 1 kilometer in size and to predict their orbits into the future. The survey officially started in 1998 and to date, over 700 objects of an estimated population of about 1100 have been discovered, so the effort is believed to now be over 70% complete and well on the way to meeting its objective by 2008. A few words of explanation on the parameters and limitations of the survey may be appropriate. The threshold of 1 kilometer in size was accepted for this survey because it is about the size asteroid that current research shows would border on having a devastating worldwide effect should an impact occur. Because of the orbital velocities involved, impact on Earth of an asteroid of this size would instantly release energies calculated to be equivalent to the detonation of almost a 100,000 megaton nuclear device, i.e., more than all the world's nuclear arsenals detonated at the same time. Not only would the continent or ocean where the impact occurs be utterly devastated, but the effects of the super-heated fragments of Earth's crust and water vapor thrown into the atmosphere and around the world would adversely affect the global weather for months to years after the event. Such an event could well disrupt human civilization anywhere from decades to a century after an impact.

## Asteroid 🡪 Extinction / Inevitable

### Extinction-causing asteroid strike is inevitable

**Smith ‘2k** (Donald Smith, December 20, 2000, National Geographic News, “Getting Serious About Asteroid Strikes,” http://news.nationalgeographic.com/news/2000/12/1220\_asteroid.html)

The early space program gave us an image of Earth as a lustrous blue pearl, serenely sailing through space. But a more accurate metaphor might be a goose in hunting season, flying though a hail of bullets. Earth orbits amidst a swarm of potentially threatening asteroids, some large enough to cause a planet-wide disaster should there be a collision. Chances of such a collision are small in the short-term, but inevitable over time, scientists say. The asteroid strike that ended the age of dinosaurs whalloped Earth 65 million years ago at what is today Mexico’s Yucatan Peninsula. However, as recently as 1986, a dangerous asteroid came within six hours of striking Earth, although no one realized how close Earth had come to disaster until much later. “These things have hit the earth in the past, and they will hit the earth in the future,” warned Eugene Shoemaker, the space-probing geologist who first alerted the world to the danger of near-earth asteroids (NEAs) before he died in 1997. “The catastrophe will exceed other natural disasters by a long shot.” The asteroid that ended the age of dinosaurs was at least six miles (10 kilometers) wide, but smaller asteroids can still be devastating. Scientists estimate that the impact of an asteroid with a diameter of one kilometer (0.6 miles) or more could kill at least a quarter of the world’s human population, as well as many other life forms. Less than a century ago a space rock only 330 feet (100 meters) wide exploded over Siberia. It leveled more than a half million acres (2,000 square kilometers) of forest. However remote, the possibility of the end of life as we know it has energized the astronomical community. The search for new asteroids, once considered the realm of space fanatics, has become serious science. OUT THERE Images of the night sky, as seen through powerful telescopes at California’s Palomar Observatory and elsewhere around the world, are systematically sifted for evidence of yet undiscovered threats. Each object that doesn’t look like an asteroid is carefully removed. The process is painstaking. So far only about half of the estimated 1,100 asteroids with a potential for a catastrophic impact with Earth have been discovered. British astronomers recently urged their government to become more actively involved in the effort.

## Asteroid 🡪 Impact Winter

### Impact winter form an asteroid outweighs nuclear winter

Marusek ‘7 (James, nuclear physicist & engineer, American Institute of Aeronautics and Astronautics, “Comet and Asteroid Threat Impact Analysis,” http://www.aero.org/conferences/planetarydefense/2007papers/P4-3--Marusek-Paper.pdf)

It has been theorized that the impact of a large comet or asteroid and the resulting fires would throw up so much dust and ash in the stratosphere that it would shut off sunlight from the surface of the planet. This would plunge the Earth into a period of darkness lasting many months and even years. In the absence of sunlight, solar heating of the Earth’s surface would come to a halt. This will lead to a severe cooling of the continents approximately 70°F (39°C) below normal and lead to an "impact winter".2 An "impact winter" is similar to a "nuclear winter" but more severe, and could lead to a new Ice Age.

### Asteroid strike causes impact winter

Marusek ‘7 (James, nuclear physicist & engineer, American Institute of Aeronautics and Astronautics, “Comet and Asteroid Threat Impact Analysis,” http://www.aero.org/conferences/planetarydefense/2007papers/P4-3--Marusek-Paper.pdf)

 The blast will eject debris into the upper atmosphere and into space in a ballistic trajectory. At impact, the comet or asteroid will be instantly vaporized along with material from the impact crater/cavity. The diameter of crater/cavity created will typically be 20 times the diameter of the impactor. This debris will be heated to temperatures exceeding 9,000°F (5,000°C).‡‡ The debris following a ballistic trajectory will reach the other side of the planet in 45 to 60 minutes.2 The debris from a large impactor will blot out the sun, the moon and the stars and turn the Earth dark as night. The vaporized rock cloud will rapidly cool and condense in space and form droplets that solidify into spherules (tiny glass beads about 1 mm in diameter). Over the next several hours and days, much of this debris will rain back down over the entire surface of the Earth. This returning debris will be fairly light and will be slowed significantly as it falls through the atmosphere and should not present a significant secondary impact hazard. The area around the impact site will become a major debris field. Some of this debris may be the size of large boulders. Massive debris will be deposited over short distances within the atmosphere. The debris field will taper off as a function of distance from point-of-impact. This debris will cause extensive damage. Whereas an ocean impact will create a vast amount of superheated steam, an impact on land will eject significantly greater solid debris into the atmosphere.

## Asteroid Impact- Blocking Sun

### Asteroid leads to blockage of the sun

Brian 11, Marshall Brian, Marshall Brain is the founder of HowStuffWorks. He holds a bachelor's degree in electrical engineering from Rensselaer Polytechnic Institute and a master's degree in computer science from North Carolina State University. Before founding HowStuffWorks, Marshall taught in the computer science department at NCSU and ran a software training and consulting company. Learn more at his [site](http://howstuffworks.com/framed.htm?parent=about-author.htm&url=http://marshallbrain.com/). “What if an asteroid hit the Earth?” May 18 2011, June 21, 2011

 By the time you get up to a mile-wide asteroid, you are working in the 1 million megaton range. This asteroid has the energy that's 10 million times greater than the bomb that fell on Hiroshima. It's able to flatten everything for 100 to 200 miles out from ground zero. In other words, if a mile-wide asteroid were to directly hit New York City, the force of the impact probably would completely flatten every single thing from Washington D.C. to Boston, and would cause extensive damage perhaps 1,000 miles out -- that's as far away as Chicago. The amount of dust and debris thrown up into the atmosphere would block out the sun and cause most living things on the planet to perish. If an asteroid that big were to land in the ocean, it would cause massive tidal waves hundreds of feet high that would completely scrub the coastlines in the vicinity.

