2013 Planetary Defense Conference: Rising to the Challenge

by Benjamin Deniston

For millions of years, asteroid and comet impacts have threatened life on Earth, periodically delivering catastrophic blows to the entire biosphere. Now, however, for the first time in the entire history of Earth, a force exists that could defend the planet from what would otherwise be inevitable future catastrophes. This was the subject of the April, 2013 International Academy of Astronomics Planetary Defense Conference, held in Flagstaff, Arizona.

Bringing together hundreds of scientists from nations all around the world, the conference covered all the main aspects of the challenge. Telescopic systems used to find and track asteroids and comets were discussed, as well as missions to better understand how they can be controlled. And, of course, defense was taken up, with many presentations on various means for altering an asteroid's trajectory, or destroying it if necessary, to ensure it does not impact the Earth.

While a depth of knowledge was demonstrated throughout the five days, it also became clear how much more is needed for a comprehensive defense of Earth.

As some of the participants remarked in various public presentations, planetary defense is nothing less than mankind changing the Solar System: to ensure the defense of Earth, the mind of man must envelop the inner Solar System as a creative force.

Unfortunately, the international strategic frameworks among governments are still far from measuring up to this reality. Although not explicitly discussed, this larger context underlay the conference, even if some participants have become deaf to the signals.

The Chelyabinsk Impact, For Example

Although the program of the Flagstaff conference was set before the asteroid impact, the organizers pulled together a special public session to discuss this remarkable event. Intriguingly, various forms of analysis applied in the attempt to determine the size, speed, energy, and orbit of the asteroid have yielded different results.

Data from seismic stations was used for separate estimations of the energy release by measuring the power of the shock-wave that hit the ground. This indicated 425 kilotons, with a 200-kiloton uncertainty.[1]

Infrasound stations around the world detect sound frequencies far too low for the human ear, but which will

1. One kiloton is a measure of energy equivalent to one thousand tons of TNT.

Table I
Energy Estimations of Chelyabinsk Impact (Kilotons)

Seismic Analysis	Infrasound Analysis	Video Analysis	Government Release
425 ±200	600	415	440

propagate for very large distances. Generally used to detect events like nuclear explosive tests, these stations can also "hear" large meteorite impacts which explode in the atmosphere, such as the Chelyabinsk impact, which generated signals that traveled around the Earth multiple times, lasting for several days. Comparing the readings from different stations, scientists calculated an approximate direction of entry, and the estimated energy released at about 600 kilotons.

In addition, nearly 400 videos of the event were collected and analyzed, to determine the brightness of the explosion, and derive the position and direction of the impact from laborious calibrations and comparisons between different videos and background objects. In video clips that did not capture the meteor itself, but caught the ground lighting up from the explosion, the brightness of the light reflected off car windshields was analyzed as another measure of the size of the explosion. The video analysis indicated an energy level of 415 kilotons.

At some point during six presentations it was casually mentioned that the values being derived from these various methods come close to the values provided by the U.S. military, 440 kilotons. While some people were measuring the light reflected off car windshields as filmed by security cameras, the U.S. government has classified military systems that provide valuable information about the size and nature of small asteroid impacts.

In January of this year, the Air Force Space Command signed a memorandum of understanding with NASA, according to which they agreed to release some information about the meteorite explosions they detect with their systems. Information about the Chelyabinsk event was the first release from this new agreement.[2] While this is seen as a positive step in cooperation between the scientific community and the military, it raises some deeper questions.

Human civilization's continued existence depends upon unleashing the creative powers unique to the human mind, expanding mankind's dominion over the Solar System. While that is fundamentally what it means to be human, it is not the current guiding priority of the institutions which govern human beings.

Detection: Finding Asteroids Before They Find Us[3]

During the conference, it was estimated that there are nine million asteroids about the size of the one that impacted over Chelyabinsk, orbiting in the inner region of the Solar System, of which only some 1000 are known.

The first step in defending the Earth is to find the threatening objects, preferably long before they hit. Since the mid-1990s, NASA has led the way, focusing on finding the largest near-Earth objects (NEOs) first.[4] While the task of finding the largest NEOs has been rather successful (since they are the easiest to see), finding the medium- and small-sized NEOs is more challenging, and there is much work to be done, as indicated in Table II.

During an overview of NASA's activities in detecting NEOs, NASA Headquarters program executive for NASA's Near-Earth Object Program office, Lindley Johnson, said the discovery rate has probably already begun to level off. He explained that the limits are being reached for what can be done with existing technologies, which are predominately ground-based telescopes. To find and track any significant portion of the small and medium-sized NEOs (ones which could destroy an entire city or nation), space-based systems will be needed.

Smaller objects reflect less sunlight, making them harder to see, and searching from the Earth's surface creates additional difficulties. Observations can only be made at night (the half of the sky facing away from the Sun), but from space it is possible to look closer towards the Sun, because there is no atmosphere to deal with. On Earth, weather, such as cloud cover, can pose a problem; not so in space. Many asteroids have orbits that ensure they will not be visible from the Earth for years, but telescopes located in different positions in the Solar System, near Venus for example, would provide a completely new vantage point to view NEO populations otherwise hidden. The Earth's atmosphere blocks certain wavelengths of light from ever reaching the surface, but some of these blocked wavelengths, in the infrared range specifically, can provide a better way to see small, dark objects that reflect little visible light.