## Asteroid 🡪 Oxygen Depletion

### Causes mass extinction via oxygen depletion

Marusek ‘7 (James, nuclear physicist & engineer, American Institute of Aeronautics and Astronautics, “Comet and Asteroid Threat Impact Analysis,” http://www.aero.org/conferences/planetarydefense/2007papers/P4-3--Marusek-Paper.pdf)

The oxygen in the atmosphere is currently stable at 21% by volume. As a general rule, an asteroid or comet impact will not dramatically alter the current oxygen level. But there is an exception. Two of the past mass extinction events (the end-Permian and the end-Cretaceous) have been linked to a dramatic decline in atmospheric oxygen. Oxygen levels fell from approximately 35% to **15%** during the end-Permian extinction.26 This represents a major decline of 200,000 ppm. Oxygen levels may also have fallen from approximately 30 % to 15 % during the end-Cretaceous extinction.27,\*\*\* The end-Cretaceous extinction has been tied to a massive K/T impact event.28 The end-Permian extinction has been theoretically tied to a series of massive impact events.4,5 **An atmosphere containing less than 19.5% oxygen is considered oxygen-deficient. Loss of consciousness, asphyxiation and, death can also occur in a matter of minutes due to oxygen starvation**. Table 6 describes the effects of oxygen deprivation. The most massive impacts, those that penetrate the Earth’s crust, can produce dramatically reduced oxygen levels by triggering massive mantle plume volcanism. The *Russian-Ukrainian Theory of Deep Abiotic Petroleum Origin* explains why the atmosphere suffered a dramatic decline in oxygen levels and why the oceans became anoxic/superanoxic after massive impacts. According to this theory, petroleum is not a fossil fuel. Petroleum comes from hydrocarbons that were basic components in planet creation. These hydrocarbons exist in a stable form under extreme pressures and temperatures on the underbelly of the Earth’s crust. These hydrocarbons bleed into the magma during volcanic eruptions. The hydrocarbons in the magma combust and burn when they are exposed to the oxygen in the atmosphere. Several gases released during volcanic eruptions, such as carbon dioxide and carbon monoxide, rather than originating as compressed gases from deep within the Earth, are in reality, a product of a combustion process near the Earth’s surface. The combustion process, not only injects acidic gases into the atmosphere, but bleeds oxygen from the atmosphere, which in turn removes oxygen from the oceans.

## Asteroid 🡪 Earthquakes & Volcanic Eruptions

### Earthquakes and volcanic eruptions from asteroids strikes can cause extinction

Marusek ‘7(James, nuclear physicist & engineer, American Institute of Aeronautics and Astronautics, “Comet and Asteroid Threat Impact Analysis,” http://www.aero.org/conferences/planetarydefense/2007papers/P4-3--Marusek-Paper.pdf)

The shock wave that passes through the Earth is referred to as Ground Shock. During the impact, the kinetic energy of the asteroid/comet is transmitted directly into the ground, producing compression and shear motions, which propagate radially outward and vertically inward from the point-of-impact.8 Ground shock is similar to an earthquake. Ground shock propagates very quickly. At large distance from the impact site, ground shock will be the first shock wave to arrive. The speed of the ground shock is estimated using analogous earthquake formulas. Earthquakes are delineated into two categories: Primary and Secondary. Primary earthquakes travel at 13,500 mph to 29,000 mph (6 to 13 km/s). These earthquakes penetrate through the crust of the earth and travel through the molten mantel. A large ocean impact will produce a ground shock similar to a Primary earthquake due to the fact that the Earth’s crust is very thin under the ocean. I expect the Primary ground shock from a large ocean impact to be the main trigger in producing the following secondary effects: earthquakes, volcanoes, lava flows and underwater landslides. Secondary earthquakes move at a speed of 8,000 mph to 12,000 mph (3.5 to 5.5 km/s). These earthquakes will travel horizontally across the Earth's crust. A large land impact will produce a ground shock similar to a Secondary earthquake. Experience from nuclear weapons testing shows this Secondary ground shock is an extremely damaging shock wave near the impact site. The ground shock at the equivalent 75-psi blast overpressure is sufficient to snap an individual’s legs in two if they are standing on a concrete floor within a blast shelter.8 But this shock wave effect rolls off very quickly, such that at the equivalent 50-psi range, the effect is minimal. In my assessment ground shock is a major component of the primary threat from a deep impact. This type of very large impact produces global mass extinction events.

### Mass extinctions from super volacanoes

Marusek, Nuclear Physicist & Engineer, 07 <James, Comet and Asteroid Threat Impact Analysis [<http://www.aero.org/conferences/planetarydefense/2007papers/P4-3--Marusek-Paper.pdf>>

In general, a comet or asteroid impact will only create a regional zone of devastation (defined as the area within the blast wave 1-psi peak overpressure). This zone of destruction is caused primarily by the shock wave with a contributing component from thermal radiation, debris and electromagnetic effects. On rare occasions a massive comet can deeply penetrate the Earth’s crust. Deep penetrations can be modeled by underground nuclear explosions; with the major effect being focused ground shock. The impact shock wave can pass through the Earth rupturing the crust on the opposite side of the planet. Vast flows of volcanic magma would be released. The gases generated from this magma release are the prime culprits of global mass extinctions.4,5

## Asteroid 🡪 Pole Reversal

### Asteroid strike causes pole reversal

Marusek ‘7(James, nuclear physicist & engineer, American Institute of Aeronautics and Astronautics, “Comet and Asteroid Threat Impact Analysis,” http://www.aero.org/conferences/planetarydefense/2007papers/P4-3--Marusek-Paper.pdf)

In general most impacts are too small to affect the Earth’s magnetic pole. It has been theorized that a massive deep impact might shift the Earth’s magnetic pole and may produce a pole reversal.2,19 Earth has undergone magnetic pole reversals in the past and a large impact might trigger this type of effect. The Earth’s magnetic pole deflects cosmic radiation. When the magnetic pole is weak or non-existent, such as at the mid-point of a pole reversal, charged particles from space can penetrate to the Earth’s surface.19 This cosmic radiation can cause direct harm to life on the planet and can also produce genetic damage in living creatures.

## Asteroid Impact- Energy

### The energy of asteroid hitting is bigger than all other possible strikes.

Nick Strobel's Astronomy Notes 10**,** phD in Astronomy, BS Astronomy and Physics, and MS in Astronomy, “Effect of an Asteroid Impact on Earth”, June 4 2010, June 21, 2011, http://www.astronomynotes.com/solfluf/s5.htm,AR

Obviously, something this big hitting the Earth is going to hit with a lot of energy! Let's use the energy unit of 1 megaton of TNT (=4.2× 1015 Joules) to describe the energy of the impact. This is the energy one million tons of dynamite would release if it was exploded and is the energy unit used for nuclear explosions. The largest yield of a thermonuclear warhead is around 50--100 megatons. The kinetic energy of the falling object is converted to the explosion when it hits. The 10-kilometer object produces an explosion of 6 × 107 megatons of TNT (equivalent to an earthquake of magnitude 12.4 on the Richter scale). The 1-kilometer object produces a milder explosion of "only" 6 × 104 megatons (equivalent to an earthquake of magnitude 9.4 on the Richter scale). On its way to the impact, the asteroid pushes aside the air in front of it creating a hole in the atmosphere. The atmosphere above the impact site is removed for several tens of seconds. Before the surrounding air can rush back in to fill the gap, material from the impact: vaporized asteroid, crustal material, and ocean water (if it lands in the ocean), escapes through the hole and follows a ballistic flight back down. Within two minutes after impact, about 105 cubic kilometers of ejecta (1013 tons) is lofted to about 100 kilometers. If the asteroid hits the ocean, the surrounding water returning over the the hot crater floor is vaporized (a large enough impact will break through to the hot lithosphere and maybe the even hotter asthenosphere), sending more water vapor into the air as well as causing huge steam explosions that greatly compound the effect of the initial impact explosion. There will be a crater regardless of where it lands. The diameter of the crater in kilometers is = (energy of impact)(1/3.4)/106.77. Plugging in the typical impact values, you get a 150-kilometer diameter crater for the 10-kilometer asteroid and a 20-kilometer diameter crater for the 1-kilometer asteroid. The initial blast would also produce shifting of the crust along fault lines.

## Asteroid 🡪 EMP

### Asteroid strike causes EMP

Marusek ‘7(James, nuclear physicist & engineer, American Institute of Aeronautics and Astronautics, “Comet and Asteroid Threat Impact Analysis,” http://www.aero.org/conferences/planetarydefense/2007papers/P4-3--Marusek-Paper.pdf)

An Electro-Magnetic Pulse (EMP) is produced by a nuclear explosion. Analogously an EMP may be generated from the energy release from an asteroid/comet impact. Of the impact effects described within this paper, this effect is theoretical and has the least level of certainty attached. If this effect materializes, I would expect a high altitude bolide explosion to produce an EMP to a far greater range than a surface impact. If an EMP is produced, the pulse would occur almost instantaneously at time of impact. This pulse would be typically of a very short duration, approximately 1 μs and is caused by the Compton-recoil electrons and photoelectrons from photons scattered in the surrounding medium. The resulting electric and magnetic fields may couple with electrical/electronic systems to produce damaging current and voltage surges. This pulse is not harmful to humans but it is deadly to electronics, especially transistors, semiconductors and computer chips. The scope of this effect has been only minimally studied. Comparing a surface impact to a nuclear weapon EMP can provide a crude measurement of the effective range of this effect. A ground-level nuclear explosion will produce a Source Region Electro-Magnetic Pulse [SREMP] as far as the distance at which the peak overpressure is 2-psi. The types of equipment damaged or destroyed by an EMP includes: • Energy Infrastructure: electrical power grids, power generating stations, the control systems in nuclear power plants, charge controllers & voltage converters in solar & wind generating electrical systems, oil and gas delivery systems, advance computer control systems. • Communications Infrastructure: television and radio broadcasting facilities, radios, cell phones, televisions, computers and networks, Internet, digital telephone switching systems, commercial telephones, microwave and satellite communications, police scanners. • Automobiles – cars manufactured after 1985 contained a variety of electronics including engine computers, electronic ignition, fuel injection systems, anti-lock breaking systems, electronic automatic transmissions, computer controlled active suspension, and four wheel steering. • Transportation Infrastructure: other forms of transportation (airplanes, buses, trucks, rail, ships), road and rail signaling, gasoline pumps, global positioning systems, radar systems, navigational aids. • Economic Infrastructure: automated machinery, banking, finance industry, stock market, computer systems in factories and offices, inventory maintenance, medical pumps and monitors, medical systems, government and corporate databases, electronic controllers used in manufacturing, chemical, petroleum product industries and metallurgical industries. Long conductors such as power lines, communication cables, radio towers, railroad tracks, large antennas, pipes, cables, metal fencing and the electronic equipment attached to them are particularly susceptible to EMP. B. Ionizing Radiation Large quantities of ionizing radiation will be produced by the impact and can severely change the environment of the upper atmosphere, producing heavily ionized regions, which can disrupt electromagnetic waves passing through those zones. The trapping mechanism for these high-energy electrons may be similar to that which produces the Van Allen radiation belts. This radiation will cause significant interruption of communications. This will interfere with all surviving telephone, television, computer and radio traffic. There will be so much static in the signal that it will be almost unintelligible. For a large impact, these disturbed regions can easily be global in size and can persist for tens of hours. This could essentially temporarily shut down all worldwide communications. C. Electromagnetic Bursters An impact can produce phantom sounds similar to a crackling or clicking sound. These strange sounds can be heard by one individual and yet another individual a few feet away will hear nothing. These sounds are commonly called electrophonic bursters. These sounds occur instantaneously at impact. It is theorized these sounds come from very low frequency (VLF) radio waves at frequencies of 10 hertz to 30 hertz that are produced during impact. These radio waves require a suitable transducer that will act as a loudspeaker to convert the electromagnetic signals into audible vibrations. Several items have been shown to work including aluminum foil, thin wires, pine needles, dry frizzy hair, and even a pair of eyeglasses.17 In another theory, they are caused by the generation of short-lived transient pulses in electric field strength.18

## Asteroid Impact – Tsunami

### Impact leads to mega tsunamis that leave no survivors.

Nick Strobel's Astronomy Notes 10, phD in Astronomy, BS Astronomy and Physics, and MS in Astronomy, “Effect of an Asteroid Impact on Earth”, June 4 2010, June 21, 2011, http://www.astronomynotes.com/solfluf/s5.htm,AR

 The oceans cover about 75% of the Earth's surface, so it is likely the asteroid will hit an ocean. The amount of water in the ocean is nowhere near large enough to "cushion" the asteroid. The asteroid will push the water aside and hit the ocean floor to create a large crater. The water pushed aside will form a huge tidal wave, a tsunami. The tidal wave height in meters = (distance from impact)-0.717 × (energy of impact)0.495/ (1010.17). What this means is that a 10-km asteroid hitting any deep point in the Pacific (the largest ocean) produces a megatsunami along the entire Pacific Rim.Some values for the height of the tsunami at different distances from the impact site are given in the following table. The heights are given for the two typical asteroids, a 10-kilometer and a 1-kilometer asteroid. The steam blasts from the water at the crater site rushing back over the hot crater floor will also produce tsunamis following the initial impact tsunami and crustal shifting as a result of the initial impact would produce other tsunamis---a complex train of tsunamis would be created from the initial impact (something not usually shown in disaster movies).

### Even small asteroids can cause destruction via tidal wave.

Prado ’11, Mark Prado is an American physicist who worked in advanced planning in the US space program, and who is a consultant working overseas for multinational engineering and construction companies operating in remote parts of the world, which is akin to the business model for developing resources in remote places in space. Notably, Mr. Prado began his career working for the U.S. Patent Office (before changing work to the two fields above), which provided insider skills in applying for patents, which is crucial for private sector entities.) “Earth Impact by an Asteroid: Prospects and Effects,” June 22, 2011, <http://www.permanent.com/a-impact.htm>

If an asteroid of size 200 meters hit the ocean (which covers 70% of the Earth), the tsunami (i.e., giant wave) it would create would inflict catastrophic destruction of coastal cities and substantial worldwide human casualties along coastlines. If an asteroid of size 1 kilometer hit Earth, it would cause a dust cloud which would block out sunlight for at least a year and lead to a deep worldwide winter, exhausting food supplies. The latter is what caused the dinosaur extinction, as well as other major extinctions of smaller creatures in geologic time scales. The 200 meter asteroid hits, which are far more common than the 1 km+ hits, wouldn't show up much in geologic histories on a global scale.

### Hitting the oceans would be catastrophic

Prado ’11, Mark Prado is an American physicist who worked in advanced planning in the US space program, and who is a consultant working overseas for multinational engineering and construction companies operating in remote parts of the world, which is akin to the business model for developing resources in remote places in space. Notably, Mr. Prado began his career working for the U.S. Patent Office (before changing work to the two fields above), which provided insider skills in applying for patents, which is crucial for private sector entities.) “Earth Impact by an Asteroid: Prospects and Effects,” June 22, 2011, <http://www.permanent.com/a-impact.htm>

The most damaging kind of impact would be an asteroid that hits the ocean, not the land. An asteroid hitting land causes mainly localized damage. An asteroid hitting the ocean can cause a tsunami (i.e., huge wave) that would inflict catastropic damage to coastal cities and assets to great distances. The Earth is covered 70% by oceans, so an ocean impact is more likely.

## Asteroid Impact- Global Firestorm

### Asteroid will ensure global firestorms

Nick Strobel's Astronomy Notes 10**,** phD in Astronomy, BS Astronomy and Physics, and MS in Astronomy, “Effect of an Asteroid Impact on Earth”, June 4 2010, June 21, 2011, [http://www.astronomynotes.com/solfluf/s5.htm,AR](http://www.astronomynotes.com/solfluf/s5.htm%2CAR)

 The material ejected from the impact through the hole in the atmosphere will re-enter all over the globe and heat up from the friction with the atmosphere. The chunks of material will be hot enough to produce a lot of infrared light. The heat from the glowing material will start fires around the globe. Global fires will put about 7 × 1010 tons of soot into the air. This would "aggravate environmental stresses associated with the ... impact."