If the number of discovered and tracked NEOs is to rise from its present level of around 10,000 to the needed levels of hundreds of thousands and then millions, it will require shifting to space-based systems. A few proposals were presented at the conference.

First, a team led by Amy Mainzer of NASA's Jet Propulsion Laboratory, is proposing a new infrared space telescope to orbit the Earth searching for NEOs. A second mission comes from the non-profit B612 Foundation, which is attempting to raise private donations to send an infrared telescope to a Venus-like orbit for the search effort. Third, the Russian Academy of Sciences is investigating designs for one or two telescopes in Earth orbit, which would search in the visible light range. While none of

2. The results are available at http://neo.jpl.nasa.gov/fireballs/

3. To borrow from the title of Don Yeomans' book, *Near-Earth Objects: Finding Them Before They Find Us* (Princeton University Press, 2012). Yeomans is the Supervisor for the Solar System Dynamics Group at JPL and Manager of NASA's Near-Earth Object Program Office.

4. The term "near-Earth object" (NEO) refers to asteroids or comets which have orbits that take them into the inner regions of the Solar System, where they can cross the Earth's orbit and possibly hit the Earth. This term distinguishes them from the larger population of main belt asteroids, orbiting between Mars and Jupiter.

Table II
Asteroid Threat Classes

Size Range (Diameter in Meters)		Range of Impact Effects	Approx. Estimated Population	Approx. Number Found	Approx. Percent-age Found
30 and less	Airburst	Could burn up in the atmosphere unnoticed, or cause structural damage and causalities on a local scale significantly worse than in Chelyabinsk.	12 Million	1,200	~0.01%
30–100	City-killer	Could completely destroy a region from the size of a city to a medium-sized nation.	500 Thousand	2,000	~0.50%
100–300	Nation-killer	Could devastate a region from the size a medium-sized nation to an entire continent. Ocean impacts could cause very wide-spread tsunami devastation.	21,000	2,100	~10%
300–1,000	Continent-killer	A territory ranging from the size of a content to the entire globe.	4,800	2,400	~50%
1,000 and greater	Civilization-threatening	The entire Earth would be affected by the impact effects, including an "impact winter."	900	860	~95%

these three options is currently guaranteed to become operational at this point, any one of them would be a step in the right direction, and all three together would be a larger step, as each alone has its unique inherent benefits, but also specific limitations.

This is what is on the table under the current budgetary and strategic conditions, but are these the fullest capabilities science can provide? How would the detection capabilities change if there were an international strategic agreement between the United States and Russia to apply the fullest capabilities available, and embark upon a serious commitment to develop new technologies to improve mankind's understanding of the structure of the Solar System?

Over the past two years, Russian government officials have proposed cooperation for what they have termed the Strategic Defense of Earth. Unfortunately these offers have apparently fallen on deaf ears in the United States, and there has been no public response.[5]

The issue of reshaping government priorities is posed even more clearly in the subject of stopping a future asteroid impact.

5. Coverage of the repeated offers for a joint U.S.-Russian Strategic Defense of Earth can be found here: http://larouchepac.com/thesde

Defending Earth, and Beyond

Asteroid and comet impacts with the Earth can be stopped, given the right technologies. The key considerations of the challenge are size and time. If the impact can be predicted many decades in advance, the action required could be as simple as slowing the NEO down a tiny amount. Even a small change in speed, if effected many years before Earth impact, can add up to enough of a change in position. The amount of energy needed to generate a particular change in speed then depends upon the size of the NEO in question. On the other hand, if there is less warning time, it may be necessary to destroy the NEO.

While a number of different deflection systems have been theorized and proposed over the years, only a few are considered feasible in the near term. The National Research Council (NRC) published a comprehensive report on planetary defense in 2010, in which they concluded that thermonuclear explosives and "kinetic impacts" (running a spacecraft into the asteroid or comet) are the only options available with existing technologies.[6]

What was not said, either in the NRC report or at the

6. "Defending Planet Earth, Near-Earth Object Surveys and Hazard Mitigation Strategies," by National Research Council's Committee to Review Near-Earth-Object Surveys and Hazard Mitigation Strategies, 2010.

Table III
Planetary Defense Technology is Decades Behind

	Propulsion Systems	Deflection/Destruction Options
Available in 1992	Chemical rockets	Nuclear explosives Kinetic impact
Expected Development by 2012	Nuclear rockets Electric propulsion (solar and nuclear) Mass drivers	Nuclear rockets as thrusters Lasers Hypervelocity penetrations Brilliant darts
Expected Development Beyond 2012	Hypervelocity lunar launch NEO defense in Earth orbit	D-He-3 fusion driver Anti-matter

Source: Workshop Summary, "Assessment of Current and Future Technologies," *Proceedings of the Near-Earth Object Interception Workshop*, Los Alamos National Laboratory, N.M., Jan. 14–16, 1992, pp. 225–34. Febuary, 1993; D.G. Rather, G.J. Canavan, J.C. Solem; Sandia National Labs, Albuquerque, N.M.