## Asteroid Impact- Climate Change

### NEOs cause impact winter—starvation and disease result

Launchspace Staff, ’09 (Launchspace Staff, Space News Magazine, 5/7/09, “The Asteroids are Coming,” 6/21/11, Lexis Nexis, MLK)

This isn't just "buzz" to get you excited about a new movie coming; we really are being buzzed by asteroids and other NEOs (Near Earth Objects), and one day these conjunctions could become collisions! There are lots of NEOs out there orbiting the sun. Some, like comets, are less worrisome since they are composed primarily of ice and small, rocky particles that dissipate upon entering Earth's atmosphere. Others, however, like asteroids are thought of as minor planets that are large enough to damage Earth and its environment if an encounter should take place. Astronomers estimate that there are approximately 1100 near Earth asteroids bigger than one kilometer in diameter and more than one million that are larger than 40 meters in diameter. Those smaller than 40 meters tend to burn up in the atmosphere, but the impact of a 40-meter diameter asteroid is equivalent to a three-megaton bomb! One megaton is the equivalent explosive power of one million tons of TNT. For comparison, the Little Boy atomic bomb dropped on Hiroshima in 1945, exploded with an energy of about 15 kilotons of TNT. Larger NEOs of about 2 kilometers in size could impart energies in the category of about a million megatons! Such an impact could result in an "impact winter" with global loss of crops and subsequent starvation and disease.

## Asteroid impact – Economy

### NEO strike collapses global economy

Dore ‘7(Mohammed, Climate Change Laboratory, Department of Economics, Brock University, Ch. 29: The Economic Consequences of Disasters due to Asteroid and Comet Impacts, Small and Large, in *Comet/Asteroid Impacts and Human Society: An Interdisciplinary Approach*, SpringLink)

Suppose the capital market disruption was accompanied by a more serious financial crisis, perhaps because of the destruction of a government along with its Central Bank. Following such an impact a government might be perceived to be financing recovery by issuing more currency. A loss of some minor currency would not be a problem. Even the loss of an internationally traded currency such as the Canadian dollar would not be a problem, as those affected would merely shift to one of the major currencies such as the US dollar, which is now the reserve currency of the world. But if the magnitude of the NEO impact were large enough to destroy confidence in a major world currency, such as the Japanese Yen, the euro or the US dollar, then its consequences could be serious on a global level. Loss of confidence in a major currency can be rapid. The worst decline in a major currency occurred in Germany between January 1921 and December 1923, as shown in Table 29.4. It shows a rapid decline in the external value of the currency, as domestic prices rose in response to the German government printing more and more currency to meet its reparation obligations. This occurred after it lost a large part of its productive capacity after WW I along with the destruction of the state apparatus and its ability to levy taxes. With regard to the social cost of this hyperinflation, it is worth noting that the real quantity of money (after adjusting for inflation) declined by 92 percent, indicating a virtual collapse of monetary exchange and a return to barter (Keynes 1923). After this loss of confidence in the German Mark, the government introduced a new currency, called the Rentenmark, and declared that one unit of the new currency would be equal to 1 trillion (i.e. 1012) old marks! Hungary, Poland and Austria had similar experiences, although the German case was the most spectacular. Thus history shows that a fiat currency can collapse, and collapse most dismally, under the right conditions. A dramatic decline in the external value of the US dollar could occur even if there were not a catastrophic NEO, but some “large” event that shakes the confidence of the international community, especially as the US has now become a debtor country and does not have enough reserves to cover its external debt, as the Table 29.5 shows. The comparison of Reserves of Foreign Exchange and Gold with external debt should be carried out with care. The external debt can be held in government bonds, or it can be held in the form of equity in real investments in corporations in the form of plant, machinery and equipment. The external debt results in an annual flow of dividends and interest payments out of the indebted countries. It is this flow that can be jeopardized when the level of reserves and holdings of foreign currencies is inadequate to meet the flow. A depreciation of the currency (in terms of its external value) can follow. If a NEO impact that interferes with this annual flow could have a serious effect on that particular currency, it could be “dumped” in the market, leading to its precipitous decline. Another set of data that is of relevance is what is called the Net Investment Position: this is in fact the total external debt of the country. That information is given in Table 29.6. The international comparison in Table 29.6 is an indicator of indebtedness and hence of vulnerability. The English speaking countries and Finland show heavy foreign investments into their countries and net indebtedness. The level of indebtedness approaches the debt of some developing countries. Of particular concern is the US debt ratio (–22.2%). Fortunately for the US, its currency is a world reserve currency, but it is all a matter of confidence. As soon as some major player, such as OPEC, prices its oil in euros, the US dollar as a reserve currency can lose ground in a matter of years. The debt service would then become burdensome and a rapid decline would be a real possibility. A NEO impact in the indebted countries would have major implications for the main creditor nations that are Japan and Switzerland, followed by countries in Western Europe. A major catastrophic impact of a NEO in the indebted countries, with destruction of factories or real estate could be viewed as a force majeure, and an act of God. When real capital is wiped out, it is the insurance companies who will have to meet the costs. Of course the insurance companies could declare bankruptcy and default on their payment obligations. Such a financial disaster would have cascading multiplier effects. Its global spread would be rapid. It is important to note that whereas financial disasters could have major consequences, the damage or destruction of real capital assets such as power stations could have enormous consequences, as the world has become more reliant on large power sources such as nuclear power stations and hydroelectric dams. Table 29.7 gives information on the world’s 11 largest hydroelectric dams. The destruction of any one of them could cause massive floods as well as disruption of economic life.

# Small Asteroids

## Impact – Ozone

### Small NEO could kill the planet via ozone depletion

MacCracken ‘7 (Michael C., fellow at the Climate Institute, Ch. 16: The Climatic Effects of Asteroid and Comet Impacts: Consequences for an Increasingly Interconnected Society, in *Comet/Asteroid Impacts and Human Society: An Interdisciplinary Approach*, SpringLink)

During and following an impact, nitric oxide could be created in several ways (Toon et al. 1997), including rapid cooling following dissociation of O2 and N2 by shock waves, in the plume following impact with the surface, as debris ejected ballistically re-entered the atmosphere, and possibly as a result of induced fires. Model simulations and observations following nuclear weapons tests indicate that injection of substantial amounts of nitric oxide into the stratosphere would lead to large-scale ozone depletion (NRC 1975). Considering the effect of an asteroid impact, Birks et al. (2007) calculate that **an object of about 0.5 km** or greater **would lead to significant depletion of the global ozone layer**; this estimated diameter is about half that cited by Toon et al. (1997), suggesting that asteroid impacts with only about one-eighth the energy have the potential for devastating global-scale impacts and substantially raising the frequency that such events have likely occurred in the past and should be expected in the future. In that ozone is the primary absorber of solar radiation in the stratosphere (balanced by loss of thermal radiation due mainly to carbon dioxide), the stable vertical structure of the stratosphere could also be disturbed, causing changes in atmospheric circulation and in the concentrations of ozone and other substances. Such depletion would allow UV radiation to pass downward toward the surface, where it could do biological harm if not otherwise absorbed by other substances. Nitric oxide injected into the lower atmosphere would also interact chemically, although the lack of light would diminish its role in ozone formation and the suppression of precipitation might slow its removal in rain. Ultimately, however, the nitric oxide (probably in the form of nitric acid) would be likely to be removed from the atmosphere and would tend to acidify water bodies and harm remaining vegetation. Despite many limitations in our understanding, the Earth’s climatic history and model simulations indicate that the impact of a large asteroid or comet would have globalscale effects on climate, which would, in turn, very adversely impact the environment and many key societal activities. While an individual might well have a chance of surviving, the impacts would be such as to make it very difficult for societies to function, leading to very large numbers of secondary deaths (even aside from direct effects of blasts, tsunamis, etc.). That mass extinctions would result from the largest impacts appears quite plausible.

### Ozone depletion causes complete extinction

Greenpeace ’95 (Full of Holes: Montreal Protocol and the Continuing Destruction of the Ozone Layer -- A GREENPEACE REPORT with contributions from OZONE ACTION -- <http://archive.greenpeace.org/ozone/holes/holebg.html>)

When chemists Sherwood Rowland and Mario Molina first postulated a link between chlorofluorocarbons and ozone layer depletion in 1974, the news was greeted with scepticism, but taken seriously nonetheless. The vast majority of crediblescientists have since confirmed this hypothesis. The ozone layer around the Earth shields us all from harmful ultraviolet radiation from the sun. Without the ozone layer, life on earth would not exist. Exposure to increased levels of ultraviolet radiation can cause cataracts, skin cancer, and immune system suppression in humans as well as innumerable effects on other living systems. This is why Rowland's and Molina's theory was taken so seriously, so quickly **- the stakes** **are literally the continuation of life on earth.**

## Ozone Depletion 🡪 Extinction

### Ozone depletion shatters DNA – making survival impossible.

Earth & Society ’98 (A Project out of the University of Michigan -- THE OZONE LAYER: IMPORTANT COMPONENTS OF OZONE EDUCATION – <http://www.umich.edu/~gs265/society/ozone.htm>)

The ozone layer is essential for human life. It is able to absorb much harmful ultraviolet radiation, preventing penetration to the earth’s surface. Ultraviolet radiation (UV) is defined as radiation with wavelengths between 290-320 nanometers, which are harmful to life because this radiation can enter cells and destroy the deoxyribonucleic acid (DNA) of many life forms on planet earth. In a sense, the ozone layer can be thought of as a “UV filter” or our planet’s “built in sunscreen” (Geocities.com, 1998). Without the ozone layer, UV radiation would not be filtered as it reached the surface of the earth. If this happened, “cancer would break out and all of the living civilizations, and all species on earth would be in jeopardy” (Geocities.com, 1998). Thus, the ozone layer essentially allows life, as we know it, to exist.

### Ozone layer is crucial to check complete extinction.

Pidwirny ‘99 (Dr. Michael Pidwirny, Department of Geography, Okanagan University College -- FUNDAMENTALS OF PHYSICAL GEOGRAPHY -- http://www.physicalgeography.net/fundamentals/7b.html)

Above the tropopause is the stratosphere. This layer extends from an average altitude of 11 to 50 kilometers above the Earth's surface. This stratosphere contains about 19.9 % of the total mass found in the atmosphere. Very little weather occurs in the stratosphere. Occasionally, the top portions of thunderstorms breach this layer. The lower portion of the stratosphere is also infuenced by the polar jet stream and subtropical jet stream. In the first 9 kilometers of the stratosphere, temperature remains constant with height. A zone with constant temperature in the atmosphere is called an isothermal layer. From an altitude of 20 to 50 kilometers, temperature increases with an increase in altitude. The higher temperatures found in this region of the stratosphere occurs because of a localized concentration of ozone gas molecules. These molecules absorb ultraviolet sunlight creating heat energy that warms the stratosphere. Ozone is primarily found in the atmosphere at varying concentrations between the altitudes of 10 to 50 kilometers. This layer of ozone is also called the ozone layer . The ozone layer is important to organisms at the Earth's surface as it protects them from the harmful effects of the sun's ultraviolet radiation. Without the ozone layer **life could not exist** on the Earth's surface.

## Small Asteroids Impact – EMP

### Even small asteroids trigger blanket EMP shockwaves

France, 9 [Colonel (USAF) Martin E. B. France (BS, USAFA; MS, Aeronautics and Astronautics Stanford University; PhD, Virginia Tech) is Permanent Professor and Head of the Department of Astronautics, United States Air Force Academy, Air & Space Power Journal, April 1, 2009, “ Planetary Defense:

Eliminating the Giggle Factor,” <http://www.airpower.au.af.mil/apjinternational/apj-s/2009/1tri09/franceeng.htm>]

As a final note in an effort to highlight the threat posed by asteroids of all sizes, one need only look back a few months and a bit north to the Yukon Territory of Canada. On 18 January 2000, a small meteor (estimated at several kg) entered the Earth’s atmosphere and exploded at an altitude of about 25 km. While the explosion (equivalent to between two and three kilotons of TNT) shook houses and was witnessed over an area of thousands of square miles in this sparsely populated region, the most interesting effect surprised many observers.8 It seems that the meteor’s explosion produced an electromagnetic pulse similar to that of a low-yield nuclear device—an effect of nuclear weapons known to have dire consequences for electronic equipment and often predicted as a precursor to a nuclear strike curing the Cold War. Figure 1 above shows the voltage spike measured in the (admittedly small) Yukon power grid.9 This spike, in turn, caused a power outage over one-third of the province with power restored some hours later. In imagining a similar incident occurring over a major metropolitan area, the possibilities for damage, panic and misinterpretation seem significant. A meteor of this size may not be large enough to identify far enough in advance to divert it (and the cost to destroy or divert it may not justify such an operation), but its timely detection and the subsequent warning of its expected strike could save many lives and reduce property damage greatly. The event also serves as another vivid reminder of the frequency with which meteor and asteroid reentries with measurable effects occur.

## Small Asteroids Impact - Economy

### Even a small strike triggers economic collapse

Glister, 7 [Paul, Writer, editor on astronomy and deep space exploration, “Sizing Up the Asteroid Threat,” APRIL 3, 2007, <http://www.centauri-dreams.org/?p=1146>]

The potential threat from near-Earth asteroids can sometimes seem purely theoretical, an academic exercise in how orbits are calculated and refined. But when we start quantifying possible damage from an asteroid strike, the issue becomes a little more vivid. Modeling potential impact points all over the planet, a University of Southampton (UK) team has worked out some stark numbers. The University’s Nick Bailey presented the results at the recent Planetary Defense Conference in Washington. The researchers put a software package called NEOimpactor to work on asteroids under one kilometer in diameter and assumed an impact speed of 20 kilometers per second. Obviously, larger objects are out there and the impact velocity is arbitary, but asteroids in this size range seem to hit the Earth every 10,000 years, frequent enough that the next one that does hit will probably fit this description. Says Bailey: ‘The consequences for human populations and infrastructure as a result of an impact are enormous. Nearly one hundred years ago a remote region near the Tunguska River witnessed the largest asteroid impact event in living memory when a relatively small object (approximately 50 metres in diameter) exploded in mid-air. While it only flattened unpopulated forest, had it exploded over London it could have devastated everything within the M25.’ Indeed, while a 100 meter asteroid could cause relatively localized damage across several countries, doubling the object to 200 meters causes tsunamis on a global scale, assuming an oceanic hit. In terms of casualties, the study sees China, Indonesia, India, Japan and the US as the most vulnerable, though obviously a direct hit on any heavily populated area would be catastrophic. Economically speaking, where the infrastructure is tells much of the tale. Put dense development along the coastlines of economically prosperous areas and you open yourself to the threat of tsunamis and earthquakes emmanating from a wide variety of impact areas. Sweden’s long coastline thus places it in high danger economically, while an impact in the north Atlantic could send devastating tsunamis into both Europe and America. Severe economic effects would clearly result from a strike involving China or Japan. Although we’re currently engaged through projects like the Spaceguard survey in cataloguing NEOs larger than one kilometer in diameter, the smaller objects represented in the Southampton study are largely undetected. The risk of being blindsided by such an object emphasizes our need to develop a space-based observation platform for tracking asteroids of this size, along with providing more accurate information about the movements of larger Earth crossers. Bailey again: “The threat of the Earth being hit by an asteroid is increasingly being accepted as the single greatest natural disaster hazard faced by humanity.”