In 1992, Edward Teller and other veterans of the SDI project participated in an international workshop at Los Alamos National Laboratory, on defending the Earth from near-Earth objects. One part of that workshop was to assess what general categories of technologies were available at the time, what could be developed within the next two decades (by 2012), and what might be available later. Even though this assessment was a step down from the technological goals of the SDI, the baseline technologies employed today are barely beyond those of 1992, as seen in this table.

Flagstaff conference, is that these are the same fundamental options that were already available in the early 1990s. Although there have been improvements in the technologies associated with these options, there have been no fundamental breakthroughs, despite the fact that the areas where these breakthroughs will occur have been known for decades. (See Table III.)

Kinetic impact and thermonuclear explosives were major focuses of the Flagstaff conference. A series of presentations covered various hypothetical scenarios: large NEOs and small ones, situations with long warning time and those with little. One of the outstanding questions that came up throughout the sessions is the uncertainty in how an NEO will respond to either a kinetic impact or a thermonuclear explosion. Differences in the material composition, density, and structure of NEOs can significantly change how they respond to being hit, and until actual tests are done, there will be no answers.

To shed some light on this matter, the European Space Agency (ESA) and NASA are supporting the kinetic impact test mission Asteroid Impact Deflection Assessment (AIDA). Andrew Cheng of Johns Hopkins University Applied Physics Laboratory presented the mission, which is scheduled for launch in 2019, and impact in 2022. AIDA will include two spacecraft, an impactor (DART), built at Johns Hopkins, and a second spacecraft to monitor the effects of the impact (AIM), built by ESA. DART will crash into the smaller asteroid of a binary asteroid system, 65803 Didymos, and AIM will be able to observe from a safe distance, to determine the efficiency of the impact by measuring the resulting change of the smaller asteroid's orbit around the larger asteroid (an effect that is easier to measure than the change in the orbit of an asteroid around the Sun). Vital information about the response of an asteroid to kinetic impacts will be gained, including crater size, material ejected, seismic effects, shock waves, etc.

A few other kinetic impact tests have been proposed as well. While these presentations elaborated the status and outstanding questions of these current options, there were some more frontier proposals as well. Perhaps most interesting are those involving high-powered lasers.

In the poster session, Philip Lubin, a University of California at Santa Barbara physicist, and Gary Hughes, a Cal Poly San Luis Obispo professor, presented their DE-STAR concept (Directed Energy Solar Targeting of Asteroids and exploRation).* This would be a scalable, modular system, which would convert solar energy into electricity to power an array of lasers. The key to this concept is the "phased array" technology, which allows for the multitude of lasers to be steered and focused to incredible energy densities at the target, vaporizing whatever material it focuses on. The vaporized material then blows off the asteroid, generating a thrust in the process. If the system were built large enough, the thrust would be more powerful than the rocket engines of the

* See interview, this issue.

Space Shuttle, and could be applied for a long period of time.[7]

DE-STAR is the most recent in a short but important list of studies investigating the application of lasers to asteroid deflection. Directed energy systems have many inherent benefits, unmatched by kinetic, explosive, or other proposed systems. Perhaps most important, they can act across space at the speed of light, instead of the days to years it may take for a spacecraft to travel to its target. Once a system is in place, it can be utilized as needed, and each individual application is relatively cheap when compared with designing, building, and launching a new dedicated rocketed space mission.

Such a system could also be multipurpose, with applications for removing space debris from Earth orbit, acquiring better positions and orbit of NEOs, and vaporizing small parts of NEOs to measure their composition and structure for scientific purposes. It may even be possible to use such a system to propel spacecraft throughout the Solar System.

To the Future

Defending the Earth from asteroid and comet impacts challenges all nations in a unique way. There is no region on the globe that is less vulnerable than another. No strategic block is exempt from the threat. It boils down to profound and fundamental questions for society: how the creative power of the human mind measures up against the universe.

With millions of hidden NEOs to discover, the whole sky to watch, and the entire volume of the inner Solar System to ultimately manage, institutions of government are being challenged to organize the potentialities of mankind as a whole, if humanity is to match the realities of living in our Solar System.

This is beyond the scope of any one nation alone. For a truly comprehensive defense, new space capabilities must be developed, new technologies are needed, and a new scientific understanding of the Solar System is ultimately required. Perhaps most important, new levels of strategic cooperation among key nations—specifically the United States, Russia, and China—are needed to focus the efforts of all mankind towards space for a peaceful, cooperative strategic defense of Earth.

Either mankind makes a decision to act in its common interests, for its defense, or mankind faces the threat of extinction, due to its artificial divisions and shortsightedness. Such were the often unspoken realities beneath the surface of the 2013 Planetary Defense Conference.

7. A small to medium-sized asteroid could even be vaporized, if need be.