### Small NEO strike crashes the economy

Kovacs & Hallak ‘7(Paul & Andrew, of the Institute for Catastrophic Loss Reduction, Univ. of Western Ontario, Ch. 28: Insurance Coverage of Meteorite, Asteroid and Comet Impacts – Issues and Options, in *Comet/Asteroid Impacts and Human Society: An Interdisciplinary Approach*, SpringLink)

The Meteor Crater in Arizona was caused by a meteorite approximately 30–50 meters in diameter. The crater that was created as a result of the impact has a diameter of 1200 meters and an area of 1.13 square kilometers.1 This is almost five times the area devastated by the World Trade Center attacks. Severe debris-pressure wave damage occurred over a much larger area. In their study, Garshnek et al. (2000), note that an asteroid or comet with a diameter of 50 meters could potentially devastate up to 1900 square kilometers, an area 7600 times larger than that damaged in New York. The Tunguska Incident, for example, resulted in severe damage over an area 8800 times larger than that in New York and was also caused by a meteorite 30 to 50 meters in diameter. According to Demographia, that level of devastation is larger in size than the total urban land area for cities such as Toronto, London, Paris, New York and the Tokyo metropolitan area. Thus overall damage that will result with the strike of an asteroid of similar size to the Meteor Crater in Arizona would lead to insurance losses far beyond anything with which the industry could cope. If an asteroid with a diameter of 30–50 meters had struck the World Trade Center in 2001, then using the level of devastation discussed by Garshnek et al. (2000), we might estimate that the direct damage and insurance claims may have approached US$ 2–4 trillion. Such losses are well beyond anything the industry has ever faced, and it is unclear how the industry could continue to function. Furthermore, **an impact** on New York **would have a devastating impact on domestic and international capital markets and could lead to a stock market crash in the United States similar to that of the 1930s** (Dore 2005).

### NEO strike kills the economy

MacCracken ‘7 (Michael C., fellow at the Climate Institute, Ch. 16: The Climatic Effects of Asteroid and Comet Impacts: Consequences for an Increasingly Interconnected Society, in *Comet/Asteroid Impacts and Human Society: An Interdisciplinary Approach*, SpringLink)

With the primary purpose of trying to understand if a large asteroid impact could explain the end of the age of dinosaurs, initial studies of the likely environmental consequences of the impact of a comet or asteroid have focused on the wide range of very disastrous impacts that could blot out sunlight and dramatically alter temperature, precipitation, and other climatic variables over the planet as a whole. A brief overview of the results of these analyses is included in the next section (also see Melosh 2007). Were such an event to occur today, even with, and maybe especially because of, our advanced technological capabilities, the result would likely wipe out the international economic support system on which virtually all societies depend, leaving probably only the few millions who could survive off the devastated natural environment. Clearly, such a situation needs to be avoided – and the effort to identify all potential threats is of critical importance.

## Small Asteroid 🡪 Accidental Nuclear War

### Small strike triggers another nuclear war

**BBC ‘2** (Asteroids 'could trigger nuclear war', 7-15, http://news.bbc.co.uk/2/hi/science/nature/2128488.stm)

A small asteroid could accidentally trigger a nuclear war if mistaken for a missile strike, experts have warned. Scientists and military chiefs studying the threat are calling for a global warning centre to be set up to inform governments immediately of asteroid impacts. The risk is seen as particularly grave if an asteroid blast were to happen in areas of military tension, such as over nuclear-armed neighbours India and Pakistan. Each year about 30 asteroids several metres in length pierce the atmosphere and explode, with even the smaller sized ones unleashing as much energy as the nuclear bomb dropped on Hiroshima in Japan. 'Panic' reaction Earlier this month, an Israeli pilot flying an airliner over the Ukraine reported seeing a blue flash in the sky similar to the type of blast caused by a surface-to-air missile, despite Ukrainian authorities saying no such missile had been fired. Experts now believe the pilot saw an explosion caused by an asteroid entering the Earth's atmosphere at high speed. Experts met last week in the US capital Washington DC to discuss what might have happened had such an explosion occurred over a volatile area such as the India-Pakistan region. "Neither of those nations has the sophisticated sensors we do that can determine the difference between a natural Neo (near-Earth object) impact and a nuclear detonation," Air Force Brigadier General Simon Worden from the US Space Command told the Aerospace Daily newspaper. "The resulting panic in the nuclear-armed and hair-trigger militaries there could have been the spark for a nuclear war."

### Causes accidental nuclear war

**Worden ‘2** (Brigadier General Simon P., Hearings on the threat of near-Earth asteroids (NEAs) before the Subcommittee on Space and Aeronautics, House Committee on Science, October 3, 2002. http://impact.arc.nasa.gov/gov\_threat\_2002.cfm)

Two and a half months ago, Pakistan and India were at full alert and poised for a large-scale war, which both sides appeared ready to escalate into nuclear war. The situation has defused-for now. Most of the world knew about this situation and watched and worried. But few know of an event over the Mediterranean on June 6th of this year that could have had a serious bearing on that outcome. U.S. early warning satellites detected a flash that indicated an energy release comparable to the Hiroshima burst. We see about 30 such bursts per year, but this one was one of the largest we have ever seen. The event was caused by the impact of a small asteroid, probably about 5-10 meters in diameter, on the earth's atmosphere. Had you been situated on a vessel directly underneath, the intensely bright flash would have been followed by a shock wave that would have rattled the entire ship, and possibly caused minor damage. The event of this June received little or no notice as far as we can tell. However, if it had occurred at the same latitude just a few hours earlier, the result on human affairs might have been much worse. Imagine that the bright flash accompanied by a damaging shock wave had occurred over India or Pakistan. To our knowledge, neither of those nations have the sophisticated sensors that can determine the difference between a natural NEO impact and a nuclear detonation. The resulting panic in the nuclear-armed and hair-triggered opposing forces could have been the spark that ignited a nuclear horror we have avoided for over a half century. I've just relayed one aspect of NEOs that should worry us all. As more and more nations acquire nuclear weapons-nations without the sophisticated controls and capabilities built up by the United States over the 40 years of Cold War-we should ensure the 30-odd yearly impacts on the upper atmosphere are well understood by all to be just what they are.

### Strike causes accidental nuclear war

Stenger ‘2(Richard Stenger, October 3, 2002, CNN, “General: Asteroid could start nuke war,” http://www.cnn.com/2002/TECH/space/10/03/asteroid.hearing/)

While astronomers scan the skies for killer asteroids, smaller cosmic boulders pose a greater overall risk and could even spark a nuclear conflict, space and military representatives told a congressional hearing Thursday. Scientists estimate that near the Earth's orbital path are slightly more than 1,000 asteroids 1 kilometer (0.6 miles) in diameter or larger that could cause global catastrophes if they hit their mark. NASA expects to conclude a census of such large near-Earth objects, or NEOs, in 2008 and has already identified almost half of the predicted population. Collisions with such monster rocks take place only once every 1 million years or so. Better to worry about those the size of cars, which hit every few weeks, or those the size of whales, which hit every few centuries, said U.S. Air Force Brig. Gen. Simon Worden. An asteroid 5 to 10 meters in diameter exploded in June over the Mediterranean Sea, releasing as much energy as the atomic bomb dropped on Hiroshima in World War II, Worden told the House Committee on Science. "Imagine that the bright flash accompanied by a damaging shock wave had occurred over India or Pakistan," said Worden. He noted that at the time the two countries were near the brink of war and that either could have mistaken it for a surprise attack. 'Nuclear horror' "The resulting panic in the nuclear-armed and hair-triggered opposing forces could have been the spark that ignited a nuclear horror we have avoided for over a half century." And, he said, if a space boulder in the 100-meter range detonated over a major city, perhaps hundreds of thousands of people might die. His point was that it wouldn't take a so-called "dinosaur killer" asteroid to cause a major catastrophe.

## Small Asteroid 🡪 Society Collapse

### Small strike will collapse society

Carusi ‘5(Andrea, IASF-INAF, Spaceguard Foundation, “Early NEO Deflections: Available, Lower-Energy Option,” *Earth, Moon, and Planets*, vol. 96, p81-94)

Smaller objects (in the 100–500 m diameter range) fall with a higher frequency (one every 103–105 years) and are less destructive. Nonetheless, they still represent a potentially great danger to the human society, not only because of the direct damage that these impacts would cause on a regional to continental scale – especially on the coastal lines – but also because of the indirect effects on the societal infrastructures. As a matter of fact, the modern society is an extremely complex system, whose internal structures (such as the food collection and distribution, the management of the energy resources, the health care services) are intimately tied together. As in every complex system, these structures communicate (and affect each other) through information channels that may be damaged or broken by external perturbations. The collapse of the most important communication channels may lead to the partial or total collapse of the entire system. Impacts at different magnitude levels are an example of external perturbations with the potential, in some cases, to induce a catastrophic collapse, depending mainly on the local spatial and temporal situation. (For a discussion on the implications for the human society of small-medium size impacts on land see An. Carusi, Al. Carusi and L. Pozio, May land impacts induce a catastrophic collapse of civil societies? ICSU Workshop Comets/Asteroids Impacts and Human Society, Tenerife 2004, in preparation.) However, contrary to the majority of other natural disasters, such as earthquakes, floods, epidemics, and volcanic eruptions, impacts may be forecast many decades in advance and their consequences may in principle be completely eliminated by diverting or destroying the object on a collision course.

### Small impactor cause mass death, ecological catastrophe, and has geopolitical impacts

Foster ‘7(Harold, Geography Prof at U of Victoria, Chapter 27: Disaster Planning for Cosmic Impacts: Progress and Weaknesses, in *Comet/Asteroid Impacts and Human Society: An Interdisciplinary* Approach, SpringLink)

Even though smaller, more frequent impactors do not create large tsunamis or long preserved impact craters, they are far from harmless. On June 30, 1908 a near-Earth object, some 50 to 70 meters in diameter, exploded 8 km above the Stony Tunguska River, in Siberia. Whether it was an asteroid or comet is still in dispute, but the resulting air blast devastated an area of some 2150 square kilometers. In the hot central epicenter the forest flashed into a huge ascending column of flame that was visible for several hundred kilometers. Fires burned for weeks destroying 1 000 square kilometers of forest. Ash and powdered fragments of tundra were drawn skywards by the fiery vortex and carried around the world by the global air circulation (Gallant n.d.). The blast felled trees outwards in a radial pattern over an area half the size of Rhode Island. The mass of the object involved was probably about 100 000 tons and the explosion’s force some 40 megatons of TNT, that is 2000 times the energy of the Hiroshima atomic bomb. St. Petersburg seismograph station, 4000 kilometers to the west recorded tremors associated with the blast. Fortunately, the Tunguska region was a very sparsely inhabited. Nevertheless, the event instantly incinerated a local herdsman, Vasily Dzhenkoul, together with his hunting dogs, and 600 to 700 reindeer (Gallant n.d.). Despite the extraterrestrial object’s relatively small size, as Chapman (1998) has pointed out, its associated destruction covered an area larger than either New York City or Washington, D.C. Had such a cosmic body exploded over a densely populated area of Europe instead of the desolate region of Siberia, the number of human victims would have been 500 000 or more, not to mention the ensuing ecological catastrophe and geopolitical ramifications (Galland 2004).

# COMETS

## Asteroid Deflection Key to Comet Deflection

### Asteroid deflection key to learn how to deflect comets

**Easterbrook ‘8** (Gregg, Editor of The Atlantic and The New Republic and Sr. Fellow at Brookings, “The Sky is Falling,” June, http://www.theatlantic.com/doc/200806/asteroids)

But when it comes to killer comets, you’ll just have to lose sleep over the possibility of their approach; there are no proposals for what to do about them. Comets are easy to see when they are near the sun and glowing but are difficult to detect at other times. Many have “eccentric” orbits, spending centuries at tremendous distances from the sun, then falling toward the inner solar system, then slingshotting away again. If you were to add comets to one of those classroom models of the solar system, many would need to come from other floors of the building, or from another school district, in order to be to scale. Advanced telescopes will probably do a good job of detecting most asteroids that pass near Earth, but an unknown comet suddenly headed our way would be a nasty surprise. And because many comets change course when the sun heats their sides and causes their frozen gases to expand, deflecting or destroying them poses technical problems to which there are no ready solutions. The logical first step, then, seems to be to determine how to prevent an asteroid from striking Earth and hope that some future advance, perhaps one building on the asteroid work, proves useful against comets.

## 1AC Comet Impact

### Oort Cloud comets cause mass extinction

**Marusek ‘7** (James, nuclear physicist & engineer, American Institute of Aeronautics and Astronautics, “Comet and Asteroid Threat Impact Analysis,” http://www.aero.org/conferences/planetarydefense/2007papers/P4-3--Marusek-Paper.pdf)

The great majority of asteroid and comet impacts will produce only limited regions of great devastation. The effects from these impacts can be quantitatively assessed by comparing the effects from equivalent air and/or surface nuclear explosion. In my assessment, global mass extinction events are extremely rare and are caused by deep impactors, those that penetrate the Earth’s crust. In general, these massive impacts are caused by inward falling comets from the Oort Cloud. The energy released by a deep impactor is split between surface effects and interior effects. The surface effects can be modeled a surface nuclear burst. The interior effects can be modeled by an equivalent underground nuclear explosions, the main component is a directional ground shock. A deep impact produces two zones of destruction: one at the point-of-impact and the other on the opposite side of the globe. The destruction at the point-of-impact produces a regional area of great devastation that wrecks havoc for several days. The shock wave from the impacts traveled through the Earth fracturing the Earth’s crust on the opposite side of the planet, producing a jumbled debris field and triggering massive mantle plume volcanism. The area of devastation on the opposite side of the Earth is significantly greater and the devastation is long-term extending thousands of years. It is this component that produces global devastation by releasing massive quantities of volcanic magma, which in turn generates acidic and poisonous gases. The gases combine with moisture to form acids that are primarily responsible for extinguishing life across the entire planet.4 The gas generation is also responsible for the drawdown of oxygen levels below minimally acceptable levels. These deep impacts are not random. Rather they occur with regularity in geological time.5

### Comet strike will puncture the earth causing extinction

**Marusek ‘7** (James, nuclear physicist & engineer, American Institute of Aeronautics and Astronautics, “Comet and Asteroid Threat Impact Analysis,” http://www.aero.org/conferences/planetarydefense/2007papers/P4-3--Marusek-Paper.pdf)

In general, a comet or asteroid impact will only create a regional zone of devastation (defined as the area within the blast wave 1-psi peak overpressure). This zone of destruction is caused primarily by the shock wave with a contributing component from thermal radiation, debris and electromagnetic effects. On rare occasions a massive comet can deeply penetrate the Earth’s crust. Deep penetrations can be modeled by underground nuclear explosions; with the major effect being focused ground shock. The impact shock wave can pass through the Earth rupturing the crust on the opposite side of the planet. Vast flows of volcanic magma would be released. The gases generated from this magma release are the **prime culprits of global mass extinctions**.4,5

## Long Period Comet – Link

### Long period comet could come at any time

**Task Force ‘2k** (British National Space Centre, Report of the Task Force on Potentially Hazardous Near Earth Objects, http://www.spacecentre.co.uk/neo/report.html)

Long period comets present new dimensions of difficulty. By definition, such comets have never been seen before. They come unpredictably at all angles from the outer reaches of the Solar System, but can usually only be seen when at a distance of about 5 AU from Earth. Warning of the approach of such a body could well be less than a year. Urgent measures and even more powerful rockets and explosives would then be essential.

## Long Period Comet 🡪 Extinction

### Impact by long period comet causes extinction

**Marusek ‘5** (James, nuclear physicist & engineer, American Institute of Aeronautics and Astronautics, The Cosmic Clock, The Cycle of Terrestrial Mass Extinctions, http://www.lpi.usra.edu/meetings/lpsc2005/pdf/1009.pdf)

These unexpected results led to a reevaluation of the impact hypothesis. The estimate of impactor size was derived from equations comparing impactor crater size to that of a comparable nuclear surface burst. But if the impactor was larger, such as a long period comet (LPC), it would have sufficient energy to penetrate the Earth’s crust (especially an ocean impact where the crust is thin) and this assumption would begin to fall apart. Deep impacts produce smaller craters because most of the energy is released within the interior of the planet. The impact energy can be thought of as the sum of the energy released at the surface and the en-ergy released deep within the Earth’s mantle. The surface component can be approximated to the blast and thermal radiation effects from a comparably-sized nuclear explosion. The effects of the impact energy released in the mantle are obscure and are only observ-able in massive flood basalt eruptions, the creation of a deep magma hot spot, kimberlite pipes and interior structure anomalies, such as magnetic pole reversals. This analysis was expanded to the end-Permian extinction, which shared distinct similarities with the end-Cretaceous. In both extinctions, massive volcanic flood basalt eruptions took place and a significant drawdown of oxygen levels in the atmosphere and oceans occurred. From this study, a hypothesis took shape describing a cluster of comet impacts over a short geological timeframe (5-8 million years) as the cause of the end-Permian extinction. Several impacts were of sufficient size to rupture through the Earth’s crust, producing deep impact effects. The impacts focused shock destruction on the opposite side of the Earth creating fractures at continent/ocean seams. The resulting Emeishan & Siberian Traps generated pro-longed periods of surface flood basalt eruptions induc-ing extensive acid rainfall. Acidification targeted evo-lutionary weaknesses within marine and terrestrial life forms, culminating in a massive die-off at the end of the Permian Period [2]. In summary, **one mechanism capable of producing a global extinction event is deep impact from a LPC**. It is theorized these massive, high velocity comets can drive through the Earth’s crust and deep into the Earth’s interior producing episodes of massive flood basalt eruptions on the other side of the globe.

\*LPC = long period comet

## Small Comet Impact

### Small comet impact could cause extinction via climate disaster

**Binzel & Thomas ‘9** (Richard, prof of planetary science at MIT and author of leading reference book on asteroids, & Cristina, graduate student, “Space Topics: Near Earth Objects, Sizing Up the Threat,” http://www.planetary.org/explore/topics/near\_earth\_objects/threat.html)

Most estimates suggest that an impacting stony asteroid about 1.5 kilometers (1 mile) across or larger marks the threshold energy for causing a globally devastating event. However, there is much uncertainty associated with making this size estimate, and realistic guesses fall between 0.5 and 5.0 kilometers (0.3 and 3 miles). One part of the uncertainty is the lack of knowledge about how our planet's ecosystem and our society would respond to the sudden and severe stress wrought by an impact. Another area of uncertainty arises from variations in the nature of potential impactors. For example, asteroids in near-Earth space typically encounter our planet with velocities of about 20 kilometers (12 miles) per second. Comets, however, encounter Earth with much higher velocities, typically 30 to 60 kilometers (19 to 37 miles) per second. Because the damaging effects are dependent on the kinetic energy of the impact (equal to half of the mass of the impactor times the square of its velocity), a comet smaller than 1 kilometer (0.6 mile) across could pack a punch with sufficient energy to initiate a global climate disaster.

## A2 – Comets Key

### Asteroids are 99% of the NEO risk

**Morrison ‘7** (David, senior scientist at the NASA Astrobiology Institute, NASA Ames Research Center, Ch. 8: The Impact Hazard: Advanced NEO Surveys and Societal Responses, in Comet/Asteroid Impacts and Human Society: An Interdisciplinary Approach, SpringLink)

Comets as well as asteroids can strike the Earth. We do not know if the impact that killed the dinosaurs, for example, was from a comet or an asteroid. Statistically, however, asteroid hits are more frequent than comet hits. This disparity increases as the size declines, to the point where comets are virtually absent below 1 km diameter (Yeomans 2003). Therefore, the discussions in this paper refer only to asteroids, which account for 99 percent or more of the risk in the sizes of primary interest.

### Active comets only represent 1% of the NEO threat

**Levasseur-Regourd ‘7** (A. Chantal, prof at Université P. & M. Curie (Paris VI), Aéronomie CNRS-IPSL, Ch. 10: Physical Properties of NEOs and Risks of an Impact: Current Knowledge and Future Challenges, in Comet/Asteroid Impacts and Human Society: An Interdisciplinary Approach, SpringLink)

The near Earth objects (hereafter NEOs) population consists of asteroids (or fragments thereof), which are rocky objects; it also includes cometary nuclei, consisting of ice and dust, which happen to eject gases and dust whenever they are sufficiently heated by the solar radiation, and of so-called defunct or dormant comets, which have lost all their ice or are coated by an insulating dust mantle. Asteroids most likely represent the main population. However, dormant and defunct comets could represent up to 18% of the total population, and active comets about 1% of the total population (Binzel et al. 2004).

## A2 – Jupiter Protects: Comets

### Jupiter launches comets at Earth

**Overbye ‘9** (Dennis, NYT Correspondent, “Jupiter: Our Cosmic Protector?” 7-25, <http://www.nytimes.com/2009/07/26/weekinreview/26overbye.html>)

But is this warm and fuzzy image of the King of Planets as father-protector really true? “I really question this idea,” said Brian G. Marsden of the Harvard-Smithsonian Center for Astrophysics, referring to Jupiter as our guardian planet. As the former director of the International Astronomical Union’s Central Bureau for Astronomical Telegrams, he has spent his career keeping track of wayward objects, particularly comets, in the solar system.Jupiter is just as much a menace as a savior, he said. The big planet throws a lot of comets out of the solar system, but it also throws them in. Take, for example, Comet Lexell, named after the Swedish astronomer Anders Lexell. In 1770 it whizzed only a million miles from the Earth, missing us by a cosmic whisker, Dr. Marsden said. That comet had come streaking in from the outer solar system three years earlier and passed close to Jupiter, which diverted it into a new orbit and straight toward Earth. The comet made two passes around the Sun and in 1779 again passed very close to Jupiter, which then threw it back out of the solar system. “It was as if Jupiter aimed at us and missed,” said Dr. Marsden, who complained that the comet would never have come anywhere near the Earth if Jupiter hadn’t thrown it at us in the first place. Hal Levison, an astronomer at the Southwest Research Institute, in Boulder, Colo., who studies the evolution of the solar system, said that whether Jupiter was menace or protector depended on where the comets came from. Lexell, like Shoemaker Levy 9 and probably the truck that just hit Jupiter, most likely came from an icy zone of debris known as the Kuiper Belt, which lies just outside the orbit of [Neptune](http://topics.nytimes.com/top/news/science/topics/neptune_planet/index.html?inline=nyt-classifier), he explained. Jupiter probably does increase our exposure to those comets, he said.